VIRTUAL MEETING

PRAGUE 2021

35th Meeting of Sedimentology:
Prague, Czech Republic
21–25 June 2021

BOOK OF ABSTRACTS

Palacký University of Olomouc

35th IAS Meeting of Sedimentology
Virtual Meeting
Prague, Czech Republic
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Edited by Ondřej Bábek
and Stanislava Vodrážková

Olomouc 2021

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Edited by: Ondřej Bábek and Stanislava Vodrážková
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CZECH GEOLOGICAL SURVEY

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Main fields of activity

Geological research and mapping
•
Rock environment and its protection
•
Mineral resources and environmental impacts of mining
•
Geohazards, prevention and mitigation of their impact
•
Geoinformation management and delivery

Dear conference participants,

It´s my greatest pleasure to welcome you to the 35th IAS Meeting of Sedimentology in Prague. The first IAS annual meeting in Czech Republic, as it should have been, turned to become the first virtual annual conference in the IAS history as a consequence of the Covid-19 pandemic.

The online IAS Meeting in Prague is the first, but it is a Pyrrhic victory. Since March 2020, organization of this meeting has been paved with constant changes and difficult decision-making. The initial decision about one-year postponement of the physical conference was followed by another one about the conference rearrangement to a fully virtual mode, and then by our desperate expectation that at least field trips and short courses could be organized physically; a hope that soon vanished. These all were heavy blows for the motivation of our organization team.

But finally, nearly two years after the last IAS meeting in Rome, the IAS community gathers again, even if it is “just online”. We are looking forward to five conference days consisting of keynote lectures, regular talks, short oral communications and posters in twelve Meeting Themes and Special Sessions, early-career scientist activities, and award ceremonies. We also have two online short courses and even one field trip! I am very curious about general impressions from the online meeting – will it be something that IAS would rather forget about soon, or will it be a step forward towards a new world of virtual communication or a better way how to attract interest of students and young researchers? But most importantly, I hope this online event will keep our scientific discussions and social contacts alive!

The international community of sedimentary geologists proved not so easy to be demotivated. More than a half thousand registered participants is a splendid figure and a big reward for our effort. I would like to thank all participants for their courage to participate in this unusual event! We also had and still have a huge moral, and indispensable organisational and financial support from the International Association of Sedimentologists, for which I would specially like to say thanks. A huge effort and time was spent during the organization of this meeting by people from the organizing committee, conveners of special sessions and theme chairs, leaders of short courses and field trips, people from the IAS and many more. They all deserve acknowledgments, but I would specially like to say thanks to the key persons, without whom, this meeting would not be possible, Barbora Fryčová, Stanislava Vodrážková, Tomáš Kumpan, Stephen Lokier, and Daniel Ariztegui.

Enjoy your conference time behind the screens of your electronic devices, and I wish I see you all soon in person at an IAS conference, or another occasion, back in normal times.

Ondrej Bábek

On behalf of all organizers

COMMITTEES

Organizing Committee

Ondřej Bábek, general chair, Palacký University of Olomouc
Stanislava Vodrážková, programme chair, Czech Geological Survey, Prague
Barbora Fryčová, GUARANT International spol. s r.o., Prague
Leona Chadimová, Czech Academy of Sciences, Institute of Geology, Prague
Tomáš Kumpan, Masaryk University, Brno
Richard Lojka, Czech Geological Survey, Prague
Roland Nádaskay, Czech Geological Survey, Prague
Slavomír Nehyba, Masaryk University, Brno
Jan Sedláček, Palacký University of Olomouc
Daniel Šimíček, Palacký University of Olomouc
Lenka Špičáková, Czech Academy of Sciences, Institute of Geophysics, Prague
David Uličný, Czech Academy of Sciences, Institute of Geophysics, Prague
Hedvika Weinerová, Czech Academy of Sciences, Institute of Geology, Prague

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Gary Kocurek, USA
Michal Kováč, Slovakia
Tomáš Matys Grygar, Czech Republic
Jiří Kvaček, Czech Republic

THEME CHAIRS AND SPECIAL SESSIONS CONVENERS

Le Heron Daniel – T01 Theme 1: Continental environments and depositonal systems
Peryt Tadeusz – T02 Theme 2: Shallow-marine clastics
Lokier Stephen – T03 Theme 3: Carbonate sedimentology
Peakall Jeffrey – T04 Theme 4: Deep-marine depositional systems
Frank Tracy – T05 Theme 5: Stratigraphic archives of evolution climate, oceans, and biota
Nehyba Slavomír – T06 Theme 6: Records of tectonics in sedimentary archives
Baas Jaco – T07 Theme 7: Physical sedimentary processes (including volcaniclastics)
Tomás Sara – T08 Theme 8: Biochemical processes in sedimentology
Knight Jasper – T10 Theme 10: Sediment routing – from source to sink
Cartigny Matthieu – T11 Theme 11: Applied sedimentology
Zeng Hongliu – T12 Theme 12: Techniques and technologies in sedimentary research- state of the art perspectives
Luo Xiaoneng – T13 Theme 13: Open Theme

CONVENERS

Basilici G. (Universidade Estadual de Campinas, Brazil) – T01-SS01 – Palaeosols: A treasure chest to understand the palaeoenvironmental and sedimentary processes in continental realm

Cojan I. (Centre de Géosciences, Mines Paris Tech, France) – T01-SS01 – Palaeosols: A treasure chest to understand the palaeoenvironmental and sedimentary processes in continental realm

Jewuła K. (Institute of Geological Sciences, Polish Academy of Sciences, Poland) – T01-SS01 – Palaeosols: A treasure chest to understand the palaeoenvironmental and sedimentary processes in continental realm

Sol Raigemborn M. (Centro de Investigaciones Geológicas, Universidad Nacional de La Plata, Argentina) – T01-SS01 – Palaeosols: A treasure chest to understand the palaeoenvironmental and sedimentary processes in continental realm

Varela A. (CONICET – Universidad Nacional de La Plata, Argentina) – T01-SS01 – Palaeosols: A treasure chest to understand the palaeoenvironmental and sedimentary processes in continental realm

Roeser P. (Leibniz Institute for Baltic Sea Research, Germany) – T01-SS02 – Lacustrine Sedimentology: From deep time and climate evolution to modern processes and human impact

Marchegiano M. (Vrije Universiteit Brussel, Brussels, Belgium) – T01-SS02 – Lacustrine Sedimentology: From deep time and climate evolution to modern processes and human impact

Gliozzi E. (Roma Tre University, Italy) – T01-SS02 – Lacustrine Sedimentology: From deep time and climate evolution to modern processes and human impact

Cosentino D. (Roma Tre University, Italy) – T01-SS02 – Lacustrine Sedimentology: From deep time and climate evolution to modern processes and human impact

Ariztegui D. (University of Geneva, Switzerland) – T01-SS02 – Lacustrine Sedimentology: From deep time and climate evolution to modern processes and human impact

Liu K. (China University of Petroleum, China) – T01-SS02 – Lacustrine Sedimentology: From deep time and climate evolution to modern processes and human impact

Liu H. (PetroChina, China) – T01-SS02 – Lacustrine Sedimentology: From deep time and climate evolution to modern processes and human impact

Pan S. (Research Institute of Petroleum Exploration & Development, Northwest, PetroChina, Lanzhou, China) – T01-SS02 – Lacustrine Sedimentology: From deep time and climate evolution to modern processes and human impact

Olariu C. (University of Texas, USA) – T02-SS01 – Gateways, straits and seaways: their sedimentology and stratigraphy importance to understand basins evolution

Rossi V. M. (National Research Council of Italy, Institute of Geosciences Georesources, Italy) – T02-SS01 – Gateways, straits and seaways: their sedimentology and stratigraphy importance to understand basins evolution

Zuchuat V. (University of Oslo, Norway) – T02-SS02 (new for 2021) – The waltz of processes in paralic environments – Rock record and modern perspectives

Vaucher R. (Simon Fraser University, Canada) – T02-SS02 (new for 2021) – The waltz of processes in paralic environments – Rock record and modern perspectives

Gugliotta M. (University of Bremen, Germany) – T02-SS02 (new for 2021) – The waltz of processes in paralic environments – Rock record and modern perspectives

Pederson C. (Ruhr-University, Germany) – T03-SS01 – Geochemistry of modern and Recent carbonates

Sánchez-Román M. (Vrije Universiteit, the Netherlands) – T03-SS01 – Geochemistry of modern and Recent carbonates

Swart P. (Rosenstiel School of Marine and Atmospheric Sciences, USA) – T03-SS01 – Geochemistry of modern and Recent carbonates

Della Porta G. (University of Milan, Italy) – T03-SS01 – Geochemistry of modern and Recent carbonates

Slootman A. (King Fahd University of Petroleum and Minerals, Saudi Arabia) – T03-SS02 – Resedimented carbonates – generation, transportation, deposition

Schnyder J. (ExxonMobil, USA) – T03-SS02 – Resedimented carbonates – generation, transportation, deposition

Playton T. (Chevron Global Frontier Exploration & Appraisal, Kurdistan Region of Iraq) – T03-SS02 – Resedimented carbonates – generation, transportation, deposition

Lokier S. (Bangor University, UK) – T03-SS02 – Resedimented carbonates – generation, transportation, deposition

Reijmer J. (King Fahd University of Petroleum and Minerals, Saudi Arabia) – T03-SS03 (new for 2021) – Carbonate Sequence Stratigraphy: Review and Update

Hollis C. (The University of Manchester, UK) – T03-SS03 (new for 2021) – Carbonate Sequence Stratigraphy: Review and Update

Betzler C. (Universität Hamburg, Germany) – T03-SS03 (new for 2021) – Carbonate Sequence Stratigraphy: Review and Update

Borgomano J. (Aix-Marseille Université, France) – T03-SS03 (new for 2021) – Carbonate Sequence Stratigraphy: Review and Update

Burgess P. (University of Liverpool, UK) – T03-SS03 (new for 2021) – Carbonate Sequence Stratigraphy: Review and Update

Eberli G. (University of Miami, USA) – T03-SS03 (new for 2021) – Carbonate Sequence Stratigraphy: Review and Update

Foubert A. (Université de Fribourg, France) – T03-SS03 (new for 2021) – Carbonate Sequence Stratigraphy: Review and Update

Kerans C. (The University of Texas at Austin, USA) – T03-SS03 (new for 2021) – Carbonate Sequence Stratigraphy: Review and Update

Mutti M. (Universität Potsdam, Germany) – T03-SS03 (new for 2021) – Carbonate Sequence Stratigraphy: Review and Update

Immenhauser A. (Ruhr-Universität Bochum, Germany) – T03-SS03 (new for 2021) – Carbonate Sequence Stratigraphy: Review and Update

Puga-Bernabéu Á. (University of Granada, Spain) – T03-SS03 (new for 2021) – Carbonate Sequence Stratigraphy: Review and Update

van Buchem F. (Halliburton Landmark, UK) – T03-SS03 (new for 2021) – Carbonate Sequence Stratigraphy: Review and Update

Lokier S. (Bangor University, UK) – T03-SS04 (new for 2021) – Open Session on Carbonates

Pederson C. (Ruhr-University, Germany) – T03-SS04 (new for 2021) – Open Session on Carbonates

Gamberi F. (Istituto di Scienze Marine, Consiglio Nazionale Ricerche, Italy) – T04-SS01 – Continental slope sedimentary systems: Processes, products and controls

Kane I. (University of Manchester, UK) – T04-SS01 – Continental slope sedimentary systems: Processes, products and controls

McArthur A. (University of Leeds, UK) – T04-SS01 – Continental slope sedimentary systems: Processes, products and controls

Patacci M. (University of Leeds, UK) – T04-SS01 – Continental slope sedimentary systems: Processes, products and controls

Gong C. (University of Petroleum, China) – T04-SS02 – Submarine canyons and channels: Their role for material transfer and burial from shelf to basin

Steel R. J. (University of Texas, USA) – T04-SS02 – Submarine canyons and channels: Their role for material transfer and burial from shelf to basin

Olariu C. (University of Texas, USA) – T04-SS02 – Submarine canyons and channels: Their role for material transfer and burial from shelf to basin

Gan Y. P. (University of Texas, USA) – T04-SS02 – Submarine canyons and channels: Their role for material transfer and burial from shelf to basin

Kabanov P. (Geological Survey of Canada, NRCan, Canada) – T05-SS01 – Paleozoic ocean, lands, ecosystems and climate imprinted in sedimentary strata: New insights from high-resolution proxies

da Silva A. C. (Université du Liége, Belgium) – T05-SS01 – Paleozoic ocean, lands, ecosystems and climate imprinted in sedimentary strata: New insights from high-resolution proxies

Frank T. (University of Nebraska–Lincoln, USA) – T05-SS02 – Climatic, environmental, and biotic crises of the Permo- Triassic: Sedimentary records of the transition to the Mesozoic world

Fielding C. (University of Nebraska–Lincoln, USA) – T05-SS02 – Climatic, environmental, and biotic crises of the Permo- Triassic: Sedimentary records of the transition to the Mesozoic world

Bourquin S. (French National Centre for Scientific Research, France) – T05-SS02 – Climatic, environmental, and biotic crises of the Permo-

Triassic: Sedimentary records of the transition to the Mesozoic world

Uličný D. (Institute of Geophysics, Prague) – T05-SS03 – Understanding a greenhouse Earth: Climate, sea level, ocean circulation and biogeochemical cycles in the Cretaceous

Batenburg S. (Université Rennes, France) – T05-SS03 – Understanding a greenhouse Earth: Climate, sea level, ocean circulation and biogeochemical cycles in the Cretaceous

Gambacorta G. (Eni, Italy) – T05-SS04 – Black shales: Past depositional systems and modern environments

Frijia G. (University of Ferrara, Italy) – T05-SS04 – Black shales: Past depositional systems and modern environments

Parente M. (University of Naples Federico II, Italy) – T05-SS04 – Black shales: Past depositional systems and modern environments

Wignall P. (University of Leeds, UK) – T05-SS04 – Black shales: Past depositional systems and modern environments

Shillito A. (University of Oxford, UK) – T05-SS05 – Sedimentary environments as the theatres of life and evolution

Davies N. (University of Cambridge, UK) – T05-SS05 – Sedimentary environments as the theatres of life and evolution

McMahon W. (Utrecht University, the Netherlands) – T05-SS05 – Sedimentary environments as the theatres of life and evolution

Rice S. (Loughborough University, UK) – T05-SS05 – Sedimentary environments as the theatres of life and evolution

Adatte T. (Lausanne University, Switzerland) – T05-SS06 – Continent-ocean interactions and their geological records: A tribute to Karl Föllmi

Bomou B. (Lausanne University, Switzerland) – T05-SS06 – Continent-ocean interactions and their geological records: A tribute to Karl Föllmi

Bodin S. (Arrhus University, Denmark) – T05-SS06 – Continent-ocean interactions and their geological records: A tribute to Karl Föllmi

Fantasia A. (Arrhus University, Denmark) – T05-SS06 – Continent-ocean interactions and their geological records: A tribute to Karl Föllmi

Van de Schootbrugge B. (Utrecht University, the Netherlands) – T05-SS06 – Continent-ocean interactions and their geological records: A tribute to Karl Föllmi

Krobicki M. (AGH University of Science and Technology, Poland) – T05-SS07 (new for 2021) – Western Tethys meets Eastern Tethys – sedimetological perspective

Gawlick H.-J. (Montanuniversitaet Leoben, Austria) – T05-SS07 (new for 2021) – Western Tethys meets Eastern Tethys – sedimetological perspective

Goričan Š. (Research Centre of the Slovenian Academy of Sciences and Arts, Slovenia) – T05-SS07 (new for 2021) – Western Tethys meets Eastern Tethys – sedimetological perspective

Huang H. (Chinese Academy of Geological Sciences, China) – T05-SS07 (new for 2021) – Western Tethys meets Eastern Tethys – sedimetological perspective

Ueno K. (Fukuoka University, Japan) – T05-SS07 (new for 2021) – Western Tethys meets Eastern Tethys – sedimetological perspective

Yilmaz İ. Ö. (Middle East Technical University, Turkey) – T05-SS07 (new for 2021) – Western Tethys meets Eastern Tethys – sedimetological perspective

Kowal-Kasprzyk J. (AGH University of Science and Technology, Poland) – T05-SS07 (new for 2021) – Western Tethys meets Eastern Tethys – sedimetological perspective

Starzec K. (AGH University of Science and Technology, Poland) – T05-SS07 (new for 2021) – Western Tethys meets Eastern Tethys – sedimetological perspective

Nohl T. (Geozentrum Nordbayern, Germany) – T05-SS08 – Diagenetic signals in the sedimentary record of environmental change

Reuning L. (Kiel University, Germany) – T05-SS08 – Diagenetic signals in the sedimentary record of environmental change

De Vleeschouwer D. (Universität Bremen, Germany) – T05-SS08 – Diagenetic signals in the sedimentary record of environmental change

Wright V. P. (National Museum Wales, UK) – T05-SS08 – Diagenetic signals in the sedimentary record of environmental change

Di Capua A. (CNR – IGAG, Italy) – T07-SS02 – When volcanoes meet the environment

Kereszturi G. (Massey University, New Zealand) – T07-SS02 – When volcanoes meet the environment

Le Pera E. (University of Calabria, Italy) – T07-SS02 – When volcanoes meet the environment

Watt S. (University of Birmingham, United Kingdom) – T07-SS02 – When volcanoes meet the environment

Rosi M. (University of Pisa, Italy) – T07-SS02 – When volcanoes meet the environment

De Rosa R. (University of Calabria, Italy) – T07-SS02 – When volcanoes meet the environment

Lebas E. (IPGP, Institut de Physique du Globe de Paris, France) – T07-SS02 – When volcanoes meet the environment

Finotello A. (University of Padova, Italy) – T07-SS03 – An expansive perspective of meandering: Patterns and processes across landscapes and scales

Durkin P. R. (University of Manitoba, Canada) – T07-SS03 – An expansive perspective of meandering: Patterns and processes across landscapes and scales

Sylvester Z. (The University of Texas, USA) – T07-SS03 – An expansive perspective of meandering: Patterns and processes across landscapes and scales

Thomas C. (University of Geneva, Switzerland) – T08-SS01 – Microbial imprint on the sediment record: From organomineralization to global biogeochemical cycling

Petráš D. (Czech Geological Survey, Czech Republic) – T08-SS01 – Microbial imprint on the sediment record: From organomineralization to global biogeochemical cycling

Pérez A. M. (Institute of Palaeontology ZRC SAZU, Slovenia) – T08-SS01 – Microbial imprint on the sediment record: From organomineralization to global biogeochemical cycling

Ruberti D. (Campania University, Italy) – T11-SS01 – Sedimentary evolution of estuaries and coastal plains: Subsidence, sediment loss and aquifer hazards

Cappucci S. (ENEA, Italy) – T11-SS01 – Sedimentary evolution of estuaries and coastal plains: Subsidence, sediment loss and aquifer hazards

Wang A. H. (Nanjing Center, China Geological Survey, China) – T11-SS01 – Sedimentary evolution of estuaries and coastal plains: Subsidence, sediment loss and aquifer hazards

Wang A. J. (Third Institute of Oceanography, China) – T11-SS01 – Sedimentary evolution of estuaries and coastal plains: Subsidence, sediment loss and aquifer hazards

Sacchi M. (CNR, Italy) – T11-SS01 – Sedimentary evolution of estuaries and coastal plains: Subsidence, sediment loss and aquifer hazards

Sztanó O. (Eötvös Loránd University, Hungary) – T11-SS01 – Sedimentary evolution of estuaries and coastal plains: Subsidence, sediment loss and aquifer hazards

Cappucci S. (ENEA, Italy) – T11-SS02 – From Holocene to Anthropocene: Human impact on sedimentary environment

Pascucci V. (University of Sassari, Italy) – T11-SS02 – From Holocene to Anthropocene: Human impact on sedimentary environment

Lentsch N. (ExxonMobil Upstream Research Company, USA) – T11-SS03 – Reservoir systems: Subaerial and subaqueous processes, morphologies and significance for sediment distribution

Fedele J. (ExxonMobil Upstream Research Company, USA) – T11-SS03 – Reservoir systems: Subaerial and subaqueous processes, morphologies and significance for sediment distribution

Finotello A. (University of Padova, Italy) – T11-SS03 – Reservoir systems: Subaerial and subaqueous processes, morphologies and significance for sediment distribution

Zeng H. (University of Texas, USA) – T12-SS01 – Seismic sedimentology of thin beds

Zhu X. (China University of Petroleum, China) – T12-SS01 – Seismic sedimentology of thin beds

Olariu C. (University of Texas, USA) – T12-SS01 – Seismic sedimentology of thin beds

Zhang X. (China University of Petroleum, China) – T12-SS01 – Seismic sedimentology of thin beds

ORAL PRESENTATIONS

Session T01-SS01 – Palaeosols: A treasure chest to understand the palaeoenvironmental and sedimentary processes in continental realm

Hall 1, June 21, 13:10-16:20

Chairs: Giorgio Basilici, Isabelle Cojan, Karol Jewuła, María Sol Raigemborn, Saeed Alshahrani

Precambrian lateritic paleosols from Aravalli Supergroup, Rajasthan: Implications for weathering and early life on Earth (id: 692)

Rohit Kumar, Nandan Kumar, Pankaj Srivastava

Presenting author: Rohit Kumar

Paleosols and palustrine facies in Devonian-Carboniferous shallow-marine carbonates in the context of land plant evolution (id: 509)

Pavel Kabanov

Presenting author: Pavel Kabanov

Characteristics, formation and significance of an early Permian palaeosol carrying a multi-aged forest and its palaeoenvironmental and palaeoclimatic implications (id: 291)

Alexandra Hellwig, Steffen Trümper, Ludwig Luthardt, Ronny Rößler

Presenting author: Alexandra Hellwig

Cryptic tubular network trace fossils evidence life in Middle Triassic arid palaeosols of South-West England (id: 766)

Mark Phillip Howson, Maurice E Tucker, Fiona F Whitaker

Presenting author: Mark Phillip Howson

Landscape and depositional controls on palaeosols of a distributive fluvial system (Upper Cretaceous, Brazil) (id: 516)

Marcus Soares, Giorgio Basilici, Paolo Lorenzoni, Agustín Guillermo Martinelli, Áquila Ferreira Mesquita, Thiago da Silva Marinho, André Marconato

Presenting author: Marcus Soares

Paleopedology of the red and yellow paleosols of NW Himalaya: implications for early Oligocene seasonality (id: 691)

Neha Upreti, Rohit Kumar, Abdul Hameed, Pooja Yadav, Pankaj Srivastava

Presenting author: Neha Upreti

Environmental magnetic study of the Dejvice loess/ paleosol sequence (Prague, Czech Republic) (id: 964)

Martin Chadima, Jaroslav Kadlec, Michaela Žatecká, Balázs Bradák, Kristýna Flašarová

Presenting author: Martin Chadima

Tracing paleosols in a UAV-based photogrammetry model of alluvial stratigraphy in the Bighorn Basin, Wyoming (id: 917)

Youwei WANG, Timothy Baars, Joep Storms, Allard Martinius, Hemmo Abels

Presenting author: Youwei WANG

Saharan dust addition to interglacial paleosols of Central European loess-sequences (id: 931)

György Varga, Fruzsina Gresina, Zoltán Szalai, János Kovács

Presenting author: György Varga

Paleopedological evolution of siwalik succession from kangra sub-basin nw himalaya, implication for climate change (id: 690)

Abdul Hameed, Pankaj Srivastava

Presenting author: Abdul Hameed

Calcretes in volcanic islands, unique records of climate/vegetation/sedimentation interactions, Gran Canaria Island, Spain (id: 64)

Ana María Alonso-Zarza, Alvaro Rodríguez-Berriguete, Andrea Martín-Pérez, Inmaculada Menendez, José Mangas, Ana Isabel Casado

Presenting author: Ana María Alonso-Zarza

Session T02-SS02 – The waltz of processes in paralic environments – Rock record and modern perspectives

Hall 2, June 21, 13:10-16:50

Chairs: Valentin Zuchuat, Romain Vaucher, Marcello Gugliotta

Richard W. Faas Research Prize Awardee

Scales of Science (id: 983)

Elizabeth Chamberlain

Presenting author: Elizabeth Chamberlain

Wave-Tide Mixed-Energy Coastal Systems: Tidal shorefaces and refinement of the coastal-environments classification scheme (id: 768)

Shahin Dashtgard, Romain Vaucher, Byongcheon Yang, Robert Dalrymple

Presenting author: Shahin Dashtgard

A down-delta hydraulic geometry model and its application to the rock record (id: 921)

Octria Adi Prasojo, Trevor Hoey, Amanda Owen, Richard Williams

Presenting author: Octria Adi Prasojo

A modern study of dynamic mud deposition: Waihou River, New Zealand (id: 806)

Ben Roche, Andrew La Croix, Julia Mullarney

Presenting author: Ben Roche

Tidal-fluvial concave-bank deposits: An integrated sedimentological and ichnological approach (id: 818)

Susanne W. Fietz, Murray K. Gingras, James A. MacEachern

Presenting author: Susanne W. Fietz

Abandonment and Rapid Infilling of a Tide-Dominated Distributary Channel in the Mekong River Delta (id: 776)

Marcello Gugliotta

Presenting author: Marcello Gugliotta

Holocene environmental dynamics of microtidal paralic systems: a multi-proxy record from the Po coastal plain (id: 863)

Veronica Rossi, Giulia Barbieri, Stefano Claudio Vaiani, Marco Cacciari, Luigi Bruno, Bruno Campo, Marco Marchesini, Silvia Marvelli, Alessandro Amorosi

Presenting author: Veronica Rossi

Multi-scale influence of topography on shallow-marine successions associated with long-term transgressions (id: 956)

Miquel Poyatos-Moré, Ernesto Schwarz, Salvador Boya, Luz Elena Gomis Cartesio, Ivar Midtkandal

Presenting author: Miquel Poyatos-Moré

Tidal amplification and mixed-energy variability in Triassic deltas prograding across a shallow platform, Edgeøya, Svalbard (id: 356)

Ingrid Anell, Valentin Zuchuat, Aleksandra Smyrak-Sikora, Ivar Midtkandal, Alvar Braathen

Presenting author: Ingrid Anell

Sheet-like delta-front sandstone bodies in a river-dominated low-accommodation setting (Dakota Group, USA) (id: 855)

Anna van Yperen, John Holbrook, Miquel Poyatos-Moré, Ivar Midtkandal

Presenting author: Anna van Yperen

Sedimentary architecture of the Middle Ordovician Hawaz Formation in the Murzuq basin (Libya) (id: 795)

Marc Gil-Ortiz, Neil David McDougall, Patricia Cabello, Mariano Marzo, Emilio Ramos

Presenting author: Marc Gil-Ortiz

Session T03-SS04-Open Session on Carbonates
Hall 3, June 21, 13:10-15:55
Chairs: Stephen Lokier, Chelsea Pederson

Carbonate fabric diversity and preservation influenced by clastic deposition archived in Neoproterozoic mixed successions (id: 192)
Daniel Smrzka
Presenting author: Daniel Smrzka

Palaeoecology for depositional model reconstruction, a case study from a Mississippian mound complex in Derbyshire (id: 825)
Alessandro Paolo Carniti, Lucia Angiolini, Giovanna Della Porta, Vanessa Banks, Michael Stephenson
Presenting author: Alessandro Paolo Carniti

Factors controlling oncoid distribution in a shallow carbonate ramp (Kimmeridgian, NE Spain) (id: 892)
Cristina Sequero, Marcos Aurell, Beatriz Bádenas
Presenting author: Cristina Sequero

Facies, sedimentary characteristics, and seismic geometry of carbonate delta drifts resemble carbonate ramps (id: 436)
Christian Betzler, Thomas Lüdmann, Jesus Reolid
Presenting author: Christian Betzler

Early-Career Scientists Award Session Keynote Lecture
Shifting shallow-water carbonate factories in the Eastern Mediterranean's Miocene (id: 248)
Or M. Bialik, Thomas Lüdmann, Yizhaq Makovsky, Giovanni Coletti, Aaron Meilijson, Axel Ehrhardt, Christian Hübscher, Nicolas D. Waldmann, Aaron Micallef, Christian Betzler
Presenting author: Or M. Bialik

Seep carbonates and associated worm tubes community preserved in the Miocene of the Anti-Atlas, Morocco (id: 719)
Ibtissam Chraiki, El Hafid Bouougri, Nezha Lazreq, Boumehdi Ahmed, Abderrazak EL Albani
Presenting author: ibtissam chraiki

The Lochkovian-Pragian boundary interval of the Barrandian area – discussion of oxygen and carbon isotope data (id: 948)
Hedvika Weinerová, Ondřej Bábek, Ladislav Slavík, Hubert Vonhof, Michael Joachimski, Jindřich Hladil
Presenting author: Hedvika Weinerová

Diagenesis and dolomitization of Jurassic carbonate rocks in SE Bohemian Massif (id: 757)
Juraj Franců, Lukáš Jurenka, Petr Jirman
Presenting author: Juraj Franců

Termination of dolostone bodies: ancient reaction fronts record the demise of dolomitization (id: 315)
Ardi Koeshidayatullah, Hilary Corlett, Jack Stacey, Peter Swart, Adrian Boyce, Cathy Hollis
Presenting author: Cathy Hollis

Session T11-SS01 – Sedimentary evolution of coastal and alluvial plains: A key to understand subsidence and aquifer hazards
Hall 3, June 21, 16:05-16:50
Chairs: Daniela Ruberti, Sergio Cappucci, A. H. Wang, A. J. Wang, Sacchi M., Sztanó O.

Holocene sedimentary evolution of the Po coastal plain (Italy) and its relation with differential subsidence (id: 430)
Luigi Bruno, Bruno Campo, Alessandro Amorosi
Presenting author: Luigi Bruno

State transition dynamics in a coastal wetland: Case study of the Venice lagoon (id: 975)
Andrea Taramelli, Emiliana Valentini, Laura Piedelobo, Margherita Righini, Sergio Cappucci
Presenting author: Sergio Cappucci

Understanding the subsidence of the Volturno River alluvial plain by combining geological and geotechnical modelling (id: 674)
Daniela Ruberti, Alessandro Mandolini, Marco Vigliotti, Regina Barbato, Carla Buffardi
Presenting author: Daniela Ruberti

Session T11-SS02 – From Holocene to Anthropocene: Human impact on sedimentary environment

Hall 4, June 21, 13:10-14:35

Chairs: Sergio Cappucci, Vincenzo Pascucci

Decoupling the human geochemical footprint in fluvial sediment sequences (id: 727)

Miguel Ángel Álvarez-Vázquez, Kamila Fačevicová, Martin Faměra, Tomáš Matys Grygar

Presenting author: Miguel Ángel Álvarez-Vázquez

Evidence of environmental tele-connections; danube river drainage basin in the bosphorus black sea outlet area (id: 902)

Dursun Acar, Erol Sarı, Namık Çağatay, Önder Kılıç, Murat Belivermiş, Tuğçe N. Arslan Kaya, Narin Sezer

Presenting author: Dursun Acar

The sedimentary dynamics of Apulian sandy beaches through a multidisciplinary approach (id: 852)

Isabella Lapietra, Luigi Capozzoli, Francesco De Giosa, Stefania Nunzia Lisco, Giuseppe Mastronuzzi, Salvatore Milli, Gerardo Romano, Giovanni Scardino, Simona Tripaldi, Massimo Moretti

Presenting author: Isabella Lapietra

Anthropized beach nourishing sieving the Posidonia oceanica organic berms (id: 707)

Vincenzo Pascucci, Sergio Cappucci, Mario De Luca

Presenting author: Vincenzo Pascucci

Microplastics as a sedimentary component in reefs systems (id: 798)

Amanda Utami, Lars Reuning

Presenting author: Lars Reuning

Sediment Budget modelling of coastal defense during the Anthropocene (id: 974)

Duccio Bertoni, Sergio Cappucci, Luigi Enrico Cipriani, Andrea Carli, Giovanni Sarti, Monica Bini, Marco Luppichini

Presenting author: Sergio Cappucci

Session T05-SS06 – Continent-ocean interactions and their geological records: a tribute to Karl Föllmi

Hall 4, June 21, 15:25-16:50

Chairs: Thierry Adatte, Brahimsamba Bomou, Stéphane Bodin, Alicia Fantasia, Ana María Alonso-Zarza, Bas van de Schootbrugge

Continent-ocean interactions and their geological records: the Legacy of Karl Föllmi (id: 351)

Thierry Adatte, Stéphane Bodin, Brahimsamba Bomou, Fantasia Alicia, Alexis Godet, Bas Van de Schootbrugge

Presenting author: Thierry Adatte

The record of the end-Triassic mass extinction in the Southern Apennines carbonate platform (Italy) (id: 934)

Andrea Montanaro, Francesca Falzoni, Alessandro Iannace, Mariano Parente

Presenting author: Andrea Montanaro

From the continent to the ocean: a basin-scale snapshot on the early Toarcian environmental perturbation (id: 343)

Francois-Nicolas Krencker, Alicia Fantasia, Jan Danisch, Rowan Martindale, Lahcen Kabiri, Mohamed El Ouali, Stéphane Bodin

Presenting author: Stéphane Bodin

Global palaeoenvironmental perturbations during the Aalenian: Mutliproxy evidence from France and Chile (id: 226)

Alicia Fantasia, Thierry Adatte, Jorge E. Spangenberg, Nicolas Thibault, Emanuela Mattioli, Enrique Bernárdez, François-Nicolas Krencker, Stéphane Bodin

Presenting author: Alicia Fantasia

Evolution of the Guerrero-Morelos carbonate platform (Mexico) during the Cenomanian–Turonian oceanic anoxic event 2 (id: 465)

Brahimsamba Bomou, Annie Arnaud-Vanneau, Thierry Adatte

Presenting author: Brahimsamba Bomou

Mixing of continental water masses during MECO (Hampshire Basin): new insight from Carbonate Clumped isotopes (id: 359)

Marta Marchegiano, Cédric M. John

Presenting author: Marta Marchegiano

Session T01-SS01 – Palaeosols: A treasure chest to understand the palaeoenvironmental and sedimentary processes in continental realm

Hall 1, June 22, 10:40-11:10

Chairs: Giorgio Basilici, Isabelle Cojan, Karol Jewuła, María Sol Raigemborn, Saeed Alshahrani

Sedimentological investigation of the famous dinosaur localities in the westernmost part of the Haţeg Basin (id: 893)

Gábor Botfalvai, Zoltán Csiki-Sava

Presenting author: Gábor Botfalvai

Recognition and implications of paleosols of middle-upper Eocene succession, south central Libya (id: 65)

Ashour Abouessa

Presenting author: Ashour Abouessa

Nature and distribution of paleosols in cenozoic fluvial succession of the ranital-kangra section, nw himalaya (id: 528)

Pooja Yadav, Pankaj Srivastava

Presenting author: Pooja Yadav

Advanced statistics of grain-size, petrophysical and geochemical data: a tool in loess-paleosol sequences paleoenvironmental interpretations (id: 572)

Daniel Simicek, Ondrej Babek, Karel Hron

Presenting author: Daniel Simicek

850 kyrs of paleoclimate evolution from magnetic and granulometric data of the Pleven loess-paleosol sequence (id: 802)

Christian Laag, Diana Jordanova, France Lagroix, Neli Jordanova, Yohan Guyodo, Ségolène Saulnier Copard, Pierre Antoine

Presenting author: Christian Laag

350 kyrs of increasing aridity reflected by geophysical proxies from the LPS of Zmajevac, Croatia (id: 906)

Christian Laag, Lara Wacha, Kamila Ryzner, Christian Zeeden, Christian Rolf, France Lagroix, Yohan Guyodo, Sumiko Tsukamoto, Manfred Frechen

Presenting author: Christian Laag

Session T01 – Continental environments and depositional systems

Hall 1, June 22, 11:10-11:15

Chairs: Daniel Le Heron

The upper paleozoic pull-a-part mulargia-escalaplano basin (s sardinia, italy): relationships between tectonics and sedimentation (id: 884)

Luca Giacomo Costamagna

Presenting author: Luca Giacomo Costamagna

Invited Pleanary Lecture

Hall 1, June 22, 12:00-13:00

Chairs: Ondřej Bábek

The giant abiotic carbonate factory of the early Cretaceous of the South Atlantic

Paul Wright

Session T05-SS05 – Sedimentary environments as the theatres of life and evolution

Hall 1, June 22, 13:10-15:40

Chairs: Anthony Shillito, N. Davies, W. McMahon, S. Rice

Epicontinental ironstone accumulation during the end-Ordovician glaciation and extinction events (id: 541)

Jackson D. Malone, Peir K. Pufahl, Eric E. Hiatt

Presenting author: Jackson D. Malone

Coupled early Paleozoic ferruginous water masses, ironstone deposition, and extinction events (id: 468)

Edward Matheson, Peir K Pufahl

Presenting author: Edward Matheson

Sedimentary controls on animal behaviour during the Siluro-Devonian colonization of the continents (id: 439)

Anthony Shillito

Presenting author: Anthony Shillito

Hot-springs through time: what changes, and what stays the same? (id: 307)

Alexander Brasier, Enrico Capezzuoli

Presenting author: Alexander Brasier

Greening of seasonally dry landscapes: the significance of Pennsylvanian red beds containing large woody debris (id: 288)

Steffen Trümper, Jörg W. Schneider, Vaclav Mencl, Birgit Gaitzsch, Ronny Rößler

Presenting author: Steffen Trümper

Influence of environmental stress on Early Triassic biota; example from Central Dalmatia, Croatia (id: 222)

Karmen Fio Firi, Katarina Gobo, Jasenka Sremac, Frane Marković

Presenting author: Karmen Fio Firi

Sedimentary conditions of the Early Jurassic Lithiotis-type bivalves facies in the Himalayan Tethys (Nepal) (id: 705)

Michal Krobicki, Krzysztof Starzec, Kabi Raj Paudyal, Magdalena Ignaczak, Krzysztof Malejka, Daniel Sobczyński, Anna Szreter, Katarzyna Warias

Presenting author: Michal Krobicki

Modeling the dynamic of shell burial, exhumation, and disintegration in Holocene-Anthropocene cores (id: 386)

Adam Tomasovych, Susan M. Kidwell, Ran Dai

Presenting author: Adam Tomasovych

Session T05-SS04 – Black shales: Past depositional systems and modern environments

Hall 1, June 22, 16:25-17:40

Chairs: Gabriele Gambacorta, G. Frijia, Mariano Parente

Black Shales as Typical Parts of Foreland-Basin, Tectono-Stratigraphic Sequences from the Appalachian Basin, U.S.A. (id: 737)

Frank Ettensohn

Presenting author: Frank Ettensohn

Anoxic events and photic-zone euxinia in an oceanographically open Devonian shelfal sea, NW Canada (id: 61)

Pavel Kabanov, Chinqing (Dennis) Jiang

Presenting author: Pavel Kabanov

The Mississippian Bowland Shale: A Synthesis of Recent Advances (id: 449)

Joe Emmings, Simon Poulton, Sarah Davies, Christopher Vane, Gawen Jenkin, Michael Stephenson, Jan Hennissen, Patrick Dowey, Kevin Taylor, Melanie Leng, Angela Lamb, Vicky Moss-Hayes, Jeremy Rushton

Presenting author: Joe Emmings

The palaeoenvironmental reconstruction of the lower toarcian (lower jurassic) lower sulphur band, Cleveland basin, UK (id: 796)

Connor O'Keeffe

Presenting author: Connor O'Keeffe

Cretaceous Black Shales in the Pacific: The Equatorial Position Hypothesis (id: 493)

Max Bouwmeester, Lydian Boschman, Nienke Berends, Jeremy Owens, Ben Gill, João Trabucho Alexandre

Presenting author: Max Bouwmeester

Session T02-SS01 – Gateways, straits and seaways: Their sedimentology and stratigraphy importance to understand basins evolution

Hall 2, June 22, 10:40-10:45

Chairs: Olariu Cornel, Rossi V. M

Tectonic setting of the modern straits: lessons for interpretations of ancient systems (id: 726)

Cornel Olariu, Valentina Rossi

Presenting author: Cornel Olariu

Session T02-SS02-The waltz of processes in paralic environments – Rock record and modern perspectives

Hall 2, June 22, 10:45-11:05

Chairs: Valentin Zuchuat, Romain Vaucher, Marcello Gugliotta

Characterizing late Quaternary paralic to shallow-marine facies associations through piezocone penetration tests (Po Basin, Italy) (id: 257)

Bruno Campo, Luigi Bruno, Alessandro Amorosi

Presenting author: Bruno Campo

Postglacial transgressive deposits sourced in the retreating Guadiana river mouth (SW Iberian Peninsula) (id: 811)

Álvaro Carrión Torrente, Francisco José Lobo, Ángel Puga-Bernabéu, Isabel Mendes, Margarita García, Susana Lebreiro, María Luján, Laura Antón, Maria Isabel Reguera, Javier Cerrillo-Escoriza

Presenting author: Álvaro Carrión Torrente

Sedimentology and architecture of a mudstone parasequence, Book Cliffs, Utah. (id: 263)

Rhys Hamlyn

Presenting author: Rhys Hamlyn

High-latitude marginal marine deposits of the Witpoort Formation, South Africa: problems and solutions (id: 789)

Christopher Harris, Zubair Ali Jinnah, Asinne Tshibubudze, Cameron Roy Penn-Clarke, Robert Wolfgang Gess

Presenting author: Christopher Harris

Session T12-SS01 – Seismic sedimentology of thin beds

Hall 2, June 22, 13:10-14:35

Chairs: Hongliu Zeng, Xiaomin Zhu, Cornel Olariu, Xianguo Zhang

How thin is a thin bed? A seismic-sedimentology perspective (id: 71)

Hongliu Zeng

Presenting author: Hongliu Zeng

Thin shoal delta characterization of seismic sedimentology in the gentle slope of Dongying Sag, China (id: 32)

Xiaomin Zhu, Shifa Zhu, Ye Qin, lei Ye

Presenting author: Xiaomin Zhu

Lithology prediction in a thin-bed mixed siliciclastic–carbonate–evaporite system in Triassic Jialingjiang Formation, Sichuan Basin, China (id: 28)

Zhaohui Xu, Suyun Hu, Wenzhi Zhao, Qilong Fu

Presenting author: Zhaohui Xu

Seismic sedimentology characterization of thin beds in Neogene paleo-Pearl River Delta front, south-eastern China (id: 18)

Xianguo Zhang, Chengyan Lin, Tao Zhang, Xiaoxiao Wu, Qi Li

Presenting author: Xianguo Zhang

Thin bed prediction derived from an interbedded substrate: a revised seismic sedimentological method (id: 23)

Huaqing Liu, Mangjiao Chen

Presenting author: Huaqing Liu

Session T04-SS01 – Continental slope sedimentary systems: Processes, products and controls.

Hall 2, June 22, 15:10-16:10

Chairs: Fabiano Gamberi, I. Kane, Adam McArthur, M. Patacci

Submarine channel behaviour on structured slopes: A quantitative synthesis from the Niger Delta system (id: 869)

Alexander Whittaker, Lidia Lonergan, Mike Mayall, Marco Pizzi, Hamish Mitchell

Presenting author: Alexander Whittaker

Dynamic MTD topography controlling submarine slope accommodation: Examples from the Eocene Aínsa Basin (Spain) (id: 932)

Ashley Ayckbourne, Rhodri Jerrett, Miquel Poyatos-More, Matthew Watkinson, Ian Kane, Kevin Taylor

Presenting author: Ashley Ayckbourne

The Tachrift channel-levée turbidite systems (Tortonian) of the Taza-Guercif Basin (South Rifian Corridor, NE Morocco) (id: 45)

Fabrizio Felletti, Mattia Marini, Imad Elkati, Hassan Tabyaoui, Simone Reguzzi, Chiara Zuffetti

Presenting author: Fabrizio Felletti

A framework to link submarine fans morphology to turbidity current flow properties using depth-integrated simulations (id: 469)

Abdul Wahab, David Hoyal, Mrugesh Shringarpure, Huafei Sun, Kyle Straub

Presenting author: Abdul Wahab

Session T08-SS01 – Microbial imprint on the sediment record: From organomineralization to global biogeochemical cycling

Hall 2, June 22, 16:25-17:25

Chairs: Camille Thomas, Andrea Martín Pérez, D. Petráš

Experimental biomineralization of carbonates from a highly alkaline lake (id: 543)

Oscar Cabestrero, M. Esther Sanz-Montero, Pieter T. Visscher

Presenting author: Oscar Cabestrero

Fossil and modern microbialites from where everything starts: Lake de Los Cisnes (southernmost Chile) (id: 549)

Clément Pollier, Daniel Ariztegui, Alejandro Nuñez Guerrero, Jorge Rabassa, Monica Salemme

Presenting author: Clément Pollier

Stromatolites of the Yacoraite Formation (Tres Cruces, Salta Basin, Argentina) (id: 405)

Sara Tomás, Michele Vallati, Wera Schmidt, Claudia Galli, Maria Mutti

Presenting author: Sara Tomás

Nature and occurrence of organic-rich strata in ancient deep-marine levee deposits (id: 813)

Celeste Cunningham, Bill Arnott

Presenting author: Celeste Cunningham

Session T04-SS01 – Continental slope sedimentary systems: Processes, products and controls.

Hall 3, June 22, 10:40-11:10

Chairs: Gamberi F., Kane I., McArthur A., Patacci M.

The Effect of Sediment Supply on the Stratal Architecture of a Deep-Marine Slope Channel Complex. (id: 958)

Patricia Fraino, R.W.C Arnott

Presenting author: Patricia Fraino

Source-to-sink pathways of clay minerals in the Cadiz contourite system over the last 25 kyrs (id: 952)

Paul Moal-Darrigade, Emmanuelle Ducassou, Viviane Bout-Roumazeilles, Vincent Hanquiez, Marie-Claire Perello, Thierry Mulder, Jacques Giraudeau

Presenting author: Paul Moal-Darrigade

Sedimentary architecture of a turbidite channel-levée complex from the Taza-Guercif Basin (upper Miocene, NE Morocco) (id: 649)

Simone Reguzzi, Mattia Marini, Fabrizio Felletti, Imad El Kati, Chiara Zuffetti, Nicolò Bellin, Hassan Tabyaoui

Presenting author: Simone Reguzzi

The Eocene-Oligocene transition in Pindos Foreland Basin (western Greece) (id: 498)

Sofia Kostopoulou, Angelos Maravelis, Chrysanthos Botziolis, Avraam Zelilidis

Presenting author: Sofia Kostopoulou

Geochemical constraints to the Paleogene provenance and tectonic setting of Pindos Foreland Basin, western Greece (id: 446)

Chrysanthos Botziolis, Angelos G. Maravelis, George Pantopoulos, Ioannis Iliopoulos, Avraam Zelilidis

Presenting author: Chrysanthos Botziolis

Seismic analysis of the Orange Basin; from a deepwater fold-and-thrust-belt to Cenozoic mass transport systems (id: 293)

Nombuso Maduna, Zubair Jinnah, Musa Manzi

Presenting author: Nombuso Maduna

Session T07-SS02 – When volcanoes meet the environment

Hall 3, June 22, 13:10-14:50

Chairs: Andrea Di Capua, Emilia Le Pera, G. Kereszturi, S. Watt, M. Rosi, R. De Rosa, E. Lebas

Carbonate sedimentation in volcanic settings – you can't keep a good carbonate down! (id: 900)

Stephen Lokier

Presenting author: Stephen Lokier

Facies and evolution of a mixed carbonate-volcaniclastic ramp: the Toqui Formation (Lower Cretaceous), Chile (45°S) (id: 268)

Hermann Rivas, Christian Salazar, Wolfgang Stinnesbeck

Presenting author: Hermann Rivas

Volcaniclastic deposits within Late Cretaceous Deccan basalt, India and their implications on Martian weathering conditions (id: 467)

Pragya Singh, Santanu Banerjee, Kanchan Pande, Satadru Bhattacharya,

Presenting author: Pragya Singh

Volcanically-induced, extremely-high sedimentation rates preserved tidal channel morphology in hypertidal Miocene estuaries of Patagonia (id: 814)

Roberto Adrián Scasso, José Ignacio Cuitiño

Presenting author: Roberto Adrián Scasso

Integrated study and stratigraphic implications of Miocene volcaniclastic deposits on Mt. Medvednica (North Croatian Basin) (id: 851)

Nina Trinajstić, Sean P Gaynor, Julie Schindlbeck-Belo, Radovan Avanić, Brlek Mihovil, Sanja Šuica, Valentina Hajek-Tadesse, Katarína Holcová, Jitka Kopecká, Viktória Baranyi, Koraljka Bakrač, Vlatko Brčić, Ivan Mišur, Kuo-Lung Wang, Hao-Yang Lee, Steffen

Presenting author: Nina Trinajstić

Interbedded volcanic and sedimentary rocks with earthquake-induced deformations in the Intrasudetic Permian Basin, Poland (id: 397)

Marek Awdankiewicz, Hubert Kiersnowski, Tadeusz Peryt, Izabela Ploch, Paweł Raczyński, Sebastian Voigt

Presenting author: Izabela Ploch

Session T07-SS03 – An expansive perspective of meandering: Patterns and processes across landscapes and scales

Hall 3, June 22, 15:10-17:10

Chairs: Alvise Finotello, Zoltan Sylvester, P. R. Durkin

Morphodymanics of a meander during an extreme flood: an example from powder river (Montana, USA) (id: 398)

Massilimiano Ghinassi, John Moody, Deborah Martin

Presenting author: Massilimiano Ghinassi

Laboratory observations on meltwater meandering rivulets on ice (id: 566)

Roberto Fernandez, Gary Parker

Presenting author: Roberto Fernandez

Depicting architecture and sedimentology of a hypertidal point bar through Lidar and sedimentary-core data (id: 657)

Marta Cosma, Dimitri Lague, Andrea D'Alpaos, Jérôme Leroux, Baptiste Feldmann, Massimiliano Ghinassi

Presenting author: Marta Cosma

Sedimentary architecture of typical short-lived meander belts in the Rhine-Meuse delta, Netherlands (id: 659)

Timotheus Gerardus Winkels, Kim Cohen, Esther Stouthamer

Presenting author: Timotheus Gerardus Winkels

Preservation and completeness of meandering rivers deposits: insights from numerical simulations (id: 808)

Jean-Louis Grimaud, Fabien Ors, Martin Lemay, Isabelle Cojan, Jacques Rivoirard

Presenting author: Jean-Louis Grimaud

The Distribution of Sediment Storage Times from the Meandering Powder River, Montana (id: 837)

Max Huffman, James Pizzuto, Sheila Trampush, John Moody, Derek Schook, Harrison Gray, Shannon Mahan

Presenting author: Max Huffman

To meander or not to meander?Predicting river patterns from streampower, bed sediment and bank strength (id: 881)

Jasper Candel, Maarten Kleinhans, Bart Makaske, Jakob Wallinga

Presenting author: Maarten Kleinhans

Session T05-SS02 – Climatic, environmental, and biotic crises of the Permo- Triassic: Sedimentary records of the transition to the Mesozoic world

Hall 4, June 22, 10:40-10:50

Chairs: Frank T., Fielding C., Bourquin S.

Sedimentary sequence of biological recovery in Feixianguan Formation of Lower Triassic in Northwest Sichuan (id: 489)

Lin Xiaobing, Tian Jingchun, Zhang Benjian, Hu Xin, Wang Zhuangsheng

Presenting author: Lin Xiaobing

Paleoclimatic control of the upper Jurassic deposits in the central Saharan atlas, Algeria (ID 901)

Chikh Younes Mahboubi, Axel Munnecke, Abdelkader Ouali Mehadji

Presenting author: Chikh Younes Mahboubi

Session T05-SS03 – Understanding a greenhouse Earth: Sedimentation, climate, sea level and biogeochemical cycles in the Cretaceous

Hall 4, June 22, 10:50-11:00

Chairs: Uličný D., Batenburg S.

Turonian-coniacian climate and sedimentation conditions of the north-west caucasus (id: 927)

Elena Yakovishina, Sergey Bordunov, Ludmila Kopaevich

Presenting author: Elena Yakovishina

Earth system changes during the cooling hothouse phase of the Late Cretaceous:Newresults on the Coniacian-SantonianOAE3subevents (id: 980)

Ahmed Mansour, Michael Wagreich

Presenting author: Ahmed Mansour

Session T05-SS06 – Continent-ocean interactions and their geological records: a tribute to Karl Föllmi

Hall 4, June 22, 11:00-11:10

Chairs: Thierry Adatte, Brahimsamba Bomou, Stéphane Bodin, Alicia Fantasia, Ana María Alonso-Zarza, Bas van de Schootbrugge

Vertebrate preservation during the Toarcian oceanic anoxic event in the Grands Causses Basin (southern France) (id: 455)

Brahimsamba Bomou, Guillaume Suan, Janci Schlögl, Anne-Sabine Grosjean, Baptiste Suchéras-Marx, Thierry Adatte, Jorge Spangenberg, Stéphane Fouché, Axelle Zacai, Corentin Gibert, Jean-Michel Brazier, Vincent Perrier, Peggy Vincent, Kevin Janneau, Jeremy E

Presenting author: Brahimsamba Bomou

The carbonate platform record of Mesozoic OAEs and ocean acidification: noisy, incomplete, invaluable! (id: 945)

Mariano Parente

Presenting author: Mariano Parente

Session T05-SS04 – Black shales: Past depositional systems and modern environments

Hall 4, June 22, 11:10-11:15

Chairs: Gabriele Gambacorta, G. Frijia, Mariano Parente

High-quality black shales in the low prospective Zaysan basin, Kazakhstan: A viable unconventional resource? (id: 844)

Riza Nurbekova, Shukhrat Mametov, Talgat Yensepbayev, Sergei Sabanov, Reinhard Sachsenhofer, Randy Hazlett, Laurent Richard, Milovan Fuztic

Presenting author: Riza Nurbekova

Session T02-SS01 – Gateways, straits and seaways: Their sedimentology and stratigraphy importance to understand basins evolution

Hall 4, June 22, 13:10-16:10

Chairs: Olariu Cornel, Rossi V. M

Invited Session Keynote Lecture

Criteria to recognize ancient tidal straits in the rock record (id: 732)

Sergio Longhitano

Presenting author: Sergio Longhitano

How the Corinth rift is connected or not with the Mediterranean sea ? (id: 294)

Romain Rubi, Aurélia Hubert-Ferrari, Elias Fakiris, Dimitris Christodoulou, Xenophon Dimas, Maria Geraga, George Papatheodorou

Presenting author: Romain Rubi

Marine transgression(s) to Middle Miocene (Badenian) evaporite basin of Central Paratethys (SE Poland) (id: 310)

Danuta Peryt, Przemysław Gedl, Tadeusz Peryt

Presenting author: Tadeusz Peryt

The Sardinian seaway: new insight from the tidal-modulated succession filling the Isili peripheral basin (id: 507)

Stefano Andreucci, Marco Pistis, Antonio Funedda, Alfredo Loi

Presenting author: Stefano Andreucci

Gravity flows in Mesozoic sediments of Chukotka microplate margin (NE Russia) (id: 568)

Marianna Tuchkova, Elena Vatrushkina, Sergey Sokolov

Presenting author: Marianna Tuchkova

Tectonically driven restriction of the Mediterranean gateway during the early Messinian: impact on sediment cyclicity (id: 794)

Francesca Bulian, Francisco J. Sierro, Francisco J. Jiménez-Espejo

Presenting author: Francesca Bulian

Paleoenvironmental study of strata from the Labrador margin, Canada: integrating ichnology and quantitative palynology (id: 797)

Lynn Dafoe, Graham Williams

Presenting author: Lynn Dafoe

A quick a robust numerical modelling method to study the propagation of tides in palaeo-seas (id: 859)

Valentin Zuchuat, Elisabeth Steel, Ryan P. Mulligan, Daniel S. Collins, J.A. Mattias Green

Presenting author: Valentin Zuchuat

The eocene monte cardiga fm (sardinia, italy): a tidal strait towards a westward coal basin? (id: 883)

Luca Giacomo Costamagna, Gior Lai, Mattia Yuri Messina, Enrico Carta, Valentina Casu, Alessandro Donato, Ilenia Fanari, Andrea Fanti, Bianca Fusco, Lorenzo Pisano, Roberto Tronci, Rita Vacca

Presenting author: Luca Giacomo Costamagna

Session T04-Deep-marine depositional systems

Hall 4, June 22, 16:25-17:10

Chairs: Jeffrey Peakall

Deep-water heterolithic deposits – their varieties and significance (examples from the Skole Nappe, Polish Carpathians) (id: 298)

Piotr Łapcik

Presenting author: Piotr Łapcik

Spatial distribution of palaeohydraulically controlled sole marks in a mixed sand–mud submarine system (id: 664)

Jaco H. Baas, Niall Tracey, Jeffrey Peakall

Presenting author: Jaco H. Baas

Sometimes planar, sometimes irregular: a bipartite bed interface dilemma. (id: 961)

Jagabir Ningthoujam, Bill Arnott

Presenting author: Jagabir Ningthoujam

Sedimentary structures and deposit geometries recorded after large-scale experimental subaqueous turbidity and debris flows (id: 199)

George Pantopoulos, Rafael Manica, Richard Ducker, Alessandro Cantelli

Presenting author: George Pantopoulos

Session T01-SS02 – Lacustrine Sedimentology: From deep time and climate evolution to modern processes and human impact

Hall 1, June 23, 10:45-11:00

Chairs: Patricia Roeser, Marta Marchegiano, Keyu Liu, Huaqing Liu, E. Gliozzi, D. Cosentino, Daniel Ariztegui, S. Pan

Palaeoenvironmental significance of Lower Triassic (Induan) lacustrine carbonates in Central Germany (id: 775)

Fabian Käsbohrer, Jochen Kuss

Presenting author: Fabian Käsbohrer

Seismic geomorphology of a Cretaceous lacustrine deep-water basin- Songliao basin, China (id: 22)

Huaqing Liu, Henry W Posamentier, Mangjiao Chen

Presenting author: Huaqing Liu

Lacustrine varves formation in Eocene Jiyang Depression, East China (id: 167)

Chao Liang, Yingchang Cao, Keyu Liu

Presenting author: Chao Liang

Invited Plenary Lecture

Hall 1, June 23, 12:00-13:00

Chairs: David Uličný

Using novel deep-sea technology to demystify turbidity currents (id: 985)

Matthieu Cartigny

Session T05-SS01 – Paleozoic ocean, lands, ecosystems and climate imprinted in sedimentary strata: New insights from high-resolution proxies

Hall 1, June 23, 13:10-13:55

Chairs: Pavel Kabanov, Anne-Christine daSilva

Volcanic related methylmercury poisoning as the possible driver of the end-devonian mass extinction (id: 815)

Michał Rakociński, Leszek Marynowski, Agnieszka Pisarzowska, Jacek Bełdowski, Grzegorz Siedlewicz, Michał Zatoń, Maria Cristina Perri, Claudia Spalletta, Hans Peter Schönlaub

Presenting author: Michał Rakociński

Localisation of environmental responses to global climate change during the Frasnian-Famennian (Late Devonian) mass extinction (id: 450)

Lawrence Percival, Leszek Marynowski, Francois Baudin, Steven Goderis, David De Vleeschouwer, Michał Rakociński, Katarzyna Narkiewicz, Anne-Christine da Silva, Philippe Claeys

Presenting author: Lawrence Percival

Early Permian intensification of low latitude upwelling driven by enhanced megamonsoonal circulation (id: 312)

Daniel Calvo Gonzalez, Benoit Beauchamp, Charles Henderson, Shuzhong Shen, Dongxun Yuan

Presenting author: Daniel Calvo Gonzalez

Session T05-SS02 – Climatic, environmental, and biotic crises of the Permo- Triassic: Sedimentary records of the transition to the Mesozoic world

Hall 1, June 23, 14:05-15:05

Chairs: Frank T., Fielding C., Bourquin S.

Facies changes, volcanism, and mass extinction conundrum: the Permian-Triassic boundary across the Barents Sea Shelf (id: 836)

Valentin Zuchuat, Lars Eivind Augland, Morgan T. Jones, Richard J. Twitchett, Francisco J. Rodríguez-Tovar, Øyvind Hammer, Kim Senger, Peter Betlem, Holly Turner, Henrik H. Svensen, Sverre Planke

Presenting author: Valentin Zuchuat

Permo-Triassic paleoenvironmental perturbations in northern Pangea: case study from the Barents Sea (id: 354)

Valentina Marzia Rossi, Niall William Paterson, Fabio Oriani, Albina Gilmullina, Julio Leva López, Elke Scheebeli-Hermann, Christian Haug Eide

Presenting author: Valentina Marzia Rossi

New sedimentological and stratigraphical data on the Permian and Triassic in northeastern Utah, USA (id: 435)

Sylvie Bourquin, Romain Rubi, Guy Desaubliaux, Emmanuelle Vennin, Arnaud Brayard, Spencer G Lucas

Presenting author: Sylvie Bourquin

Climatic and environmental changes across the Permian-Triassic transition along a southern high latitude continental margin (id: 203)

Tracy Frank, Christopher Fielding, Katarina Savatic, Steve McLoughlin, Vivi Vajda, Chris Mays, Robert Nicolls, Malcolm Bocking, Arne Winguth, Jim Crowley

Presenting author: Tracy Frank

Session T05-SS07 – Western Tethys meets Eastern Tethys – sedimetological perspective

Hall 1, June 23, 15:20-16:45

Chairs: Michal Krobicki, Hans-Jürgen Gawlick, Hao Huang, Ismail Omer Yilmaz, Dmitrii Aleksandrov, Š. Goričan, K. Ueno, J. Kowal-Kasprzyk, K. Starzec

Late Paleozoic siliciclastics of the Changning-Menglian Belt in western Yunnan, China and their paleogeographic indications (id: 910)

Jianbin Zheng, Xiaochi Jin, Hao Huang, Zhen Yan

Presenting author: Jianbin Zheng

Construction model of a Middle Permian Archaeolithoporella-microbial-sponge reef of the Changning-Menglian Belt, western Yunnan, China (id: 911)

Zhen Yan, Xiaochi Jin, Hao Huang, Jianbin Zheng

Presenting author: Zhen Yan

Lithiotis-type bivalves in the Lower Jurassic carbonates of the Central and Southern Velebit Mt., Croatia (id: 228)

Maja Martinuš, Igor Vlahović, Damir Bucković, Ivo Velić, Silvija Brcko, Michał Krobicki

Presenting author: Maja Martinuš

Carbonate sedimentation along southern margin of the Tethys with Lithiotis-type bivalves – similarities and differences (id: 966)

Michal Krobicki

Presenting author: Michal Krobicki

Paleoclimate and sedimentary evolution of Cretaceous successions in Central Pontides, Central Taurides and Arabian Platform (id: 537)

Ismail Omer Yilmaz, Oguz Mulayim, Bilal Sarı, Kemal Tasli, Sacit Ozer, Izzet Hosgor

Presenting author: Ismail Omer Yilmaz

Session T06 – Record of tectonics in sedimentary archives

Hall 2, June 23, 10:45-10:55

Chairs: Slavomír Nehyba, Roland Nádaskay

Neoproterozoic glaciogenic sediments in southeastern Siberia re-interpreted as a sedimentary archive of tectonic activity (id: 480)

Presenting author: Dmitrii Aleksandrov

Influence of basement rocks on fluid chemistry during deformation. An example from the Pyrenees (id: 299)

Daniel Muñoz-López, Gemma Alías, David Cruset, Irene Cantarero, Anna Travé

Presenting author: Daniel Muñoz-López

Pashayurdu Fan Delta Deposites Karasu Depression; Sedimentary Structures and Facies, Erzurum Basin. Eastern Turkey. (id: 973)

Mehmet Salih Bayraktutan

Presenting author: Mehmet Salih Bayraktutan

Session T02 – Shallow-marine clastics

Hall 2, June 23, 10:55-11:15

Chairs: Tadeusz Peryt

Reservoir characterization and modeling of tidal delta reservoir in halfaya oilfield, Iraq (id: 29)

Zhou Lyu, Youjing Wang, Zhuo Liu, Shudai Peng

Presenting author: Zhou Lyu

Recognition of inundite deposits in shallow-marine clastics: towards a facies model (id: 109)

Dmitriy Grazhdankin

Presenting author: Dmitriy Grazhdankin

Sedimentary characteristics of a low accommodation, highstand delta from the Albian succession of Saudi Arabia (id: 530)

Kanchan Dasgupta, Camilo Polo

Presenting author: Kanchan Dasgupta

The first-discovery of Thalassinoides and reappraisal of depositional environment for Middle Cambrian Miqrat Formation, Oman (id: 632)

Mohamed El-Ghali, Olga Shelukhina, Iftikhar Ahmed Abbasi, Mohammed Farfour, Mohamed Moustafa, Aleksandar Ilic

Presenting author: Mohamed El-Ghali

Session T13 – Open Theme

Hall 2, June 23, 13:40-17:15

Chairs: Xiaoneng Luo

Early-Career Scientist Award Session Keynote Lecture

Insights from the southwestern Tethys – the Cretaceous evolution of the Levant Platform (id: 982)

Or M. Bialik

Presenting author: Or M. Bialik

The impact of authigenic clay on porosity evolution and reservoir quality of gas-bearing sandstone (id: 283)

Jianli Lin, Xianguo Zhang, Chunmei Dong, Chengyan Lin, Fang Zeng

Presenting author: Jianli Lin

Investigating plastic as a sediment (id: 570)

Catherine Russell, Sarah Gabbott, Roberto Fernandez, Connor Burchell, Jan Zalasiewicz, Stuart McLelland, Sarah Davies, Daniel Parsons

Presenting author: Catherine Russell

Sedimentary evidence (and oral legends) of a prehistorical giant tsunami in northern Kiribati, central Pacific (id: 11)

James Terry, Gennady Gienko, Robert Karoro, Annie Lau, Marta Wieczorek

Presenting author: James Terry

The Neoproterozoic Oxygenation Event and the Cryogenian-Ediacaran Bambui Group, central Brazil (id: 842)

Leandro Silva, Peir K. Pufahl, Noel P. James, Edi Mendes Guimaraes, Carolina Reis

Presenting author: Leandro Silva

Settling velocity of Lingula anatina shells: an experimental approach to bioclastic granular phosphorites (id: 895)

Maria Duperron, Dominique Mouazé, Bernadette Tessier, Roberto Adrián Scasso, Takeshi Takeuchi

Presenting author: Maria Duperron

Evidences of a biodiversity crisis from a Rhaetian peritidal carbonate succession from westernmost tethys (sicily) (id: 152)

Simona Todaro, Manuel Rigo, Pietro Di Stefano

Presenting author: Simona Todaro

Coastal muddy flats to rudist-dominated lagoons in a ramp-type platform (latest Cretaceous, Iberian Basin) (id: 887)

Diego Torromé, Marcos Aurell, Beatriz Bádenas

Presenting author: Diego Torromé

Sea level and sediment flux paced by insolation during the Early Pleistocene, Taiwan (id: 769)

Romain Vaucher, Shahin E. Dashtgard, Chorng-Shern Horng, Christian Zeeden, Antoine Dillinger, Yu-Yen Pan, Romy Ari Setiaji, Wen-Rong Chi, Ludvig Löwemark

Presenting author: Romain Vaucher

Fracture distribution in a folded fluvial succession: the Puig-reig anticline (south-eastern Pyrenees) (id: 774)

Xiaolong Sun, Enrique Gomez-Rivas, Juan Alcalde, Juan Diego Martín-Martín, Daniel Muñoz-López, David Cruset, Irene Cantarero, Albert Griera, Anna Travé

Presenting author: Xiaolong Sun

Forced or normal regression signals in a lacustrine basin? Insights from 3D stratigraphic forward modelling (id: 865)

Ádám Kovács, Attila Balázs, Marko Spelić, Orsolya Sztanó

Presenting author: Ádám Kovács

Sedimentation modeling vs seismic facies analyses (id: 43)

Tatiana Olneva, Victoria Ovechkina, Elena Zhukovskaia

Presenting author: Tatiana Olneva

Session T04-SS02 – Submarine canyons and channels: Their role for material transfer and burial from shelf to basin

Hall 3, June 23, 10:45-10:50

Chairs: Gong C., Steel R. J., Olariu C., Gan Y. P.

Interactions between turbidity flows and bottom currents in sinuous unidirectionally migrating channels in offshore Mozambique (id: 492)

Yuhang Chen

Presenting author: Yuhang Chen

Session T04-Deep-marine depositional systems

Hall 3, June 23, 10:50-11:05

Chairs: Jeffrey Peakall

Sustained flows and their deposits in the deep-marine Cergowa Beds (Outer Carpathians, Oligocene) (id: 654)

Paweł Godlewski, Joanna Pszonka, Marek Wendorff

Presenting author: Paweł Godlewski

Textures and structures of Oligocene-age mixed siliciclastic-carbonate turbidites in Szczawa Tectonic Window, Polish Outer Carpathians (id: 679)

Piotr Siwek, Marek Wendorff

Presenting author: Piotr Siwek

Depositional styles in the underfilled phase of the Miocene Carpathian Foreland Basin fill, SE Poland (id: 655)

Paweł Ryder

Presenting author: Paweł Ryder

Session T06 – Record of tectonics in sedimentary archives

Hall 3, June 23, 14:05-17:00

Chairs: Slavomír Nehyba, Roland Nádaskay

Linkage of isolated and coherent syndepositional faults: Insight for sedimentation pattern in lacustrine rift basin (id: 767)

Pengjie Ma, Chengyan Lin, Lihua Ren

Presenting author: Pengjie Ma

Multiple pulses in lacustrine turbidites can reveal earthquake doublets (id: 857)

Katleen Wils, Maxim Deprez, Catherine Kissel, Morgan Vervoort, Maarten Van Daele, Mudrik R. Daryono, Veerle Cnudde, Danny H. Natawidjaja, Marc De Batist

Presenting author: Katleen Wils

Formation and provenance of Jurassic sedimentary mélanges in the Circum-Pannonian orogens (Western Tethys) (id: 292)

Hans-Jürgen Gawlick, Sigrid Missoni

Presenting author: Hans-Jürgen Gawlick

Evolution of Krkonoše Piedmont Basin (Czech Republic) in Pennsylvanian – Caenozoic: extension to basin inversion. (id: 676)

Karel Martínek, Kryštof Verner, Martin Svojtka

Presenting author: Karel Martínek

Late Cretaceous syn-inversion sedimentation within the Polish Basin based on analysis of seismic data (id: 939)

Piotr Krzywiec, Aleksandra Stachowska, Quang Nguyen, Łukasz Słonka, Michał Malinowski, Christian Huebscher, Łukasz Grzybowski, Regina Kramarska

Presenting author: Piotr Krzywiec

Evidence of lost orogenies in the Mesozoic sedimentary record of the Kutch Basin, western India (id: 264)

Angana Chaudhuri, Santanu Banerjee, Kaushik Das, Emilia Le Pera

Presenting author: Angana Chaudhuri

Reconstructing tectonic history of active plate margins with Nd isotope composition of hydrocarbon-seep carbonates (id: 385)

Michal Jakubowicz, Steffen Kiel, Luis M. Agirrezabala, James L. Goedert, Jolanta Dopieralska, Andrzej Kaim, Zdzislaw Belka

Presenting author: Michal Jakubowicz

Tectono-sedimentary pattern of the Yen Bai Basin (Red River Fault Zone, northern Vietnam) (id: 272)

Anna Wysocka, Stanisław Mazur, Piotr Krzywiec, Anna Filipek, Phan Dong Pha, Nguyen Quoc Cuong, Do Van Thang, Nguyen Van Kieu, Daniel Zaszewski

Presenting author: Anna Wysocka

Origin and significance of shelf-derived MTDs in the tectonostratigraphic evolution of trench-slope basins (Hikurangi margin) (id: 864)

Barbara Claussmann, Julien Bailleul, Frank Chanier, Geoffroy Mahieux, Vincent Caron, Adam Mcarthur, Corentin Chaptal, Hugh Morgans, Bruno Vendeville

Presenting Author: Barbara Claussmann

Constraining the onset and migration of the central-southern Apennine foreland basin (Italy) by Sr-isotope stratigraphy (id: 867)

Monia Sabbatino, Stefano Tavani, Stefano Vitale, Amerigo Corradetti, Lorenzo Consorti, Mariano Parente

Presenting author: Monia Sabbatino

Session T05-SS01 – Paleozoic ocean, lands, ecosystems and climate imprinted in sedimentary strata: New insights from high-resolution proxies

Hall 4, June 23, 10:40-10:50

Chairs: Pavel Kabanov, Anne-Christine daSilva

Sedimentary environment and depositional evolution of a Cambrian-Ordovician ramp from the Zagros Basin (Southwestern Iran) (id: 720)

Andrea Sorci, Simonetta Cirilli, Amalia Spina, Mansour Ghorbani, Masoud Ovissi, Roberto Rettori

Presenting author: Andrea Sorci

Bryozoan-rich stromatolites (bryostromatolites) from the Silurian of Gotland and their relation to global 13C excursions (id: 907)

Anna Lene Claussen, Axel Munnecke, Andrej Ernst

Presenting author: Anna Lene Claussen

Session T03-SS02 – Resedimented carbonates – generation, transportation, deposition

Hall 4, June 23, 10:50-11:05

Chairs: Arnoud Slootman, Ted Playton, Stephen Lokier, J. Schnyder

Shallow lacustrine carbonate debrites: facies and flow types, sources, triggers and underlying controls (id: 571)

Pilar Clemente

Presenting author: Pilar Clemente

Hydrocarbon generation and accumulation of limestone organic matter in a lacustrine mixed sedimentary environment (id: 791)

Qilu Xu

Presenting author: Qilu Xu

Fractionation of skeletal carbonate deposits due to shape-dependent settling velocity (id: 602)

Arnoud Slootman, Max de Kruijf, Guenther Glatz, Rainer Zuhlke, John Reijmer

Presenting author: Arnoud Slootman

Session T03-SS03 – Carbonate sequence stratigraphy: Review and update

Hall 4, June 23, 11:05-11:10

Chairs: John Reijmer, Cathy Hollis, Christian Betzler, Jean Borgomano, P. Burgess, Gregor Eberli, A. Foubert, C. Kerans, M. Mutti, Immenhauser A., Puga-Bernabéu Á., van Buchem F.

Quantitative sequence stratigraphy applied to the Barremian/Lower Aptian Urgonian carbonate platform (Provence, France) (id: 918)

Mickael Barbier, Philippe Léonide, Cyprien Lanteaume, Jean Borgomano, Gérard Massonnat

Presenting author: Mickael Barbier

Session T03-SS01 – Geochemistry of modern and Recent carbonates

Hall 4, June 23, 11:10-11:15

Chairs: Pederson C., Sánchez-Román M., Swart P., Della Porta G.

MDACs of Tatar Strait: Implications for methane flux and low-salinity cap-water in MIS2 (id: 970)

Ryo Matsumoto, Alexander Derkachev, Anatoly Obzhirov, Renat Shakirov, Akihiro Hiruta, Tsai-Luen Yu, Chuan-Chou Shen

Presenting author: Ryo Matsumoto

Session T03-SS02 – Resedimented carbonates – generation, transportation, deposition

Hall 4, June 23, 13:10-15:50

Chairs: Arnoud Slootman, Ted Playton, Stephen Lokier, J. Schnyder

Mass transport deposits (MTDs) in a shallow-marine succession of the Dinaric Foreland Basin (id: 258)

Katarina Gobo, Ervin Mrinjek

Presenting author: Katarina Gobo

Surface sediment distribution and reworking processes on Al Wajh carbonate platform, N-Red Sea, Saudi Arabia (id: 520)

Alexander Petrovic, Manuel Ariza Fuentes, Indah Putri, Sam J. Purkis, Volker Vahrenkamp

Presenting author: Alexander Petrovic

Influence of hinterland movements on mixed carbonate-siliciclastic shelf margins. Jurassic, Moroccan Atlantic Margin. (id: 682)

Aude Duval-Arnould, Rémi Charton, Stefan Schröder, Jonathan Redfern

Presenting author: Rémi Charton

Sedimentary environment of upper Olenekian (Triassic) phylloid algal limestones in the Holy Cross Mountains, Poland (id: 420)

Karolina Bieńko, Wiesław Trela

Presenting author: Karolina Bieńko

Carbonate megabeds of Istrian Flysch (Dinaric foreland basin, Croatia) (id: 156)

Krešimir Petrinjak, Stanislav Bergant, Tvrtko Korbar

Presenting author: Krešimir Petrinjak

Depositional and diagenetic evolution of carbonate slope reservoir facies, Tengiz Field, Republic of Kazakhstan (id: 333)

Ted Playton, Dana Tolessin, Assem Bibolova, Ilyas Tussupbayev, Chalak Amanbay, Elrad Iskakov, Evan Earnest

Presenting author: Ted Playton

Facies heterogeneity along a tectonically-controlled carbonate slope (Western Sicily Cretaceous Escarpment, Italy) (id: 703)

Vincenzo Randazzo, Johan Le Goff, Pietro Di Stefano, Johannes Jozef Gerardus Reijmer, Simona Todaro, Maria Simona Cacciatore

Presenting author: Vincenzo Randazzo

Downslope re-sedimentation from a short-living carbonate platform: record from Upper Triassic Hosselkus limestone (Northern California) (id: 903)

Andrea Fucelli

Presenting author: Andrea Fucelli

Resedimented carbonates partially controlling submarine-fan morphodynamics: Insights from the Middle Eocene deep-marine Jaca Basin (id: 784)

Pauline Cornard, Kevin Pickering

Presenting author: Pauline Cornard

Session T03-SS01 – Geochemistry of modern and Recent carbonates

Hall 4, June 23, 16:15-17:15

Chairs: Pederson C., Sánchez-Román M., Swart P., Della Porta G.

Workflow to Optimize Portable XRF Calibration and Analysis for Sedimentary Rocks. (id: 453)

Anne-Christine daSilva, Triantafyllou Antoine, Delmelle Nicolas

Presenting author: Anne-Christine daSilva

A 600-year Record of the Atlantic Multi-Decadal Oscillation in the Skeleton of a Sclerosponge (id: 306)

Peter Swart, Amanada Waite, Amy Clement, Jeremy Klavans, Lisa Murphy, Volker Liebetrau, Anton Eisenhauer

Presenting author: Peter Swart

Does a unique geochemical signature of lime mud formation persist in the recent geological record? (id: 709)

Amanda Oehlert, Sam Purkis, Peter Swart, Heather Hunter, Thomas Dobbelaere, Emmanuel Hanert

Presenting author: Amanda Oehlert

Assessing the role of depositional environment on the geochemistry of atoll sediments from French Polynesia (id: 962)

Sam Purkis, Eberhard Gischler, Peter Swart, Amanda Oehlert, Colleen Brown

Presenting author: Colleen Brown

Session T05-SS05 – Sedimentary environments as the theatres of life and evolution

Hall 1, June 24, 10:40-10:55

Chairs: Anthony Shillito, N. Davies, W. McMahon, S. Rice

A new model for the genesis of carbonate-hosted Mn ores, Longtou deposit, South China Block (id: 792)

Fangge Chen, Peir Pufahl, Qingfei Wang, Edward Matheson

Presenting author: Fangge Chen

Lower Cretaceous carbonate deposits of Mt. Svilaja, Croatia: biostratigraphy vs. chemostratigraphy (id: 229)

Blanka Cvetko Tešović, Bosiljka glumac, Tvrtko Korbar, Damir Bucković

Presenting author: Blanka Cvetko Tešović

Paleoenvironmental influence on decapod crustaceans preservation, abundance and diversity from Eocene at south-central Pyrenees (Spain) (id: 801)

Fernando Ari Ferratges, Samuel Zamora, Marcos Aurell

Presenting author: Fernando Ari Ferratges

Session T03-SS04-Open Session on Carbonates

Hall 1, June 24, 10:55-11:05

Chairs: Stephen Lokier, Chelsea Pederson

Multi-scale outcrop analysis of carbonate depositional geometries: Middle Jurassic, Portugal vs Lower Cretaceous, subsurface U.A.E. (id: 472)

Joao Barata, Luís Duarte, Ana Azerêdo, Jorge Gomes

Presenting author: Joao Barata

High-resolution stratigraphic analysis of the Yacoraite Formation in the Tres Cruces Sub-Basin (Salta Basin, Argentina) (id: 711)

Michele Vallati, Sara Tomás, Gerd Winterleitner, Claudia Galli, Maria Mutti

Presenting author: Michele Vallati

Session T13 – Open Theme

Hall 1, June 24, 11:05-11:15

Chairs: Xiaoneng Luo

Crystallinity characteristics and controls of different origin silica in marine shale of the Sichuan Basin (id: 770)

Guoheng Liu, Gangyi Zhai

Presenting author: Guoheng Liu

Effects of microscopic characteristics of tight sandstone on permeability and mobile fluid distribution (id: 266)

Siqi Ouyang

Presenting author: Siqi Ouyang

Session T11-SS03 – Reservoir systems: Subaerial and subaqueous processes, morphologies and significance for sediment distribution

Hall 1, June 24, 13:00-14:00

Chairs: Nate Lentsch, Juan Fedele, Alvise Finotello

Pore-throat structure characteristics and influencing factors of seepage capacity in tight sandstone reservoir (id: 843)

Dingding Zhao, Jiagen Hou, Wei Sun

Presenting author: Dingding Zhao

System-scale architectural analysis of fluvial-fan successions: an example from the Palaeogene Wasatch Formation (Utah, U.S.A.) (id: 838)

Davide Carraro, Dario Ventra, Ryan D. Gall, Lauren Birgenheier, Andrea Moscariello

Presenting author: Davide Carraro

Digital pore scale assessment of potential subsurface carbon storage reservoirs (id: 785)

Ryan Payton, Domenico Chiarella, Andrew Kingdon, Mark Fellgett, Saswata Hier-Majumder, Brett Clark

Presenting author: Ryan Payton

Implementation of astronomical climate forcing in subsurface predictive models for floodplain-rich, low N/G alluvial stratigraphy (id: 673)

Timothy Baars, Youwei Wang, Allard Martinius, Hemmo Abels

Presenting author: Timothy Baars

Plenary Keynote Lecture

Hall 1, June 24, 14:15-15:15

Chairs: David Uličný

The influence of landscape dynamics on paleoclimate-signal preservation in the stratigraphic record

Elizabeth Hajek

Session T11-SS03 – Reservoir systems: Subaerial and subaqueous processes, morphologies and significance for sediment distribution

Hall 1, June 24, 15:30-16:55

Chairs: Nate Lentsch, Juan Fedele, Alvise Finotello

Processes, morphologies and depositional record of small-scale upslope-migrating bedforms in submarine channels. (id: 596)

Matthieu Cartigny

Presenting author: Matthieu Cartigny

Lithological prediction in contourites and bottom-current reworked sands: the link between geometry, process and facies (id: 411)

François Raisson

Presenting author: François Raisson

Channels or valleys? Investigating updip to downdip evolution of paralic strata in a low-accommodation basin (id: 204)

Antoine Dillinger, James A. MacEachern, Shahin E. Dashtgard, Mark Radomski, Romain Vaucher

Presenting author: Antoine Dillinger

Building realistic models of meandering rivers and submarine channels: Implications for fluid flow (id: 688)

Zoltan Sylvester, Jacob Covault, Paul Durkin

Presenting author: Zoltan Sylvester

Paleohydrostratigraphy of the Paleoproterozoic Kombolgie Basin, Australia: oxygenation and stratigraphic sequences in unconformity-related uranium deposits (id: 827)

Eric Hiatt, Kurt Kyser, Paul Polito, Jim Marlatt, Peir Pufahl

Presenting author: Eric Hiatt

Session T03-SS03 -Carbonate sequence stratigraphy: Review and update

Hall 2, June 24, 13:00-16:40

Chairs: John Reijmer, Cathy Hollis, Christian Betzler, Jean Borgomano, P. Burgess, Gregor Eberli, A. Foubert, C. Kerans, M. Mutti, Immenhauser A., Puga-Bernabéu Á., van Buchem F.

Sequence stratigraphic patterns of benthic marine carbonate factories (id: 978)

Frans van Buchem, Emmanuelle Vennin, John Reijmer

Presenting author: Frans van Buchem

Sequence stratigraphy of the Cretaceous Arabian platform: data based guide lines for conceptual models ? (id: 972)

Carine Grélaud, Philippe Razin, Emmanuel Dujoncquoy, Jeremy Robinet

Presenting author: Carine Grélaud

New sequence stratigraphic methods are inappropriate for carbonate systems (id: 824)

Gregor Eberli

Presenting author: Gregor Eberli

Drone-based photogrammetry: new insights for sequence stratigraphic interpretation of a Jurassic oolitic ramp (Amellago, Morocco) (id: 965)

Aurélien Bordenave, Emmanuel Dujoncquoy, Philippe Razin, Paul Daguinos, Raphaël Bourillot, Jeroen Kenter, David Hodgetts

Presenting author: Aurélien Bordenave

Coupling Global Paleoclimate models to Carbonate Sequence Stratigraphy (id: 896)

Jean Borgomano, Yannick Donnadieu, Jeroen Kenter, Cyprien Lanteaume, Marie Laugié, Alexandre Lettèron, Julien Michel, Alexandre Pohl, Jhosnella Sayago

Presenting author: Jean Borgomano

Environmental control on carbonate platform stratigraphy – forward stratigraphic modelling the Neogene of the Maldives (id: 854)

Thomas Van der Looven, Gerd Winterleitner, Maria Mutti

Presenting author: Thomas Van der Looven

Spatial self-organization and autogenic dynamics of peritidal carbonate system: insights from stratigraphic forward modelling (id: 805)

Haiwei Xi, Peter Burgess

Presenting author: Haiwei Xi

Investigating autogenic responses to allogenic control on the evolution of the Llucmajor platform (id: 466)

Timothy Tella, Gerd Winterleitner, Maria Mutti

Presenting author: Timothy Tella

Session T11-SS02 – From Holocene to Anthropocene: Human impact on sedimentary environment

Hall 3, June 24, 10:40-10:55

Chairs: Sergio Cappucci, Vincenzo Pascucci

Carbonate precipitates in cellars: a specific product of human-modified environment (id: 704)

Michał Gradziński, Filas Sylwia, Jacek Motyka

Presenting author: Michał Gradziński

Can the blind source separation methods facilitate interpretation of geochemical trends from XRF core scanning? (id: 933)

Kamila Fačevicová, Martin Žídek, Ondřej Bábek, Klaus Nordhausen, Karel Hron

Presenting author: Kamila Fačevicová

Session T11-SS03 – Reservoir systems: Subaerial and subaqueous processes, morphologies and significance for sediment distribution

Hall 3, June 24, 10:55-11:00

Chairs: Nate Lentsch, Juan Fedele, Alvise Finotello

Infill dynamics and depositional patterns in gravel-bed chute cutoffs channels: the Ain River, France (id: 809)

Léo Szewczyk, Jean-Louis Grimaud, Isabelle Cojan, Hervé Piégay

Presenting author: Léo Szewczyk

Session T01 – Continental environments and depositional systems

Hall 3, June 24, 13:00-16:55

Chairs: Daniel Le Heron

Where are rivers forced to flow? Revision of differential subsidence effects on alluvial facies distribution (id: 155)

Michal Šujan, Régis Braucher, Matúš Tibenský, Klement Fordinál, Samuel Rybár, Michal Kováč

Presenting author: Michal Šujan

Upper Jurassic large-scale distributive fluvial system in Paraná Basin, Western Gondwana: a quantitative approach (id: 672)

Adriano Domingos dos Reis, Claiton Marlon dos Santos Scherer, Amanda Owen, Francyne Bochi do Amarante, Ezequiel Galvão de Souza, João Pedro Formolo Ferronatto, Manoela Bettarel Bállico, Carrel Kifumbi, Rossano Dala Lana Michel

Presenting author: Adriano Domingos dos Reis

Low and High Discharge Variability Fluvial Styles: example of the Jaicós Formation, Parnaíba Basin, Brazil (id: 518)

Monica Manna, Claiton Scherer, Manoela Bállico, Adriano Reis, Lucas Vargas, Lorenza Ferrari, Henrique Roisenberg, Victor de Oliveira

Presenting author: Monica Manna

A mesoproterozoic hybrid dry-wet aeolian system: Galho do Miguel Formation, SE Brazil (id: 502)

Giorgio Basilici, Áquila Ferreira Mesquita, Marcus Vinícius Theodoro Soares, Juraj Janocko, Nigel Philip Mountney, Luca Colombera

Presenting author: Giorgio Basilici

Gravel laminae in inland dune sediments: new data on the aeolian transport capabilities (id: 417)

Krzysztof Ninard, Piotr Łapcik, Alfred Uchman

Presenting author: Krzysztof Ninard

Facies models for aeolian systems in rift basins (id: 942)

Sophie Behrendsen, John Howell, Adrian Hartley, Florian Bremer, Holger Rieke

Presenting author: Sophie Behrendsen

Active deposition of sieve deposits on alluvial fans in Alpine environment (Planica Valley, NW Slovenia) (id: 547)

Andrej Novak, Tomislav Popit, Marko Vrabec, Andrej Šmuc

Presenting author: Andrej Novak

Complex development of a 300-million-year old subglacial unconformity in southern Namibia (id: 182)

Daniel Le Heron, Christoph Kettler, Neil Griffis, Pierre Dietrich, Isabel Montañez

Presenting author: Daniel Le Heron

A Neoichnological Approach to Interpreting Bird and other Trace Fossils (id: 954)

Jon Noad

Presenting author: Jon Noad

Session T05-SS04 – Black shales: Past depositional systems and modern environments

Hall 4, June 24, 10:40-11:00

Chairs: Gabriele Gambacorta, G. Frijia, Mariano Parente

Deposition of black shales of the Ediacaran Khatyspyt Formation in Siberia (id: 369)

Tatyana Parfenova, Vladimir Kashirtsev, Dmitry Melnik, Dmitry Grazhdankin

Presenting author: Dmitry Melnik

Lithofacies summary and depositonal setting of Namurian A mudstone, Namur Synclinorium and Campine Basin (Belgium) (id: 409)

Wei Wei, Rudy Swennen

Presenting author: Wei Wei

The effect of redox conditions on the chemical behavior of uranium in the Bazhenov Formation (id: 552)

Nadezhda Khaustova, Yulia Tikhomirova, Elena Poludetkina, Elena Kozlova, Andrew Voropaev, Mikhail Mironenko, Mikhail Spasennykh

Presenting author: Nadezhda Khaustova

Clay minerals of the Vaca Muerta Formation, Neuquén Basin (Argentina): distribution and origin (id: 946)

Ignacio Capelli, Roberto Scasso, Diego Kietzmann, Fernanda Cravero, Jorge Spangenberg, Thierry Adatte

Presenting author: Ignacio Capelli

Session T05-SS05 – Sedimentary environments as the theatres of life and evolution

Hall 4, June 24, 11:05-11:10

Chairs: Anthony Shillito, N. Davies, W. McMahon, S. Rice

Phanerozoic glendonite occurrences and their significance for palaeotemperature reconstruction (id: 575)

Mikhail Rogov

Presenting author: Mikhail Rogov

Session T08-SS01 – Microbial imprint on the sediment record: From organomineralization to global biogeochemical cycling

Hall 4, June 24, 11:10-11:15

Chairs: Camille Thomas, Andrea Martín Pérez, D. Petráš

Ferruginous coated grains in the Lower Devonian Řeporyje Limestone (Prague Basin, Czech Republic) (id: 937)

Stanislava Vodrážková, Radek Vodrážka, Tomáš Kumpan, Jiří Kalvoda, Axel Munnecke, Jiří Frýda, Magdalena Koubová, Markéta Holá

Presenting author: Stanislava Vodrážková

Session T10 – Sediment routing – from source to sink

Hall 4, June 24, 13:00-16:55

Chairs: Jasper Knight

Source-to-Sink: Regional Grain Size Trends to Reconstruct Sediment Volumetric Budgets and Catchment Areas (id: 49)

Nikolaos Michael, Rainer Zuhlke

Presenting author: Nikolaos Michael

The zircon story of the Pearl River (China) from Cretaceous to present (id: 482)

Jie He

Presenting author: Jie He

Spill communication: evolution of deep-water sedimentation patterns across the Hikurangi subduction margin, New Zealand (id: 168)

Adam McArthur, Alexander Wunderlich, Adriana Crisostomo Figuero, Alex Karvelas, William McCaffrey

Presenting author: Adam McArthur

3D Seismic Geomorphology Analysis of the Moki and Mount Messenger Formations, Taranaki Basin, New Zealand. (id: 804)

Erman Kamaruzaman, Andrew La Croix, Peter Kamp

Presenting author: Erman Kamaruzaman

Source area composition indicated by coalified tree-trunk hosted in deep-marine turbidites (Oligocene, the Outer Carpathians) (id: 915)

Marek Wendorff, Paweł Godlewski, Magdalena Zielińska, Joanna Pszonka

Presenting author: Joanna Pszonka

Different approaches in determining provenance and tectonic setting of the Slovenj Gradec Basin sedimentary successions (id: 951)

Kristina Ivančič, Mirka Trajanova, Andrej Šmuc

Presenting author: Kristina Ivančič

Establishing the depositional environment of the Viga Conglomerate, Catanduanes, Philippines using sedimentological analysis (id: 330)

Kerve Supnet, Allan Gil Fernando

Presenting author: Kerve Supnet

Provenance of sediments across the northern Indian Plate: is it the Aravalli Range? (id: 337)

Hazel Beaumont, Stuart Burley, Stuart Clarke, Thomas Gould

Presenting author: Hazel Beaumont

Origin and evolution of the Late Cretaceous reworked phosphorite in the north of Saudi Arabia (id: 872)

Yunlong Zhang, Ziying Li, Saleh M. Dini, Mingkuan Qin, Ahmed S. Banakhar, Zhixing Li, Longsheng Yi, Abdullah M. Memesh, Abdullah M. Shammari, Guochen Li

Presenting author: Yunlong Zhang

Johannes Walther Award Plenary Lecture

Hall 1, June 25, 12:00-12:45

The limits of microbialite preservation in recent and past times (id: 984)

Emmanuelle Vennin

Session T05-SS08 Diagenetic signals in the sedimentary record of environmental change

Hall 1, June 25, 13:00-14:25

Chairs: Theresa Nohl, Lars Reuning, D. De Vleeschouwer, Paul Wright

Searching for reliable redox proxies: constraints from a multi-method investigation of Silurian marine mudstones (id: 908)

Maciej Bojanowski, Alfred Uchman, Beata Marciniak-Maliszewska

Presenting author: Maciej Bojanowski

Assessing the impact of multiple fault zone overprint on Devonian carbonates (Rhenish Massif, Germany) (id: 898)

Mathias Mueller, Chelsea L. Pederson, Kevin Lippert, Benjamin F. Walter, Peter K. Swart, Adrian Immenhauser

Presenting author: Mathias Mueller

Multiphase cementation and dissolution in Aalenien-Oxfordian carbonates of Aquitaine basin inferred from U-Pb dating (France) (id: 928)

Quentin Deloume-Carpentras, Benjamin Brigaud, Simon Andrieu, Eglantine Husson, Thomas Blaise, Frédéric Haurine

Presenting author: Quentin Deloume-Carpentras

Assessing diagenesis in deep-time geochemical archives: statistics to the rescue! (id: 556)

Rute Coimbra, Maurits Horikx, Stefan Huck, Luís Vitor Duarte, Fernando Rocha, Ulrich Heimhofer, Adrian Immenhauser, Jorge Dinís

Presenting author: Rute Coimbra

Diagenetic variation of aragonite material and controlling factors (id: 186)

Chelsea Pederson, Vasileios Mavromatis, Martin Dietzel, Adrian Immenhauser

Presenting author: Chelsea Pederson

Statistically learning complex Archean carbonate diagenesis (id: 177)

Fulvio Franchi, Ash Abebe

Presenting author: Fulvio Franchi

Session T05-SS03 – Understanding a greenhouse Earth: Sedimentation, climate, sea level and biogeochemical cycles in the Cretaceous

Hall 1, June 25, 14:55-16:10

Chairs: Uličný D., Batenburg S.

Invited Session Keynote Lecture

Cretaceous eustasy: magnitudes, pace, and drivers (id: 37)

Michael Simmons, Andrew Davies, David Ray, Benjamin Greselle, Graham Baines, Frans van Buchem

Presenting author: Michael Simmons

Two types of hyperthermal events in the Mesozoic-Cenozoic: Environmental impacts, biotic effects, and driving mechanisms (id: 178)

Xiumian Hu, Juan Li, Zhong Han, Yongxiang Li

Presenting author: Xiumian Hu

Neodymium isotopic evidence for large-scale oceanographic change during the collapse of the Cretaceous hothouse (id: 418)

Sietske Batenburg, Eleanor Drage, Elaine Yi Gao, Lauren K. O'Connor, Hugh C. Jenkyns, Andrew S. Gale, Stuart A. Robinson

Presenting author: Sietske Batenburg

Palynofacies as sea-level proxy in Early Cretaceous marine mudstones – a critical evaluation (id: 905)

Hauke Thöle, Ulrich Heimhofer, Andre Bornemann, Jochen Erbacher

Presenting author: Ulrich Heimhofer

Session T01-SS02 – Lacustrine Sedimentology: From deep time and climate evolution to modern processes and human impact

Hall 2, June 25, 13:00-14:40

Chairs: Patricia Roeser, Marta Marchegiano, Keyu Liu, Huaqing Liu, E. Gliozzi, D. Cosentino, Daniel Ariztegui, S. Pan

Depositional and diagenesis control on the conglomerate reservoir quality of the ES4 member of Lijin (id: 826)

Kouassi Louis Kra

Presenting author: Kouassi Louis Kra

Sedimentary dynamics and water resurgences from high-resolution seismic reflection survey in Lake Altaussee (Austrian Alps) (id: 423)

Guillaume Jouve, Damien Leloup, Alban Bouchard, Philippe Alain, Emmanuel Chapron

Presenting author: Guillaume Jouve

A classification scheme for deep-lacustrine turbidite fans: examples from the North Falkland Basin (id: 372)

Thomas Dodd, Dave McCarthy, Stuart Clarke, Darren Jones, Gayle Plenderleith, Thomas Randles

Presenting author: Thomas Dodd

Holocene evolution of Lake Ulaan basin, southern Mongolia (id: 963)

Alexander Orkhonselenge, Munkhjargal Uuganzaya, Tuyagerel Davaagatan

Presenting author: Alexander Orkhonselenge

Facies architecture of the late pliocene (piacenzian) deposits of the fucino lake (central apennines, italy) (id: 314)

Presenting author: Gianmarco Mondati

Early Permian ichnofossils assemblage from Bieganów quarry and surrounding localities, Słupiec Fm – Intrasudetic Basin (id: 685)

Hubert Kiersnowski, Aleksander Kowalski, Izabela Ploch, Paweł Raczyński

Presenting author: Hubert Kiersnowski

Session T02 – Shallow-marine clastics

Hall 2, June 25, 14:55-16:10

Chairs: Tadeusz Peryt

Detailed sedimentology of the late-Ordovician Soom Shale Lagerstatte in South Africa (id: 77)

Claire Browning, Sarah Gabbott, Emese Bordy

Presenting author: Claire Browning

Syn-rift siliciclastic shallow marine depositional environments: a tectonostratigraphic evolution (Mid-Norway, Middle Jurassic to Lower Cretaceous) (id: 348)

Romain Grime, Bernard Pittet, Sten Rasmussen, Francesco Borraccini, Sébastien Landru, Alexandre Bouche

Presenting author: Romain Grime

Allocyclic controls on shoreface deposits of the Gippsland Basin, SE Australia: 70 Ma of deposition (id: 246)

Liz Mahon, Malcolm Wallace

Presenting author: Liz Mahon

Evolution and internal architecture of an active mixed sand-gravel barrier spit (Somme Bay, Northern France) (id: 406)

Léo Pancrazzi, Pierre Weill, Bernadette Tessier, Laurent Benoît, Sophie Le Bot

Presenting author: Léo Pancrazzi

Simultaneous breakdown and recementation of an unusual beachrock facies on a high-energy coastline (South Africa) (id: 591)

Michaela Falkenroth, Andrew Green, Andrew Cooper, Gösta Hoffmann

Presenting author: Michaela Falkenroth

Session T04-SS02 – Submarine canyons and channels: Their role for material transfer and burial from shelf to basin

Hall 3, June 25, 13:00-15:55

Chairs: Gong C., Steel R. J., Olariu C., Gan Y. P.

Invited Session Keynote Lecture

Geomorphology and process dynamics of the world's longest calciclastic submarine channels (id: 421)

Jeffrey Peakall, Jim Gardner, Andy Armstrong, Brian Calder

Presenting author: Jeffrey Peakall

Morphology and recent sedimentary processes in two shelf-indenting submarine canyons in the Alboran Sea (id: 812)

Javier Cerrillo Escoriza, Ángel Puga-Bernabéu, Francisco Jose Lobo, Patricia Bárcenas, Jose Antonio Caballero, Álvaro Carrión, Marga García, José María García Guerrero, Antonio García Ledesma, Sergio García Pozo, Serge Gofas, Adrían Lopez Quirós, María Lu

Presenting author: Javier Cerrillo Escoriza

A global database-informed analysis of controls on submarine-canyon geomorphology (id: 601)

Laura Bührig, Laura Bührig, Luca Colombera, Marco Patacci, Nigel P. Mountney, William D. McCaffrey

Presenting author: Laura Bührig

Systems Feeding Sediment to Canyon Heads (SFSCH) in the Tyrrhenian Sea: understanding deep-sea stratigraphy (id: 624)

Fabiano Gamberi

Presenting author: Fabiano Gamberi

How mass-transport deposits and knickpoint-zones build the stratigraphy of the deep-water Hikurangi Channel (id: 929)

Daniel Tek, Adam McArthur, Miquel Poyatos-Moré, Luca Colombera, Marco Patacci, Ben Craven, Bill McCaffrey

Presenting author: Daniel Tek

Is Turbidity Current Activity Predictable? (id: 380)

Lewis Bailey, Michael Clare, Ivan Haigh, Ed Pope, Matthieu Cartigny, Peter Talling, Daniel Parsons, Stephen Simmons, Gwyn Lintern, Cooper Stacey, Maarten Heijnen, Sophie Hage

Presenting author: Lewis Bailey

Controls on submarine slope channel development: insights from 3D seismic and numerical modelling (id: 816)

Adriana Crisostomo Figueroa, Adam D. McArthur, Lawrence A. Amy, Robert M. Dorrell, William D. McCaffrey

Presenting author: Adriana Crisostomo Figueroa

E-POSTERS

T01 – Continental environments and depositional systems

Study on Sedimentary Microfacies of Tidal-controlled Estuary in M1 of Oriente Basin (id: 128)

Tianyu Zhang

Presenting author: Tianyu Zhang

Quantitative characterization of architecture elements in deep-water hyperpycnal systems in lacustrine rift basins (id: 772)

Wenmiao Zhang

Presenting author: Wenmiao Zhang

Basin evolution during incipient rifting of ribbon terranes: an example from the bohemian massif (id: 329)

Reza Syahputra, Jiří Žák

Presenting author: Reza Syahputra

Sedimentary architecture and dating of Pleistocene breach deposits from Vranić sand pit (Croatia) (id: 358)

Adriano Banak, Krešimir Petrinjak, Zsófia Ruszkiczay-Rüdiger, Radovan Avanić, Anita Grizelj, Marko Budić

Presenting author: Krešimir Petrinjak

Lateral migration of fluvial systems preserved in outcrop? (id: 376)

Hazel Beaumont, Catherine Russel

Presenting author: Hazel Beaumont

The Ségure basin (Corbières, France) compared to the Stephanian basin of Saint-Etienne (French Massif Central) (id: 569)

Matthieu Saillol, Markus Aretz, Frédéric Christophoul

Presenting author: Matthieu Saillol

Early Permian fluvial-lacustrine system interaction in the Krkonoše Piedmont Basin, NE Czech Republic (id: 728)

Kateřina Schöpfer, Roland Nádaskay, Karel Martínek

Presenting author: Kateřina Schöpfer

Sedimentary facies analysis of the Upper Cretaceous Shendi Formation in Musawwarat-Naga area, Shendi-Atbara Basin, Sudan (id: 777)

Mohamed Diaeldin Babkir Hassan Babkir, Matthew Essien Nton, Ali Ahmed Mohamed Eisawi

Presenting author: Mohamed Diaeldin Babkir Hassan Babkir

A Neoichnological Approach to Interpreting Bird and other Trace Fossils (id: 954)

Jon Noad

Presenting author: Jon Noad

Implications of paleo-environmental variations from Mesozoic sedimentary records: example from a syn-rift Gondwana basin, India (id: 969)

Sanghita Dasguta

Presenting author: Sanghita Dasguta

T01-SS01 – Palaeosols: A treasure chest to understand the palaeoenvironmental and sedimentary processes in continental realm

Paleosols in the Old Red succession of Podolia (Ukraine) (id: 137)

Małgorzata Kozłowska

Presenting author: Małgorzata Kozłowska

Variations of aquic conditions in Paleocene Vertisols (Esplugafreda Formation, Catalan Pyrenees, Spain): morphological and/or climatic causes (id: 504)

Giorgio Basilici, Marcus Vinícius Theodoro Soares, Luca Colombera, Nigel Philip Mountney, Paolo Lorenzoni, Áquila Ferreira Mesquita

Presenting author: Giorgio Basilici

Palaeosol-landscape relationships in the Late Cretaceous Bauru Basin, Brazil (id: 904)

Marcus Soares, Giorgio Basilici, Paolo Lorenzoni, Agustín Guillermo Martinelli, Áquila Ferreira Mesquita, Thiago da Silva Marinho, André Marconato

Presenting author: Marcus Soares

Paleosol architecture in a quaternary incised valley and surrounding areas (id: 920)

F. Xavier Castelltort Aiguabella, J. Carles Balasch, Jaume Boixadera, Rafael Rodríguez, Rosa M. Poch

Presenting author: F. Xavier Castelltort Aiguabella

T01-SS02 – Lacustrine Sedimentology: From deep time and climate evolution to modern processes and human impact

Human impact induces formation and preservation of varves: case studies from northern Poland (id: 600)

Anna Poraj-Górska, Alicja Bonk, Maurycy Żarczyński, Małgorzata Kinder, Wojciech Tylmann

Presenting author: Anna Poraj-Górska

Advances in understanding calcite varve formation from a dual lake monitoring in the southern Baltic (id: 668)

Patricia Roeser, Nadine Dräger, Dariusz Brykała, Florian Ott, Sylvia Pinkerneil, Piotr Gierszewski, Christin Lindemann, Birgit Plessen, Brian Brademann, Michał Kaszubski, Michał Fojutowski, Markus J. Schwab, Michał Słowiński, Mirosław Błaszkiewicz, Achim

Presenting author: Patricia Roeser

The sedimentary record of contamination in modern oxbow lakes; Ostrava urban agglomeration area, Czech Republic (id: 714)

Jan Sedláček

Presenting author: Jan Sedláček

Sequence stratigraphic distribution of OM in shale: Insight from the controlling factors and development process (id: 135)

Jing Wu, Chao Liang

Presenting author: Chao Liang

Instability and Soft-Sediment Deformation of a Triassic Lacustrine Delta, Ordos Basin, Central China (id: 558)

Yi Gao, Jingong Zhang

Presenting author: Yi Gao

Dolomite origin and sedimentary environment characteristics of mixed siliciclastic-carbonate sediments affected by volcanism, Santanghu Basin, China (id: 762)

Yongshuai Pan, Zhilong Huang

Presenting author: Yongshuai Pan

Channel-lobes in lacustrine turbidite fan: Insight from Triassic Yanchang Formation, Ordos Basin, China (id: 771)

Jungang Pang

Presenting author: jungang pang

Impact of Depositional Environment on the Evolution of Shale Lithofacies (id: 779)

Danish Khan, Longwei Qiu, Chao Liang, Kamran Mirza, Muhammad Kashif

Presenting author: Danish Khan

Analysis of genetic mechanism and main controlling factors of lacustrine multicomponent mixed sediments (id: 828)

Quanquan Li, Zhidong Bao

Presenting author: Quanquan Li

The genetic mechanism of overpressure in Funing Formation in Gaoyou Sag, Subei basin (id: 874)

Futao Qu, Xianzhi Gao, Lei Gong

Presenting author: Futao Qu

T02 – Shallow-marine clastics

Detrital heavy minerals from Albian sands as a tool in provenance study, Glanów-Stroniczki, southern Poland (id: 237)

Jakub Kotowski, Krzysztof Nejbert, Danuta Olszewska-Nejbert

Presenting author: Danuta Olszewska-Nejbert

Unravelling deltaic architecture using borehole image logs in the Brasse Field, North Sea (id: 387)

Donatella Mellere, Andras Uhrin, Dagfinn Veiberg, Elisa Scagnetto, Zbynek Veselovsky

Presenting author: Andras Uhrin

Internal architecture of coarse-grained barriers in hypertidal environments (France and Argentina) : A GPR study (id: 412)

Léo Pancrazzi, Bernadette Tessier, Pierre Weill, Dominique Mouazé, José Cuitiño, Maria Duperron, Roberto Scasso

Presenting author: Léo Pancrazzi

Entobia ichnofacies from the Middle Miocene of Szydłów (Carpathian Foredeep, Poland) (id: 447)

Weronika Łaska, Michał Stachacz

Presenting author: Weronika Łaska

Transgressive system tract and continental shelf morphology: an example from the Hyblean foreland ramp offshore (id: 627)

Salvatore Distefano, Fabiano Gamberi, Salvatore Urso, Agata Di Stefano

Presenting author: Salvatore Distefano

Baer knolls as non-aeolian landforms of the Northern Caspian lowland (id: 786)

Daria Lobacheva

Presenting author: Daria Lobacheva

Determination and quantification of salt marsh sedimentation using end-member modelling of grain-size data (id: 922)

Nina Lenz, Sebastian Lindhorst

Presenting author: Nina Lenz

Faciological architecture of tempestites from the Teresina formation, southern Parana basin (id: 943)

Jean Toledo, Ezequiel Galvão de Souza, Gabriel Góes Marins

Presenting author: Jean Toledo

Depositional environment interpretation of early to middle miocene offshore peninsular malaysia (id: 53)

Puntira Henglai, Kasira Laitrakull, Kelly Poret

Presenting author: Puntira Henglai

Sedimentary environment and distribution of source rocks in slope belt of the Xihu Depression, China (id: 322)

Jing Zhao, Zhilong Huang, Yiming Jiang, Sizhe Tan

Presenting author: Jing Zhao

Evaluation of wave and wind power operated in foreshores using grain shapes and size distributions (id: 897)

Yuki Kajiyama, Tohru Ohta

Presenting author: Yuki Kajiyama

T02-SS01 – Gateways, straits and seaways: Their sedimentology and stratigraphy importance to understand basins evolution

The north-eastern Sicilian continental shelf: a tidal-shelf in the Messina Strait approach (id: 848)

Salvatore Distefano, Fabiano Gamberi, Agata Di Stefano, Alessandra Mercorella

Presenting author: Salvatore Distefano

T02-SS02 – The waltz of processes in paralic environments – Rock record and modern perspectives

A global meta-study of shelf-edge delta architecture and geometry (id: 793)

Laura Bührig, Luca Colombera, Nigel P. Mountney, William D. McCaffrey

Presenting author: Laura Bührig

A continuously exposed strongly river-dominated delta of the Focsani depression (Romania) reveals obliquity forcing (id: 849)

Anton Matoshko, Arjan de Leeuw, Marius Stoica, Oleg Mandic, Wout Krijgsman

Presenting author: Anton Matoshko

T03-SS01 – Geochemistry of modern and Recent carbonates

Spatial distribution of grain size and isotope geochemistry in the modern Abu Dhabi lagoon (id: 196)

Ozioma Uwakwe, Chelsea Pederson, Yuzhu Ge, Stephen Lokier, Adrian Immenhauser

Presenting author: Ozioma Uwakwe

Diagenesis investigation: A Case Study from Early Miocene Carbonate Succession, Sawadi Islands, Northeast Oman, Oman (id: 693)

Mohamed Moustafa, AbdulRazak Al Sayigh, Musaab Al-Sarmi, Manar Al Hadhri, Zainab Al Maqbalia, Hasina Al Rajaibia

Presenting author: Mohamed Moustafa

Morphological and geochemical characterisation of seep carbonates in the southeastern Mediterranean Sea (id: 699)

Reinhard Weidlich, Or Bialik, Andres Rüggeberg, Bernard Grobéty, Torsten Vennemann, Yizhaq Makovsky, Anneleen Foubert

Presenting author: Reinhard Weidlich

Redox geochemistry of the Baltoscandia's red orthoceratite limestones: Possible linkage to mid Ordovician palaeoceanographic changes (id: 925)

Kateřina Kolková, Ondřej Bábek, Mikael Calner, Jiří Frýda, Tomáš Kumpan, Daniel Šimíček, Lukáš Ackerman

Presenting author: Kateřina Kolková

Geochemical analysis of the lower Cretaceous "Vigla Shales" in the Ionian Basin, Greece (id: 926)

Nicolina Bourli, Nikolaos Pasadakis, Maria Sianni, Avraam Zelilidis

Presenting author: Nicolina Bourli

The genesis and evolution of laminated carbonate in lacustrine mudrock from Jiyang Sub-basin, China (id: 107)

Chenyang Bai, Bingsong Yu, Shujun Han, Zhenhuan Shen

Presenting author: Chenyang Bai

Impact of paleogeomorphy on diagenesis of the qixia formation in the northwestern sichuan basin (id: 197)

Wendong Liu

Presenting author: Wendong Liu

Lithological and isotopic characteristics of lacustrine stromatolite in Tibetan Plateau: Implications for Miocene Stromatolite Riddle (id: 287)

Lu Han, Zhiqiang Shi, Dan Qiao

Presenting author: LU HAN

T03-SS02 – Resedimented carbonates – generation, transportation, deposition

Sedimentary facies study of the Lower Cambrian Xiaoerblak Formation in Tarim Basin (id: 443)

Yufang Xue, Zhongxian Cai

Presenting author: Yufang Xue

Depositional architecture of a mixed volcaniclastic-carbonate slope succession: the seismic-scale Crepe Rosse outcrop (Ladinian, Dolomites) (id: 625)

Fabiano Gamberi, Anna Breda, Piero Gianolla, Gian Andrea Pini

Presenting author: Fabiano Gamberi

Geometric and paleoenvironmental reconstruction of discontinuous carbonates: relevance of statistical approach to quantitative microfacies data. (id: 944)

Adriano Guido, Giuseppe Palladino, Matteo Sposato, Franco Russo, Giacomo Prosser, Mario Bentivenga, Adelaide Mastandrea

Presenting author: Adriano Guido

T03-SS03 – Carbonate sequence stratigraphy: Review and update

Lower Ordovician sequence stratigraphy and its control on microbial rocks in Songzi area, Hubei (id: 262)

siyu zhou, dakang zhong, chuantao xiao

Presenting author: siyu zhou

Controls on accommodation and sediment supply, Santonian Sant Corneli Formation, south-central Pyrenees, Spain (id: 873)

Peter Drzewiecki, Jaume Verges, David Hunt, Wayne Wright

Presenting author: Peter Drzewiecki

Multivariate regression approach to estimate lithology from well log Data, Khabbaz Oil Field, Northern Iraq (id: 888)

Hussein Hussein

Presenting author: Hussein Hussein

Influence of tectonics on the evolution of Aalenian-Oxfordian carbonate system in intracontinental basins (west France) (id: 930)

Quentin Deloume-Carpentras, Simon Andrieu, Benjamin Brigaud, Eglantine Husson, Eric Lasseur, Jocelyn Barbarand

Presenting author: Quentin Deloume-Carpentras

T03-SS04 – Open Session on Carbonates

Genesis and distribution of dolomite reservoirs in the qixia formation in northwestern sichuan basin (id: 90)

Xueqi Liang

Presenting author: Xueqi Liang

The Mesozoic carbonate succession of the Ionian Basin in Kastos Island and NW Peloponnesus, Greece (id: 339)

Nicolina Bourli, George Iliopoulos, Elena Zoumpouli, Penelope Papadopoulou, Avraam Zelilidis

Presenting author: Nicolina Bourli

Reservoir characteristics and its controlling factors of the T2l3 formation in the northwestern sichuan basin, China (id: 350)

SiQiao Peng, DaKang Zhong, Zhen Li

Presenting author: SiQiao Peng

Quantitative Characterization of Pore Structure of Dolostones in the Lower Cambrian Reservoirs of Tarim Basin (id: 368)

Qingbing Liu

Presenting author: Qingbing Liu

The Dolomites Genesis Of Upper Sinian In Tarim Basin (id: 845)

Li Zongfeng, Bao Zhidong

Presenting author: Li Zongfeng

Sequence, facies and reservoir characteristics of lower Cretaceous Yamama formation in main oilfields, southeast Iraq (id: 494)

Guosheng Qin

Presenting author: Guosheng Qin

Structural characteristics of the botryoidal structures of Sinian Dengying formation in Sichuan basin (id: 780)

Guanxiong Ren

Presenting author: Guanxiong Ren

Diagenetic differentiation and reservoir quality of saline lacustrine carbonate sediments as response to lake-level fluctuations (id: 834)

Wu Qianran

Presenting author: WU Qianran

The development and demise of an early Cambrian shallow-water carbonate factory in South China (id: 940)

Hong Li, Fei Li

Presenting author: Hong Li

Far-field effects of the Darriwillian (Mid-Ordovician) ice age: agglutinated stromatolites in a temperate epeiric platform (id: 198)

James R. Wheeley, Lesley Cherns, Paul Wright

Presenting author: Paul Wright

Sedimentology and trace element geochemistry of Upper Cretaceous platform carbonates in the Borizana section (Albania) (id: 536)

Ana Fociro, Agim Sinojmeri, Oltion Fociro

Presenting author: Ana Fociro

Dolomitization and dedolomitization of Upper Cretaceous Carbonates: A case study from the Borizana section, Albania (id: 617)

Ana Fociro, Çerçis Durmishi

Presenting author: Ana Fociro

Unravelling the origin of widespread pelagic carbonate successions in the mid-Carboniferous Variscan foreland basin (id: 663)

Óscar Merino Tomé, Giovanna Della Porta, Elias Samankassou, Luis Pedro Fernández, I. Emma Quijada, Juan R. Bahamonde, Iván Díaz-García, Angeles G. Borrego, Adam C Maloof, Arsenio Muñoz, Jaime Martín-Llaneza, Alison Campion

Presenting author: Elias Samankassou

Depositional environment of early Miocene carbonate succession, Oman. Is it an equivalence of Sur Formation? (id: 677)

Musaab Al Sarmi, Abdul Razak Al-Sayigh, Mohamed Moustafa, Osman Hersi, Hasina Al Rajaibi, Manar Al Hadhri, Zainab Al Maqbali

Presenting author: Musaab Al Sarmi

Travertine deposition and diagenesis in Ca-deficiency perched hot spring systems: Insights from Shihuadong, China (id: 790)

Lianchao Luo, Huaguo Wen, Enrico Capezzuoli

Presenting author: Lianchao Luo

Upper Jurassic – Lower Cretaceous carbonates from the Postăvaru Massif (Romania). Microfacies and microfossils (id: 803)

Cristian Victor Mircescu, Ioan Bucur, George Pleș

Presenting author: Cristian Victor Mircescu

Measuring the significant cyclicity and variability of non-water carbonates – interfluve Hungary, using CT data (id: 823)

Nour Alzoubi, Sandor Gulyas, Janos Geiger

Presenting author: Nour Alzoubi

Progressive opening of the Oliete bay (Spain) around the Barremian-Aptian transition: facies evolution, controlling factors (id: 878)

Álvaro García-Penas

Presenting author: Álvaro García-Penas

Sedimentary facies analysis and depositional environment modeling of the Oxfordian Hanifa Formation, central Saudi Arabia (id: 979)

Mazin Bashri, Michael Kaminski, Osman Abdullatif, John Humphrey, Mohammed Makkawi, Rudy Swennen, Omer Ali, Ammar Adam, Moaz Salih, Jarrah Babiker

Presenting author: Mazin Bashri

New information on the structure of the Osinsky horizon in East Siberia (Lower Cambrian, Russia) (id: 924)

Elizaveta Maksimova, Kseniya Chertina, Irina Novosadova

Presenting author: Elizaveta Maksimova

T04-Deep-marine depositional systems

The influence of topography on subaqueous sediment gravity flows and degrees of confinement (id: 941)

Gabriel Giacomone, Cornel Olariu, Ronald J. Steel

Presenting author: Gabriel Giacomone

Ichnological-sedimentological indicators of deep-sea environment in Lower Eocene deposits of the Borjomi region (Georgia) (id: 234)

Tamar Beridze, Zurab Lebanidze, Alfred Uchman, Koba Lobzhanidze, Sophio Khutsishvili, Rusudan Chagelishvili, Nino Kobakhidze, Davit Makadze, Nino Khundadze, Kakha Koiava

Presenting author: Tamar Beridze

Sedimentology and ichnology of the Satavadoskhevi section (the eastern segment of the Trialeti Ridge, Georgia) (id: 503)

Nino Kobakhidze, Davit Makadze, Alfred Uchman, Zurab Lebanidze

Presenting author: Nino Kobakhidze

The wide variety of soft-sediment deformation structures in the Oligo-Miocene Numidian Flysch of NW Algeria (id: 612)

Bouabdellah Menzoul, A.J. (Tom) Van Loon, Mohamed Adaci

Presenting author: Bouabdellah MENZOUL

Deep water renewals caught in action (id: 763)

Korhan Ayranci, Shahin Dashtgard

Presenting author: Korhan Ayranci

T04-SS01 – Continental slope sedimentary systems: Processes, products and controls.

Characterizing hemipelagites and homogenites using grain-size analysis: Examples from offshore SW Taiwan (id: 13)

Radha Krishna Pillutla, Andrew Tien-Shun Lin, Chih-Chieh Su, Shu-Kun Hsu

Presenting author: Radha Krishna Pillutla

Sediment wave development in flow constrained area of the Neogene forearc basin of Southwest Japan (id: 74)

Yoshiro Ishihara, Shiori Iwao, Yuri Onishi, Miwa Yokokawa

Presenting author: Yoshiro Ishihara

An oceanographic and sedimentary study of mounded contourite drifts offshore Ireland: preliminary results (id: 400)

Alice Matossian, Eoghan Daly, Thomas Vandorpe, Martin White, David Van Rooij

Presenting author: Alice Matossian

Quaternary shelf-margin clinoforms in the southern Song Hong-Yinggehai Basin, offshore Vietnam (id: 561)

Kieu Nguyen Van, Szczepan J. Porębski, Dung Bui Viet, Trang Pham Hong, Man Ha Quang, Hien Doan Huy

Presenting author: Kieu Nguyen Van

The influence of channel planform and slope topography on turbidity current overbank processes (id: 656)

Elena Scacchia, Fabiano Gamberi, Roberto Tinterri

Presenting author: Elena Scacchia

Late Jurassic-Early Cretaceous tuff sandstones of the Ust-Belsky Mountains (Koryak Highland, NE Russia) (id: 764)

Mariia Gushchina, Artem Moiseev, Marianna Tuchkova

Presenting author: Mariia Gushchina

Fill-spill cycles with multiple exit points: stratigraphic evolution above a dynamic stepped-slope (id: 799)

Junia Casagrande, David Hodgson, Jeffrey Peakall

Presenting author: Junia Casagrande

Stratigraphic architecture and characterization of a Neoproterozoic continental slope system, Windermere Supergroup, British Columbia, Canada (id: 817)

Simona Ruso, William Arnott

Presenting author: Simona Ruso

Cyclic dominant depositional processes on a mixed turbidite-contourite system in northern Campos Basin, SE Brazil (id: 822)

Bruna T. Pandolpho, Antonio Henrique da Fontoura Klein, Isadora Dutra, Michel M. Mahiques, Adriano R. Viana, Gilmar Vital Bueno, Arthur Antonio Machado, Yuri L. Camargo, Cízia M. Hercos, Yhaohannah Lima, Antonio Fernando H. Fetter Filho, Carlos E. Theodor

Presenting author: Bruna T. Pandolpho

Depositional evolution of successive confining basins – inferences from observations and numerical modelling (id: 866)

Ádám Kovács, Attila Balázs, Lilla Tőkés, Orsolya Sztanó

Presenting author: Ádám Kovács

T04-SS02 – Submarine canyons and channels: Their role for material transfer and burial from shelf to basin

A comparison of channel morphologies, architectures, and population densities between trajectory regimes and climate states (id: 81)

Chenglin Gong, Ronald Steel, Kun Qi

Presenting author: Chenglin Gong

The Afam Canyon, a subsurface case of submarine dendritic pattern and multiphase infilling (Tortonian, Nigeria) (id: 949)

Louison Mercier, Massimo Dall'Asta, Sébastien Migeon, Vincent Delhaye-Prat, François Lafont, Jean-Loup Rubino

Presenting author: Louison Mercier

Depositional setting of Triassic turbidites deposits in Semanggol and Semantan basins across Suture, Peninsular Malaysia (id: 631)

Zulqarnain sajid, Mohd Suhaili Ismail, Tanzila Hanif, Qamar UZ Zaman

Presenting author: Zulqarnain sajid

T05 – Stratigraphic archives of evolution of climate, oceans, and biota

A ~61 m.y. astronomical time scale for the uppermost Mississippian through Early Permian (id: 831)

Huaichun Wu, Qiang Fang, Shu-zhong Shen, Linda A. Hinnov, Shihong Zhang, Tianshui Yang

Presenting author: Huaichun Wu

Change of conodont assemblages before the Smithian-Spathian (Early Olenekian) extinction in South Primorye (id: 146)

Liana G. Bondarenko, Yuri D. Zakharov

Presenting author: Liana G. Bondarenko

Foraminiferal, palynofacies and dinoflagellate records of environmental changes at the Badenian/Sarmatian boundary in Central Paratethys (id: 316)

Danuta Peryt, Przemysław Gedl, Marek Jasionowski, Andriy V. Poberezhskyy

Presenting author: Danuta Peryt

An Early Eocene carbon-cycle perturbation on the North Iberian turbiditic continental margin (id: 550)

Naroa Martinez-Braceras, Aitor Payros, Javier Arostegi, Jaume Dinarès-Turell

Presenting author: Naroa Martinez-Braceras

Deep-time paleoclimate events preserved in Svalbard's rock record – a review (id: 909)

Aleksandra Smyrak-Sikora, Lars Eivind Augland, Peter Betlem, Thomas Birchall, Sten-Andreas Grundvåg, William Helland-Hansen, Maria Jensen, Malte M. Jochmann, Erik P. Johanessen, Morgan T. Jones, Gareth S. Lord, Atle Mørk, Snorre Olaussen, Sverre Planke, K

Presenting author: Aleksandra Smyrak-Sikora

Preliminary comparative stratigraphic analysis between the Coquimbo Formation and the Bahía Inglesa Formation, northern Chile. (id: 914)

Benjamin Araya Rojas, Pablo Oyanadel-Urbina, Diego Partarrieu, Jaime Villafaña, Patricia Canales, Jorge Campos, Marcelo Rivadeneira

Presenting author: Benjamin Araya Rojas

T05-SS01 – Paleozoic ocean, lands, ecosystems and climate imprinted in sedimentary strata: New insights from high-resolution proxies

Mid-Carboniferous evaporitic deposits recording a sea-level fall during the closure of Panthalassa-Paleotethys gateway (N Spain) (id: 559)

Iván Díaz-García, Óscar Merino-Tomé, I. Emma Quijada, Juan R. Bahamonde, Luis Pedro Fernández, Giovanna Della Porta, Elias Samankassou, Federico Ortí, Ángeles G. Borrego, Jaime Martín-LLaneza, Marta Valenzuela

Presenting author: Iván Díaz-García

Geochemical identification of carbonate sedimentary environment: A case study of Nanjinguan Formation in Songzi area (id: 669)

siyu zhou, dakang zhong, chuantao xiao

Presenting author: siyu zhou

Isotopic geochemical proxies and facies across Pragian–Emsian boundary in the Zinzilban Gorge (Uzbekistan) (id: 684)

Olga Izokh

Presenting author: Olga Izokh

Palaeoenvironmental context of the Famennian red pelagic limestones in the Křtiny quarry (Czechia) (id: 716)

Vojtěch Cígler, Tomáš Kumpan

Presenting author: Vojtěch Cígler

T05-SS02 – Climatic, environmental, and biotic crises of the Permo- Triassic: Sedimentary records of the transition to the Mesozoic world

Sedimentology of the Permo-Triassic boundary in high palaeolatitude, coastal plain successions of eastern Australia (id: 123)

Christopher Fielding, Tracy Frank, Allen Tevyaw, Katarina Savatic, Vivi Vajda, Stephen McLoughlin, Chris Mays, Robert Nicoll, Malcolm Bocking, James Crowley

Presenting author: Frank Tracy

Late Permian climate record in the continental and palustrine facies in SE Central European Basin (id: 444)

Karol Jewuła, Wiesław Trela, Anna Fijałkowska-Mader

Presenting author: Karol Jewuła

The Anisian continental-marine transition in Sardinia (Italy): new palynological data and regional chronostratigraphic correlation (id: 810)

Lorenzo Stori, José Bienvenido Diez Ferrer, Manuel Antonio Juncal Rosales, Raúl De la Horra, Violeta Borruel Abadía, Javier Martín-Chivelet, José Fernández Barrenechea, José López-Gómez, Ausonio Ronchi

Presenting author: Lorenzo Stori

Determination of palaeotemperature trends by δ15N data (rationale of a new method) (id: 172)

Yuri D. Zakharov, Micha Horacek, Alexander S. Biakov, Nikolay A. Goryachev

Presenting author: Yuri D. Zakharov

Paleoclimate history of the Carnian Pluvial Event in the Mine Group, southwest Japan (id: 860)

Takae Hirai, Tohru Ohta

Presenting author: Takae Hirai

T05-SS03 – Understanding a greenhouse Earth: Sedimentation, climate, sea level and biogeochemical cycles in the Cretaceous

87Sr/86Sr record of Barremian-Albian invertebrates: first evidence from the Caucasus and its palaeogeological significance (id: 173)

Yuri D. Zakharov, Anton B. Kuznetsov, Mikheil V. Kakabadze, Mevlud Z. Sharikadze, Anastasia A. Gavrilova, Aleksei Yu. Kramchaninov

Presenting author: Yuri D. Zakharov

A new C-isotope (δ13Ccarb) reference for global correlations in the Aptian: The Cau-core, westermost Tethys (id: 223)

Pedro Alejandro Ruiz-Ortiz, José Manuel Castro, Roque Aguado, Ginés Alfonso de Gea, Ian Jarvis, José Miguel Molina, Luis Miguel Nieto, Richard David Pancost, María Luisa Quijano, Matías Reolid, Rafael Martínez-Rodriguez, Helmut Jürg Weissert, Peter W Skel

Presenting author: Pedro Alejandro Ruiz-Ortiz

Cretaceous Chondrodonta (Bivalvia) accumulations from Istria (Croatia) and Gargano (Italy): a comparative study (id: 675)

Gabriella Del Viscio, Michele Morsilli, Renato Posenato, Gianluca Frijia, Alan Moro, Alex Mezga

Presenting author: Gabriella Del Viscio

Intermittent mass-occurrences of microbial carbonates during the late Aptian (Basque-Cantabrian Basin, Northern Spain). (id: 730)

Joanaitz Pérez Malo, Pedro Ángel Fernández Mendiola

Presenting author: Joanaitz Pérez Malo

Paleoclimate evaluation during the mid-Cretaceous in Zhejiang Province, southeast China (id: 832)

Kohki Okano, Arisa Nakano, Tenichi Cho, Tohru Ohta, Gang Li

Presenting author: Kohki Okano

Paleoclimate analysis during the mid-Cretaceous Supergreenhose in Southeast Asia (id: 858)

Kohei Ikenaga, Tohru Ohta, Dinh Nguyen

Presenting author: Kohei Ikenaga

T05-SS04 – Black shales: Past depositional systems and modern environments

The black shales of the Cambrian Kuonamka complex of the Siberian platform: chemofossils, microbio-community, facies (id: 373)

Tatyana Parfenova

Presenting author: Tatyana Parfenova

Characterization of the luminescent layers of the Bazhenov Formation (id: 434)

Timur Bulatov, Elena Kozlova, Evgenia Leushina, Ivan Panchenko, Andrey Voropaev, Natalia Pronina, Nikita Morozov, Yulia Kostina, Mikhail Spasennykh

Presenting author: Timur Bulatov

The rhythmic expression of mid-Cretaceous Oceanic Anoxic Event 2 southwest of Australia (IODP U1513, U1516)

Sietske Batenburg, Kara A. Bogus, Matthew M. Jones, Kenneth G. MacLeod, Mathieu Martinez

Presenting author: Sietske Batenburg

Review of the Upper Jurassic black shales of the Russian Platform (id: 576)

Mikhail Rogov, Elena Shchepetova, Victor Zakharov

Presenting author: Mikhail Rogov

Aptian anoxic basin of the Russian Platform: recognizing a responses to global and regional controls (id: 708)

Elena Shchepetova, Mikhail Rogov, Alexey Ippolitov, Vladimir Seltser, Alexandr Mironenko, Boris Pokrovsky, Bhawanisingh G. Desai

Presenting author: Elena Shchepetova

Organofacies and paleodepositional environments of the “black shale heaven”, Mangyshlak Peninsula, Kazakhstan (id: 846)

Renat Ilutkov, Riza Nurbekova, Aidyn Tileugabbylov, Laurent Richard, Milovan Fustic

Presenting author: Milovan Fustic

Volcanic trigger a mid-tournaisian anoxic event in carnic alps (austria) (id: 912)

Daria Książak, Michał Rakociński, Agnieszka Pisarzowska, Jakub Kucharczyk, Leszek Marynowski

Presenting author: Michał Rakociński

T05-SS05 – Sedimentary environments as the theatres of life and evolution

Karoo palaeosols at the end-Capitanian extinction event suggest increasing landscape stability (id: 183)

Susan Marriott, Emese Bordy, Michael Day, Francisco Paiva, Bruce Rubidge

Presenting author: Susan Marriott

Environmental engineering in the Pragian? (id: 184)

Susan Marriott, Robert Hillier, Paul Wright

Presenting author: Susan Marriott

Psilonichnus upsilon ichnofosssils as a tool of environmental study in Albian sands, Glanów-Stroniczki, southern Poland (id: 236)

Danuta Olszewska-Nejbert, Jakub Kotowski, Krzysztof Nejbert

Presenting author: Danuta Olszewska-Nejbert

Seasonal Miocene precipitation pattern recognized in marginal marine deposits of Mt. Medvednica (Croatia) (id: 389)

Jasenka Sremac, Antonia Šeparović, Marija Bošnjak, Anja Jarić, Štefica Kampić

Presenting author: Marija Bošnjak

The Neoproterozoic Uk Formation in the South Urals: organic geochemistry of a stromatolite reef complex (id: 505)

Dmitry Melnik, Tatyana Parfenova

Presenting author: Dmitry Melnik

Sedimentary and diagenetic environments of the terminal Ediacaran Khatyspyt Formation (Arctic Siberia) (id: 686)

Olga Izokh, Vladimir Rogov, Ekaterina Podugolnikova, Dmitry Grazhdankin

Presenting author: Olga Izokh

Carbonate factory changes associated with the Middle Eocene Climatic Optimum: Apulia Carbonate Platform, Gargano, Italy (id: 700)

Michele Morsilli, Luigi Rizzo, Morabito Claudia, Daniel J. Lehrmann, Jonathan Payne, Khalid A. Al-Ramadan, Lamedee O. Babalola, John D. Humphrey

Presenting author: Michele Morsilli

Large benthic foraminifers-corals facies transition during the Middle Eocene: Tremiti Islands (Italy) (id: 953)

Claudia Morabito, Michele Morsilli

Presenting author: Claudia Morabito

T05-SS06 – Continent-ocean interactions and their geological records: a tribute to Karl Föllmi

Carbonate vs. clay fractions: contrasting paleoenvironmental interpretations in ancient shallow-platform deposits (Early Kimmeridgian, S Iberia) (id: 960)

Rute Coimbra, Federico Olóriz, Fernando Rocha

Presenting author: Rute Coimbra

T05-SS07 – Western Tethys meets Eastern Tethys – sedimetological perspective

Environmental and tectonic controls on the Norian-Jurassic sedimentary succession in the Northern Calcareous Alps (Stumpfmauer-Austria) (id: 829)

Alessandro Mancini, Giovanna Della Porta, Fabrizio Berra

Presenting author: Alessandro Mancini

Facies of deep-water sand-prone fan lobes at Kłęczany, the Cergowa Beds (Oligocene), Polish Outer Carpathians (id: 899)

Piotr Siwek, Anna Waśkowska, Marek Wendorff

Presenting author: Piotr Siwek

Fossil wood as indicator of palaeo-environmental scenario during the Cergowa Beds sedimentation (Outer Carpathians, Poland) (id: 913)

Magdalena Zielinska, Joanna Pszonka, Marek Wendorff, Paweł Godlewski

Presenting author: Magdalena Zielinska

Early Permian warming pulse in eastern peri-Gondwana evidenced by oolites in the Tengchong Block, China (id: 916)

Hao Huang, Xiaochi Jin

Presenting author: Hao Huang

T05-SS08 Diagenetic signals in the sedimentary record of environmental change

Multistage burial dolomites of the Lower Permian Qixia Formation in the Northwestern Sichuan Basin (id: 342)

Xinyao Zeng, Dakang Zhong

Presenting author: Xinyao Zeng

Limestone-marl alternation formation: detecting original variations in aragonite and calcite (id: 579)

Theresa Nohl, Manuel J. Steinbauer, Matthias Sinnesael, Emilia Jarochowska

Presenting author: Theresa Nohl

The sedimentary record of sea-level change and near seafloor diagenesis on a subtropical carbonate ramp (id: 522)

Lars Reuning, Hanaa Deik, Benjamin Petrick, Margot Courtillat, Maria-Angela Bassetti

Presenting author: Lars Reuning

T06 – Record of tectonics in sedimentary archives

Oil and Gas Distribution and Tectonic Evolution of Cambrian Bottom Unconformity Surface in Tarim Basin (id: 88)

Haowei Yuan, Shuping Chen

Presenting author: Haowei Yuan

Main Ethiopian Rift landslides formed in contrasting tectonic and surface settings (id: 233)

Karel Martínek, Kryštof Verner, Tomáš Hroch, Leta Megerssa, Veronika Kopačková, David Buriánek

Presenting author: Karel Martínek

Late Jurassic Carbonate Platform formed on top of the obducted Dinaridic ophiolites (southwestern Serbia) (id: 290)

Hans-Jürgen Gawlick, Sigrid Missoni, Milan Sudar, Roman Aubrecht, Felix Schlagintweit

Presenting author: Hans-Jürgen Gawlick

Structural-driven fluid flow from the Kalpin thrust belt, South Tianshan, NW China (id: 331)

Lanpu Chen

Presenting author: Lanpu Chen

Diagenesis of carbonate sedimentary breccias formed during Late Jurassic extension, Bas Agly syncline (Pyrenees, France) (id: 429)

Tarik Kernif, Thierry Nalpas, François Fournier, Michel De Saint Blanquat, Sylvie Bourquin, Milton Boucard, Pierre Huruguen, Marc Poujol, Sarah Boularand

Presenting author: Tarik Kernif

Late Paleozoic–Mesozoic tectonosedimentary evolution of the northern Bohemian Massif: state-of-the-art (id: 433)

Roland Nádaskay, Jiří Žák, Karel Martínek, Bedřich Mlčoch, Kateřina Schöpfer, Jiří Sláma, Martin Svojtka, Tamara Sidorinová, Radim Jedlička, Jaroslav Valečka

Presenting author: Roland Nádaskay

The detrital zircon geochronology of the Hayang Group sandstones in the Gyeongsang Basin in Korea (id: 651)

Taejin Choi, Min Gyu Kwon

Presenting author: Taejin Choi

Neotectonic activity of Mariánské Lázně Fault (western Czech Republic) and associated sedimentary outliers (id: 508)

Jan Flašar

Presenting author: Jan Flašar

The Structural measurements of bertakari and bneliKhevi deposite area (Bolnisi ore field southern Georgia) (id: 578)

David Maqadze, Mirian Maqadze, Samuel Rice

Presenting author: David Maqadze

Thermal maturity of flysch-type Grajcarek succession based on vitrinite reflectance analysis, Poland – preliminary results (id: 639)

Magdalena Zielinska

Presenting author: Magdalena Zielinska

Healed speleothems: testimony of neotectonic activity of karst areas (id: 710)

Przemysław Sala, Pavel Bella, Michał Gradziński, Juraj Littva, Jacek Szczygieł, Wojciech Wróblewski

Presenting author: Michał Gradziński

Tectonics of the south-eastern part of the North-Sudetic Synclinorium – SW Poland, Bolesławiec Syncline (id: 756)

Karol Durkowski, Andrzej Głuszyński

Presenting author: Karol Durkowski

New Upper Cretaceous depositional architecture above the cratonic edge in central Poland (id: 947)

Aleksandra Stachowska, Piotr Krzywiec

Presenting author: Aleksandra Stachowska

Evidence for Tithonian unroofing from the Eastern Alps (id: 955)

Timotheus Martin Christoph Steiner, Hans-Jürgen Gawlick, Frank Melcher

Presenting author: Timotheus Martin Christoph Steiner

T07-SS02 – When volcanoes meet the environment

Sedimentary petrography of subaerial pyroclastic density current (PDC) deposits emplaced underwater: the 1993-2005 Montserrat event (id: 110)

Andrea Di Capua, Sebastian Watt

Presenting author: Andrea Di Capua

The use of mineral interfaces in sand-sized volcanic rock fragments to infer mechanical durability (id: 217)

Emilia Le Pera, Consuele Morrone

Presenting author: Emilia Le Pera

Compositional and textural study of modern sands in the volcanic area of Campania region (Italy) (id: 221)

Consuele Morrone, Emilia Le Pera, Rosanna De Rosa, Kathleen M. Marsaglia

Presenting author: Consuele Morrone

Temporal and Spatial significance of volcanic particles in sand (stone) (id: 279)

Salvatore Critelli

Presenting author: Salvatore Critelli

Coroglio tuff cliff (Naples, southern Italy): weathering processes and related landslides (id: 390)

Fabio Ietto

Presenting author: Fabio Ietto

Physical volcanology of the lava flows and associated interflow horizon at Toki section, South Georgia (id: 606)

Tamar Beridze, Ketevan Gabarashvili, Purva Gadpallu, Manana Kavsadze, Giorgi Vashakidze, Koba Lobzhanidze

Presenting author: Tamar Beridze

Lake-level and flood reconstructions from tephra-derived particles in lake sediments since 33ka in Southern Patagonia (id: 683)

Guillaume Jouve, Pierre Francus, Agathe Lisé-Pronovost, Claudia Zimmermann, Arnaud De Coninck, Reinhard Pienitz, Nora Maidana, Cristina Recasens, Daniel Ariztegui, Bernd Zolitschka

Presenting author: Guillaume Jouve

Deep-marine sedimentation in the northwest side of the Stromboli volcano (southern Tyrrhenian sea) (id: 717)

Consuele Morrone, Rosanna De Rosa, Antonella Bertagnini, Alessio Di Roberto, Fabiano Gamberi, Michael Marani, Marco Pistolesi, Mauro Rosi

Presenting author: Consuele Morrone

Sedimentary response of lacustrine environments to temporal changes in sediment supply after explosive volcanic eruptions (id: 853)

Yong Sik Gihm

Presenting author: Yong Sik Gihm

T07-SS03 – An expansive perspective of meandering: Patterns and processes across landscapes and scales

Are meander cutoffs in tidal coastal landscapes really that rare? (id: 96)

Alvise Finotello, Andrea D'Alpaos, Eli D. Lazarus, Massimiliano Ghinassi, Andrea Rinaldo

Presenting author: Alvise Finotello

Exploring the morphological kinship between submarine and alluvial meander planforms (id: 391)

Alvise Finotello, Massimiliano Ghinassi, Alessandro Cantelli, Eli D. Lazarus, Alberto Salaorni, Andrea D'Alpaos

Presenting author: Alvise Finotello

Grain-size variability within point-bar deposits: a case study from the Holocene Venetian Plain (Italy) (id: 564)

Elena Bellizia, Massimiliano Ghinassi, Jacopo Boaga, Giorgio Cassiani, Alessandro Fontana, Marta Cosma, Andrea D'Alpaos

Presenting author: Elena Bellizia

Piracy-controlled deactivation of tidal meandering channels and its effects on point bar geometries (id: 658)

Marta Cosma, Alvise Finotello, Alessandro Ielpi, Dario Ventra, Oriol Oms, Andrea D'Alpaos, Massimiliano Ghinassi

Presenting author: Marta Cosma

Replicating channel bottom morphology of meandering fluvial channels: an experimental approach (id: 938)

Riccardo Maitan, Massilimiano Ghinassi, Andrea D'Alpaos, Alvise Finotello, Davide Tognin, Chris Paola

Presenting author: Massilimiano Ghinassi

T08 – Biochemical processes in sedimentology

Reconstruction of hypoxia on the Black Sea shelf over the Holocene with a multi-proxy approach (id: 269)

Sarah Robinet, Alice Ofélia Matossian, Arthur Capet, Lei Chou, Audrey Plante, Marilaure Grégoire, Nathalie Fagel

Presenting author: Sarah Robinet

T08-SS01 – Microbial imprint on the sediment record: From organomineralization to global biogeochemical cycling

Methods to induce mineral precipitation using excised microbial mats (id: 544)

Oscar Cabestrero, Cinthya Tebes, Pablo del Buey, M. Esther Sanz-Montero, Cecilia Demergasso, Pieter T. Visscher

Presenting author: Oscar Cabestrero

Origin and diagenesis of microbial fabrics in cave pearls and moonmilk deposits (id: 724)

Andrea Martín Pérez, Adrijan Košir

Presenting author: Andrea Martín Pérez

Lateral accretion of a stromatolitic reef by means of subhorisontal growth of stromatolite columns (id: 741)

Dmitriy Grazhdankin

Presenting author: Dmitriy Grazhdankin

Autopsy of the tlayua fossils: the role of microbial biofilms in fossilization (id: 755)

Elizabeth Chacon, Jesús Alvarado Ortega

Presenting author: Elizabeth Chacon

Microbial and metal enrichment in the Dead Sea shores (id: 847)

Camille Thomas, Nuphar Gedulter, Yaniv Darvasi, Irina Bundeleva, Adi Torfstein, Amotz Agnon, Daniel Ariztegui

Presenting author: Camille Thomas

Unusual biomineralization: a new tool for the study of biosignatures in the fossil record (id: 935)

Adriano Guido, Matteo Sposato, Giuseppe Palladino, Alessandro Vescogni, Domenico Miriello

Presenting author: Adriano Guido

T10 – Sediment routing – from source to sink

Source-to-sink dynamics and impact factors on an episodic-jump back-arc basin (id: 51)

Chao Fu, Shengli Li, Shunli Li

Presenting author: Chao Fu

Provenance and diagenesis of the Upper Miocene sandstones from the Pannonian Basin System (id: 181)

Mario Matošević, Marijan Kovačić, Davor Pavelić

Presenting author: Mario Matošević

Sandstone petrology of buried Permian siliciclastic group (Puglia 1 Well, Apulia Unit), southern Italy (id: 274)

Salvatore Critelli, Sara Criniti

Presenting author: Salvatore Critelli

Fluvial morphometric analysis of modern and Quaternary-rivers of the Sarawak basin in a source-to-sink framework (id: 481)

Habibah Hanan Binti Mat Yusoff, Howard Johnson, Lidia Lonergan, Alex Whittaker

Presenting author: Habibah Hanan Binti Mat Yusoff

Sedimentology of late Quaternary periglacial slope sediments in the western approaches of northwest Europe (id: 513)

Jasper Knight

Presenting author: Jasper Knight

Paraglacial coasts – different sedimentary and geomorphic processes during the paraglacial response cycle (id: 514)

Jasper Knight, Mateusz Strzelecki

Presenting author: Jasper Knight

Sediment flux and marine influence on the depositional architecture of marginal marine deposit, Sydney Basin. (id: 539)

Terfa Garba, Khairul Azlan Mustapha, Meor H. Amir Hassan

Presenting author: Terfa Garba

T11 – Applied sedimentology

The hydrothermal potential of Calcalpine carbonate rocks related to a geothermal life cycle assessment (id: 538)

Eva Wegerer, Guenter Hoffellner

Presenting author: Eva Wegerer

Organic geochemical characteristics of Upper Post-Rift Sediments in the Orange Basin, South Africa (id: 560)

Nura Abdulmumini Yelwa, Khairul Azlan Mustapha, Mimonitu Opuwari

Presenting author: Nura Abdulmumini Yelwa

Source Rock Potential of the Upper Cretaceous Abu Roash Formation, East Beni Suef Basin, Egypt (id: 567)

Ahmed Yousef Tawfik, Gerd Winterleitner, Maria Mutti

Presenting author: Ahmed Yousef Tawfik

Characteristics and Distribution of Pyrite in the Es3x Shale (Shahejie Formation), Zhanhua Sag, East China (id: 778)

Danish Khan, Longwei Qiu, Chao Liang, Kamran Mirza, Muhammad Kashif, Yang Baoliang

Presenting author: Danish Khan

T11-SS01 – Sedimentary evolution of coastal and alluvial plains: A key to understand subsidence and aquifer hazards

Prediction of Porosity and Analysis of the Relationship between Compaction and Accumulationof Tight Reservoir (id: 99)

Xiangyang Li, HanCheng Ji, Qingping Weng

Presenting author: Xiangyang Li

Experimental tidal channel evolution in aggradational vs. degradational settings (id: 278)

Nate Lentsch, Alvise Finotello, Chris Paola, Massimiliano Ghinassi, Alessandro Cantelli, Andrea D'Alpaos

Presenting author: Nate Lentsch

Stratigraphic reconstruction of the Volturno river mouth: mandatory step to apply a reliable hydrogeological model (id: 661)

Carla Buffardi, Gianluigi Busico, Nicolò Colombani, Micol Mastrocicco, Marco Vigliotti, Daniela Ruberti

Presenting author: Daniela Ruberti

Intra-point bar grain-size variability: an example from the Holocene succession of the Venetian Plain (Italy) (id: 694)

Elena Bellizia, Massimiliano Ghinassi, Jacopo Boaga, Giorgio Cassiani, Alvise Finotello, Marta Cosma, Alice Puppin, Andrea D'Alpaos

Presenting author: Elena Bellizia

Sedimentological analysis of the Pokur Formation deposits in the north of West Siberia, Russia (id: 862)

Alena Khramtsova, Alexey Snokhin

Presenting author: Alena Khramtsova

T11-SS02 – From Holocene to Anthropocene: Human impact on sedimentary environment

Stratigraphy and anthropogenic contamination of dam-reservoir sediments from the Váh river dam cascade (id: 588)

Martin Žídek, Ondřej Bábek, Zuzana Lenďáková, Jan Sedláček

Presenting author: Martin Žídek

Chemostratigraphy of the "Anthropocene" in sediment sequences of Galician Rias, past and future research. (id: 680)

Miguel Ángel Álvarez-Vázquez, Ricardo Prego

Presenting author: Miguel Ángel Álvarez-Vázquez

T11-SS03 – Reservoir systems: Subaerial and subaqueous processes, morphologies and significance for sediment distribution

Reservoir Characterization of Unayzah Fomrations in Saudi Arabia: Insights on Stratigraphic Evolution and Structural Controls (id: 47)

May AlSheikh

Presenting author: May AlSheikh

Sedimentary Environment and Basin Modeling at the Silurian-Ordovician Post-Glacial Continental Margin (id: 174)

Saeed Alshahrani

Presenting author: Saeed Alshahrani

Burial modification in a Carboniferous organic-rich mudstone, UK: understanding element mobility during early diagenesis (id: 218)

Jingyue Hao

Presenting author: Jingyue Hao

Hydrocarbon evolution and reservoir evolution of marine shale: Insight into marine shale gas accumulation (id: 261)

Jiaqi Chang, Zhenxue Jiang, Xingmeng Wang

Presenting author: Jiaqi Chang

Reservoir characteristics and influence factors of chang6 reservoir in xiaojiahe area of Ordos basin (id: 630)

Guoxiong Li, Chenglin Liu

Presenting author: Guoxiong Li

Shale fractal characteristics and its implication to gas storage capacity in the Sichuan Basin, China (id: 744)

Jiaqi Chang, Zhenxue Jiang, Xingmeng Wang

Presenting author: Jiaqi Chang

Characteristics and genesis mechanism of carbonate source rocks in the Middle–Upper Ordovician, Tarim Basin, China (id: 787)

Junqing Chen, Kuiyou Ma, Xiongqi Pang, Haijun Yang

Presenting author: Junqing Chen

Secondary migration of hydrocarbons in the Ordovician carbonate reservoirs in Tabei Uplift, Tarim Basin, China (id: 788)

Junqing Chen, Kuiyou Ma, Xiongqi Pang, Haijun Yang, Meiling Hu

Presenting author: Junqing Chen

Control of diagenetic facies and sedimentary microfacies on physical properties in low permeability reservoir (id: 879)

Chengzhou Jiang, Guiwen Wang, Jin Lai, Xianglong Zhang

Presenting author: Chengzhou Jiang

Pore structure characteristics of organic-rich laminated carbonate rock reservoirs affected by tephra, Santanghu Basin, China (id: 50)

Yongshuai Pan, Zhilong Huang

Presenting author: Yongshuai Pan

Bedding features from borehole images and their geological significance in shale gas reservoirs (id: 277)

Yanqiu Zhou, Guiwen Wang, Yuhan Tan, Fengsheng Zhang

Presenting author: Yanqiu Zhou

Effect of microscopic pore-throat heterogeneity on gas phase percolation capacity of tight sandstone reservoirs (id: 308)

Fan Zhang, Zhenxue Jiang

Presenting author: Fan Zhang

Self-sealing characteristics and formation mechanism of the lower Silurian Longmaxi shale in the Sichuan basin, China (id: 515)

Chengxiang Wan

Presenting author: Chengxiang Wan

Top calcareous cementation layers in the Zhujiang Formation reservoirs in the Panyu-A Oilfield, China (id: 555)

Keyu Liu, Qingqing Zhang

Presenting author: Keyu Liu

Carbonate-siliciclastic mixed deposits (Lower-Middle Jurassic transition) as potential reservoir units in the Lusitanian Basin, Portugal. (id: 471)

Joao Barata, Luís Duarte, Ana Azerêdo, Jorge Gomes

Presenting author: Joao Barata

Field and petrographic study on sediment waves and their sedimentologic properties (id: 712)

Kathryn Denommee, Juan Fedele, Timothy Demko, Nicole Bayliss

Presenting author: Juan Fedele

T12 – Techniques and technologies in sedimentary research – state of the art and perspectives

A fast adaptive non-local mean filtering and its application for stratum imaging improvement (id: 171)

Shenghou Wang, Yatong Cui, Zhongxian Cai

Presenting author: Shenghou Wang

Comparative analysis of different lithofacies and shales in continental facies of the Sichuan Basin (id: 379)

Hengyuan Qiu

Presenting author: Hengyuan Qiu

Analysis of Transitional Facies Shale Micro-Pore Structure and Influence Factors of Reservoir Capacity (id: 428)

Hengyuan Qiu

Presenting author: Hengyuan Qiu

Cross-beds and sedimentary facies: The applicability of OSL as a sedimentological proxy in aeolianites (id: 876)

Gloria I. López, Miren del Val, Cristina Alonso

Presenting author: Gloria I. López

T12-SS01 – Seismic sedimentology of thin beds

Seismically informed thin-bed sedimentary analysis (id: 72)

Hongliu Zeng, Xiaomin Zhu

Presenting author: Hongliu Zeng

Seismic sedimentological response of gravity flow in Panshan depression of Bohai Bay Basin, China (id: 108)

Ke Yang, Xiao Min Zhu

Presenting author: Ke Yang

Applying seismic sedimentology for high-resolution anatomy of fluvial-deltaic systems in a complex strike-slip fault zone (id: 129)

Zhiwei Zeng

Presenting author: Zhiwei Zeng

Sedimentary facies and reservoir in a deep Cambrian carbonate platform-to-basin area, Tarim Basin, China (id: 875)

zhaohui xu, Hongliu zeng, Lu Wang, Junlong Zhang, honghui li, wei liu, Yinghui Cao, Debo Ma, Aiyun Wang

Presenting author: zhaohui xu

T13 – Open Theme

Exhumation of the SE Pyrenean fold and thrust belt inferred from fluid geochemistry (id: 365)

David Cruset, Irene Cantarero, Jaume Vergés, Cédric M. John, Antonio Benedicto, Richard Albert, Axel Gerdes, Anna Travé

Presenting author: David Cruset

High resolution carbon isotope chemostratigraphy and the age of the Tuwaiq Mountain Formation, Saudi Arabia (id: 747)

Jalel Jaballah, Luis Gonzalez, John Reijmer

Presenting author: Luis Gonzalez

Calcite cementation in a folded and fractured fluvial succession: the Puig-reig anticline (South-eastern Pyrenees) (id: 773)

Xiaolong Sun, Enrique Gomez-Rivas, Juan Alcalde, David Cruset, Daniel Muñoz-López, Juan Diego Martín-Martín, Irene Cantarero, Anna Travé

Presenting author: Xiaolong Sun

Application of mass spectrometry methods in coral reef science (id: 835)

Igor Pessoa, Mauro Geraldes, Luzia Antonioli

Presenting author: Igor Pessoa

Possible changes in carbon fixation in the southern ocean indicated by salps fecal pellets (id: 840)

Javier Maldonado

Presenting author: Javier Maldonado

Rare-earth element geochemistry in vertebrate fossils: a tool for determining depositional environment (id: 894)

Gábor Botfalvai, László Kocsis

Presenting author: Gábor Botfalvai

Study on sensitivity parameters of shale gas multi-well development model, application to Wufeng-Longmaxi shales (id: 26)

Jie He

Presenting author: Jie He

Simple polycyclic aromatic hydrocarbons separation procedures: Main controlling factors (id: 44)

N'Guessan Francois De Sales Konan

Presenting author: N'Guessan Francois De Sales KONAN

Pore throat structure characteristics of tight sandstone reservoirs and its influence on movable fluid saturation (id: 276)

Fan Zhang, ZhenXue Jiang

Presenting author: Fan Zhang

The Depositional Setting and Astronomical Tuning of the East Georgia Konkian (id: 382)

Alena Rybkina, Yuliana Rostovtseva

Presenting author: Alena Rybkina

The Bréche à Micmacca limestones:A unique window to biota of the lower–middle Cambrian boundary interval (id: 607)

Kamal MGHAZLI, Gerd Geyer, Nasrrddine Youbi, Nezha Lazreq

Presenting author: Kamal Mghazli

Differential analysis of diagenesis-pore evolution of tight sandstone reservoirs in different sedimentary environments (id: 765)

Jiang Jun Cao

Presenting author: Jiang Jun Cao

Characteristics of Chlorite of Uranium Deposits and Its Geological Significance in Northeastern Ordos Basin (id: 833)

Xiaoneng Luo

Presenting author: Xiaoneng Luo

Vertical variation in the muddy deposit offshore Tagus mouth: an imprint of tsunami backwash? (id: 959)

Joaquim Pombo, Aurora Rodrigues, João Duarte, Anabela Oliveira

Presenting author: Joaquim Pombo

Plenary Keynote Speakers

The giant abiotic carbonate factory of the early Cretaceous of the South Atlantic

Paul Wright

Natural Sciences, National Museum of Wales, Cardiff, United Kingdom

During the Aptian (Cretaceous) a vast hyperalkaline lake system developed in what is now the South Atlantic, covering at least 330,00 km2. Carbonates, up to over 500m thick, formed in this lake system, in what are now the offshore Santos and Campos Basins (Brazil) and Kwanza Basin (Angola). Current evidence supports the view that almost all this carbonate was chemogenic in origin, precipitated from shallow lake waters by evaporation. This unit, best documented from offshore Brazil and known as the Barra Velha Formation (Santos Basin) and the Macabu Formation (Campos Basin), consists of just two basic carbonate components, mm-cm sized crystal shrubs and spherulites. These are commonly in situ but can also be reworked into a range of detrital facies. Demonstrable microbialites are generally rare. These carbonates are associated with Mg silicates (as clays) which had a profound influence not only on the textural development of the in situ carbonates, but also on their diagenesis. The dissolution of the clays produced much of the porosity in these limestones, which are the hosts for multi-billion barrel oil fields.

This lake system constituted the largest chemogenic carbonate factory in geological history and its unique development requires unique conditions. The source of the carbonate is most likely from metasomatic alteration of continental basalts related to Atlantic opening, with some contribution from much older continental basement. Clear evidence that serpentinization of possible exhumed mantle is lacking but mantle CO2 is likely to have been a critical factor in determining the composition of the fluids from which the carbonates formed. To what extent mantle CO2 from these basins, and CO2 released by the likely rapid formation of these carbonates, impacted on the global climate and even on OAE 1a is unclear.

Many aspects remain controversial. There is still disagreement over how to interpret the seismic expression of these lakes, with some groups favouring the former presence of lacustrine carbonate platforms rising >1 km above the lake basin floors. The chemogenic nature of the carbonates is still a contentious issue, with many unwilling to accept the apparent lack of microbial textures although elevated levels of CO2 can impact adversely on the formation of some microbial carbonates. The origin of the Mg clays is also a disputed topic and even how best to describe many of the carbonate textures lacks agreement. In addition, the diagenetic history is complex with the congruent dissolution of the Mg clays likely to have been the major factor in affecting the carbonates where hydrothermal processes during later burial were less active; this Mg clay-influenced diagenetic pathway is unique.

The influence of landscape dynamics on paleoclimate-signal preservation in the stratigraphic record

Elizabeth Hajek

PennState, USA

The preservation of time in sedimentary strata is controlled by a combination of external controls on sediment accumulation and internal sedimentary-system dynamics. In some cases, internal system dynamics can be large, imparting significant spatial variability in sediment preservation, which can mimic or overprint signals of paleoenvironmental change in the sedimentary archive. Here we use modeling and field-based case studies explore how differences in landscape dynamics can impact the resolution and accuracy of reconstructed paleoclimate signals in different environments. In environments where stochastic processes are prevalent (e.g., fluvial and shallow-marine settings impacted by strong, intrinsic sediment-transport dynamics and/or storms and floods), high spatial sampling is required to accurately reconstruct a robust representation of a paleoclimate signal. In general, the threshold of sampling required for complete stratigraphic representation of time increases with the degree of environmental stochasticity relative to the long-term sedimentation rate. However, some systems with strong internal dynamics also preserve isolated but highly resolved snapshots of paleoenvironmental conditions. Improved understanding of the role of landscape dynamics in building the sedimentary archive provides new perspective on where and how to sample and correlate paleoenvironmental records from different environments, and offers new ways of reconstructing information about high-resolution sediment-transport dynamics on ancient landscapes.

Using novel deep-sea technology to demystify turbidity currents

Matthieu Cartigny

University of Durham, UK

The ocean floor comprises two thirds of our planet, and it hosts spectacular networks of channels and canyons formed by often powerful episodic sediment-laden flows, called turbidity currents. These submarine channels can extend for thousands of kilometres into the deep ocean, and are fed by submarine canyons that are as big as the Grand Canyon. The turbidity currents that created these channels remain poorly understood, as measurements of their velocities and sediment concentrations are only available in seven locations worldwide. This lack of observations reflects the relatively inaccessible and powerful nature of the flows, some of which powerful enough to drag 2,000 kg anchors for kilometres along the ocean floor. Fortunately, new technology now allow us to monitor turbidity currents in unprecedented detail.

These new field observations are important as turbidity currents are of societal and economic relevance. These flows are the main supplier sediment, organic carbon and nutrients to much of the deep-sea, as turbidity currents rival rivers in their global capacity to transport sediment across our planet. These fluxes make turbidity currents an important part of the carbon cycle that affects long term climate change, and they sustain ecological communities on the deep sea bed. Turbidity currents pose a hazard to submarine infrastructure, and have forced pipeline operators to invest millions of dollars in re-routing pipelines. Furthermore, these flows create the largest sedimentary bodies on our planet (e.g. the Bengal submarine fan holding tens of million km3 of sediment), and these sedimentary body host a significant part of our oil and gas reservoirs.

Here I will present an overview of the observations of turbidity current in modern systems to test how these observations compare to a wide range of subaqueous sediment density flow models. The results show how the observations reflect different subaqueous density flows depending on whether the observations are made on the head, body or tail of the event. More specifically, the data from four test sides (Squamish, Bute, Monterey and Congo) shows that the head of the flow is most like a modified grain-flow, the body resembles a high-density turbidity current and only the tail resembles the more classical low-density turbidity current.

Johannes Walther Awardee

The limits of microbialite preservation in recent and past times

Emmanuelle Vennin

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Microbialites are perhaps the most important geobiological yardsticks of the evolution of life of the history of our planet. Microbialites are organosedimentary structures formed by photosynthetic benthic microbial mats through in-situ mineralization and/or trapping and binding of sedimentary particles (Burne and Moore, 1987; Visscher et al., in press). Microbialites form through complex interactions between functionally diverse microbial communities and abiotic, environmental properties. These structures are abundant in modern – sometimes "extreme" – environments (e.g., hypersaline lakes; hydrothermal springs; caves). Microbialites are commonly found in the fossil record, hence constitute an invaluable archive of past Earth's evolution. Furthermore, microbialites arguably have been successful in adapting to planetary change for billions of years and represent the oldest undisputed evidence of life on Earth (~3.5 Ga). Despite their typical character shape, uncertainties surround the processes of their formation (e.g., the specific identity and functional roles of microorganisms associated with the microbialites), the interplay between local environmental conditions and the biota, their evolution through time, and especially their preservation potential in the fossil record.

Metabolic reactions of the microbial community impact the precipitation (mechanism) and modify the mineralization potential, sediment architecture and the composition of the minerals. Although the metabolic activities and interactions within the microbial mat are a prerequisite for mineralization, the environmental conditions and controlling factors also constitute major driving forces, which are often underestimated. The biogeochemical reactions resulting in mineral precipitation are defined by the local chemical conditions in the environment. Dissolved solids, produced by weathering, significantly contribute to the sedimentary dynamics of basins and may enhance physicochemical and/or biological precipitation, especially in the case of calcium carbonates. The quantification of calcium dynamics from source to sink, including biological reactions that affect sediments formation, offers a novel perspective, enhancing the understanding of the sedimentary record in fossil basins. In the literature, the influence of extrinsic factors is often limited to changes in microbial communities, or small scale physical and chemical conditions. In our projects, we aim to place microbial deposits in a context of their formation to highlight the significance of external properties (i.e. tectonics, water level variations, volcanism, basin physiography) on: (1) the mineralization processes. and the formation of microbialites, (2) the morphologies of microbial structures observed, and their spatial distribution, (3) the relationship between microbial mats and microbialites and their environment, and (4) the preservation potential.

A microbialite consists of minerals products, which have been bound together and preserved as a single structure. However, the presence of a mineralization process does not necessarily imply the formation of microbialite: preservation of the mineralization products is necessary to lithify a microbial mat, and thus, to form microbialites. The lithification process is therefore a major driver of the preservation of these microbial structures in the fossil record. As the result of biological (e.g., grazing), physical (e.g., hydrodynamics) and chemical (e.g., dissolution) processes, minerals that are precipitated are not necessarily preserved and can be dislodged and/or dissolved. In the absence of preservation, we can question the future of these minerals. Several modern and fossil examples have been studied to clarify the impact of the controlling factors described above on the formation of microbialites and how they are preserved. This is a necessary "next step" in uncovering the true value of these remarkable geobiological (eco)systems.

Early-Career Scientists Awardee

Insights from the southwestern Tethys – the Cretaceous evolution of the Levant Platform

Or M. Bialik

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The Levant Platform had developed through a cycles of build, fill and emersion through the Mesozoic. Bringing it to its most extensive, and final, form in the Cretaceous. This platform offers us an interesting aperture into the dynamics of the lifecycle of a hinterland attached carbonate platform.

The initial establishment of the platform began in the Aptian with a reflooding, possibly accompanied by climate change, of the shelf. With this reflooding, intermit stratification began developing off shelf. Under these conditions extensive carbonate production began to reinstate across the entire area, limited by inherited steep margins of the underlying Jurassic platforms. By the Albian, the platform had extended over a hundred kilometer landwards and continued expending. This platform extended from the southern margin of the Palmyride trough and the modern Israeli shelf/coastal plain in the northwest and ~ 100km inland (south east) in the Albian to >200 km in the Turonian. The outer part of this platform was characterized by rudist buildups while the inner parts of the platform were dominated by shallow water depths.

As the platform expended, widespread calcification and early diagenetic processes (notably dolomitization) began interacting with the waterbody above the platform, resulting in the develop of a significant lateral geochemical gradient across the platform. The intensity of this gradient varied depending on relative connectivity of the epi-platform waters and the open ocean, being most significant during lowstands. These cycles of varied connectivity continued through late Albian and the Cenomanian. During these lowstands, extreme conations expended across the platform manifesting in widespread microbialite beds.

The outer buildups at the platform margins decreased in size with the ongoing sea level rise through the Albian and Cenomanian. From large linear bioherms in the Albian to isolated atolls atop local highs in the Cenomanian which persisted only during lowstands before drowning. The entire platform eventually drowned and backstepped during and following the Turonian, due to a combination of sea level rise, local tectonics, and adverse oceanographic conditions, notably the development of extensive upwelling during the Coniacian with new smaller platforms establishing farther into the hinterland.

The observations in the Cretaceous Levant platform differ then those observed in Cenozoic isolated platform, indicating that the geometry of a hinterland attached platform and the fluid regimes around and in them differs. The potential decupling of water chemistry atop the platform joins other sets of evidence calling for more careful evaluation of epi-continental records.

Richard W. Faas Research Prize Awardee

Scales of Science

Elizabeth Chamberlain

Soil Geography and Landscape, Wageningen University, Wegeningen, Netherlands

Research integrating across space and time and linking process to sequence is essential for interpreting the stratigraphic record of ancient deltas and developing sustainable management practices for modern ones. Here, I show how just a tiny pinch of silt grains can be used to reconstruct the movement of the biggest rivers on Earth. This Dr. Richard W. Faas Keynote Lecture highlights work by my team to develop optically stimulated luminescence (OSL) dating approaches for the Ganges-Brahmaputra Delta and apply those methods to two archives: (i) a scroll plain of deposits in the western fluvial delta plain capturing the timing of activity and aggradation rates accomplished by small, meandering distributaries that offtake from the large, braided mainstem Ganges River, and (ii) a rare sand-dike field recording a major prehistoric earthquake, positioned on the bank of an immense and underfilled paleochannel scar. These archives reveal competing processes that determine trunk-channel avulsion timescales yet appear underrepresented in the Holocene stratigraphic record.

We find that the upper ~5 m veneer of the Ganges delta plain is composed in part of sandy point-bar deposits localized within distributary-channel belts. The channel-belt deposits are separated by mud-capped basins featuring well-developed paleosols. Quartz silt OSL chronology shows that minor distributary channels preferentially reoccupy the same pathways over several thousands of years and have delivered sufficient sediment to fill the accommodation generated by subsidence through the late Holocene. In this way, the distributaries inhibit superelevation and thereby suppress avulsion of the Ganges trunk channel. Interestingly, these little channels are rarely recorded in the deeper (up to 90 m-thick) Holocene succession of the Ganges-Brahmaputra system. This is because shallow deposits are scoured and erased to depths of ~20 m when the area is ultimately reoccupied by the Ganges River. The small distributary channels nonetheless have a stabilizing effect on the trunk channel and in this way guide the stratigraphic archive of the delta.

By contrast, major earthquakes present a mechanism for triggering dramatic trunk-channel avulsions in this seismically active system. This is supported by matching OSL ages for paleochannel abandonment and sand-dike emplacement plus the immense, underfilled, and muddy character of the paleochannel associated with the sand-dike archive. The results of these two linked projects indicate that, under conditions of minimal relative sea-level rise (i.e., a few mm/yr), the Ganges-Brahmaputra Delta river network can reach a quasi-equilibrium configuration supported by autogenic activity of minor distributary channels. This stability may be perturbed by enhanced local subsidence, global sea-level rise, or allogenic, high-magnitude seismic events (i.e., earthquakes) which appear much more important than previously recognized in dictating river channel network reorganization and configuration.

Invited Session Keynotes

Cretaceous eustasy: magnitudes, pace, and drivers

Michael Simmons, Andrew Davies, David Ray, Benjamin Greselle, Graham Baines, Frans van Buchem

Halliburton, Abingdon, United Kingdom

Isolating the eustatic signal from the sedimentary record remains challenging, yet much progress is being made toward understanding the timing, pace, magnitude, and rate of eustasy on both long-term and short-term scales throughout the Phanerozoic. Knowledge of timing, magnitude, and pace, in turn, provides insights into driving mechanisms (tectono-eustasy vs. climatically mediated eustasy; e.g., glacio- or aquifer-eustasy). As an example, we review the current state of knowledge of Cretaceous eustasy. A literature-based review of sea-level change estimates has been conducted, and the results were evaluated against the different driving mechanisms. A further evaluation of driving mechanisms has been derived from a global geodynamic and associated paleoclimate model.

An analysis of short-term sea-level cycles reveals four broad episodes of magnitude change. Three of these episodes reflect trends of increasing sea-level change magnitudes from the Berriasian to early Hauterivian, late Hauterivian to Aptian, and Santonian to Maastrichtian. The fourth episode reflects a decreasing magnitude trend from the Albian to Coniacian. In addition, the maximum magnitude of sea-level change, at an approximate stage level, has been identified and categorised as slight (less than 10 m), modest (10 to 40 m), or significant (41 to 65 m). Significant magnitudes are inferred for the Valanginian, Aptian, Albian, and Maastrichtian; exclusively slight magnitudes are restricted to the Berriasian.

Because climatically driven eustasy at orbital forcing periodicities is the likely cause of short-term sea-level change, an assessment of the characteristic maximum magnitude limits of the principal climatic drivers (thermo-, aquifer-, and glacio-eustasy) has been made. Such a comparison argues for glacio-eustasy as the driver of significant short-term sea-level change and is supported by climate proxy data demonstrating that the Valanginian, Aptian, Albian, and Maastrichtian are intervals of cooling.

While the mechanisms, frequency, and magnitude short-term sea-level cycles linked to thermo- and glacio-eustasy are understood, the likely contribution of aquifer-eustasy remains enigmatic and, for the most part, untested. To better understand the role of aquifer-eustasy, paleoclimate simulations aimed at assessing the spatio-temporal pattern of aridity and humidity under differing CO2 forcing have been undertaken during time slices considered reflective of the differing Cretaceous climates and paleogeographic configurations (Valanginian, Turonian, and Maastrichtian). Only modest changes in the spatial extent of arid and humid zones are observed in response to large changes in CO2 forcing. The simulations also demonstrate that the greatest aquifer charge is more likely during lower CO2/cooler intervals, indicating that aquifer-eustasy works in phase with both glacio- and thermo-eustasy in contrast to the aquifer-eustasy paradigm. Additionally, using information on modern water table depths, we estimate that aquifer eustasy would be unable to contribute significantly to Cretaceous sea-level change. Indeed, even in the most optimistic case, the largest possible total aquifer-eustasy response remains smaller than 7 m. Our results indicate that glacio-eustasy is the most likely driver of Cretaceous short-term eustatic cycles because aquifer-eustasy is unable to account for the estimated Cretaceous magnitudes.

Geomorphology and process dynamics of the world's longest calciclastic submarine channels

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Approximately 1100 miles to the south of the Hawaiian Islands lie the Northern Line Islands, a chain of atolls, coral islands, guyots and seamounts. We show using new multibeam data, and seismic data, that this island chain produces spectacular submarine channels in excess of 500 kilometres long in some cases. These are by far and away the longest and most surprising submarine channels of their kind ever discovered. The flows that traverse these channels are fed from the seamounts and guyots of this chain, yet at the end of these giant channels there is not so much as a hint of a submarine fan, or any other deposition. Here we examine these calciclastic submarine channels, examine how they come to be twice as long as any known calciclastic system, ancient or modern, and discuss why such large channels exhibit no hint of deposition at their termini. Come and join us to examine these spectacular channels, their morphology, and sedimentary processes, and to help solve 'the case of the vanishing submarine fans'.

Criteria to recognize ancient tidal straits in the rock record

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Sedimentation in tidal straits is partly predictable, as tidal current amplification replicates hydrodynamic conditions common to a wide number of modern examples, although with differences due to local morphological and oceanographic variables. Tidal straits can be divided into four main depositional zones: (i) the strait center, which is the narrowest or shallowest part of a strait, where tidal currents reach peak velocity, sedimentation is reduced to zero and by-pass conditions dominate; (ii) the dune-bedded zones, corresponding with two wider areas where tidal currents decelerate and sedimentation produces a spectrum of bedforms whose size scales with the decreasing flow strength; (iii) the strait-end zones, representing the peripheral exits of a strait towards open-marine conditions, where currents slow down until they stop and reverse, for initiating a new tidal cycle; and (iv) the strait margins, where river floods, waves, delta progradation and rock collapses from steep cliffs are processes interplaying with the strait hydrodynamics, generating specific accumulations.

The sedimentary signature of each of these zones can be detectable in the rock record, based on basic stratigraphic and sedimentological criteria, which are here presented:

(i) The strait-center zone is an area of residual, coarse-grained deposition. Gravel pavements or lags can be associated with rests of organisms preferring highly ventilated waters. These deposits are transgressively buried by more distal and deeper strait facies, in case of marine flooding during late stages of basin development, or may be incised being highly discontinuous, in case of strait emergence due to post-depositional tectonic uplift.

(ii) The dune-bedded zones are represented by overthicken, vertically-stacked cross-bedded sand-rich successions, deriving from the superimposition of bedforms (ripples, dunes and ridges). These facies represent the thickest portions of ancient tidal straits and the internal physical attributes of the cross bedding, as well as the orderliness of discontinuities bounding cross sets, reveal information on the ancient strait dynamics.

(iii) The strait-end zones are recorded in mud-rich successions containing sporadic sandier intercalations. Mud occurrence suggests processes of accumulation from settling of the fine-grained fraction transported by decelerating tidal currents, whereas sand reflect isolated bedform fields. Structures indicate the hydrodynamics of tidal inversions that occur in these distal sectors and the eventual presence of rotatory circulation. Ichnofossils correspond with traces of organisms preferring low-energy conditions.

(iv) The strait-margin zones reflect high rates of sediment accumulation, deriving from river/fan deltas, subaqueous landslides or shorefaces. The resulting succession often contains a number of erosional discontinuities, reflecting tectonically unstable or block-faulted margins. Channel-fills are common elements. The strait-margin vertical facies sequence includes erosional bases, gravel/breccia lags, normally-graded sandstones and tidally-reworked tops. Fluid escape structures and soft-sediment deformation indicate rapid emplacement. Tidal cross-beds alternate with gravity flow deposits.

Field-based examples from some Neogene-to-Quaternary strait-fill successions exposed in outstanding outcrops of southern Italy are here provided as the fossil expression of these zones. The presented basic sedimentological and stratigraphic criteria are not here considered as universal elements for detecting strait-fill strata, but are suggested as proxies to decipher the signature of straits developed in a geological past.

Contributed Abstracts

Recognition and implications of paleosols of middle-upper Eocene succession, south central Libya

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The studied outcrop (130–150m thick) is a well exposed siliciclastic rocks escarpment, located at the southern reaches of Sirt Basin. It is composed of a variety of simple and composite paleosol profiles that alternate with pedogenically unmodified mud and sandstone strata. Based on the differences in the nature of the paleosols and their degree of development, the entire succession is divided into three successive intervals: the lower is 80m thick, in which paleosols are intercalating with very fine sand and mudstones bearing evident shallow marine indicators; the middle interval, 20–30m, where the thickest paleosol profile terminates a continuum of coarse sandstone cosets that preserve both tidal and fluvial indications; the top interval is 30–40m in which paleosols are interbedded with very coarse grained continental (fluvial) sandstones.

The temporal variations concerning types of preserved pedogenic features, soil maturity, and thickness and stacking pattern of the horizons, all these, together with the associated biogenic trace fossils are attributable fundamentally to the climatic changes. Those that are prevailed during the time of formation of these paleosols, ~38–39Ma ago.

This communication attempts to categorize the paleosols encountered and compare them with modern analogs in order to deduce changes of paleoclimate in the area during the late Middle Eocene. The criteria preserved by the paleosols suggest changes from tropical humid to dry semiarid climatic conditions. Comparisons with contemporaneous global paleoclimate will be highlighted. Moreover, the paleosols stacking pattern leads also to distinguish stratigraphic gaps of various magnitude. Paleosols attributable to minor sea level fluctuation in the lower interval are contrastingly different from those attributable to low stand system tract at the top of the middle interval which links the arrival of semiarid climate to the absolute termination of marine influence.

Fluid escapes in sedimentary basin and their physical classifications with structure of escape environments

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Vertical or horizontal pore water displacement may occur during the deformations of underwater sediments' horizontal movements during tectonic and sudden seismic movements. Porewater integrations turn to fluid escapes on integrational way points as slit of interferenced wave crests as depending to the p wave intensity , source sequence during friction, sediment weight, grain, water saturation and volumetric deformation specifications of whole basin. Pressure and heat takes role for variety of spewed material from mud to optically clean water. Cold fluid escapes referred to if water or bed sediments are not exposed to heat sources of tectonic gates or magmatic plumes. Still unclear points are existing on such as subjects buildings or pipelines which 'sinking into the ground and being pushed off the ground' about effects of P wave on particles and water – lithologic particle movement in soil mechanics, seismic and sediment deformation. The vertical displacement (slump and thrust-throwing) behavior characteristics of these structures can be used as an advantage in regional seismic measures. Therefore, we studied the effects of intense p waves on particles in water using ultrasound for help emerge classification of the water outlets, so it become easier to understand the effects on the sediment-structure of the seabed and terrestrial grounds. The presence of fluid escape alters the entire nearby sediment element distribution with vertical or horizontal discontinuities, and hence their presence in the past or at the time of sampling makes it difficult to establish the correct paleo-environment interpretations from sediments due to subsidence and erosive transport. (with refer to contaminations by displacements).

For this reason we tried to make the classification of fluid escapes in the simplest and most understandable way according to our experiences. Their classification is divided into 4 main groups as 'temperature', escape velocity ,suspended content and the development of discontinuities that form liquid flow. 'Suspended content' is three members as fluid (depending on low ratio solid , dissolved suspended material or oil) plus mud and sand volcanoes. The 'escape velocity' specifications is related 2 subgroup; the first is sedimentation structure & shape of escape gate and second is place of chemical processing in water as related completely about ratio of mixing , crushing and sedimentation of carried material. High velocity is the reason for white and black smoker type chimney (organic and inorganic pipe cones). 'Liquid flow former discontinues' at 3 subgroup , first is tectonic (fault ruptures, elevational deformations at basin), seismic is second (liquid integration from pores by P-wave as water filled fissures) and last goup is captured water by Interface deformations of sediment mass (with slip, creep, density currents). The derivatives of all these main groups contribute to each other's formation such as high temperature of mantle plume fluid interactions which effects to high escape velocity and forms smoker (black and white) type chimney with fast fluid escapes and gas bubbles around ocean ridges.

Evidence of environmental tele-connections; danube river drainage basin in the bosphorus black sea outlet area

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High resolution evidence of heavy-metal inputs from the Danube river in the Black Sea was traced in the distant core sediments in the Bosphorus outlet area of the Black Sea (Tubitak supported Project 114Y240). Existence of Anthropogenic enrichment from 1970s and 1980s shows significant increase in pollution. In particular, variation of Cu and Pb sourced from Central Europe in the 210Pb-dated sediment core correlates well with the annual water delivery of the Danube river. We believe that the metals adsorbed on the clay and organic particles of Danube River sediments are transported in suspension to the Black Sea Romanian and Bulgarian coasts, and from there to the core site by the cyclonic Black Sea rim current. Hence, the heavy metal pollution caused by the Danube inflow does not end in the Danube delta, but extends far to other parts of the Black Sea, and most likely to the Sea of Marmara and the Agean Sea via the surface current of the Turkish Straits System.

Continent-ocean interactions and their geological records: the Legacy of Karl Föllmi

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Continent-ocean interactions and their records, in particular in Mesozoic shallow-water carbonates, were one of the favourite research topics of Karl Föllmi, who died on 30 September. Although is not easy to sum up the scientific career of Karl Föllmi, we aim to share his thought that sedimentology and stratigraphy was a dynamic science tremendously important to understand our past, present and future Earth.

Föllmi's research was based on a multiproxy approach with a special focus on the phosphorous cycle that he was considering as a crucial element to understand shallow carbonate platforms development. His investigations of early Cretaceous sediments from the Helvetic domain allowed him to build a model explaining the rise and demise of the reefs and carbonate platforms during this greenhouse period of the Earth's history. Using a modern and holistic approach including sophisticated analytical tools, Karl was one of the first sedimentologist to show that fossil reef and platform systems were vital and interactive compartments of the Earth and its biosphere. Karl demonstrated convincingly that, in spite of many differences between Early Cretaceous and present-day time periods (e.g. the palaeogeography, oceanic circulation pattern and the absence of ice caps), the study of ancient carbonate platforms appeared to be applicable to the present-day world. Early Cretaceous reefs and carbonate platforms in general were very sensitive to environmental change (especially changes in trophic levels, sea level, pH, temperature and influx of freshwater) and, by comparison with other depositional situations, were the first to be destroyed and the last to recover. Karl's approach was strongly motivated by the parallels existing with present-day anthropogenic changes. Increasing phosphorous flux into the oceans, mainly coming from anthropogenic sources is generating eutrophication and oxygen depletion in modern marginal oceanic basins near heavily urbanized areas and consequently leading to a severe degradation of the reefs and carbonate platforms. Karl's research added and still adds much exciting information to the field of palaeoenvironmental and palaeoceanographic research on platform systems, most acquired through the so-called 'multi-proxy' analysis of rock records that he applied not only to Early Cretaceous series but also to Jurassic and Miocene successions. He was persuaded that this trend will continue and that new methods and fields will result in new, innovative and holistic interpretations of the ancient environments and climates. As such, many challenges are present in today's research on ancient carbonate platforms and thanks to Karl, there is a bright future for stimulating discoveries. With the passing of Karl Föllmi, the sedimentology and stratigraphy community lost a scientist of international reputation, a gifted teacher and mentor, and above all a good friend.

Depositional environment of early Miocene carbonate succession, Oman. Is it an equivalence of Sur Formation?

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The Sawadi region (Barka), ~70 km west of central Muscat on the northern side of the Sultanate of Oman, contains an exclusively early Miocene thick carbonate deposition represented by Sawadi Island (a Sur Formation outcrop-equivalent?). The outcrop was studied in order to define its microfacies, facies zones, and paleoenvironment. Combined fieldwork and petrological studies guided the distinction and identification of six microfacies types, which are integrated with the dominance of biological constitutes and their distribution across shelf gradient. This combination has led to the suggestion that carbonate sedimentation took place in six Facies Zones. These involve the peritidal zone, lagoon, shoals, and open marine of the inner ramp, as well as the middle ramp and outer ramp. The carbonate succession of the Sawadi Island can be subdivided into three distinct units outlined below: (1) Lower Sawadi unit with microfacies types suggests inner to proximal-middle ramp. (2) Middle Sawadi unit of thickly bedded lime mudstone with hummocky cross-stratification and rare planktonic foraminifera indicate a proximal side of an outer ramp. (3) Upper Sawadi unit shows tidal channels and cross-laminated wave ripples as well as microfacies types, suggesting an inner ramp. Accordingly, the carbonate succession of Sawadi Island is interpreted to be deposited in a homoclinal carbonate ramp without an effective barrier that separates the lagoonal from the open ocean. The early Miocene carbonate shows two major depositional cycles that were interpreted as a T-R sequence.

Keywords: Early Miocene, Sawadi Island, Sur Formation, Barka, Oman

Neoproterozoic glaciogenic sediments in southeastern Siberia re-interpreted as a sedimentary archive of tectonic activity

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Palaeoclimatic reconstructions in the Proterozoic geological record critically rely on our correct recognition of the products of glaciations (glaciogenic sediments, landforms and glacitectonic structures) and the interpretation of genetic processes that formed these products. Diamictites are often and rather enthusiastically used as the only evidence of past glaciations; however, the diamictites can form by a variety of process in glacial, glacially influenced and non-glacial settings. Furthermore, diamictites often record tectonic events related to basin evolution and localised glaciation of uplifted margins. In certain sections a subaqueous debris-flow origin of the diamictites cannot be entirely excluded. Results of a comprehensive sedimentological study of a section of Proterozoic glaciogenic deposits cropping out along the Uda River in the East Sayan Ranges, southwestern Siberia suggest that even the universally accepted Cryogenian succession is of no exception to these recurrent problems. Areas such as Siberia where the Proterozoic glaciogenic deposits are almost entirely absent is of particular importance for testing the Snowball Earth hypothesis.

A 500-m-long riverbank outcrop at the mouth of the Karapchetui Creek, Uda River has been the focus of particular attention. Here, a ca. 100-m-thick succession of planar- and cross-bedded sandstones and finely laminated dolostones (traditionally referred to as the Karapchetui Member of the Marnya Formation) passes laterally into a thick 'faceted-boulder breccia that has a peculiar sub-vertical contact with Mesoproterozoic stromatolitic dolostones (Tagul Formation) and siltstones (Ipsit Formation). The Karapchetui Member was previously interpreted as glaciofluvial and glaciolacustrine sediments, whereas the breccia was thought to represent a tillite deposit. It is not surprising that the sub-vertical contact has been reconstructed as a glacial valley incised into Mesoproterozoic strata. Importantly, the base of the Karapchetui Member is marked by a thin (0.1–0.2 m) unit of 'ferruginous silicified cataclastic rocks' that turned out to be heavily altered basaltic rocks. Upon careful examination, the faceted-boulder breccia has been re-interpreted as a conglomerate consisting of winnowed and reworked silica-cemented siltstone concretions: some of the so-called 'boulders' occasionally merge with each other or overgrow the adjacent boulders, whereas the clasts in the breccia could be fragments of the concretions chipped off in the process of winnowing and re-deposition. The concretions derived from the Ipsit Formation where they were observed in situ. The sub-vertical contact between the 'breccia' and the Ipsit Formation, however, is puzzling. Underlying the Ipsit siltstones are stromatolitic dolostones of the Tagul Formation that host enigmatic vertical wedge-shaped bodies previously interpreted as sand-filled glacial crevasses extending along the sub-vertical contact with the 'breccia'. When studied in petrographic thin-sections, these 'sand-filled crevasses' turned out to be silicified dolostones. Presumably, the silicification was due to silica fluid penetration from the overlying Ipsit Formation along a system of palaeofaults. By analogy, the sub-vertical contact between the 'breccia' and the Ipsit Formation is here re-interpreted as a palaeofault formed as a result of local tectonic activity. The above-mentioned basaltic rocks at the base of the Karapchetui Member could be related to the tectonic activity. The entire geological history of the East Sayan Ranges can now be re-interpreted.

Calcretes in volcanic islands, unique records of climate/vegetation/ sedimentation interactions, Gran Canaria Island, Spain

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Calcretes in volcanic terrains have received less attention than those formed in sedimentary basins. In volcanic settings calcretes form with no previous carbonate hostrock. Gran Canaria Island can be considered itself as a microcontinent with varied relief, climate and vegetation and due to situation in the vicinity of the Sahara Desert it is under the direct influence of the SAL (Saharan Air Layer).The five studied calcretes profiles profiles are multi-storey and composed of the following horizons: 1) prismatic formed by vertical carbonate structures (prisms or cylinders) of about 5–10 cm across and from 0.1 to 1 m in length, 2) massive sandy mudstones, 3) laminar, with different scale lamination from dm to mm, calcified roots are common and in cases the top of the horizon show brecciation and pseudo-anticlines, 4) pisolithic, up to dm with coatings formed by laminated micrite, 5) ooidal, composed by small grains coated by laminated micrite, 6) peloidal, 7) sandy mudstones with rhizoliths and, 8) brecciated. The horizons have varied microfabrics and features including: 1) homogenous laminated micrite or containing clastic grains, ooids, clays, alveolar septal structures and spherulites, 2) desiccated micrite with peloids, micrite fragments and filaments, 3) very porous, fine crystalline dolomite, 4) micrite-clay groundmass, 5) oriented clays and clay minerals and 6) pisoliths, ooids and peloids.

Carbon isotope values vary between -3.26 and -9.18 ‰ VPDB and oxygen between +0.86 and -3.24 ‰ VPDB. The 87Sr/86Sr ratios are between 0.707504 and 0.708860 very different to tufa-travertine deposits from the same island, and similar to the values of marine Phanerozoic carbonates, indicating that calcium was mostly supplied from the aeolian dust coming from the Sahara Desert. The location of the calcretes was controlled by the direction of the winds from the east but also by the vegetation and climate favoring better development of calcretes in the relatively arid and lowland areas. Climate and vegetation imprinted the lighter carbon values of the profiles situated at higher altitudes. The detailed analysis of the profiles shows the interplay of sedimentation/erosion and pedogenesis processes in both long and short term sequences of calcrete formation. The thick laminar horizons brecciated at the top are indicator of long term stages of sedimentation (more arid) followed by plant colonization and calcrete formation (wetter), erosion accounted for brecciation in stages of very low sedimentation and calcretization rates. The smaller scale lamination indicates short-term climatic-vegetation changes. Calcrete features point to a mostly biogenic control at macro and microscale, indicated by features such as alveolar septal structures, spherulites, coated-grains, pseudo-anticlines, laminar and prismatic horizons or peloids.

Our study shows that in volcanic islands calcretes do no only reflect the palaeoenvironmental controls on their formation, but also, due to the input of aeolian calcium-rich dust from the Sahara, and to the role of macro and microorganisms in the fixation of carbonate in soils, calcretes are natural sinks of CO2.

Sedimentary Environment and Basin Modeling at the Silurian-Ordovician Post-Glacial Continental Margin

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During the Late Ordovician to Early Silurian, the northern part of the Peninsula was located on the north-eastern margin of the Gondwana supercontinent. Many studies have focused on the Late Ordovician to the Early Silurian continental margin (e.g., the Hirnantian glacial and peri-glacial depositional environments and subsequent lower slope to basinal systems of the Rhuddanian with high TOC). The glacio-fluvial to deltaic deposits (unit 2) and the transgressive prograding shoreface and offshore deposits (Unit 3) are located between the glacially-derived pre-glacial continental margin Ordovician sediments (unit 1) and the post glacial basinal shales are interfingering with the Silurian fine grained silty sandstone (unit 4). There has been some controversy whether units 2 and 3 are the lowermost member of unit 4 or the uppermost member of unit 1. This controversy is about the locality of the Silurian-Ordovician sequence boundary contact as exposed in the Middle East. This location relative to units 2 and 3 has important implications for the potential distribution of laterally equivalent units within the models of sequence stratigraphy.

Unit 3 was discovered to the west of the Northern part of the Middle East in the first time by Vaslet et al. (1987) and was later discovered in the central Middle East by Vaslet (1994). The sequence stratigraphy, chronostratigraphy, and the potential petroleum system implications of this member are still poorly understood because of the limited presence of units 2 and 3 and lack of palynological data. In addition, exceptional organic matter preservation in some outcrops has raised many questions that need to be explained through a proper model of the basin evolution. This study looked into ten stratigraphic sections with data collecting from: (1) 21 outcrop sections, (2), 14 shallow wells, and (3), 12 deep well cores.

Unit 3 is a shallowing and thickening upward sequence subdivided into six lithofacies in central Middle East, and becomes a deepening and fining upward sequence of four lithofacies units in the northwest. In both locations, unit 3 has basal sharp contacts with underlying and overlying successions. The lower contact is recognized as an erosive rock fragments surface whereas the upper contact is as a sharp bioturbated hard ground surface. This study also indicates that units 2 and 3 are Late Ordovician units separated from the Silurian overlying successions by marine flooding surface. This work suggests that unit 3 is laterally equivalent in both locations and interpreted as post-glacial prograding beach and shallow-marine parasequences prior to true marine conditions. The relation between both locations indicates a proximal to distal relationship. Interpretation of unit 3 shows that it is part of the post-glacial sediments (unit 4) rather than the glacial sediments (units 1 and 2). To further validate plausible geologic scenarios of organic matter preservation in these units, a 3D basin model will be simulated and calibrated to temperature and virtinite reflectance data. The results of the basin model provide insights on the likely geologic scenarios of preservation of organic matter along with the corresponding implications for petroleum system development.

Decoupling the human geochemical footprint in fluvial sediment sequences

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Anthropogenic signals have been found in stratigraphic records as ancient as the Holocene beginning. All these signals were object of intense discussion to set a new (still proposed) chronostratigraphic division, i.e. the "Anthropocene", depicted by important human-driven changes in the geological and ecological spheres. Currently there is some kind of consensus pointing to an inflexion point in the mid-20th century, when industrialization and urbanization becomes global and synchronous, resulting in intense changes in natural biogeochemical cycles. In this context, sediments are targeted as records being formed currently and possibly preserving the human signal for next millennia. Risk elements, in particular Cu, Pb, and Zn, are among the most widespread indicators of human footprint. These elements are natural constituents in sediments at an average content <100 mg/kg, but their enrichment is common and related to products and wastes of both industry and households. The challenge in using these elements for stratigraphy is the difficulty to separate their natural and artificial portions. Factors like local lithology or possible post-depositional migrations need to be considered here.

Our study of floodplain sediment profiles in Czechia showed that after geochemical normalization by a "conservative" element (typically Al, but in many cases other elements such as Fe, Rb, and Ti are better performing), pristine sediments can be identified by normal distribution of these normalized concentrations, while increasing contamination causes departures from normality and poly-modal distributions. Ignoring the statistical properties of compositional data (CoDa) can lead to incorrect results, e.g., if the least-squares (ordinary) regression and conventional statistical tests based on normal (Gaussian) distribution are applied to CoDa. There are two options here. (1) Expert-based identification of preindustrial layers in sediment cores, modal analysis of CoDa, calculation of background functions using a single normalizing element as independent variable and risk elements as dependent variable, and calculation of local enrichment factors (LEF). (2) Robust regression using log-ratio methodology (RR), which is suitable for real CoDa and is not limited to expert-based decisions and selection of a single normalising element. Both approaches make it possible to characterise departures of CoDa from the natural background, both potentially fully respecting local parent rocks, maturity of their weathering products, and grain-size sorting on transport and deposition. RR is perhaps the only existing statistical tool suitable for the examination of departures of CoDa from natural composition of sediments implementing appropriate mathematical principles and potentially also geochemical-mineralogical principles. Our contribution will show the implementation of the latter in analyses of the real floodplain sediment archives.

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Chemostratigraphy of the "Anthropocene" in sediment sequences of Galician Rias, past and future research.

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Independently from its formal definition as a chronostratigraphic fact, the “Anthropocene” is currently a strong cultural zeitgeist being addressed by multiple disciplines, among them the Environmental History which looks for delineation of the relationship between society and the physical world across time. Geochemical indicators of human pressure, sedimentary sequences and dating techniques are powerful tools to study the society-nature interactions along history. Some trace metals (e.g. Cu, Sn, Pb) are linked to human activities and their release to the environment describes society evolution, particularly around the processes of industrialization-urbanization arising after the Industrial Revolution, when big amounts of metals were released into the environment as consequence of exponential growth of settlements and mass production of goods. Galician Rias (NW Iberian Peninsula) consist of a coastline characterized by former fluvial incised valleys flooded by sea level rise, with a delayed industrialization in the European context and current high socio-economic importance (e.g. aquaculture), together with a marked from-inland-to-coast migration phenomenon during the 20th century. All these facts make their sedimentary sequences a good target to characterize the evolution from a subsistence rural society to the current industrialized and populated region.

Geochemical studies of dated sedimentary sequences in the rias have been published mainly in the current century. A total of 27 sedimentary cores were found in the literature addressing time-dependent metal contamination, most of them poorly or indirectly dated due to post-depositional migration of target isotopes (e.g. Cs-137), low number of dated depths (e.g. C-14), or sediment bioturbation and reworking. Furthermore, they are irregularly distributed and only 12 out of 18 Galician Rias have been addressed, mainly with published results of just one core per a locality. The most studied contaminant metals are Cu, Pb and Zn, whose impact is described as local and related to specific activities (canning industry, tanneries, vineyards, shipbuilding, fertilizer industry, metal carbide industry, population nuclei, etc). Contamination is diachronic, it was dated back to the 15th century (Ria of Muros) or to the 18th century (Ria of Ferrol), but there is a certain boundary in the mid-20th century (1950s-1970s) when the sum of all the local impacts become in a regional phenomenon coherent with the concept of the “mid-20th century Great Acceleration”, related to a widespread European or even global progress of industrialization and urbanization after the World War II. Finally, although the majority of the results were published in the 21st century, the changes in the human-nature relationship and subsequent impact derived from environmental protection regulations and policies (e.g. the European Water Framework Directive or the ban of Pb in gasoline) is barely addressed although it certainly deserves scientific attention.

Consequently a more systematic work is proposed, regarding (i) the determination of reliable background levels, (ii) accurate dating of sediment sequences, and (iii) identification of generalizable indicators of time-dependent human-pressure. The long-term aim is to assess the “Anthropocene” imprint in sediments deposited in the contact of marine and continental realms.

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Measuring the significant cyclicity and variability of non-water carbonates – interfluve Hungary, using CT data

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Non-marine dolomite formed in Danube – Tisza interfluve is a complex phenomenon in the lacustrine environment. The deposition of lacustrine marls and the formation of freshwater carbonates have been traditionally linked to the Boreal phase of the Early Holocene in Hungary. The sequence is found in the vicinity of the village of Csólyospálos in the central part of the

Great Hungarian Plain. The bedrock is derived from Pleistocene wind-blown sands partly covered by sandy lacustrine carbonates and lacustrine marl of the Holocene age. In some cases, the precipitated lacustrine marl was transformed syngenetically into magnezito-calcite or dolomite.

The model of carbonate mineral formation in freshwater lakes in the Carpathian basin has been defined in the 1970s, where the stability of the water level, pH, dissolved mineral content, and the ratio of Ca to Mg were all important components leading to the formation of calcite (Ca/Mg ratio <2), high magnesium calcite, proto-dolomite, dolomite (Ca/Mg ratio 2–7, 2–12) or dolomite, magnesite, Huntite (Ca/Mg ratio > 12).

Different factors control non-marine dolomite, for instance; geochemical, climatic, and environmental factors. Extensive freshwater carbonate sequences with a composition of dolomitic limestone and dolomite formed in interdune alkaline ponds. These lakes are generally fed by groundwater, which dissolved Mg from the bedrock of windblown sands corresponding to reworked alluvial fan deposits of the Danube.

During the summer because of extensive draughts water level drops, pH reaches values above 11, and dissolved mineral concentration ranges between 8–11,000 ppm. These conditions favor the precipitation of high magnesium calcite syngenetically turning into protodolomite, dolomite forming carbonate mud in the lakebed. Fall precipitation brings Ca-rich water into the desiccated ponds contributing to the diagenesis of carbonate mud leading to the formation of dolomite rocks.

To understand the cyclicity present in the carbonate sequence we need quantitative information on the composition and physical properties of members of the sequence. This work presents preliminary results gained via the statistical analysis of the physical properties of the freshwater carbonates by using the CT technique. Heterogeneity of block samples was visualized and assessed based on Hounsfield units corresponding to density values gained from the CTs. Definition of the range boundary and distribution for carbonates was made using statistical, geostatistical tools.

Histogram and Box-whisker plot mainly used for statistical analysis and the preliminary results of the quantitative HU values have defined the barriers of carbonate component in three main groups: Limestone mud, Lime-dolomite-mud, and Dolomite mud with ranges (1950 – 2521), (2521 – 3073) and (3073 – 3317) respectively.

Considering here CT interval values need to apply in different formation samples to measure percentage error and predict intervals for other carbonate minerals such as Huntite.

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The Sardinian seaway: new insight from the tidal-modulated succession filling the Isili peripheral basin

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The Corse-Sardinia block at the onset of the Miocene was part of the southern European continental margin, located closed to the present-day Gulf of Lion, and represented the Arc- zone associated with the westward subduction of Adria plate under south-Europe.Such geodynamic context segmented west side of the Sardinia Island in several sub-basins and subsequently allowed the formation of a 100-km long, 50-km wide, NNW-SSE elongated seaway in the current geographical position. This, so called "Sardinian Seaway", was punctuated by wave and/or tidal dominated phases during its history. This work discusses the rise and demise of the Isili peripheral basin (SE Sardinia, Italy, Western Mediterranean). In particular, the backstripping procedure applied on the 100-m long siliciclastic-carbonate succession allow to define the role played by the tectonic and global sea level fluctuations in controlling the basin evolution.

The siliciclastic succession dominated by planar to trough cross-stratified gravelly to coarse sandy deposits are referred to coastal plain, submerged delta plain and shoreface settings. In particular, sandy bodies clearly exhibit flaser and wavy laminations typical of a tidal modulated flat system. The overall depositional profile shows a paleo-bathymetric range from 0 up to -30 m below sea-level.

The carbonate deposits are characterized by the alternation of planar to trough cross-stratified and ripples cross-laminated rudstone/grainstone and floatstone/packstone bodies. In particular this system resembles a flat-topped carbonate flat with decametric-long foresets prograding landward over a shallow-water embayment. The faunal constituents point to a paleo-bathymetry of 5–30 metres depth. The flat is interpreted to represent a wave dominated, tidal modulated system within a meso-macro tidal regime.

The presence of peculiar surface such as the Maximum flooding and regressive surfaces allow us to subdivide the succession in two different order of Transgressive-Regressive cycles. The high-frequency T-R cycles, perfectly match the 100-ka long oxygen-isotopic cyclicity. The latter encompass four 100-ka T-R cycles and is therefore interpreted as 4th-order cycle (400ka). The overall 100-m long succession encompasses almost 1 Ma of years and developed during the Burdigalian (17.7- 16.65 Ma). The backstripping procedure highlighted that the opening of the basin phase was extremely rapid with a subsidencerate >250 m/Ma occurred during a long-term eustatic regressive phase. Nevertheless, the Isili basin was intermittently filled by marine deposits showing evidence of tidal origins. In particular, tides become predominant during the late-transgressive and early-regressive high-frequency semi-cycles.The ”mature” phase of basin development underwent with a constant subsidence rate (c.a. 150 m/Ma) and during a long-term sea-level transgression. The sedimentary succession become fully carbonate and exhibits tidal structures.

This study confirms that tidal-dominated deposits are preferentially developed in seaway system both during long term sea-level rise (incised valley-fill type) and/or during extremely rapid subsidence basin during long-term sea-level falls.

Tidal amplification and mixed-energy variability in Triassic deltas prograding across a shallow platform, Edgeøya, Svalbard

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The study examines how a paralic prograding system was affected during passage across a shallower part of the Barents Shelf during the Triassic. The prism-scale clinoforms seen in the seismic data across the SW Barents Shelf are characterized by having a much lower height and very low-angle foreset as they approach the shallow Svalbard Platform. The shift in clinoform scale that occurs around Edgeøya; from prism to deltaic, is important in understanding the fundamentals that govern clinoform development and how process-regimes in a mixed-energy system are affected by the transition onto a shallower shelf. Through the study of sedimentary logs and an extensive photogrammetric model the effects are observed on the depositional development, sedimentary geometries and sand distribution in the De Geerdalen Formation on SW Edgeøya.

The deposits consist of a decoupled compound clinoform system forming stacked deltaic successions. Across the shallowing Svalbard Platform as the slope-angle of the clinoforms lowered, advance and deposition became more rapid and the vertical constriction amplified the tidal signal. The delta-front is characterized by along-strike mixed-energy influence interpreted to reflect variation in sediment influx. Heterolithic mouth-bars are occasionally preserved in areas of high sedimentation, but more often the strong tidal energy redistributed sediment forming extensive amalgamated sandy dune-fields in the delta-front. In areas of lower sedimentation the subaqueous platform was narrower with less wave-dampening, and combined with the lower sedimentation lead to more reworking by storms. Rapid deposition of significant amounts of sand led to growth-faulting in the delta front, and fault-zones likely further amplified the tidal energy as it was funnelized.

The tidal energy effectively moved sand from the coastline leading to the formation of an extensive subaqueous platform between the coast and the delta-front. The platform dampened incoming wave energy, and tidally dominated deposits dominate the sub-tidal near-shore successions. Tidally dominated channels dissecting the platform were highly meandering and form kilometre long successions of inclined heterolithic stratification while fluvial distributary channels are generally straighter, narrower and much sandier.

Preliminary comparative stratigraphic analysis between the Coquimbo Formation and the Bahía Inglesa Formation, northern Chile

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The Bahía Inglesa and Coquimbo formations (Miocene-Pleistocene in age), located at the southern coast of the Atacama Desert, include some of the most important and richest marine fossiliferous sites in Chile. Both formations are geographically adjacent, and have been subject of sedimentologic and stratigraphic studies since more than 150 years. Previous studies suggest that the Coquimbo and Bahía Inglesa formations are correlated. However, detailed analyzes comparing both geological formations are scarce. Based on those studies, this work presents theoretical analyzes that intend to compare the descriptive criteria used to geologically characterize the formations. Furthermore, it establishes bases to determine possible lithostratigraphic, biostratigraphic and chronostratigraphic correlations between the units belonging to the Coquimbo formation and the Bahía Inglesa formation. Our results show that in most lithostratigraphic units, it is possible to establish correlations based on sedimentological attributes, based on quantitative granulometric values. The fossil content shows a high degree of overlap, but the low taxonomic resolution for certain groups and the uncertainties in the assignments make it difficult to elaborate biostratigraphic units. The information regarding the dates, series and floors for each formation, but they are not sufficient for a chronostratigraphic correlation. Although the sedimentological and fossiliferous composition could suggest that both units correspond to the same formation, it constitutes a report to the discussion on the existing stratigraphic relationships between the Bahía Inglesa and Coquimbo formations. To validate this idea, more detailed stratigraphic information is needed, a field test of data to align the terminology used in the different publications, taxonomic and granulometric analyzes in the laboratory, and robust radiometric analyzes with homologated methods for the main reference locations of each formation. Acknowledgements: Project ANID-FONDECYT #1200843

Interbedded volcanic and sedimentary rocks with earthquake-induced deformations in the Intrasudetic Permian Basin, Poland

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Our contribution is dedicated to the memory of Joachim Szulc – a wonderful colleague and great scientist – who was planning to present, during this meeting, some results of the ongoing transnational investigation of the Permian of the Intrasudetic Basin that have resulted in more comprehensive view on the relations between sedimentary and volcanic processes in the Tłumaczów-Broumov region.

The Intrasudetic Basin represents one of the larger late- to post-Variscan intramontane troughs of Europe. It is situated at the northern margin of the Bohemian Massif. The Basin represents a fault-bounded synclinorial structure and was formed as a depression framed by tectonically active margins. During the Permian period the Basin was filled with dominantly fine-grained deposits of alluvial to lacustrine environments accompanied by volcanic rocks. The Lower Rotliegend Krajanów and Słupiec formations are interpreted as two successive finning upwards megacyclothems consisting, from base to top, of alluvial fan, fluvial and lacustrine deposits (Wojewoda and Mastalerz, 1989; Kurowski, 2004). The sedimentary processes were influenced by volcanic activity which evolved with time and comprised emplacement of subvolcanic intrusions, effusion of lava flows as well as deposition of widespread ignimbrites (Awdankiewicz, 1999). Intensive exploitation of trachynadesites in a new quarry Gardzień near Tłumaczów reveals relations of fresh but consolidated mainly lacustrine deposits invaded by the several thick, sill-like intrusion of trachyandesites. Some parts of the sediments are bent to vertical position by the intrusions. There is also a record of synsedimentary earthquakes documented by deformation structures such as disturbed lamination, synsedimentary faults and liquefaction structures. Locally abundant clasts of volcanic rocks in these deposits indicate contemporaneous silicic volcanism and/or redeposition of slightly older volcanogenic material. A similar record was found also in other outcrops from this region. The earthquakes and volcanism were possibly interrelated and the lacustrine environment represented a favorable environment the deposits of which preserved the record of these activities. Earthquake-driven deposit was also described from clastic sediment above the Słupiec formation (Wojewoda, 2008).

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Dynamic MTD topography controlling submarine slope accommodation: Examples from the Eocene Aínsa Basin (Spain)

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Mass-transport deposits (MTDs) on submarine slope successions generate relief that can influence subsequent sediment gravity flows (SGFs). MTD domains are characterised by extensional (evacuation scars, normal faults), compressional (slump folds, thrust faults) and translational features (rafted blocks, strike-slip faults). Their impact on slope sedimentation is well documented in subsurface studies, but their sub-seismic (e.g. outcrop) characterization, and the complex kinematics of their emplacement and influence on sediment routing are still not fully resolved.

This study characterizes two outcrop examples of MTD extensional and compressional kinematic domains from the Eocene slope succession of the Aínsa Basin (Spanish Pyrenees). These two locations are studied via detailed sedimentary logs, palaeoflow measurements, and soft sediment transport vergence readings, supplemented with high-resolution UAV imagery, 3D-outcrop modelling and 2D-panel digitisation.

The slope succession is dominated by mudstones, but deposits overlying MTDs form local coarser-grained accumulations, where three facies associations are recognised: up to several m-thick packages of thin-bedded mudstones (FA1), thin-bedded normally-graded, very fine to fine-grained sandstones (FA2), interpreted as low density turbidites (LDTs), and up to 5 m-thick amalgamated deposits of medium to thick-bedded, normally-graded, fine to coarse grained sandstones (FA3), interpreted as high density turbidites (HDTs).

In the extensional domain, erosionally-based, fining-thinning-upward (from FA3 to FA1) successions form up to 6 m-thick channelised geometries in the hanging walls of half grabens; they exhibit growth towards faults. Fault movement concurred with sedimentation, driving bypass, channelisation and net-erosion. Eventually, either due to faults 'locking up' or a downstream obstruction, channels were infilled initially by coarse-grained (FA3) deposits and progressively capped by finer-grained thin deposits (FA2-FA1). By comparison, in the contractional domain, relief generated by folds and thrusts are infilled by a thickening-and-coarsening-up (FA1-FA3) then thinning-and- fining-up (FA3-FA1) successions, which exhibit growth towards the synclines. The dynamic generation of MTD relief led depocentres to be increasingly able to trap the coarse-grained sediment at the base of flows. Eventually, the rate of topography generation decreased, allowing infill and deposition of thinner, finer-grained beds.

In the extensional domain, bathymetric relief generated by syn-sedimentary normal faults formed more rapidly than creeping slump folds, increasing confinement of higher energy, more erosive SGFs, that drove channel formation and sustained periods of bypass. By contrast, in the compressional domain, folding generated lower amplitude relief resulting in net-deposition due to less lateral confinement and lower velocity, less erosive flows. Systematic thickening and folding into half grabens and anticlines shows that MTDs were subject to prolonged down-slope 'creep' after their original emplacement. Consequently, deposits of SGFs were incorporated into the MTD during a "syn-creep" phase, rather than forming a post depositional drape onlapping an instantaneously emplaced deposit.

The erosional surfaces and successions controlled by dynamic MTD topography observed in this study could be identifiable in well-log and core data, and miss-interpreted as the product of other autogenic processes (e.g. channel formation and/or avulsion, lobe progradation and/or compensational stacking) or controlled by wider allogenic controls. Consequently, such miss-interpretations might lead to false predictions relating to local slope palaeogeography and by extension; reservoir properties, volume and morphology.

Deep water renewals caught in action

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Deep-water renewal (DWR) events are inflow currents that cause fluctuations in chemical oceanographic properties such as salinity, dissolved oxygen, temperature and nutrient content. However, their physical characteristics, such as sedimentation rate and turbidity, are less known. Utilizing 11 years of real-time physical and chemical oceanographic data and seafloor videos, we identified these events in the Strait of Georgia, Canada. Six to thirteen DWRs occur per year at 300 m water depth. They typically initiate during neap tides continuing for several days and are associated with increased turbidity. Although the timing and magnitude of DWRs differ from year to year, we demonstrate that these events show three main characteristics throughout the year mainly based on variations in the fluctuation patterns of chemical properties. Several possible parameters control these events including upwelling in the Pacific Ocean, El-Nino periods, and biogenic factors.

High-resolution seafloor videos captured these events in action. These videos show that DWRs comprise plumes of high-suspended sediment concentration that flow parallel to the basin axis. Each DWR deposits approximately 1.5 cm of sediments per event. With a sedimentation rate of potentially 9–19.5 cm yr-1, DWRs should be considered an important sediment transport mechanism in straits and enclosed seaways (e.g., fjords). DWRs also have the potential to periodically increase oxygen concentrations in bottom waters, thus may be a contributor to reduced total organic carbon preservation in the rock record, such as deep-water unconventional reservoirs.

Implementation of astronomical climate forcing in subsurface predictive models for floodplain-rich, low N/G alluvial stratigraphy

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High sediment supply in concert with fast generation of accommodation space is thought to result in floodplain-rich, low N/G alluvial stratigraphy. Better predicting the alluvial architecture of these series depends on our ability to trace, understand and quantify the controlling mechanisms on sedimentation. These can be divided into internal processes, intrinsic to the depositional system, and external processes, like climate, tectonics, and eustacy. Astronomical climate forcing is recognized as a dominant driver of sedimentation in a wide array of marine and terrestrial sedimentary environments. Tracing astronomical forcing in alluvial stratigraphy remains, however, hard, due to the interaction with internal processes causing heterogeneity at similar spatial and temporal scales. The cyclic nature of astronomical forcing could produce a rich predictive value for subsurface alluvial stratigraphy. However, it remains poorly elaborated and thus hardly used.

Here, we report on our efforts in three study areas to analyse the impact of astronomical forcing in outcrop and subsurface case studies and to implement these findings in work-flows for improved subsurface characterization. For all the study areas, we look for the basic aggrading building blocks of floodplain deposition. In each study, by identification of the floodplain successions, an average floodplain framework can be established with various success. Subsequently, the framework can be refined into a predictive stratigraphic model by deducing the relationship between sandbodies and floodplain and by deducing how 1D data holds the 3D information. The outcrop study is conducted in the Paleocene-Eocene Bighorn Basin, Wyoming, USA, where floodplain deposits record phases of relative aggradation and stability alternating at 20-kyr precession timescale. Here we make use of large (10 km2) high-resolution photogrammetry panels to laterally trace floodplain successions and to generate a floodplain stratigraphic framework. These outcrop observations can be correlated to 1D core and petrophysical observations and yield useful information of lateral variability in the subsurface. The other two studies, the Late Triassic red beds on the Norwegian shelf and Late Carboniferous coal deposits in the Southern North Sea, focus on subsurface recognition and implementation. In the Triassic study, we identify basic aggrading building blocks using core material and petrophysic well-logs. Here an index curve is generated by quantification of the level of soil development in the floodplain. This soil development index captures depositional variation and our first insights show a cyclic stacking pattern in core material. In addition, a higher-order zonation also shows a stable vertical thickness. In the Carboniferous study, due to an absence of long core intervals we focus on petrophysic well-logs. Here we successfully identify the building blocks making use of an integrated prediction error filter (INPEFA) on spectral gamma-ray logs. Floodplain intervals show strong cyclic stacking patterns over a large number of wells fitting integrated stratigraphic tie-points. Using these successions, correlation is attempted over a large spatial scale. For both subsurface studies, subsequently, statistics on sandbody dimensions, style, and occurrence is gathered and combined with the 3D insights from the outcrop study to better elaborate and utilize astronomical forcing in depositional models for the subsurface.

Spatial distribution of palaeohydraulically controlled sole marks in a mixed sand–mud submarine system

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SHORT SUMMARY – Comprehensive field data from the Aberarth section in the Aberystwyth Grits Group (West Wales) show that sole mark type below mixed sand–mud gravity flow deposits is closely related to the inferred turbulent, transitional and laminar properties of these flows. Moreover, facies associations interpreted as submarine channel fill, channel levee, channel–lobe transition zone, and proximal and distal lobe have unique suites of sole marks. These observations help in the interpretation of sedimentary process and depositional environment in other deep-marine successions.

DETAILED INFORMATION – Sole marks are common below sediment gravity flow deposits in deep-marine successions. Flute marks, groove marks, and other scour and tool marks are used routinely for measuring palaeoflow directions, but there are strong reasons why these sole marks could also be valuable as flow type indicators, similar to other current-generated sedimentary structures, e.g. ripples and dunes. In order to test predictable relationships between type and size of sole mark and the properties of deposits formed by turbulent, transitional and laminar flows, sedimentological fieldwork was conducted in the Aberarth section of the deep-marine Aberystwyth Grits Group (West Wales). This location has a rich variety of sole marks combined with ample evidence for the formation of turbidites, hybrid event beds, and debrites by mixed sand–mud flows of different cohesive strength.

Based on high-resolution sedimentary logging, detailed sole mark descriptions, drone imagery, and 3D laser scanning, we found that the deposits of turbulent flows, i.e. turbidites, are dominated by flute marks and that groove marks dominate the deposits of laminar flows, i.e. debrites. Transitional flow deposits, which include hybrid event beds, show a variety of sole marks, but groove marks and discontinuous tool marks, e.g. prod marks and skim marks, are most common. These observations support the notion that turbulent flow is needed to form regular scour marks, whereas groove marks mainly form below laminar flows, in which tools are not able to rotate around their axes or move vertically while dragged along the muddy sea bed.

Facies associations in the Aberarth section of the Aberystwyth Grits Group were interpreted as submarine channel fill, channel levee, channel–lobe transition zone, proximal lobe, and distal lobe. The channel fill, levee, and distal lobe successions display almost exclusively scour marks, mainly parabolic and spindle flutes. In contrast, the channel–lobe transition and proximal lobe successions mostly show groove marks, with subordinate occurrences of flute marks. These observations agree well with the dominance of turbidites in channel fill, levee, and distal lobe successions, and transient turbulent flow deposits in the channel–lobe transition and proximal lobe successions.

Further measurements show that flutes, discontinuous tool marks, and groove marks generally occur below progressively thicker beds. Moreover, the width, depth, and length of parabolic flutes decrease with increasing downstream distance, which may indicate a progressive decrease in erosive capacity as the flows travelled from the channel to the distal lobe.

Although specific to the studied field site, the above observations may aid the interpretation of depositional process and environment from sole marks in other deep-marine systems.

Sedimentary facies analysis of the Upper Cretaceous Shendi Formation in Musawwarat-Naga area, Shendi-Atbara Basin, Sudan

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This study examines both vertical and lateral facies changes as well as petrographic characteristics of the outcropping section of Upper Cretaceous Shendi Formation in Musawwarat-Naga area with a view of interpreting the depositional environment, provenance, and tectonic setting that prevailed during the deposition of the sediments. Field studies revealed the presence of 8 different sedimentary lithofacies. The predominant is the trough cross-bedded sandstone facies (St), representing 75% of the total succession. Four architectural elements were recognized: channel fill (CH), sandy bedforms (SB), gravelly bars, and bedforms (GB), and overbank fill (OF). Moreover, the mean value of paleocurrent directions was 285.3° which is suggestive of a southeasterly located source area. The majority of the sandstones are classified as quartz arenites with subordinate sublithic-arenites. Ternary plots of Quartz-Feldspar-Lithic fragments (QFL) revealed that the tectonic setting of the area is predominantly within the interior craton. It can be suggested that the sediments were sourced from the southeast region and associated with a braided, proximal, fluvial depositional environment within interior cratonic realm. The results of this study provide outcrop analog data that might be useful in the exploration of hydrocarbons. Specifically, it can enhance the understanding and prediction of the proximal fluvial depositional styles in the subsurface deposits in the Shendi-Atbara Basin, Sudan, and the region.

The genesis and evolution of laminated carbonate in lacustrine mudrock from Jiyang Sub-basin, China

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Laminated carbonate in mudrock is attracting increasing attention, as recent exploration efforts have indicated that its formation process is closely related to shale oil accumulation. Understanding the genesis and evolution of laminated carbonate in mudrock is critical for theory development in relation to unconventional oil exploration. This research herein focused on analysis of the inter-bedded layers of laminated carbonate and lacustrine mudrock from the Jiyang Sub-basin, Bohai Bay Basin, China. We explored the genesis and evolution of laminated carbonate based on observations made from drill core, thin sections, and high-resolution scanning electron microscopic (SEM) data, as well as results of fluorometric, cathodoluminescence and geochemical analysis. Results indicate that laminated carbonate is consisted of two categories, crystalline and micritic carbonates. The crystalline carbonate is lenticle in form, well crystallized, and contains oscillatory zoning under cathodoluminescence. Negative δEu (0.84) anomaly in the crystalline carbonate is stronger than those of micritic carbonate (0.73) and the adjacent mudrock (0.67). Moreover, Sr contents in the crystalline carbonate (2056~8552 µg/g, average 4047 µg/g) are higher than those of micritic carbonate (1149~3951 µg/g, average 2204.4 µg/g) and the adjacent mudrock (731~2708 µg/g, average 1638 µg/g). In addition, correlation between 87Sr/86Sr ratios measured from the crystalline carbonate and the adjacent mudrock is poor (R2=0.1061). Lastly, δ18O values of the crystalline carbonate (-5.70~-13.20‰, average -11.16‰) are smaller than that of micritic carbonate (-8.40~-11.50‰, average -9.49‰). These aforementioned findings support the idea that crystalline carbonate is mainly developed in the diagenetic cracks and bedding fissility of shale, as calcite crystalizes from diagenetic fluids and filling the void space. The diagenetic fluids may have mixed sources, including transformation process of early stage aragonite to low-Mg calcite, clay mineral transformation in burial environment, and the deep basinal brine from craton. The micritic carbonate is not well crystallized and has biotic textures. SEM observation of micritic carbonate showed evidence of spherical calcites, sheath- and rod-like structures, extracellular polymeric substances (EPS) textures, and algal/nannofossil debris (indicating biological activities). Existing theories have determined that the relationship between organic and inorganic C isotopes defines the effects of biological activities on the formation of micritic carbonate. In the study area, δ13Ccarb and δ13Corg of the micritic carbonate shows a strong negative correlation (R2=0.769), indicating high biological activities in the lake during calcite formation. This finding therefore suggests that micritic carbonate is formed from direct deposition, and is controlled by biological effects in the stratified flows of this seasonal lake.

Is Turbidity Current Activity Predictable?

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Individual turbidity currents can reach velocities up to 20 m/s and therefore pose a threat to seafloor cables and hydrocarbon pipelines, infrastructure that now underpins our daily lives. Avoidance of areas prone to turbidity current activity is not always possible, therefore understanding the frequency and triggering mechanisms of powerful flows is important. It was generally thought that long runout, damaging turbidity currents are triggered by large external events, such as earthquakes, large storms and river floods. Technological advances and direct monitoring now allow the exact time of turbidity current flow initiation to be compared to potential triggering mechanisms and therefore test these hypotheses. Recent studies have shown that powerful flows can initiate without a major trigger and that not all earthquakes, storms and river floods result in a turbidity current. However, the small number (< 15) of flows recorded in these studies do not permit robust statistical analysis and flow timings are only compared to individual triggers.

Here we show multivariate statistical analysis to understand the relationship between multiple triggering mechanisms of more than 100 turbidity currents. We use an unusually detailed monitoring dataset with six ADCPs moored within a river-fed fjord submarine channel at Bute Inlet, British Columbia during the summers of 2016 and 2018. We find that not all peaks in discharge relate to flows. Instead increases in sediment supply during the summer meltwater season acts as the 'switch on' for turbidity current activity. Flows are triggered either following rapid deposition resulting in delta-lip failure or sediment settling from the river plume when sufficient sediment load is attained. Both mechanisms almost exclusively occur at low tides when the delta-top channel width is restricted. Using these results, we model flow likelihood at Bute Inlet, and other similar settings, to show that turbidity current activity is predictable under given conditions (e.g. river discharge and position in tidal cycle) once triggering mechanisms are well understood.

Sedimentary architecture and dating of Pleistocene breach deposits from Vranić sand pit (Croatia)

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The Neogene formations at the marginal parts of the Pannonian Basin in Croatia include numerous quartz sand deposits. Vranić sand pit has been considered to be one of them. It is located at the southern foothills of the Papuk mountain in the eastern part of the country. The deposition of quartz sand during the Miocene and Pliocene in this area was cyclic. Cyclicity was induced by the regional tectonic events and repeated transgressions and regressions accompanied by intense weathering of exposed rocks (Pavelić, 2001). This weathering occured under moderately warm and humid climatic conditions.

Vranić locality is abandoned sand pit 300 m long and more than 30 m thick. Sedimentology of Vranić has been previously described as a sand deposit in which sand was transported from adjacent Papuk mountain. In this research we have collected samples for sedimentological, SEM analysis and cosmogenic nuclides dating. Grain size analysis proved that coarse sand is dominant fraction (in range from 38 % to 97 % depending of the sample). SEM images of quartz grains display dominance of angular and subangular grains. Only a few of them are sub rounded. This confirms a theory of short transport from a nearby mountain. This research, which included dating of the sediment yielded much younger age then previous research sugested. Considering the field estimate sample depth of 10 m and a sediment density of 2 g/cm3 the burial duration is 1 608±403 ka. This places Vranić sand pit sediment in Lower Pleistocene, rather than Pliocene or Upper Miocene. The coupled pre-burial denudation rate is 591±148 m/Ma, which in agreement with the sedimentological properties observed at the outcrop suggests fast erosion of the source area and quick deposition of the sediment.

Results from our research sugest at least two cycles of reworking of sandy material before final deposition during the Lower Pleistocene. Structureless facies of lower and middle part of the Vranić sand pit point out to breaching as a dominant and most probable depositional process.

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Carbonate-siliciclastic mixed deposits (Lower-Middle Jurassic transition) as potential reservoir units in the Lusitanian Basin, Portugal

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The mixed carbonate-siliciclastic units that characterize the upper CC5 member of the Cabo Carvoeiro Formation in the uppermost Lower Jurassic-lowermost Middle Jurassic (Toarcian-Aalenian(?)) of the Lusitanian Basin (LB) were deposited during the regression phase of a transgressive-regressive cycle. They are defined as grainstones composed of well to moderately sorted, carbonate allochems (mainly ooids and intraclasts) and well-rounded quartz grains originating from the nearby high-energy platform margin depositional environments of the uplifted Berlengas block to the West. These deposits are found locally in the Peniche area, in contrast with the mostly hemipelagic marly sediments found in coeval sections cropping out in the wider basinal area, and they overlay organic-rich units of the Pliensbachian, which show hydrocarbon generation potential.

The Peniche studied deposits show calcite cementation fully occluding the interparticle space, but there is potential for the development of similar sections in comparable depositional settings in other offshore locations within the LB, where favorable diagenetic processes might have occurred, such as low interparticle cementation enhancing the preservation of moderate porosity. Considering the hypothetical chance for the development of effective trapping mechanisms promoting hydrocarbon accumulation, these units can be regarded as having strong reservoir potential.

Observations are done on well logs and thin sections from two nearby offshore wells, as well as data from an outcrop section of over 1 km, including collected samples from selected strategic locations for petrographic analysis. An interpretative outcrop to subsurface correlation is done based on the analyzed data and on previously published studies. The Peniche area is here interpreted to have represented a localized depression delimited by a combination of tectonic, structural and halokinetic features, comparable to similar developments elsewhere in the offshore Northern LB, identified in published studies supported by seismic data. Correlation with subsurface well data shows regional variations in depositional facies. The grainstone facies found in the Peniche area are present in very low quantities in the coeval sections of nearby wells drilled on relative structural highs, where mostly micritic wackestone facies are observed.

This study allows for conceptual models to be proposed and will provide further insight on the possible development of potential hydrocarbon reservoirs in comparable sedimentary units deposited within similar structural and depositional settings, as part of one of the defined petroleum systems in the LB.

Multi-scale outcrop analysis of carbonate depositional geometries: Middle Jurassic, Portugal vs Lower Cretaceous, subsurface U.A.E.

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Outcrop observations offer valuable insights into the depositional architecture as a primary control on facies variability and, potentially, on reservoir properties heterogeneity, being of crucial interest for subsurface cases, where observation points are limited to well locations. This approach was used, comparing the potential reservoir facies of the Bathonian-Callovian carbonate succession of the central Lusitanian Basin cropping out at the Maciço Calcário Estremenho (MCE) region, Portugal, with a subsurface carbonate reservoir of Lower Cretaceous age from Abu Dhabi (U.A.E.). The MCE case study is characterized by high-energy inner ramp facies exhibiting moderate heterogeneity, which is partially influenced by the complex architecture of deposition. This succession is exposed in recently-cut quarry fronts (several were analysed) showing minimal weathering effects, offering an invaluable opportunity to address depositional features and geometric relationships at considerable levels of detail. The Abu Dhabi case study is characterized by facies of mid to inner ramp, that were studied and interpreted using data from 4 wells, including core slabs and thin sections.

The observed geometries on outcrop range from tabular and wedge-like geobodies to lensoids and coral build-ups, controlling the vertical and lateral distribution of different depositional facies, which are generally defined as oobiointraclastic grainstones, biointraclastic grainstone-rudstones and coral/algal boundstones. A multi-scale outcrop analysis shows larger-scale depositional packages with moderate continuity over moderate distances, at a metre/decametre scale, but considerable geometric variations at smaller centimetre/meter scales, driving the spatial variability in facies and, potentially, petrophysical properties over short distances. Moderate similarities were identified in terms of depositional geometries between both cases. In the Abu Dhabi case, strong to moderate continuity of the reservoir subdivisions is known to occur across fields, but at a smaller scale, strong heterogeneity is observed. This case study also shows a similar general evolution from tabular, wedge-like and lenticular geobodies into rudist-rich intervals, but shows considerable differences in terms of depositional facies and settings. In general terms, the MCE case is interpreted to reflect depositional conditions of relatively higher energies, when compared to the U.A.E. case.

The ultimate objective of such studies is to help to reduce uncertainty levels, offering information that can be used to improve reservoir models and the predictability of reservoir properties variations in inter-well areas.

Quantitative sequence stratigraphy applied to the Barremian/Lower Aptian Urgonian carbonate platform (Provence, France)

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Sequence stratigraphy is an essential tool for interpreting and predicting carbonate sedimentary systems. In this study, we propose a new method of quantitative stratigraphy applied to the Barremian Urgonian Platform in South of France. The method is based on the quantification and then the correlation of apparent accommodation spatial trends and uncertainties between 23 sparse and distant locations along a platform-to-slope sedimentary profile. The method allowed defining 11 markers of major apparent accommodation variations. The identified stratigraphic architectures of the Urgonian Platform were then quantitatively interpreted regarding the tectonic, eustatic, paleoclimatic and oceanographic evolution in early Cretaceous.

From early Barremian to the late Barremian (G.Sartousiana), apparent accommodations are higher in North Provence (+475m) than in South Provence (+250m). During this time, the stratigraphic architectures showed an evolution from a carbonate ramp to a flat carbonate platform. This morphologic change would first result from climatic and oceanographic evolutions at the early/late Barremian transition. Indeed, the ologitrophic and arid conditions would have promoted the development and progradation of the rudist Urgonian Plaftorm toward the more subsident North Provence. Futhermore, two major negative apparent accommodation events (-45m) that may be linked to eustatic falls have led to the subaerial exposure of the inner platform in South Provence and would have help the final settle of inner platform in North Provence.

The end of the late Barremian would be marked by an inversion of the subsidence polarity toward the South Provence. Here, the higher apparent accommodation values (+250m) and the pelagic sedimentation would reflect the influence of the North Pyrenean Fault System. Conversely, even though the important lateral variations in the accommodation values (from 80 to 200m) suggesting a local subsidence effect, North Provence displays the lower accommodation compared to South Provence. It would probably have promoted the development and extension of rudist platform. The latter has been affected by a final negative apparent accommodation event (-75m) related to either an eustatic fall (-55m) or uplift of the North Provence leading to the subaerial exposure of the carbonate platform.

The late Barremian / early Aptian transition is characterized by 1) a change in a sedimentary pattern favored by a climatic-driven meso-eutrophic conditions and 2) the final drowning of the North Provence platform as a response to drastic increase in the accommodation rates coeval with the OAE1a event.

The non-uniform and non-stationary geographic and temporal evolutions respectively of apparent accommodations indicates the complex interactions of local and global driving factors. In this study, we defined three scenarios of quantified eustatic fluctuations and subsidence rates evolutions. Further investigations will focus on the role of the climate and carbonate production changes on the stratigraphic architecture using forward stratigraphic modelling tools.

Sedimentary facies analysis and depositional environment modeling of the Oxfordian Hanifa Formation, central Saudi Arabia

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The depositional environment of the Hanifa Formation, which represents a shallow marine carbonate succession deposited during the Oxfordian Stage and formed on the eastern flank of the Neotethys Ocean's passive continental margin, has been the subject of several hypotheses. Due to the economic importance of the Oxfordian succession in the Arabian Plate, either as a hydrocarbon reservoir or source rock, a comprehensive understanding of its sedimentology is important. A detailed depositional model is developed using high resolution (centimetre-scale) study and analysis of eight vertical outcrop sections through the Hanifa Formation to help decipher the uncertainty surrounding the understanding of the Oxfordian depositional environment. The outcrops under study are located along a curved 535-kilometre traverse in central Saudi Arabia. The total vertical thickness of the analyzed sections is 461 m, with 587 high-resolution imaged slabbed rock samples and 138 thin sections in the data collection. Fine carbonate samples were analyzed using X-ray diffraction and scanning electron microscope techniques. The number of interpreted sedimentary facies is nine, and they are grouped into four facies associations: outer-ramp, mid-ramp, non-reefal and reefal inner ramp. The outer-ramp zone includes basinal intraclast rudstone (F1) and argillaceous carbonate mudstone (F2), whereas the mid-ramp zone includes lower shoreface skeletal sponge spiculitic wackestone/packstone (F3) and horizontally-laminated siltstone/claystone (F4). The non-reefal inner-ramp zone includes upper shoreface cross-bedded skeletal quartz peloidal grainstone (F5) and trough cross-bedded calcareous sandstone (F6), while the inner-ramp reefal association includes gravel-dominated fore-reef slope floatstone (F7), reef-crest stromatoporoid/coral framestone (F8), and open reef-flat/back-reef oncoidal rudstone (F9). The facies succession allows for the identification of two depositional phases, lithostratigraphically corresponding to the Mid Oxfordian Hawtah and Late Oxfordian Ulayya Members, respectively. Facies succession and attitude show that the older phase 1 was deposited on a gently sloping carbonate ramp, whereas phase 2 resembles phase 1 unless the reefal inner-ramp facies association is found. The existence of the reef association is responsible for the observed carbonate rimmed-shelf criteria, either as facies characteristics or bedding geometries. These criteria are the fore-reef slope floatstone, the formation of the associated sand shoals, which are different from the synchronized and older upper shoreface grainstone of phase 1, in addition to the back-reef partially restricted lagoon that is proved by the scattered eroded dasyclad green algae grains in the shoal grainstone. For the first time in the Oxfordian succession of Saudi Arabia, siliciclastic deposits are observed and described, in the southern part of the studied traverse. The siliciclastic deposits represent the younger section of phase 2, and they are shallow marine coarse calcareous sandstone and laminated siltstone, deposited in upper and lower shoreface depositional environments, respectively. The presence of sedimentological distinguishing features of both carbonate ramp and rimmed-shelf settings, in the Oxfordian Hanifa Formation, is evidenced in this research.

A mesoproterozoic hybrid dry-wet aeolian system: Galho do Miguel Formation, SE Brazil

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Based on Phanerozoic and present-day cases, aeolian systems are categorised into dry, wet and stabilising types. It is questioned here whether these models are applicable to Proterozoic systems when environmental conditions on the Earth's surface were markedly different. Facies and architectural-element analyses have been applied to the Mesoproterozoic aeolian succession of the Galho do Miguel Formation, SE Brazil. The aim is to identify and discuss what controlling factors govern the construction and preservation of Proterozoic aeolian systems, and to explain how these differ from Phanerozoic models. In the metaquartzarenites of Galho do Miguel Formation four aeolian subenvironments – megadunes (draas), large-scale isolated dunes with dry interdunes, small-scale isolated dunes with damp or wet interdunes and salt flats – coexisted and alternated temporally and spatially.. The construction of megadunes, large-scale dunes and dry interdunes occurred in topographically elevated areas, usually above the water table, but occasionally flooded; isolated dunes with damp and wet interdunes, and salt flats formed in low-lying areas with water table at or close to the surface.

A long-lived sediment supply combined with ongoing tectonic subsidence enabled the accumulation of a thick aeolian succession (1,000–1,500 m) that covered a large area (4,000 km2). The water table controlled the accumulation of this unit. Where it was close to the accumulation surface, it acted to limit the availability of the wind-blown sand, hampering the construction of large and compound bedforms and allowing the deposition of damp and wet interdunes and salt flats as a wet aeolian system; Where large and compound bedforms with dry interdunes developed as a dry aeolian system, slow but progressive subsidence-driven water-table rise provided accumulation space that enabled system preservation. The Galho do Miguel Formation constitutes a hybrid aeolian system, in which both dry and wet environmental conditions were coeval.

In the Mesoproterozoic, the absence of rooted-vegetation capable of acting as a sand stabilising agent allowed the widespread generation of aeolian systems in humid as well as arid environments. In humid environmental settings, water played a significant role in the accumulation and preservation of aeolian deposits, preventing their reworking by the wind or other exogenous agents.

Variations of aquic conditions in Paleocene Vertisols (Esplugafreda Formation, Catalan Pyrenees, Spain): morphological and/or climatic causes?

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Palaeosols are excellent palaeoenvironmental markers, linked to time, climate, vegetation cover, parent material and landscape. Palaeosols in sedimentary succession are associated with and influenced by depositional processes, themselves linked to palaeoenvironmental variations. Thus, palaeosols represent an important record of controls on the sedimentary processes that generate depositional architectures in continental environments.

This research analysed palaeosol profiles in terms of variations in so-called 'aquic conditions', i.e., with regards to saturation, reduction, and morphological indicators of a soil to a depth of 2 m. Aquic conditions are determined by soil morphological transformations linked to dissolution, transport and concentration of chemical compounds of Fe, Mn and Nitrate. This research attempts to establish the causes of these variations and to assess their relationships with the hydraulic regime, the depositional processes and the architecture of a fluvial system.

To this end, a study was undertaken of a Paleocene fluvial succession, c. 50 m thick, forming part of the Tremp Group in the Catalan Pyrenees, Spain (uppermost Esplugafreda Formation). The succession consists of cumulative sandy mudstone palaeosol profiles laterally associated with sparse ribbon channel deposits, and is overlain by a markedly erosional surface on which fluvial strata of the Claret Formation have been deposited. Two pedotypes were recognised, named Pont d'Orrit pedotype (Ass/Bss-Bss-Bssk) and Areny pedotype (Bssg-Bss). The first pedotype dominates the lower portion of the study succession, whereas the second pedotype prevails in the upper part. Slickensides, wedge-shaped aggregated, mukkara structures, redoximorphic features, and clay content >60% (mainly smectite) indicate that these palaeosols are belonging to Vertisols Order. The Pont d'Orrit pedotype exhibits brownish red horizons; it regularly displays a Bk horizon, redoximorphic concentrations of hematite and rare redoximorphic depletion in macropores associated with roots and slickensides. The Areny pedotype exhibits upper horizons that are light yellowish brown, a structure constituted of angular/subangular blocky peds, pedofeatures consisting in redoximorphic concentrations of goethite and abundant depletion features in planar macropores associated with blocky peds, and slickensides and channel associated to roots; a Bk horizon is absent.

Expandable clay minerals and seasonal precipitation, which permit repeated alternations of dry and wet conditions, are basic factors controlling the genesis of Vertisols. In poorly drained soils, like these, heavy rainfall causes stagnant and reducing conditions in macropores, generating redoximorphic features. The Areny pedotype shows a greater quantity of depletion features, high content of Fe hydroxides and absence of calcium carbonate in the profile, demonstrating that its development occurred under aquic conditions characterised by greater presence of moisture than those linked to the Pont d'Orrit pedotype. A preliminary application of climate function based on the relationships of molecular weathering ratios of more soluble and less soluble elements indicates an increase of palaeoprecipitation from the lower to the upper portion of the study succession. This progressive increase in precipitation preceded the event that led to widespread erosion at the base of the Claret Formation, and might have heralded a phase of deposition under overall wetter conditions.

The rhythmic expression of mid-Cretaceous Oceanic Anoxic Event 2 southwest of Australia (IODP U1513, U1516)

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The widespread deposition of organic-rich black shales during the mid-Cretaceous hothouse at ~94 Ma marked a climatic extreme that is particularly well studied in the Northern Hemisphere. The expression of Oceanic Anoxic Event 2 (OAE 2) in the NH was characterised by low oceanic oxygen concentrations, likely caused by the input of nutrients through volcanism and/or weathering in combination with a peculiar geography in which the proto-North Atlantic was semi-restricted (Jenkyns, 2010; Trabucho Alexandre et al., 2010). The extent of water column anoxia outside the North Atlantic and Tethyan domains remains poorly resolved, as few Southern Hemisphere records have been recovered that span OAE 2, and only a portion of those Indian and Pacific Ocean localities experienced anoxia and organic matter deposition (Dickson et al., 2017; Hasegawa et al., 2013).

Here we present new results from IODP Expedition 369 offshore southwestern Australia. Sedimentary records across the Cenomanian-Turonian transition from Sites U1513 and U1516 in the Mentelle Basin (Indian Ocean) display rhythmic lithologic banding patterns. The OAE 2 interval is marked by a dramatic drop in carbonate content and the occurrence of several thin organic-rich black bands. The spacing of dark bands within a rhythmic sequence suggests a potential orbital control on organic matter deposition at our study sites. Time series analyses of high-resolution (cm-scale) elemental data from XRF-core scanning reveal the imprint of periodicities that can be confidently linked to Earth's orbital parameters. The new OAE 2 records from Sites U1516 and U1513 allow us to i) evaluate existing time scales over the Cenomanian-Turonian transition, and ii) investigate the mechanisms leading to a recurrent lack of oxygen in the Indian Ocean.

Climatic mechanisms translating changes in insolation to variations in organic matter deposition may have included variations in nutrient input from nearby continents and shifts in water column structure affecting local to regional stratification versus deep water formation and advection. Investigating ventilation of the deep sea during the OAE2 interval is of heightened relevance as current global warming is leading to a worldwide expansion of oxygen minimum zones (Pörtner et al., 2019).

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Neodymium isotopic evidence for large-scale oceanographic change during the collapse of the Cretaceous hothouse

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After the peak hothouse conditions of the Late Cretaceous, ending at ~91 Ma, climate was characterised by a gradual decrease in temperatures and CO2 levels, an absence of major carbon cycle perturbations, and a reorganisation of deep-water circulation patterns. Throughout this time, the Atlantic Ocean was gradually opening and sea level was higher than at present, with large parts of north-western Europe covered by shallow epicontinental chalk seas. The role of surface-water oceanography in the long-term Late Cretaceous climatic cooling is poorly understood, as reconstructed upper-ocean circulation patterns are based on relatively low-resolution records that have often been assembled from multiple localities. Here we present a ~28 Myr continuous record of neodymium-isotope ratios (εNd) of fish debris from the Trunch borehole of Norfolk, England, to reconstruct the evolution of upper ocean waters of the Boreal-Tethyan epicontinental shelf during the Late Cretaceous.

During the Cenomanian–Turonian, background εNd values are in the range of -9 to -10, comparable to previously published high-resolution datasets from the elsewhere in southern England that span Oceanic Anoxic Event 2 (OAE 2). Unfortunately, OAE 2 is marked by a disconformity in the Trunch core. Surprisingly, our record shows a ~5 unit positive excursion during the mid–late Turonian, a much larger shift than those recorded in southern England during OAE 2. The εNd excursion lasts ~1.5 Myrs, and coincides with cooling observed in oxygen-isotope and faunal records across the Chalk Sea, a global positive δ13C excursion, and a major change in sea-level, suggesting a potentially global driver of climate- and circulation change. The high εNd values (peaking at -5.9 units) indicate basalt–seawater interactions, probably in the Boreal Sea, suggesting that volcanic activity and/or basalt weathering accompanied the cooling.

After the late Turonian, Nd-isotope values return to relatively steady background levels of -11 to -12 in the Coniacian–Campanian; this long-term stability of circulation in the Chalk Sea suggests that circulation in this region was neither driving nor responding to the long-term global cooling trend. Further, the strongly unradiogenic signature of the Trunch record suggests a decline in influence from other water masses—Boreal or Tethyan—consistent with a restriction of low-latitude Pacific–Tethyan gateways.

Our εNd data, particularly the unexpected Nd-isotope variability in the Turonian, highlight the necessity to look beyond abrupt climate perturbations and to generate long-term continuous proxy records to gain a thorough understanding of climate processes in a greenhouse world.

Pashayurdu Fan Delta Deposites Karasu Depression; Sedimentary Structures and Facies, Erzurum Basin. Eastern Turkey

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Extraordinary examples of submarine slump structures recognized in Pasayurdu Fan Delta deposites, Karasu Depression. A series of Fandelta stacks formed as overlapping coalescent delta deposits along the NNE trending tectonic threshold seperating Daphan Plain and Karasu Depression. Erzurum Basin lies near a convergence of major thrust trends. To its north are NE-trending thrusts passing through Askale and Tortum. The Palandoken Volcanics are succeeded by the Gelinkaya Formation, which consists of fine-grained deposits of white diatomaceous mudstone, marl, minor tuff and conglomerate representing stable dominantly continental freshwater environmental conditions. The stratigraphic sequence thus records a change from marine to terrestrial conditions, resulting from collision-related uplift of the region. Erzurum basin developed in two sub-environments; Daphan Plain and Karasu Depression, under transpression lithospheric dynamics. Northern margin of the Erzurum Basin has ENE-strike. Clastic debris sourced from NNW provenance area, and deposited SE ward into Karasu Lake Area. formed Fan Delta stacks.

Some of these complex folds in Gelinkaya are clearly seen to be enclosed by planar beds. These folds are interpreted to be intraformational slump folds produced by slope steepening and gliding of lava layers on incompetent pyroclastic beds. The trend of the fold axes is roughly parallel to the northern margin of the Erzurum Basin. These are also probably related to slumping and formed in more competent layers which broke up during gliding. Pasayurdu Fan Delta deposites located at 7.5 km NW of Ilıca, presents ideal example of ‘submarine slumping’ in delta foresets. Landslides initiated by sliding of thick overlying Conglomerate Mass caused slump folds, in fine grained sequences. In some horizons breccia beds composed of dominantly angular fragments with unsorted composition. Very poorly sorted, matrix-rich, polymictic and heterolithic texture. Coarse sedimentary breccia and conglomerates as flood debris flows, deposited along fault scarp (paleo shore line) which slided over stack of semi-consolidated clayey layers. The gravity flow of heavy massive gravel debris slided down southeast and eastwards, into deep water of Karasu Lacustrine Area. The load exerted by rapid gravity flow caused formations of overturned anticlinal and slump structures, in delta forests.

Forset beds dipping apprx at 30 degrees to NE, E and SE ward depending on lateral migration of main stream. There are several coallescing fan delta deposites, merging from NW margin Braided River flood deposits. Here, gravel rich deltas sourced from nearby Gelinkaya Highlands. Fan deltas occupy a belt between fault-bounded nortwesthern margin and Karasu lake area, reflecting the strike of west margin of Karasu Depression. Extremely intense precipitation caused heavy soil erosion, triggered flash floods of debris flows which continue as subaqueous debris flows. Pleistocene Delta exposed in the Ilıca Askale Road pit. Fan Delta is at least 20 m thick. Close views show sandy foresets with thin bedded interfan deposites. Topsets are dominatly sandy laminated and crossbedded. Foresets reveals numerous local discordances and through crossbeddings, reflecting shifted stream flows, sediment supply and local slumping. Low angle reverse faults, slump sutructures and frequent overturned folds reflect NNW-SSE trans-compressional kinematics currently responsible for active tectonic framework of Erzurum Basin.

Provenance of sediments across the northern Indian Plate: is it the Aravalli Range?

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Outcrops of Lower Cretaceous sandstones across NW India and Pakistan are scattered within rift basins (the West Indian Rift System: WIRS and the Lower and Middle Indus Basins: LMIB) and are dominated by fluvial sequences (the Ghaggar-Hakra and Dhanduka formations and the Nimar Sandstone) draining to the Cretaceous palaeo-north into deltaic and shallow marine environments (Goru, Sembar and Bhuj formations) of the Indo-Tethys Ocean. Recent studies have focussed on the sedimentology of these sequences to establish facies, sediment architecture and distribution in the context of structural framework. It is generally assumed, with little to no evidence, that the fluvial systems were sourced from the Aravalli Mountain Range, a prominent, long-lived terrain on the NW Indian craton. However, recent plate reconstructions suggest that the provenance of the Lower Cretaceous sediments must be much more diverse because of long-distance transport routes. To further constrain these provenance reconstructions, simple calculations for removing the diagenetic effects on detrital compositions have been developed in order to reconstruct of the original detrital mineralogy.

For the Ghaggar-Hakra Formation 99 thin sections from both outcrop and core were point-counted. Virtually all the studied sandstones are quartz-arenites or sub-lithic arenites with almost no detrital feldspar. Published data for the Lower Cretaceous sandstones of the WIRS indicate that they are predominantly quartz-arenites to sub-lithic arenites, apart from in the Kachchh Basin which has an overall arkosic detrital composition. The LMIB sandstones are mineralogically sub-lithic arenites.

Petrographic studies indicate that these sediments have been significantly affected by diagenetic dissolution and replacement processes. To provide understanding of the source provenance we need to reconstruct the original detrital mineralogy which is accomplished by:

1. Summing oversized pores, grain-replacive calcite cement and authigenic kaolinite together to recalculate the original detrital feldspar content, and;
2. Adding authigenic chlorite, smectite, opaque minerals and iron-replaced grains to recalculate the lithic total.

This mineralogical reconstruction indicates that the sandstones from the Barmer, Cambay, Narmada and Jaismaler basins remain within the quartz-arenite and sub-lithic arenite ranges. The sandstones from the Kachchh Basin are arkosic and the LMIB were originally lithic arkoses to feldspathic arenites. Of these 99 thin sections 15 samples have been analysed for heavy mineral analysis which indicate a heavy mineral assemblage comprising of andalusite, zircon, tourmaline, augite, muscovite and haematite.

Significant differences in the mineralogy across all the sandstones indicate widespread development of quartz arenites, lithic arkose and feldspathic arenite ranges reflect variation in sediment provenance. Using well-established sandstone provenance triangular plots, these sandstones are dominated by quartzose recycled, dissected arc and transitional continental ranges indicating that the sediments of the Bhuj, Goru and Sembar formations derived from local highs whilst the sandstones of the WIRS (except the Kachchh Basin) are likely to be derived from the late Precambrian Marwar Supergroup sandstones suggesting they are at least second generation quartz detritus.

Lateral migration of fluvial systems preserved in outcrop?

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Lateral migration in modern regimes on fluvial settings is a well-developed method that is undertaken by core logs, ground-penetrating radar data and aerial photogrammetry. These techniques have worked well in developing our understanding of how rivers move on an order of scales from the channel belts down to the individual bars and understanding the facies that these movements preserve. From these methods and datasets, we have developed a methodology in order to obtain similar information from outcrop in a bid to determine channel bar migration of the Ord Red Sandstone (ORS). In this pilot study the aim was to determine whether a combination of methodologies allow for prediction of channel migration.

Sedimentary logging, architectural element and palaeoflow analysis combined with aerial photogrammetry has provided an exhaustive dataset which has been interpreted in the light of the in-depth literature review. From this comprehensive descriptions and interpretations of the fluvial environment has been completed in the context of the palaeogeography. Each of the fluvial bars analysed has a distinct palaeoflows to the southeast, west and northwest, to determine the overall movement moving average analysis was completed to give an overall southerly direction.

Facies models for aeolian systems in rift basins

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Aeolian systems are a common feature in arid rift basins, both modern and ancient. Existing facies models for aeolian systems typically focus on deposits laid down in unconfined settings and while the basic depositional elements such as dunes, inter-dunes and sandsheets are similar, their distribution, proportions and geometries are different in confined systems such as extensional rift basins. These basins are typically elongate and relatively narrow with significant topography around the margins of the basin that create local wind flow patterns. Sediment, derived from the reworking of alluvial fans on the basin margins and axial fluvial systems entering through the depo-centre, will be reworked by aeolian processes. Conversely, fluvial systems fed by local or regional drainage areas will flow to topographic lows reworking dunes. Many arid basins contain semi-permanent playa lakes which are endoreic and as such prone to significant climatically driven lake level fluctuations which shift depo-centres within the basin. Finally, the long term preservation of aeolian sediments is controlled by subsidence, the distribution of which varies spatially within extensional basins. The combinations of these factors suggests that rift basins will have complex but ultimately predictable distribution specific factors will control the distribution of dunes and dune types and the ultimate preservation of the aeolian systems.

This study documents the distribution of different aeolian deposits within several modern rift basins from satellite imagery (GoogleEarth) to produce facies models for these systems. The distribution of arid deposits in 26 dominantly extensional, arid modern basins from the western US, Mexico and central Asia are mapped. That data were analysed to build conceptual models of four endmembers for confined aeolian systems based upon the relative climate (arid vs semi-arid) and the size of the fluvial drainage basins feeding the depocentre. Other parameters such as the orientation of the basin with respect to the prevailing wind direction and the bedrock geology were also considered. The model predicts the distribution and proportions of the various facies, as well as the scale and morphology of dunes in different parts of the basin and dune system.

As aeolian deposits are major reservoirs and aquifers in the subsurface, the resultant models have implications for the analysis of aeolian systems in the subsurface where the basin structure can be mapped from seismic data but individual facies are below the resolution of the seismic.

Intra-point bar grain-size variability: an example from the Holocene succession of the Venetian Plain (Italy)

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Lowland and coastal areas are nowadays drained by fluvial and fluvio-tidal meandering channels which, over the past millennia, shaped modern landscapes and accumulated thick sedimentary successions. These successions host today most of the main surficial aquifers, which are exposed to a number of criticalities including propagation of pollutants and saltwater intrusion. Understanding sediment distribution and connectivity within these meandering-river deposits is a crucial issue to predict fluid and pollutant propagation within them. The Venetian Plain (northeast Italy), forms the eastern sector of the Po Plain, the largest Italian alluvial plain (ca. 47.000 km2), and was generated during Holocene transgression by aggradation of fluvial meandering rivers, such as Po and Adige. Being morphologies of these channels still visible from satellite images, the Venetian Plain is a key site to deepen our knowledge about internal architecture and sediment properties of sand-bodies generated by fluvial and fluvio-tidal meandering channels.

The present study focuses on two paleo-meanders of the coastal sector of the Venetian Plain (9 km far from the present-day coastline) and aims to define a 3D model depicting geometry of related point-bar bodies, with a specific focus on along-bar sediment grain-size distribution. The study paleo-channel was ca. 25 m wide and defines two adjacent bends, named here bend 1 and bend 2. Bend 1 is a wide, strongly asymmetric bend, whereas bend 2 is an open, poorly asymmetric bend. The planform evolution of these bends has been reconstructed by analysing scroll-bar patterns of the associated point bars. Bend 1 and bend 2 progressively expanded during their evolution, and bend 1 was affected by a marked rotation of the bend apex during its final stage of growth. Geophysical investigations (Frequency Domain Electro-Magnetometer) allowed depicting 3D geometries of sedimentary bodies basing on a marked electric conductivity contrast between sandy bar bodies and encasing muddy overbanks. Geophysical data were calibrated through comparison with several sedimentary cores recovered from the two bends. This integrated approach between geophysical and sedimentological data provided a link between meander bend planform evolution and grain-size distribution within the related point-bar bodies, with implications on aquifer and reservoir management.

Grain-size variability within point-bar deposits: a case study from the Holocene Venetian Plain (Italy)

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Meandering fluvial and fluvio-tidal channels drained modern and ancient coastal landscapes, accumulating sedimentary successions, which host today the main surficial aquifers or become important hydrocarbon reservoirs. Understanding sediment distribution and connectivity within these meandering-river deposits is a timely issue of crucial importance to predict fluid propagation within them, with implications either on reservoir development or aquifer management. The present study focuses on the intra-bar connectivity within point-bar deposits of a Holocene paleo-meander of the Venetian Plain, Italy. This work is based on a multidisciplinary approach, which integrates remote sensing, geophysical and sedimentological data. This approach allowed us to define a 3D model depicting point-bar geometry and along-bar sediment grain-size distribution.

The Venetian Plain is located in northeast Italy and represents the eastern sector of the Po Plain, the largest Italian alluvial plain (ca. 47’000 km2). The study area has been formed since the Holocene transgression by aggradation of fluvial meandering channels, thus, the Venetian Plain is a key site to improve our knowledge about internal architecture and sediment properties of sand-bodies generated by fluvial meandering channels in coastal areas. The investigated paleochannel has a depth ranging between 0.5 and 5.4 m and defines a sandy point bar that is ca. 160 m wide (i.e. riffle to riffle distance). An overall expansional evolution of the meander has been reconstructed by analysing scroll-bar patterns, which are still visible from high-resolution satellite images. Geophysical investigations (Frequency Domain Electro-Magnetometer) allowed to depict 3D geometries of the bar, mapping the marked electric conductivity contrast existing between sandy bar body and the encasing muddy overbank deposits. The point-bar body is about 4.5 m thick and forms a curved body around a relict muddy overbank deposit, indicating that bar accretion started from a channel that already developed a certain sinuosity. Geophysical data have been calibrated by recovering several sedimentary cores, which allowed to locally link different in-bar values of electric conductivity with specific sediment grain sizes. Integration between geophysical data and core analysis reveals that point-bar deposits mainly consist of well-sorted medium sands, which grades to fine sand and mud in the uppermost part of the bar. No relevant changes in grain size have been detected along the bar. Channel-fill deposits are also sandy, pointing out to a gradual abandonment of the channel bend.

Traces of Pleistocene earthquakes in layers with liquefaction-induced SSDS from the Southern Peribalticum area

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Recognition of sedimentological traces of earthquakes in the form of seismites within Pleistocene sediments was the main objective of the GREBAL project. Field studies, conducted during the last four years in the northern part of Germany, Poland, Lithuania, Latvia, and Estonia (the Southern Peribalticum area), were followed by sedimentological analyses (logging, lithofacies analysis, grain size analysis, structural analysis), microstructural analysis, OSL datings, and numerical modelling of glaciation-induced stress state changes with its possible implications for glacial isostatic adjustment (GIA)-induced earthquakes.

We interpreted the continuous layers with liquefaction-induced soft-sediment deformation structures (i.a. load structures, injection structures) interbedded by undeformed sediments as seismites in glaciolacustrine, lacustrine and fine-grained fluvial sediments of Pleistocene-age in ten study sites (three study sites in Poland, one study site in Germany, two study sites in Lithuania, one study site in Estonia, and three study sites in Latvia).

Results of sedimentological studies, stratigraphical and geochronological data in relation to the broader geological context led us to the following conclusions: 1) seismic activity of low to moderate magnitude did accompany Saalian and Weichselian glaciations and occurred in different periods of the glacial cycle – during or after the deglaciation and during ice-advance periods; 2) earthquakes caused by the reactivation of deeply-rooted pre-Quaternary faults due to glacially-induced stress state changes (loading/unloading by the Scandinavian Ice Sheet masses) were in most cases proposed as a source of the interpreted seismic activity; 3) in some cases, glacial earthquakes caused e.g. by large-scale stick-slip motion were also discussed as a possible source of seismic activity.

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Physical volcanology of the lava flows and associated interflow horizon at Toki section, South Georgia

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The Javakheti Volcanic Province is situated in the central part of the Lesser Caucasus mountain ranges consisting of a sequence of volcanics erupted from Neogene to Quaternary, most of which erupted during the Pliocene epoch. The volcanics form a part of continental flood basalts that are spread across southern Georgia, central and northern Armenia and NE Turkey called South Caucasus Province. Despite an active research by Georgian and foreign workers in this province, documentation of the physical volcanology of these widespread basalt lavas seems to be poorly undertaken.The present work included lava flow mapping of critical sections exposed in the gorges of Kura (Mtkvari) and Paravani rivers with special emphasis on accurate documentation of physical volcanology of the lava flows and interflow horizons. The results of recent investigations have revealed some fundamental inconsistencies between the available and recently obtained data. According to previous work carried out by numerous researchers, the number of the lava flows at Toki site varies from 24 to 62. Besides, in all mentioned publications is emphasized that no evidence of erosion surface, paleosol development, or sedimentation has been observed between these lava flows. However, our recent studies revealed that there are only four compound pahoehoe lava flows comprising numerous lobes, which were erroneously considered as separate lava flows by previous researchers. The lowermost two lava flows are separated by 1.5m thick interflow horizon of lacustrine sediments. According to published data, the K-Ar ages of lower basalt flows at Toki are 3.22–3.11 Ka, while the ages of the upper basalts are defined as 1.74–1.54 Ka. The discovery of the interflow sedimentary horizon therefore explains the time gap between these lava flows.

Ichnological-sedimentological indicators of deep-sea environment in Lower Eocene deposits of the Borjomi region (Georgia)

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The present study focuses on the results of integrated ichnological-sedimentological analysis of the Lower Eocene strata in the Borjomi region on the steep, southern flank of the Borjomi Anticline (environs of Ardagani settlement, along the Borjomi-Bakuriani motorway (section Ardagani III)) undertaken in 2019. The study area belongs to the central part of the Achara-Trialeti Fold-and-Thrust Belt. The extensional (rift) Achara-Trialeti Basin was formed in the Late Cretaceous–Paleocene–Eocene within the Transcaucasian Massif (island-arc system). The Borjomi area is the typical locality for the Paleocene-Lower Eocene Borjomi Flysch/Borjomi Suite. According to its lithofacies architecture, the formation could be subdivided into five members: 1) lower shaly member; 2) sandy-rich member; 3) middle shaly member (according to historic subdivision, these three members form the Paleocene (Thanetian) Tusrebi Suite); 4) volcanogenic-sedimentary member (Boshuri Suite) and 5) upper shaly member (Bolevani Suite). The latest two members are dated to the Lower Eocene (Ypresian). According to previous studies, the Lower Eocene part of the Borjomi Flysch was deposited under shallow marine and hemipelagic conditions.

Recent studies revealed that the volcanogenic-sedimentary member contains rich volcanic material in deformed (slumped) sediments and related debris flow deposits, graded sandstones (typical turbidites), and amalgamated and interbedded massive sandstones. Following trace fossils have been identified in these deposits: Chondrites intricatus (Brongniart), Ch. targionii (Brongniart), Nereites irregularis (Schafhäutl), Ophiomorpha anulata (Książkiewicz), O. rudis (Książkiewicz), Planolites isp., Scolicia strozzii (Savi & Meneghini), Spirophycus bicornis (Heer), Thalassinoides isp., Trichichnus linearis Frey. This member is characterized by low ichnodiversity and domination of post-depositional trace fossils, which could be indicative to channel off-axis (intrachannel or the channel-lobe transition) environment.

The upper part of the upper shaly member is formed by deep-sea heterolithic deposits (thin alternations of turbidites with pelagites/hemipelagites). Their trace fossils include: Belorhaphe zickzack (Heer), Chondrites intricatus (Brongniart), Ch. targionii (Brongniart), Cochlichnus isp., Halimedides isp., Helmintopsis isp., Helmintoraphe isp., Megagrapton submontanum (Aspeitia Moros), Ophiomorpha anulata (Książkiewicz), O. rudis (Książkiewicz), Paleodictyon arvense, P. goetzingeri, P. minimum, Planolites isp., Protopaleodictyon incompositum Książkiewicz, Scolicia strozzii (Savi & Meneghini), Spirophycus bicornis (Heer), Thalassinoides isp., Trichichnus linearis Frey, and Urohelmintoidea appendiculata (Heer).

The dominance of graphoglyptids indicates the Paleodictyon subichnofacies of the deep-sea Nereites ichnofacies, which is most common in deep-sea fan environments, such as the channel margin, depositional lobe or fan fringe.

The section Ardagani III shows an overall thinning-and-fining upward trend. Deposition took place in channelized submarine fan system. Defined facies types were formed from various sediment gravity flows (high-and low-density turbidity currents) and hemipelagic deposition in a deep-sea submarine fan environment (from slope canyon to the distal basin floor). Slumps as well as associated debrite-turbidite deposits have been documented in Paleogene formations of the Achara-Trialeti Fold-and-Thrust Belt. They evidence sudden events of slope instability related to extensional (syn-rift) tectonism and volcanic activity.

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Sediment Budget modelling of coastal defense during the Anthropocene

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Assessment of the anthropogenic sediment budget is a key issue for sustainability of coastal zone management. In the present study we analyze the Northern Tuscany (Italy) littoral cells, that is composed by both natural and highly urbanized coastal area. Erosion and accretion processes are described as well as the human interventions carried out to mitigate coastal erosion processes (groins, breakwaters, emerged and submerged barriers, geo-containers, etc).

In the study area, sedimentation is concentrated in a convergent zone and updrift of port structures. Sediment deposition have determined a series of actions, from offshore dumping and disposal into confined facilities (sediment output), to bypassing and redistribution interventions (sediment transfer); conversely, river mouths and coastal areas protected by groins and breakwaters are subjected to severe erosion and shoreline retreat, resulting in many beach nourishments (sediment input).

The anthropogenic sediment budget has been calculated as an algebraic sum of sediment inputs, outputs and transfer (m3) within a 40 year time interval (1980–2020). A negative anthropogenic sediment budget is documented. The majority of soft coastal protection interventions were carried out to redistribute sand from one site to another within the study area, while the sediment input almost matched the sediment output in the considered time interval.

Our study confirm that sediment management strongly influences the sediment budget and, even if its evaluation is crucial to assess the efficiency of a coastal management policy, it is often difficult to quantify the anthropogenic contribution to sedimentary processes.

Different types of intervention are carried out by a variety of competent authorities over time (Municipalities, Provinces, Port Authorities), and the correct accountability of sediment budget is no longer known, or possible, for the scientific community.

Facies, sedimentary characteristics, and seismic geometry of carbonate delta drifts resemble carbonate ramps

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The facies and sedimentary characteristics of a Miocene carbonate delta drift is presented, based on seismic and well data from IODP Expedition 359 to the Maldives. In contrast to siliciclastic drift bodies, this carbonate sediment drift system has an important contribution from shallow water in-situ carbonate production. The internal stratal architecture of the delta drift consists of sigmoidal clinoforms that thin out towards proximal and distal settings. The outer shape of the delta drift is lobate. Diagnostic criteria of the delta drift deposits are as follows: Proximal settings are characterized by coarse-grained facies with abundant shallow-water components; Proximal facies belts are grain-supported in contrast to the distal, micrite-rich facies; The main shallow-water components of the deposits are large benthic foraminifera (Amphistegina, Cycloclypeus, Lepidocyclina, Operculina, Heterostegina), fragmented red algae and bryozoans, equinoid debris, and Halimeda plates; Fragmentation of bioclasts is intense; Large channels and bigradational intervals are representative sedimentary structures. The delta drift presents signatures of tractive bottom currents and from gravity flows with development of cyclic steps. Condensed intervals in the succession may result from winnowing by enhanced bottom-current activity. We propose that our study object in the Maldives archipelago is not a singular case. Similar settings and situations are given in many carbonate platforms, such as for example seaways between individual banks, where current reworked sediments accumulate on the downcurrent sides of the passages. We therefore propose to critically test cases where similar platform configurations were described. For example, in absence of a three-dimensional control of the depositional geometries, a two-dimensional section of a carbonate delta drift may be mistaken to present a ramp depositional system.

Shifting shallow-water carbonate factories in the Eastern Mediterranean's Miocene

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The accumulation and bioconstruction patterns of shallow-water calcifying organisms in the Mediterranean realm have changed dramatically from Tethyan times to the modern, much of it during the Miocene. Unfortunately, there are very few sites where the entire succession across the Miocene can be observed in shallow water facies. Due to this much of the narrative had to be reconstructed from quilt work of records at different sites across the Mediterranean. The Eratosthenes Seamount (ESM) is one of these rare sites where a combination of scientific and industrial 2D seismic lines offers a unique opportunity to trace the changes in geometries of shallow-water carbonate accumulations and platforms across the Miocene. Moreover, recent analyses of ODP Site 966 and newly published data from the adjacent Levant basin offer a detailed stratigraphic framework to contextualise these changes.

Detailed analysis of the seismic facies present in the ESM block reveals two marked changes in character across the Miocene. The early Miocene is characterized by a well-developed and large flat-topped carbonate platform that stretches over the entire ESM block. The middle Miocene sees a decrease in the size of this platform and transition to a grain-dominated production carbonate factory mode marked by large clinoform bodies. During the late Miocene, carbonate platforms are reestablished, although smaller than their older counterparts. This reestablishment of platforms also occurs in other localaties in the region including Cyprus and Malta, where the former develops coral rich platforms and the later still exhibit coralline rich acumilations of the same character encountered in the ESM during the middle Miocene.

We suggest that these changes in geometry and production modes of the ESM carbonate factories during the Miocene are a manifestation of the Mediterranean's changing oceanographic and climatic conditions. The transition to a grain-dominated environment was driven by the shift to less stable conditions during the termination of the Indian Ocean connection. Once more stable conditions were established, steep platforms were able to readjust, but were not as successful in the cooler and more oligotrophic settings.

Sedimentary environment of upper Olenekian (Triassic) phylloid algal limestones in the Holy Cross Mountains, Poland

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In the late Olenekian (late Early Triassic) the Holy Cross Mountains (HCM) were located in the SE part of the semi-closed Germanic Basin, which was connected with the Tethys Ocean through the Silesian-Moravian and East-Carpathian gates (Szulc, 2000 and references herein). The late Olenekian marine transgression contributed in development of normal marine carbonate platform in the southern and western margin of the HCM (Trammer, 1975), which passed westward and northward into more restricted settings, that is a semi-closed evaporitic basin with clastic sediments at its periphery. A conspicuous facies of this platform are phylloid algal limestones occurring in the western part of the HCM. They form up to 10 m thick section consisting of thick to thin-bedded calcarenites and calcisiltites, which show hummocky cross stratification, large-scale cross bedding, rare current ripples and scattered large intraclasts in some layers. In the microfacial terms the Olenekian limestones from the HCM can be classified as algal grainstones or mixed grainstones/packstones since their main components are densely packed thalli of phylloid algae. They are largely preserved as abraded and rounded grains or curled and flat-lying undulatory forms with internal structure obliterated due to pervasive calcite recrystallisation and micritisation. Fragments of phylloid algae are accompanied by subordinate gastropods, bivalves, ostracods, crinoids, peloids and rare initial ooids. A common feature of these microfacies is early diagenetic marine cement including thin rims of fibrous to bladed calcite crystals developed on bioclasts. Sedimentological features of studied limestones provide evidences of their deposition under intense seawater circulation due to wave and storm activity on a shallow carbonate platform. Rare events of extremely strong erosional activity produced thin horizons consisting of large intraclasts. The marine ecosystem of upper Olenekian phylloid algal limestones from the HCM seems to be similar to the modern submarine algal meadows with a specific benthic community and unique trophic structure. Their lateral extent and skeletal composition allow to assume that they represent a few meter-scale build-up, or its marginal part, formed on the late Olenekian carbonate platform by the hydrodynamic accumulation of algal debris. This build-up shows a strong similarity to the late Palaeozoic and modern algal mounds developed at platform margins.

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Fluvial morphometric analysis of modern and Quaternary-rivers of the Sarawak basin in a source-to-sink framework

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Central Luconia is located along the eastern margin of what is currently the world's largest tropical epicontinental sea (the Sunda Platform) and adjacent to a Neogene fold-thrust belt (NW Borneo). Since extensive carbonate deposition in the Middle-Late Miocene, much of the area has been dominated by fluvial siliciclastic sedimentation (Pliocene to present-day), sourced from the uplifted fold-thrust belt. However, the morphology, style, and relationship of these paleo-rivers to their modern equivalents remains unclear; and the controlling factors that caused a significant supply of sediment to the area are poorly understood. This study attempts to understand the longer-term evolution patterns of both Quaternary and modern rivers in the region within a source-to-sink framework. Quaternary fluvial systems in the Central Luconia area were mapped and evaluated using three-dimensional seismic data, two-dimensional high-resolution seismic data, and shallow boreholes (~130 m thickness) imaging the shallow subsurface. Seismic horizons were interpreted semi-automatically using Paleoscan covering an interval of stratigraphy of 100 ms TWTT to 300 ms TWTT (~160 m) thick beneath the seabed (~120 ms TWTT). Seismic attributes were evaluated to establish their seismic-geomorphological significance and to determine the fluvial architecture of the Quaternary succession. Modern rivers in Central Sarawak (NW Borneo), corresponding to the likely source zone, were analysed using 30 m ASTER DEM and satellite imagery. The planform morphometric parameters of both mapped Quaternary paleo-rivers and their modern equivalents were quantified. Measured variables included: (i) channel width (CW); (ii) meander belt width (MBW); (iii) meander wavelength (ML); (iv) channel length (La); (v) sinuosity (SI); (vi) radius of curvature (RC) and (vii) channel orientation (CO). In the seismic data, we detect incised valleys at 160 to 180 ms TWTT, meandering channels at 160 to 150 ms TWTT, and tributary channels at 140 ms to 130 ms TWTT beneath the seabed. The Quaternary meandering channels are highly sinuous (SI: 1.3 to 1.5) and ~200 m to 500 m wide. In comparison to the meandering modern river in Sarawak (i.e. Baram river), the modern river width is narrower (~80 m to 300 m) than the Quaternary channels. The main result suggests that Quaternary fluvial channels on the Sunda platform likely had greater water discharge than their modern equivalents; we evaluate the extent to which their morphology reflects changing sediment discharge over time.

Searching for reliable redox proxies: constraints from a multi-method investigation of Silurian marine mudstones

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Various sedimentological, biotic, mineralogical, petrographic, and geochemical (inorganic and organic) proxies are employed for paleoredox reconstructions in ancient marine basins. Most of these proxies were discovered in modern settings and were subsequently applied to ancient rocks based on the actualistic approach. However, modern sediments are hardly modified by diagenesis, whereas ancient rocks usually have complex diagenetic histories and have experienced strong alterations during million to billion years-long post-depositional evolution. Since the redox conditions may be different in the bottom water and below the seafloor, the original marine redox record may be overwritten by the post-depositional effects. Yet, many studies dealing with reconstruction of paleoredox conditions are based on one or two proxies and the possible influence of diagenetic processes is not evaluated. Among the most controversial approaches, in our opinion, is the application of indicators based on redox-sensitive trace elements (RSTEs) using the thresholds established in the literature for various elemental ratios, such as V/(V+Ni), Ni/Cr or Mo/U, without checking for potential diagenetic imprint or without confronting them with other paleoredox proxies.

We have applied several widely-used paleoredox proxies to the Silurian marine mudstones from Poland, which were deposited during fluctuating redox conditions and experienced early-diagenetic modifications. Our intention was to check which of the proxies applied provide a reliable paleoredox indication and which were modified (and how) by diagenesis. The foundation of our work was the high-resolution study of sedimentary features and trace fossils associations, which were used as the reference of redox conditions occurring at the sea bottom. Several paleoredox facies were distinguished ranging between fully anoxic to well-oxygenated. Among the intermediate facies, one was formed by quickly fluctuating redox conditions resulting in "zebra" intervals, whilst other by deposition under anoxic conditions and subsequent reoxygenation of the sediment after a switch to well-oxygenated conditions resulting in dark-colored sediment with burrows filled with light-colored material. We have analyzed TOC and TS contents, C and N isotope ratios in organic matter, S isotope ratio in pyrite, bulk-rock major and trace element concentrations, and the size of pyrite framboids.

Pyrite-based proxies appear to preserve the original redox record despite the diagenetic overprint. Indicators based on RSTEs exhibit values, which do not agree with the actual paleoredox conditions at the sea bottom in case of the intermediate paleoredox facies. We show that during rapid redox changes in the basin, diagenetic leaching lead to depletion of many RSTEs, which was rather predictable. Surprisingly, some of RSTEs exhibit anomalously strong enrichment, which is explained as a result of leaching and subsequent re-immobilization during switching of redox conditions. This work shows that a reliable paleoredox reconstructions based on the distribution of RSTEs requires: (1) application of another robust proxy, (2) high-resolution sampling, (3) detailed sedimentological and diagenetic study of the material, (4) avoiding intervals affected by drastic redox fluctuations.

Evolution of the Guerrero-Morelos carbonate platform (Mexico) during the Cenomanian–Turonian oceanic anoxic event 2

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The Guerrero-Morelos carbonate platform (southwestern Mexico) is one of the rare platforms that persisted throughout the Cenomanian–Turonian oceanic anoxic event 2 (OAE 2). This study is based on the detailed evolution of this carbonate platform using high resolution micropaleontological, mineralogical and geochemical approach.

Our results exhibit several key-points allowing a better understanding of the response of shallow carbonate platforms to the OAE2 :

– A well-developed carbonate platform occurs in a shallow tropical sea environment with rudists and large benthic foraminifers before the carbon isotopic positive excursion, which characterizes the OAE2. Shells and skeletons are mineralogically quite diverse, from aragonite (e.g. rudists, green algae) to low and high magnesium calcite (e.g. echinoderms, miliolids).

– The onset of the positive d13C excursion coincides with a remarkable karstified surface, which corresponds to an emersion (SB Ce5) suggesting a ca. 40m sea-level drop.

– During the OAE2 interval, the establishment of depleted oxygen conditions is highlighted by extensive stromatolites deposition, organized in regular laminations made of low magnesium calcite. An short-lived reestablishment of more oxic conditions marked by return of benthic foraminifera like the miliolids is observed towards the top of these deposits.

– Just above the Cenomanian-Turonian boundary, the return to more oxygenated conditions is evidenced by the occurrence of an open-marine fauna dominated by echinoderms made of calcite or low magnesium-calcite.

– During the basal Turonian, the carbonate platform returned to a more open and oxygenated environment, with the reappearance of pre-OAE microfauna, but without the large benthic foraminifera, which did not survive. The definitive drowning of Guerrero-Morelos carbonate platform took place after in the Early Turonian, well above the end of the d13C shift.

These data suggest that during OAE2, the Guerrero-Morelos carbonate platform was marked by low oxygen mesotrophic conditions and potential acidification leading a change of the faunal and floral calcifiers.

Vertebrate preservation during the Toarcian oceanic anoxic event in the Grands Causses Basin (southern France)

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Several specimens of marine vertebrates have been yielded during paleontological excavations realized by our group in Toarcian shales (Lower Jurassic) of the Grands Causses Basin in Roqueredonde (Hérault, France). The newly discovered specimens are partly or entirely preserved in anatomical connection and include a partial ichthyosaur skeleton with soft tissues and a thalattosuchian longirostrine marine crocodile. Bulk and clay mineralogy, Rock-Eval pyrolysis, phosphorus and mercury contents analyses have been performed in order to replace these findings in a well-defined temporal and paleoenvironmental context, and hence constrain the factors that led to their remarkable preservation. The fossiliferous section exposes a 3 m-thick upper Pliensbachian interval of marl and nodular carbonate beds, overlain by a 3 m-thick interval of lower Toarcian laminated shales and limestone beds. High-resolution ammonite biostratigraphy, combined with inorganic and organic carbon isotope chemostratigraphy, shows that the fossiliferous Toarcian strata were deposited at a time of global warming and major carbon cycle perturbation known as the Toarcian Oceanic Anoxic Event (T-OAE). The studied succession shows several similarities with the classical coeval fossiliferous levels of the Posidonia Shale in SW Germany, including high organic matter and hydrocarbon contents as well as extremely reduced sedimentation rates. These results indicate that the unusual richness in well-preserved vertebrates of the studied site can be explained by a combination of warming-induced, low salinity and stratified waters, prolonged seafloor anoxia and reduced dilution by low carbonate and terrigenous input due to rapid sea-level rise. Significant peak in mercury at the base of the T-OAE interval is observed, consistent with that recorded in several coeval sections (e.g. Portugal, Morocco, Argentina, Chile). This mercury anomaly, most likely resulting from intense volcanic activity Karoo-Ferrar large igneous province, suggests that widespread exceptional vertebrate preservation during the T-OAE was initiated by a suite of severe environmental perturbations ultimately triggered by intense volcanic emissions.

Change of conodont assemblages before the Smithian-Spathian (Early Olenekian) extinction in South Primorye

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The middle and upper parts of the lower substage (Smithian) of the Olenekian Stage in South Primorye are represented by two ammonite regional zones: Nevolini and Shimanskyi. The first of them correlates with the regional zones of Compressus, Pilatoides, Multiplicatus and Angustecostatus of the Salt Range (Pakistan) and the Spiti region (India; Bruhwiler et al., 2012), and the second with the Distructus, Postarius, and Sinuatum of these regions. At the boundary beds of the Nevolini and Shimanskyi zones in South Primorye, a negative δ13Corg excursion was found, accompanied by a negative δ15N one (Zakharov et al., 2018). Similar results were reported from various localities worldwide. Besides, the latest Smithian is marked by a major shift in climate, changing from hot to cool conditions (e.g., Romano et al., 2012). A number of researchers (e.g, Galfetti et al., 2007; Thomazo et al., 2019) associate the reduction in the taxonomic diversity of ammonoids and the subsequent extinction of many of their groups at the end of the early Olenekian with a sharp change in their environmental conditions, which are reflected in C-, O -, N- and S-isotope events. However, the question connected with the change of conodont assemblages at the end of the early Olenkian is raised by us for the first time.

According to the anology with ammonoids, the conodonts of the Nevolini Zone in the Western and Eastern SMID and Artyomovka sections of South Primorye are distinguished by their relatively high taxonomic diversity (about 29 species of 15 genera; Burij, 1979; Bondarenko et al., 2013) and abundance. Scythogondolella milleri (Müller) dominates at this stratigraphic level (Milleri conodont Zone). Depending on the facies, the abundance and taxonomic diversity of conodonts vary significantly from section to section in South Primorye region.

In the uppermost Smithian Shimanskyi Zone, the taxonomic diversity and abundance of conodonts in South Primorye are sharply reduced (about 7 species of 5 genera), which we associate with change in both global and local environmental conditions. In the Nevolini and Shimanskyi zones a number of conodont species are common (e.g., Ellisonia triassica Müller, Furnishius triserratus Clark). Of the species in the Shimanskyi Zone, of particular interest are the following, so far known mainly in the upper substage (Spathian) of the Olenekian: Neogondolella jubata Sweet, Novispathodus aff. pingdingshanensis (Zhao and Orchard) and others. Neogondolella jubata and Novispathodus aff. pingdingshanensis, common for lower Spathian Tirolites-bearing beds, were found in the Shimanskyi Zone in association with typical late Smithian ammonoids (Shimanskyites shimanskyi Zakharov et Smyshlyaeva, Xenoceltites? subvariocostatus Zakharov et Smyshlyaeva, Arctoceras subhydaspids (Kiparisova)).

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Drone-based photogrammetry: new insights for sequence stratigraphic interpretation of a Jurassic oolitic ramp (Amellago, Morocco)

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The Amellago cliffs are considered a world class reference outcrop for oolitic carbonate ramp systems with a seismic-scale, continuous and structurally undeformed geometry. Located in the southern High Atlas in Morocco, this Lower to Middle Jurassic ooid-dominated ramp system is exposed along a 37 km long series of steep cliffs allowing for reliable geological interpretation. The geological setting and the scale of this outcrop make it a good example to investigate multiscale sequence stratigraphic architecture of oolitic ramp systems. However, limited accessibility to some parts of the cliffs remains a challenge for conventional fieldwork to unravel the 3D architectural complexity of this sedimentary system.

The development of drone technologies in the last decades, followed by the improvement of image processing, photogrammetry and interpretation software, allows for the accurate determination of 3D stratigraphic architecture. A 15km linear section drone-based photogrammetric model covering the inner to outer ramp was acquired along the Amellago cliffs. This study describes the workflow and results of the model interpretation based on the integration of datasets from fieldwork and literature. While previous studies have detailed the sequence stratigraphy and architecture of the Amellago Formation, a detailed mapping from high-resolution drone-based photogrammetric model enabled the refinement of pre-existing sequence stratigraphic architecture. This work resulted in an updated scheme at dm-resolution, sequence terminations, thickness, and facies variations along the proximal-distal profile of this oolitic carbonate ramp.

A two-scale approach using a 3rd order stratigraphic (x 1myr) sequences and High Frequency cycles (HF cycles – x100 kyr) is proposed in this study. Two 3rd order sequences have been mapped and both evolve from a tabular geometry in transgressive stages to slightly inclined (0.1°) geometries in regressive stages. Thickness variations on the proximal-distal profile were quantified by serial digital logs, which have been calibrated to fieldwork data. A thickening downward sequence is only observed during regressive stages for each sequence (20m and 30m, respectively). Each 3rd order sequence is subsequently divided into HF cycles. The two studied 3rd order sequences comprise 11 and 10 HF cycles, respectively. The architecture and geometry of these cycles show a complex nature and organisation of their Maximum Regressive Surfaces, corresponding to various onlap, toplap and downlap surfaces. Furthermore, the detailed mapping of these surfaces resulted in the identification of HF systems tracts. Transgressive system tracts are poorly developed in the middle and outer ramp domains, while prograding wedges are better developed with the presence of Highstand, Falling Stage and Lowstand system tracts.

Thanks to the highly detailed photogrammetric acquisitions and interpretation of the Amellago Formation, a more accurate reconstruction of the sequence stratigraphic architecture (3rd order to HF cycles) and associated facies partitioning can be proposed. This type of dataset, when acquired along a seismic scale cliff outcrop, leads to the improvement of our understanding of sedimentary and stratigraphic dynamics in carbonate ramp systems.

Coupling Global Paleoclimate models to Carbonate Sequence Stratigraphy

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Carbonate sequence stratigraphy principles imply the links among carbonate stratigraphic architectures, topography, accommodation and carbonate sedimentary fluxes to be established as a function of time. In general eustatic sea-level change –one of the accommodation parameters together with subsidence– is the main focus of carbonate sequence stratigraphy studies to the expense of of carbonate sedimentary fluxes and subsidence. Despite the obvious difficulty to reconstruct sea-level variations based on carbonate sedimentary records, eustatic sea-level changes are abundantly interpreted as the most critical driver of carbonate sequence stratigraphic systems in the Phanerozoic. This is probably because "eustatic sea level change" is generally confused with "relative sea level change". The latter corresponds to accommodation (volume over time) and is known not to be spatially uniform. The overall consequence of such study bias is that most carbonate sequence stratigraphic architectures are matched exclusively to eustatic sea-level curves without referring to topography, subsidence or sedimentary fluxes, or even worse, by assuming those as constant parameters through space and time.

These fundamental methodological issues arise from a combination of factors: (1) the existence of extensively published eustatic sea-level curves for the Phanerozoic, (2) the well-established glacio-eustatic control on recent and modern carbonate sedimentary systems, (3) the complexity of inverting all controlling parameters from carbonate sedimentary records and subsequently integrating non-unique solutions, (4) the lack of global carbonate production curves through the Phanerozoic in relation or not to carbonate factory evolution and climate changes and (5) the poor knowledge on paleo-oceanographic drivers of the marine carbonate production. Furthermore, the control of geodynamic changes on carbonate stratigraphic architectures is generally ignored or misinterpreted. In summary, strong methodological issues arise from the combined intrinsic complexity of carbonate stratigraphic systems and the poorly documented contribution of factors other than eustatic sea level (points 4 & 5).

Variations in carbonate production rates through space and time probably constitute the most critical parameter overlooked in carbonate sequence stratigraphic studies. Recent works highlighted the links between paleoclimate changes and carbonate platform extension during the Cretaceous and Oligo-Miocene. It is also possible to model variations of the distribution of carbonate factories in space and time in response to paleoclimate changes, which constitute a critical driver of carbonate production. We here build on these pioneering studies and propose to couple paleoclimate models to carbonate sequence stratigraphic models in order to estimate carbonate production changes at the global scale through time. We test this innovative approach on Neogene and Cretaceous case studies. We show that paleoclimate modeling can improve our understanding of carbonate sequence stratigraphic systems by adding semi-quantitative external constraints other than eustatic sea level. The ultimate goal is to derive global and regional carbonate production trends on dedicated stratigraphic intervals from reconstructed paleoenvironmental conditions (e.g., temperature, pCO_2, salinity, primary productivity). These trends will then be coupled with stratigraphic forward models to simulate different scenarios and (in)validate interpretations and estimate uncertainties of carbonate sequence stratigraphic models.

Sedimentological investigation of the famous dinosaur localities in the westernmost part of the Haţeg Basin

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During the fall of 2019, we devised and conducted several weeks of fieldwork around, Vălioara village in the westernmost part of the Haţeg Basin (Southern Carpathians, western Romania), in order to rediscover the historical dinosaur-bearing fossiliferous sites excavated by Ottokár Kadić at the beginning of the 20th century, as well as to survey the local successions of uppermost Cretaceous (Maastrichtian) deposits in detail and to search for new potentially bone-bearing horizons. Besides its palaeontological significance, the aim of the new field survey was to understand the sedimentological conditions under which the specimens of the historical collection were preserved, as well as to identify the palaeoenvironmental conditions represented by the rocks in/around these sites, information that can then be used in subsequent palaeoecological investigations. Overall, the uppermost Cretaceous continental deposits cropping out in the investigated area belong to the Densuş-Ciula Formation, and are interpreted to have been deposited within the confines of alluvial fan and braided river depositional systems. Previous sedimentological research in the Densuș-Ciula Formation focused mainly on the central-eastern parts of its outcropping area, but the sedimentary make-up of the successions exposed in more westerly areas was relatively poorly known until our survey. Our detailed stratigraphical and sedimentological investigations showed that these westernmost uppermost Cretaceous sedimentary successions near Vălioara are dominated by fine-grained, waterlogged, poorly–drained floodplains deposits, and better-drained, moderately to well-developed paleosols only become more common towards the upper part of the local succession. These types of changes seen in floodplain deposits of a braided fluvial system can be interpreted as follows: the sediments present in the lower part of the section were deposited near the main channel system, in areas characterized by higher sedimentation rates and relatively high water-table, resulting in more hidromorphic conditions. Meanwhile, the fine-grained sediments from the upper part of the succession point to floodplain positions farther away from the main riverbeds, characterized by a limited sediment input and well-drained conditions during paedogenesis. A similar west-to-east lithofacies change also appears detectable at a larger spatial scale in the sedimentary succession of the Densuş-Ciula Formation, where the western parts are characterized by a dominance of overbank deposits accumulated in poorly-drained floodplains, whereas well-drained floodplain deposits dominate in the more eastern part of the outcropping area. Since based on the strike and dip of the beds in the investigated area (as well as across the entire outcropping area of the Densuş-Ciula Formation) the deposits of this unit become younger towards the east, the detected lithofacies shift represents a time-progressive change during the basin evolution. The investigated part of the Haţeg Basin hosts some of the most important Late Cretaceous vertebrate-bearing localities of Europe consisting of several types of bonebeds preserved in different palaeoenvironmental settings, thus detailed stratigraphical positioning and correlation of the different facies types of the Densuş-Ciula Formation is extremely important and may contribute to a deeper understanding of the evolution and palaeoecology of the Haţeg vertebrate faunas during the latest Cretaceous.

Rare-earth element geochemistry in vertebrate fossils: a tool for determining depositional environment

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Fossil bioapatite has a strong affinity for the rare-earth elements (REE), which are only sparingly present in body fluids, but soil and pore waters often contain somewhat larger concentrations of these elements. When bones and teeth exposed to these during fossilization, the concentrations of REEs increase dramatically in a relatively short time, hence the buried remains record fingerprints or signatures diagnostic of the burial environment. Based on these listed features, fossils in different depositional settings inherit different REE composition and thus variations in the REE signatures within a bonebed can be used to infer the depositional environment contributing to more detailed palaeoenvironmental reconstructions. Fossils from several important vertebrate localities from different well-characterised and dated terrestrial and marine fossil localities, ranging in age from Cretaceous to Miocene, are analysed to determine how the REE composition can be linked to different palaeoenvironmental settings. The REEs can be subdivided into light (LREE), middle (MREE), and heavy (HREE) rare earth element groups based on their ionic radius. In the terrestrial environment, the HREE are preferentially mobilised as dissolved or colloidal complex, and thus they remain in solution and migrate with pore waters to river waters and run-off, whereas the LREE are preferentially retained within the weathering profile or are adsorbed onto particle surfaces. We investigated several terrestrial vertebrate fossils from different bone accumulations of the Late Cretaceous, Densuș-Ciula Formation (Romania) in order to determine how the REE composition of fossil bones vary depending on whether they fossilized in channel-fills, well-drained or poorly-drained paleosols. The REE signatures in the natural water are highly variable between the marine and the terrestrial environments, where the seawater are characterized by a strong HREE enrichment and negative Ce-anomaly, in contrast, the river waters are relatively enriched in MREE and LREE. However, the REE composition of transitional environments (e.g., estuaries, lagoon or tidal flat) is less known. Therefore, we also investigated the REE composition of bones deposited in a self-region (Ambug Hill, Borneo; late Miocene as well as Danitz-puszta locality; Hungary; middle Miocene) and a tidal-flat (Máriahalom, Hungary, early Miocene) palaeoenvironments in order to detect how the freshwater input affects the REE compositions incorporated into bones.

Geochemical constraints to the Paleogene provenance and tectonic setting of Pindos Foreland Basin, western Greece

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The Pindos foreland basin is an elongated, NW-SE trended and parallel to the Pindos Orogen depocenter that is bounded to the east by the Pindos thrust and to the west by the Ionian thrust. Further, other internal thrusts, such as Gavrovo, internal and middle Ionian thrusts complicate the basin development. The Upper Eocene – Lower Oligocene sedimentary fill in the basin is represented by submarine fan deposits. These sedimentary rocks have been petrographically and geochemically analysed, adding additional constraints to their origin and tectonic setting. This study also reveals the sedimentary processes, such as weathering, sorting and recycling that influenced the deposition of the sediments.

Prior to sample collection, systematic field work was conducted to define the sedimentary processes, depositional environments and the stratigraphic evolution of the study area, assuring that the samples cover the entire sedimentary succession. Forty fine- to coarse-grained sandstone samples were collected for petrographic analysis. The thin-sections were analysed using a B-810 Series Optica Italy microscope. Characteristics, such as grain shape, types of mineral and rock fragments were utilized to define the detrital assemblages in the samples and reveal their provenance, using the Gazzi-Dickinson point counting method. Additionally, Cathodoluminescence was examined using a special cathodoluminescence microscope. Furthermore, forty mudstone samples were selected for geochemical analysis at ACME – Bureau Veritas Laboratories (following the ICP-OES and ICP-MS package methodology).

The petrographic analysis suggests that the sandstones are poorly to moderately sorted with angular to sub-rounded grains. The sandstones are mostly lithic arenites. Major, trace elements and REE are commonly used as proxies for the interpretation of paleoenvironment, provenance, tectonic setting, and other sedimentary processes. The results document high ICV and relatively low CIA values, indicating that the sediments are immature and underwent low to moderate degree of weathering. Further, the 15*Al2O3-Zr-300*TiO2 diagram suggests low levels of sediment recycling. All samples yield relatively high Al2O3/TiO2 ratios and have strong negative Eu anomalies. The LREEs/HREEs differentiation, combined with Th/Sc, Zr/Sc, La/Th and Co/Th ratios, document an intermediate to felsic source rock composition. The elevated Cr and Ni values, along with the high Cr/V ratios indicate the influence of a mafic source rock. This is further supported by the Cr vs. Ni and Cr/V vs. Y/Ni plots.

Provenance data, combined with published palaeocurrent measurements point to an NE to SE-positioned sedimentary source, which is represented by the Pindos Orogen. The chemical variation exhibited is probably the result of mixing between a dominant continental source (Pindos sedimentary units) and a mafic source (Pindos ophiolites). Conglomerates are composed of chert, limestone and sandstone fragments, suggesting this mountain belt as a likely source area. Multi-dimensional discrimination diagrams suggest an active continental margin and agree with the published sequence stratigraphic framework.

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The Mesozoic carbonate succession of the Ionian Basin in Kastos Island and NW Peloponnesus, Greece

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The Mesozoic-Paleogene Ionian basin is part of the external Hellenides orogen, bounded westwards by the Ionian Thrust and eastwards by the Gavrovo Thrust. From Triassic to upper Jurassic the basin was characterized by a pre-rift stage; whereas from upper Jurassic to early Eocene by a rift stage. During the rift-stage, the basin was sub-divided into sub-basins (internal, middle and external) due to synchronous activity of synthetic and antithetic normal faults that produced grabens and highs. The sedimentary successions of the Mesozoic sequence both in Kastos Island (external sub-basin) and in NW Peloponnesus (internal sub-basin) are incomplete, Jurassic to Eocene deposits were outcropped in Kastos Island and Cretaceous to Eocene deposits in NW Peloponnesus.

In Kastos Island on the bases of lithological and sedimentological characteristics, the depositional environments that have been recognized are deep sea and deep shelf environment, toe of slope-to-slope condition and open marine to restricted condition. More specifically, the lower Jurassic (Pantokrator limestones) deposits consist of wackestone-grainstone and locally boundstone (SMF18-19) accumulated in an open marine-restricted environment (FZ7-8). The lower Cretaceous deposits (Vigla limestones) were classified as mudstone/wackestones with planktonic foraminifera and radiolarian limestones (standard microfacies SMF1-3), indicating deep sea to slope environment (FZ1-4). In Early Cretaceous (Valanginian) the observed mudstone-wackestone, skeletan grains with fossiliferous biomicrite and spiculites (SMF3, SMF1) classified as deep-sea envrironment (FZ1). Calciturbidites of upper Cretaceous were classified as packstones with microbreccia and plaktonic foraminifera (|SMF4) in a slope environment (FZ4). The Paleocene deposits consist of with grain-supported wackestone-grainestone with biomicrites and skeletan grains. In addition, the Early Eocene deposits consist of a deep-shelf environment with wackestone-packstone biomicrites (SMF2).

In Araxos peninsula, the lower Cretaceous “Vigla limestones” were classified as wackestones with planktonic foraminifera and radiolarian limestones (standard microfacies SMF3), indicating a toe of slope or a platform margin environment (FZ4-FZ3). Upper Cretaceous microbreccia or breccia deposits include biopelmicrites with scattered benthic foraminifera and echinoderm fragments (SMF16); bioclastic rudstones or floatstone breccia with rudists and echinoderm fragments; and allochthonous biomicrites. Fenestral cavities and geopetal fractures in allochthonous material may indicate a source from a restricted or shallow shelf environment (FZ8) with the influence of meteoric water. Calciturbidites were classified as packstones with sorted fragments of shallow water fauna including rudists, echinoderms and benthic foraminifera (SM 4) and interbedded or incorporated pelagic wackestones with radiolaria or planktonic foraminifera (SMF3), suggesting deep-water depositional conditions (FZ3-4). The same conditions apply also for the Paleocene pelagic wackestone calciturbidites containing planktonic foraminifera and radiolaria (SMF 3), corresponding to a deep shelf environment (FZ 2).

The above introduce many depositional changes across the Ionian basin and especially in NW Peloponnesus (Araxos peninsula) (interal Ionian sub-basin) during Cretaceous and many depositional changes in Kastos Island (external Ionian sub-basin) during Paleocene/Eocene. The above changes in depositional conditions could be related with different stages of tectonic activity in Ionian basin from E-W, and especially from one sub-basin to the other. It seems sedimentary condition during Cretaceous were different between Kastos Island and Araxos peninsula.

Geochemical analysis of the lower Cretaceous "Vigla Shales" in the Ionian Basin, Greece

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The Mesozoic-Paleogene Ionian basin is part of the external Hellenides orogen, bounded westwards by the Ionian Thrust and eastwards by the Gavrovo Thrust. From Triassic to upper Jurassic the basin was characterized by a pre-rift stage; whereas from upper Jurassic to early Eocene by a rift stage. During the rift-stage, the basin was sub-divided into sub-basins (internal, middle and external) due to synchronous activity of synthetic and antithetic normal faults that produced grabens and highs. The lower Cretaceous "Vigla shales" is suggested as a main source for hydrocarbon production in Ionian basin, according previous published works. Therefore, geochemical analysis took place only in lower Cretaceous Vigla shales in b oth studied areas Kastos Island (external Ionian sub-basin) and NW Peloponnesus (Araxos peninsula in Gianiskari coast) (Internal Ionian sub-basin). Vigla shales ranges from 0–100m, due to the accumulation into asymmetrical subsided troughs and so on, it could be different organic carbon accumulation along and across the above asymmetrical troughs. Moreover, are composed by yellow marly or shally limestones and shales with chert intercalations, and red to green or locally black clay layers. The latter could be equivalent with the anoxic events of Selli (OAE1a) during the Aptian-Albian, Paquier Evet (OAE1b) of Early Albian age in the Ionian zone, and extends to Italy and Albania.

Seventeen (17) samples, from Kastos Island, and thirty-one (31) samples, from Araxos peninsula, were selected for further analysis. For the geochemical analysis ROCK-EVAL VI pyrolysis was used in order to show the content and quality of total organic carbon (TOC) for further analysis. The obtained data showed that TOC (0.02–3.45%) indicating good oil potential and a type II/III kerogen with the ability to produce liquid and gaseous hydrocarbons, for Kastos Island, and TOC (0.01–0.72%) with fair oil potential and type IV kerogen for Araxos peninsula. The procedure was followed for further analysis was the extraction SOXHLET, and the determination of biomarkers. Four samples from Kastos Island were capable to show values, and their results based on the Odd to even predominance, OEP(27–31), OEP(2) and OEP(1), an anoxic deposition environment was indicated. The fact that there is a great difference in geochemical indices between the two studied areas during the same period, probable different depositional conditions are suggested. It seems that, the richness in Kastos Island could be related with the neighboring Apulian Platform. On the other hand, the poorness in Araxos peninsula could be related with the Gavrovo platform. An additional problem for the above differences could be the fact that this two studied areas probably are not connected to each other due to the existing intrabasinal highs that developed at the beginning of the rift stage and there are not transfer faults to connect them. Although sedimentation in Vigla shales interpreted as pelagic and basin configuration influenced by synthetic and antithetic normal faults, it seems that the presence of few samples in both areas showing terrestrial input during sedimentation could be related with the neighboring platforms.

New sedimentological and stratigraphical data on the Permian and Triassic in northeastern Utah, USA

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We present the Permian to Triassic sedimentological evolution in the Vernal area, northeastern Utah, to determine: (1) the magnitude of the Permian-Triassic (P-T) unconformity, (2) the depositional environments above the unconformity, as well as (3) their evolution in space and time. Within this area, Permian deposits consists of the Weber Sandstone, which represents aeolian deposits, overlain by the Park City Formation, composed of silty and sandy marine limestones, dolomites and phosphatic shales. In some places, an unconformity is observed at the top of the Weber Sandstone, which is directly overlain by the Moenkopi Group. This formation is mostly composed of siltstone, with gypsiferous levels and ripple marks, deposited in nearshore continental to marine environments. Within the studied area, this formation is assumed to be Early Triassic. A second unconformity at the base of the Chinle Group truncates the Moenkopi Group. The base of the Chinle Group is characterized by the Gartra Formation composed of coarse-grained and conglomeratic sandstones that are stream and river deposits overlain by red beds that are stream (primarily floodplain) and lake deposits.

The P-T succession in northeastern Utah encompasses a profound unconformity and is not a complete succession that could be used to analyze P-T boundary extinctions. Detailed sedimentological analyses allow the characterization of the depositional environments across the P-T unconformity. The upper Permian deposits preserved below the unconformity show erosion or non-deposition in the Vernal area. Above the unconformity, sandstone facies including coiled and uncoiled nautiloids, as well as stromatolite mounds, which suggest an open marine environment and attributed to the Permian based on its faunal content. These marine deposits are abruptly overlain, above a breccia surface, by more classical Moenkopi facies attributed here to delta and turbidite facies overlain by sabkha deposits with gypsum and microbialites. The unconformity above the Moenkopi Group is overlain by either fluvial deposits of the Gartra Formation or red bed facies of the Chinle Group. This study also helps to define the relationships between the Gartra Formation, the red beds and the paleosols within the Petrified Forest Formation of the Chinle Group.

Cretaceous Black Shales in the Pacific: The Equatorial Position Hypothesis

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Although anoxia is rare in modern oceans, the marine stratigraphic record is punctuated by sedimentary and geochemical evidence for episodes of widespread oceanic anoxia. The last time in Earth history that a large volume of the ocean became anoxic was in the middle Cretaceous: black organic-carbon-rich muds were repeatedly preserved on the deep seafloor during oceanic anoxic events (OAEs).

Sedimentary and geochemical evidence for oceanic anoxia during OAEs comes mainly from the Atlantic and Tethys Oceans. Data from the Pacific Ocean, which was the largest ocean basin in the middle Cretaceous, is scarce and equivocal. Based on black shales deposited at depths of about 500–1500 m on seamounts, Monteiro et al. (2012) have suggested that at least 50 vol% of the ocean was anoxic at the climax of Cretaceous oceanic anoxia during the late Cenomanian. They also included a single black shale at DSDP Site 585 in the Mariana Basin as evidence for anoxia in the deep Pacific. We will show, however, that this is a mud turbidite reworked from shallower water.

For this study, we reviewed all available data and publications from scientific drilling that recovered Cretaceous sediments in the Pacific Ocean. The little available Cretaceous record from the Pacific consists mainly of well-oxidized sediments. The exceptions are black shales that occur at depths of about 500–1500 m on seamounts. Takashima et al. (2011) have shown that the Asian and North American continental margins of the Pacific were indeed oxic for most of the late Cenomanian OAE.

We used a new paleomagnetic reconstruction of the Pacific plate back to 150 Ma to show that all investigated Cretaceous organic-carbon-rich sediments in the Pacific Ocean were deposited while the site was located in the Equatorial Divergence Zone (10°S to 10°N). We therefore argue that organic matter deposition in the Pacific Ocean might not have been directly related to OAEs, but rather be associated with the passage of seamounts beneath the equatorial belt of high productivity.

Several authors have challenged suggestions that OAEs were characterized by globally pervasive anoxic deep water and pointed to the difficulty in sustaining whole-ocean anoxia, even in warm oceans. We agree and our results show that oceanic anoxia in the Pacific is a local phenomenon superposed on a global trend of expanded oxygen minima in the ocean.

Hot-springs through time: what changes, and what stays the same?

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Scientific studies of hot-springs have been carried out for at least two hundred years. Here we collate physical, chemical and biological data from Italian hot-springs to show what has changed, and what has apparently stayed the same over the last two centuries. Parameters that will be discussed include water temperature, pH, flow rate, elemental chemistry, mineralogy and biology as well as travertine growth rate. We will discuss the spatial and temporal scales on which 'syn-sedimentary' changes occur, ranging from seconds to centuries and thousands of years or longer. We will go on to compare our observations of Italian hot-springs with the fossil record of geologically ancient examples including the siliceous sinters of the Devonian Rhynie Chert (Aberdeenshire, Scotland, UK) famous for their fossil content, and Palaeoproterozoic dolomitic travertines of Fennoscandian Russia that lack any microbial fossils. Finally, we will ask whether the data we have collated from modern and Recent Italian hot-springs illuminates the question of why so few ancient (micro)fossil-containing hot-springs have been found.

Detailed sedimentology of the late-Ordovician Soom Shale Lagerstatte in South Africa

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The late-Ordovician Soom Shale Lagerstätte (Cedarberg Formation, South Africa) is perhaps best known for its rich, unique and exceptionally well-preserved fossils. The Soom Shale is 440 million years old and records a critical interval in Earth's climatic history in the immediate aftermath of the Hirnantian glaciation. The ecosystem lived in an unusually cold-water and intermittently anoxic environment – these conditions may account for the low diversity of the fauna and occasional gigantism of taxa, best seen in the conodonts.

To date research has focussed on the palaeontology of the fauna; the sediments that host the fossils are less well-understood. A single study recorded interbedded distal turbidites with a laminated facies displaying concentrations of out-sized clay and quartz clasts that are intimately associated with organic matter, possibly of algal origin. Such anomalous clasts in an otherwise typical shale were suggested to be the result of wind-blown material being deposited into the basin. However, this hypothesis has not been tested or scrutinised until now.

Here we employ detailed millimetre-scale logging of the sediment from cores, alongside thin-section textural analyses and micro-CT imaging to reveal that the unusual facies discovered in previous studies is persistent throughout the Soom Shale Member and into the lower Disa Member (~17 meters of core) and occurs at multiple localities, some of which are separated by over 200 kilometres along strike.

CT imaging shows the clusters of out-sized quartz grains possess a fairly circular shape in bedding-plane-view and are intimately associated with small (~3μm diameter) framboids. Elliptical clay bodies, occasionally lined by framboids, share the bedding planes with clusters. The facies thus appears to be unique and its origin remains enigmatic. We discuss various hypotheses including depositional processes operating with this palaeoenvironmental context as well as the unusual taphonomic conditions that led to the exceptional preservation of the Lagerstätte.

Holocene sedimentary evolution of the Po coastal plain (Italy) and its relation with differential subsidence

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Vertical land movements measured trough high-precision levelling, GPS and InSAR techniques point at human activities (water and gas withdrawal) as the main drivers of subsidence in the Po coastal plain. The anthropogenic signal tends to obscure the effects of natural processes. A detailed knowledge of late Quaternary stratigraphy and sedimentary evolution may help in the quantification of the natural component of subsidence, providing refined predictive tools for land management in a sea-level rise scenario.

The Po coastal plain experienced dramatic environmental changes during the Holocene in response to sea-level and climate oscillations. During the early Holocene (11.5 – 7 ky BP) a wave dominated estuary migrated landward, at the impressive rates of 10 m y-1, in response to the last pulses of post-glacial sea-level rise (melt water pulses 1B, 1c and 1d). Wide areas of the former alluvial plain were progressively inundated and converted into extensive freshwater swamps and salt marshes. Core-based stratigraphic and paleogeographic reconstructions revealed mutual relationships between estuarine sedimentary evolution and differential subsidence. The morphology of the flooded surface, which was modelled by differential subsidence, strongly influenced the distribution of inundated areas through time. The rates of natural subsidence are extremely variable across the Po coastal plain. Long-term subsidence rates (SR) were calculated over the last 1500 My based on the elevation of an unconformity identified in seismic profiles and corresponding to the first occurrence of Hyalinea Baltica in exploration-well cuttings. We also calculated subsidence on intermediate time scales (over the last 120 ky) using an extensive coastal sand body dated to the Marine Isotope Stage 5e as a refence marker bed. Comparison with deep stratal architecture highlighted the strict relation between differential subsidence and structural setting, characterized by the presence of buried Apennine thrust-related anticlines. Maximum subsidence rates away from the buried anticlines are in the range of 0.8–1.5 mm y-1. Minimum values of 0.3 mm y-1 were obtained above the anticline culminations. The distribution and thickness of highly compressible estuarine sediments, which were preferentially deposited away from the buried anticlines, enhanced differential subsidence. Based on a laterally extensive lagoon horizon, identified in shallow cores at depth < 20 m and dated to the last 5.6 ky, we calculated vertical land movements at the turnaround from estuarine sedimentation and Po delta progradation. Estimated subsidence rates fluctuate between 0.8 mm y-1 (above the anticline culmination) and 2.0 (in syncline depocenters) mm y-1. The late Holocene sedimentary evolution of the Po delta plain was mainly driven by autogenic processes, such as distributary-channel avulsion and delta-lobe switching. In this phase, topographic anomalies are primarily the result of depositional processes rather than differential subsidence.

Stratigraphic reconstruction of the Volturno river mouth: mandatory step to apply a reliable hydrogeological model

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Seawater intrusion (SWI) becomes a serious worldwide issue, especially within coastal aquifers where fresh groundwater resources are significantly threatened by saline water. This problem become more serious due to the combined effect of climate change, sea-level rise, land use changes, population growth and groundwater over-pumping through years. Numerical modelling is a useful and worldwide applied tool to understand and predict seawater intrusion. Nevertheless, such models require very specific information especially concerning deep geology and geometry to proper simulate the water flow through the saturated zone. For this purpose, a geomorphological, and stratigraphical reconstruction, for the application of a three-dimensional, groundwater flow and transport model has been realized to simulate and predict actual and future SWI. The study area is in the coastal floodplain pertaining to the Volturno River mouth, in the Campania Plain (Southern Italy). Morphologically the site is a low-lying area, with mean ground elevation above sea level of approximately 1–2 m. The stratigraphic architecture of the site has been reconstructed within 2 strikes sections, integrating several lithostratigraphic logs from boreholes reaching depths of 10 to 50 m below ground level. Different depositional environments have been recognized above the Campanian Grey Tuff (CGT) representing the main lithological facies of the whole Campania plain. A superficial alluvial and delta system mainly made by an alternance of fine sands and clay respectively, characterize the final stretch of the river lying on a beach barrier environment made of silty-fine and medium-coarse sands. Here is hosted the coastal aquifer where local silt lenses (0.5–1.0 m thick), generate semi-confined conditions. Prodelta deposits, has been identified between 18 and 25 m beneath the surface, witnesses of ancient marine flooding condition. This prodelta is characterized by silty-clay formation representing the underlying acquiclude. This reconstruction represents the starting point for the correct building of a hydrogeological conceptual model.

A global database-informed analysis of controls on submarine-canyon geomorphology

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Submarine canyons constitute important conveyors of sediments, nutrients, organic matter and pollutants between the shallow-marine and deep-marine environments, influencing the evolution of sedimentary systems and ecosystems, but also posing a potential geohazard due to intra-canyon slope failures triggering tsunamis and canyon morphology exerting control on tsunami propagation. Moreover, canyon fills, and linked submarine-fan and contourite-drift systems are important targets for hydrocarbon exploration. Despite intensive research efforts, the controls on submarine canyon-formation and long-term evolution are still not well understood. Global-scale canyon studies are limited in number and have only considered a small set of canyon morphometrics. Moreover, conceptual models accounting for submarine canyon-evolution are largely based on individual or regional studies.

The aim of the study was to investigate the role of autogenic and allogenic drivers on canyon geomorphology from the assessment of relationships between canyon morphometrics and external controls. For this purpose, a database of canyon geomorphology and controlling factors was built. Data was sourced from 290 globally distributed late-Quaternary submarine canyons, including literature-derived datasets of seabed and subsurface studies from 300+ publications and open-source worldwide bathymetry. The database includes key canyon morphometrics (e.g. dimensions, cross-sectional and planview shape, sinuosity, axial thalweg gradient, and sidewall steepness) and information on the physiographic setting (e.g. bathymetry, location of the canyon head relative to river mouths and to the shelf edge). In addition, the database records the configuration and physiographic setting of the catchment, shelf and slope (e.g. dimensions, gradient, process regime), margin configuration and type, oceanographic environment, latitude, climate and the location of the canyon with respect to eleven defined oceanic regions. Canyon morphometrics and parameters related to physiographic setting have been investigated from distributions and correlations, and as a function of the considered external factors. The statistical significance of the correlations has been evaluated with a number of statistical tests (e.g. Pearson's correlation coefficient and Spearman's rank correlation coefficient).

This study demonstrates that the interplay of controlling factors on canyon geomorphology is more complex than hitherto considered in published canyon models. Selected findings show that: (i) canyon morphometrics for the eleven oceanic regions have specific signatures, implying that canyon models based on regional case studies should not be regarded as universally valid; (ii) lengths, widths and depths of canyons in active versus passive continental margins do not show statistically different distributions, indicating that the type of continental margin does not constitute a principal control; (iii) the maximum canyon widths display statistically-distinctive differences as a function of latitude and oceanographic setting, but not when tested against canyon-head location and margin type, suggesting that the former controlling factors influence canyon width, whereas the latter do not; (iv) maximum canyon sidewall steepness shows high variability when tested against all investigated external controls, a strong indicator that it is controlled by multiple factors.

A global meta-study of shelf-edge delta architecture and geometry

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The genesis of shelf-edge deltas is often related to phases of marine regression during which fluvial systems have extended basinward to shelf margins. In some cases, this arises due to forced regression where relative sea-level fall drives the emplacement of river deltas at the shelf edge. This partly explains the paucity of modern (highstand) shelf-edge deltas. However, river systems can prograde to the shelf edge independently of sea-level change (i.e. normal regression) if shelves are narrow and sediment supply is sufficiently high. Additional factors that play a role in shelf-edge-delta evolution include river hydrology, marine hydrodynamic processes, and the physiography of the terrestrial catchment, shelf and upper slope. However, the relative importance of individual controls on the architectural organisation and geometry of shelf-edge deltas remains unclear. Moreover, it has yet to be determined whether specific architectural and geometric characteristics of these deltaic systems can be linked to individual attributes of their environmental setting. To address these problems, a comparative, global-scale study of many examples has been undertaken.

Relationships between the sedimentary record of shelf-edge deltas and environmental conditions have been assessed through a meta-study of >40 Late Triassic to late Quaternary successions. Datasets from field-, seafloor- and subsurface studies derived from >60 publications have been utilised to investigate the geometry (e.g. dimensions, thickness and gradients) of deltaic architectural elements (e.g. delta complexes, delta lobes, distributary mouth bars) and facies belts (e.g. delta top, delta front) in the context of their physiographic setting (e.g. catchment- and shelf configuration; bathymetric setting), hydrodynamic regime (fluvial attributes, storm-, wave- and current influence), margin type and palaeolatitude. Relationships between these attributes have been analysed statistically.

Results show that the sedimentary record of shelf-edge deltas reflects the complex interplay of several environmental controls. Selected findings are as follows: (i) hydrodynamic regime constitutes a principal control on the architecture and geometry of shelf-edge deltas from system- to element scale; (ii) architectural components of shelf-edge deltas do not display strong scaling relationships with geometric attributes of the shelf and upper slope; (iii) geometries of deltaic constructional units (e.g. delta lobes and complexes) are not dependent on the margin type; (iv) shelf-edge delta architecture is linked to palaeolatitude, suggesting that climate has a primary influence on sediment supply and dispersal.

The insights gained from this study can be applied to outcrop- and subsurface studies to aid the reconstruction of shelf-edge deltaic systems and their environmental setting.

Characterization of the luminescent layers of the Bazhenov Formation

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The Bazhenov Late Jurassic – Early Cretaceous Formation (BF) located in Western Siberia is considered to be one of the largest marine source rock formations in the World with more than 1 billion barrels of shale oil reserves. The BF considerably varies in lithology, content and maturation of kerogen due to different conditions of sedimentation and post-diagenetic transformations.

The objective of this study was to characterize two types of very specific luminescent layers recently found in the BF. The luminescent layers are located at the same stratigraphic level of the BF but are characterized by completely different mineral composition and organic matter (OM) content.

The first type is tuff layers with a very small thickness up to 0.02 m. The light gray layers have yellow-orange luminesce under ultraviolet (UV) light. The organo-mineral matrix consists mostly of clay minerals (up to 80 vol. percent). Contents of other minerals, including feldspar, mica and kerogen, are very low. The origin of tuffs in the BF black shales is associated with activity of ancient volcanoes. This conclusion is confirmed by the presence of such layers in the Bazhenov interval in most parts of the West Siberian basin.

The luminescent layers of the second type are characterized by the thickness up to 0.2 m, layered structure containing layers of luminescent alginite (an organic matter of algae genesis) and non-luminescent shales with zoo- and phytoplankton. The organo-mineral matrix consists of OM and quartz in almost equal proportion. Clay minerals, pyrite, and mica are minor. The genesis of alginite-rich layers is still questionable. It could be related both to upwelling zones and to methane seeps, i.e., in areas where high biological productivity took place. However, indirectly these layers could also be related with volcanic activity, which may result in the growth of bacterial communities.

Geochemical study of luminescent layers including Rock-Eval pyrolysis, isotope (C, S, N) composition, FTIR spectroscopy and GC-MS analysis of extracts have been performed. According to results of pyrolysis, tuff layers are characterized by low TOC (less 1 wt. percent), whereas in alginite-rich layers, TOC content is much higher, up to 25 wt. percent. The carbon isotope composition of organic matter in tuff and alginite rich layers are also different: -28.8 to -29 promille (PDB) in tuff and -31.1 to -31.9 promille (PDB) in alginite-rich layers. Sulfur and nitrogen show even higher differences in isotope compositions.

The study of luminescent layers provides deep insight into understanding the diversity and complexity of processes that occurred during the sedimentation stage of the BF. As far as the luminescent layers are easily detected under UV light, they could be very useful for well correlation of the Bazhenov Formation for a considerable part of Western Siberia.

Tectonically driven restriction of the Mediterranean gateway during the early Messinian: impact on sediment cyclicity

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Though the Strait of Gibraltar today is the only seaway that connects the Mediterranean Sea with the global ocean, in the late Miocene the Mediterranean-Atlantic gateway was composed of multiple connections through the Betic and Rifian corridors. Due to the position of the Gibraltar Arc in region of convergence of the African European plates, the area has been tectonically active and once the convergence slowed down, the consequent slab rollback deceleration initiated a slab tear that propagated from the eastern margin of the current Spanish southern coast until the Atlantic Ocean. From around 7–8 Ma the resulting dynamic topographic movement rose the Betics while the crustal thickening produced by the Moroccan Margin indentation in the south uplifted the Rif area, progressively restricting the Mediterranean-Atlantic seaways.

The progressive isolation of the Mediterranean Sea from the global ocean culminated at 5.97 Ma with one of the most extraordinary geological events of all times known as the Messinian Salinity Crisis (MSC). Nonetheless, the first evidence of environmental changes was registered in the sedimentological and micropaleontological records all over the Mediterranean already at 7.2 Ma. The well ventilated open marine late Tortonian-early Messinian Mediterranean environments characterized by hemipelagic sedimentation and high productivity, sharply changed as the Mediterranean waters become increasingly stratified, while at the bottom organic matter started to accumulate, developing in the eastern sectors sapropelitic layers.

In this work we propose a detailed analysis of the elemental geochemistry and stable isotopic content of ODP Site 976 located in the West Alboran Basin (WAB) before and after the 7.2 event. Due to its location, close to the Atlantic-Mediterranean gateways, this Site is ideal to study the changes produced in the basin in the first stages of a tectonically driven gateway restriction. As predicted, Site 976 sediments register a clear change in sediment origin and composition paired with an increase in sedimentation rate after 7.2 Ma which can be linked with the uplift of the Gibraltar Arc. In addition, we observe different cyclical patterns thorough the record that clarify to a certain extent how sedimentary cyclicity driven by orbital cycles is expressed differently in an open vs. restricted basin.

Experimental biomineralization of carbonates from a highly alkaline lake

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Microbial carbonates commonly precipitate in modern playa-lakes associated with microbial mats. Modern and natural evaporitic microbial environments are important analogs for understanding brine evolution and mineral precipitation pathways in shallow water settings that have existed since the Archean on Earth and perhaps on Mars.

Microbialites comprised of up to 45% hydromagnesite, 25% of calcite and 20% of dolomite have been recognized by microscopy and XRD in Eras playa-lake, Central Spain (Cabestrero and Sanz-Montero, 2016). Calcite, dolomite and hydromagnesite are commonly supersaturated in the analyzed waters although experiments replicating lake physicochemistry (using filtered natural water samples) showed that they do not precipitate directly from the brine. Many authors also confirmed the difficulties to precipitate Mg/Ca carbonates inorganically. In addition, a microorganism of the Firmicutes group (Desemzia Incerta) that has been isolated from Eras is enhancing the precipitation of these carbonates (Sanz-Montero et al., 2019).

Micro niches cannot be directly assessed by common techniques (microscopy and XRD), so, in order to understand mineral formation, several forced precipitation experiments were designed. The experiments used biomass developed by the growth of microorganisms in the laboratory. In order to grow these, intact manipulation of microbial mats and mat enrichments were used. Small pieces of microbial mats and enrichments were incubated under different controlled conditions (variating light to no light environment, absence and presence of oxygen, different atmosphere, among others). By fixing these parameters, the specific growth of some organisms is promoted, so that, understand the associated metabolisms and the paragenesis of the minerals found in the experiments is possible. Light and electronic microscopy was used to control the growth of the microorganisms and the precipitation of the minerals. DNA analysis confirmed the main groups that were enhanced by the forced precipitation experiments. The minerals precipitated in the laboratory resemble those formed naturally, helping to arrange all the parameters and confirming previous hypotheses.

According to the results obtained, heterotrophic or mixotropic mechanisms of microorganisms such as Plantomycetes, Proteobacteria, Cyanobacteria and Chloroflexi participate in the precipitation of magnesium carbonates. In addition, Cyanobacteria and sulfur-oxidizing bacteria are related to the precipitation of calcium carbonates.

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Methods to induce mineral precipitation using excised microbial mats

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The process of mineral formation may be observed in modern shallow lakes, where carbonates, sulfates, chlorides and silicates precipitate in association with microbial mats. Classical models explained the precipitation of most of the phases with pure physicochemical weather-controlled factors such as ions concentration and temperature (i.e. evaporation). Sulfates, chlorides, Na-carbonates and nesquehonite, among others, are supposed to precipitate directly from the brine as it evaporates, but they are commonly undersaturated in the water samples. Recently, more and more authors agree that these phases which precipitate within the mats reach supersaturation enhanced by microbial-mineral interactions. Therefore, the controversy about the origin of these minerals still exists.

Typically, lake microorganisms were isolated in order to analyze their capability of precipitating specific minerals; i.e., Mg-carbonates in Sánchez-Román et al. (2009) and Sanz-Montero et al. (2019), Ca-carbonates in Machulás et al. (2008), Gallagher et al. (2012), among others. These minerals might have precipitated favored by microbial mats matrix due to EPS ion exchange. Alternatively, in this study, several experiments were carried out by taken the whole community of the mats to better constrain the processes of formation of some carbonates and sulfates.

Small pieces of microbial mats from various lakes were submerged in different types of water (changing salinities, ions content). They were incubated under different controlled parameters of light and temperature mimicking their respective natural environments. Mineralogical, microscopic, and physicochemical analyses along with microbiological techniques were applied to monitor microbial mats. Specifically, light and electronic microscopy were used to evaluate the growth of the microorganisms and the precipitation of the minerals.

Thus, the observations made in the experiments, including the development of the mats and the minerals precipitated, can be used as a tool for understanding microbial-mineral interactions by comparison with field observations. Remarkably, the minerals precipitated in the laboratory resemble the natural precipitates in textures and paragenesis. In addition, grown mats can be also used for further specific experiments (i.e. aisle).

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Early Permian intensification of low latitude upwelling driven by enhanced megamonsoonal circulation

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The Early Permian recorded a critical transition in the earth systems marked by the end of the late Paleozoic ice age (LPIA) near the Asselian-Sakmarian boundary. The LPIA was the longest and most extensive glaciation of the Phanerozoic. It is currently understood as a dynamic glacial epoch of alternating icehouse and greenhouse intervals that started in the Tournaisian, peaked in the Asselian, and culminated during the latest Asselian-earliest Sakmarian. The end of the LPIA coincided with a rise in CO2 and atmospheric temperature, as well as with the intensification of megamonsoonal circulation across low latitudes of Pangea. Here we examine post-glacial (Artinskian) carbonate rocks deposited at least 3 Myrs after the end of the LPIA on tropical shallow carbonate platforms of the Panthalassa and Paleotethys oceans and provide evidence for millennial-scale pulses of cool upwelling along both the western and eastern oceanic margins of Pangea. Three Artinskian limestone formations from New Mexico (Apache Dam Formation), Austria (Zottachkopf Formation), and South China (Chihsia Formation) were analyzed. The three studied sites were located at tropical latitudes during the Artinskian, but record sedimentation in three different geographic settings in the Panthalassa and Paleotethys oceans, hence providing a broad snapshot of post-glacial equatorial oceanic conditions at that time. The studied formations are composed of 20 to 50 cm thick beds of wackestone, packstone and floatstone containing a highly diversified photozoan association (green calcareous algae, fusulinids, oncoids, corals, ooids, etc.) associated with early marine cements, punctuated by sharply bounded, ~2 cm-thick interbeds containing a poorly diversified heterozoan association (echinoderms, bryozoans, ostracods, and small foraminifers), negligible early marine cement, and elevated concentrations of organic matter and locally, iron oxides. Photozoan carbonates are indicative of shallow, well-lit, open platform conditions with seawater temperatures well above 20 C, based on modern comparisons. The thin heterozoan interbeds irregularly occur at centimetre- to metre-scaled intervals in the otherwise photozoan-dominated successions. This suggests the shallow platform areas episodically cooled to temperatures in the 15–20 C range, and possibly lower, also based on comparisons with modern cool-water shelves. Conodont populations were also affected by that shift, being more abundant and diversified in the cool heterozoan carbonates, but only rare to non-existent in the photozoan carbonates. Considering that modern rates of photozoan carbonate accumulation are one to two orders of magnitude greater than rates of heterozoan sedimentation, estimates of photozoan limestone sedimentation rates in the Apache Dam Formation, where heterozoan interbeds are the most ubiquitous, suggest the recurrence of ~20 cm-thick photozoan beds between heterozoan interbeds represents a millennial scale fluctuation. This precludes eustatic sea-level fluctuations as an explanation for the recurrence of the inferred rapid shifts in seawater temperatures. We here propose that strong, cool upwelling currents enhanced by the intensification of megamonsoonal circulation in the Artinskian, i.e. a few million years after the end of the LPIA, was the driver of the millennial alternations of warm and cool water carbonates at low tropical latitudes on either side of Pangea.

Characterizing late Quaternary paralic to shallow-marine facies associations through piezocone penetration tests (Po Basin, Italy)

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Piezocone penetration tests (CPTUs) have been historically utilized for the geotechnical characterization of unconsolidated sediments. If properly used in conjunction with coring programs, CPTUs can also represent an effective tool, much less expensive than borehole drilling, for subsurface facies correlation and for tracking key stratigraphic surfaces on a regional scale.

In this study, detailed characterization of paralic to shallow-marine facies associations relied upon accurate calibration of CPTU tests with sediment core descriptions from 20 drilling sites of the southern Po Plain. CPTUs were carried out within a distance of 20 meters from the corresponding coring site, and alluvial, deltaic, and coastal to shallow-marine depositional systems were investigated in downdip direction. For each facies association identified in core, we measured geotechnical parameters (cone resistance Qc, sleeve friction Fs, pore water pressure u and friction ratio FR) from the corresponding CPTU.

Paralic facies associations have diagnostic CPTU signatures: distributary channels and bay-head delta sands show high Qc and generally negative u values. Fine-grained deposits display distinctive engineering properties that can be tracked basinwide: (i) the poorly-drained floodplain facies association is made of soft clays with Qc ranging between 1.0–1.8 MPa, Fs (0.05–0.1 MPa) and $u \gg 0$. (ii) Swamp deposits consist of very soft clays with Qc invariably < 1.0 MPa (~ 0.6–0.8 MPa) and Fs < 0.02 MPa (~ 0.01–0.025 MPa). (iii) Peat layers are laterally extensive marker beds typified by four diagnostic peaks in Qc, Fs, u and FR. Lagoonal deposits can be distinguished into (iv) central-lagoon and (v) outer-lagoon facies associations. The former is predominantly made of very soft gray clays, with very low Qc (0.5–0.6 MPa), Fs (0.025) and $u>0$. The latter is characterized by $1<Qc<5$ MPa and $0.01<Fs<0.025$, with peculiar seesaw profiles, highly variable u and low FR ($<1\%$).

Shallow-marine facies are similar to lagoonal deposits, with characteristic seesaw-shaped profiles (offshore-delta front transition facies association) or low to very low Qc (<0.8 MPa) and Fs (~ 0.02 MP) values (offshore and prodelta facies associations), and their distinction can be ambiguous on the basis of CPTU analysis alone. Coastal facies generally includes sandy deposits formed as washover fans, transgressive sand sheets, beach ridges and delta fronts. All these facies display high Qc and low to negative u.

Geotechnical characteristics of all facies associations were plotted onto the latest soil behavior chart. Clayey-swamp is projected towards “sensitive fine-grained”, whereas peaty-swamp towards “organic-soil”. Lagoonal facies are widespread between class 6 (“sand and silt mixture” – outer-lagoon) and class 1 (“sensitive fine-grained” – central-lagoon). Shallow-marine deposits plot between class 4 (“silt mixtures: clayey silt and silty clay”) and class 3 (“clay to silty clay”).

This study proves the great value of CPTUs for the high-resolution stratigraphic analysis of unconsolidated sediments of late Quaternary age. This technique can expand significantly the coverage of one-dimensional core data, allowing refined stratigraphic correlation, mapping, hydrogeological and geotechnical characterization of paralic (deltaic, estuarine) to coastal and shallow-marine facies associations.

To meander or not to meander? Predicting river patterns from streampower, bed sediment and bank strength

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Rivers exhibit a wide variety of channel patterns, and predicting changes in channel pattern is important to reconstruct flow conditions from preserved deposits, and to forecast river responses to climate change and river restoration. The latter often considers meandering rivers as the ultimate pristine river type, while many single-channel, sinuous rivers do not actively meander when they have relatively low stream power compared to river bank strength.

Last decades, many discriminators were developed to define approximate boundary conditions for different channel patterns, based on channel-pattern-controlling variables such as discharge and valley gradient. However, presently available discriminators have two main shortcomings. First, they perform poorly for rivers with cohesive, relatively erosion-resistant banks. For this subset, discriminators tend to indicate an actively meandering channel pattern, whereas the river morphology and dynamics show that many of these rivers should be classified as laterally stable. Second, channel pattern discriminators are only valid when variables are used that are independent of actual channel pattern. However, many often-used discriminators have channel slope or channel width–depth ratio as input, which are not independent variables.

To resolve both shortcomings, we first show there exists an additional class of rivers with scroll bars and tortuous channel patterns, in which lateral mobility is inhibited due to their self-formed cohesive deposits. Second, we compare frequently used empirical and mechanistic channel pattern discriminators in their success in predicting channel pattern and their independence of the used causal factors. Third, we present a novel, quantitative channel pattern predictor that includes mechanistic effects of a cohesive floodplain, using the average silt-plus-clay fraction of the river banks as proxy.

The new predictor outperforms past empirical and mechanistic approaches, and successfully predicts channel pattern for 87% of the rivers from a dataset of 70. This new predictor is widely applicable, as it is relatively simple and based on easily obtainable, and independent, variables.

Differential analysis of diagenesis-pore evolution of tight sandstone reservoirs in different sedimentary environments

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Shallow delta-deep water gravity flow sandbodies are developed in Chang 8-Chang 7 oil-bearing formation of upper Triassic Yanchang Formation in southwestern Ordos Basin, however, due to the influence of the early sedimentary environment and the late differential diagenesis, the reservoir is low physical properties, strong microheterogeneity, and relatively densification. In order to analysis the influence of differential diagenesis on reservoir pore evolution under different sedimentary environments, casting thin section, scanning electron microscope, mineral XRD, high pressure mercury injection, physical properties, and other data are used, on this basis, combined with previous research results to study Chang 8 and Chang 7 reservoirs in Heshui area, southwestern Ordos Basin. The purpose of this is to analyze reservoir characteristics and diagenesis-pore evolution differences, to establish the time sequence relationship between diagenesis and pore evolution, to provide a basis for the prediction of favorable reservoirs. The results show that: (1) The delta front underwater distributary channel sand body of Chang 8 oil-bearing formation in the study area is mainly type of reservoir, the lithology is mainly medium-fine grained lithic arkose (Q30.1F31.5R24.6) with high maturity; The content of cement is low (12.0%), mainly chlorite (5.3%), followed by ferrocalcite (2.4%) , the content of matrix is low (2.3%); The microheterogeneity is relatively weak and the physical properties are better (φ=9.1%; K=0.7×10–3μm2). The sandy debris flow and turbidity flow sand bodies of Chang 7 oil-bearing formation in the study area is mainly type of reservoir, the lithology are mainly fine grained lithic arkose and fine grained feldspar litharenite (Q39.3F21.9R23.3) with low maturity; The content of cement is high (15.0%), mainly illite (8.2%), followed by ferrocalcite (2.1%) , the content of matrix is high (6.5%); The microheterogeneity is relatively strong and the physical properties are poor (φ=7.3%; K=0.2×10–3μm2). (2) The initial porosity of Chang 8 reservoir is high (40.7%) before 225 Ma due to the influence of shallow water delta sedimentary environment; During the syndiagenesis-Eodiagenesis A of 225~143Ma, the reservoir is mainly affected by strong compaction, and the porosity reduced from 40.7% to 18.6%; During the Eodiagenesis B-Mesodiagenesis A of 143Ma to present, the reservoir is mainly affected by weak cementation, and the porosity reduced from 18.6% to 5.7%; After 120Ma, the porosity of the reservoir increased by 3.6% due to weak dissolution; The present porosity of the reservoir is 9.3 %. The initial porosity of Chang 7 reservoir is low (38.6%) before 220Ma due to the influence of deep water gravity flow sedimentary environment; During the syndiagenesis-Eodiagenesis A of 220~138Ma, the reservoir is mainly affected by weak compaction, and the porosity reduced from 38.6% to 19.8%; During the Eodiagenesis B-Mesodiagenesis A of 138Ma to present, the reservoir is mainly affected by strong cementation, and the porosity reduced from 19.8% to 1.5%; After 115Ma, the porosity of the reservoir increased by 6.3% due to strong dissolution; The present porosity of the reservoir is 7.8 %. Finally, the present porosity of Chang 8 reservoir is higher than Chang 7 reservoir, favorable reservoirs are well developed.

Clay minerals of the Vaca Muerta Formation, Neuquén Basin (Argentina): distribution and origin

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The Vaca Muerta Fm (VMFm) is an organic-rich, marine succession deposited during the Tithonian-Berriasian in the Neuquén Basin, Argentina. Due to its high total organic carbon content (TOC) which may reach up to 12 wt.%, the VMFm is considered as an outstanding unconventional hydrocarbon shale reservoir but very little is known about its clay mineralogy. In the framework of an integral study of the VMFm the <2 μm fraction was studied by X-ray diffraction in more than 250 outcrop samples with a twofold objective: 1) to characterize the distribution of the clay minerals throughout the basin and 2) to understand, which are the main driving factors of the distribution of the clay mineral assemblages. Samples were collected in three sections placed from south to north: Zapala (southern Neuquén Basin), Chos Malal (central Neuquén Basin) and Malargüe (northern Neuquén Basin). Beds mostly consist of mudstones, marls and limestones corresponding to the basinal deposits of a carbonate ramp. In addition, Rock-Eval analyses were used to compare the maturity of the organic matter (OM) with the clay mineralogy.

In the Zapala section the clay mineralogy is mostly constituted by smectite, with low contributions of kaolinite, I/S, illite and chlorite, whereas the OM is immature (Tmax ~ 422–427 °C). In the Malargüe section the clay mineralogy mostly consists of kaolinite, illite and I/S (R1 ordering type) and the OM is slightly matured (Tmax ~ 434–439 °C). In this section C/S is recorded but only in rocks located close to andesitic sills. In the Chos Malal section the clay mineralogy is constituted by I/S (R1 to R3 ordering types), Fe-rich chlorite and illite and the OM is overmatured (Tmax > 470 °C).

The clay mineralogy analysis of the VMFm suggests that smectite was progressively transformed to I/S during burial, in agreement with the OM maturation trend. The difference reported in the clay mineralogy of Zapala and Malargüe is related to the provenance of the sediments. The smectite observed in Zapala section was developed through weathering of volcanogenic soils of the North Patagonian Massif, located in the southeast of the basin. Conversely, the kaolinite, illite and probably smectite present in the Malargüe section were formed through the weathering of acidic rocks (rhyolites/dacites) of the San Rafael Block, placed to the northeast of the basin. In spite of the different provenances, changes of the relative abundance of the clays in each section (e.g., kaolinite/illite ratio) suggest two periods of enhanced humidity in the hinterlands (early Tithonian and early Berriasian), separated by a period of more arid conditions (late Tithonian) in agreement with the Tethyan paleoclimatic reconstructions.

Three variables regulate the clay mineralogy of the VMFm: the intensity of burial diagenesis, the provenance of the sediments and the paleoclimate prevailing in the hinterlands. Burial diagenesis and the provenance are the variables with more influence in the final clay mineralogy, whereas the paleoclimatic conditions in the hinterlands regulate the relative abundance of the clays in each section.

Palaeoecology for depositional model reconstruction, a case study from a Mississippian mound complex in Derbyshire

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Palaeoecology can provide vital information for refining the depositional model of fossil reefs. This was the case in the study of the brachiopod fauna in an upper Visean mud mound complex cropping out in Derbyshire (UK). The complex belongs to the Monsal Dale Limestone Formation, which was deposited in an intrashelf carbonate ramp on the Derbyshire Carbonate Platform. The mound complex is a composite build-up formed by the coalescence of metre-size mounds and developed on top of fine-grained peloidal skeletal packstone-grainstone beds indicative of low-energy, sheltered inner ramp environment.

The complex consists of basal nodular packstone-rudstone beds with patches of clotted peloidal-leiolitic micrite boundstone, interbedded with tabular clotted peloidal-leiolitic micrite/fenestellid bryozoan boundstone mounds (Facies Association 1). The overlying dome-shaped mounds consist of an association of fenestellid bryozoan/clotted peloidal-leiolitic micrite boundstone with radiaxial fibrous calcite cement and accreted to form the decametre-size dome-shaped massive core of the mound complex (Facies Association 2). Core flank beds are characterized by clotted peloidal-leiolitic micrite/fenestellid bryozoan boundstone, passing downslope to skeletal packstone beds with brachiopods and crinoids (Facies Association 3). Clotted peloidal-leiolitic micrite textures are interpreted as originated from microbially mediated precipitation.

Unsorted, crinoid-rich packstone/grainstone-rudstone beds, of moderate energy, middle ramp environment, occur laterally to the mound complex.

Beds of moderately sorted crinoid-rich grainstone, of inner ramp environment, affected by meteoric diagenesis due to subaerial exposure, overlie and onlap the complex.

The mound complex hosts a rich and diversified brachiopod fauna (at least 29 species belonging to 23 genera, 6 orders). The assemblages are interpreted as life to neighbourhood ones, based on the dominance of articulated specimens with no sign of transport, some in life position. Limited winnowing of assemblages supports the hypothesis of moderate energy, middle ramp depositional environment for the mound complex.

Substrate relationships of the brachiopod fauna have been investigated: seminfaunal productids are dominant in Facies Association 1. Likely, this results from the abundance of softgrounds, formed by detrital lime mud from the disruption by currents of the clotted peloidal micrite precipitates.

Pedicle attached orthotetids, orthids, spiriferids, rhynchonellids and terebratulids are more common in Facies Association 2, suggesting the presence of varied soft, firm, and hard substrates. Firm substrates were likely represented by calcified microbial mats; hard substrates were biogenic, as brachiopod shells and bryozoan fronds.

Combining palaeoecological information with facies analysis, a depositional model for the mound complex is proposed. The complex developed during a deepening of the depositional environment from the colonisation of the seafloor by microbial mats. Microbial precipitates were colonised by brachiopods and bryozoans, forming mounds whose vertical growth was prevented by currents (FA1). A further deepening of the environment, indicated by the inferred decrease in softgrounds, allowed vertical growth and coalescence of dome-shaped mounds (FA2). Inclined flank beds (FA3) developed as a result of the mound complex core relief over the seafloor. A phase of relative sea-level fall and subaerial exposure led to the demise of the mound complex.

System-scale architectural analysis of fluvial-fan successions: an example from the Palaeogene Wasatch Formation (Utah, U.S.A.)

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The prediction and interpretation of internal architecture in alluvial deposits represent a major challenge when continental successions in the subsurface are analyzed for reservoir characterization (e.g. for geothermal or hydrocarbon exploration and production), as connectivity and stacking density of high net-to-gross channel elements are key controls on reservoir potential. Due to the inherent heterogeneity displayed by alluvial deposits, the success of exploration for subsurface resources relies greatly on the chosen stratigraphic model. Recent developments in fluvial geomorphology and sedimentology suggest that fluvial fans (known also as distributive fluvial systems) may be responsible for the accumulation of large volumes of clastic successions in continental basins. The possibility of identifying a stratigraphic signature for aggrading fluvial fans opens a new perspective to interpret continental records and increase success potential for exploration.

This research presents preliminary results from an outcrop-based study of architectural trends and of spatio-temporal patterns in avulsion mechanisms across a proximal-to-distal transect through Palaeocene-Eocene fluvial-fan successions of the Wasatch Formation in the Uinta Basin, central Utah. Three-dimensional digital outcrop models were generated from a photographic data-set acquired by drone fly-bys over several laterally continuous outcrop belts, ground-truthed by numerous sedimentological logs covering most of the vertical stratigraphic extent of the formation. This enabled the reconstruction of the system's depositional history and internal architecture based on the definition of major architectural elements identified in the field such as ribbon-shaped channel-fills, channel-belt sheet sandstones, mudstone-dominated floodplain elements, and overbank-splay heterolithics.

Along a radial transect over tens of kilometers through the system, three sectors are distinguished here based on the geometry and relative volumes of architectural elements, ultimately characterizing the net-to-gross trend. High net-to-gross values and latero-vertical connectivity define the proximal sector, where channel-belt deposits are highly amalgamated, with only minor preservation of mudstone-prone lenses representative of overbank deposition. The relative volume and amalgamation of channel-fill deposits decrease in the medial sector in which channel-belt units are laterally extensive but vertically compartmentalized by thick, mud-rich floodplain units. Net-to-gross values decrease drastically in the distal, northernmost sector of the system, where isolated, ribbon channel-bodies are encased in a claystone-dominated succession. Textural, compositional, and primary porosity trends documented by QEMSCAN analysis of petrographic thin-sections further accompany the definition of net-to-gross values at system scale. Outcrop observations will be complemented by analyses of publicly available well-log and core data in order to test the recognition of architectural elements in the subsurface and to better define the regional extent of fluvial-fan sectors in areas where natural exposures are absent or inaccessible. The research approach described here emphasizes the efficacy of digital outcrop models, supported by ground-based surveys, as a tool to describe and quantify architectural complexity in clastic successions. The regional-scale stratigraphic trends provide a first-order validation of the expected fluvial-fan model, with observed differences possibly related to the influence of step-wise transgression during the onset of the Green River lacustrine system.

Postglacial transgressive deposits sourced in the retreating Guadiana river mouth (SW Iberian Peninsula)

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After the last glacial maximum (LGM), the alternation of periods with different rates of sea-level rise provided ideal conditions to study the postglacial sedimentary response to sudden shelf flooding. In the Gulf of Cadiz (NE Atlantic Ocean), previous studies revealed the occurrence of a set of postglacial transgressive parasequences off the Guadiana River. Based on detailed high-resolution seismic stratigraphic, sedimentological analyses and eight AMS 14C age datings, we: (1) Characterise the individual deposits and the sedimentary processes during each episode of shelf flooding to understand the response of coastal systems to variable rates of sea-level rise; and (2) Define the stratigraphic stacking pattern of shallow lithosomes formed off an ancient paleovalley in the context of postglacial high-frequency climatic and glacio-eustatic fluctuations.

Four backstepping seismic units linked to the retreating river mouth were interpreted. These seismic units have a wedge-shape geometry and are located over the inner-middle shelf, overlying a regional unconformity formed during the LGM. Each unit can be subdivided into several sub-units with distinctive seismic facies, showing a consistent pattern with similar stratigraphic organization. The lower sub-units are mainly composed of up to 10 m thick gentle tangential oblique clinoforms (<0.5°). Over the top of the clinoforms, channelized facies with transparent to chaotic configurations are locally observed infilling a channel-like horizon. The distal and/or lateral parts of the clinoforms are often buried by sheet-shaped semitransparent subunits that extend laterally over a few kilometres. The upper sub-units are identified over the proximal and central part of each seismic unit, showing a thin sheet-like external shape and transparent seismic facies with some weak internal reflections. Sedimentologically, fine-grained sands with intercalated silty layers dominate the lower part of each unit. The upper part is characterised by reworked facies, composed of very fragmented bioclasts within a silty sand matrix, and mud deposits are identified on top.

The internal structure of each unit provides clues about their genesis. The first evolutive phase involved the development, under a coastal regime, of shallow-water, coarse-grained prodeltas, which were occasionally eroded by a network of distributary channels, suggesting the occurrence of minor regressions driven by massive and episodic sediment fluxes. Subsequent channel infilling promoted the sediment export towards the shallow-water realm and the deposition of sediment drapes, possibly generated by river floods. The upper subunits were generated by the reworking of the original clinoforms under a marine erosion regime. 14C ages together with the correlation with a suite of postglacial sea-level curves indicates that the formation of the postglacial transgressive deposits is framed within the 14–8 ka interval. During this period, the study deposits were related to phases of enhanced sea-level rise mostly driven by meltwater pulses rather than to periods of reduced sea-level rise, such as the Younger Dryas event. Therefore, we suggest that pulses of enhanced sediment fluxes are not necessarily coupled with phases of slow sea-level rise.

Processes, morphologies and depositional record of small-scale upslope-migrating bedforms in submarine channels.

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Upslope-migrating bedforms characterise many submarine channels. These bedforms can be divided into larger km-scale bedforms and smaller tens-of-metres-scale bedforms. This presentation focusses on the smaller-scale bedforms. Many of the most basic questions related to these bedforms remain unanswered, for example: Why are they often there, but not always? What physical process is driving their formation? Why is their depositional record so variable? Do they disappear during exceptionally powerful events? What is their relation with slope failures? This presentation aims to provide a brief overview of the insights gained so far from physical experiments, numerical modelling, outcrop studies and seafloor monitoring. Some areas of general consensus are summarised, but the main focus of the presentation will be on other areas where data from different methods and location are still in apparent contradiction.

Fill-spill cycles with multiple exit points: stratigraphic evolution above a dynamic stepped-slope

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Seafloor topography has a major influence on the behavior of sediment gravity flows and sites of erosion and deposition. Largely static topographic configurations over the duration of a turbidite system are widely documented as a control on depositional architecture and facies distribution, as proposed in classic fill-and-spill models. Here, using a high-resolution 3D seismic reflection data and more than 100 wells from a 40 km long Oligo-Miocene stepped-slope fan system (Campos Basin, offshore Brazil), we provide evidence to demonstrate that slope topography was dynamic during the evolution of a turbidite system and that more elaborate models are needed to explain the resultant depositional architecture.

The stepped-slope fan system comprises two distinct depositional domains. The up dip proximal domain is characterized by low to high seismic amplitude anomalies that display elongate and sub-parallel features, which truncate underlying reflectors and are interpreted as submarine channels. Well calibration shows that high amplitude features have moderate to high sandstone percentage (average 55%) and cores indicate fine-grained structured sandstones as the main facies. The low amplitude features are mud-prone, suggesting bypass. In the down dip distal domain, three high amplitude lobate features are obliquely stacked towards NE and are interpreted as lobe complexes, which record overall progradation of the system. The average sandstone percentage is higher than up dip (~75%), and fine-grained structureless sandstones are intersected in cores.

Lithological attributes, seismic geomorphology and thickness patterns indicate that low sinuosity sandy channel complexes were truncated by a network of mud channel-fills in an up dip slope step. Down dip, lobe complexes were fed by multiple channels and evolved above another step. An intervening area with dim amplitudes and locally deep erosion is interpreted as a steeper ramp between the steps. In the up dip step, a strong migration of channels feeding the lobe down dip towards NE is recorded. The depositional signature, built by the lateral association of several fill and spill cycles, is interpreted to reflect different episodes of accommodation creation, healing and bypass within the slope step. A dynamic mobile substrate is invoked to explain variations in step gradient during deposition, prohibiting a single conduit to be established across the upper step and ramp, as recorded in systems with a static topography.

Paleosol architecture in a quaternary incised valley and surrounding areas

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The Lower Ebro, in the NE Iberian Peninsula, is a river reach affected by the influence of the backwater length (BL) from the Mediterranean Sea. The BL reached 90 km inland during the Quaternary. Glacio-eustatic climatic fluctuations have resulted in several nested incised valleys in the Cubeta de Móra, 75 km far from the Ebro Delta.

Incised-valley fills registered entire depositional sequences with subaerial unconformities (SU), as sequence boundaries, at the base and the top, accordingly to base-level cycles from climatic fluctuations. The average thickness of a Lower Ebro incised-valley fills is around 50 m. Further from an incised valley, tributaries' inputs resulted in flights of attached stair-stepping terraces, as well as calcareous paleosols formed on their top.

Internal incised-valley unconformities, which separate high frequency sequences, rarely present any pedogenesis. Close to the incised valley, tributaries have developed up to five stacked highly developed calcic paleosols on as many other coarse-grained stacked paleochannels. The calcic paleosols are characterized by a strong accumulation of calcium carbonate on gravelly matrices, as Bk or Bkm horizons depending on their degree of cementation, usually on the top of a sequence. These paleosols are intercalated by clayey red paleosols developed in fine-grained sediments, with clay illuviation and redoximorphic features as Fe nodules and redox depletions, as well as with vertic features; very often recarbonated. Occasionally, loess deposits are intercalated.

Both the highly developed calcic paleosols and the red clayey paleosols with hydromorphic features were formed in the tributaries during pulses of incision and aggradation. The highly developed calcic paleosols formed during a lower base level and increased aridity. They are interpreted as stratigraphic hiatuses and sequence boundaries, and thus, they should be considered as SU. If a tributary's low reach remained under the BL influence, terrace deposits stacked and calcic paleosols formed on them because of base level fluctuations. During stages of base level rise, sediment aggradation occurred and cumulative, red clayey paleosols with hydromorphic features were formed, separating the stacked calcic paleosols. In contrast, if a tributary reach was out of the BL influence, subsequent terraces incised, and thus, the calcic paleosols were also affected. At the same time, while terraces incised, calcic paleosol ramps connected the primary paleosols.

From the quality and the stratigraphic position of paleosols, some conclusions can be inferred. The high frequency of erosive and sedimentary processes decreased pedogenesis on the channel subenvironment. SU outcropping out of the incised valley as stacked calcic paleosols in the tributaries can be correlated with channel unconformities, showing that SU are compound boundary surfaces. Alternances of paleosol types in the tributaries show climate fluctuations as well, affecting incised valley sedimentation by pulses of incision and sediment aggradation. Paleosols architecture also reveals changes in the sedimentary and stratigraphic architecture of an incised valley and the surrounding areas.

Morphology and recent sedimentary processes in two shelf-indenting submarine canyons in the Alboran Sea

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Submarine canyons are major morphological features incising continental margins and constitute the main pathways for shelf-to-basin sediment transfer and flux of contaminants and waste. The effectiveness of present-day canyon sediment transport depends largely on the proximity to a major sediment source from the continent, such as riverine or littoral drift inputs. In this sense, the degree of shelf incision is critical, since it determines the amount of sediment transported and/or deposited in shallow waters that can be potentially captured by the canyons.

In this work, we characterize the morphology and recent sedimentary processes of two shelf-indenting submarine canyons (Motril and Carchuna) in the northern margin of the Alboran Sea. We aim at understanding the modern sedimentary processes acting in these two canyons, their role as sediment conduits interacting with shallow-water processes on the shelf, and the imprint of such processes on the canyon morphology and recent sedimentary record. To achieve this aim, we used: (1) Multibeam bathymetric data for morphometric characterization and geomorphological interpretations. (2) Seafloor imagery taken from a Remote Operated Vehicle to make qualitative observations on the submarine canyons seafloor. (3) Surficial sediments, rock samples and short sediment cores (up to 50 cm) that have been used to provide genetic constrains of seafloor sedimentary facies and rocks and of sediment sources.

The Carchuna Canyon is deeply incised in a 2.1 km wide shelf, as its head is located just 200 m off the coastline. It shows a straight morphology with a total length of 20 km, 2 km maximum width and 226 m of maximum incision. The canyon walls are steep with gradients up to 34º and they are largely eroded by gullies and mass-movement scars. In general, muddy sands prevail along the thalweg, with interbedded fine to medium sands. In contrast, the head of the Motril Canyon is wider (4.3 km) and incises the shelf edge at 100 water depth. On the slope, the canyon valley exhibits a sinuous morphology with 27 km of total length, up to 1 km wide and 179 m of maximum incision. Its walls are gentler than the Carchuna Canyon, with gradients up to 16º. The surficial sediment on the canyon floor is mainly composed of muds. Below 450 m water depth, both canyons evolve downslope into extensive levee and lobe morphologies with superimposed bedforms. These depositional forms extend at least to water depths up to 900 m.

The geomorphological and sedimentary differences between both nearby canyons suggest that they have played different roles in the recent patterns of sediment transport and accumulation. The higher sinuosity of the Motril Canyon and the fact that it is draped by a veneer of muddy sediments indicates a high influence of low-energy depositional processes. In contrast, the Carchuna Canyon is an active system that is undergoing vertical and lateral erosion; its significant incision and its proximity to the coastline favour the capture of littoral drift sediments, and their subsequent transport and redeposition in deep-water settings, as revealed by the occurrence of interbedded sands.

Autopsy of the Tlayua fossils: The role of microbial biofilms in fossilization

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The studies on fossilization are multiple, diverse ,and have been reported continuously in recent decades; however, the research on control factors of preservation processes are complex since each paleontological site is unique, either because of its environmental origin, its diagenetic history, or the fossilization process is especific for certain groups and their organic remains. There are environmental, depositional and post-depositional factors that determine the fossilization processes that, in one way or another, have been determined in the so-called taphonomic laws; however, there are still many questions about how biotic and abiotic factors trigger and control the fossilization processes, especially in extraordinary conservation sites or Konservat-Lagerstätten. Such fossil assemblages show abundance, biodiversity, and retain microstructural characteristics of mineralized tissues (skeletons) and / or soft (muscles, cells or intercellular components). In this work we show results of a taphonomic study at the microstructural level of the Tlayúa Quarry, the first mexican Lagestätte. This Albian locality corresponds to the Tlayúa Formation, located in the vicinity of Tepexi de Rodriguez, Puebla. The Tlayúa fossils have been recovered, now sheltered in the National Collection of Paleontology (Institute of Geology, UNAM), which represents a diverse assemblage that include plants, invertebrates and vertebrates of continental and marine origin. Although plants and invertebrates are relatively poorly conserved, the vertebrates recovered show an extraordinary conservation that preserves soft tissues, well-preserved phosphatized subcellular cells and components, as well as bacteria and fungi involved in their decay . So far, studies in Tlayúa have focused mainly on systematic and taxonomic aspects. Our results indicate that microbial processes during early diagenesis enhace and promote the preservation of fosiil remains by organomineralizatin.

Environmental magnetic study of the Dejvice loess/paleosol sequence (Prague, Czech Republic)

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Loess/paleosol sequences contain variable amount of detrital magnetic particles derived from the source material of the aeolian dust during cold glacial or stadial phases. In addition, in warmer (interglacial and interstadial) periods, pedogenesis results in formation of paleosol horizons which are magnetically enhanced by the in-situ neo-formed nanoscale ferromagnetic particles.

In this contribution, we present an environmental magnetic and magnetic fabric study of the Dejvice loess/paleosol sequence with an aim to demonstrate how rock magnetic methods can be effective tools for characterizing sedimentary, pedogenic, and post-depositional processes during paleoenvironmental reconstructions. This research covers the 15-meter-long loess/paleosol section which was recently temporarily accessible during the construction works in the Vienna House Diplomat Hotel in Prague (quite ironically, this hotel was the intended venue of the IAS2020/21 meetings). The exposed part of the sequence contained at least four different paleosol horizons and covered the time interval from ca. 130 ky to recent (Flašarová et al., 2019). For the purpose of this study, 425 orientated samples (8 ccm) were collected evenly covering the studied section.

The applied rock-magnetic techniques included measurements of (1) magnetic susceptibility (MS), (2) frequency-dependent susceptibility (kFD), (3) out-of-phase magnetic susceptibility (opMS), and (4) viscous magnetization (Mv). While MS very sensitively reflects the relative amount of all magnetic particles, the other methods (kFD, opMS, and Mv) mirror solely the contribution of the neo-form nanoscale particles. In addition to these rock magnetic parameters, (5) anisotropy of magnetic susceptibility (AMS) was measured in order to obtain magnetic fabric reflecting the preferred orientation of magnetic minerals. Magnetic fabric can be primarily interpreted in terms of paleotransport directions and it may provide some evidence for post-depositional reworking and/or redeposition such as pedogenic (e.g., bioturbation and vertical material migration) and sheet-wash processes.

All paleosol horizons possess significantly higher values of MS, kFD, opMS and Mv compared to the rest of the section. This indicates that the increased amount of magnetic particles in paleosols is exclusively due to the magnetic enhancement caused by the neo-formation of nanoscale particles during pedogenesis. In addition, the values of kFD, opMS, and Mv mutually intercorrelate very tightly. This indicates that all these independent methods are reliable proxies for the quantification of ultra-file particles in loess/paleosols horizons.

In addition of the paleotransport direction, the magnetic fabric reflects secondary sedimentary processes. This involves the displacement of clastic particles by water and the redeposition along the slope. The direction of movement of these sediments corresponds to the current geomorphology. We can conclude that the sediments of the section were not deposited solely by aeolian processes.

Hydrocarbon evolution and reservoir evolution of marine shale: Insight into marine shale gas accumulation

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Most of the shale gas developed in north America exists in marine stratum. Although many lacustrine basins have developed in China, the commercial development of shale gas is still in marine stratum. Previous studies on hydrocarbon generation process and pore structures evolution of marine shale have been carried out, but few studies have combined them. Samples of the low-maturity Xiamaling Formation (Mesoproterozoic) in north China, containing kerogen Type I and Type II1, 0.6% of the vitrinite reflectance value and 6.74% of the total organic carbon contents, are selected to investigate evolution of shale gas system during thermal maturation from laboratory work. First, Standard columnar samples were heated to 320 to 600 °C for 48 hours in autoclave. The corresponding hydrocarbon expulsion pressure is set, and the gaseous and liquid products are collected when the hydrocarbon expulsion pressure is reached. Second, TOC content, vitrinite reflectance and X-ray diffraction are conducted on artificially matured shale samples. Meanwhile, gas component and carbon isotope are tested to characterize the compositional evolution of marine shale gas system during thermal maturation. Finally, pore structures characteristics of samples before and after thermal simulation experiments are investigated by using scanning electron microscope and low-pressure gas adsorption.

The results indicate that hydrocarbon generation rate and products have variation characteristics with progressing thermal maturity. Ro < 1.5% is the main oil generation period of kerogen, with the oil generation peak from 1.0–1.3% Ro. The main period of kerogen cracking to gas is 1.0–2.5% Ro, with the gas generation peak of 1.1–1.6% Ro (gas generation peak 1). When Ro > 1.6%, the gas generation rate by kerogen cracking gradually comes down, while migrated or secondary OM begins to crack for gas. The main gas generation period by migrated OM cracking is 1.6–3.5% Ro, with the gas generation peak of 2.5–3.2% Ro (gas generation peak 2). Gas generation gradually dries up as Ro > 3.5%.

Pore volume (PV) and specific surface area (SSA) first increase and then decrease with increasing thermal maturity. PV and SSA have two favorable development periods with 1.5–1.8% Ro and 2.5–3.2% Ro, respectively, which are two peak periods for PV and SSA development. The formation of abundant OM pores is related to kerogen and secondary OM cracking to hydrocarbon (especially to gas). To a large extent, the increase of total pore volume is attributed to the OM pores.

Shale fractal characteristics and its implication to gas storage capacity in the Sichuan Basin, China

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Shale is generally characterized as a complex and heterogeneous porous material, and the pore structure directly influences the rock properties such as storage, adsorption, and seepage. Fractal theory has provided a new method to quantitatively characterize the spatial distribution and pore structure parameters in fractal dimensions. To investigate the fractal characteristics and its implication to the shale gas content, a detailed experimental program combining rock composition analyses of total organic carbon (TOC) analysis, vitrinite reflectance analysis and X-ray diffraction (XRD), and pore structure characterization by field emission scanning electron microscopy (FE-SEM), and low temperature nitrogen adsorption/desorption analysis were conducted on 25 marine shale samples and 25 continental shale samples from Sichuan Basin, China. The Frenkel–Halsey–Hill model was used to obtain the double-fractal dimensions (D1 and D2) of shale pores for different suits of samples, and the methane adsorption experiments were used to determine the adsorption capacity of shale.

Analysis shows that (1) the total organic carbon content and organic matter maturity of marine shale are higher than that of continental shale. The marine Longmaxi Formation shale has more quartz, while the continental Ziliujing Formation shale has more clay minerals. In addition, the content of kaolinite in the Ziliujing Formation shale is relatively high, accounting for 9.0%~27.0% of the total amount of clay minerals. (2)The contribution of organic matter to pore structures in marine shale is greater than the contribution of organic matter to pore structures in continental shale. The specific surface area (SSA) and pore volume (PV) of marine shale are larger than that of continental shale, but the average pore diameter (APD) of continental shale is larger than that of marine shale. (3)The fractal dimension D1 and D2 respectively ranges from 2.2209 to 2.6950 and 2.6316 to 2.8988. The fractal dimension D1 and D2 has a positive correlation with SSA, a negative correlation with APD, and a low correlation with the PV. (4) SSA have positive effects on the Langmuir volume of methane adsorption. The fractal dimension D1 and D2 has a positive correlation with the Langmuir volume of methane adsorption. The fractal dimensions is influenced by the intrinsic properties of shale, such as TOC content, Ro, mineral composition, etc. Therefore, fractal dimension can well reflect the storage capacity of shale for natural gas.

Evidence of lost orogenies in the Mesozoic sedimentary record of the Kutch Basin, western India

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Sedimentary rocks preserve the records of lost outcrops and orogenic belts. The Middle Jurassic to Early Cretaceous sedimentary succession in the Kutch Basin preserves 70 Ma of geological history. These sediments were deposited in the pericratonic Kutch Rift Basin. In this study, we integrate results of detrital zircon and monazite geochronology with those of petrography, mineralogy and geochemistry to constrain the source rocks of these sediments and reconstruct their paleotectonic context. Detrital zircon and monazite dates involving U, Th and Pb isotopes confirm the age of the source rocks and identify dominant detritus from the late Neoproterozoic Pan-African orogeny (500–650 Ma) along with significant input from the Cambro-Ordovician Bhimphedian (aka Kurgiakh) (400–500 Ma) orogeny. This finding challenges the existing idea regarding the predominant Mesoproterozoic source rocks in north and north-western India, inferred primarily from south-westerly paleocurrent pattern in the sedimentary record. Rocks equivalent to the Pan-African orogeny are poorly exposed in the north-western India. But, this orogeny is extensively reported from the southern granulite terrain (India), Madagascar and Seychelles. Since Madagascar and Seychelles were juxtaposed with India during the time of this orogeny, rocks equivalent to the age of the southern granulite terrain possibly continued into western India before reappearing in Madagascar and Seychelles. Therefore, their absence in north-western India relates to either extensive erosion during Mesozoic greenhouse climate or burial under the Deccan Flood Basalts. The Chemical Index of Alteration (CIA) calculated for these sediments reveal intermediate to intense weathering supporting erosional loss of these outcrops. Rocks equivalent to the Bhimphedian orogeny occur as isolated outcrops in the Himalayas (north India). Thrusting in the Himalayas might have obliterated outcrops of these rocks. The youngest measured detrital zircon grain (458 Ma) reveals absence of post-Ordovician tectono-thermal events in the source area. The large gap between the youngest detrital zircon and the depositional age of the Mesozoic sediments suggests long-distance sediment transport as well as sediment recycling. Dominance of arkosic sandstones in the study area indicates felsic source rocks. LREE enrichment and positive Eu anomaly in the associated shales corroborate the above contention. Trace element concentration (Sc, V, Ni, Zr, Th) and ratios (Th/Sc, Cr/V, Y/Ni, Th/Co, La/Sc) support predominantly felsic source. However, concentration of V, Ni and Ti reveal mafic input in these sediments, thus supporting more than one source rocks as revealed by geochronology. Dominantly metapelitic and subordinately metamafic input inferred from rutile chemistry support mafic source. While garnet chemistry reveals dominant sediment flux from intermediate-acidic igneous and metasedimentary rocks, tourmaline chemistry throws light on the various grades of metamorphic source rocks. Th/U ratio in zircons reflects magmatic source rocks with minor metamorphic input. The Index of Compositional Variability (ICV), high values of Zr/Sc and high Hf concentrations corroborates recycled sediment input evidenced by the presence of detritus from the Bhimphedian orogeny. This study, therefore, indicates the existence of widespread orogenic rocks in north and north-western India which although scarcely outcropping in the present day, served as the main source rocks of the Mesozoic Kutch Basin.

A new model for the genesis of carbonate-hosted Mn ores, Longtou deposit, South China Block

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The lower Carboniferous Luzhai and Baping formations (ca. 359 Ma) of the South China Block comprise an ca. 170-m-thick clastic-carbonate succession capped by Mn ore horizons. Excellent exposure of the succession surrounding active mines near the town of Longtou, Guangxi Province, provides an unparalleled opportunity to investigate the origin of carbonate-hosted Mn deposits, which are an enigmatic and important ore deposit.

Lithofacies associations suggest inner and middle shelf clastics accumulated with deposition of carbonates on a mesotrophic middle to distal shelf. Proximal facies are siltstones with spiculitic chert dominated by terrigenous input from the shore, which provided silt, mud and dissolved Si. Vertical facies trends indicate the more widespread accumulation of carbonates during marine transgression. Mid-shelf packstones and grainstones host a diverse assemblage of crinoids, bryozoans, and brachiopods. Further outboard, laminated lime mudstone is typical of peri-platform ooze shed from a shallow-water platform. Coastal upwelling is interpreted to have elevated the concentrations of nutrients on the outer shelf, producing a standing stock of phytoplankton that promoted the prolific growth of filter feeders. Carbonate deposition during marine transgression culminated with the precipitation of high-grade Mn-carbonate ores during maximum flooding.

Mn ore horizons are composed of amalgamated alabandite-bearing rhodochrosite, Mn-calcite, and braunite laminae. Historically, Mn-carbonates have been interpreted as forming in an oxic water column via the reduction of Mn-oxides during organic matter degradation. However, paragenetic relationships and δ13C values similar to seawater indicate the Mn-carbonates of Longtou were precipitated authigenically beneath the seafloor as upwelling delivered anoxic, Mn-rich bottom water to the distal shelf. Such anoxia is interpreted to have shut down the carbonate factory and diminished sedimentation, a prerequisite for the concentration and precipitation of Mn-carbonates in pore water. These bottom waters were also enriched in Ba, REEs, and other metals that are toxic to carbonate producing organisms.

This model for the formation of carbonate-hosted Mn ores supports the notion that areas of the deep Paleozoic ocean were periodically anoxic and tapped by coastal upwelling to produce Mn- and related Fe-rich deposits. Application of this new ore deposit model provides a more complete understanding of giant, sediment-hosted Mn deposits, improving resource exploration and exploitation.

Keywords: Lower Carboniferous, carbonate-hosted Mn ore, South China Block, sedimentology, sequence stratigraphy, ore deposit model, coastal upwelling, Paleozoic ocean oxygenation

Characteristics and genesis mechanism of carbonate source rocks in the Middle–Upper Ordovician, Tarim Basin, China

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Large volumes of marine oil have been discovered within Ordovician carbonates in the Tarim Basin (northwest China); however, the carbonate source rocks of the Middle–Upper Ordovician (O2+3) are of high maturity. These rocks presently contain a low amount of total organic carbon (TOCpd ≤ 0.5%). In this study, the source rocks that have expelled hydrocarbons in the basin are identified using a mass balance approach. The characteristics and genesis mechanism of hydrocarbon expulsion from low-TOCpd (present-day TOC) source rocks are studied, which is significant for the hydrocarbon exploration in the Tarim Basin. Results showed that an O2+3 source rock with low TOCpd having expelled hydrocarbons was of type I and had a very narrow oil window. With high maturity, nearly 80% of the generated hydrocarbons were expelled, and the original TOCo (original TOC) values were over 1%. The oil and source rock extracts were relatively lean in gammacerane and C28 steranes, with the distribution of regular steranes having a V-shaped trend, suggesting a possible genetic relation between these source rocks with low TOCpd and the marine oils in the Tabei area. The genesis mechanism for the low-TOCpd carbonate source rocks is as follows. The main hydrocarbon parent materials were hydrogen-rich planktonic algae or acritarchs, distributed in the subsiding platform-slope facies. Organic matter was preserved under reducing conditions, and source rocks were formed with a good kerogen type and moderate hydrocarbon generation potential. Thus, hydrocarbon expulsion could have occurred, resulting in TOCpd ≤ 0.5%.

Secondary migration of hydrocarbons in the Ordovician carbonate reservoirs in Tabei Uplift, Tarim Basin, China

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Secondary hydrocarbon migration is important to the formation of oil and gas resources in the Tarim Basin in China. However, it has been a challenge to study the secondary migration in this region due to lack of direct physical evidence. In this study, we investigated the secondary hydrocarbon migration in Ordovician carbonate reservoirs in the Tabei Uplift in the Tarim Basin based on the analysis of the regional structure as well as the experimental data on the oil and gas properties, nitrogen compounds parameters, biomarkers and carbon isotope of n-alkane characteristics. The results indicate that the crude oil in the studied reservoirs has relatively low amounts of heavy n-alkanes, bearing a V-shaped trend in their regular steranes distribution. The oil is also lean in gammacerane, and has relatively light carbon isotope in the n-alkanes. These characteristics are similar to those of the Middle–Upper Ordovician source rocks, which are therefore identified as the source for the accumulations in the Ordovician reservoirs. Based on the variation of oil density, carbazole nitrogen compound contents and the gas to oil ratios, we derived the secondary hydrocarbon migration pattern in this region: the hydrocarbons migrated along the directions from southwest toward northeast in the Yingmaili area in the western Tabei Uplift, and from the H13 well block toward the surrounding areas in the Halahatang area in the central Tabei Uplift, and from east to west in the Lunnan area in the eastern Tabei Uplift. The findings of this research provide insights on the hydrocarbon migrations in this region and can help the exploration in the Tarim Basin.

Structural-driven fluid flow from the Kalpin thrust belt, South Tianshan, NW China

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Abscract: Structural-driven fluid flow has been widely reported and is receiving increasing attention in the world. Affected by the India-Eurasia collision, the Tianshan was uplifted rapidly during the Miocene, resulting in the formation of the Kalpin thrust belt, which is located between the Tarim Basin and the South Tianshan and consists of E-W trending arcuate thrust sheets towards the Tarim Basin. A set of NW-NNW striking strike-slip fault developed across the thrust sheets. Infill in the faults includes multiple stages of calcite, terrestrial muddy sediments, breccias and multiple stages of bitumen. The bitumen is interbedded with calcite. Analysis shows that there are seven stages of calcite and six stages of bitumen, indicating that several stages of fluid flowing had occurred within the faults. The δ13C values of the calcite range from -7.88‰ to -3.5‰, which tend to increase gradually from the phase I to phase VII. While, except for one stage of calcite having the δ18O values between -7.71‰ to -7.38‰, the δ18O values of the other stage of calcite are similar and range from -12.23‰ to -9.68‰. The negative values of δ13C may indicate the effect of organic carbon. The analysis of REE shows that all stages of calcite have a negative Ce anomaly which may indicate the oxidation environment. All stages of calcite show a similar REE distribution which may indicate the same origin of diagenetic fluid. Based on the Yb-La and Yb-Ca variation, all calcite falls into hydrothermal field, indicating that the diagenetic fluid may come from the deep. Characteristics of mineralogy and geochemistry of the infill indicate that the deep-seated fluid may have flowed upward along the fault to the surface. Combining with the structural history, this study suggests that the Himalayan orogeny was responsible for the fluid migration within the faults. The faults, which formed during orogeny, connected the deep paleo-oil reservoir. Driven by structural stress, the deep-seated fluid, including hydrocarbon and inorganic fluid, flowed upward along the faults, then calcite precipitated from the fluid due to the sudden decrease of pressure at the surface. The δ13C of the calcite may be influenced by organic carbon from the hydrocarbon. The intermittent opening and closing of the faults, due to the episodic uplift, resulted in the episodic migration of fluid within the faults. So the Himalayan orogeny may play an important role in hydrocarbon migration in the Tarim Basin.

Keywords: Orogeny; Fluid flow; Structural-driven; Fault; Geochemistry

Interactions between turbidity flows and bottom currents in sinuous unidirectionally migrating channels in offshore Mozambique

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Unidirectionally migrating channels formed from the interaction between turbidity flows and bottom currents have been studied intensively. However, most previous studies have only focused on the straight section of channels, and therefore the related analysis on the interactions between turbidity flows and bottom currents cannot demonstrate the flow processes in different parts of channels, led to limiting the knowledge on the formation mechanism and evolution of the whole unidirectionally migrating channels.

By applying three-dimensional seismic data, the current study not only depicted the geomorphology and internal architecture of the sinuous unidirectionally migrating channels in the Rovuma Basin (offshore north-eastern Mozambique) but also quantified the effect of bottom currents on turbidity currents in both straight and bend sections of the channels. Results show that the interaction between turbidity flows and northern flowing bottom currents led to the formation of the unidirectionally migrating channels. In the straight section of channels, fine-grained material from the upper parts of turbidity flows was deflected northward via flow stripping induced by bottom currents, and this material was finally deposited as sandy lateral accretions and muddy drifts. The lateral deposits steepened northern channel banks and forced the southern migration of channel axes. However, in the bend section of channels, the upper parts of turbidity flows are forced towards the inner (southern) bank, due to the helical flow induced by centrifugal forces, which may offset the effect of bottom currents, and therefore no lateral drifts developed. The effects of bottom currents on turbidity flow are related to the relative direction of turbidity flow and bottom currents. Bottom currents can induce flow stripping in the upper parts of turbidity flows when an angle exists between turbidity flows with forming lateral accretions and drifts. The formation mechanism of unidirectionally migrating channels depends on the lateral deposition (lateral accretions and drifts) and corresponding erosion induced by bottom currents, channels migrate towards the erosional side but away from lateral deposition.

The detrital zircon geochronology of the Hayang Group sandstones in the Gyeongsang Basin in Korea

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The Gyeongsang Basin is the largest Cretaceous nonmarine basin in Korea as the East Asian continental margin. It was formed by extension due to the subduction of the Paleo-Pacific plate in the Early Cretaceous. The basinfill of the Gyeongsang Basin comprises the Sindong, Hayang, and Yucheon groups upsequence subdivided according to the increasing frequency of synsedimentary volcanic activity. The lowermost basinfill, the Sindong Group, was deposited in an elongated Nakdong Trough since Aptian as a fluvio-lacustrine environment. It received sediments from the Precambrian basement rocks (The Yeongnam Massif) located to the west and northwest of the trough. The Hayang Group consists of three separate subbasins during the eastward extension of the Gyeongsang Basin with episodic volcanic activity: Yeongyang, Euiseong, and Milyang subbasins from north to south. The Hayang Group sediments are supposed to have been supplied mostly from the Yeongnam Massif but also Japan. The different characteristics between the Sindong and Hayang groups suggest the changes in the tectonic setting of the Gyeongsang Basin during their deposition. Thus, we analyzed the detrital zircon U-Pb ages of the Hayang Group sandstones in the Yeongyang and Euiseong subbasins to investigate changes in provenance and tectonic setting of the East Asian continental margin.

Total 1152 detrital zircons analyzed show a wide range of ages ranging from 3560 Ma to 99 Ma and comprise mainly Cretaceous, Jurassic, Triassic, and Paleoproterozoic zircon grains. The zircon age populations have the following characteristics indicative of temporal changes in the provenance of both subbasins. Paleoproterozoic zircon grains are predominant in the lower strata, whereas Mesozoic zircon grains become dominant in the upper strata. The Mesozoic zircon ages also show differences in the age groups among the samples; for example, Jurassic peaks ages become younger up sequence. The statistical test on the analytical results suggests that the primary source rocks of the Hayang Group sandstones are the Yeongnam Massif, the Sindong Group sediments, and Mesozoic igneous rocks. Temporal and spatial variation of sediment supply from these source rocks may represent the shared detrital drainage systems and their evolution during the deposition of the Hayang Group, although further study is necessary because the Mesozoic igneous rocks have a wide distribution in both Korea and Japan.

Seep carbonates and associated worm tubes community preserved in the Miocene of the Anti-Atlas, Morocco

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A well preserved evidence for seepage and associated worm tubes has been found in a Miocene carbonate succession of the Anti-Atlas Mountain (Morocco). The succession up to 30m thick consists of variety of micritic carbonate deposits with interbeds of carbonate breccias, and clastic conglomerates with carbonate cements. The authigenic micritic carbonates as well as associated deposits preserve evidences for conduits of seepage and include, among other features, dense network of straight to sinuous tubes filled partially or completely with white to pinky calcite, occasionally associated with black calcite. Petrographic features consist of a groundmass of authigenic micrite with vuggy fabrics interpreted as related to degassing vesicles of likely gas hydrates. The micritic groundmass preserves brecciated features along the cross-cutting carbonate network of veins and fissures, which are filled by microsparitic and sparitic calcite. Wide networks of veins and cracks indicate fluid or gas overpressures and are filled by downward injection of overlying sediments and subsequent carbonate cements. The associated fossils consist of worm tubes with circular cross-section and an average diameter up to 1 mm. Microtomography data shows interwoven vertically growing tubular organisms, highlighting their primary flexible character and suggesting dense living colonies. Petrographic features indicate that the skeleton of the tubes, up to 40 µm thick, consists of micritic carbonate and preserve organic remains. The inner cavity is filled with drusy spar, while the skeleton is surrounded by thick radixial fibrous calcite. Some tubes preserve external ornamented surface with fine concentric transverse growth lines and longitudinal ridges similar to that of Siboglinidae. The overall features suggest that the Miocene carbonate of the Anti-Atlas may have formed in an environment with active seepage and preserve an exceptionally worm tube fossils that resemble to modern cold-seep community.

Palaeoenvironmental context of the Famennian red pelagic limestones in the Křtiny quarry (Czechia)

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Red coloured limestones are common phenomenon of a pelagic depositional systems through the Phanerozoic, relatively frequently deposited in the greenhouse climate. The red carbonate beds are documented from several sections of the Famennian throughout the Europe, e.g. "Griotte" facies from France and Spain and similar facies from Carnic Alps or Rhenish Massif. This contribution is focused on the grey to red Famennian Křtiny Limestone that are exposed in the Marble Quarry (49°17'35.943"N; 16°44'5.806"E) at the Křtiny village in Czech Republic. In this study, we employed analysis of trace elements (ICP-MS, ED-XRF) and microfacies in order to determine the palaeoenvironmental conditions in the time of the deposition of the red sedimentary intervals. The studied interval ranges from the marginifera to ultimus conodont zones. First, thinner level of reddish to pinkish nodular limestones occur in marginifera/trachytera conodont zones interval, and second, thicker red level occurs in expansa to ultimus conodont zones interval. Both intervals are separated by grey limestones. The grey limestones are getting gradually darker with culmination just before the second red interval. Microfacies analysis shows that the section is mostly composed of bioturbated radiolarian and ostracod wackestones to lime mudstones with occasional packstone levels and breccia, deposited in the upper carbonate slope setting. Dark gray interval that is preceding the second red interval shows increased values of the redox proxy U/Th. These values indicate fluctuating dysoxic to anoxic conditions. Simultaneously, increased productivity is recorded by rising P and TOC content in the dark grey interval. Conodont assemblages revealed manca/expansa age and, therefore, this interval is tentatively correlated with the global hypoxic Dasberg Crisis (following high-resolution conodont biostratigraphy studies must evidence the correlation). U/Th values in the subsequent red interval are ten times lower and reflects oxic environment. Detrital proxies Ti/Al and Zr/Al show steady conditions of clastic input for most of the section, without significant changes in grain size or provenance. K/Al reveals systematically higher values in the red intervals and as such it can display more intense physical weathering which might indicate an affinity towards cooler climate. Positive $\delta^{13}C_{carb}$ excursion (3 ‰) has been previously documented from the second red interval and probably records increase in carbon burial during shift from dark grey to red facies. Change from the Famennian dark grey limestones, deposited in times of increased productivity and reducing condition, to predominantly reddish limestones of cooler climate is similar e.g. to change from the Cenomanian black shales of the OAE1 to the oceanic red beds, or to occurrence of the Lower Devonian red pelagic limestones deposited in times of switching between mesotrophic and cooler oligothrophic marine conditions.

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Bryozoan-rich stromatolites (bryostromatolites) from the Silurian of Gotland and their relation to global 13C excursions

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Bryozoan-stromatolite associations (bryostromatolites) formed conspicuous reef structures throughout the Sheinwoodian (Wenlock) to Ludfordian (Ludlow) stratigraphy on Gotland but have not been described so far. They are mainly composed of encrusting bryozoans forming a complex intergrowth with poro- and spongiostromate microbes and thus differ significantly in composition from the abundant stromatoporoid-coral-algal reefs. In the bryostromatolite reefs different growth stages can be identified. The observed succession can be taken as evidence for small-scale cyclic environmental changes during reef growth. Stenohaline reef-dwelling organisms such as echinoderms, sponges, corals and trilobites, indicate fully marine salinities. Ten localities exposing bryostromatolites were discovered. Individual bryostromatolites are small with few decimeters up to one meter in size, and occur solely in very shallow marine areas. Common features of these reefs on Gotland are cauliflower-like growth, a high bryozoan diversity, enhanced bioerosion, and Palaeomicrocodium crusts. The high abundance of Palaeomicrocodium as well as the alternation with other crust-forming contributors indicates a growth directly at the palaeo-sea surface, probably in times of minor but high-frequency seal-level fluctuations. All bryostromatolites were formed in times of strongly elevated delta13C values. The unusual combination of sedimentological and palaeoecological features as well as their occurrence exclusively during times of strong positive delta13C and delta18O excursions are evidence that the bryostromatolite development is directly related to the – still enigmantic – climatic/oceanographic changes expressed by the isotope excursions.

Origin and significance of shelf-derived MTDs in the tectonostratigraphic evolution of trench-slope basins (Hikurangi margin)

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Continental shelves supply some of the greatest mass-wasting events recorded worldwide (i.e., attached systems), yet most studies on shelf-derived mass-transport deposits are based on seismic-reflection data with little input from outcrop analogues.

In this study, we use a combination of traditional fieldwork data (e.g., detailed sedimentary sections), photogrammetric data (acquired from a drone) and taphonomical analysis in order to address this knowledge gap bringing new high-resolution, outcrop-scale insights on both the nature of the reworked sediments, and their mechanisms of development and emplacement along tectonically active margins. More particularly, we examine new occurrences of attached systems, sourced from the shelf, outcropping in the exhumed southern portion of the Hikurangi subduction margin (Coastal Ranges, North Island of New Zealand). The related products are Middle Miocene in age and include several episodes of mass-wasting that reworked shelf-derived material (shells and sediments), can reach about 100 metres (minimum thickness) at outcrop and were deposited across several trench-slope basins along a 70 km long transect (Whareama, Te Wharau and Akitio Basins).

Sea-level changes and high sedimentation rates are commonly inferred to be the main causal mechanisms triggering the large-scale destabilization, downslope mass-movement and resulting deposition of shelf-derived sediments into deep-water. Yet, the role of tectonics is undoubtedly important, particularly along active margins where it exerts a crucial control on the stratigraphic development of the related confined intra-slope basins (e.g., trench-slope basins).

Our results show that periods of repeated tectonic activity (shortening, uplift, related seismicity) in such compressional settings not only affect and control the development of shelfal environments at mature stages of margin evolution. They also drive the recurrent generation and destruction of oversteepened slopes, which in turn, favour the destabilization and collapses of the shelves and their substratum.

At outcrop-scale, these events produce both large-scale, shelf-derived sediment mass-movements and debris flows close to the source region. Downslope, they can eventually break down into a series of coalescing, erosive, genetically-linked surging flows.

Recognition of tectonic activity as another essential causal mechanism for large-scale shelf failure (in addition to sea-level fluctuations, high-sedimentation fluxes) has implications for both stratigraphic predictions and understanding the tectonostratigraphic evolution of deep-marine fold and thrust belts.

Shallow lacustrine carbonate debrites: facies and flow types, sources, triggers and underlying controls

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Resedimented lacustrine carbonates appear to be more common than previously thought. This refers specially to medium and fine-grained debris flows. Mixed, fluvio-lacustrine siliciclastic and carbonates are unconventional petroleum systems. They are frequently interpreted as low-energy water bodies or as shoreface deposits. The identification of resedimented carbonates is important to palaeogeographic reconstructions and to the distribution of source rocks and reservoirs.

The Cameros basin in Northern Spain is a Lower Cretaceous extensional basin, with low-gradient basin margins. It was supplied with siliciclastics from a high-relief hinterland and with minor clastics and carbonate-rich waters from a low-relief borderland. Extension was followed by tectonic inversion, uplift and partial erosion, and as a result, a partly eroded syn-rift mega-sequence is cropping out across the basin. The Golmayo Formation is the remnants of the Enciso super-sequence in the small sector of Soria-South Cameros. It is 800 m thick and consists of an alternation of siliciclastics and detrital carbonates ones thought to represent interdistributary ponds and lakes. Detailed fieldwork, measured sections, photopanels, polished hand specimens and thin sections were used to describe the facies and flow types, to correlate channels and lobes, so as decipher the sub-lacustrine systems. The background lithologies are thick reddish mudstones and thin to thick green marls and calcisilts indicative of shallow freshwater-to brackish marine environments. The main sub-lacustrine system consists of dark grey to black middle-bedded limestones of microbialites and coated grains. The facies are massive clast-supported calcirudites, massive and graded calcarenites, and calcisilts with floating clasts. They were deposited in channelled lobes by debris flows of low to moderate cohesive strength. The second sub-lacustrine system is made of middle-bedded charophytic limestones. They include three facies, massive pseudo-brecciated packstones, massive and laminated wackestones and mudstones with floating clasts deposited by cohesive debris flows. The third sub-lacustrine system made of orange thin-bedded calcisilts, rippled and laminated deposited by low-density turbulent flows. Load casts, broken beds, flame and other fluid scape structures indicative of rapid instantaneous sedimentation are common.

The coated grains and charophytes were sourced from a cryptic carbonate ramp attached to the low-gradient carbonate borderland. The debris flows resulted from the transformation of slumps triggered by a combination of storms, river floods and overland flows. Extensional tectonics controlled the low gradient of the basin margin. The carbonate borderlands favoured the cryptic carbonate ramp with microbialites and charophytes meadows. The climate controlled the carbonate factory, the dynamics of the system, the storms, river floods and overland flows that triggered the sediment gravity flows. The resedimented carbonates show a transitional environment between a fluvial system and a large shallow coastal lake. They indicate a larger basin than the current outcrops. They highlight the fact that the basin margins and lacustrine carbonate ramps have high chance of being eroded. The most 'marginal' outcrops do not represent low-energy water bodies, but sublacustrine systems deposited by sediment gravity flows.

Assessing diagenesis in deep-time geochemical archives: statistics to the rescue!

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Chemostratigraphic approaches are commonly used while exploring past environmental conditions, but a wide possibility of diagenetic pathways tends to mask original information. A fast and simple way to separate noise from meaningful signals is the use of data reduction strategies, which are even more relevant when dealing with large and complex geochemical datasets.

The potential of statistical approaches will be demonstrated on a current case-study dedicated to a 3D geochemical approach to dolomite occurrence on Jurassic and Cretaceous from the Lusitanian Basin. This study was designed to capture the mechanisms controlling the spatial distribution of dolomite across a variety of depositional settings along the same ancient platform.

New geochemical and petrographic data was obtained. Aliquots of the samples previously measured for stable isotope C&O analysis were investigated for their Ca, Mg, Sr, Fe, Mn and Ba elemental composition using inductively coupled plasma- atomic emission spectrometry (ICP-AES). Based on complementary petrographic evidence, geochemical data was compared to optical properties of selected samples. Through data reduction, Principal Component Analysis depicted potential patterns within the obtained geochemical dataset, providing further insight on the processes responsible for the variability of the proxies under evaluation.

Four geochemical variables of interest were selected: Mg, Fe, O-isotopes and Mn, all known to be sensitive to the presence of dolomite/(de)dolomitization and/or early to late diagenesis. The results obtained by Principal Component Analysis explain 70% of the total variability of the dataset. The strong positive affinity between Fe, Mg and O-isotopes marks the presence of dolomite when these proxies denote higher values (or less negative, for the case of O-isotopes). In contrast, a separate component is influenced mainly by high values of Mn and less significantly by only a few samples with lowered elemental values (mean Mg of 1963ppm) and remarkably low O-isotope values (mean value of -7‰). Three main geochemical groups of samples were so far differentiated based on their geochemical signatures: two different types of dolomite-dominated materials (from intermediate to very high Mg abundance); and a third group of samples with overall low elemental content, also showing the lowest records of δ18O, interpreted as corresponding to cemented siliciclastic horizons. In such a complex context, the main cluster including calcite-dominated samples reveals little geochemical variability. Nevertheless, this group must definitely be further explored as it includes data from a variety of depositional settings, certainly enclosing valuable paleoenvironmental information.

Carbonate vs. clay fractions: contrasting paleoenvironmental interpretations in ancient shallow-platform deposits (Early Kimmeridgian, S Iberia)

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Two Kimmeridgian shallow-marine carbonate sequences, sharing the same paleoclimatic conditions, were previously explored using carbonate chemostratigraphy. The goal was to detect signals related to paleo-platform bottom physiography, degree of connection with oceanic waters and overall circulation patterns. Largely, geochemical trends could be attributed to the differential action of forcing mechanisms operating along the south-Iberian paleomargin during Early Kimmeridgian times. These included a high degree of continental influence for the most proximal setting, which faded out along the mixed carbonate-fine siliciclastic rhythmic deposition in more open settings.

Complementarily, bulk mineralogical composition and clay mineral fractions are now under investigation to contrast and complement previous information, aiming for a more complete overview of continent-ocean dynamics along shallow-carbonate platforms.

For the most proximal setting, abundant quartz was still reaching this area, but decreasing as calcite deposition dominated the sedimentary record. In contrast, for the comparatively seawards and distal location, quartz abundance was verified mainly as sharp and prominent peaks, coinciding with pulses of continental influx. As for the clay fraction, each location provided very distinct patterns. The most proximal setting revealed a significantly higher abundance of smectite (and illite) when compared to the more distal site, this is especially relevant at the lowermost portion of the Rocha Poço section, and probably related to distal relative lockdown by carbonate shelves forcing restricted connection to open sea, Tethyan epioceanic waters. A scarce presence of kaolinite is also characteristic for this proximal site. At the more distal site, clay mineral abundance was overall lower, comprised mainly by illite and illite/smectite (and small amounts of kaolinite). The absence of smectite confirms the more distal position of the Puerto Lorente site along the paleoplatform, and is coherent with interpretations based on independent geochemical and ecological evidence. A conspicuous increase in the clay mineral assemblage towards the topmost horizons of this rhythmic carbonate-siliciclastic deposit is a novel feature, not previously detected. Interestingly, the terrigenous pulses identified both in geochemical and bulk mineralogical data are not very expressive in the clay mineral record. The information retrieved from mineralogical data provided new evidence on depositional contrasts resulting from local differences in platform configuration, allowing a better understanding of the mechanisms controlling the terrigenous fraction of shallow-water carbonates.

Resedimented carbonates partially controlling submarine-fan morphodynamics: Insights from the Middle Eocene deep-marine Jaca Basin

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The Middle Eocene Hecho Group deep-marine lobe-and-related deposits in the Jaca Basin, South Pyrenean foreland basin, are characterised by the presence of several very thick (up to >200 m thick) carbonate megabreccias. For decades, these carbonate breccias, have been referred to as "megaturbidites". They are good marker beds that help with stratigraphic correlations. The carbonate "megaturbidites" in the Jaca Basin have been interpreted as forming due to episodic large-scale collapse of the northern and southern carbonate platform, likely triggered by large-magnitude earthquakes with a mean periodicity of about 800 kyr. Their depositional features are not characteristic of turbidites and, therefore, lead us to redefine the deposits as sediment slide/cohesive-flow deposits (SSCF deposits).

A total of 9 SSCF deposits have been recognised, SSCF-1 (the oldest) to SSCF-9 (the youngest). One of these, previously called the "Roncal bed", can be followed for ~135 km across the entire basin floor with a thickness up to 200 m (i.e., SSCF-5), with an original volume probably > 200 km3. SSCF deposits can be described as fining upward sequences. The base of the SSCF deposits are defined by rip-up clasts of shallow-marine limestones and slope marlstone, and abundant fossil debris. Component clasts are also impressive, some reaching several hundred meters in length and up to 100 m in thickness. The upper part of the SSCF deposits are well organized and characterised by homogeneous marlstone overlying calcarenite, mainly composed of bioclastic material such as large benthic and pelagic foraminifera. The caps represent suspension settling following the catastrophic slope/shelf failure events.

A detailed study of the Hecho Group siliciclastic deep-marine lobe-and-related deposits between the SSCF deposits in the Jaca Basin show that in proximal-to-distal and axial-to-lateral directions there are local increases in bed thickness, together with a progressive decrease in grain size. A relatively high-proportion of deposits related to high-energy (supercritical) flow, such as antidunes, have also been observed in the most distal part of the submarine lobe-and-related deposits of the Jaca Basin. These observations could partly be explained by enhanced local confinement due to the SSCF deposits. The presence of the SSCF deposits created significant topographic features in the deep-marine Jaca Basin, thereby forming local accommodation and relative confinement. The presence of SSCF deposits in the distal parts of the Jaca Basin created local accommodation as seen in bed thickening during a period of basin narrowing. The increase in local confinement induced by the SSCF deposits (acting as seafloor obstacles) would have affected the incoming siliciclastic sediment gravity flows (SGFs) by initially increasing flow velocity, offsetting any decrease in flow velocity as the SGFs travelled father basinwards, allowing energetic siliciclastic SGFs to reach the distal parts of the Jaca Basin.

This study shows that resedimented carbonates played an important role in generating local seafloor topography and subsequent flow confinement. The SSCF deposits, therefore, significantly influenced the morphodynamics of the siliciclastic submarine fans and associated deposits.

Piracy-controlled deactivation of tidal meandering channels and its effects on point bar geometries

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A major goal in studying coastal landscapes is the development of critical comparisons between morphodynamics of fluvial and tidal meandering channels. Freely migrating fluvial meanders are known to produce laterally extensive point-bar bodies which commonly exhibit width:thickness ratios up to 250. Nevertheless, where channel networks are characterized by a high drainage density, like in case of tidal networks, meandering channels can hardly migrate laterally for long distances without interacting with adjacent channels and change their morphodynamic behaviour. In order to better understand how the interaction between adjacent tidal meandering channels controls growth patterns of related point bars, two point-bar bodies from the Eocene Castigaleu Formation (Spain) are investigated and compared with the geometry of a modern tidal point bar from the northern Venice Lagoon (Italy). The Castigaleu point bars are characterized by a low width:thickness ratio (<30), interpreted as the result of premature abandonment of their parent channels. Such abandonments were likely related to avulsive piracy operated by adjoining tidal channels, and likely prevented formation of laterally extensive, tabular point-bar bodies. This interpretation is corroborated by direct time-lapse observations of similar dynamics in modern tidal networks, and by morphodynamic and sedimentological evidence from recent deposits of the Venice Lagoon. We conclude that, in densely drained tidal networks, meander bends often interact with adjacent channels, thereby triggering piracy events and premature channel abandonments that generate point-bar bodies with a low width:thickness ratio.

Depicting architecture and sedimentology of a hypertidal point bar through Lidar and sedimentary-core data

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Morphodynamic behaviour of tidal meanders and internal architecture of related sedimentary bodies have received scarce attention, although they are ubiquitous features of coastal landscapes. Expansion of tidal meanders is known to produce a progressive increase of bend sinuosity, along with accretion of point-bar deposits and formation of inclined heterolithic strata. These deposits are considered to be rich in fine-grained sediments and tend to record tidal rhythmic deposition in the upper part of the bar, being the lower bar deposits dominated by erosional and bypass processes. Although these criteria are widely accepted, facies models for tidal point bars still lack a 3D perspective and overlook the along-bend variability of sedimentary processes. This knowledge gap can have a direct impact on understanding intra-point-bar heterogeneities and connectivity, with implications for reservoir production. The present study focuses on a 3 m deep tidal meandering channel located in the salt marshes of the hypertidal Mont-Saint-Michel Bay (France), and investigates sedimentology of a time-framed bar accretionary package by means of Lidar-topographic data, geomorphological-field surveys and sedimentary cores. The studied accretionary package was accreted along the bar between 28/03/2012 and 29/11/2012. Integration between Lidar and sedimentary-core data shows that over this time the bar expanded alternating depositional phases along its seaward and landward side. The maximum thickness of deposits was accumulated in the bar apex zone, and just landward of it, where the largest amount of mud was also stored. High accretion rate of the bar apex zone endorsed also a better preservation of rhythmites, which are almost missing from deposits accumulated along the bar sides (i.e. close to riffles). We suggest that alternating depositional loci and high sediment accretion at the bend apex zone emerge due to a combination of factors, including: i) the spatio-temporal asymmetric nature of tidal currents, which influenced deposition and preservation of flood and ebb deposits along the bend; and ii) the development of low-energy conditions at the apex due to ebb and flood flow configuration, which also promoted mud settling.

This study highlights that mud and tidal rhythmites are not uniformly distributed within point-bar deposits, and their occurrence is strongly controlled by the asymmetric and mutually evasive nature of ebb and flood tides.

The upper paleozoic pull-a-part mulargia-escalaplano basin (s sardinia, italy): relationships between tectonics and sedimentation

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The Mulargia-Escalaplano late to post-Variscan molassic basin in central Sardinia preserves a 300 m thick succession of continental deposits. Alluvial fan-(deltas?), braided and sinuous stream to lacustrine-palustrine?/playa sediments were laid down under wet climates evolving to dryer conditions. Sediments are organized in two superposed main depositional cycles punctuated by recurring volcano-tectonic spikes. The lower cycle is related to the limnic Rio Su Luda Fm (Late Pennsylvanian to Early Permian), while the upper cycle, subdivided into two sub-cycles, is related to the red bed Mulargia Fm (Early to Middle? Permian). The transition between the two stratigraphic units is marked by coarse deposits showing a gradual color change from dark grey to red. If there is any significant stratigraphic gap between them is still unclear yet. Nonetheless, the Mulargia Fm reworked the Rio su Luda Fm, as demonstrated by the embedded pebbles. The deepening of the source of the pebbles testifies an ongoing unroofing process reaching in times the lowest tectonic Variscan units of this part of the chain. Evidence of synsedimentary tectonics as small faults, slumpings, and debris flow are scattered especially in the NW part of the basin. In the limnic cycle and in each of the red bed sub-cycles the depositional energy decreases gradually upwards and SE-ward until the onset of the following tectonic phase. Thus cycles and sub-cycles represent erosive responses to volcano-tectonic climax producing, in the end, the smoothing of the surrounding relieves. High-energy passing to low-energy continental environments develop gradually in times and show a vertical and lateral evolution. Based on analogies with coeval and fossil similar examples, the investigated depositional basin is a pull-a-part one related to a main NNW/SSE listric fault: the sedimentary facies and the stratigraphy are organized accordingly, with both coarsest deposits and finest and deepest deposits located close to the master fault. The basin widens progressively in times and its depocenter shifts SE-wards. The sedimentological features show this strong directional control, with a SE-directed sediment flow. Sedimentary structures, as cross-bedding and imbrications, support this SE flow direction. The bed shape of the coarsest lithologies changes southeastward from tabular to lenticular, as well as their architectural organization, showing growing evidence of lateral accretion in the same direction. Thus the fluvial style evolves southeastward from braided towards sinuous channel patterns. Compositional and textural maturity of the siliciclastic deposits grows southeastward likewise. Carbonate deposits of low-energy, containing subordinate evaporites, grow also SE-ward. Stratigraphical, environmental, and evolutional correlations between the presently separated NW and SE part of the basin have been reconstructed and evidenced by considering the leading role of the tectonics. The Mulargia-Escalaplano basin outcrops show a well-exposed example of the tectono-sedimentary evolution of a late to post—Variscan sedimentary pull-a-part basin, successfully comparable with its analogs of SW Europe, as the Autun, Lodeve (France), and Saar-Nahe ones (Germany).

The eocene monte cardiga fm (sardinia, italy): a tidal strait towards a westward coal basin?

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Paleogene deposits are scattered in S Sardinia. According to previous reconstructions, during the Paleogene an E-W transition between open to confined environments occurred, giving place to a restricted gulf in the W.

In SW Sardinia the uppermost Paleocene – Lower Eocene 200 m thick Produttivo group rests unconformably over older rocks. Its base is formed by continental siliciclastics (Arenarie di Monte Margiani Fm, 0–25 thick). These siliciclastics are followed by the marine Miliolitico limestones (30–50 m), and by the Lignitifero siliciclastic to carbonate succession with lignite layers at the top (70–120 m), of coastal-deltaic (tidal?) environments. This succession represents the tectono-sedimentary transgressive – regressive Pyrenean cycle. The Middle Eocene – Lower Oligocene continental Cixerri Fm follows unconformably.

The link between the SW and the SE Sardinia successions is represented by the central Sardinia 35 m thick Nuraghe Sioco Lower Eocene siliciclastic to minor carbonate fossiliferous succession. It represents an emerged(?) mudflat featured by frequent marine ingression. The exposed sections of this unit are too restricted to allow any reconstruction by now. Limited tidal influences are possible.

In SE Sardinia crops out a 250 m thick Early-Middle? Eocene transgressive-regressive sedimentary cycle. It rests unconformably over all the previous units and it is represented by the 10 m thick Santa Caterina Fm, followed by the unconformable 240 m thick Monte Cardiga Fm. The Santa Caterina Fm is a palustrine-lacustrine-alluvial unit reworking the Triassic carbonate substrate and followed by thin siliciclastic deposits. The upper Monte Cardiga Fm is featured by siliciclastic deposits with carbonate-siliciclastic intercalations. Five lithofacies delimited by gradual boundaries are present. They are, from the bottom 1) continental, siliciclastic coarse lithofacies; 2) transitional sandstone-carbonate lithofacies; 3) laterally discontinuous, lens-shaped marine calcarenitic lithofacies; 4) marine to transitional carbonate-sandstone-pelitic lithofacies; 5) continental sandstone-conglomerate lithofacies. Every lithofacies represents a specific depositional environment. Following the continental environment of the lithofacies 1, the transitional lithofacies 2 is represented by sandstones whose bedforms are arranged in meanly EW fashion as meter-sized dunes with 35°-dipping foresets. The lithofacies 3 carbonate nummulite-bearing intercalations stick out as EW-elongated humpback from a plateau: they are organized as lens-shaped, slim bodies featured by fossiliferous grainstones-packstones with cross-bedding EW-oriented. The lithofacies 4 show possible tidal bundles with slack-water laminae. The lithofacies 5 marks a return to the original continental conditions. Sandstones are litharenites rich in rock fragments from the Variscan basement passing to lithic arkoses with k-feldspars deriving from the lower granitoid and so implying the unroofing of the basement itself.

The features of the Monte Cardiga Fm marine part suggest deposition in tide-influenced environments with elongated tidal bars. The outcrops distribution and the former palaeogeographic reconstructions indicate that a tidal mechanism forced by a tectonics-related funneling was in effect. Ephemeral communications between the Sardinia SW and SE sectors were assured by the shallow, choked Tanca Aru strait where a thin Produttivo Group succession 7–8 m thick featured by lagoonal to palustrine-lacustrine deposits.

This way the S Sardinia Eocene outcrops have a possible paleoenvironmental framework.

Controls on submarine slope channel development: insights from 3D seismic and numerical modelling

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Understanding the evolution of channels on tectonically active submarine slopes is complicated by subsequent deformation and limited preservation potential. Channels might exhibit different channel-structure interactions creating tortuous pathways combined with phases of net erosional, net depositional or equilibrium flow conditions that influence channel fill and sediment distribution across submarine slopes. Channel evolution and fill models exist to better understand the architecture of slope channels, but usually lack hydrodynamic constraints to better link the possible character of palaeoflows with the resulting morphology. Here we combine 3D seismic data interpretation with numerical flow modelling to estimate whether flows were net erosional, net depositional or at equilibrium at the various stages of channel evolution. In addition, we perform a sensitivity analysis of the flow model to better constrain interpretations of paleoflow conditions.

The case study is based on the Neogene Omakere Channel Complex, offshore North Island, New Zealand. The channel runs from the inner to mid-portion of the East Coast Basin, which comprises a series of elongate basins on the actively growing Hikurangi subduction wedge. On the upper part of the slope, the ~57 km long channel is confined and runs axially along the Omakere Trough (NE-SW), parallel to the Omakere Ridge, before being diverted ~ 90o to run to the SE. Channel stories making up the channel fill stack vertically with limited observed lateral offset in the most confined portion; they range from ~350 m to 900 m in width and are usually < 50 m high. Continuous moderate-to-high amplitude reflections through individual fills suggest sand-prone intervals overlaid by low amplitude, potentially mud-dominated sediments. Chaotic, discontinuous amplitudes interpreted as MTDs ~35 m thick also contribute to the channel fill.

Variations in channel fill observed from seismic facies combined with the flow modelling suggest that erosional flows prevailed in the early phases of channel development with flow characteristics being controlled partly by changes in confinement, substrate changes and gradients that reflect evolving tectonic structures. The phases of net erosion and net equilibrium flow conditions allowed the transport of sediments tens of kilometres down-channel into distal basins. Deceleration of current velocities and loss of flow competence enhanced deposition both in the channel-prone portion and at its terminus where both sediment distribution maps derived from the modelling and attribute maps suggest the presence of sand-prone deposits.

Insights into the range of flow conditions controlling the evolution and fill of a submarine slope channel and the intra-slope accommodation it traverses could constitute a powerful method to increase our understanding of and better constrain channel development in other tectonically active margins and could therefore aid the assessment of hydrocarbon prospectivity in such areas.

Temporal and Spatial significance of volcanic particles in sand (stone)

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Volcanic particles have particular geodynamic significance. Despite abundant dataset on volcanic-derived sand(stone), the distinction between spatial and temporal distribution of volcanic particles within the sedimentary record is poorly documented. One of the most intricate tasks in optical analysis of volcaniclastic sand(stone) is the distinction of grain eroded from ancient volcanic rocks (paleovolcanic, noncoeval grains) from grains generated by active volcanism during sedimentation (neovolcanic coeval grains). Petrological methods are useful for decipher temporal significance of volcanic particles in detail between paleovolcanic and neovolcanic, and for active volcanism to decipher syneruptive versus posteruptive processes during deposition in sedimentary basins close to volcanoes. sedimentary processes during syneruptive, intereruptive and posteruptive phases are well described in continental environments in terms of changing sedimentary facies, whereas they are more difficult in deep-marine environments. Examples of volcaniclastic sedimentation derived from both paleovolcanic and neovolcanic sources are discussed in diverse geotectonic settings.

Sandstone petrology of buried Permian siliciclastic group (Puglia 1 Well, Apulia Unit), southern Italy

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Late to post-Variscan Permian siliciclastic signature in sedimentary basins in the Mediterranean region occurs locally in surface or are intersected in well-log in subsurface. The Apulia region, is one of the main paleogeographic domain after assemblage of the Pangae supercontinent that includes Permian sedimentary siliciclastic strata. These strata occur in the Apulia Unit between 7070 m to 6110 m in depth, for 960 m in thickness, of dominantly sandstone, mudstone and breccia. The onset of Permian siliciclastic strata is in response of major tectonic partitioning between the Pennsylvanian to Permian times during post-Variscan tectonic assemblage. Particularly, the Permian major tectonic and climatic events include a well documented sedimentary cycle, mostly characterized by red-bed deposits. Here we provide new insights on Permian strata of the Apulian Unit, that has been sampled in a deep core (Puglia 1 Well) of property and with permission of ENI. Permian sandstone and related mudrock record a synchronously phases of post-Varisian collision and subsequent final closure of Paleotethyan ocean. Sedimentological and stratigraphic architecture associated to the distribution of mineralogical composition of sandstone and mudrock, are pivotal factors to reconstruct the sedimentary evolution of the Permian paleogeography. Sandstones are quartzolithic, having abundance of quartz and metasedimentary lithic (mainly phyllite and schist) fragments. Feldspars are minor. Sandstone and mudrock experienced burial and diagenetic history. The diagenetic evolution of redbeds has been evaluated using chemical-mineralogical signatures. Carbonate cements are dominant, and consist of crystals of dolomite, ankerite and calcite (related to dedolomitization/calcitization processes of the first carbonates), which leaves the carbonate grains with iron oxides. Sandstones have also experienced intense reduction of intergranular space (IGV) from the early stages of burial evidenced by contrasting compactional porosity loss (COPL) versus cementational porosity loss (CEPL). These data support the minor role of cementation as a reducing porosity process during diagenesis and the key rule of compaction as the main process destroying primary pores. Mudrocks display K-enrichments, intense paleoweathering under a hot, episodically humid climate with a prolonged dry season, and sediment recycling. Sandstone detrital modes are quartzolithic reflecting a provenance from recycled orogenic Paleozoic section of Cambrian-Carboniferous mainly metasedimentary rocks having occurrence in Calabria-Peloritani, southern Alps and in internal domains of the Circum-Mediterranean orogens.

Exhumation of the SE Pyrenean fold and thrust belt inferred from fluid geochemistry

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Fluid flow analysis in fold and thrust belts provides information about the exhumation of foreland basins. In this contribution, we decipher the evolution of the SE Pyrenean fold and thrust belt from Late Cretaceous to Oligocene by means of petrographic observations and geochemical studies of fracture-filling calcites. We have used δ18O, δ13C, 87Sr/86Sr, clumped isotopes thermometry, U-Pb dating, major and Rare Earths + Yttrium (REE+Y) element analysis in the three supperposed SE Pyrenean thrust sheets north of the Ebro foreland basin. From top-and-older to bottom-and-younger these thrust sheets are the Bóixols-Upper Pedraforca (latest Cretaceous–Paleocene), the Lower Pedraforca (early–middle Eocene), and the Cadí (middle Eocene–late Oligocene).

Clumped isotopes thermometry of fracture-filling calcites indicates a progressive decrease of fluid temperature in each individual thrust sheet and the Ebro foreland basin as they exhumed. These structures show δ18O depletion through time when they are not detached above evaporites, although an enrichment in δ18O occurs occasionally in the Ebro basin when thrust faults are detached above thick evaporite units. REE+Y content in calcite cements from the Upper Pedraforca thrust sheet shows a progressive increase of the Ce anomaly and a decrease of the Y/Ho ratios of fluids from Eocene to Oligocene, interpreted as the increasing influence of syn-orogenic sediments through exhumation of the SE Pyrenees. Contrarily, in the Cadí thrust sheet, during the same period, a decrease of both the Ce anomaly and Y/Ho ratio is observed along time. This is interpred as the progressive input of oxidizing meteoric fluids as the Cadí unit exhumed. The absence of increasing Ce anomalies in fracture-filling calcites from this unit is inferred to be related to the lower influence of syn-orogenic sediments due to burial of the Cadí beneath the Upper and Lower Pedraforca thrust sheets.

At the scale of the whole SE Pyrenean fold and thrust belt, U-Pb dating coupled with strontium isotopes of fracture-filling calcites show a progressive increase of the 87Sr/86Sr ratios from Late Cretaceous to Oligocene. This increasing trend is interpreted as the growing influence of syn-orogenic sediments derived from the exhumation and concomitant erosion of the igneous and metamorphic basement. This exhumation started at ~55–60 Ma according to thermochronology data published by previous authors. The increase of the 87Sr/86Sr ratios along time in the SE Pyrenees has a positive correlation with clumped isotopes data, which evidence increasing temperatures from ~90 ºC to ~180 ºC from Upper Cretaceous to Oligocene. This increase of the fluid temperature is interpreted as the interaction of fluids with deeper basement thrust units during the thick-skinned deformation from middle Eocene to Oligocene. Finally, major elements content shows a progressive depletion in Fe and Sr from middle Eocene to Oligocene. The Fe depletion has been interpreted as the progressive input of oxidizing meteoric fluids, whereas the Sr depletion is consistent with a decrease of marine conditions in the SE Pyrenean foreland basin.

Nature and occurrence of organic-rich strata in ancient deep-marine levee deposits

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Modern deep-marine levees have been shown to sequester a large proportion of the world's total buried organic carbon; however, few studies have attempted to assess this in ancient deep-marine sedimentary rocks. Deep-marine levees are areally extensive features that experience high rates of sedimentation, making them ideal sites for significant carbon burial and preservation. Examining the distribution of organic material in ancient levee deposits could provide insight into paleoenvironmental conditions and the evolution of ancient ocean and climate systems.

In levee deposits of the Neoproterozoic Windermere Supergroup at the Castle Creek study area (B.C., Canada), total organic carbon content (TOC) is highly variable and ranges from < 0.1% to 1.7% (uncorrected for the effects of greenschist metamorphism). Organic-rich strata commonly occur as either organic-rich mudstone beds or as distinctive black clay-rich laminae in sand-rich turbidites with anomalously high intragranular porosity filled with carbonate cement. Scanning electron microscopy (SEM) shows that organic carbon occurs primarily as nano-scale coatings on clay grains, but also uncommonly as sand-sized organomineralic aggregates and discrete sand-sized amorphous particles in the sandstone part of the bed. Much of this organic material is interpreted to have originated as freely suspended micro- and nano-scale organic compounds and extracellular polymeric substances (EPS) that made up part of the dissolved organic carbon pool in the upper water column over the continental shelf and further offshore. This material then became physically adhered and/or chemically adsorbed onto the surface of clay minerals and subsequently was resedimented by suspension settling and active transport in turbulent suspensions into the deep sea. During advective transport, low-density organic material and fine-grained clay minerals were preferentially sequestered in the upper portion of turbidity currents, and hence were more likely to overspill the channel margin and become deposited. Due to negligible erosion, and hence high rates of net sedimentation, this sediment became rapidly buried and therefore protected from extensive oxidative and microbial degradation.

In addition to commonly being associated with highly carbonate-cemented sandstone, organic-rich clay laminae and thicker beds of organic-rich mudstone contain an abundance of framboidal pyrite. Both the pyrite and the carbonate cement are interpreted to be microbially mediated, although the origin of the carbonate cement is somewhat more complex. To better understand the origin and diagenesis of the cement and its possible microbial signature various physical and geochemical analyses will be performed, including examination using optical and scanning electron microscopy, cathodoluminescence, and stable carbon isotope analysis. By studying the nature and occurrence of organic-rich rocks and their associated strata in this ancient outcrop, this study aims to provide insight into basin-wide conditions and dynamics, including primary productivity and platform development on the shelf, and sediment provenance and delivery mechanisms. This will ultimately improve our understanding of the complex interplay of physical, chemical, and biologic processes that govern marine sedimentation, and their relationship with past global climate and oceanographic conditions.

Lower Cretaceous carbonate deposits of Mt. Svilaja, Croatia: biostratigraphy vs. chemostratigraphy

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Two chronostratigraphically equivalent successions (Milešina and Jarebinjak) of Cretaceous (Aptian–Albian) Adriatic Carbonate Platform (AdCP) deposits exposed only 7 km apart differ significantly in their facies composition and Aptian emersion features. Both successions reveal similar microfacies characteristic of the Lower Aptian (OAE 1a interval), but differ in their thickness. They are both composed of wackestones and oncoid-bioclastic floatstones with Bacinella irregularis RADOIČIĆ and requieniid rudist fragments. The beginning of the Lower Aptian succession at Jarebinjak has a rudist assemblage (Offneria sp., Praecaprina sp., and Glossomyophorus costatus MASSE et al.) within bioclastic floatstones indicating an Early Aptian age. The thicker Lower Aptian interval at Jarebinjak, as well as the caprinid assemblages indicate an open sea influence and a greater accommodation space, probably as a consequence of synsedimentary tectonics.

At Milešina, several metres thick successions of algal wackestones and peloid-miliolid packstone-grainstones to wackestones directly overlie Lower Aptian strata. Thin layers of breccia or abundant charophytes, reflecting an increased fresh water influence, indicate subaerial exposure and regressive trends that are common in this interval elsewhere in the AdCP area. At Jarebinjak, in contrast, this interval with 7 to 8 thin beds of clay and marl associated with subaerial exposure features, exhibits more distinct regressive trends. Limestone deposits within this occasionally emergent horizon are characterized by algal wackestones and rare species of Mesorbitolina foraminifera.

Above the emergence horizon, the Upper Aptian–Lower Albian successions at both localities contain micritic limestones with variable amounts of peloids and skeletal grains (miliolids and ostracods), irregularly alternating with thin layers of peloid-intraclastic-skeletal packstone-grainstones and peloid wackestone-packstones with molluscs (commonly gastropods) and benthic foraminifera (e.g., Mesorbitolina texana (ROEMER)). Increased fresh water influence is indicated by abundant charophytes (identified as Munieria grambasti sarda CHERCHI et al.). The layers with charophytes also contain dasyclad alga Salpingoporella and indicate that fossil dasyclads can inhabit brackish environments.

Stratigraphic determinations are based on benthic microfossil assemblages, including foraminifera and dasyclad algae, which are very good paleoenvironmental indicators. However, their usefulness in biostratigraphy can suffer from low resolution and poor correlation with standard biochronologic scales based on planktonic foraminifera, calcareous nannoplankton and ammonites. Therefore, this research also involved a chemostratigraphic study including stable isotope analyses that proved useful for stratigraphic correlation between the examined successions and improved their age determination, despite limitations due to potential masking of global marine isotope signatures in restricted depositional environments. The results include refinements in the placement of the Barremian–Aptian boundary, recognition of the OAE 1a (in the Lower Aptian strata) and OAE 1b (straddling the Aptian–Albian boundary) intervals, and correlation with carbon-isotope stages C1 to C8. This provided critical information for correlating these Mt. Svilaja strata to other coeval successions that span the time interval of major global oceanographic changes and carbon-cycle perturbations associated with Lower Cretaceous oceanic anoxic events.

Paleoenvironmental study of strata from the Labrador margin, Canada: integrating ichnology and quantitative palynology

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The Labrador Sea developed during rifting that began in the Early Cretaceous, with eventual seafloor spreading between the Greenland plate and the paleo-North American plate from the Maastrichtian to late Eocene. A record of this tectonism is preserved along the Labrador margin, offshore eastern Canada in a succession with an established lithostratigraphic framework. We aim to establish comparative relationships between ichnofossil and palynomorph trends in paleoenvironmental analyses of these rocks using 23 conventional core intervals from 14 wells for the: Lower Cretaceous Bjarni Formation (syn-rift), Upper Cretaceous Markland Formation (late rift), and Middle Paleocene to lowermost Eocene Gudrid Formation (post-rift). Palynomorph counts were conducted on 64 samples from unsieved palynomorph slides for the following groups: dinoflagellate cysts (dinocysts), acritarchs, bisaccates, other miospores, and other palynomorphs, with ratios providing a sense of the depositional distance from the shoreline. We see expected relationships within fully marine strata. Shales of the Markland Formation deposited in slope-equivalent water depths, possibly deposited under dysoxic conditions, show high proportions of dinocysts and acritarchs (marine indicators) relative to miospores. From the same formation, homogenized sandy mudstones contain trace fossil suites of the Cruziana Ichnofacies, again with high proportions of dinocysts to miospores within inner to outer shelf deposits. Brackish bay or lagoonal deposits are generally devoid of dinocysts and acritarchs, suggesting significantly reduced salinity, in agreement with the depauperate trace fossil assemblages and early rift setting of the Bjarni Formation. However, they do contain bisaccates and a few other miospores. Both storm and wave-influenced deltaic strata in the Bjarni and Gudrid formations show small influxes of dinocysts and acritarchs, as would be expected where riverine influx is mitigated by wave or storm action. These strata contain trace fossil suites consistent with weakly stressed expressions of the Cruziana Ichnofacies, mostly lacking in vertical structures of inferred dwellings. Some bisaccates and limited numbers of dinocysts and acritarchs are found in cores of the Bjarni Formation, presumably reflecting deposition in river-influenced deltaic settings. Here, sedimentary structures dominate over bioturbation, with a highly stressed expression of the Cruziana Ichnofacies indicating high sedimentation rates and reduced salinity. One exception is the river-influenced deltaic strata of the Markland Formation, which contain samples overwhelmed by dinocysts and explained by progradation of the delta into deeper water. Finally, river-dominated deltaic deposits in the Bjarni Formation and a tidal channel succession of the Gudrid Formation lack dinocysts and acritarchs. These strata are dominated by sedimentary structures showing high sedimentation rates, ample current and wave activity, and rare trace fossils. In summary, well constrained paleoenvironmental results can be generally obtained by combining sedimentology and ichnology. Dinocyst and acritarch abundances generally parallel that of the marine trace fossils, but can be misleading in highly brackish settings where a paucity suggests nonmarine conditions. However, palynomorph counts can provide key evidence where macroscopic observations are not conclusive and can also highlight unique mixing of shallow and deeper water conditions.

Sedimentary characteristics of a low accommodation, highstand delta from the Albian succession of Saudi Arabia

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Deltas formed in shallow water, in a low accommodation setting, are known to display unique facies, stacking patterns, and stratigraphic complexities. This study describes one such system from the Uppermost Albian succession of Saudi Arabia. Several thousand feet of legacy cores were described in detail to evaluate the sedimentological and ichnological characteristics of their constituent lithofacies. Their overall characteristics and associations aided in identifying sedimentary processes and depositional environments. Additionally, palynological analysis were undertaken to constrain the age, and integrate the palynological results with core-derived depositional environments. Finally, the core-based interpretations were integrated with wireline logs of several hundred wells to create a sequence stratigraphic framework.

The studied deltaic system can be classified as river dominated, tidally influenced with minor to nonexistent wave modifications. Overall, 14 facies were identified that are grouped into three facies associations (FA1 through FA3). Key stratigraphic surfaces include flooding surfaces recording field-wide transgressive events and localized erosional surfaces associated with lobe avulsion. A recurrent overprinting of delta front deposits by deep-penetrating roots, pedogenic processes, and the widespread development of Glossifungites-demarcated discontinuity surfaces suggest a low accommodation setting in a shoal-water delta. Sedimentological interpretations and trace fossil associations presented in this study refine the existing interpretations of the paleoenvironmental history. Furthermore, it establishes a framework to characterize the distribution of siliciclastic units between the major carbonate-dominated periods in the study area.

Implications of paleo-environmental variations from Mesozoic sedimentary records: example from a syn-rift Gondwana basin, India

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The Pranhita-Godavari basin, India preserves the most complete succession of Gondwana rocks, ranging in age from the Late Carboniferous to Cretaceous, compared to the other Gondwana basins worldwide. Talchir Formation showed only the presence of few shallow marine trace fossils, while Barakar Formation known for its profuse coal deposits have plant fossils. The Kundaram and basal part of Kamthi Formation however shows herbivorous non-mammalian therapsids (land vertebrate). Yerrapalli consists of numerous fossils of fishes, amphibians, herbivorous non-mammalian therapsids, reptiles and also trace fossils. Apparently, no faunal assemblages have been found in the Bhimaram Formation, apart from plant fossils and few fragments of vertebrate fossils. The Maleri Formation has an exceptionally rich vertebrate assemblage consisting of aquatic, semi-aquatic as well as terrestrial vertebrate fossils, invertebrates, coprolites, ostracodes and plant fossils. The Dharmaram vertebrate fauna is characterized by fishes and reptiles. However, very large petrified woods are also present. The early Middle Jurassic Kota limestones comprise of exceptionally rich fossil content that includes large sauropod dinosaurs, flying reptiles, fishes, amphibians, ostracods, estherids along with remains of mammalian fauna. Gangapur Formation consists of various types of plant fossils only. Thus, there has been an evolution with respect to flora and fauna, landscape and vegetation along with change in lithologies.

The fluvio-lacustrine syn-rift deposits of Mesozoic succession are exposed amidst the Proterozoic sedimentary rocks. The present work deals with petrographic characters, mineral composition and geochemistry of the early Middle Triassic to early Early Jurassic sediments, comprising of sandstones, mudrocks and carbonates, from the Pranhita-Godavari syn-rift basin, India. Siliciclastic and carbonate sediments of the four confirmable formations (~235–196Ma) -Yerrapalli, Bhimaram, Maleri, Dharmaram, are observed to investigate provenance and give further insight to similar deposits. Compositional and textural maturity of sandstones gradually increases upwards excluding immature sandstones of Dharmaram Formation. We identified quartz-rich sandstones, K-feldspar predominance and lesser lithic-fragments. Prominent, variable, negative Eu anomaly; low to moderate LREE/HREE ratio (5.54–14.93); flat HREE pattern (higher than Proterozoic Shales); enriched in Zr, Hf, U, Th, Sc along with trace element ratios; enriched LIL (Rb, Cs, Ba, Pb) elements than UCC and Pakhal shales, negative Sr anomaly-reflecting sediments derived from old recycled environments/passive continental marginal settings, suggesting predominantly felsic source. Compatible element enrichment suggests input from mafics. Plots of major oxide compositions show similar patterns except enrichment in CaO and MnO than Pakhal shales. ICV (0.49 -1.37) and CIA (60.75 – 93.89) values of Gondwana samples reflect clay mineral dominance over non-clay silicates suggesting moderate to intense weathering of Proterozoic shales, granites and gneisses. The concentration of Cr and Ni, ratios of Eu/Eu* and (GdN/YbN) indicate predominantly post-Archean source. Negative δ13C and δ18O (≈-7.36, -5.18 respectively) values for Mesozoic Gondwana carbonates indicate precipitation in freshwater environment under ambient temperature, derived mostly from calcareous tufa and few from lacustrine environment. There was a gradual change in palaeoclimate from semi-arid to humid condition and palaeocurrent direction suggesting change in basin tectonism as well.

Wave-Tide Mixed-Energy Coastal Systems: Tidal shorefaces and refinement of the coastal-environments classification scheme

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Coastal depositional systems are normally classified based on the relative input of wave, tide, and river processes. While wave- through to river-dominated environments are well characterized, environments along the wave-to-tide continuum are relatively poorly understood and this limits the reliability and utility of coastal classification schemes. Two tidal shoreface models, open-coast tidal flats (OCTF) and tidally modulated shorefaces (TMS), have been introduced for mixed wave-tide coastal settings. Following nearly two decades of research on tidal shorefaces, a number of significant insights have been derived, and these data are used here to develop a unified model for such systems. First, OCTFs are components of larger depositional environments, and in multiple published examples, OCTFs overlie offshore to lower shoreface successions that are similar to TMS. Consequently, we combine OCTFs and TMSs into a single tidal shoreface model where TMS (as originally described) and TMS-OCTF successions are considered as variants along the wave-tidal continuum. Second, tidal shoreface successions are preferentially preserved in low- to moderate- wave energy environments and in progradational to aggradational systems. It is probably difficult to distinguish tidal shorefaces from their storm-dominated counterparts. Third, tidal shorefaces, including both TMSs and OCTFs, should exhibit tidally modulated storm deposits, reflecting variation in storm-wave energy at the sea floor resulting from the rising and falling tide. They may also exhibit interbedding of tidally generated structures (e.g., double mud drapes or bidirectional current ripples), deposited under fairweather conditions, and storm deposits (e.g., hummocky cross stratification) through the lower shoreface and possibly into the upper shoreface.

The development of the tidal shoreface model sheds light on the limitations of the presently accepted wave-tide-river classification scheme of coastal environments and a revised scheme is presented. In particular, tidal flats are components of larger depositional systems and can be identified in the rock record only in settings where intertidal and supratidal deposits are preserved; consequently, they should not represent the tide-dominated end member of coastal systems. Instead, we suggest that tide-dominated embayments should occupy this apex. Tide-dominated embayments exhibit limited wave and river influence and include a wide range of geomorphological features typically associated with tidal processes, including tidal channels, bars and flats.

Workflow to Optimize Portable XRF Calibration and Analysis for Sedimentary Rocks

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Portable X-Ray fluorescence (PXRF) instruments has become more and more common and versatile tools in the last few years for geochemical analysis (major, minor and some trace elements) in carbonates and sedimentary rocks for multiple paleo-environmental studies. PXRF is a relatively cheap non-destructive and fast technique that prevents tedious sample preparation. Manufacturers calibration are usually made for a very large range of rocks or materials under optimized analysis conditions. However, for a given set of rock types and their matrix, the quantification of multi-elemental concentration can be improved but required a specific/dedicated calibrations method..

Firstly, we first prepared and analysed (with a Bruker Tracer V) powder pellets of a global set of certified standard reference materials (SRM), which covers a large range of sedimentary lithologies and compositions (sandstone, shales, marls, carbonates). We implemented different calibration approaches: (1) Basic Regression Curve (using an homemade spreadsheet); (2) Bruker tracer V calibration (i.e. GeoExplorer and GeoMining); (3) Free and Open Source Software (R platform, CloudCal v. 3.0); (4) Easycal software developed by Bruker. Secondly, each of these calibrations' methods were tested and validated by analyzing a second set of sedimentary samples with known composition.

For each calibration techniques, we investigated the impact of (i) regression line shape (linear, polynomial, anchoring to origin), (ii) of illumination's conditions of the PXRF source using different voltages and a single vs multiple illumination phases (i.e. 15 kv, 30 kv or 50 kv), (iii) of different specific corrections parameters (including matrix effect, peak interferences).

Ultimately, we propose a workflow to implement a calibration method which is optimized for sedimentary rocks and can be adapted for a given range of elements of interest.

Cretaceous Chondrodonta (Bivalvia) accumulations from Istria (Croatia) and Gargano (Italy): a comparative study

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Chondrodonta is an oyster-like bivalve which occurs commonly in worldwide Barremian – Turonian rudist-bearing limestones and shows particularly high concentrations and predominance with respect to other biota in specific stratigraphic intervals. However, the causes of the flourishing of Chondrodonta are still unclear and it is not completely understood whether and how the Cretaceous palaeo-climate perturbations may have played a dominant role in the explosion of this bivalve in carbonate platforms. In this work we will highlight similarities and differences in the sedimentological and taphonomic signatures of the Chondrodonta accumulations during two specific stratigraphic intervals of the Cretaceous.

As first case study we present a sedimentological and taphonomic analysis of the upper Cenomanian Chondrodonta joannae (Choffat) accumulations, which crop out in the Adriatic Carbonate Platform (Istria Peninsula, Croatia). These accumulations occur within moderate-energy inner carbonate platform facies, deposited in a tidal flat/lagoonal setting where intertidal alternates to subtidal foraminiferal wackestone-packstones and rudist floatstones. C. joannae is very abundant in the upper part of the succession, where floatstone-rudstones to boundstones beds with Chondrodonta prevail over rudists. The thickest concentration is recorded within a lens-shaped beds-set, with a maximum thickness of about 1.8 m and some tens of meters of lateral extension. The shells are densely packed in horizontal sheets with scattered autochthonous and small individuals, arranged in bouquet-like aggregates, in the lower part, and very elongated parautochthonous individuals in a toppled position in the upper part.

Sedimentological and taphonomic characteristics of C. joannae concentrations are compared to lower Aptian Chondrodonta glabra (Stanton) accumulations from San Giovanni Rotondo Limestones of the Apulia Carbonate Platform (Gargano Promontory, Italy). These older accumulations occur below the peak of OAE1a, in a succession composed of stromatolites and shallow-subtidal mud-rich facies. C. glabra shows an analogue interval of predominance with respect to the other bivalves and crops out in almost monospecific para- to autochthonous accumulations, arranged in metrical tabular- to small mound-shaped boundstone beds-sets. The shells are closely packed and show a variable orientation changing from horizontal in dense sheets to chaotical and sub-vertical with scattered bouquet-like aggregates.

Influence of tectonics on the evolution of Aalenian-Oxfordian carbonate system in intracontinental basins (west France)

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Carbonate production and sedimentary architecture depend on the interaction of complex factors that control the development of a carbonate platform as climate, eustatic variations, tectonics, structural heritage and trophic conditions. Andrieu et al. (2016) highlights how long-term climate evolution controls carbonate platforms growth and demise and producers types during Middle and Late Jurassic in the western France. However, the spatial variations of carbonate environments, architectures and production rates over a same depositional sequence cannot be explained by climate only. Andrieu et al. (2016) also suggests that tectonics controls sedimentation rates and platform architectures while specific influence of tectonic movements is complex to characterize in intracontinental basins. However, this study only focuses on four localities hundreds of kilometres far from each other, and a larger number of points would allow to spatialize more precisely the deformations and to compare it with spatial distribution of the facies, sedimentary geometries and basement inherited structures.

Eighty-two sedimentary outcrops have been newly described and gathered with the sedimentary logs from 145 boreholes and 102 sedimentary outcrops from the literature, representative of the Aalenian-Oxfordian carbonate deposits in the Aquitaine and Paris basins. This comprehensive dataset is used to address the following questions relating to tectonic control on carbonate systems: (1) what is the link between accommodation, tectonic subsidence, spatial facies distribution and stratigraphic architecture? (2) What is the role of basement inherited structures on the deformations and vertical movements in intracontinental basins?

From 16 correlation transects, twenty-two third-order depositional sequences were identified. Tectonic subsidence and accommodation maps were produced from 60 localities. During the Aalenian, the carbonate platform is marked by very low accommodation rates in both Aquitaine and Paris basins. Bajocian-Bathonian times correspond to generalized and relatively homogenous tectonic subsidence in the Paris Basin, while the Aquitaine Basin shows a strong spatial variation of tectonic subsidence rates that influences facies distribution. The Callovian to early Oxfordian interval is characterized by differential subsidence. The southwestern Paris Basin – whose basement corresponds to the Moldanubian and Nappe de Mauge domains – is uplifting, while the northwestern Paris Basin and the Aquitaine Basin are subsiding.

Our results suggest that block tectonics, expressed through Variscan inherited structures, control large scale and low amplitude variations of subsidence over the Paris and Aquitaine basins, especially during the Callovian to early Oxfordian. Vertical movements influence the spatial distribution of bathymetries and thus carbonate production rates and facies. In the northern Aquitaine Basin, tectonics seems to have a major control on facies types as: (1) strong tectonic subsidence is associated with high carbonate production rates and lagoon facies, (2) moderate tectonic subsidence is associated with moderate carbonate production rates and shoreface facies, and (3) weak tectonic subsidence is associated with low sedimentation rates and both offshore and supratidal facies.

This large-scale study reveals the influence of syn-sedimentary tectonics and basement inherited structures on the distribution of facies and depositional environments in intracontinental basins. Basement vertical movements are synchronous with the opening of the Central Atlantic and control both carbonate production and stratigraphic architecture.

Multiphase cementation and dissolution in Aalenien-Oxfordian carbonates of Aquitaine basin inferred from U-Pb dating (France)

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Carbonate rocks form major aquifers whose characterization is essential to move toward better management of water resources. Their reservoir properties are affected by fluid flows leading to successive phases of dissolution-recrystallization. Diagenetic cements can inform on paleofluids circulation and help predicting the spatial distribution of reservoir properties. This study focuses on the Aalenian-Oxfordian carbonate deposits of the northeastern edge of the Aquitaine basin in Quercy-Périgord area (SW France), which constitute a key area to address the following scientific questions: (1) can calcite and dolomite cementation and dissolution phases be related to major geodynamic events? (2) how can a dissolution phase be dated?

A detailed petrographical study of about 250 thin sections was coupled with in situ U-Pb geochronology method on calcite cements infilling micrometre to millimetre pores, fractures and karsts cavities.

The first fracture-filing and blocky calcite Cal1 is dated, with the same age, taking account uncertainties, from late Jurassic (146.6±7.4Ma) to early Cretaceous (135.6±9.5Ma). A Cretaceous pervasive dolomitization phase (Dol1) fills intergranular spaces, next affected by a massive dissolution leading to the formation of moldic and vug pores. Then, successive phases of blocky calcite occurred (Cal2, Cal3 and Cal4), both infilling factures and intergranular spaces and respectively dated at 78.2±3.0Ma, 61.0±2.0Ma and 46.5±1.6Ma. These calcites are interspersed by two dissolution phases. Finally, the last blocky calcite Cal5 precipitates during the Miocene (13.8±2.6Ma) and infills millimetre vug pores and meter-scale karst cavities.

The first calcite Cal1 precipitates during the Tithonian to Berriasian interval. This fracture-filing and blocky calcite is synchronous with the Bay of Biscay rifting. Dol1 precipitates during the Cretaceous, whose precise age remain uncertain, and could be related to the influx of a basinal brine during the Aptian to Cenomanian hyper-extension event at the Iberia-Europe plates boundary. The following dissolution could have occurred during the late Cretaceous and caused by large-scale exposure of the northeastern Aquitaine basin. Then, meteoric phreatic fracture-filling and blocky calcite Cal2 to Cal4 precipitate during the Pyrenean orogeny: Cal2 is synchronous with the beginning of Pyrenean orogeny during the Campanian, while Cal3 and Cal4 respectively form during the Selandian and Ypresian-Lutetian, the latter corresponding to the maximum intensity of Pyrenean compression. A dissolution phase occurs between the cementation of Cal2 and Cal4 (Maastrichtian to Ypresian). A final dissolution and calcite precipitation stages is associated with the incision of the Quercy-Périgord valleys from Oligocene to Miocene.

This detailed petrographic study and in situ U-Pb dating of calcite cements makes it possible to propose a precise and detailed timing of the successive cementation and dissolution stages, and to link the flow of fluids to geodynamics. Porosity development stages are replaced in a specific timing constrained by calcite cements dated before and after dissolution processes.

Field and petrographic study on sediment waves and their sedimentologic properties

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Antidune-like large-scale sediment waves are being increasingly recognized as common bedforms in both modern and ancient deep-marine settings. Fluvial (subaerial) antidunes tend to be ephemeral and poorly preserved features which are commonly formed in coarser sediments. However, both laboratory and subsurface data suggest that their deep-water counterparts (associated with gravity flows such as turbidity and density currents) are more stable and able to form in a much wider range of grain sizes (very fine- to coarse-grained sediments). Despite their recently discovered ubiquity, little is known about the formative flow and sediment transport processes associated to these antidune-like sediment waves, and the resultant sedimentary properties of their deposits such as grain-size and sorting trends and internal small-scale sedimentary structures and textures. Here we present results of a multi-scale study of continuously exposed antidunes within the Lycium Member of the Fish Creek – Vallecito Basin of Southern California (USA) where we have conducted a detailed outcrop and petrographic investigation of several wavelengths of these bedforms. We link observed stacking patterns, sedimentological trends (grain size and soring), and sedimentary structures (from m, to cm, to mm) to the potential hydraulic processes responsible for their deposition, with the ultimate goal of generating recognition criteria for these deposits which can be used to aid in their identification in both outcrop and core. Of particular interest to this study are petrographic observations from locations along continuous bedform beds (i.e. stoss, crest, lee) which reveal distinctive small-scale internal structures that appear to be characteristic of bedload (or alternatively bedload-suspension) responses to prevailing local flow conditions over antidunes. Additionally, downstream grain size and sorting trends have been used to infer, at first order, the overall composition of the sediment load and the down-flow hydraulic fractionation properties of the flows. Given the observed net depositional characteristics of the deposits we interpret these as lobes built by the bedforms, and a product of expanding and unconfined turbidity currents.

Sedimentary petrography of subaerial pyroclastic density current (PDC) deposits emplaced underwater: the 1993–2005 Montserrat event

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The study of the mechanisms that lead to the accumulation of volcaniclastic sequences in subaqueous realms has received a major input in the last 10 years, due to the growing importance that volcaniclastic sequences have gained in different contexts (e.g., hazard assessment and risk mitigation, oil and gas exploration, geothermal exploitation). However, apart from welded pyroclastic deposits, whose primary volcanic features (e.g., petrographic texture) are well recognizable, a major gap still exists in the recognition and interpretation of the emplacement mechanisms and diagnostic sedimentary characteristics of volcaniclastic deposits generated by the transport of disaggregated clasts into marine environments (e.g. via explosive eruption mechanisms, pyroclastic density current generation, and other mass-transport processes).

In 2003, partial collapse of the andesitic lava dome generated by the ongoing eruption of Soufriere Hills volcano, Montserrat, generated a block and ash flow, which discharged material into the Caribbean Sea. After this event, the JR-123 cruise recovered over 50 shallow marine sediment cores from the subaqueous deposit of material emplaced by the 2003 event and other dome-collapse derived deposits from the 1995- eruption. These cores provided insights into the stratigraphic architecture of submarine PDC-derived deposits, and represented the first direct documentation of what happened as a PDC entered seawater, generating turbidity currents and emplacing marine volcaniclastic deposits. However, at that time a classical work on the textures and petrography of these volcaniclastic sedimentary units, as conceived by the community of sedimentary petrography, was not carried out. At that time, in fact, neither microtextural analyses on the samples were carried out, nor point-counts following the Gazzi-Dickinson method were performed.

Thus, the present work aims to fill this gap, deciphering the grain- and bed-scale deposit textural features within the JR-123 cores. For the first time, several undisturbed samples of fine-grained detritus have been sampled from the cores using so-called Kubiena boxes, items used in paleosol sampling, then impregnated with resin under vacuum and cut into standard thin sections. Through this process, the samples preserved their primary textures and can be investigated both under the optical microscope and the scanning electronic microscope. This has been used to define characteristics of a PDC-derived volcaniclastic sand, which may then be used to identify the possible markers of a direct eruption-associated volcanogenic origin of beds within volcaniclastic sequences. In addition, the loose sandy part of the subaqueous deposits was sampled, impregnated with resin and cut into standard thin sections for Gazzi-Dickinson point-counts. The result is the first detailed description of the in-situ petrographic characteristics of a subaerially generated PDC settled in a subaqueous realm.

Mid-Carboniferous evaporitic deposits recording a sea-level fall during the closure of Panthalassa-Paleotethys gateway (N Spain)

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The deposition of massive evaporites commonly coincides with the closure of marine basins in continental collisional settings. In the course of the Variscan-Alleghenian Orogeny, the convergence between Gondwana and Laurentia led to the closure of the Rheic Ocean, the gateway connecting the Panthalassa and Paleotethys oceans, progressively narrowing the marine foreland basins adjacent to the orogen. The mid-Carboniferous successions from northern Spain and southern France (Cantabrian Zone and Pyrenees) record the evolution of the distal realms of the wide foreland basin that developed on Gondwana's lithosphere. The preserved outcrops extended over an area more than 200,000 km2 in size and 300 km in width, in which a 60–400 m-thick succession of homogeneous pelagic, dark laminated calci-mudstones accumulated (Barcaliente and Iraty Fms, late Serpukhovian–early Bashkirian).

A remarkable decametre- to metre-thick stratal package characterized by the abundant evaporites of late Alportian age (early Bashkirian) is recognizable over most of that area of the basin. The base of this stratal package is gradational as the characteristic laminated calci-mudstones with common radiolaria biomolds begin containing calcite pseudomorphs after gypsum crystals, which become more abundant gradually upwards until reaching 60% of the rock volume. The pseudomorphs display monoclinic prismatic and, less commonly, lenticular habits, and frequently deform the lamination of the surrounding matrix. This fabric suggests an intrasedimentary growth of the gypsum crystals within the carbonate mud at, or slightly underneath, the sediment–water interface. Furthermore, the upwards increase in pseudomorph abundance is accompanied by a gradual change in size and arrangement of crystals. These are up to 2 cm in size and randomly distributed in the lower part and become smaller than 1 mm in size and arranged in continuous laminae in the upper part, which is indicative of a salinity increase. In some localities, crinkly laminae with filamentous (probably microbial) microstructures resembling stromatolites and mm-sized irregular porosity can also be recognized in the upper part of the evaporitic interval. Locally, the upper part of the evaporitic–microbial interval is totally or partially absent and, instead, a nodular breccia containing intraclasts with pseudomorphs after gypsum and root-like structures occurs, recording subaerial exposure.

The occurrence of the studied evaporitic interval in pelagic–hemipelagic deposits suggests that large areas of the marine foreland underwent hypersaline conditions (supported by organic geochemistry results), followed by local subaerial exposure, over a large region of the Variscan marine foreland basin. This subaerial exposure coincides with the prominent Alportian eustatic sea-level fall recorded in other wide-world basins. Nevertheless, an accurate estimation of the paleowater depth during the evaporite deposition remains elusive. The common radiolaria biomolds might be indicative of a relatively deep-subtidal realm. The development of a strong ocean stratification with deep brines and shallow normal marine waters would explain the co-occurrence of intrasediment evaporites and radiolarians in the deposit.

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Channels or valleys? Investigating updip to downdip evolution of paralic strata in a low-accommodation basin

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The Clearwater and Grand Rapids formations and their equivalent allomembers comprise the upper strata of the Lower Cretaceous Mannville Group in the Western Canadian Sedimentary Basin, and coincide with a progradational pulse of the shoreline during the protracted transgression of the Boreal Sea in North America. A large subsurface dataset exists for the Mannville Group due to extensive petroleum exploration and exploitation in Alberta and Saskatchewan. The complexity and lateral variability of these paralic paleoenvironments have resulted in multiple, and sometimes contradictory, stratigraphic frameworks over the past 25 years. Nevertheless, the tectonic stability and slow subsidence rate of the foreland basin potentially allow for the correlation of subaerial unconformities and marine flooding surfaces over 100s of km, and thus the opportunity to carry out basin-wide stratal correlations.

This study integrates drill-core and geophysical well-log datasets in an attempt to decipher the large-scale architecture of the upper Mannville Group, and determine the stratigraphic significance of the various channelized elements. The interval chiefly consists of a stacked series of 5–15 metre-thick, coarsening-upward stratal packages, interpreted to record the progradation of river- to wave-dominated deltas and embayed shorelines. These packages are dissected by 10s of m-thick, commonly heavy-oil-bearing sandstone bodies that represent the fills of straight through to meandering channels showing fluvial and fluvial-tidal characteristics. The widespread perception is that thick, channelized elements correspond to the fills of paleovalleys cut during base-level falls on a low-gradient paleoshelf. However, the overall absence of mature paleosols (indicative of prolonged subaerial exposure) undermines the systematic interpretation of subaerial unconformities throughout the interval. Moreover, the presence of similar facies residing at the same stratigraphic level across great distances is unrealistic in a low-accommodation paralic system where diachronism along stratal surfaces is inherent. This study aims to investigate the downdip evolution of channel complexes to differentiate those corresponding to paleovalley systems linked to lowstand shorelines and those tied to basinward shifts of trunk fluvial systems feeding highstand, normal regressive shorelines. The resulting refinement in paleogeographic reconstructions enhances our understanding of reservoir units in the upper Mannville Group, and complex deltaic paleoshorelines in low-accommodation basins.

The north-eastern Sicilian continental shelf: a tidal-shelf in the Messina Strait approach

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In the central Mediterranean Sea, the Messina Strait separates the Italian Peninsula from the Sicily Island, and connects the Ionian and the Tyrrhenian Seas. Tide-dominated oceanographic processes are known to control the sediment distribution and seafloor morphology of the Messina Strait and its northern and southern approaches. In this paper, through the interpretation of multibeam bathymetry and seafloor reflectivity data, and CHIRP sub bottom profiles, we show that they also dominate the north-eastern Sicilian continental shelf to the west of the Messina Strait. Close to the strait, offshore of Capo Rasocolmo, at a depth of about 20 m, a flat area connects seaward to steeper narrow seafloor sectors. The latter corresponds with progradational clinoforms with 30-m-high foresets reaching a depth of about 50 m. Although the lack of any deep-penetrating seismics does not rule out the possibility that the dipping reflectors are merely the results of the draping of an erosional step; a plausible explanation is that they are part of a compound delta. In the latter case, they can be associated to processes of expansion of the flows exiting the Messina Strait constriction and concomitant sediment deposition to form a delta-like subaqueous body. Bottom-currents of tidal origin, control sediment distribution also further offshore, as shown by sediment mounds separated by areas with sediment bypass or erosion. Further to the west along the margin, and away from the Strait, various trains of sediment waves rework the High Stand System Tracts (HST) deposits. The amplitude and wavelength of the bedforms decrease away from the strait. In some cases, two trains of sediment waves interfere and give rise to a complex bedform geometry. In some areas, smaller scale megaripples are superimposed on the larger-scale bedforms. The sediment waves form a belt along the continental shelf, whose width is constrained seaward by the offshore limit of the TST and landward by Posidonia meadows and mattes developed in the shallower water areas along the coast and inhibiting sediment reworking.

Further west, and further away from the strait, the seafloor reflectivity data shows very narrow (100 m in width), stripes of alternating higher and lower reflectivity. They indicate an uneven sediment distribution and can correspond with erosional furrows or sediment ribbons that must have a very subdued morphology. In some cases, the area with the longitudinal bedforms interrupt features transverse to the shelf such as prodelta channels.

Our work shows an example of the variability of the bedforms' character in the shelf, furnishing a record of sediment transport pathways away from a strait. It also shows that tide-dominated processes can control the sedimentary architecture of continental shelves even in micro-tidal seas, such as the present-day Mediterranean, as a result of the physiography of the coast. Our contribution also better outline the spatial extent of seafloor features connected with the tidal dynamics of the Messina Strait, thus contributing to better determine the pattern of the currents that are activated by the complex relationships between the Ionian and Tyrrhenian water-masses.

Transgressive system tract and continental shelf morphology: an example from the Hyblean foreland ramp offshore

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Coastal deposits have a wide range of characters that reflects different process-regimes and genetic environments, strictly connected to the sea-level changes. The morphology of continental shelves, often resulting from the combined effect of tectonic activity and eustatism, also plays an important role in controlling features and preservation of coastal environments, characterized by peculiar deposits and forms.

Seismic high-resolution data from coastal areas are often the unique aid to reconstruct continental shelves morphology and deposits connected to the sea level changes (e.g. Transgressive and Highstand System Tracts (TST; HST).

Such an approach is adopted in the present study to investigate a coastal area and the related offshore, located in the southernmost sector of SE Sicily.

The interpretation of high-resolution "Sparker" profiles, allowed us to reconstruct the late Quaternary evolution of this area characterized by peculiar alluvial and lagoonal environments, whose permanence and development are strictly linked to the sea-level changes inferred by glacial and interglacial periods.

The seismic profiles show an acoustic substratum, characterized by wavy reflectors interpreted as corresponding to the Pliocene marls formations and/or the older sedimentary successions outcropping in the southern sector of the study area. Upwards, the seismic reflectors laterally continuous and characterized by high amplitude are interpreted as corresponding to the Tyrrhenian Calcarenite formation, widely outcropping in the nearby on-land area. The upper boundary appears as an evident unconformity with a marked irregular trend and is interpreted as the subaerial erosional surface developed during the last sea-level falling stage and lowstand. It cuts wide depressions and v-shaped incisions that can be interpreted as incised river valleys. Within the lower part of these valleys, the variability in the acoustic response of the sedimentary units reveals the intrinsic sedimentological variations of the alluvial and lagoonal deposits, formed during and successively the last glaciation (Wurm, 110–11.7 ky). They are highlighted by a sequence of medium-high amplitude reflectors, moderately continuous, probably representing bay head deltas or lagoon environment, locally deposited in the low-energy environments during Holocene transgressive stage. Upwards, a marked and lateral continuity reflection is interpreted as the Holocene Maximum Flooding Surface. It bounds the bottom of the highstand deposits characterized by marked sub-parallel stratification and interpreted as corresponding to the actual shoreline deposits. Finally, another unit characterized by chaotic stratigraphic setting and outcropping on some morphological highs of the calcarenite substratum is correlated with the cliff environment deposits of the last highstand stage.

A classification scheme for deep-lacustrine turbidite fans: examples from the North Falkland Basin

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Deep-lacustrine settings represent a complex sedimentary environment, particularly when compared with their deep-marine counterparts. Their size, geometry, variable fluid-fill and autogenic controls (e.g. tectonic and climatic) make deep-lacustrine basins, and their internal sedimentary systems, unique and interesting environments. In contrast, deep-marine turbidite systems have received significant attention since the early 1970s, and robust characterisation and classification schemes of their overall geometries and internal morphological features have developed; these classification schemes are perhaps less applicable to deep-lacustrine settings. As deep-lacustrine basins have become favourable targets for the hydrocarbon exploration worldwide (e.g. Bohai Bay Basin in China, and the North Falkland Basin, Falkland Islands), due to their typical high-quality source rocks, excellent turbidite fan reservoirs and competent sealing lithologies, the need for a more robust understanding of this dynamic sedimentary environment is only too clear. In particular, deep-lacustrine turbidite fan systems require better characterisation as they are responsible for transporting a large proportion of the coarse-grained material into the low-energy, fine-grained deep-lake setting, and therefore form excellent fluid containment reservoirs in the subsurface. Through detailed mapping of 3D seismic data, integrated with well data, from the 'Transitional' and 'Early Post-Rift' tectonostratigraphical units of the North Falkland Basin, this study documents and characterises a suite of deep-lacustrine turbidite fan systems. From this analysis, a generic classification scheme for deep-lacustrine turbidite fan systems is proposed, which establishes a descriptive and interpretative hierarchy.

Examples from 12 contrasting turbidite fan systems are provided, including: the Rhea, Isobel Deep, Isobel, Mackerel, Liz, Bleaker 20, Bleaker 15, Sea Lion North, Sea Lion, Casper, Beverley and Zebedee fans. Seismic-based features have been identified, at a range of scales, including: 'systems' (c. 5–15 km in width), 'forms' (c. 2–10 km), and 'elements' (c. 0.1–2 km). Systems describe a single but broad sedimentary entity, defined by a common sediment delivery position along a basin margin. Internally, the systems are composed of generally multiple form-scale features such as fans or lobes, which are in-turn made up of element-scale architectures. In the North Falkland Basin dataset, elements include a diverse suite of intriguing morphologies that are here classified as: feeders, feeder-lobe transition zones (FLTZ), sinuous and anastomosing lobe axis deposits, flow deflection, stranded lobe fringe areas, flow constriction/lobe to terminal mouth lobe transition zones (LTTZ) and terminal mouth lobes. These morphologies are linked to a particular suite of bed-scale sedimentary processes that occur within the fan system. Where possible, this link between seismic-based interpretations and sedimentary processes has been validated using available core data.

Controls on accommodation and sediment supply, Santonian Sant Corneli Formation, south-central Pyrenees, Spain

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The Sant Corneli Formation (Santonian), exposed in the south-central Pyrenees of Spain, is one of several backstepping carbonate platform sequences formed on the southern margin of the Pyrenean basin. The platforms formed in response to a regional increase in accommodation caused by the initiation of Alpine compression. Local accommodation changes related to syndepostional growth of the Sant Corneli/Boixols anticline are superimposed on this regional trend. Two distinct but interacting sediment sources are identified: (1) a regional northward-progarding quartz-rich skeletal grainstone source (Aramunt Vell Member), and (2) an isolated westward-prograding rudist-coral-sponge ramp, localized on the crest of the Sant Corneli/Boixols anticline (Collades de Basturs Member). Complex interactions among these regional and local controls on accommodation and sediment supply resulted in very different carbonate facies distribution and cyclicity patterns in relatively closely spaced (about 2 km) outcrops on opposite sides of the anticline.

The northern flank of the Sant Corneli/Boixols anticline records deposition on a high energy ramp and preserves decameter-scale cycles of steeply (up to 12°) prograding quartz-rich grainstone shoals interbedded with deeper-water rudist-coral-sponge biostromes. These cycles are interpreted to be the result of fluctuations in relative base-level and the interaction of two distinct sediment sources. In contrast, contemporaneous strata on the southern limb of the anticline record three orders of cyclicity between deeper marl and shallower rudist biostrome and skeletal grainstone-rudstone facies, likewise interpreted to be primarily driven by changes in relative base-level. The highest frequency cycles produced meter-scale successions composed of in situ rudist biostromes and reworked skeletal debris. These stack into decameter-scale shallow platform units that prograde and retrograde in response to eustasy and tectonically controlled changes in accommodation. Finally, the entire Sant Corneli Formation (nearly 500m thick) is one of several backstepping late Cretaceous sequences that formed on the southern margin of the Pyrenean basin in response to regional accommodation increases. Slumping on the flanks of the growing anticline locally influenced facies distribution, particularly in the distal ramp setting. On both flanks of the anticline, the abundance of rudist facies decreases to the west (away from the anticline crest) as quartz-rich grainstone facies increases.

Local trends in accommodation and sediment dispersal patterns associated with growth of the Sant Corneli/Boixols anticline are superimposed upon the regional, longer-term trends related to basin dynamics. Syndepositional growth of the eastern part of the Sant Corneli/Boixols anticline produced a bathymetric high that nucleated growth of a rudist platform on the anticline crest, isolated from the regional, land-attached quartz-rich grainstone system. Carbonates on the crest of the anticline developed laterally extensive low-angle rudist-coral-sponge biostromes that prograded westward off the crest. At the same time, the quartz-rich grainstone system prograded northward over the western end of the current Sant Corneli/Boixols anticline, indicating it had yet to form a topographic barrier.

Settling velocity of Lingula anatina shells: an experimental approach to bioclastic granular phosphorites

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Granular phosphorites composed by linguliform brachiopod shells and siliciclastic sediments represent a globally distributed phosphorus resource. The brachiopod bioclasts are characterized by an organo-phosphatic composition and laminar shape which defines a particular hydrodynamic behaviour that has not been investigated yet. Their study is crucial in understanding the concentration mechanisms acting in the formation of such phosphorites, as well as for enrichening the knowledge of mixed-sediments and sediment dynamics in general. We present the results of settling velocity measurements made on whole and fragmented shells of Lingula anatina, a modern linguliform brachiopod species. The results will be applied to a case study of ancient bioclastic phosphorites (Ordovician of northwestern Argentina).

The shells are characterized by a complex shape and variable density across them. The study and classification of their fragments included taphonomic observations on their breakage patterns, bulk density and morphometric measurements, in order to interpret their settling behaviour. PVC sheets were also used as possible analogs to Lingula shells.

Density measurements yielded very low density values (range: 1013–1330 kg/m^3), with the thickest, more mineralized shells and shell fragments showing higher values. 3D nominal diameter values ranged between 1–9 mm, at the coarse sand to gravel size. Settling velocities ranged between 0.02–0.08 m/s. Shape factor ranged between 0.01–0.05. The whole set of settling velocity results show a wide dispersion when plotted as a function of particle diameter.

When the particles are classified according to their characteristics, clear trends in settling velocities are revealed. Particles with higher density and shape factor, show higher settling velocities (0.05 – 0.08 m/s), whereas those with lower density and shape factor, show lower settling velocities (0.02 – 0.05 m/s). The behaviour of the platy PVC sheets is noteworthy: they show low settling velocities (≈ 0.04 m/s) in spite of higher density (1324 kg/m^3); this means that, for the set of particles under study, variations in shape might weigh more heavily on settling velocity than variations in density. With respect to their settling equivalence, the sets of lower- and higher- shape factor particles have fall diameters corresponding respectively to fine-to-medium and to medium-to-coarse quartz sand.

The Ordovician phosphorites are composed of linguliform brachiopod fragments, comparable in size with the experimental clasts, and siliciclastic coarse silts to fine sands. These sediment fractions appear either well-mixed or interlaminated. Siliciclastics are finer than the bioclast fall diameter: the mixed sediments were thus not equivalent in terms of settling, the phosphatic bioclasts being the faster-falling. In the interlaminated deposits suspension settling was probably the main depositional mechanism, producing millimetric-scale compositional segregation in absence of coarser-grained siliciclastics. In the mixed deposits, suspension settling was probably not the main depositional mechanism. Differences in settling behaviour between both sediment fractions probably contributed to their segregation during transport. Although sedimentary processes other than settling probably acted in the formation of phosphorites, contrasting settling behaviour between the phosphatic bioclasts and the siliciclastics may have been important in controlling the deposits formed.

Tectonics of the south-eastern part of the North-Sudetic Synclinorium – SW Poland, Bolesławiec Syncline

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The North Sudetic Synclinorium is a complex synclinal structure, whose structure and shape has been significantly modified by secondary processes. Initially, the North Sudetic Synclinorium was one of the intramontane sedimentary basins within a series of structural lows accompanying the European Variscan chain beyond the main fold zone (Chrząstek i Wojewoda, 2011). The basin became filled with sediments from the latest Carboniferous to the Cretaceous (Kaczawa Stage sensu Teisseyre, 1957). It remained connected with the German-Polish Basin from the west between the Permian and Cretaceous, therefore the infillings of both basins have many common features. Laramian events lead to the formation of numerous horsts, grabens, as well as half-horsts and half-grabens occurring alternatively and arranged in a scale-like pattern (Oberc, 1972). These processes caused the development of secondary units, such as the Bolesławiec Syncline located in the eastern part of the structure, which is the subject of this abstract.

Recently, 22 drillings and 23 2D seismic profiles have been made within the Bolesławiec Syncline. The obtained seismic and borehole data were analyzed with regard to the tectonic structure of the area. The interpretation of the course of fault zones is based on a correctly recognized lithological and stratigraphic succession of rocks building the rock massif. Due to continuous coring, the best recognized interval in all boreholes represents the Zechstein. The remaining lithostratigraphic intervals were cored in only 6 boreholes. Structural interpretation was based on 2D surface seismic and borehole seismic data, particularly dipmeter measurements. The structural interpretation of seismic data has shown the presence of extension structures, such as normal faults, as well as compression structures represented by overthrusts and folds. Analogous deformation structures – fine faults, minor folds, deformation bands (complementary cataclase zones) – were observed in the boreholes. Both types of deformation structures indicate a NW-SE elongation. Our observations indicate that the largest deformation intensity occurs at the boundary of the structure with the Fore-Sudetic Block and decreases towards the south-west, to the axis of the North Sudetic Synclinorium. Borehole data point to the presence of tectonic repetitions of Zechstein and Triassic rocks, as evidenced by anomalous thicknesses, accompanying deformation structures and repetitions of lithostratigraphic intervals observed in boreholes, as well as borehole seismic data. The mutual relations of the recognized tectonic structures indicate that the first deformation stage between the Middle Triassic and the Early Cretaceous (?) resulted in the development of extensional structures. Compression structures (reverse faults, overthrusts, folds) were formed during the subsequent, main deformation stage. This stage should be linked with the inversion of the German-Polish Basin at the Cretaceous/Paleogene boundary.

Influence of hinterland movements on mixed carbonate-siliciclastic shelf margins. Jurassic, Moroccan Atlantic Margin

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An extensive mixed carbonate-siliciclastic shelf margin developed from Portugal to Guinea-Bissau during the Jurassic drift phase of the Central Atlantic Margin. This platform directly overlies the Triassic syn-rift to sag basin continental succession. The Jurassic passive margin phase might be expected to be a tectonically quiescent time, when the sedimentation was controlled dominantly by climatic and eustatic variations. However, thermochronology studies along the margin show evidence for significant local vertical movements of the hinterland during the Jurassic and Cretaceous. Exhumation of the main potential source domains can be correlated to multiple periods of siliciclastic influx along the Moroccan coast. These observations raise some questions regarding the carbonate platform: How does the quantity of clastic sediment eroded and redeposited into the system influence the current and overlying carbonate environments and what was the response of carbonate factory? Do hinterland movements produce variation of accommodation and was that of a magnitude to induce facies variations that can be identified in the carbonate platform?

This study analyses the sedimentary record of the mixed carbonate-siliciclastic deposits from the Moroccan Atlantic Margin. Both open and restricted marine carbonates are observed, interrupted by three distinct periods of siliciclastic deposition. An initial Sinemurian-Pliensbachian carbonate ramp, is extensively eroded and followed by Toarcian continental siliciclastics. The erosive phase and siliciclastic deposits can be linked to hinterland movements of the central Anti-Atlas. The following Toarcian shallow marine platform deposits, are dominated by oolitic grainstones, dolomites, breccias and stromatolites, organised in peritidal cycles. They present little lateral variations and include small volumes of quartz, reflecting minor siliciclastic pulses. The Middle Jurassic is highly variable across the margin. In the Essaouira-Agadir Basin the continental to shallow-marine siliciclastics to shallow-marine carbonates lateral evolution can be correlated to movements of the Anti-Atlas. The Callovian records the establishment of a transgressive carbonate ramp. The initial spatial facies variability is interpreted to record the influence of paleotopography, and the temporal (vertical) facies evolution suggests a deepening of the bioclastic, brachiopod-rich depositional environments. The Oxfordian is marked by the establishment of coral buildups over a large part of the Moroccan Atlantic Basins. The Gharb and Rif Basins do not record the presence of frame builders, but are dominated by siliciclastic-rich deposits produced by the erosion of the hinterland. Finally in the Kimmeridgian and Tithonian there is a return to carbonate dominated environments, with the development of an extensive platform covering the entire Moroccan Atlantic shelf from Agadir to the Rif. In conclusion, throughout the Jurassic, hinterland exhumation generated multiple phases of siliciclastic influx along the carbonate-dominated Moroccan Margin. The main effect of the influx of siliciclastics on the carbonate factory was generally a change from bioconstructions to reworked carbonates deposits. During more acute periods of siliciclastic production, the siliciclastic deposits completely replace the carbonates over extended areas. Finally, the exhumation of the hinterland, when not producing clastics, still influence the carbonate environments by reducing the accommodation space which induce regressive trends.

New sequence stratigraphic methods are inappropriate for carbonate systems

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The classic sequence stratigraphy is an unconformity-based method has been proven to be robust for giving the sequence boundaries chronostratigraphic significance. Two emerging methods, however, define sequences either on the response of the system to varying rates of coastal accommodation increase and decrease relative to the rate of sediment flux or by subdividing the stratigraphic succession with seven stratigraphic surfaces that reflect main events in a base-level cycle. Both methods take the sedimentary response of the siliciclastics to base level variations as a guide for the sequence stratigraphic analysis. This anchoring on the clastics system is a challenge when applying these sequence stratigraphic methods in carbonates and mixed systems because the carbonate system, particularly steep-sided carbonate platforms, can be 180˚ out of phase to the siliciclastic system.

Carbonate sediment production and distribution relative to sea level are different in carbonate and clastic systems. Carbonates produce most sediment and display highest rates of progradation during sea-level highstands when sea level falls the platform is exposed and sediment production stops. As a result, the maximum regressive surface that marks the end of a base level fall in clastics are rare in carbonates. During a sea-level lowstand, carbonates can develop a lowstand (reef) terrace whose top would be coeval to a maximum regressive surface in the clastics. During the subsequent base level rise, the (reef) terraces can migrate up-slope, producing a series of backstepping parasequences. This motif of transgression is best developed on carbonate ramps, as documented in the Holocene on the Florida shelf. Along steep-sided platforms, the base-level rise generally leaves little record until the rate of carbonate production outpaces the rate of sea-level rise. If sea level oversteps the underlying platform, accommodation is created. In this case, the flooding surface on the platform coincides with the underlying sequence boundary, which is an exposure horizon. High production during the base-level high will result in progradation of the carbonate platform. With the onset of the base level fall, the steep-sided platform is exposed and an unconformity develops that represents the top sequence boundary.

If maximum progradation is equated to the maximum regression, the interpretation of its position within the base level cycle is vastly different in carbonates versus siliciclastics. In carbonates maximum progradation is at the end of a sea level highstand while in siliciclastics it is in the sea level lowstand. In addition, on the windward side of isolated carbonate platforms vertically aggrade, producing no other sequence stratigraphic surfaces than exposure horizons. When applying accommodation succession method to carbonates similar problems arise, because of the complexities of carbonate sediment production and distribution rates relative to changes in rate of accommodation creation. In addition, both methods do not account for the drowning unconformities that are prominent sequence boundaries in carbonates.

In summary, if the emerging new methods of sequence stratigraphy that are developed in siliciclastic systems are applied to carbonate successions, misinterpretations of highstand versus lowstand strata will occur and an entire category of sequence boundaries cannot be identified.

The first-discovery of Thalassinoides and reappraisal of depositional environment for Middle Cambrian Miqrat Formation, Oman

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The discovery of Thalassinoides and the new collected field data from the Huqf region outcrops in Central Oman have helped to propose an alternative depositional environment interpretation for the Miqrat Formation. The Miqrat Formation is Middle Cambrian in age and is a major oil/gas producing horizon in Oman Interior Basins. Lithostraigraphically, the Miqrat Formation is subdivided into three informal members; lower, middle and upper. The lower member is well-exposed and mostly is traceable laterally over 3 km. This member attains a thickness of ca. 80 m representing coarsening upwards cycles of reddish-brown mudstones to sandy siltstones grading upwards into very fine-grained sandstones. The mudstones contain scattered quartz grains and interbedded with siltstones showing large scale desiccation cracks in its uppermost part. The sandstones are thickening upwards and showing parallel to low-angle cross lamination and wave ripples. This may suggest that the lower member was deposited in marginal marine, supratidal to intertidal environments. The middle member is also well-exposed and traceable laterally over 3 km. This member is ca. 40 m thick of light-brown to buff and sometimes white, fine- to coarse-grained sandstone. The sandstones display low- to high-angle tabular to trough cross-bedding with wave ripples at tops in many cases. The sandstones with trough cross-bedding in the uppermost part encompass five-levels of well-preserved Thalassinoides trace fossils. The Thalassinoides display a polygonal network of smooth-walled branched cylindrical burrows forming mostly Y-junction. This suggests that the middle member was deposited in intertidal to subtidal marine environments. The upper member is poorly exposed but showing similar lithology characteristics of the lower member and thus suggests a marginal marine, supratidal to the intertidal environment. The depositional environment interpretation from these outcrops may serve as an analogue for the subsurface Miqrat Formation and thus contribute to a better understanding and characterization of the reservoir intervals. Moreover, this new proposed interpretation can play a key role in exploration, appraisal, development, production, and enhanced recovery strategies in the region.

The Mississippian Bowland Shale: A Synthesis of Recent Advances

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The UK Mississippian Bowland Shale Formation is one of the thickest, rapidly deposited, organic-rich and metalliferous black shale successions in the world. The Bowland Shale is an important component of hydrocarbon and mineral systems in the UK, including the Pennine-type Pb-Zn mineral deposit. Here we explore our recent advances in understanding the physical and biogeochemical processes which operated during deposition and burial of the Bowland Shale. Carbonate-rich, siliceous, and siliciclastic, argillaceous mudstone facies developed in response to a combination of fourth-order sea level cyclicity, fault activity at the basin margins and supply from a nearby tropical delta system. Sea level highstand facies comprise carbonate-rich, macrofauna-bearing mudstones associated with normal marine water column conditions, anoxic bottom waters and methanogenesis close to seabed. Falling sea level initially deposited mud-clast-rich ('lenticular') muds, followed by an interbedded succession of turbidites, debrites, hybrid event beds, microbial-mat bearing muds, and tempestites. Most anoxic facies contain pervasive early diagenetic quartz crysts, which apparently 'buttress' the sedimentary matrix, enhancing fluid storativity. Quartz cementation is linked to a biogenic (radiolarian) source and was likely catalysed, perhaps by Fe oxides or organic matter (OM).

We show falling sea level triggered a switch in the style of bottom water redox conditions, from (i) periods of high sea level associated with anoxic and at least intermittently sulphidic bottom water conditions, in general with a 'stable' water column chemocline, to; (ii) periods of falling sea level defined by 'redox oscillation' between ferruginous and sulphidic conditions within shallow sediment pore waters. Redox oscillation is recognised by a distinctive diagenetic mineral suite and selective redox-sensitive trace element enrichment pattern. This process generated considerable acidity that promoted total dissolution of primary carbonate and enhanced OM degradation. It also promoted formation of organic sulphur, and likely selectively retained metals (e.g., Pb, Zn) and/or intermediate S species in temporary solution within pores. Metal fixation and preservation of OM and carbonate, under anoxic conditions, was therefore a function of bottom and pore water redoxcline stability. Coupled increased input of Mn-Fe oxyhydroxides and enhanced physical reworking at seabed best explain the development of oscillatory redox conditions during periods of reduced sea level.

These findings suggest the Bowland Shale defines an end-member black shale associated with the following; (i) productivity-driven bottom water anoxia within weakly restricted, and likely thermally stratified basins; (ii) a relatively high mean sediment accumulation rate linked to a tropical delta system; (iii) therefore high loadings of biogenic silica, labile OM and metal oxides, with high potential for precipitation of authigenic silicates; (iv) a complex bathymetric setting, with high capacity for temporary storage of reactive Fe on shelves; (v) high frequency, high magnitude sea level fluctuation which promoted pulsed transfer of reactive Fe from shelves to basins, and as a result the ability to; (vi) develop oscillatory redox conditions, and; (vii) host (and possibly transfer) a relatively large volume of early diagenetic fluids, which were potentially S- and/or metal-bearing.

Black Shales as Typical Parts of Foreland-Basin, Tectono-Stratigraphic Sequences from the Appalachian Basin, U.S.A.

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Black-shale deposition in the geological record clearly reflects a variety of processes and settings, unique to given times and places. Most black-shale deposits occur in relatively widespread basinal settings, and hence, development of suitable, large-scale basin repositories may have been one of the most critical aspects controlling black-shale deposition. Such basinal repositories not only provide space for accumulation, but also protection from later exposure and erosion. The most common black-shale repositories are created through tectonics, and in this paper, foreland-basin-type deposits generated during Appalachian convergence will be emphasized.

The Appalachian Basin is a composite, retro-arc foreland basin, which exhibits 13 third- to fourth-order unconformity-bound cycles—most with extensive, marine, black shales—that have been interpreted to be flexural, foreland-basin manifestations of distinct episodes of tectonism, called tectophases, during five orogenies. These orogenies represent closure of the Iapetus and Rheic oceans during formation of Pangea.

Each orogeny was typically a polyphase event, which included two or more deformational episodes, or tectophases, commonly focused at different places and times along an orogen. The sedimentary record in the Appalachian Basin, along with available radiometric, deformational, and magmatic data, suggests that during five Paleozoic orogenies along the Laurentian/Laurussian margin, tectophase timing and occurrence were mediated by diachronous convergence at successive, projecting, continental promontories. The intensity of deformation and resulting deformational loading at promontories generated a flexurally subsiding foreland basin that migrated in line with diachronous convergence. Loading-related subsidence, followed by periods of crustal relaxation, generated distinct, unconformity-bound, tectono-stratigraphic sequences, called tectophase cycles, in each foreland basin.

The cycles show a consistent sequence of lithologies. Overlying an unconformity generated by bulge move-out, marine black shales initiate most cycles and reflect rapid subsidence with little clastic influx, as most of the loading at this time was subaqueous and generated little clastic influx. These basal black shales are prominent, easily mapped, and mark the time of maximum deformational loading and flexural subsidence. Moreover, mapping the distribution of these black shales shows that the shale basins migrated in time and space, tracking the along-strike progress of orogeny relative to promontories. The shales in each cycle are overlain by a series of relaxational clastics, including deeper-water, flysch-like clastics followed by more shallow, marginal-marine, molasse-like clastics. These clastics reflect the advent of crustal relaxation and the concomitant development of surficial loads and drainage nets suitable for the generation and transportation of clastic debris into the basin. Clearly, there was a major tectonic component in the development of these black shales and the overlying clastic parts of the sequences.

Similar tectophase cycles are known from the Black Warrior, Alpine and South China foreland basins, and may be present elsewhere. The cycles suggest that some black shales, as hydrocarbon source and reservoir rocks, and overlying clastics, as major reservoir rocks, are the product of distinctive tectonic settings, and aside from any economic value, may provide additional controls on the timing and location of tectonic events.

Can the blind source separation methods facilitate interpretation of geochemical trends from XRF core scanning?

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This contribution is focused on analysis of element intensities measured by portable energy-dispersive X-ray fluorescence (EDXRF) device on split sediment cores. Core scanning by portable EDXRF device is a low-cost alternative to the expensive XRF core scanners, which allows non-destructive and easily obtainable extraction of element intensities in soft sediments. A simple apparatus was developed for this study employing a fixed core rack and a sliding, manually operated EDXRF device holder. The operator can set the sampling interval according to the required stratigraphic resolution.

However, direct XRF scanning of soft sediment surface is sensitive to inhomogeneity of the measured surface including sediment porosity, variable water content and grain size distribution, what prevents from correct geochemical interpretation of element intensities. A useful approach to solve this problem is calibration of the XRF element intensities to concentrations obtained from sample aliquots by conventional destructive methods using compositional data analysis. Even though this approach is already well settled in literature, we see its drawback mainly in non-robustness of the calibration curves over different samples and distortion of the relative structure between elements during the calibration process. In this contribution, methods of blind source separation (BSS) of compositional time series are proposed as an alternative. These methods treat all element intensities measured at a given depth as a whole composition and respect a possible presence of correlation between vertically adjacent measurements. BSS methods combine the measured elements into new latent variables, signals, mapping the stratigraphic trends imprinted to the geochemical structure of the sediment. In addition, the BSS results model a noise component, which is responsible for the inaccuracy of element intensities as compared to concentrations obtained from dried sample aliquots. Removal of the noise can lead to better performance of any further analysis of element intensities.

The pros and cons of the proposed method will be discussed on a set of EDXRF scans of underwater sediment cores taken from the Nosice, and Hričov dam reservoirs, Váh River, Slovakia. Sample aliquots were taken from the scanned intervals and analysed by EDXRF (powdered samples) and ICP-MS methods (lithogeochemistry analysis with total digestion). Special attention will be paid to the vertical distribution of common lithogenic elements (Al, Si, Rb, Zr, Ca) and potential risk elements partially derived from anthropogenic sources (Pb, Zn, Cu, As). The observed geochemical trends will be compared with trends in grain-size (laser granulometry) and pore water content (weight loss during drying).

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Simultaneous breakdown and recementation of an unusual beachrock facies on a high-energy coastline (South Africa)

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Beachrocks are coastal sediments that are lithified through the precipitation of carbonate cements. It is widely acknowledged that lithofacies in beachrocks are variable and their interpretation is useful when using beachrock as a sea level indicator (Vacchi et al. 2012, Mauz et al. 2015) or when studying shoreline evolution over the centurial to millennial scales (Cooper 1991). Surprisingly however, the facies variability of beachrocks remains understudied as they are almost exclusively described as seaward dipping, slab-shaped outcrop forming in low energy dissipative beach environments. The Mission Rocks coastline of north-eastern South Africa is in stark contrast. Here the coast comprises an up to 3 m thick raised shore platform of beachrock, where a variety of sedimentological facies are observed. These comprise seaward-dipping planar bedded sandstones and conglomeratic units, often interbedded with bimodally-orientated trough cross bedded sandstones. In our study we aim to use sedimentological facies analysis, petrography and cathodoluminescence to unravel the deposition- and cementation processes of this beachrock facies.

In particular, an unusual beachrock breccia interposed amongst the breakdown remnants of the platform forms the basis of this paper. The breccia documents a cycle of simultaneous erosional breakdown and depositional buildup of the beachrock platform, a yet undescribed process for the development of beachrock. Since it forms as a thin veneer (< 0.10 m), with a slightly thicker infill (≤ 0.5 m) amidst erosional hollows and gullies of the + 2 m high rocky platform, it raises into question the necessity of a thick sedimentary overburden, that is typically considered the requirement for beachrock cementation in the mixing zone. Timing of beachrock formation is constrained by recent anthropogenic activities, as the underlaying platform was mined for building purposes during WWII and it is in these quarry slots and crack that the beachrock is found. While it is generally suspected that beachrocks may form at the centennial scale, evidence for this remains weak. Not only can the interpretation of this facies contribute to our understanding of the long term processes that form and break down beachrocks on high energetic coastlines, it provides insight into rapid beachrock formation and as such its utility as a sea level index point.

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Global palaeoenvironmental perturbations during the Aalenian: Mutliproxy evidence from France and Chile

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Over the last decades, studies on Jurassic palaeoenvironments have been mostly focussed on the early Toarcian as this latter was marked by the Toarcian Oceanic Anoxic Event (T-OAE; ca. 183 Ma), which was one of the most extreme hyperthermal of the Phanerozoic. Hence, little is know about palaeoclimatic and palaeoenvironmental changes during the Aalenian time interval, although it is likely marked by an abrupt cooling in the aftermath of the Toarcian warm mode. Available palaeontological and geochemical datasets suggest that the Aalenian is also characterized by faunal turnovers and potential carbon-cycle perturbations. Despite those evidence, there is still no consensus about the modality of Aalenian palaeoenvironmental and palaeoclimatic changes as well as their potential triggering mechanisms. In addition, data from outside Europe are absent, leading to large uncertainties whether the observed changes are of gobal significance.

In this study, we focus on the upper Toarcian–lower Bajocian interval of two marl/limestone alternation successions, namely Le Brusquet (Vocontian Basin, SE France) and El Peñon (Andean Basin, N Chile). Palaeoenvironmental and palaeoclimatic conditions are inferred based on high-resolution mineralogical (whole-rock and clay fraction) and geochemical (carbon isotopes, Rock-Eval pyrolysis, phosphorus, mercury) analyses. Additionaly, we provide a cyclostratigraphic framework for the Aalenian based on high-resolution magnetic susceptibility spectral analysis. The carbon isotope composition of bulk organic matter reveals evident correlatable fluctuations between sites from both hemispheres, providing the first evidence that the carbon cycle was globally and repeatedely disturbed during the Aalenian. The Toarcian–Aalenian transition is associated with a decrease in detrital and nutrient input (phosphorus), which is likely related to the shift towards the Aalenian cool mode. Interestingly, the middle–upper Aalenian transition is characterized by a sharp increase in terrigenous and nutrient influxes suggesting a more humid and warmer episode. The concomitance between strongly expressed precession cycles and palaeoenvironmental changes suggests moreover the influence of orbital parameters on the Aalenian sedimentary record.

The Tachrift channel-levée turbidite systems (Tortonian) of the Taza-Guercif Basin (South Rifian Corridor, NE Morocco)

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Turbidite channel-levée complexes have been the focus of extensive research from a number of modern and ancient deep-water turbidite systems over more than forty years. Although high-resolution 3D seismic have recently yielded unprecedented imaging of these deposits, the internal facies complexity of a channel-levée complex remains elusive. To fill this gap, extensive well-exposed outcrops are particularly important, as they provide information on fine-scale facies heterogeneity. Despite this, documented outcrops of deep-water channels where accordant levées and overbank sediments can be observed are relatively few and, at best, too small to understand the full-range of architectural complexity.

This contribution reports on the field mapping of 9 superimposed channel-levée complexes belonging to the Tachrift turbidite systems (Tortonian- Early Messinian) of the Taza–Guercif Basin (Rifian Corridor, NE Morocco), exceptionally well-exposed on the eastern side of the Zobzit river opposite Douar Tachrift. Arid climate and deep incision by ephemeral streams make for world-class extensive outcrops covering an area of roughly 16 km2. They provide insights into 3D geometry and facies heterogeneity of deep-water channel-fills and channel margins, where the accordant levée are clearly seen. Separated each from another by hemipelagic marls, the mapped channel-levée complexes exhibit individual thickness in the range 3–15 m totaling a thickness of about 600 m. Field mapping led to recognition of four main facies associations corresponding to as many depositional elements: (1) fine- to coarse-grained, amalgamated to channelized sandstones, making the bulk of the channel-fill; (2) very thin-bedded heterolithics of fine-grained sandstone-mudstone couplets, recording overbanking in levées; (3) mud-rich chaotic beds resulting from in-channel accumulation of failed levée deposits and (4) structureless to laminated hemipelagic mudstones. Based on planform, cross-sectional geometries, thickness and gross facies architecture, these channel complexes can be subdivided into two end-member types, resulting from different modality of channel belt development, namely: (a) relatively thin complexes formed by sinuous levéed channels which migrate laterally with only minor vertical aggradation (b) thicker complexes with a dominantly aggradational staking of component elements.

Laboratory observations on meltwater meandering rivulets on ice

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We present a set of observations on meltwater meandering rivulets on ice and compare them (qualitatively and quantitatively) to morphologies commonly found in meandering channels in different media. The observations include data from planned centimeter-scale experiments, and from incidental self-formed millimeter-scale rivulets. Our data show pulsed lateral migration features, undercut banks and overhangs, meander bend skewness, and meander bend cutoffs. The data also compare well with planform characteristics of alluvial meandering rivers (sinuosity, wavelength-to-width ratios, and meander bend fatness and skewness). We discuss the (ir)relevance of scale in our experiments, which in spite of being in the laminar flow regime, and are likely affected by surface tension effects, are capable of shedding light into the processes driving formation and evolution of supraglacial meltwater meandering channels. Our observations suggest that sinuosity growth in meltwater meandering channels on ice is a function of temperature differences between flow and ice, and flow velocity. In the absence of recrystallization (depositional analog to alluvial rivers), bends are more likely to be downstream skewed and have lower sinuosities.

Paleoenvironmental influence on decapod crustaceans preservation, abundance and diversity from Eocene at south-central Pyrenees (Spain)

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The Eocene was a critical period for decapod evolution, with the appearance of many modern taxa. More than 900 decapod species have been described from Eocene sedimentary successions throughout the world, with the highest diversity concentrated in Europe. However, few studies have dealt with the changes in distribution and diversity of decapod crustaceans across the different environments of a sedimentary system. This is mostly due to limited outcrops, the existence of homogeneous formations, and the limited fossilization potential.

Here, we present an exceptional example of distribution of middle-upper Eocene (Bartonian-Priabonian) decapod crustaceans, based in the analysis of the in Arguis-Pamplona Formation (Jaca Basin, South-central Pyrenees). The studied sites are distributed in the proximal to distal areas of a mixed carbonate-siliciclastic system that spans about 1000 square km of well-exposed outcrops at the Huesca province (northern Iberia). The Arguis-Pamplona Formation also represents a wide range of environments ranging from shallow reef complexes to prodelta/outer platform conditions as a result of a progradation of deltaic facies to the west. The field work carried out in the studied formation has allowed to collect more than 500 specimens of decapod crustaceans included in almost 22 families from different lithofacies.

Preliminary results show unequal distribution in decapod crustacean assemblages and associated faunas in different environments, and varies dramatically in its abundance and composition across different stratigraphic intervals of the studied formation. The major peaks in diversity are correlated with specific taphonomic conditions in the proximal prodelta environments; which also host most articulated specimens. The characterized of decapod assemblages provide a great opportunity to study the spatio-temporal distribution of a single systematic group in a well-defined area, and allow a better understanding of the paleoenvironmental factors controlling the observed distribution.

Sedimentology of the Permo-Triassic boundary in high palaeolatitude, coastal plain successions of eastern Australia

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Upper Permian to Lower Triassic coastal plain successions of the Sydney, Gunnedah, and Bowen Basins in eastern Australia have been investigated in outcrop and continuous drillcores. The purpose of the investigation is to provide an assessment of paleoenvironmental changes at high southern paleolatitudes in a continental margin setting for the Late Permian, across the end-Permian Extinction (EPE) event, and into the Early Triassic. These basins were affected by explosive volcanic eruptions during the Late Permian and to a much lesser extent, during the Early Triassic, allowing high-resolution age determination on the numerous tuff horizons. Late Permian depositional environments were initially shallow marine and deltaic, but coastal plain fluvial environments with extensive coal-forming mires became progressively established during the early Late Permian, reflected in numerous preserved coal seams. The terrestrial EPE, as marked by complete and permanent loss of the Glossopteris flora, occurs above the uppermost coal within an immediately overlying laminated shale interval, where preserved. The timing of this event predates the Permo-Triassic boundary by some 400 ky. In some locations, however, this horizon was erosionally excised by the base of an overlying (probable basal Triassic) channel sandstone body. The shale is interpreted to record flooding of the alluvial landscape following extirpation of the flora and establishment of a "dead zone". Following this, "normal" fluvial environments were re-established, coincident with the first elements of the Early Triassic recovery flora. The fluvial style of coastal plain channel deposits varies geographically. But apart from the loss of peat-forming mires, no significant change in fluvial environment (grain-size, architecture, or sediment dispersal direction) was noted across the EPE (pinpointed by turnover of the paleoflora). There is no evidence for immediate aridification across the boundary despite a loss of coal from successions. Rather, the EPE marks the base of a long-term, progressive trend towards better-drained alluvial conditions into the Early Triassic. The character of the surface separating coal-bearing pre-EPE from coal-barren post-EPE strata varies across the basins. In basin-central locations, the contact varies from disconformable, where a fluvial channel body has cut down to the level of the top coal, to conformable where the top coal is overlain by mudrocks and interbedded sandstone-siltstone facies. In basin-marginal locations, however, the contact is a pronounced erosional unconformity with coarse-grained alluvial facies overlying older Permian rocks. There is no evidence that the contact is everywhere a disconformity or unconformity.

Tidal-fluvial concave-bank deposits: An integrated sedimentological and ichnological approach

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Fine-grained concave-bank deposits (CBDs) form at the bar-tail of downstream-migrating (translating) point bars. The sedimentological expression of fluvial CBDs has received much attention; however, CBDs are not restricted to fluvial environments, and can be commonly observed in modern tidal-fluvial meandering channels. Despite their common occurrence, no study has been undertaken to constrain the sedimentological and ichnological expression of tidal-fluvial CBDs.

In fluvial environments, translating point bars are associated with flow impingement against erosion-resistant bank material, subsequent flow separation, and upstream-directed eddy currents. In tidal-fluvial environments, the relative influence of tides on the fluvial discharge varies regionally across the tidal-fluvial transition zone, locally across a point bar, and temporally on a daily to decadal scale. The resulting physico-chemical stresses (e.g. salinity fluctuations, duration of exposure, substrate consistency) dictate the abundance and behavior(s) of infaunal organisms.

This study investigates the sedimentological and ichnological expression of a modern tidal-fluvial, brackish-water CBD at the mouth of the Serpentine River, Surrey, BC, Canada. Bathymetry, grain size, TOC analysis, population counts, and box cores are presented and discussed in the light of hydrological processes and ecological stresses acting on the CBD and its associated upstream point bar.

Channel morphology and seaward bar accretion indicate the dominance of ebb-currents. During high river discharge, suspended material is deposited on the CBD. Low river discharge and flood-directed currents deposit sand in the upper and middle intertidal bar of the CBD. By contrast, only silt is found in the intertidal part of the associated upstream bar. The coarsest intertidal sediments are found at the bend apex; the result of funneled flow from the wide, bench-like CBD morphology into a narrow, steep-sided channel bend during the flood tide. Most of the intertidal point bar is dominated by Abarenicola pacifica, Nereis virens and bivalves, which produce Arenicolites, Polykladichnus, and Siphonichnus, respectively. The lower intertidal CBD is dominated by the sediment-interface feeding organisms Saccoglossus kowalevskii and bivalves, which make Gyrolithes and Siphonichnus, respectively. The abundance of sediment-interface-feeding behavior suggests a link to elevated tidal transport and deposition of marine-derived nutrients on the CBD.

Interestingly, fluvially dominated CBDs typically build channelwards as a response to downstream sediment transport, whereas this tidally dominated CBD receives a notable component of sediment from the basinward direction. This is evidenced by the distribution of sand on the CBD and the delivery of viable food resources to the marine invertebrates. This integrated sedimentological and ichnological process-response model for this tidal-fluvial CBD helps to refine our understanding of the intricate infaunal colonization patterns that might be expected in tidal-fluvial point bars and CBDs.

Are meander cutoffs in tidal coastal landscapes really that rare?

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Highly sinuous meandering channels are common landforms in fluvial and coastal environments. As meanders migrate laterally, driven by sediment erosion and deposition along their outer and inner banks, respectively, they eventually cut off, leaving behind the characteristic crescent-shaped morphologies of scroll-bars and oxbow lakes. Oxbows are particularly important not only from ecological perspectives, for the diverse habitats they provide, but also because they retain signatures of the flow characteristics that shaped them, thus allowing for paleoflow reconstruction.

While alluvial plains carved by meandering rivers are littered with scars of meander cutoffs, tidal coastal settings have been perceived by geomorphologists for much of the past century as lacking morphological evidence of active meandering – even though both environments exhibit similar meander-planform dynamics and width-adjusted migration rates. In particular, the thesis that streams flowing at tide level have no tendency to meanders nor power to enlarge or to cut off meanders already in existence is a long-living one.

Here we analyze the planform characteristics and evolution of meander cutoffs from a variety of fluvial and tidal landscapes around the world. We combine field observations and remotely sensed data to track the abandonment of individual meander bends and the subsequent progressive infill and vegetation colonization of the meander cutoffs.

We show that tidal-meander cutoffs tend to be symmetric in planform, seldom disconnected from their parent channel, and fill up as much as 10 times more rapidly than neck cutoffs formed by meandering rivers.

We suggest that cutoffs in tidal meanders are far more widespread than previously thought, and that their supposed paucity is explained by several processes typical of tidal landscapes that collectively militate against the formation and preservation of meander oxbows after cutoff.

These results have important implications for the conservation and restoration of critically endangered coastal environments, as well as for better assessing the capacity of tidal wetlands to store large amounts of blue carbon.

Exploring the morphological kinship between submarine and alluvial meander planforms

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Submarine channels are common morphological features of the seafloor and represent the main conduits through which continental sediments are transported and deposited in deep marine environments. Sedimentary deposits associated with sinuous submarine channels have important implications for carbon sequestration and oil production, and for reconstruction of paleoenvironmental conditions.

Remote-sensing and sampling technologies for deep marine environments are rapidly improving, but monitoring the formation and evolution of meandering submarine channels remains a daunting task. Useful physical insights into submarine channel dynamics can potentially come from sedimentary and numerical analysis of meandering terrestrial rivers as analogs. Although sinuous submarine and fluvial channels are characterized by different formative processes, their planform dynamics and the resultant morphologies are generally similar. However, the nature of such dynamical similiarity – or differentiaton – has not been closely examined in quantitative empirical terms.

We analyzed the planforms morphologies of 26 submarine meandering channels worldwide, containing ~14000 individual meander bends in total. The planforms of submarine meandering channels, which were hand-digitized using available bathymetric datasets or reconstructed from literature, are compared with those of freely meandering alluvial rivers found in different climate and geological settings.

We highlight striking similarities and subtle differences in the planform expressions of submarine and fluvial meandering channels. We also demonstrate that these two types of landforms can be distinguished on the exclusive basis of their planimetric configurations.

Our results provide critical information for reconciling the current knowledge of terrestral and deep-water meandering channels, which may improve and validate numerical morphodynamic models of submarine meandering and the associated sedimentary deposits.

Influence of environmental stress on Early Triassic biota; example from Central Dalmatia, Croatia

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Lower Triassic clastic and carbonate deposits crop out at several localities in Central Dalmatia, and have been well studied, especially in the area of Muć (Herak et al., 1983). The 230 m thick study succession is well exposed along the local road between Muć and Ogorje villages and comprises reddish micaceous sandstones, siltstones and mudstones in its lower part and yellowish-grey carbonate deposits interbedded with siltstones and mudstones in the upper part. The occurrence of slumps and storm deposits in the lower, siliciclastic part of the succession suggests deposition in offshore transition and shoreface environment on a broad and relatively stable shelf (Aljinović, 1995; Aljinović et al., 2018).

Frequent changes in lithology are noted in the upper, carbonate-dominated part of the succession, in which fossil remains include mostly gastropod, bivalve, rare ammonite remains and bioturbations (Vudrag & Sremac, 2015; this study). However, barren limestones are also common in this part. Clastic influence seems to be stronger than previously thought, indicating significant and frequent relative sea level fluctuations, probably stemming from enhanced tectonic activity – resulting in carbonate production during transgressions and its suffocation due to siliciclastic input during regressive stages.

Our aim is to discuss and determine changes throughout the studied succession, with emphasis on the carbonate part due to the presence, but also very common absence of fossil remains, variations in Total carbonate content (50.1 to 99.1%.), frequent occurrence of thin dark laminae and presence of pyrite. These findings will help in determination of environmental conditions during the Early Triassic and of the ongoing influence of stress to already stressed biota.

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Neotectonic activity of Mariánské Lázně Fault (western Czech Republic) and associated sedimentary outliers

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The Mariánské Lázně Fault (MLF) is more than 100 km long tectonic structure which was active already in the late-Variscan times. The presence of Pleistocene volcanism as well as present-day mineral-rich springs is connected with the fault activity. The Holocene activity of the fault has been paleoseismologically proven in its northern part, however the neotectonic activity in the central and southern part is still poorly understood. This study is focused on the manifestation of possible neotectonic activity in the morphology and identification of localities for the subsequent paleoseismological survey of the fault. The analyses of the water stream longitudinal profiles, the Stream-Length (SL) index, mountain front sinuosity and basin asymmetry were used based on Lidar Digital Elevation Models. Over 100 water streams and about 200 water stream subbasins were studied along the MLF. The longitudinal profiles and the SL index analyses showed the signs (knickpoints, convex profiles etc.) of the recent tectonic activity especially in the southern part. In addition, the trend in the subbasins' asymmetry suggested similar results. Hydrological features, together with the general morphology, has led to a hypothesis that the tectonic activity in the central section of MLF took place earlier than the movements in the northern and southern sections and possibly the bulging of the central part of the fault. The multiple cases of river captures, changes of river catchment geometry and tectonically induced occurrence of the Plio-Pleistocene fluvial depocenters were registered during the analyses and in agreement with previous studies (Spicakova et al., 2001; Teodoridis et al., 2017). The subsequent paleoseismological survey in this southern part of the fault (especially the most promising locality of Nová Hospoda) is essential to complement the studies from the northern part, where the recent activity is proved and dated. Then, the complex tectonosedimentry evolution along the MLF during the Pliocene and Pleistocene could be deciphered.

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Dolomitization and dedolomitization of Upper Cretaceous Carbonates: A case study from the Borizana section, Albania

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In the shallow-water carbonates early diagenetic dolomitization is a common feature recognized all through geologic record. After their formation, frequently dolomites are subject to dedolomitization (dissolution of dolomite and replacement by calcite). It takes place usually under fresh water influence during emersion. Based on detailed logging and sampling of the outcrop together with sedimentological and petrographic work, theoretical models on early diagenetic dolomitization and dedolomitization and their mechanisms were evidenced for the Upper Cretaceous carbonate platform in the Borizana section. Two types of early diagenetic dolomites were observed, microdolomite and matrix dolomite. Early formed crystals possess different petrographic and cathodoluminescence (CL) characteristics. Polymodal planar-e to planar-s microdolomite have almost totally replaced the micritc matrix. Polymodal matrix dolomite crystals, have dark core and white clean borders. Under CL these matrix dolomite exhibits bright yellow/orange luminescence for inner core and orange luminescence for the crystal borders. Different types of dolomites are interpreted to have been formed by a combination of two different mechanisms, seepage reflux dolomitization due to frequent sea-level changes and sabkha dolomitizaton. During early diagenesis, percolating fresh meteoric waters can be considered to be the general origin of the centrifugal replacement type of dolomite crystals by calcite, of the carbonate rocks that underlie a subaerial exposure. The results can play an important step to better understand a possible link between high-frequency sea-level oscillations and early dolomitization under Mesozoic greenhouse conditions.

Sedimentology and trace element geochemistry of Upper Cretaceous platform carbonates in the Borizana section (Albania)

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Kruja Platform (Albania) is located in the Apulian eastern passive margin. Petrographic and sedimentological study coupled with geochemical analysis (X-ray fluorescence, ICP-OES) were carried out on Upper Cretaceous shallow water carbonates that crop out in the Makareshi structure, Borizana section. Based on XRF analyses and petrographic study the upper part of the Campanian-Maastrichtian formations is composed of limestones and dolomitic limestones, with idiotopic texture that testifies an early dolomitization in a supratidal environment. The lower values in Sr and Na contents along the section have the same trend. The Fe and Mn values tend to be close to each other and to opposite to Sr and Na. This is attributed to a meteoric diagenesis influence, in a water-buffer system. The low Sr content associated with relatively high Fe and Mn content indicates a low salinity environment, near subaerially exposed islands. They are located in the proximal part of a reconstructed theoretical depositional profile. This explains the lack of evaporite sequences and pseudomorphosis of evaporite minerals. The lowest negative peak of Sr and positive peak Fe and Mn, at the 270m level of the lithological column suggests an emersion surface of the platform during Upper Cretaceous. This is supported by petrographic observations also. Such event has been recorded in the Island of Brač. This sea level fall is consistent with a global one reported from the southern margins of the Tethys, in the central Atlantic and in the Boreal realm.

The Effect of Sediment Supply on the Stratal Architecture of a Deep-Marine Slope Channel Complex.

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Commonly reported in previous seismic, outcrop, and stratigraphic forward modelling studies is the systematic evolution of deep-marine slope channel systems from an initial composite sheet-like stratigraphic unit made-up of laterally offset channel fills to a succession of isolated, aggrading channel fills. Presently, many models attribute this upward change in channel trajectory to changes in sediment supply, and more specifically, the sand-mud ratio. However, this model is based largely on the interpretation of seismic data with at best sparse core control. At the Castle Creek study area (BC, Canada), a superbly exposed channel system term Isaac channel complex 1 (ICC1) crops out. ICC1 is 220 m-thick, exposed over an area ~5 km wide, and made-up of four vertically-stacked channel units. ICC1 overlies a sequence boundary that separates mixed carbonate-siliciclastic strata of the ~200 m thick first Isaac carbonate from siliciclastic strata of ICC1. This indicates the cessation of carbonate production and the exclusive delivery of siliciclastic sediment from the continental hinterland, and accordingly the opportunity to investigate the influence of sediment supply, as controlled by changes of relative sea level, on the stratal architecture of ICC1.

Based on lithological, textural, and stratal trends, two styles of channel fills and stacking patterns are recognized – disorganized stack of aggradationally filled channels and organized stack of laterally-accreting channel fills. Aggradationally filled channels fill from the bottom up and exhibit upward and axis-to-margin fining and thinning, reflecting deposition from poorly-sorted, (vertically) density-stratified flows. In contrast, laterally-accreting channels are consistently filled with moderately well-sorted, coarse and very coarse sand with little upward or lateral fining or thinning. Forming at the top of the channel complex, laterally-accreting channel fills suggest a change in the character of through-going turbidity currents, which here is interpreted to be the result of a change in the granulometric make-up, principally sorting, rather than sand:mud ratio, of the sediment supply and its influence on the flow's density structure; specifically, the development of a coarse, negligibly stratified basal layer. This change in sediment supply reflects a shift from a hinterland- to shelf-dominated sediment source associated with a long-term (possibly 3rd order) rise of relative sea level that progressively expanded continental shelf (topset) accommodation and allowed for the retention and progressive accumulation of coarse relict and palimpsest sediment. Superimposed on the long-term trend were shorter duration (4th / 5th order) changes that transported coarse sediment to the shelf edge for later resedimentation downslope. As relative sea level rose, the comparative contribution of coarse, moderately well-sorted, shelf-derived sediment increased and eventually became the principal component in the sediment supply. In channel bends the coarse, moderately well sorted sediment in the lower part of the flow developed a cross-flow density gradient that resembled the hydraulic pressure conditions in fluvial channel bends, which then promoted continuous lateral channel migration with deposition on the inner bend (point bar) and erosion on the outer bend (cutbank).

Statistically learning complex Archean carbonate diagenesis

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The classification and petrology of carbonate rocks have long been a subject of debate among geoscientists as the significance of carbonates was growing due to the demands of the oil industry and other strategic sectors. The existing classifications are mostly based on optical petrographic description of the specimens and have revealed to be subject to biases due to the operators' own interpretation of literature; as a consequence, descriptions of lithofacies and microfacies are often inconsistent and not reproducible.

This problem is amplified when the petrographic analyses are functional for the geochemical characterisation of carbonate rocks. Geochemical data are often riddled with noise due to the large natural heterogeneity of the carbonates, diagenetic overprint as well as oversimplification of the rock classification. This has serious repercussions on the precision of our knowledge of the deep past as often we rely on geochemical proxies to investigate the geological evolution of ancient environments.

Here statistical and machine learning methods were applied to achieve unbiased classification of Precambrian stromatolitic dolostone micro-fabrics on the basis of their trace elements and rare earth elements (REE) distribution investigated through laser ablation induced coupled plasma – mass spectrometry (LA-ICP-MS).

Six (6) different dolomite textures have been identified under optical microscope in transmitted light: i) planar-e (euhedral, E) dolomite forming idiotopic mosaic, characterized by rhombohedral crystals with well-defined crystal margins; ii) planar-s (subhedral and hypidiotopic, H) dolomite, characterized non-rhombohedral crystals with straight boundaries; iii) non-planar (xenotopic, X) dolomite, characterized by crystals with curved or irregular boundaries; iv) coarse non-planar dolomite (S), with same crystal shape of the previous but larger texture (normally filling pores or veins); v) microcrystalline dolomite (M); vi) ooidal dolomite (O), characterized by cortex layers of dolomite and quartz.

Multivariate statistical analyses and supervised statistical learning have revealed that different dolomite fabrics, previously thought as products of aggrading diagenesis, are in fact clustering together. At the same time the algorithm has revealed that an optically homogeneous microcrystalline dolomite is in fact geochemically inhomogeneous because of ripening and recrystallization processes which contribute to element mobilization.

The machine learning test has highlighted that textures of dolomite that are visually different (i.e., planar-e, planar-s and non-planar dolomite) are chemically the same. This means that chemical composition of dolomite is not bound to fabrics or texture but it is rather dependent from processes related to the different lithofacies meaning that the products of diagenetic neomorphism inherit the same fractionation patter of the original sediments (i.e. environmental processes rather than diagenetic). It is therefore proven that diagenetic processes that cause the re-crystallization of dolomite and the consequent change of fabrics and textures, is not affecting the distribution of major and trace elements.

Flood and drought records in the Limpopo River Basin: preliminary insights from reservoir sediments

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The Limpopo River Basin (LRB) in Southern African is in a long-term state of water scarcity. The Limpopo River cuts across arid to semi-arid areas in four riparian countries: Botswana, South Africa, Zimbabwe and Mozambique. The region is under critical water stress, primarily due to increasingly severe and prolonged cyclical droughts and intermittent floods that threaten the quality and quantity of water resources. Recently, the 2017 extreme flood event (return period >28 years) associated to the tropical storm Dineo, followed a multi-year drought that caused damage and water stress throughout the LRB. The long-term effect of such extreme and more frequent events on water reserves and water security is not yet clear.

The work carried on in one of the Limpopo sub-catchments in Botswana after tropical storm Dineo has demonstrated that extreme rainfall/flood events have a tremendous effect on the quality of surface water and groundwater. This is particularly true within a scenario of global climatic change and in rural Africa especially in areas where human activities are rapidly expanding. Changes in land uses may lead to changes in the sediments dynamic (erosion and transport) especially during flood events that follow prolonged droughts. Changes in sediments dynamic can directly affect the morphometry of rivers and alter their role in recharging groundwater, change the volume available within surface water reservoirs/dams, release pollutants into surface water and modify environmental parameters influencing biodiversity and ecosystem functions. These processes are only exacerbated by the increased frequency of extreme events due to climatic changes.

In this work, we present a novel sediment data set obtained from artificial reservoirs (dams) from the four LRB riparian countries and collected as part of the Connect4WR project studying the resilience of the LRB to extreme climatic events.

Two dams in Zimbabwe (Zhovhe and Ripple Creek dams), three dams in South Africa (Houtriever, Mutshedzi and Nwanedi dams) one dam in Mozambique (Massingir) and two dams in Botswana (Lotsane and Shashe dams) have been surveyed and shallow cores of ca. 60 cm have been collected. Sediments from cores have been characterized for grain size, organic matter content, major and trace elements distribution. Data from the cores have been correlated with existing rainfall series and dam levels to pinpoint floods and flood couplets. Selected cores have been dated using 137Cs (the first of its kind in this part of the world) in the attempt of marking clear weather events reported in the last ca. 50 years.

The preliminary results highlight: i) enhanced erosion after prolonged dry periods; ii) effects of floods can be mitigated by the physiography of sub-catchments and by the presence of small dams (buffer effect); iii) an overall increase of extreme weather events in the last 2 decades.

Diagenesis and dolomitization of Jurassic carbonate rocks in SE Bohemian Massif

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Upper Jurassic Vranovice limestones and dolomites occur on the south-eastern slopes of the Bohemian Massif below the Western Carpathian thrust belt. They represent a special type of reservoir rocks in the potential geothermal systems and exhibit highly variable porosity, permeability, and flow mechanisms due to different type of diagenesis and pervasive dolomitization. Florescence and translucent light microscopy was used for more detailed petrographic analysis of Vranovice limestones and dolomites. Isopachous, syntaxial and dolomitic cements were distinguished along with fossils recrystallization. Two generations of dolomite were identified – matrix dolomite and zonal cementation dolomite, which suggests a number of changes in the formation water chemical composition during dolomitization process. Extent of the observed dolomitization is inversely related to the porosity of the Jurassic rocks. Tectonic deformation associated with open and closed fissures were visualized by bright fluorescent colour of the thin section fixation polyester. In the studied samples of Vranovice limestones and dolomites the fissures represent the most important migration avenues, more than pore throats themselves. Further genetic information on petroleum migration is interpreted from intercrystalline porosity filled with precipitated solid bitumen. Present results provide basis for further investigations in pore-water-rock interactions and changes in chemical conditions during diagenesis. The mineral diagenesis shows close relationship with organic matter maturation. Kerogen in carbonate rocks is of type II, i.e. marine phytoplankton algal origin. The highest amount of organic matter is accumulated in the Mikulov Fm., which is deposited in the slope or basin facies during the Upper Jurassic (Malmian). Kerogen is thermally immature down to depth of 3–4 km, as documented by Tmax parameter of the Rock-Eval pyrolysis and biomarkers. In a number of samples with visible fissures, pores or fluid inclusions bitumen is observed with yellow or orange-yellow colour. Geochemistry of the bitumens show genetic relationship to the oil accumulations found in Jurassic reservoirs.

Climatic and environmental changes across the Permian-Triassic transition along a southern high latitude continental margin

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Rapid climate change was a major contributor to the End-Permian Extinction (EPE). Although well-constrained for the marine realm, relatively few records document the pace, nature, and magnitude of climate change across the EPE in terrestrial environments. The Bowen and Sydney basins of eastern Australia contain a unique record of the Permian-Triassic transition in a high-latitude, coastal margin setting. Numerous tuff horizons within the succession have allowed for the development of a high-resolution geochronology. We integrate geochemical proxies with sedimentology, paleofloral data, and climate modeling to assess climatic and environmental changes leading up to, during, and following the End Permian Extinction (EPE). We generated proxy records for chemical weathering and land surface temperature through the late Permian and Early Triassic from continental margin deposits of the high-latitude, southeastern margin of Gondwana. Regional climate simulations provide additional context. Results show that Glossopteris forest-mire ecosystems collapsed during a pulse of intense chemical weathering and peak warmth, which capped c. 1 m.y. of gradual warming and intensification of seasonality. Erosion resulting from loss of vegetation was short-lived in the low-relief landscape. Early Triassic climate was c. 10–14°C warmer and landscapes were no longer persistently wet. Aridification, often linked to the EPE, developed only gradually, potentially providing a refuge for moisture-loving terrestrial groups. Results contrast with terrestrial records from other regions of the globe, which indicate abrupt aridification across the extinction horizon. In illustrating a unique response to Permo-Triassic changes in global climate, results highlight the importance of regional records in capturing the globally uneven response to environmental changes associated with the largest mass extinction of Earth history.

Source-to-sink dynamics and impact factors on an episodic-jump back-arc basin

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The East China Sea Basin (ECSB) is a multi-episodic back-arc basin with complex tectonic movement that has caused the evolution of its source-to-sink (S2S) systems to vary significantly in their temporal and spatial characteristics. This study focuses on the provenance evolution and insights regarding the corresponding S2S dynamics based on sedimentological and sequential-stratigraphic interpretation. Most previous studies have researched the facies association distribution during plate convergence, whereas there is less understanding about the transition from a closed-lacustrine to an open marine S2S system, and then back to a semi-open marine S2S system, as they respond to the plates' episodic jumps. With the analyses of detrital zircon U-Pb chrono-stratigraphy data, the heavy mineral assemblage distribution, and stable content (zircon–tourmaline–rutile) data, we characterize the change in direction of the sediment provenance from being western, namely the Zhe-Min Caledonian fault belt, to all around the sag. Then, we integrate the core, well-logging, and grain size data, and reconstruct the facies association distribution. Based on the trace element and micropaleontological assemblage, we identify the corresponding water salinities in the ECSB from the early Paleocene to the early Eocene. The facies association on the west side shows a transition from a river-dominated setting to tide-dominated and then wave-dominated. The coupled relationship between the sediment process and the evolutionary stage of the water salinity shows a transformation from a closed to open S2S system, and then back to a semi-opened one. We divided the episodic back-arc basin formation into three stages, multi-provenance steep, short, and shallow systems to multi-provenance wide and shallow systems, and then to single-provenance wide and deep systems. Coarse fan or near-shore subaqueous fans were developed in the rifting stage, with the catchment area increasing in the latter tectonic stages. All the above transitions in the sedimentary-facies association were synchronized with the tectonics after the early Paleocene, which show complex interacting terrestrial and marine processes and mass conservation in the transformation from a closed to an open S2S system. During the first stage of transformation from a closed to an open S2S system in the early to late Paleocene, most fine-grained sediment, such as the delta front and deep turbidities, were reworked by the injection of external water. This destroyed the mass balance in the S2S system, whereby the elevation height (H) was the main factor in the S2S system that developed. In the second stage, the back-open S2S system became semi-open. The sediment (S) and elevation height (H) are both critical factors in the development of the S2S system.

Downslope re-sedimentation from a short-living carbonate platform: record from Upper Triassic Hosselkus limestone (Northern California)

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Despite their discontinuous occurrence and poor preservation, knowledge about Triassic carbonates from North America increased considerably during last years. Their characterization represents a unique way to better assess life evolution and recovery after the major Permo-Triassic biological crisis in the Panthalassa Ocean. The Eastern Klamath terrane, located in Northern California, is a key terrane due to its geographic position. It is indeed placed halfway between those of the Canadian Cordillera and the Northern Mexico counterparts, both extensively studied and characterized in the last decades, leaving a gap along the Pacific coasts of the United States. Few kilometers north-east of Redding, Shasta County, California, Upper Triassic carbonates (i.e., Hosselkus limestone) crop out as a narrow north-south belt about 20 km long, near the artificial reservoir of Lake Shasta. There, all the accessible localities have been extensively sampled for microfacies and micropaleontological analysis, leading to new insights about depositional condition and age of Hosselkus limestone. A depositional model has been proposed for the first time, corresponding to a steep slope system subjected to platform progradation and collapse, recording shallow water facies and associated fauna in the form of calcareous breccia. Numerous conodont specimens have documented the whole succession as Upper Carnian.

Systems Feeding Sediment to Canyon Heads (SFSCH) in the Tyrrhenian Sea: understanding deep-sea stratigraphy

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Sediment transfer from the shallow water areas to the deep-sea is initiated by Systems Feeding Sediment to Canyon Heads (SFSCHs). SFSCHs are very sensitive to sea-level variations to perturbations in sediment production and redistribution and to variations in accommodation in the shelf. Through the analysis of bathymetric and subbottom data, I review the variability in time and space of SFSCHs in the eastern Sardinian and northeastern Sicilian margins of the Tyrrhenian Sea. Three main types of SFSCHs, both coast-connected and coast-disconnected, have been recognized: type I corresponds with shelf-edge deep-water coastal systems; type II corresponds with continental shelf, shoal-water coastal systems; type III is coast-disconnected. Further subdivisions involve the degree of confinement and the process regime at the shelf-edge for Type I SFSCHs, and the process regime and the distance of the coastal system from the canyon head for type II SFSCHs. Coast-disconnected systems consist of shelf-wide depositional belts (both channalised and unchannalised) and of landslide complexes.

Each of the different SFSCHs has its distinct process regime that regulate its capacity of sediment transfer to the canyon and eventually to the deep-sea. SFSCHs of type IA and IB develop coastal depositional bodies at the shelf-edge, whereas type IC SFSCHs are characterized by a direct connection between a river and a canyon leading to shelf-edge sediment bypass. Type IC SFSCHs operate through direct hyperpycnal discharge and landslides and have the largest efficiency in transferring sediment to the deep sea. The efficiency of the Type II SFSCHs depends mainly on their distance from the canyon head and on the ability of hyperpycnal flows, both from plunging river-floods and from wave resuspension, and storm waves in transporting sediment offshore. Type IIC SFSCHs play a minor role in the study area due to the microtidal regime of the Mediterranean Sea. Similarly, given the restricted extent of the areas where the shelf-wide continental shelf depositional belt reaches the canyon heads, type IIIA SFSCHs operate only rarely. Type IIIB SFSCHs also have a restricted frequency but can contribute a large amount of sediment to the deep-sea.

Sea-level variations have the largest influence on SFSCHs evolution along the two margins of the study area. Type I prevails during the falling-stage and the lowstansd of sea level. They are however active also during the present high stand of sea level in the tectonically active Sicilian margin. Type II SFSCHs dominate the TST but their activation is diachronous, being dependent also on inherited margin physiography.

The present review shows that SFSCHs have a large spectrum of processes and consequently they have a variable capacity of sediment transfer to the deep-sea. It also shows that they have a large impact on the propagation of the environmental signals from source to sink areas within depositional systems.

Depositional architecture of a mixed volcaniclastic-carbonate slope succession: the seismic-scale Crepe Rosse outcrop (Ladinian, Dolomites)

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Mixed volcaniclastic-carbonate deep-water environments are being progressively recognized in the modern oceans, however, few outcrop examples are available to detail their geomorphic elements, stratigraphic architecture and evolution. One example is here described from the Triassic of the Dolomites (Southern Alps, Italy), where, during the late Ladinian, a tectono-magmatic episode temporally halted carbonate platform development. Successively, the post-volcanic renewal of the carbonate factories is testified by carbonate megabreccia (Cipit) intercalated with thick volcaniclastics of the Marmolada Conglomerate (Wengen Formation). A roughly 250 m-thick, wedge-shape package of mixed volcaniclastic-carbonate deposits, cropping out in the Crepe Rosse cliff, records slope progradation, possibly tectonically controlled, from the shallow-water carbonate Marmolada Massif. The outcrop, furnishes mainly strike cuts of the progradational suite, showing laterally-restricted clinothemes with different hierarchy and reciprocal onlap relationships. Clinothemes show differences in main lithology, bounding surfaces, and geometry of their internal units. Carbonate megabreccia, volcanoclastic and mixed clinothemes stack and interfinger with a variety of mutual relationships. The carbonate megabreccia clinotheme is a thick, laterally continuous carbonate body consisting of large isolated carbonate blocks, thick megabreccias with a range of lateral continuity, thinner and more laterally widespread carbonate breccias; local erosional surfaces define channelized bodies with few-m-sized incisions and small lateral extent. The carbonate megabreccia clinotheme comprises different debris horizons forming units that stack compensationally and become progressively less widespread laterally. The carbonate megabreccia clinotheme is interpreted to record frequent collapses of a relatively large portion of the carbonate margin, resulting in the coalescence of lobes and tongues of debris fed by narrow gullies. The volcaniclastic clinotheme consists mainly of laterally continuous or wedge-shaped units of stratified sandstones and conglomerates, with occasional basal erosional surfaces, and thicker, mainly disorganized, debris-flow deposits; parallel or cross laminated sandstones are rare. The volcaniclastic clinotheme is interpreted to represent a slope apron formed by the deposits of laterally unconfined hyperconcentrated or high-density flows forming low-relief channels and bars within an otherwise relatively featureless seafloor. The mixed clinotheme is composed of units of carbonate debris accumulations onlapped by volcaniclastics. Since the carbonate debris deposits shift along strike in successive units, we interpret the mixed clinotheme to result from punctuated episodes of localized margin collapses forming local relief, successively healed by volcaniclastics. As a whole, we interpret the succession to be indicative of a margin where a carbonate source intermittently overprinted a background volcaniclastic source. We explain the clinotheme and unit variability to reflect changes in the frequency and spacing of repeated relatively small-scale failures and mass-collapses of an upper slope carbonate factory. When failures produced small-scale, laterally-isolated embayments, the mixed clinothemes formed; when failures coalesced laterally, the carbonate clinothemes formed. An autigenic control is envisaged for the development of gravitational instability of the margin with consequent development of margin embayments and local debris body emplacement; an allogenic forcing can be responsible for the overall stacking of successive clinothemes. The combined effects of these controlling processes resulted in a highly complex prograding slope wedge, where marked heterogeneities occur at different hierarchical levels, from single beds to clinothemes.

Instability and Soft-Sediment Deformation of a Triassic Lacustrine Delta, Ordos Basin, Central China

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The Ordos Basin, a vitally important hydrocarbon province in China, accounts for nearly one-third of the total oil and gas output and is famous for its tight sandstone reservoirs. The main reservoirs in the southwest Ordos Basin are located in a lacustrine deltaic system of the Upper Triassic Yanchang Formation. For a long time, this deltaic system was thought to be characterized by shallow-water deltas with lobes amalgamated laterally to form a large delta lobe apron. However, the soft-sediment deformations, which have been found abundantly in this deltaic system, are peripheral in previous research and have never been systematically studied.

In this study, based on detailed measurements and descriptions of core data, the instability of the Upper Triassic deltaic system in the southwest Ordos Basin has been examined. Nine lithofacies associations are identified, including undeformed and deformed channel deposits, sandy and muddy slumps, sandy debrites, sandy dykes, undeformed and deformed fringe silty deposits, and muddy deposits. Quantification of the vertical and horizontal spatial distribution of these sediments reveals the deformed sediments can comprise more than one third of the entire cored interval in more than half of the wells, indicating the significance of soft-sediment deformations as essential components of this deltaic system. A depositional model is constructed, which highlights the location of deformed and remobilized sediments and their relationships with undeformed sediments. In the proximal part, the undeformed and deformed channel deposits and sandy slumps dominate the sandy sediments, which are interbedded to form thick amalgamated sandstones. In areas distant from these massive sandstones, undeformed and deformed fringe fine-grained deposits are well developed, which could generate muddy slumps. In the distal part, besides undeformed and deformed fringe fine-grained deposits, sandy debrites are present as isolated sandbodies. The main trigger mechanism for initial deformation is seismicity. The high percentage of soft-sediment deformations in this delta influences the reservoir heterogeneity of the three main types of sandstones (undeformed channel deposits, sandy slumps and sandy debrites). Porosity-permeability analysis reveals that reservoir quality of these three types varies significantly, and thus distinguishing deformed sediments from undeformed deltaic sediments is essential for hydrocarbon development in this area.

Sediment flux and marine influence on the depositional architecture of marginal marine deposit, Sydney Basin

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The Sydney Basin has a prolific history of geologic activities that took place before sedimentation; characterised by massive faulting impacted by the Lachlan Fold Belt to the southwestern part of the basin and the Hunter Mooki Thrust belt associated with the New England Fold Belt and volcanic activities to the northeastern part of the basin. These geologic activities created a platform that would shape the source of sediment and how much of the sourced sediment is supplied to the basin.

This research work highlights the flux of sediment as well as the marine influence that shaped the depositional architecture of the marginal marine deposit in the basin. This research also rely on the interpretation of over 72 seismic lines (data) on both onshore and offshore Sydney Basin, about 36 well logs, reports on core descriptions as well as organic geochemistry data available to conclude how sediment flux and marine influence played a great role on the depositional architecture of the marginal marine deposit in the basin. This understanding will better enhance our knowledge of the basin and consequently lead to a better prospectivity of the basin.

Keywords: Sediment Flux Marine Depositional Architecture Marginal

Progressive opening of the Oliete bay (Spain) around the Barremian-Aptian transition: facies evolution, controlling factors

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The progressive opening of an Early Cretaceous (late Barremian-earliest Aptian) shallow marine mixed carbonate-siliciclastic bay has been reconstructed through the analysis and correlation of 10 high-resolution logs in the Oliete subbasin. This relatively small (30x30 km wide) subbasin represents the sedimentation in the northwestern margin of the Maestrazgo Basin (NE Spain). The studied stratigraphic series corresponds to the Alacón Formation, which represents the onset of marine conditions in the Oliete subbasin following the deposition of the continental-to-transitional Blesa Formation during the latest Hauterivian-Barremian. Four medium-scale genetic stratigraphic sequences bounded by discontinuities have been recognized, which represent four discrete stages of paleoenvironmental evolution of the bay. The first sequence is characterized by marls, mud-supported limestones and sandstones with low-diversity faunal associations consisting mainly of ostracods, small mollusks, charophytes and occasional dinosaur footprints, evidencing a very shallow restricted bay with variable salinity. The second sequence is defined by shallow marine bioclastic packstones and marls containing the first euhaline marine taxa (echinoderms, green algae). The generally low faunal diversity and frequent monospecific Ceratostreon (Gryphaeidae) accumulations suggest a stressed environment, probably due to salinity oscillations. The third sequence is marked by the stabilization of euhaline conditions, evidenced by faunal diversification and the generalization of endobenthic taxa (Pholadomyidae, Trigoniidae, Thalassinidea). The fourth sequence is characterized by finely bioclastic limestones and sandstones with diverse shallow-water benthic communities, deposited in a shallow marine bay with progressively greater connection with the open marine urgonian-type shallow carbonate platforms developed in the central and eastern Maestrazgo Basin. Metric cross-bedded bioclastic limestone and sandstone levels appear at the top of the fourth sequence in most of the studied sections; they have been interpreted as migrating sand banks developed when a stable seaway connecting the Oliete subbasin to the Maestrazgo basin was established, allowing for widespread sea circulation and tidal currents.

Keywords: Barremian, Iberian Basin.

Formation and provenance of Jurassic sedimentary mélanges in the Circum-Pannonian orogens (Western Tethys)

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Component analyses of ancient Neo-Tethys mélanges along the Eastern Mediterranean mountain ranges allow both, a facies reconstruction of the Middle Triassic to Middle Jurassic outer passive margin of the Neo-Tethys and conclusions on the processes and timing of the Jurassic orogenesis. This Middle-Late Jurassic mountain building process in the Western Tethyan realm was triggered by west- to northwestward-directed ophiolite obduction onto the former western/northwestern passive continental margin (wider Adriatic plate) of the Neo-Tethys Ocean.

Ophiolite obduction onto the former passive continental margin started in the Bajocian and trench-like deep-water foreland basins formed in sequence within the northwest-/westward propagating nappe fronts in the footwall of the obducting ophiolites. Deposition in these basins was characterized by coarsening-upward cycles, i.e. forming sedimentary mélanges as synorogenic sediments, in cases tectonically overprinted and incorporated in the nappe stack. In the Middle Jurassic (Bajocian to Callovian), the oceanic realm and the most distal parts of the former passive margin were incorporated into the nappe stacking. The Bajocian-Callovian ophiolitic and Meliata mélanges were formed as most oceanward preserved relics of trench-like basins in front of the propagating obducting ophiolitic nappe stack, often with tectonically incorporated components from the continental slope. In the course of ongoing ophiolite obduction, thrusting progressed to the outer shelf region (Hallstatt Limestone facies zone). In Bathonian/Callovian to Early Oxfordian times the Hallstatt nappes with the Hallstatt mélanges were established, expressed by the formation of the up to 900 m thick basin fills comprising its material mainly from the outer open-marine shelf region. In Callovian to Middle Oxfordian times the nappe stack reached the former carbonate platform influenced outer shelf region and the reef rim of the Triassic platform configuration. Newly formed basins received material from this ancient shelf region, occasionally mixed with material from the approaching ophiolite nappes. Ongoing shortening led to the formation of the proximal Hallstatt nappes/reef rim with concomitant mobilisation of Hallstatt Mélanges. Persistent tectonic convergence caused the partial detachment and northwest- to west-directed transport of the older basin groups and nappes originally formed in a more oceanward position onto the foreland.

Comparison of mélanges identical in age and component spectrum in different mountain belts (Eastern Alps/Western Carpathians/Dinarides/Albanides/Pelso) figured out one Neo-Tethys Ocean in the Western Tethyan realm, instead of multi-ocean and multi-continent scenarios. The evolution of several independent Triassic-Jurassic oceans is unlikely considering the fact that re-sedimentation into newly formed trench-like basins in front of a west- to northwestward propagating nappe stack including ophiolite obduction is nearly contemporaneous along the Neotethyan Belt. The Middle to Late Jurassic basin evolutions with their sedimentary cycles and component spectra are comparable everywhere.

Late Jurassic Carbonate Platform formed on top of the obducted Dinaridic ophiolites (southwestern Serbia)

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The actual controversial discussions about the provenance and the tectonic interpretation of the Dinaridic-Hellenic ophiolites show that a large number of data from all the sedimentary rocks which are in contact with the ophiolites is still needed. However, by mélange analysis and age dating of the metamorphic soles it becomes clear that the closure of the western part of the Neo-Tethys Ocean started around the Early/Middle Jurassic boundary and west- to northwestward-directed ophiolite obduction onto the wider Adriatic shelf started in Middle Jurassic times. Propagating ophiolite obduction led to the formation of a nappe stack in lower (wider Adriatic plate) plate position in front of the obducting ophiolitic nappe stack. Formation of a Late Jurassic carbonate platform started around the Oxfordian/Kimmeridgian boundary on top of the obducted ophiolites and nappe fronts representing the sealing sequence in a period of relative tectonic quiescence. Mountain uplift from the Kimmeridgian/Tithonian boundary onwards caused the partly erosion of the platform on top of the ophiolitic nappe stack and the underlying ophiolites. Tithonian carbonate turbidites in a deep-water foreland basin in southwestern Serbia below overthrust ophiolites contain Kimmeridgian-Tithonian shallow-water clasts together with Triassic open marine clasts and chrome spinels of a harzburgitic source (suprasubduction and MOR ophiolites). Our results constrain a Middle to Late Jurassic orogeny in the Western Tethys realm triggered by Bajocian to Oxfordian ophiolite obduction and subsequent formation of a Kimmeridgian-Tithonian carbonate platform on top of the obducted ophiolites. The detection of a Late Jurassic carbonate platform formed above of the Dinaridic ophiolites close an important gap in knowledge about the geodynamic evolution of the Inner Dinarides and confirm Middle to early Late Jurassic and not Late Jurassic to Early Cretaceous ophiolite obduction in the Dinarides. From the Tithonian onwards the ophiolites with its overlying platform became uplifted and partly eroded. Mountain uplift triggered unroofing and further west-directed gliding transport of the nappe stack including the obducted ophiolites along low-angle plains near to its present position in the Dinarides as proven by our new results from component analysis of Tithonian carbonate turbidites. The Jurassic geodynamic evolution of the Inner Dinarides is very well comparable with other mountain ranges (Eastern and Southern Alps, Western Carpathians, Albanides-Hellenides) in the eastern Mediterranean orogens: Middle to Early Late Jurassic ophiolite obduction and formation of a thin-skinned orogen in lower plate position, a Kimmeridgian-Tithonian shallow-water evolution with formation of platforms also on top of obducted ophiolites, and mountain uplift from the latest Jurassic onwards with subsequent west-directed transport of the nappes is time-equivalent everywhere, but best preserved in the Inner Dinarides. The Inner Dinarides were located relatively in the central part of the Jurassic orogen, named Neotethyan Belt, and their evolution clearly proves the one one-ocean model rather than a multi-ocean concept also for the Dinarides.

Morphodymanics of a meander during an extreme flood: an example from powder river (Montana, USA)

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Effects of large-scale floods include deepening and/or widening of river channels, lateral shifts of river bends and development of erosional- bypass surfaces in point-bar deposits. Although understanding of hydrology and morphodynamic processes associated with large scale floods recently improved following significant advances of modern technologies, our knowledge on exceptional flood deposits is still poor, and a clear link between flood discharge and in-channel sedimentation processes still needs to be established. The meandering Powder River (Montana, USA) is a perfect natural environment to investigate connections between flood discharge and point-bar sedimentation processes, being the river not affected by any human modification. Additionally, a large amount of high-resolution hydrological and geomorphological data is available for Powder River since 1977. Powder River originates in the Big Horn Mountains (Wyoming) and flows northward through Wyoming and Montana, drains an area of 34.706 km2 in a cold semi-arid climate with an annual average discharge of ~12.7 m3/sec. Powder River transports a range of particle sizes spanning from gravels and sand to silts and mud. We focus here on point-bar deposits resulting from a 50-year recurrence flood which had an instantaneous peak discharge of 930 m3 /sec. This flood was caused by snowmelt and lasted about 14 days in May 1978.

At this site, this flood caused ~70 m of outer bank retreat, and a similar accretion of the inner bank, with accumulation of a large volume of point bar deposits. In September 2018, a trench (up to 2 m deep and 70 m long), was excavated through the axial point-bar deposits, and the 1978 flood deposits were detected based on georeferenced pre- and post-flood surveys. Flood deposits consists of well-stratified sand and gravels and record internal changes in growth pattern and stratal architecture, which allowed to define different bar growth stages, which were associated with increasing and decreasing of flood-flow discharge. Sedimentological evidence for changes of flood-flow discharge include: i) changes of sediment grain size; ii) changes in thickness of cross strata; iii) variations in paleoflow patterns; iv) development of different bedforms and v) development of different vertical grain size patterns.

The influence of topography on subaqueous sediment gravity flows and degrees of confinement

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Subaqueous sediment gravity flows experience modifications when they interact with slope and basin floor topography, impacting facies, geometries and architectural patterns. Understanding these processes is critical for reservoir quality and trap predictions as deep water stratigraphic plays gain attention.

A literature summary of the topographic influence on subaqueous gravity flows, a new classification scheme on degree of confinement and an interpretation applied to the basin floor turbidite system of the late synrift Los Molles Fm. in the Neuquen Basin are provided.

About 70 articles were used to compile signals of the sediment gravity flows to topography interaction process. In the study area, a high resolution satellite image, drone imagery and 30 logs (5000 m of deposits) were measured, with focus placed on facies analysis, palaeocurrents, bed thicknesses and large scale thickness variations.

Studies describing topography confinement of sediment gravity flows have used five approaches. (1) Palaeocurrent analysis: palaeocurrents following structural trends and variations within the same bed (flow deflection and reflection). (2) Small-scale (dc-m) thickness variations: beds thickening towards topography, beds thinning on top of the topography (onlaps), and low thinning rates (flow stripping). (3) Large-scale thickness (tens of meters) variations: increased fan system thickness across topographic lows. (4) Architectural analysis: aggradational stacking, lateral stacking away from barriers, and fill and spill successions. (5) Facies analysis: increase number of hybrid beds and debrites near barriers (flow transformation), loading, convoluted structures and oscillatory ripples (flow reflection), and couplets sand – mud or thick mudcaps (flow ponding).

A classification scheme on degree of confinement is proposed. Unconfined: no evidences present. Weakly confined: regional palaeocurrent variations, minor thickness variations against small relief barriers, large scale thickness variations. Confined: onlaps against high relief barriers. Highly confined: palaeocurrent variations on the same bed, bed thickening against topography, facies evidencing flow reflection, increased number of hybrid beds, aggradational stacking and tabular beds. Ponded: couplets sand – mud or thick mudcaps. Higher confinement categories might have indicators from the weaker confinement categories.

The Los Molles Fm. turbidite system is classified as weakly confined. A complex sediment routing followed structural trends inherited from the rift. The basin floor had irregularities that led to preferred sites of deposition. Hybrid beds are mostly found at the fringes of the lower part of the succession and might be associated with an above grade slope profile on a footwall scarp. Lastly, beds present low thinning rates (average 1.5 m/km) and the system stacks compensationally, pointing to null interaction against basin margins.

Sedimentary response of lacustrine environments to temporal changes in sediment supply after explosive volcanic eruptions

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Understanding of depositional processes in the subaqueous environments after explosive volcanic eruptions are relatively scarce owing to difficulties to directly observe the processes. We studied the resedimented volcaniclastic deposits in the lacustrine sediments to unravel detailed physical depositional processes when volcaniclastic sediments meet the lacustrine environments after explosive eruptions. The Cretaceous Beolgeumri Formation is the lacustrine volcano-sedimentary successions. We investigated about 50 m thick, resedimented volcaniclastic sediment succession, which exhibit vertical changes depositional features. The base of the succession is represented by more than 25 m thick, welded lapilli tuff (pyroclastic density current deposits), overlain by the laterally extensive bedded chert. The bedded chert is overlain by inverse to normally graded volcaniclastic sandstones (hyperpycnal flow deposits) and massive volcaniclastic gravelly sandstones (debris flow deposits) showing a coarsening upward trend and progradational geometry. These sandstones are overlain by multiple sheet-like beds of normally graded volcaniclastic (gravelly) sandstones (surge-like turbidity current deposits) with fining-upward trends. These volcaniclastic sediments are finally covered by laminated mudstones formed by settling of suspended sediments in the lake. After explosive volcanic eruptions forming the basal welded lapilli tuff, the drainage basins of the lakes would be covered by co-ignimbrite ash, and frequent subaerial floods carried large amounts of eruptive materials to the lake with the formation of delta at its margin. The progradation of delta resulted in accumulation of volcaniclastic sediments showing a coarsening-upward trend and progradational geometry. The above normally graded volcaniclastic sediments with showing fining-upward trends reflect a gradual decrease in volcaniclastic sediment supply, interpreted as a result of a decrease in available volcaniclastic sediments and recovery of vegetation in the drainage basin. The topmost laminated mudstones are suggestive of supply of the volcaniclastic sediments returning to pre-eruptive state. This study shows that disturbed and subsequent recovery of drainage basins after the explosive volcanic eruptions played major roles on accumulation of the volcaniclastic sediments in the lacustrine environments.

Sedimentary architecture of the Middle Ordovician Hawaz Formation in the Murzuq basin (Libya)

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The Middle Ordovician Hawaz Formation is a siliciclastic lithostratigraphic unit well represented in the north-central part of the Murzuq basin (SW Libya), which appears to extend for hundreds of kilometres across the Saharan Platform. It constitutes a proven oil-bearing reservoir within the Ordovician-Silurian petroleum system in the Murzuq basin.

The present-day architecture and distribution of the Hawaz Formation bear little relation to its original configuration and depositional profile during the Middle Ordovician, when deposition occurred in a marginal to shallow marine environment over a continuous, areally extensive, very low gradient cratonic margin characterizing the northern margin of Gondwana. During the subsequent Upper Ordovician Hirnantian Glaciation, a series of icesheets often greatly truncated the Hawaz succession leaving a characteristic relief of paleohighs and paleovalleys which were partially infilled later by periglacial and subglacial clastic deposits, and then sealed by a thick succession of shales of the Silurian Tanezzuft Formation.

The Hawaz succession was deposited during Darriwilian to Sandbian Stages of the Middle Ordovician and facies distribution patterns were tightly linked to relative sea level fluctuations. Tidally-influenced facies belts dominated during transgressive stages whereas tide- and wave-dominated facies belts prevailed during high stand stages in an overall global greenhouse period. Seven facies associations were identified including, from proximal to distal, sandy tidal flat, subtidal bar and dune complexes, abandoned subtidal complexes, middle to lower shoreface, burrowed shelfal and lower shoreface, burrowed inner shelf and shelfal storm sheet deposits. These facies associations have been proven to form laterally extensive correlatable facies belts extending for tens to hundreds of kilometres over the area of study and probably further across the Saharan craton. Their extension and distribution can be linked to a genetic stratigraphic framework of three main depositional sequences and their respective systems tracts, which form the basis for a sequence-stratigraphic zonation supported by both petrophysical and reservoir quality properties.

By making use of an extensive and diverse subsurface dataset, a series of stratigraphic correlation panels were created to clarify possible facies lateral changes, together with paleogeographic gross depositional environment maps in order to infer the spatial distribution of facies across and down depositional dip within the study area in an apparently layer cake succession.

The results of this study suggest that the Hawaz Formation was deposited in a non-linear, relatively protected or embayed shoreline with multiple bays/estuaries most likely influenced by the subtle effects of pre-existing north-northwest to south-southeast Pan-African structures controlling accommodation space and reactivated during Ordovician times. The main sediment entry points are represented by fluvio-tidal to subtidal bar and dune complexes during transgressive stages (TST), whereas interbay sub-environments appear to be represented by extensive burrowed sand-prone tidal flats. In contrast, burrowed shelf to shoreface deposits prevailed during periods of relative high sea level (HST) offshore, whilst prograding tidal flat deposits dominated the most proximal zones of the system, covering a significant extension of the study area.

Mass transport deposits (MTDs) in a shallow-marine succession of the Dinaric Foreland Basin

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Mass transport deposits (MTDs) are common in relatively deep and tectonically active settings and represent distinct “events” in the development of a sedimentary basin. The present study from the Dinaric Foreland Basin documents a rare example of a 300 m thick shallow-marine succession characterised by about 50 MTD units interbedded with calcilutites and calcarenites of the offshore and offshore transition zone. The succession crops out in the vicinity of Novigrad in northern Dalmatia, Croatia, and represents the infill of a sub-basin that developed in the wedge-top part of the evolving foreland during the Middle Eocene to Early Oligocene (Ćosović et al., 2018).

Four types of MTDs, ranging in thickness from 20 cm to 600 cm and extending for more than 600 m have been identified: (1) slumped offshore and offshore transition strata, commonly displaying convoluted bedding and signs of sediment torsion; (2) slides comprising blocks of clast supported beachface conglomerates and/or bioturbated shoreface calcarenites encased in offshore strata; (3) blocky-flow deposits comprising matrix-supported conglomerates with large blocks of deformed shoreface and/or offshore transition strata; and (4) debrites comprising massive, matrix-supported conglomerates. Large calcarenite and/or conglomerate blocks in MTD types 2 and 3 were incorporated as consolidated blocks into the mass transport, suggesting significant erosion of older units.

The study succession shows several transgressive-regressive cycles and progressive deepening of the sedimentary basin with an accompanying increase in MTD incidence, especially of types 2–4. Small-scale slumps of type 1 occur throughout the succession and commonly within transgressive offshore deposits. Where parasequences can be recognised, other types of MTDs tend to be associated with regressive offshore transition and offshore deposits. Relative sea-level fluctuations probably stemmed from non-synchronous uplift and subsidence of neighbouring blind thrust anticlines, possibly leading to coeval transgressions and regressions on opposite limbs of the same synclinal sub-basin (Mrinjek et al., 2012; Ćosović et al., 2018). The multitude of MTDs in the uppermost part of the succession was likely favoured by basin floor steepening associated with increasingly frequent uplift pulses, possible emergence and erosion of the basin bounding growth anticline. Contrarily, basin deepening and ramp extension during transgressive stages could have favoured mass-flow transformations. A generic relationship between relative basin depth and MTD type is suggested, whereby slides would be indicative of a somewhat shallower environment compared to blocky flow deposits and debrites. Such alternation of various types of MTDs in a shallow-marine succession attests the colossal power of syn-sedimentary tectonics during basin development and may give a clue on small scale transgressive regressive cycles when flooding surfaces and/or correlative conformities cannot be readily identified.

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Sustained flows and their deposits in the deep-marine Cergowa Beds (Outer Carpathians, Oligocene)

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The Cergowa Beds form an elongated lenticular lithosome within a succession of the bituminous Menilite Beds (the Outer Carpathians, Oligocene). The lithosome consists of two main lithofacies: sandstones in the axial part and sandstones interbedded with mudstones at the margins. The Cergowa Beds are interpreted as a submarine fan and as an infill of the slope troughs in the confined tectonically partitioned synorogenic deep-marine basin. The clastic material was derived from the Silesian Ridge elevated to the NW of the depository. The Cergowa Beds were deposited from diverse types of sediment density flows, and their characteristic feature is the abundance of coalified plant detritus, even fragments of tree trunks. Detailed sedimentological bed by bed logging was conducted at three localities in Poland: Skrzydlna in the NW, Lipowica and Żubracze in the axial part and at one locality in Slovakia: near Snina in the SE.

In general, two types of sediment density flows are distinguished considering flow duration: (i) relatively short-lived unsteady flows (losing energy with time); (ii) sustained steady or quasi-steady flows. Several features of the Cergowa Beds indicate deposition from the sustained flows, namely: A – dune-scale cross-bedded sandstones resulting from deposition of dunes, B – extraordinarily thick-bedded massive or graded sandstones (up to 8m), C – grain size fluctuations in the vertical section of individual beds, D – frequent admixtures of coarser detritus, up to fine pebbles, in generally fine-grained sandstone, E – intercalations of parallel or low-angle cross-lamination within massive or graded sandstone; F – aligned intraclasts within massive or graded sandstone, G – intra-bed scours. The features D through G are often laterally discontinuous.

Dunes (A) require sustained flow to be generated. Sandstones (B) are deposited from long-lasting aggrading flows with high suspended load. Variations of grain size in general (C) and varying admixture of coarser material (D) within bed may reflect competence fluctuations of a sustained quasi-steady flow. Features E and F are the result of traction and together with the intra-bed scours (G) show temporary and local energy variations within the individual flow. Intercalations of traction-related structures within the suspension-deposited intervals result from intermittent decrease of the fallout rate during single, long-lasting flow.

The co-occurrence of these features with abundance of plant fragments suggests deposition from sustained quasi-steady "pulsating" flows characterised by frequent energy changes in time and space generated as hyperpycnal effluents. Significant input of such hyperpycnal flows in the slope troughs and at the mouths of the submarine fan channels implies direct supply from the shelf fringing the source area, including shelf-edge deltas.

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A comparison of channel morphologies, architectures, and population densities between trajectory regimes and climate states

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Differences in channel morphologies, architectures, and population densities between trajectory regimes and climate states remain poorly constrained, and are highlighted by a global sampling of 142 submarine channels. From the perspective of channel kinematics, turbidite channels exhibit lateral – random – vertical trajectories or persistent alongslope trajectories, whereas contourite channels display persistent upslope trajectories, assisting in obtaining a complete picture of channel kinematics. Turbidite channels tend to be thick and narrow; and have 2–3 times more lateral migration, whereas contourite channels tend to be thin and wide and have 2–3 times more vertical accretion. We relate such difference in channel morphologies and architectures between different trajectory regimes to the density contrast in flow and ambient fluid between contourite and turbidite channels, which would have favored lateral channel migration in turbidite channels but channel thalweg deposition in contourite channels. From the perspective of climate states, greenhouse channels represent the minority in channel family (8%) and display low amplitudes of morphological and architectural variations, whereas their icehouse counterparts represent the majority in channel family (92%) and exhibit high amplitudes of morphological and architectural variations. We ascribe such differences in channel stratigraphy and publication densities between different climate states to the contrast in sea-level behavior between greenhouse vs. icehouse settings, which were directly coupled to less frequent and more diluted turbidity current activity during greenhouse periods but vice versa in icehouse settings.

Carbonate precipitates in cellars: a specific product of human-modified environment

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Carbonate precipitates known under the term speleothems that originate in caves have been extensively studied in recent years. Conversely, their analogues that form in artificial underground spaces, such as cellars, mines and tunnels as well as under constructions such as bridges have received relatively less attention. This study is focused on precipitates that are being formed in an abandoned wine cellars in the village of Frydman, Poland. The aim of the study is to unravel the process responsible for their formation.

The cellars were constructed in the early 19th century. They consist of two storeys, each of them has three tunnels reaching 100 m in length and maximal height of 4 m. Their ceilings and walls are constructed of sandstone blocks, bricks and granite cobbles laid using a lime mortar.

Carbonate precipitates occur on the ceilings, walls and floors of the cellars. They have a form of stalactites, draperies and stalagmites which are white, beige to grey in colour. The stalactite length reaches 40 cm whereas the stalagmite height a dozen centimetres. The lower storey contains definitely more stalactites and stalagmites than the upper storey. Precipitates are composed of calcite that display fan, columnar or microcrystalline fabrics. Thus their internal structures are akin to those of speleothems. They are characterized by extremely low values of both δ13C (–34.6‰ to –30.6‰) and δ18O (–23.4‰ to –21.9‰). This resulted from strong isotope fractionation leading to depletions of precipitated calcite.

The studied precipitates grow faster than speleothems do. A limestone tablet installed on the cellar floor was covered with a 1.8 mm thick calcite layer during one year. The growth rate was as high as 0.171 mg/cm2/day.

Growing forms are fed by thin film of water analogously to speleothems. However, the water is highly alkaline (pH >9) and contains up to >1400 mg/l of Ca. Both pH and total dissolved solids are higher in water in the lower storey than in the upper one, which corresponds to the distribution of precipitates. The difference may result from different building material or, most probably, from higher residence time of water dripping in the lower storey. The water composition is governed by high solubility of a lime mortar which contains soluble calcium hydroxide.

High growth rate, hyperalkaline type of feeding water and extremely low values of stable isotope ratio collectively prove that the growth of the studied precipitates is controlled by absorption of CO2 from the atmosphere by the solution. This process is quite opposite to that governing growth of speleothems. Thus, the studied precipitates in spite of their shape and structural similarity to speleothems, originate in a different way. Although they have some genetic counterparts in natural environment (e.g., travertine fed with water draining ultramafic rocks), they are typical of human-modified environment. Thus, they can deserve to be classified under the name 'anthropothems' (anthropo – related to humankind, thema – deposits), the term similar to 'speleothems' coined by Moore (1952).

Moore, G.W., 1952. Natl. Spel. Soc. News, 12, 6: 7.

Recognition of inundite deposits in shallow-marine clastics: towards a facies model

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A comprehensive sedimentological study was undertaken of exceptionally fossiliferous Ediacaran strata comprising a peripheral foreland basin in the northeast of the East European Platform (Russia), with the aim to constrain habitat environment and burial history of the Earth's oldest macroscopic organisms. Without this Lagerstätte, we would never have known the age of the oldest bilaterians, found the oldest evidence of motility, and discovered fossil-specific biomarkers; however, the habitat and burial conditions of this celebrated fossil biota remain elusive. Fieldwork analyses based on a continuous White Sea coastal cliff exposure in the Winter Mountains allowed a provisional identification of two depositional systems: wave dominated prodelta passing into distal delta-plain, both demonstrating strong influence of sustained turbulent flows. Interestingly, there is a sharp reversal in progradation and sediment dispersal trend between the prodelta and the overlying delta plain depositional systems suggesting changes in hydrodynamic process dominance as a result of the foreland basin evolution. The prodelta depositional system is characterised by isolated sandstone gutter casts, 0.3–0.4 m thick, with steep and overhanging sides, all aligned along the same direction. Gutter casts are thought to be a diagnostic feature of tempestites, specifically the bypass-zone of high-velocity, sediment-laden near-bottom water motions produced by storms. Other than that, there is no unequivocal evidence of storms and storm deposits in the sedimentary succession. The gutter casts are here re-interpreted as a product of buoyancy reversal of inundated flows of river-flood origin. A plunging dense flow is expected to accelerate and erode deep gutters in the underlying fine-grained sediment. As the gutters become immediately cast by coarser sediment, a partial discharge of the suspended load results in a decrease of the bulk flow density and a reversal of the buoyancy leading to a lofting of the flow. The delta-plain depositional system is characterised by isolated channelised sandstone packages, up to 1.8 m thick. Each package comprises planar-laminated sandstones infilling deep (up to 0.4 m) erosional scours (occasionally with accumulations of flat mud pebbles), followed by sandstones with unidirectional multi-storied cross-lamination. Importantly, the planar- and cross-laminated sandstones interstratify with wave-rippled sandstones suggesting a complete ceasing and subsequent rejuvenation of the unidirectional flow. In previous studies the channel casts were interpreted as distributary channels of fluvial origin. Careful re-examination of the channel-hosting sediment suggests that it is an intertidal depositional system. The channel casts are here re-interpreted as traction deposits (sediment fallout) associated with strong unidirectional inundated flows of river-flood origin in shallow-water environments dominated by weak oscillatory flows. The channel and gutter casts can be described in terms of clastic facies associated with hyperpycnal systems (Zavala et al. 2011), specifically the facies related to the collapse of suspended load in a subaqueous setting. With this information in hand, the sedimentary environments and facies of the fossil Lagerstätte can now be re-considered. Indeed, the prodelta and distal delta-plane depositional systems could represent subtidal to intertidal sediments with strong influence by river floods. The study is supported by Russian Foundation for Basic Research grant 19-05-00927.

Lateral accretion of a stromatolitic reef by means of subhorisontal growth of stromatolite columns

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Stromatolites defined as ‘an attached, laminated, lithified sedimentary growth structure, accretionary away from a point or limited surface of initiation’ were capable of building reefs that occupied a variety of niches, similar to their younger counterparts: major barrier reefs adjacent to large seaways, patch reefs and pinnacle reefs located on gentle ramps facing open seaways, and even downslope bioherms that grew entirely within a deeper, quieter-water setting. Stromatolitic reefs could grow from deeper, quiet water settings upwards into the shallow zone of continual wave agitation to resist and continue growth in the zone of wave action and expand laterally to significant sizes so as to influence their surroundings by affecting circulation, salinity, and sediment production. Although Proterozoic stromatolitic reefs possess all the properties of true ecologic reefs, their basic frame-building constituent remains elusive (Grotziner & James 2000). I have addressed this question by studying a stromatolitic reef of the upper Tonian (<720 Ma) Uk Formation in one of the most complete and well exposed sections near the town of Ust-Katav (South Urals, Russia). Most notable are inclined and subhorizontal stromatolite columns, all growing in the same direction, that constitute asymmetric bioherms, with a steep nearly vertical side and a more gently sloping side. A comprehensive sedimentological study of this stromatolitic reef was undertaken with the aim to identify carbonate microfacies and reconstruct the architecture of the complex. I suggest that (1) the inclined and subhorizontal stromatolite columns in the Uk Formation have formed on a steep slope of a carbonate platform margin; (2) the Uk Formation in the section near Ust-Katav comprises a series of clinoforms with a relatively steep angle of progradation; and (3) each clinoform represents a parasequence consisting of distal fore-reef grainstones, proximal fore-reef grapestones, and stromatolite boundstone. The proximal fore-reef grapestones consist of aggregate grains, – micritised ooids, peloids, stromatolite clasts, and other grains bound together by carbonate cements, and coated by thin finely laminated, presumably microbially mediated micrite. There are a number of hypotheses about the controls on aggregate grains formation, each requiring that periods of bottom mobility alternate with periods of bottom stability (grapestone sites have been traditionally regarded as areas of nondeposition or at least reduced deposition). I argue that mechanism of the aggregate grain formation is dominantly abiotic and the loci of aggregation are determined by both carbonate saturation and sediment transport mode; abrasion seems to play an important role in the aggregate grain genesis. The distal fore-reef grainstones are characterised by the ubiquitous molar tooth structure, which is indicative of early carbonate lithification. The reef itself grew by lateral accretion manifested in the inclined and subhorizontal increment of individual stromatolite columns. The stromatolite columns consist of highly discontinuous laminae, consistent with an origin by sediment precipitation (as opposed to sediment binding). I interpret growth of the stromatolites to have been dominated by chemogenic precipitation in response to an increase in calcium carbonate saturation of surface seawater. The study is supported by Russian Foundation for Basic Research grant 18-05-00062.

Sequence stratigraphy of the Cretaceous Arabian platform: data based guide lines for conceptual models?

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An extensive carbonate platform covered the Arabian plate during the Cretaceous period. The combination of field work and seismic interpretation results in a multiscale reconstruction of the sequence stratigraphic organization of this carbonate system combining facies distribution and stratal geometries. This reconstruction provides several points that could be relevant for carbonate sequence stratigraphy conceptual models. After a tectonically controlled exposure followed by the re-flooding of the platform during Late Tithonian, the Early Cretaceous carbonate systems were organized in successive prograding wedges without any major backstep nor drowning events disrupting the northward migration of the platform margin. The carbonate production was always equal or higher than the accommodation rate and this ratio was responsible for distinctive types of clinoforms. Eustatic sea level variations are clearly recorded from the architecture of these clinoforms, particularly the high amplitude ones, during the Berriasian and Valanginian (80 to 120 m). Several generations of intrashelf basins and shallow troughs were created as a consequence of differential carbonate aggradation processes during periods of highest accommodation rate. The tectonic imprint on these stratigraphic structures is minor if not absent. Anoxic conditions in these basins favored the preservation of organic-rich deposits. In such a carbonate system, most of the argillaceous facies intercalated within the carbonates are shallow marine inner platform deposits, even those containing some pelagic fauna. The shales come from exposed area (e.g. Arabian shield) and disappear towards the platform margin. Numerous stratigraphic and paleogeographic misinterpretations are due to the occurrence of these argillaceous deposits that are classically considered as deep marine deposits indicating maximum flooding stages. The inner platform deposits are extremely tabular and organized in thickening-up and “grainy-up” sequences that should not be interpreted as shallowing-up sequences but as the response to a progressive increase of the accommodation rate on the platform top. During maximum flooding periods, the increase of hydrodynamic processes on the inner platform domain is responsible for a tidal bar and channel complex of grainy composition that constitute the upper part of the sequences. Numerous exposure surfaces bound these shallow marine sequences but are not conspicuous as karstic features did not extensively develop on this very flat and stable platform. Karsts generally developed during periods and in areas affected by structural deformation, particularly at the top of the Cretaceous platform at the time of incipient compressive movements. The high-energy facies that characterize platform margin settings are mainly made up of oolitic-bioclastic grainstone, or occasionally corals, stromatoporoïd and microbial boundstone. Rudist biostromes are found in back-barrier settings, but no rudist build-ups have been observed at outcrop in Early Cretaceous to Turonian platform margin setting, despite they have been interpreted (or misinterpreted?) on some seismic sections. Carbonate gravity-driven sedimentation occurred when the clinoforms were the steepest, i.e. when the aggradation rate of the platform, therefore the accommodation rate, was maximum. Tectonic deformations only had a major impact at the times of platform initiation and demise: Late Tithonian, Late Aptian and Turonian.

Preservation and completeness of meandering rivers deposits: insights from numerical simulations

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Assessing the contribution of geomorphic processes to the (non-)preservation of sedimentary deposits is necessary to account for potential distortion of measured accumulation rates in the stratigraphic record. In this study, a series of numerical simulations of fluvial meandering successions is performed using the FLUMY software by focusing on different styles of river mobility, namely lateral migration/erosion and avulsion. The goal is thus to measure how varying rates of aggradation and lateral migration, and frequency of avulsions impact the preservation and completeness (C) of sedimentary deposits. Resulting completeness maps show contrasted distribution depending on these forcing parameters. As first-order assessments, we develop tools to measure non-deposition (stasis S) and reworking (R) of previously deposited sediment in between iterations. We find that these metrics can be used to approximate the average completeness along 2D geological sections using C = [1-S] [1-R]. A rough inverse relation between completeness and channelized deposit fraction is also suggested, although it is modulated by aggradation rate type. Finally, results suggest that the synthetic stratigraphy is built following a Brownian motion with uncorrelated positive and negative jumps, the former being mostly driven by compensational stacking (related to avulsion) and the latter by lateral channel migration. These results may potentially be of use to estimate completeness in the field.

Syn-rift siliciclastic shallow marine depositional environments: a tectonostratigraphic evolution (Mid-Norway, Middle Jurassic to Lower Cretaceous)

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Tectonostratigraphic evolution during syn-rift period highlights the implication of multiple factors during the deposition of shallow marine siliciclastic environments. In order to decipher the distribution of sedimentary environments related to tectonics, paleoreliefs or eustatic sea-level changes, seismic and well-log data interpretations as well as facies description of available cores were combined. Eleven sedimentary facies in the Vingleia fault complex (Southern part of the Halten Terrace located offshore Mid-Norway) have been identified based on the description of almost half a kilometer of cores highlighting two main depositional environments. The first depositional environment is interpreted as wave-dominated shoreface to foreshore environment and the second is interpreted as coarse-grained delta environment that can be sub-divided in two sub-environments. Muddy to sandy facies have been recognized as characterizing prodelta environment whereas coarse-grained sandstone to grain-supported conglomerate facies corresponding to delta front environment. In parallel, seven stratigraphic sequences have been identified with the recognition of sequence boundaries and maximum flooding surfaces both from Gamma-Ray logs and sedimentary cores. These sequences have been dated using dinocyst assemblages resulting in a good time-constrain. Moreover, the interpretation of a 635 km2 of 3D seismic survey has resulted in a set of key surfaces and faults. A detailed structural map has been produced, clearly highlighting relay ramp systems acting as sediment entry points. Evolution of shallow marine syn-rift siliciclastic environments is controlled by multiple factors for instance tectonic activities, sea level variations and pre-existing paleo-topographies. On the one hand, coarse-grained delta deposits are located in the hanging wall of active major faults. Relay ramps act as sediment feeders for these delta deposits. The steepness and the distance of the sediment source will impact on subaqueous sedimentary density flows (SSDF) deposits. SSDF deposits are composed of a continuum of density flow types caused by flow velocity fluctuations. Hyperconcentrated flow and turbidity flow deposits are two kinds of SSDF deposits present in delta front and prodelta respectively. On the other hand, when faults are minor or less active and when topography is smoother, near-shore environments will develop. Sea level rise coupled with pre-existing paleo-topography will contribute to increase the accommodation space available in order for the shoreline to backstep alongside of the hanging wall of the active major faults.

Abandonment and Rapid Infilling of a Tide-Dominated Distributary Channel in the Mekong River Delta

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The ancient tide-dominated Ba Lai distributary channel of the Mekong River Delta was abandoned and infilled in geologically recent times, providing a unique opportunity to investigate the sedimentary infill, timing, and mechanisms of channel abandonment in tide-dominated deltaic systems. Based on four new sediment cores, we show that the channel was active and connected to the deltaic network since at least 2.6 ka, whereas abandonment occurred at 0.7 ka as marked by the abrupt disappearance of the sand fraction and increase in organic matter as well as accumulation rates. The active channel aggraded at a rate of a few millimeters per year, whereas the abandoned channel was infilled by tidal currents at rates of centimeters to decimeters per year. We suggest that the channel was abandoned due to an increase in regional sediment supply in the delta and its upstream basin, which was likely caused by allogenic rather than autogenic factors, such as climate change and/or human impact. We remark that examples of abandoned tide-dominated deltaic channels are scarce in nature and that the mechanisms responsible for abandonment and infilling of these channels do not entirely fit models developed for fluvial environments.

Geometric and paleoenvironmental reconstruction of discontinuous carbonates: relevance of statistical approach to quantitative microfacies data

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The main goal of this research is the geometric and paleoenvironmental reconstruction of a Middle Triassic buildup cropping out in the central part of the Southern Apennines. Middle Triassic reefs of the western Tethys realm in the Northern and Southern Alps are well known. In contrast, there are few studies of the Anisian-Ladinian carbonate platforms of the southern Apennines due to the tectonic disruption and diagenetic alteration that hinder their paleoenvironmental and stratigraphic reconstruction. In an attempt to fill this gap, and to improve the knowledge on the Anisian – Ladinian carbonates of central Mediterranean area, this research is focused on a carbonate buildup cropping out in the "La Cerchiara" succession, Sasso di Castalda (Basilicata, Southern Italy). This buildup, disrupted in four units by intense tectonic deformation associated with the development of the Apennine thrust and fold belt, was studied using quantitative microfacies analyses with a statistical approach. The methodology enabled the reconstruction of the original geometric-stratigraphic relationships of the various buildup fragments and the distal to upper slope facies. The allochthonous fabrics (packstone/wackestone) at the base of the section (Unit IIIa) pass gradually upward into autochthonous (boundstones) facies (Units IIIb, I), consisting of microbialites (clotted peloidal micrite, stromatolitic laminae and aphanitic micrite), microproblematica and cyanobacterial crusts, with few encrusting skeletal organisms.

The statistical evaluation of the quantitative data confirms a linear trend from detrital to autochthonous carbonate. The positive linear regression of the sample positions vs quantitative amount of autochthonous constituents toward the top of the succession, and the negative linear regression of sample positions vs detrital constituents supports this hypothesis.

The thin Unit II, between Unit IIIb and I, records an abrupt change to micritic distal slope facies. This apparent change in depositional environment could be due to tectonic displacement of Unit II. The absence of metazoan primary reef framework, and the richness of micro-encrusters, autochthonous micrite and synsedimentary cements, suggests a mud mound platform environment in this part of the Tethys realm of the Southern Apennine during the Anisian.

Unusual biomineralization: a new tool for the study of biosignatures in the fossil record

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Biomineralization is a generic term to indicate biological-mediated mineral formation. In carbonate mineralization, nucleation of crystals can be controlled directly by the organisms, like in the skeletal formation of most metazoans; induced by microbial communities, by indirect precipitation mediated by their metabolic activities; influenced by organic matter decay, with mineral precipitation on specific non-living organic cell surfaces. The recognition of these products is a direct marker of biological activity in time and space and is a key element in the study of the biological evolution and of its interactions with the geological processes. In this reserach, primary carbonate cements from the Anisian microbial buildup of the "Monte Facito" Formation (Basilicata region, Southern Italy), have been studied from a geobiological point of view. Optical microscopy, UV-epifluorescence and micro-Raman spectroscopy have been applied to investigate a possible organic mediation on their precipitation. The cements formed in microcavities or on grain substrates, and often show a microstromatolite-like pattern of growth. They are composed of alternations of cloudy organic and whitish inorganic bands, that point to a double phase of mineralization. In the first phase, a biologically induced/influenced biomineralization is indicated by the presence of organic matter strictly connected with the cloudy bands. This phase is followed by a pure abiotic mineralization, that leads to the formation of whitish bands. This process repeated cyclically, ending at the complete filling of the microcavities or because of changes in the chemical conditions of the microsystem, for example due to burial processes. This model of mineralization is similar to that proposed for primary cements forming in recent beach rocks. The Monte Facito cements could be considered as the product of "unconventional biomineralization", and suggest that this component could represents an innovative tool in the research of biological signatures in the fossil record.

Late Jurassic-Early Cretaceous tuff sandstones of the Ust-Belsky Mountains (Koryak Highland, NE Russia)

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The territory of Ust-Belsky Mountains is located in the northeast of Russia and included to the northwestern part of the Koryak-Kamchatka folded system, which formed in the process of successively docking different terranes to the continent. The region characterizes by a fold-thrust structure. The structures of two main fold belts of the Koryak-Kamchatka folded system combined in this region. The West-Koryak fold belt represents by the Ust-Belsky terrane. The Anadyr-Koryak fold belt represents by the Algan terrane. The time of thrusting is lower Aptian determine by undeformed Apt-Albian sediments cover. The Algan terrane is covered with the Ust-Belsky terrane on the north-west. This work presents the results of mineralogical and granulometric compositions of the Late Jurassic-Early Cretaceous tuff sandstones of Algan and Ust-Belsy terranes.

The Ust-Belsky terrane consists of several tectonic sheets. Late Jurassic-Early Cretaceous tuff sandstones form the structures of northwestern Udachninskaya (K1v) and southeast Mavrinskaya (K1v) sheets. We discuss only sediments of the north part of the Mavrinskaya sheet. The tuff sandstones of both sheets containing 7–12% quartz, 35–63% feldspars, and 29–51% lithic fragments. Basic and intermediate volcanic lithic fragments are dominant. The rounding of the grains is poor, but there are grains of medium and good roundness (most often grains of rock fragments). Tuff sandstones of the Udachninskaya sheet containing a larger amount of volcanic-clay cement (20%), than tuff sandstones of the Mavrinskaya sheet (5–7%). The grains of the Udachninskaya sheet are larger and worst sorted than the grains of the Mavrinskaya sheet. Tuff sandstones of the Udachninskaya sheet formed by highest-speed flows.

The Late Jurassic-Early Cretaceous rocks of Algan terrane represent by Algan formation (J3tit-K1v), which includes volcanic-siliceous-terrigenous rocks. We discuss only the sediments of area riv. Pereval'naya in this work. The tuff sandstones of Algan formation containing 5–11% quartz, 34–51% feldspars, and 38–55% lithic fragments. Basic and intermediate volcanic lithic fragments are dominant. There are two groups of fragments of volcanic rocks. The grains of the first group are unrounded. The second one has a good rounding. Sorting is bad. Deposits have volcanic-clay cement (5–10%). Tuff sandstones of Algan formation formed by high-speed flows.

According to the results of granulometric, geochemical and mineralogical data: tuff sandstones were formed due to the erosion of volcanic formations in a moderately deep marine environment by high- and medium-speed turbid currents, near the coast, where deltas provided clastic materials. The source was located in the northwest of the region. Sedimentation occurred synchronously with volcanism of intermediate and basic composition, which was associated with the existence of volcanic arc (for example, Uda-Murgal arc (J3-K1) is coeval of the studied sediments). Tuff sandstones of Ust-Belsky terrane formed in different parts of the forearc basin. Tuff sandstones of Algan terrane formed in the trench-slope basin.

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Paleopedological evolution of siwalik succession from kangra sub-basin nw himalaya, implication for climate change

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In this study, we investigated micromorphology and clay mineralogy of lower and middle Siwalik Paleosols (~12 Ma -5 Ma) that formed during the deposition of Siwalik sediments in the Himalayan Foreland Basin. About 2.7 km section is exposed along the Katilu Khad (stream) covering lower, middle and upper Siwalik in the NW Himalaya. Micromorphological observations of thin sections suggested that dominance of well-developed paleopedofeatures in the lower parts and moderately-weakly developed paleopedofeatures in upper parts of the sequences. The paleosols are 1–2 m thick, with Bw, Bt, Bk, Bss and BC horizons. The paleopedogenic processes are well-preserved as blocky and wedge shaped peds, rhizocretions, pedogenic calcium carbonate, thin-thick clay coatings, slickensides, Fe-Mn mottles, and concretions reveal variation in the pedogenic maturity among and within the paleosol profiles. The macro and micro-morphological attributes of studied paleosols suggest a variation of climatic conditions during the formation of paleosols from ~12 Ma -5 Ma. The pedogenic carbonate occurs as impure micritic nodules with diffused boundaries and it decreases upwards in the successions. The particle size distribution showed an increase of total clay (<2μm) in Bw and Bt horizons with clay coatings and intercalations due to an illuvial process.

The XRD of total clay (<2μm) and fine clay (<0.2μm) show the varying distribution of chlorite, illite, kaolinite, smectite, vermiculite and mixed layers in these paleosols. The clay mineral assemblage with a dominance of smectite and vermiculite in the lower part changes in upper parts with a dominance of kaolinite and the absence of any major amount of smectite and vermiculite. It is also marked by the alteration of vermiculite as hydroxyl interlayering (HIV). The clay-mineral assemblage of the paleosols varies with time and depth among and within profiles of lower and middle Siwalik sub-group. Clay minerals indicating the development of a more seasonal climate starting at ~8 Ma. Clay mineralogy of the total and fine clay fractions has been useful to assess the weathering and diagenetic overprinting. The presence of smectite in the lowermost part of our study area shows some aridity and the presence of kaolinite in the upper part shows humid to sub-humid climate.

The micromorphology and clay mineralogy of the paleosols from Siwalik succession suggest a change of paleoclimatic conditions from arid-semiarid conditions to subhumid-humid conditions at about 8 Ma. This study in confirmation of the fluctuating southwestern monsoonal conditions during this period, which is marked by a strengthening and increased precipitation during 7–8 Ma.

Keywords: Paleosols, Siwalik, Micromorphology, Clay Minerals, Pedogenic carbonate.

Sedimentology and architecture of a mudstone parasequence, Book Cliffs, Utah.

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The exceptional exposures of the Book Cliffs (Utah, USA) provide an opportunity to analyse the down-dip mudstone expressions of shallow-marine parasequences of the late Campanian Blackhawk Formation within a well-established sequence stratigraphic framework. This study aims to characterise the local-scale, three-dimensional variability in facies and depositional architecture within a mudstone parasequence of the Mancos Shale.

We focused on distal deposits of the Grassy Member parasequence 4, that ranges in thickness from 13.55 m to 19.10 m. Sixteen sections, logged at millimetre scale, over 48 km2 of continuous exposure define three constituent 2.5 m to 7.6 m thick coarsening-upward bedset. The base of parasequence 4 is marked by a regional cemented horizon with the top by the laterally extensive development of spherical concretions. The three bedsets are composed of a repeated, well organised internal stacking pattern of discontinuous, millimetre thick fine-grained mudstone laminae/beds at the base that thicken- and coarsen-upward into well-preserved, millimetre to centimetre thick normally-graded, coarse-grained mudstone beds. These packages are capped by 0.5 cm to 15 cm thick very-fine to fine-grained, normally-graded sandstone beds. Three to four sub-bedset packages that range from 1 m to 5 m are also identified in proximal sections within the uppermost bedset. Samples collected from measured sections often display a disorganised texture interpreted to be a result of sediment reworking by wave-action and/or faunal activity. However, identifiable normal grading structures in outcrop and in thin-section suggest turbidity currents were the primary delivery source of sediment.

The parasequence and each of the three constituent bedsets typically display a 2 m to 3 m down-dip thickening to thinning trend over 8 km, producing sigmoidal geometries that are interpreted as clinoforms. They also show 2 m to 3 m across-strike thickness variability over 6 km, which may indicate some rugosity to the palaeoshoreline in this parasequence. The overall spatial thickness variability is interpreted to be generated by offshore-directed turbidity currents that bypass the topset region and deposit within the foreset region of clinoforms. This suggests the gradient of foreset slopes was low enough to deposit turbidity currents rather than resuspend material, consequently driving the basinward progradation of mudstone clinoforms. This mechanism has implications for the reconstruction of ancient, low-angle, shallow-marine settings as prograding mudstone clinoforms may be an underestimated process in filling available accommodation in low-angle, mudstone-dominated settings.

Lithological and isotopic characteristics of lacustrine stromatolite in Tibetan Plateau: Implications for Miocene Stromatolite Riddle

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Miocene lacustrine carbonate rocks in the Northern Tibetan Plateau (NTP) were sensitive to climate fluctuation. This paleoclimatic information was thought to be recorded effectively in the typical dark lamination (algae-rich) and light lamination (crystal-rich) of the Miocene stromatolites. In fact, during the Miocene there was a relatively explosive growth of stromatolites, referred to as Miocene stromatolite riddle (MSR) in this study in terms of its puzzling cause. The stromatolites in the NTP presented in different types, such as hummocky, stratiform, domelike. Under the microscope, the crystal-rich lamination contains obvious calcite or dolomite crystals, while the algae-rich lamination consists of mud-calcium calcite and algae fossils, indicated from the scanning electron microscope. The negative carbon and positive oxygen isotope values we tested show that the isotopic values of algae-rich laminations are higher than those from crystal-rich laminations, implying that the algae-rich lamination formed in the environment with a relatively high temperature which was suitable for algae growth. Low correlation between the carbon and oxygen isotopes indicates the stromatolite formed in an open lake, and the characterizes of carbon and oxygen isotopes might relate to the elevation of Tibetan Plateau during the Miocene (25~10 Ma). The ratio of Sr/Ba is used as paleo-salinity proxy as well. As the depth decreases, the value of Sr/Ba increases, showing that the stromatolite tends to grow in the condition of relatively higher salinity. It's deduced that this Miocene open lake in the NTB was with relatively high temperature and evaporation. There has a correlation between dolomite frequency and stromatolite occurrence. Dolomite can form as a primary and early diagenetic feature in the arid depositional environments, as we counted for the Miocene case. In this study, therefore, it's concluded that the lacustrine stromatolite is more common in an evaporitic environment, implying that drought climate might cause the MSR.

Burial modification in a Carboniferous organic-rich mudstone, UK: understanding element mobility during early diagenesis

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An appreciation of the diagenetic processes impacting organic-rich basinal mudstones is important for understanding the properties of shale-gas reservoirs and the nature of fluids that have circulated within basins. This study utilizes petrographic and mineralogical data from mudstones from the Carboniferous Morridge Formation (equivalent to Bowland Shale in age) in the Widmerpool Gulf, UK to investigate the paragenetic succession and associated mineral cementation during diagenesis of these mudstones. Of particular focus in this study are the sources of silica and aluminium that formed authigenic kaolinite in mudstones during diagenesis.

Lower Namurian (Arnsbergian) mudstones intersected in the studied borehole (the Carsington Dam Reconstruction C4 borehole) are characterized by relatively high total organic carbon contents ranging from 1.3 to 4.3 wt%. A constructed burial history model indicates that these organic-rich mudstones reached maximum burial depths of nearly 2 km and maximum burial temperatures of nearly 80 °C in the late Cretaceous, indicating that these mudstones were buried into the early oil window. Integrated whole rock X-ray diffraction (XRD) analysis with scanning electron microscopy-energy dispersive X-ray spectroscopy (SEM-EDS) analysis was used to determine the major authigenic minerals present. Kaolinite, non-ferroan dolomite, ferroan-dolomite, calcite, pyrite, siderite and quartz are the major diagenetic phases. Pyrite is divided into three types, namely framboidal, anhedral and euhedral pyrite. Framboidal pyrite is trapped in the kaolinite cement and considered to be the first product formed during diagenesis. Kaolinite cements are particularly common and usually infill intraskeletal pores. Anhedral pyrite is present at the rims of kaolinite assemblages indicating its formation postdates the latter. In some cases, the calcite cement is present with the kaolinite cement in the same shelter porosity and they appear to have precipitated approximately simultaneously. Based on the inclusive relationship between pyrite and dolomite, euhedral pyrite was formed after anhedral pyrite and before non-ferroan dolomite. Ferroan dolomite commonly occurs as the rim of non-ferroan dolomite and is surrounded by siderite in some cases. Quartz is a later diagenetic product and usually present as a cement surrounding kaolinite cements and pyrite.

The widespread presence of kaolinite cements in the studied samples reveals the mobility of dissolved silica and aluminium plays an important role during diagenesis. These mudstones were not buried deep enough for the transformation from smectite to illite, and therefore amorphous siliciclastic detritus and biogenic amorphous silica, possibly from radiolarians, are possible sources for silica. The possible sources for aluminum include unstable detrital clays and Al-rich detritus. Also, Al likely complexed with organic acids originating from organic matter maturation to improve its mobility in pore-fluids. Authigenic kaolinite is common in other mudstones and this research adds to understanding of its formation and gives a better understanding of element mobility in muds during early diagenesis.

High-latitude marginal marine deposits of the Witpoort Formation, South Africa: problems and solutions

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The Late Devonian is a significant time in Earth history because, 1) it represents the end of the Siluro-Devonian hothouse, with the first continental glaciations recorded since the Hirnantian (Late Ordovician) glaciation, 2) important radiations of stem tetrapods and terrestrial plants occurred and 3) a series of catastrophic biocrises decimated marine organisms at various trophic and taxonomic levels. The causes and ramifications of Late Devonian bioevents are still debated despite a plethora of studies on the subject, among which very few pertain to the high latitude record of this time. In many Gondwanan basins, Upper Devonian strata have been removed by Late Carboniferous glacial erosion. The Witteberg Group of South Africa, however, provides a continuous shallow to marginal marine sedimentary record from a Late Devonian sub-polar setting. Ongoing palaeontological investigation is elucidating floral and faunal biodiversity within the Famennian-aged Witpoort Formation (Witteberg Group). Much of the evidence arises from the Waterloo Farm lagerstätte. In addition, new fossil localities are providing evidence for variable environmental and biotic diversity within lagoonal and/or estuarine ecosystems. Stratigraphy and sedimentology of these marginal marine deposits needs further study and revision. Complex structural deformation, lack of biostratigraphic indicators and a paucity of research on this formation are limiting factors. The present study involves a cross-disciplinary approach to better constrain palaeoenvironmental and biodiversity changes within the Witpoort Formation, within which, recognition of eustatic shifts may enable integration with global chronostratigraphy of this time. A combination of structural geology and high-resolution sedimentary facies analysis of the Witpoort Formation across the Cape Fold Belt will provide a key dataset toward understanding high latitude environments of the Late Devonian.

Study on sensitivity parameters of shale gas multi-well development model: application to Wufeng-Longmaxi shales

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Compared with conventional reservoirs, shale gas reservoirs usually have no natural productivity or lower productivity, and the production decline is faster in the later stage. The production effect of shale gas can be effectively improved by designing well pattern reasonably or fracturing in the later stage. Therefore, It is critical for shale gas reservoir to study on how to design well pattern and set up reasonable fracturing parameters reasonably in order to make it effectively developed.Based on the adsorption, desorption and diffusion of shale gas, and considering the contribution of rock compression to the production of fluid, the mathematical model and numerical model of gas-water two-phase seepage in shale gas reservoir are established respectively and the productivity formula of the shale gas Multi-well development mode at different seepage stages is deduced.Factors are verified by Matlab program and orthogonal experiment, including gas reservoir parameters and engineering parameters.The experimental results show that : the order of gas reservoir parameters that affect the development of shale gas is as follows: Langmuir pressure, inter-porosity flow coefficient, diffusion coefficient, Langmuir volume;the order of engineering parameters that affect the development of shale gas is as follows: the number of cracks, the length of horizontal section, production pressure, fracture length, row spacing and well spacing, which promotes the understanding of the complex and special micro seepage mechanisms in shale gas reservoirs.The shale gas recovery is enhanced by 1.2% after applying it to Wufeng-Longmaxi.

The zircon story of the Pearl River (China) from Cretaceous to present

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The modern Pearl River originates from SE Tibet and debouches into the South China Sea. The development of the Pearl River is closely related to the evolving topography following the tectonic evolution of the southern China continental margin and uplift of Tibet caused by the India-Eurasia collision. How topographic changes affected the development of the Pearl River, however, is still unclear. Here we use original and literature data on detrital zircon ages from both modern Pearl River sands and ancient strata drilled in offshore basins to reconstruct the evolution of the paleo-Pearl River catchment through time. Six phases are identified: 1) Early Cretaceous: the paleo-Pacific plate was subducting beneath the South China block and topography in South China was tilted to the west. The paleo-Dong River began to develop with limited length. 2) Late Cretaceous: back-arc extension in the South China Sea contributed further to the west-tilted topography. The paleo-Bei River started to develop and the paleo-Dong River continued to expand across southeasternmost China. 3) Paleocene to Eocene: active rifting in the South China Sea induced a major topographic change. The paleo-Dong and paleo-Bei joined, forming the paleo-Lower Xi River. 4) Early Oligocene: active uplift of Tibet and onset of sea-floor spreading in the South China Sea led to subsidence in the Cathaysia block. The paleo-Dong, paleo-Bei, and paleo-Lower Xi rivers remained limited to eastern Cathaysia. 5) Late Oligocene: accelerated uplift of eastern Tibet and post-rift subsidence of the northern South China Sea margin induced a radical change in the landscape of southern China, and transition from west-tilting to east-tilting topography. The paleo-Pearl River started to incorporate also its present western branches. 6) Early to middle Miocene: the east-tilting topography was enhanced during rapid uplift of Tibet and progressive closure of the proto-South China Sea, while the Pearl River evolved to its present configuration.

Characteristics, formation and significance of an early Permian palaeosol carrying a multi-aged forest and its palaeoenvironmental and palaeoclimatic implications

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Pyroclastic deposits have the potential of preserving whole ecosystems in a snapshot of earth history and may reveal palaeoenvironmental and ecological relations of ancient biotas in great detail. The Chemnitz Fossil Forest represents an early Permian ecosystem which was buried instantaneously due to a volcanic eruption 291 Ma ago by the Zeisigwald Tuff. As a consequence, the forest is three-dimensionally preserved in growth position with its fossil and palaeosol record. The succession is part of the Leukersdorf Formation and comprises fine-grained alluvial red beds which interfinger with coarse clastics of semi-arid type alluvial fans from the basin margins. The covering Zeisigwald Tuff can be traced over a distance of around 10 km from the eruption centre in the Northeast of Chemnitz (Central Germany). The pyroclastic deposits offer the possibility of reconstructing relief, sedimentation and tectonic history as well as palaeoenvironment and climate of the depositional area.

This study presents two sedimentary successions from Chemnitz sites, one from Hilbersdorf and another one from the 1.5 km adjacent Sonnenberg. Both yield palaeosol profiles, covered by the Zeisigwald Tuff, which are despite their proximity highly variable. The Hilbersdorf palaeosol profile is built on red silty sandstone that experienced extensive bleaching. Carbonate nodules and haematite glaebules occur throughout. The upper part yields densely distributed root systems of the former forest vegetation. Hilbersdorf shows only incipient pedogenesis and lacks extensive alteration features. Nevertheless, the presence of calcrete nodules of the groundwater type suggests at least the involvement of ground water and ascending capillary water. The Sonnenberg palaeosol develops upon alluvial sediments, mainly red clayey siltstone. Colour mottling and fine root adpressions signalise pedogenesis. The uppermost 30 cm are bleached and cemented with silica that most likely originated from the overlying pyroclastics by diagenetic migration. The characteristics of the Sonnenberg palaeosol indicate a poorly drained substrate which formed under waterlogged conditions.

The two sites offer the chance to study lateral variabilities in catena, palaeoenvironment and taphonomy of the fossil forest with Hilbersdorf as an eruption centre-proximal and Sonnenberg as an eruption centre-distal location. Clay mineralogy reveals the presence of swellable clay minerals, which indicate an alternation of wet and dry phases. Element geochemical proxies show higher chemical weathering intensities in the Sonnenberg palaeosol than in the Hilbersdorf palaeosol due to higher moisture availability following a higher ground water table. The lack of pedogenic carbonate in the Sonnenberg palaeosol reinforced a higher groundwater table inappropriate for calcrete formation. Chemical weathering led to a pronounced formation of clay minerals and grain size decrease as well as the destruction of sedimentary structures.

The Chemnitz forest ecosystem with represents a wet biome amongst the general aridization trend of equatorial Pangaea with almost unvegetated, semi-arid biomes and evaporation exceeding precipitation. The diverse forest vegetation is ascribed to the presence of a 'wet spot' with a local long-term stable, higher groundwater table with seasonal fluctuations, implying a deeper groundwater table during drier conditions and a shallower during less dry conditions.

Depositional environment interpretation of early to middle miocene offshore peninsular malaysia

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The Malay Basin is located in Offshore Peninsular Malaysia. It was formed during the Eocene with the collision of India and the Asia Plates. Its orientation is NW-SW trending, connecting to the Gulf of Thailand in the north and Penyu and Natuna Basins in the south. During the Oligocene rift phase, the environment of deposition was continental lacustrine and then coastal plain during the early Miocene post-rift phase before transitioning to shallow marine in the Middle Miocene until present day.

In late 1960's Esso Malaysia subdivided the stratigraphic section into 11 seismic groups, shallow to deep named A to M. This research focuses on stratigraphic interval H, I, J, and K. Updated environment of deposition maps were created using the integration of biostratigraphy, well-logs, and seismic data.

Stratigraphic markers were interpreted using the biostratigraphic scheme proposed by Yakzan (1996) for each marker. Key flooding surfaces are defined on smoothed GR curves in key wells and then interpreted in wells lacking biostratigraphy data. Well-defined markers are tied to 3-D seismic data for horizons interpretation. Seismic stratigraphy flattening techniques were used to extract stratigraphic features and establish the sequence stratigraphy and environment of deposition.

Group K, the lowermost stratigraphic unit, is a lacustrine deposit. It contains Maganastriates Howardii, Acrostichum, and Bisaccate pollens. The top of Group K is marked by a regional shale named "K shale" or "Trengganu Shale". Low-frequency seismic data does not image K stratigraphy very well; therefore, the paleogeography map is constructed based on the interval isochore. The thickness of K increases from west to east indicating a deepening trend into the basin.

Group J was deposited in a coastal setting. A slight marine incursion is noticed from the presence of foraminifera and glauconite. It observes the presence of Globigerinoides Trilobus and abundant palynomorphs, Florschuetzia Trilobata and regular F. Semibolata. Seismic quality is too low frequency to image most of J; however, fluvial and tidal channel geometries are imaged in the shallow interval. Similarly to interval K, this interval has a thickening trend toward the basin center.

Group I is characterized by coastal plain deposits. Numerous fluvial channels develop in the east and various tidal channels are present in the west. Biostratigraphy contains F. Trilobata and F. Levipoli. Top I is difficult to pick based on the smoothing GR curve because it lacks the lateral continuity of flooding surface. Isochore map shows a thickening trend into the basin; however, the depositional pattern does not change suggesting the sediment supply keeps place with subsidence rate.

Coastal plain setting continues into the base of Group H and gradually grades into a complete marine condition at top of H marked by the presence of Sphenolithus Heteromorphous (NN5). The top of H was eroded in some areas due to a tectonic inversion with well-defined incised valleys imaged in the seismic data.

Paleohydrostratigraphy of the Paleoproterozoic Kombolgie Basin, Australia: oxygenation and stratigraphic sequences in unconformity-related uranium deposits

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Large-scale unconformity-related uranium systems formed in a window in Earth history from ca. 2.1 to 1.4 Ga, the peak of which occurred between 1.7 and 1.6 Ga. This interval resulted from the confluence of several factors, including rising oxygen concentrations following the Great Oxidation Event (GOE) to the point that groundwater could carry dissolved uranium complexes, and a global tectonic regime marked by continental basin formation and later stability resulting in deposit preservation. The absence of intrabasin organic matter meant that uranium remained mobile until it encountered reducing lithologies. The Paleoproterozoic Kombolgie Basin, located on the Arnhem Land Plateau, contains large uranium deposits and is a well-preserved successor of the larger McArthur Basin in northern Australia. This intracratonic basin is filled with 1 to 2 km thick, relatively undeformed, siliciclastic rocks of the Kombolgie Subgroup.

Tectonic events controlled the basin's internal stratigraphic architecture and led to the accumulation of three unconformity-bounded sequences that were punctuated by periods of volcanism. The three sequences represent a stepwise evolution of the basin from fluvial to marine environments. The first sequence records the onset of basin formation and is comprised of coarse-grained sandstone and polymict lithic conglomerate deposited in proximal braided rivers that transported sediment away from basin-margins. Uranium mineralization occurred where this sequence intersects intra-basin paleohighs. Paleo-currents in the upper half of this lower sequence, and those of overlying sequences, are directed southward and indicate that initial intra-basin topographic highs no longer existed. The middle sequence has similar coarse-grained fluvial facies, followed by distal fluvial, and finally marine and eolian facies. An interval marked by mud-rich, fine-grained sandstones and mud-cracked siltstones representing tidal deposition characterizes the top of this sequence. Distal fluvial and marine facies that contain halite casts, gypsum nodules, stromatolites, phosphate, and glauconite dominate the upper sequence and indicate a marine transgression. The repeating pattern of stratigraphic sequences produced well-defined coarse-grained diagenetic aquifers with 5 to 30% detrital feldspar, which inhibited quartz cementation during burial. These permeable facies were capped by compositionally mature distal fluvial, shoreface, and eolian units, interbedded with volcanics, which led to intense quartz cementation, and a well-defined heterogenous hydrostratigraphy. Basinal brines migrated within this framework and, combined with paleo-topography, diabase intrusion, faulting, and burial diagenesis, led to economically important uranium deposits. Strata were buried to a depth of at least five kilometers and temperatures of 200°C by 1700 Ma to form the oldest known unconformity-associated uranium mineralization (1680 Ma).

Proterozoic continental sedimentary basins contain a unique record of the evolving Earth in their sedimentology, stratigraphy, and the large-scale, redox-sensitive mineral deposits they host. Most of Earth's largest high-grade iron and uranium deposits formed in response to the initial hydrosphere and atmosphere oxygenation following the GOE. Unconformity-related uranium mineralization, like that found in the Kombolgie Basin, highlights the interconnected role that oxygenation, sedimentology, stratigraphy, and diagenesis played in creating these deposits. Unconformity-related uranium systems, like iron formation and phosphorites, are the products of the geosphere and biosphere co-evolution and are the consequence of the Earth's oxygenation.

Paleoclimate history of the Carnian Pluvial Event in the Mine Group, southwest Japan

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The Carnian Pluvial Event (CPE) proposed by Simms and Ruffell (1989) is a humid climatic event that emerged in the Late Triassic Carnian. The CPE has been recognized extensively in Europe, however it has recently been detected also in India, South China and the pelagic region of the Panthalassa Sea (Hornung et al., 2007; Sun et al., 2016; Nakada et al., 2014). Therefore, CPE has been increasingly viewed as a global environmental change event.

The duration of CPE is about several million years that occurred from the late Jurian to the early Tuvalian of the middle Carnian. In this study, we investigate the western coast of the Panthalassa Sea, where few studies have been conducted, aiming to elucidate the global extent areas affected by CPE. In particular, The Late Triassic Mine Group, distributed in Yamaguchi Prefecture, Southwest Japan was investigated.

The Mine Group is composed of terrestrial to marine sediments of the Late Triassic Carnian age. The whole-rock chemical composition of mudstone samples was analyzed by XRF (X-Ray Fluorescence). Principal component analysis of the total chemical compositional data extracted principal component 1 (PC1), which is highly correlated with the hinterland weathering index (W value of Ohta, 2007). Therefore, mudstone composition of the Mine Group is predominantly controlled by the hinterland weathering. We quantitatively evaluated paleoclimate changes of the Mine Group using the W value. As a result, the W value of the Mine Group shows large variation ranging from 50 to 95. Particularly, the W value increases drastically in the middle unit of the Mine Group (Momonoki Formation), which corresponds to the middle Carnian period. The range of W value detected is comparable to the W values of recent soils developed in temperate climate zone to tropical rainforest zone. Therefore, the present result suggests that the initial temperate paleoclimate, turned into warmer and humid paleoclimate comparable to the tropical rainforest climate during the middle Carnian. The period of increasing humidity recorded in the Mine Group is time equivalent with the CPE described in previous studies. However, the W value does not show a consistently high value during the middle Carnian, and rather show a high fluctuation. The cause of this high fluctuation and how it is related to CPE needs to be assessed in future studies. However, in terms of lithology, fossiliferous strata and coal beds are concentrated in the middle Carnian Momonoki Formation, suggesting a favorable paleo-environment for biota. Therefore, the interpretation that SW Japan turned out to more humid and temperate paleoclimate during middle Carnian remains valid.

In summary, the Mine Group records a significant increase in humidity and temperature comparable to that of modern tropical rainforest climate during the Middle Carnian. We note that this event is time equivalent with the CPE, and thus, may had induced by the CPE. If this is true, the area affected by the CPE extends to the western coast of the Panthalassa Sea, supporting the view that CPE was a global event.

Cryptic tubular network trace fossils evidence life in Middle Triassic arid palaeosols of South-West England

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Evidence of life in the terrestrial Middle Triassic strata of South-West England is rare or unrecorded. We describe and interpret novel tubular network structures, consistent with a biogenic origin, that are inferred to be of Anisian to Carnian age. These occur at Portishead on the North Somerset coast within basal continental sediments of the Dolomitic Conglomerate, the marginal facies unit of the Triassic Mercia Mudstone Group. Photomicrographs, thin-section petrography and three-dimensional images developed from high-resolution micro-focus computed tomography (μ-CT) allow study of form and complexity, the effect of post-depositional changes and, ultimately, an understanding of the formative organisms.

The fossils occur in 5–30 cm sub-angular reworked clasts and comprise dense networks of unfilled burrows and tubular constructions (‘tubules’). These occur within a friable and porous palaeosol with a grain size of 10 – 30 μm, a mineralogy of residual hydrated iron oxides, possibly clays, partly cementing carbonate, and sporadic post-depositional baryte replacement. The presence of relict marine fossils indicates derivation from weathered Carboniferous Limestone.

Most of the tubules (Type I) have a circular-section where 90% of the internal diameters are 0.1–0.35 mm. They have calcite linings, at minimum 0.01 mm thick, but in voids or friable substrate, typically thickened to 0.2 mm with overlapping calcite layers that may include evidence of repair. They have slight internal circumferential 0.02 mm ripples, are randomly orientated in three-dimensions and include several subtypes. The majority are ‘irregular maze’ networks of meandering tubules with Y-shaped junctions typically 1 mm apart with local anastomosis. These are linked at T-shaped branches to fewer ‘galleries’ that may be relatively straight for at least 15 mm, of 0.2–0.5 mm diameter with calcite linings thickened up to 0.3 mm. Rare irregular rounded chambers with up to 0.4 mm linings, are up to 4 mm long, 1 mm across, accessed by narrower tubules, and usually located adjacent to apparently resistant, un-burrowed substrate. Many of these features suggest collaborative and possibly eusocial behaviour.

Conspicuous but less numerous Type II burrows, of diameter 1–2 mm, are unlined with irregular ovoid cross-sections and randomly orientated. They intersect Type I indiscriminately, with evidence of breakage, and may be attributable to a second, unrelated, possibly predatory organism. Some Type I lined tubules have apparently been re-constructed within older Type II burrow cavities.

The palaeosol clasts containing the tubules were part of a partially cemented regolith developed during subaerial weathering of limestone hills in an arid subtropical continental climate. They record biological activity within the regolith, with synchronous calcite cementation, prior to erosion. The friable palaeosol was eroded and transported after rainfall along and down a palaeo-gully where it was buried as clasts in a sandy-pebbly dolomitic matrix. Following torrential rain, these sediments were partly re-eroded but then buried by 1–4 m thick fanglomerate deposits.

This depositional archive provides a rare window on a Middle Triassic terrestrial ichnofacies. Many questions await research, with speculation on formative organisms, including plants, fungi, annelids, micro-molluscs and/or arthropods, even insects with early eusocial traits.

Two types of hyperthermal events in the Mesozoic-Cenozoic: Environmental impacts, biotic effects, and driving mechanisms

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A deeper understanding of hyperthermal events in the Earth's history can provide an important scientific basis for understanding and coping with global warming in the Anthropocene. Two types of hyperthermal events are classified based on the characteristics of the carbon isotope excursion (CIE) of the five representative hyperthermal events in the Mesozoic and Cenozoic. The first type is overall characterized by negative CIEs (NCHE) and represented by the Permian-Triassic boundary event (PTB), the early Toarcian oceanic anoxic event (TOAE), and the Paleocene-Eocene Thermal Maximum event (PETM). The second type is overall characterized by positive CIEs (PCHE) and represented by the early Aptian oceanic anoxic event (OAE1a) and the latest Cenomanian oceanic anoxic event (OAE2). Hyperthermal events of negative CIEs (NCHE) were triggered by the eruption of large igneous province (LIP) in continental environment, leading to massive release of light carbon and rapid global warming. During the onset of these events, as defined by negative CIEs, volcanism associated with continental LIP released massive light carbon into the atmosphere-ocean system, leading to dramatic changes in temperature, sedimentation, and biodiversity. These events caused frequent occurrence of terrestrial wildfires, extreme droughts, acid rain, destruction of ozone layer, metal poisoning (such as mercury), changes in terrestrial water system, and carbonate platform demise, ocean acidification, ocean anoxia in marine settings, and various degree extinction of terrestrial and marine life, especially in shallow marine. In contrast, hyperthermal events of positive CIEs (PCHE) were triggered by volcanism associated with LIPs in deep-sea environment. During the onset of these events, as defined by the positive CIEs, heat and nutrients were directly released into deep-sea system, resulting in rapid warming of seawater and widespread oceanic anoxia, large-scale burial of organic matter and associated black shale deposition. During the initiation of such events, the released greenhouse gases were buffered by seawater due to their eruption in the deep sea, which thus exerted more significant impacts on deep-water marine life, but little impacts on shallow sea and terrestrial life. The implication of the proposed classification of hyperthermal events lies in that the types of hyperthermal events and their driving mechanisms can be inferred from the characteristics of carbon isotopic excursions. The comparison of onsets between these two types of hyperthermal events shows that the current anthropogenic global warming is most similar to NCHE events, but with much higher warming rate, carbon isotopic excursion rate, and carbon emission rate. Following the current warming trend, the Earth is highly likely to encounter the environmental consequences of hyperthermal events similar to the PETM and PTB at hundred- to thousand-year time scales.

Early Permian warming pulse in eastern peri-Gondwana evidenced by oolites in the Tengchong Block, China

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The Tengchong Block and Baoshan Block in western Yunnan, China have been acknowledged to be parts of the eastern peri-Gondwana region during the late Paleozoic. Discovery of Early Permian fusulinid-bearing oolites from the Tengchong Block enable to refine paleoclimatic understanding of this region. A monotonous Eoparafusulina fusulinid assemblage was recovered from the lower part of the Dadongchang Formation in the northern Tengchong Block. This assemblage correlates well to late Sakmarian–Artinskian Kalaktash assemblages, which pioneered in the peri-Gondwana region posterior to the Gondwana glaciation.

Due to their low diversity and dominance of cosmopolitan taxa, these fusulinid assemblages have been interpreted to indicate temperate-water conditions. Moreover, the eastern peri-Gondwana region have been demonstrated to be even more temperate than the western region in terms of the Early Permian paleoclimate, because 1) fossils in the eastern region are more impoverished; 2) glaciogenic diamictites occur in the eastern region, in contrast to sporadic oolites in the western region.

However, the fusulinids of this study occur within oolitic facies, which is unexpected, as ooids have never been reported in Early Permian strata from the eastern peri-Gondwana region. The occurrence of oolitic carbonates, characteristic for warm shallow marines, seems inconsistent with the present understanding as previously introduced. Almost all ancient and modern marine ooids are confined within warm-water (paleo)latitudes, and Holocene aragonitic ooids mostly form where summer sea-surface temperature (SST) exceeds ca. 25 Celsius. On the other hand, extant symbiont-bearing larger benthic foraminifera, a modern analogue to fusulinids, cannot survive where persistent SST remains below 14 Celsius. Accordingly, it seems reasonable to infer that ancient fusulinids could adapt to SST slightly lower than the threshold SST for ooid formation in shallow marines.

Consequently, our discovery suggests that the Early Permian SST of the Tengchong Block was markedly warmer than previously envisaged. We tend to interpret that this warming episode is more likely to be facilitated by short-time local favorable geographic conditions in the context of post-glacial warming, rather than significant northward drift of the this block into the subtropics. This interpretation is consistent with a relatively higher latitude of this block throughout the Early and Middle Permian, which can be inferred from 1) the persistence of anti-tropical Monodiexodina in both Early and Middle Permian strata; 2) the absence of Neoschwagerinids and Verbeekinids diagnostic for tropical region during the Middle Permian.

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The Distribution of Sediment Storage Times from the Meandering Powder River, Montana

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As sediment is transported through river corridors, it can experience periods of immobility in alluvial storage reservoirs. The time spent within these storage reservoirs can greatly exceed that of the time spent in transport. Thus, the timescales of sediment transport from source to sink are often dominated by storage timescales, which have implications towards the fate and transport of contaminants, the development of effective watershed restoration plans, and the delivery of sediment signals. Our understanding of the probability distribution of storage times is largely limited to short timescales (on the order of a few hundred years) or to results from physical and numerical models, with a notable lack of field data over geologic timescales. In this study, we quantify the storage time distribution for Powder River from 1998–2013 over a 30-km reach by determining the age distribution of eroded sediment. Our approach integrates surveyed cross-sections, analysis of historical aerial imagery, aerial LiDAR obtained in 2016, geomorphic mapping of lateral-accretion elements, and age control provided by optically stimulated luminescence (OSL) and dendrochronology. Laterally eroded sediment dated using dendrochronology provides the first 150 years of the distribution. The remainder of the distribution is defined from OSL samples from banks with sediment ages ranging from 520 to nearly 6100 years, and erosion volumes determined at cross-sections that have been surveyed repeatedly from 1975 through 2019. The complete storage time distribution has a mean (residence time) and median values of 928 +/- 167 and 788 +/- 435 years, respectively. Our results show that exponential, Weibull, and Pareto distribution functions are all reasonable models of our data, suggesting that the distribution of alluvial storage times can be adequately represented by several different mathematical functions. Improved precision in dating and geological mapping is needed to resolve whether meandering rivers have an equal probability of eroding stored sediment regardless of age or if younger sediment is preferentially eroded.

Multivariate regression approach to estimate lithology from well log Data, Khabbaz Oil Field, Northern Iraq

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Stratigraphic modeling of geological formations from well log data requires a proper calibration to rock lithology. In this study, we use multivariate regression of well-log and well rock cutting samples to reconstruct lithological sequence to upper Cretaceous carbonate succession of the Kometan formation in Khabbaz oil field, Iraq. This study limits the explanation of conventional well log analysis basic theory to carbonate sedimentary rocks, focusing on shale and clean formations based on the different responses of logging tools. For multivariate regression, the density logs, sonic logs, and neutron logs in the open hole were used as input independent values to predict lithology as a dependent value. In addition, the gamma-ray log was used to determine the shale volume of the formation. The major procedures developed in this study include (i) codification, (ii) Fuzzification. The cutting sample lithologies were subdivided into 1, 0.9, 0.8, and 0.7 which corresponded to limestone, shaly limestone, marly limestone, and marl respectively. Al concentrations were used for the main lithologies (using EDXRF of well cuttings) as a proxy for shaliness in the carbonate-shale continuum. A good matching between the described lithology and the predicted lithology was achieved. Results of multivariate regression of this study indicate that the included logs are more precise to lithological identification. The prediction accuracy of the multivariate regression system was fairly good (0.6 – 0.86%" for the coefficient of correlation) based on the results. We conclude that the multivariate regression method would be a good alternative to rock derived lithology for the whole well intervals, which has economic importance from cost and time-consuming points of view.

Coroglio tuff cliff (Naples, southern Italy): weathering processes and related landslides

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Coastal cliffs, developed in pyroclastic flows, are prone to undergo fast geomorphological evolution mainly due to intense weathering processes, making the areas inclined to erosion and landslides. Landslides on the coastal cliffs are among the major geo-hazard in worldwide, causing fatalities, damage to infrastructures and significant economic loss. Therefore, the study of the weathering process, as a predisposing factor to the landslides triggering, raised great attention in the last decades.

This study focuses on the weathering processes affecting the pyroclastic deposits of the Coroglio coastal cliff, in Naples, susceptible to frequent landslides. These pyroclastic rocks, ascribed to the Neapolitan Yellow Tuff (NYT), constitute the eastern edge of the Campi Flegrei caldera, belonging to the Campania magmatic Province. The NYT is characterized by high heterogeneity due to the diverse occurrence, within the mineral rock paragenesis, of pumices, glass, obsidian fragments, crystals and lithics set in an altered ashy matrix, and ranging in composition from trachyte and alkalitrachyte to phonolite. The phenocrysts are mainly constituted by salitic and diopside clinopyroxene, alkali feldspar, biotite, plagioclase and magnetite. Smectite content is generally less than 6%, representing the first step of weathering process of volcanic glass; the further transformation step consists of crystallization of zeolites. The NYT can be classified as a weak rock. Indeed, bulk density and porosity scatter in a wide range: ≈8–15 kN/m3 and ≈35–65% respectively and they are inversely correlated. Uniaxial compressive strength ranges from 0.3 to 10.7 MPa, while ultrasonic P-waves range from 1500 to 2000 m/s. The wide variability of these parameters show a high inhomogeneous features of the rock, occurring in the same outcrop as well. The poor quality of rock is further dependent by its petrophysical features rather physical parameters. Indeed, the mechanical behavior and its attitude to undergo weathering processes, depend mainly by three factors: pumice content, matrix content, mineralogic assemblage. The increase of the first factor generates a worsening of the mechanical properties, instead an increase of the fine matrix generates its improvement. Finally, better mechanical quality were observed with higher contents of feldspar.

The main factors causing weathering processes on the Coroglio cliff are related to rainfall, wind blowing directly from sea and the marine aerosol actions. The collected data allowed a classification of the outcropping volcanoclastic rocks in the IV-V weathering class. The strong weathering processes affecting the escarpments gave rise to weathering forms representing the progress of honeycombing, enhancing the terrains to collapse. On the Coroglio escarpments the abundance of these forms occupy about 80 % of the steep slopes. The shape evolution of the honeycombs occurs through an enlargement of the form, for effect of the weathering process, causing a subsequent dismantling of the separation wall between two close forms. Thus, large and irregular forms are produced by the coalescence of two or more honeycombs. Over the time, the evolution of the process produces a widespread instability of the slopes, causing rock fall, rock topple and rock slide.

Paleoclimate analysis during the mid-Cretaceous Supergreenhose in Southeast Asia

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Mesozoic was a time of global warmth, and among this, the middle Cretaceous is particularly known as Supergreenhouse condition because seawater temperature was approximately 10°C higher than that of today due to extremely high atmospheric CO2 concentration (Takashima et al., 2006).

Several studies revealed an aridification in the inland area of Southeast Asia during the warmest period of the Cretaceous (e.g., Hasegawa et al., 2012). This suggests that the arid climate zone migrated southward to around 20°N during the middle Cretaceous Supergreenhouse period. However, paleoclimate analyses in Southeast Asia had been conducted mainly in continental interior basins. Therefore, it is not clear whether this aridification had reached the coastal areas. Inland basins may turn arid by local factors such as orogenic rain shadow effects. Meanwhile, continental margin basins are less affected by these and seem to be more sensitive to global climate change.

In this study, Jurassic to Cretaceous strata distributed in the Dalat Basin, southern Vietnam were investigated. This site is located on the eastern margin of the Asian continent, and low latitude position than the previously studied that determined aridification. Thereby, allowing to examine whether the aridification was a consequence of global climate change, as well as, aiming to speculate the southern limit of arid climatic zone that suddenly appeared in the middle Cretaceous.

Mudstones were taken from the La Nga Formation of the middle Jurassic, the Nha Trang Formation of the lower Cretaceous, the Dak Rium Formation of the middle Cretaceous, and the Don Duong Formation of the middle – upper Cretaceous in the Dalat Basin.

Major elements were measured using XRF, and W values (Ohta and Arai, 2007) and CIA (Nesbitt and Young, 1982) were utilized as chemical weathering indicators. The results show that the Jurassic to early Cretaceous mudstones is highly weathered, and the degree of weathering decreases from the middle to late Cretaceous. Moreover, clay mineral composition measured by XRD revealed the presence of kaolinite, which is produced by the intensified weathering, is exclusively distributed in the Jurassic to early Cretsceous strata.

Therefore, both results indicate cessation of hinterland paleoweathering during middle to late Cretaceous, which can be achieved by aridification and/or cooling. Climate cooling is unlikely since middle Cretaceous was in the Supergreenhouse condition. Therefore, the present result indicates that the coastal areas of Southeast Asia also underwent aridification during the Supergreenhouse. The verification of arid climate in coastal area suggests that aridification in Southeast Asia was not due to the enhancement of inland dry climate and/or the orographic rain shadow effect. It was more likely a consequence of renewed global climate system operated under the Supergreenhouse condition. When compared to the analysis derived from northern Vietnam (Higuchi et al., submitted) where severe aridification was detected, the aridification in the Dalat area, southern Vietnam was moderate. Therefore, we speculate that the southern limit of the arid climate zone was situated around southern Vietnam, however, further work is necessary to precisely locate the geographical extent of this middle Cretaceous arid climate zone.

Organofacies and paleodepositional environments of the "black shale heaven", Mangyshlak Peninsula, Kazakhstan

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Mangyshlak Basin is located in western Kazakhstan and comprises Triassic, Jurassic, Cretaceous, and Cenozoic sedimentary successions. These units are superbly exposed in the Aktau and Mangistau mountain ranges north of the basin. This study utilizes black shale outcrop exposures to better understand the origin of organic-rich strata and their role in the petroleum and basin evolution. The studied localities include i) Tauchik (Triassic); ii) Karadimien (Triassic and Jurassic); iii) Jarsu (Triassic and Jurassic); iv) Shershilly (Triassic, Jurassic, and Cretaceous); v) Shair (Jurassic); vi) Sherkala 1 and 2 (Jurassic); vii) Tyubedzhik (Cretaceous); viii) Aksurtau/Koksyrtau (Cretaceous); ix) Jarmish (Cretaceous); and x) Zhaprakty (Cretaceous). Minimal weathering, easy access, and the ability to correlate the units laterally for tens of kilometers on satellite images and land sites are heaven-like for those studying black shales.

Preliminary interpretations suggest various autochthonous and allochthonous controls on paleobioproductivity and organic matter preservation. Moreover, the integration of sedimentological observations from outcrops, pyrolysis, and X-ray fluorescence of over 80 black shale samples has provided valuable insights into the paleodepositional environments, paleoecology, and organic richness:

i) The Triassic black shales represent mostly deep marine (turbidite) deposits with transported organic matter of mixed origin and siltstone and sandstone interbeds up to hundreds of meters thick. The observed bituminous sandstone intervals arguably suggest very short oil migration distances. The active syn-depositional volcanism may have provided temporary nutrient fluxes via mineral-rich volcanic ashfalls.

ii) The Lower Jurassic black shales are up to 60 m thick and were deposited in lacustrine environment (organofacies Type C). These deposits suggest stratified water column and high algal bioproductivity. The accommodation space was likely formed by graben-like depressions created by strike-slip faults, while the deposition probably coincided with the Toarcian anoxic event (AOE).

iii) The Middle and Upper Jurassic strata are usually represented by 1–5 m thick swamp deposits of coastal and/or deltaic origin (organofacies D–F).

iv) The Cretaceous Aptian deposits are approximately 50 m thick and represent stacked shelf and/or prodelta successions (organofacies B). The timing of their deposition coincides with AOE 1a (Selli event).

v) The Cretaceous Albian deposits comprise a 4–5 m thick black shale unit (organofacies B) formed in a shallow shelf environment.

vi) The Cretaceous Cenomanian and Turonian black shales are 8 and 10 m thick, respectively, separated by approximately 20 m thick sandstone, shale, and phosphatic interbeds. Their deposition coincides with AOE 2 (Bonarelli event).

The ongoing integration of these preliminary results with literature findings and publically available subsurface data allows us to refine previously made interpretations and generate more reliable depositional models. Specifically, the sedimentological and geochemical evidence suggests that the Lower Jurassic lacustrine deposits are the most prolific source rocks. They likely charged most of the Mangyshlak Basin fields and may present a significant potential for unconventional oil-shale development. These findings are supported by precursory ultimate expulsion potential calculations performed with KINEX (product of ZetaWare Inc.).

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Sediment wave development in flow constrained area of the Neogene forearc basin of Southwest Japan

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Sediment waves are often well developed on channel-lobe transition zones, levees, and channels of modern deep-sea floors. Large-scale bedforms such as sediment waves form easily on the channel-lobe transition zone of slope breaks because those areas have the potential for rapid sedimentation and erosion, often which is associated with hydraulic jumps. Outcrop examples of long-wavelength sediment waves may allow for detailed depictions of the continuity of sediment gravity flow deposits (SGFDs) with thickness variations and internal sedimentary structures, while such examples are not frequently encountered. The Neogene Aoshima Formation distributed along the Nichinan Coast of Kyushu Island in southwest Japan is a turbidite succession that fills a forearc basin. The formation is deposited on a slope-base to basin floor environment offshore of a fandelta and includes SGFDs with good continuity along the palaeocurrent. The sediment waves with wavelengths of 300–400 m and amplitudes of 1–2 m are developed in the uppermost part of the formation. These sediment waves developed from a mudstone-dominated horizon to thickness-fluctuating SGFDs and have created cyclic topography along the palaeocurrent. Bed thickness changes of the SGFDs were found to be significant, but no evidence of channels was observed. Dominant sedimentary structures of the SGFDs are affected by upper flow regime bedforms in the region, such as upstream flanks that have sedimentary structures indicating a hydraulic jump and downstream flanks that are dominated by sedimentary structures of 'traction carpets'. However, SGFD traces in the sediment wave horizon suggest that the sediment waves only can be observed in a limited area of the outcrops. In this study, we performed detailed bed-by-bed correlations of SGFDs in the continuous outcrops and clarified the detailed sedimentary environment of the sediment wave formation.

The bed-by-bed correlations of SGFDs, including the sediment wave horizon, were performed along the well-outcropped coast for approximately 9 km. The main results are as follows. (1) Each SGFD in a horizon under the sediment waves shows good continuity along the coast. (2) The sediment waves were observed only at intervals of 1–1.5 km and, curiously, the SGFDs can be traced easily except for within the interval of the sediment wave formation. (3) Palaeocurrents observed in the sediment waves are about 20–30° oblique to those in the upcurrent and downcurrent areas. (4) Slide deposits with slump folds are intercalated at 40 m lower than the sediment wave horizon. (5) Small-scale slump folds suggesting upcurrent-ward slipping are present in the most downcurrent part of the sediment waves. Based on the slide deposit intercalation and bed-by-bed correlations, a slope-base to basin-floor setting is suggested as the sedimentary environment for the sediment waves of the formation. The oblique palaeocurrents, discontinuous SGFDs in the sediment waves, and small-scale slump folds suggest that the sediment waves were developed in a low-relief channel that constrained sediment gravity flows and did not erode lower successions. Sediment gravity flows flowing on the fandelta slope may have converged around the slope break and could have consisted of relatively high-concentrated flows that formed sediment waves.

Different approaches in determining provenance and tectonic setting of the Slovenj Gradec Basin sedimentary successions

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The Slovenj Gradec Basin (SGB) represents the western margin of the Pannonian Basin System. It is located between the Lower Austroalpine unit of the Pohorje Mts to the east, the Southern Alps to the south and the Eisenkappel igneous belt, the Upper Austroalpine units of the Strojna and the Northern Karavanke nappe to the west. The area represents an excellent perspective for the study of provenance and tectonic setting, reflecting the various geodynamic processes associated with the evolution of the Pannonian Basin and the collision of the Alps.

The origin of the sediments was determined by measuring the paleo-current indicators, determining pebbles in conglomerates and grains in thin-sections of the sandstone and their connection to a specific source area, and by geochemical analyses. Measurements of cross-stratification, dip of the foresets and imbrications indicate sedimentary input from the west, northwest, north, south, and southwest. The tonalite and granite pebbles presumably originate from the Eisenkappel igneous zone. Conglomerate breccias indicate a proximal influx of material, probably from the Southern Alps. Very rare grains of weathered basalt and serpentinite presumably originate from the Austroalpine unit (Sauaple or Koralpe; Ivančič et al., 2018). Data from geochemical analysis were used in discriminant functions. The samples are arranged in the Quartzose Sedimentary provenance field. This corresponds to the provenance of the material in the SGB from recycled orogens, which coincides with the provenance in the Eastern Alps. The results indicate that the majority of sediments in the SGB originate from the northern, northwestern, western and southwestern directions and subordinately from the south. The origin of the sediments is mostly represented by the Eastern Alps, the Eisenkappel igneous belt and locally also the Southern Alps (Ivančič et al., 2018).

The tectonic setting was determined by petrographic and geochemical analyses (Ivančič et al., 2018). Based on the modal analysis, QFL and QmFLt triangular plots were made. The origin of the sandstone samples represents recycled orogens. Geochemical analyses were based on interpretation of major oxides. Multidimensional diagrams determine the collisional setting of the sediment source area (Ivančič et al., 2018). This coincides with the end of the Mesozoic and Cenozoic Alpine collisions that led to orogeny and thrusting (Neubauer et al., 1995). On the other hand, the discriminant function indicates the passive margin setting. The results reveal that sedimentation in the SGB was associated with early Miocene lithospheric extension and subduction, which caused the extension of the crust and formation of the PBS (Royden and Horváth, 1988). In our case, discriminant functions proved to be an excellent tool for identifying and determining different tectonic settings.

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Isotopic geochemical proxies and facies across Pragian–Emsian boundary in the Zinzilban Gorge (Uzbekistan)

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The Zinzilban Gorge located in the Zeravshan–Gissar Ranges (Kitab State Geological Reserve, Uzbekistan) hosts a continuous Lower Devonian carbonate succession of Lochkovian–Emsian strata and the current Emsian GSSP. Importantly, the section also provides a detailed depositional record of gradual changes in the carbonate sedimentary environments: an extensive development of microbial mud mounds in the Lochkovian, a gradual slow down in the microbially induced carbonate sedimentation rate in the Pragian, and a predominance of bedded carbonates starting from the Emsian interval. We conducted an integrated isotope and geochemical study of the carbonate succession in the Zinzilban section in order to elucidate and understand the associated changes in palaeoecological conditions on a basin scale. The Pragian–Emsian stratigraphic interval is of particular importance for the ongoing discussion whether or not the current Emsian GSSP should be redefined. Carbon and oxygen isotope and geochemical studies of this interval allow us to identify global carbon isotope events that are coupled with changes in palaeoenvironmental proxies. Furthermore, the isotope-geochemical record can be correlated with phylogenetic shifts in the lineage of the conodont genus Polygnathus that has been extensively studied in this section. In the Zinzilban section, stratigraphic levels corresponding to major phylogenetic transitions in the Polygnathus lineage appear to be attended by significant shifts in δ13C values on the carbon isotope variation curve for carbonates in this section. In particular, a notable negative excursion in δ13Ccarb values with a magnitude of ~1‰ is here associated with the emergence of the species Eognathodus jurii, whereas another excursion with a magnitude of ca. 2‰ in the section coincides with the appearance of several species of Polygnathus (P. sokolovi, kitabikus, pannonicus, hindei, tamarae). These same stratigraphic levels are also associated with negative excursions on the organic carbon isotope variation (δ13Corg) curve suggesting global changes in the isotopic carbon reservoir. The most notable shifts are confined to the Pragian/Emsian boundary interval. Isotopic composition of organic matter is affected by global shifts in δ13C values for the dissolved carbon dioxide being a source for both carbonate precipitation and biomass build-up, as well as by the CO2 content in the system because the magnitude of fractionation decreases under CO2 deficiency leading to an increase in δ13Corg values and at the same time having no effect on the isotopic composition of carbonates. Variation in carbon isotope discrimination factor Δ13C (the difference in magnitude between δ13Ccarb and δ13Corg values) up-section, therefore, can be used as a proxy for CO2 content in the system. An increase in Δ13C suggests an increase in CO2 content and vice versa. We also studied geochemical proxies for anoxic conditions (V/Al, U/Al, Mo/Al), nutrient fluxes (Ni/Al, Cu/Al, Zn/Al) and bioproductivity (Ba/Al, P/Al) in the Pragian/Emsian boundary interval. The largest perturbations in these proxies coincide with the negative δ13Ccarb excursion at the base of the Emsian and the radiation of the genus Polygnathus. In conclusion, the observed changes in carbonate sedimentary environments in the studied section reflect a significant palaeoceanographic event and associated ecosystem transformations.

Sedimentary and diagenetic environments of the terminal Ediacaran Khatyspyt Formation (Arctic Siberia)

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The terminal Ediacaran (555–544 Ma) Khatyspyt Formation of northeastern Siberia has been in the focus of attention because of the unusual carbonate-hosted preservation of soft-bodied organisms, the oldest evidence of bioturbation on Earth, and the unparalleled diversity of macroscopic fossil algae collectively offering a unique, perhaps the final glimpse into the structure and functioning of relatively deep-water ecosystems prior to the Cambrian explosion of ecological and morphological complexity. The formation is thought to represent a starved intracratonic rift basin developed in the inner ramp setting. We conducted a high-resolution study of carbon and oxygen isotope variations in relation to different lithofacies for the entire depositional system of the Khatyspyt Formation. Isotope variations in the studied sections range between –7‰ and +4‰ for carbon and between –10‰ and +2‰ for oxygen. The formation is divided into four members. The first member comprises intraclastic dolomitized limestones interstratified with thick-bedded and finely laminated limestones. It is characterised by positive δ13C values ranging between 2‰ and 4‰, with 3‰ on average, whereas δ18O values show a larger range of values between –7‰ and –2‰. The second member consists of limestones and shale interbeds interstratified with finely laminated limestones, thick-bedded limestones, and occasionally intraclastic limestones. Limestones in the second member are characterised by a gradual up-section 13C depletion, with δ13C values decreasing from +4 to as low as –5‰, followed by an increase to +3‰ towards the top of the member. The associated δ18O values, on the contrary, show an increase to +2‰ followed by a decrease to –9‰ in one of the studied sections (0601); however, no such trend has been observed in a coeval section (1811). The origin of the negative excursion of δ13C values, therefore, is unresolved. The third member comprises finely laminated limestones interstratified with thick-bedded limestones and limestone-shale alternations. It is characterised by mostly positive δ13C values, with an acme at +3‰, followed by a decrease in δ13C values where at least two negative excursions, with nadirs at –5‰ and –2‰, are separated a minor positive excursion (up to +1‰). The associated δ18O values show an increase from –8‰ to –3‰. In the upper part of the third member, there is a gradual up-section 13C enrichment, with the acme of δ13C values at +2‰; this trend is repeated in all studied sections, with exception of 0701 where δ13C are close to 0 and can even be negative. The associated δ18O values range between –8‰ and –2‰ slightly increasing up-section. The observed variations in δ13C values could be related to secondary alterations of carbonate material, possibly due to sediment bioturbation and subsequent diagenesis. The fourth member consists of intraclastic dolomitized limestones, finely laminated limestones and intervals of alternating thin layers of limestones and shales. It is characterised by a positive excursion of δ13C values, whereas δ18O values range between –10‰ and –2‰ with no particular trend. This work was supported by the Russian Science Foundation (grant 20-67-46028) and Russian Foundation for Basic Research (grant 18-05-7011).

High resolution carbon isotope chemostratigraphy and the age of the Tuwaiq Mountain Formation, Saudi Arabia

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The Jurassic Tuwaiq Mountain Formation (TMF) of Saudi Arabia, as recently defined by W. Hughes in 2018, is host to three significant hydrocarbon reservoirs (Hadriyah, Upper Fadhili, and Lower Fadhili). The formation includes five members from youngest to oldest are the Daddiyah (Tm-5), Maysiyah (Tm-4), Baladiyah (Tm-3), Hisyan (Tm-2), and Atash (Tm-1). The age of the TMF has been reported to range from Early Callovian to Middle Kimmeridgian. The latest TMF age assignment is upper Middle Callovian (Coronatum) to lower Upper Callovian (Athleta) and is based on micro- and macrofossil assemblages. Ammonites from the TMFhave only been recovered from two zones. In the upper part of TMF (Tm-5), El-Asa'ad in 1992 reported ammonites he considered Athleta-Lamberti equivalent. Ammonites equivalent to the Coronatum biozone have been recovered from the middle of Tm-3 by several researchers with the earliest recovery reported by W. J. Arkell in 1952.

Here we report on high-resolution carbon isotope chemostratigraphy of a TMF subsurface core from eastern Saudi Arabia. We correlate our record to the carbon isotope profiles reported for central Saudi Arabia outcrops and shallow cores. To constrain the age of the TMF, we calibrate the Saudi Arabian carbon isotope records against a well-dated carbon isotope profile from the Eastern Paris Basin (EPB). Sixteen carbon isotope excursions (CIEs) (ten positive and six negative), five trends (three enrichments and two depletions), and nine pattern segments (S0 to S8) are present and correlatable between the TMF and EPB records. Based on the correlation of the patterns, the depletion and enrichment trends, and the CIEs we conclude that in central Saudi Arabia the base of the TMF is early Callovian in age with thin intervals preserving the Gracilis (previously of an uncertain age) and Jason biozones (previously assigned to Coronatum). The early Callovian Gracilis and Jason zone are absent in the eastern Saudi Arabia TMF core interval. On the outcrop and subsurface TMF, the Coronatum zone extends from the boundary of pattern segment S0 to the lower part of segment S4 up to positive CIE 3a.

The Athleta zone extends from CIE 3a in segment S4 to the lower 2/3 of segment 5 and CIE 4c. In central Saudi Arabia, this segment was assigned mostly to Coronatum, and only the last 10 meters were assigned to Athleta. The Lamberti zone is present in the uppermost 1/3 of segment S5 and lower half of S6 up to CIE 5a. Consistent with many studies that assigned uppermost TMF to the Early Oxfordian, the uppermost TMF CIE correlates with the Early Oxfordian Mariae Scarbur Zone. The unconformity atop the TMR coral rich layer and the shaly lower Hanifa (Hawtha Member). In the subsurface of eastern Saudi Arabia, the TMF extends into the Lower Oxfordian and through the equivalent of the Mariae praecor zone. The boundary between the TMF and the underlying Dhruma Formation and the overlying Hanifa Formation are diachronous and younger in the easternmost Saudi Arabia.

Reconstructing tectonic history of active plate margins with Nd isotope composition of hydrocarbon-seep carbonates

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Recent studies have addressed the potential applicability of the Nd isotope system in studies of subseafloor migration patterns of fluids feeding deep-marine methane seeps (Jakubowicz et al., 2015, 2019). The method has been shown to provide a faithful record of former interactions between the seeping fluids and mafic igneous materials. Nevertheless, the prospects of the system to address broader geological questions, such as those regarding structural architecture of seep-hosting sedimentary basins, remained largely unexplored. Here, we have performed multiproxy geochemical analyses of two suites of hydrocarbon-seep deposits underlain by thick mafic volcanic packages: mid-Eocene seeps of the Cascadia convergent margin (Washington, USA), and mid-Cretaceous seeps of the Basque-Cantabrian continental rift system (Basque Country, Spain). For Cascadia, the studied deposits represent the oldest seeps of the Pacific Northwest, providing a record of fluid expulsion during a period of dramatic margin reconfiguration, following docking of the large, igneous Siletzia terrane at 50–45 Ma. The observed strongly radiogenic εNd(t) values and unradiogenic 87Sr/86Sr carbonate isotope signatures consistently point to former interactions between the seeping fluids and volcanic sequence of the Siletzia terrane comprising the forearc basement. The carbonate δ13C values imply, in turn, thermogenic origin of methane at most studied Cascadia seeps. In a broader context, the study documents that a fluid expulsion system typical of convergent accretionary margins was already active prior to maturation of arc magmatism in the Cascades, lending support to the models placing the onset of the Cascadia subduction before development of the typical Cascade volcanic arc. Notable enrichment in volcanic-derived, radiogenic Nd has been observed also for the seep deposits of the Basque-Cantabrian Basin. In this case, the increased εNd(t) values point to a critical role of igneous intrusions in hydrocarbon formation from the rift-filling sedimentary succession, confirming previous hypotheses as to the controls on mid-Cretaceous fluid generation and expulsion in the Basque-Cantabrian area based on indirect data. Further, these analyses provide documentation of divergent responses of the fluid generation systems to different styles of intrusion emplacement, enabling field-based validation of some theoretical models on the mechanisms of hydrocarbon generation in thermal aureoles of igneous intrusions. Both our cases studies show that the Nd isotope investigations, especially in combination with other proxies, such as 87Sr/86Sr, rare earth element or stable isotope analyses, can provide a powerful tool to better understand tectonic evolution of many convergent and divergent plate margins, most of which contain a number of similar, fossil methane-seep deposits.

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Late Permian climate record in the continental and palustrine facies in SE Central European Basin

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Upper Permian continental deposits from the NW marginal part of the Holy Cross Mountains, Poland (SE part of the Southern Permian Basin, SPB) comprise a set of lithofacies which developed under arid and semi-arid climatic conditions in the saline mudflats and sabkha. They are represented by over 100 m thick sequence of redbeds with common accumulation of evaporites (including gypsum, anhydrite, dolomite, and calcite pseudomorphoses after evaporites) which are the lateral, continental equivalent of thick halite and carbonates of marine Zechstein cyclothems (Z1-Z4; Werra-Ohre cyclothem) recognised in the central part of the SPB. Harsh arid conditions are also highlighted by the scarcity of palynological material (with exception of some xerophytic forms) as well as the mineralogical composition with unaltered plagioclases, feldspars, and micas. The presence of the latter could also indicate deposition from a volcanic aerosol fallout.

With the onset of the Aller cyclothem (Z4) a subtle change in the climate towards more semi-arid conditions is reflected by the disappearance of evaporitic facies and introduction of vertisols – soils typical for floodplains with high climatic drying-wetting contrasts. These pedofacies are commonly interbedded with the heterolithic intervals with widespread calcification, emersion structures (desiccation cracks), and locally with rootlets, suggesting presence of semi-perennial to ephemeral lakes. In places, especially in relative vicinity of thick carbonate conglomerates, nodular, brecciated, and oncoidal floatstones can be found, which are commonly penetrated by thin rootlets. Microfacies analysis displays various features including circular cracks, pseudomicrokarst and pedorelicts. Cathodoluminescence reveals multiple cementation and dissolution phases which point to underground water oscillations likely caused by highly variable climatic conditions. Such micro- and macroscopic features indicate development of palustrine carbonates at the toe of an alluvial fan system. Integrated sedimentological, microfacies, mineralogical, and carbon and oxygen isotope analyses indicate strong seasonality in the latest Permian period which might be linked to the already unstable environmental conditions preceding the Permian-Triassic extinction event.

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Control of diagenetic facies and sedimentary microfacies on physical properties in low permeability reservoir

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The Chang 8 (eight member of Upper Triassic Yanchang Formation) reservoirs in Huanxi-Pengyang area of Ordos Basin are characterized by low permeability due to the diagenetic modifications and deposition of braided river delta. Therefore it is necessary to investigate the microscopic pore structure and macroscopic reservoir quality in order to clarify the regularity of oil accumulation. To address the challenge, petrologic characteristics, petrophysical properties and logging responses and prediction of reservoir can be studied by means of core observations, thin section observations, scanning electron microscopy and X-ray diffraction analysis.

The reservoir in this area has experienced two large-scale hydrocarbon charging in the process of burial with complex diagenesis, and the diagenetic minerals include quartz, carbonate and clay minerals. The pore spaces include intergranular pores, intergranular and intragranular dissolution pores as well as micropores.

As a consequence, similar sedimentary microfacies and diagenetic facies can be classified based on diagenesis and diagenetic minerals, with the aim for comprehensive evaluation of reservoir characteristics: (1) Dissolution facies corresponding to the braided channel; (2) Chlorite-coating diagenetic facies corresponding to the braided channel; (3) Cementation facies corresponding to the overbank deposits and braided channel; (4) Tightly compaction-clay mineral filling facies corresponding to the interdistributary bay and overbank deposits. Combined with the type of pore structure and physical properties, the reservoir can also be divided into four types in order: (1) Type I reservoir characterized by medium-low porosity and low permeability with many unstable mineral components is the best reservoir; (2) Type II reservoir is a low porosity and permeability reservoir with intergranular pores; (3) Type III reservoir is a tight reservoir with quartz and carbonate mineral cementation; (4) Type IV reservoir characterized by intensive mechanical compaction is the poorest tight reservoir. The classification indicates that the reservoir characteristics are closely related to pore structure, sedimentary microfacies and diagenetic facies.

The existing evidence of petrophysical experiments combined with the reservoir physical properties calculated by logging can determine reservoir types. This method can be used to uncored intervals and predict the distribution of high quality reservoirs in a single well or the whole area. The results show that the reservoir distribution trend is NE-SW, Type II reservoir has a high proportion, Type I and Type III reservoirs are locally developed, and Type IV reservoir is sporadically distributed in this area. The above research could enrich the theory of reservoir geology and have implications for the exploration in new area with similar geological settings.

Lake-level and flood reconstructions from tephra-derived particles in lake sediments since 33ka in Southern Patagonia

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In southeastern Patagonia, strength and position of the Southern Hemisphere Westerly Winds (SWW) control precipitation dynamic. Currently, due to the rain shadow effect of the Andes Mountains, strong westerlies impose dry conditions in southeastern Patagonia. Moreover, westerlies prevent precipitation to come from the Atlantic Ocean. In this region, paleohydrological and paleowind records obtained from the analyses of lake sediments can thus reveal latitudinal shifts of the SWW over time. Here we present results from the ICDP-PASADO project, and show how combining micro-scale sedimentology (especially tephra-derived particles), geochemistry (µ-XRF) and diatom analysis allows detailed reconstructions of past lake level changes and shifts in SWW intensity/position between 33 and 10 ka BP in Southern Patagonia (Laguna Potrok Aike, 52°S).

The Antarctic Isotope Maximum 4 is an analogue of the current global warming and it strongly impacted SWW dynamics in South America as evidenced by decreases in the thickness of flood-induced turbidites, increases in wind burst deposits and the remobilization of emerged tephras, all of which reveal drier conditions and lower lake levels during this period. These results agree with paleoproductivity (diatom concentration) and paleowind (magnetic properties) from the same core. In addition, the cyclic diatom assemblage shifts, as well as the changes in Ca/Si (µ-XRF) and micropumice fragment profiles before, during and after the Antarctic Cold Reversal (ACR) and the Younger Dryas (YD) chronozones reveal at least five major lake level fluctuations. The periodicity of those lake level changes indicates millennial-scale variability of latitudinal SWW positions that correspond to Antarctic ice sheet discharge events during the Late Glacial.

Sedimentary dynamics and water resurgences from high-resolution seismic reflection survey in Lake Altaussee (Austrian Alps)

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Alpine lake sediments have proven their efficiency to record regional climate variability and geohazard history at several timescales. However, the understanding of lake responses to external environmental factors depends on a precise knowledge of internal lake functioning. High resolution imaging of lake sedimentary infill is crucial to unveil internal and external factors impacting sedimentary processes. In memory of Walter Munk and to his considerable contribution to underwater geophysics, we present high-resolution seismic reflection data from Lake Altaussee (Walter Munk hometown lake in Austrian Alps), recently acquired using iXblue Echoes 10 000 sub-bottom profiler. Interpretations are supported by multibeam echosounder bathymetry and hydrochemical data.

Lake Altaussee is situated at 713 m a.s.l. in Northern Calcareous Alps (Salzkammergut, Austria). Lake depression is 2.6 km long, 1 km width and mean water depth is 53 m. Three main echofacies are observed: High/low intensity reflectors following the lake bed topography, Structureless weak amplitude layer on top of the bedrock, Massive and discontinuous structures at the eastern part of the lake.

First type suggests a great potential to reconstruct Late Holocene environmental and climatic events. Second type is probably associated to landslides. Third type is located on top of holes and water resurgence (also visible in the bathymetry) and is attributed to carbonate sedimentation due to supersaturation and oxygenated conditions at the karstic system output. This hypothesis is supported by lower temperature and salinity measured at the karstic system output. Using iXblue Delph Seismic software, we constructed 3D modeling of the lake sediments by generating isopaches of main reflectors and estimated spatial distribution of sediment volume. Our model helps at deciphering different sedimentary dynamics along the lake infill history and to suggest the deposition of historical geohazard events on top of the bedrock.

Paleosols and palustrine facies in Devonian-Carboniferous shallow-marine carbonates in the context of land plant evolution

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Knowledge on the early development of vegetated landscapes during the Middle Paleozoic mostly arrives from the floodplain successions where paleosols co-occur with plant body fossils. Due to better preservation in the sedimentary record, the shallow-marine carbonates avail much broader areas of former land surface preserved at disconformities, although the associated fossil floras are rarely preserved there. This review demonstrates how much can be learned from this underused sedimentary archive.

Devonian: Exploration-drilling cores from the Northwest Territories, Canada, reveal hundreds of subaerial discontinuities in peritidal carbonates of the Emsian-Eifelian age. These discontinuities range from incipient surfaces with solution vugs to paleokarst profiles of several meters in thickness and thick (≤1.7 m) calcretic-clayey paleosols. Two of these paleosols preserve moderate δ13C offset towards lighter values. However, none of paleokarst and paleosol profiles contain traces of vascular-plant roots. These strata also contain numerous palustrine intervals, which is the earliest known occurrence of such facies in a coastal carbonate plain environment. Palustrine beds are characterized by fine synsedimentary brecciation, incipient pedogenic micromorphology, and swarms of thin rhizoliths.

Mississippian: This study kept focus on outcrops of Moscow Basin, Russia. The Middle Mississippian paleokarst profiles, occasionally with pedogenic claystone in their upper parts, are often capped by thin coaly seams. A distinct dark-colored marly sediment is developed as lenses or continuous beds above several paleokarst profiles. This facies, interpreted as palustrine sediment, is composed of a mix of isotopically light micritic calcite and authigenic saponite, and Stigmaria (anchoring structures of arborescent Lycopodiophyta) abound. Stigmaria also occurs in shallow-marine limestones indicating a mangrove-like niche of lycopod trees.

Pennsylvanian: Paleosols developed at seven successive disconformities in the Middle Pennsylvanian of Moscow Basin consist of an upper claystone layer, a crust of rhizogenic calcrete, and a karsted limestone underneath. Microcodium structures are common. Rhizoliths penetrate to at least 3 m below disconformities. Claystone composition is palygorskitic to smectitic. A detailed study of a palygorskitic paleosol reveals shallow pedogenic carbonate and 1.1–1.5% of fulvate dominated organic matter resembling the organic matter from present-day dryland soils, which suggests a surprisingly high primary productivity for such old semi-arid landscape.

The root structures are extremely rare in such settings until the Carboniferous: two reports from the Frasnian and Givetian and none from the Famennian and pre-Givetian. This indicates that the land surface in carbonate coastal landscapes remained a barren regolith (primary desert) long after the spread of vascular plants in wetland settings, and only ponded habitats like coastal marshlands became colonized by small-stature tracheophytes as imprinted in palustrine carbonates. Furthermore, paleobotanical evidence for the restriction of vegetation to wetland habitats for the entire Devonian prompts to think that the areas of unvegetated regoliths prevailed over vegetated land surface for quite long. The embryophytic green cover of even older, pre-Devonian land was confined to amphibian loci, and its biomass could be only negligible, which discredits a hypothetical link between the advent of land plants and the Late Ordovician atmospheric oxygenation-decarbonization event.

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Anoxic events and photic-zone euxinia in an oceanographically open Devonian shelfal sea, NW Canada

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The latest Eifelian – Frasnian (Devonian) strata of the Mackenzie Plain, NW Canada, provide an excellent archive of paleoceanographic signals imprinted in oxic and anoxic facies deposited in close proximity. Fondoformic black-shale strata preserve fingerprints of four global anoxic events (Kačák-otomari, Frasnes, Middlesex- punctata, and Rhinestreet), which receives confirmation with stable carbon itotope data. The discovery of 2,3,6- and 3,4,5-trimethyl aryl isoprenoids (biomarkers of green sulfur reducing bacteria) at and between the levels of anoxic events contributes to the growing evidence of photic-zone euxinia as a common state of oceanographically open and semi-restricted shelfal basins of the Middle Devonian – Early Mississippian, a condition impossible under present-day vigorous thermohaline circulation, but consistent with models of greenhouse ocean depicting drastic slowdown in watermass turnover, reversals of deep ocean circulation, greatly expanded oxygen minimum zones, and profoundly changed nutrient flows. The studied rocks were deposited in an oceanographically open basin with fluctuating chemocline as attested by unstable presence of gammacerane in GCMS spectra and co-occurrence of signatures of water-column euxinia and pyritized hyalosponge spicules indicating episodes of weak bottom oxygenation. Shallow-water carbonate banks in the same basin show signatures of reduced hydrodynamic activity and do not imprint sea level changes in excess of several meters, which lines up with the shortage of evidence for high-amplitude (e.g., exceeding ~30 m) base-level fluctuations in coeval strata worldwide. This supports discarding changes in sea level as the principal control over Devonian anoxic events and instead suggests pulsatory expansions of thick, semi-continuous oxygen minimum zones of the greenhouse ocean. Sea level fluctuations could still be involved as thermal transgressions of ~10 m magnitude or less at peaks of ocean warming.

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Evaluation of wave and wind power operated in foreshores using grain shapes and size distributions

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Sedimentary grains acquire their overall shape and surface roughness through the sedimentary environment-specific hydrodynamics. Therefore, the shape of grains possesses important information for estimating the transportation history that grains underwent. Numerous indices have been proposed of the investigation of grain shapes (e.g., Roundness Index of Wadell (1932)). Recently, Suzuki et al. (2015) quantitatively evaluated sand grain shapes using elliptic Fourier and principal component analysis (EF-PCA) and proposed the elongation index (REF1) and the boundary smoothness index (SEF).

In this study we adopt EF-PCA to evaluate foreshore sand grains, aiming to extract wave and/or wind power operated in different foreshores. In addition to the single grain shape parameters mentioned above (REF1 and SEF), the skewness and kurtosis of the overall grain size distribution were measured by Camsizer-P4 (Retsch Tech).

Samples were collected from 16 foreshore sites in Japan. The grain shape and grain size distribution parameters obtained from sediments were regarded as explanatory variables to predict following objective variables; the wave and wind power operated in each site as well as geographic characteristics such as expansiveness of strand plain and fetch.

Principal component analysis was conducted using all above-mentioned variables, i.e., sand grain proxies and foreshore physical parameters. The principal component 1 (PC1) is highly correlated with mean annual wind power and SEF. In addition, if the expansiveness of strand plain increases (wider backshore sand dune field), the PC1 scores tend to increase. Therefore, the PC1 can be interpreted as a latent environment variable representing the aeolian-dominant foreshore regime. Since SEF shows high correlation with PC1, it suggests that subaerial gliding by wild power operates efficiently to smooth the grain boundary. The principal component 2 (PC2) shows correlation with wave intensities as well as REF1 and Kurtosis. The PC2 can be interpreted as a latent environmental variable representing the wave-dominant foreshore regime. The PC2 suggests that subaqueous grain collisions and sorting by wave actions tend to transform grain shapes from elliptical to circular, and the grain size distribution becomes more leptokurtic. On PC1-PC2 biplot, 16 foreshore sites will be scattered depending on their wind and wave powers. However, two distinct clusters are revealed. Foreshores facing an open ocean (Pacific) tend to plot on the right side of PC1-PC2 biplot, whereas those of close ocean (Sea of Japan and Sea of Okhotsk) are generally located on the left side.

Therefore, we conclude that by the use of the grain shape parameters and skewness and kurtosis of grain size distribution, aeolian- and wave-dominant environments can be distinguished. Furthermore, the scale of the ocean that each foreshore is facing can be speculated. In future studies, we attempt to extract the quantitative numerical values of aeolian power and wave power by using the grain shape and grain size distribution indices of the foreshore sediments.

3D Seismic Geomorphology Analysis of the Moki and Mount Messenger Formations, Taranaki Basin, New Zealand

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Southern Taranaki Basin is an ideal location to explore the evolution of shelf-slope sedimentary systems because of a thick Miocene to Pleistocene succession and the wide availability of 3D seismic data. Current interpretations show that the Miocene shelf-slope system was incised by submarine canyons containing large-scale feeder channel complexes. However, the details of the evolution of these depositional systems remain poorly constrained, especially for the Mount Messenger Formation. A seismic geomorphological analysis is necessary to improve understanding of the shelf-slope depositional elements and their sediment transport pathways. Published examples of such analyses do not presently exist in the Southern part of the basin, and we fill that void.

We investigated the Moki Formation and Mount Messenger Formation in the Maui 3D volume through a detailed seismic geomorphological analysis. The Moki Formation is a sand-rich turbidite complex deposited during the Middle Miocene, enclosed by Manganui Formation mudstones. The Mount Messenger Formation comprises sand-filled channels, deposited during the Late Miocene. Major regional seismic reflectors were interpreted from surrounding key wells, calibrated against biostratigraphy data. Seismic attribute extraction, including RMS, coherence, dip, and spectral decomposition were used to image submarine channels from both stratigraphic intervals. Quantified differences between channel geometry were used to infer changes in sediment transport mechanisms, slope gradient and stability, sediment supply, and other related factors. Results show that the Moki submarine channels display little to no lateral channel migration, and they show low sinuosity. Sand supply terminated abruptly by the Waiauan Stage in the Moki system, which was then proceeded by a large volume of mud deposition. The Mount Messenger Formation sand was deposited in highly meandering channels with lower width-to-depth ratio channels than the Moki channels. The Mount Messenger channels developed contemporaneously alongside progradational muddy foresets. The composition of both channel systems is mixed mud and sand, however, the Moki system has higher sand-to-mud ratio than the Mount Messenger system.

The analysis concluded that during Moki deposition (Middle Miocene), the source of sediment was relatively proximal (early uplift and erosion of Southern Alps). In contrast, the source of sediment during Mt. Messenger time (Late Miocene) was the erosion of the Southern Alps and inversion of Southern Taranaki Basin, which produced higher mud-to-sand ratios in the Mount Messenger channels on a broad shelf and gentle slope margin. The slope became unstable in the Late Miocene due to an increased influx of sediment and prominent fault re-activation along the Taranaki Fault. Both drainage systems transported sediment to the northwest and morphed into submarine fans distributed across an extensive area of the basin and extending to the Western Stable Platform. These findings are important because they can be used to infer shifts in sediment volume and supply within submarine fan depositional systems in New Zealand and other parts of the world. Future efforts should focus on understanding the architecture of potential reservoir columns in both formations.

Palaeoenvironmental significance of Lower Triassic (Induan) lacustrine carbonates in Central Germany

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We propose a new facies classification scheme of the cyclic lacustrine carbonates of the Bernburg Formation (Lower Triassic, Induan), with a major focus on the microbial biota and grains. Our data are based on a detailed bed-by-bed outcrop study in Central Germany, within a robust (litho)stratigraphic framework. We concentrate on two intervals of the Bernburg Formation: one around the Calvörde/Bernburg Formation boundary, and a second around the ninth cycle near the upper formation boundary. The textural and mineralogical composition of the two endmember components: skeletal stromatolites and oolites, and the macro-, meso-, and microstructural characteristics (supplemented by μ-XRF-data) allow to classify the carbonates into five lithofacies types. They are interpreted with respect to the development of an ideal lacustrine depositional cycle, embedded between a lake level rise and a lake level fall. The microfacies attributes of the microbialites include various lamination types, shrubs, spherulites, and laminated/clotted/fenestral microfabrics. All sedimentologic (macro-, meso, and microscale) and geochemical data of this study indicate nearshore deposition of the carbonates at marginal shoals in a major endorheic lake (playa lake) with high alkalinity and salinity, and strongly fluctuating lake levels, under arid climates. The lacustrine carbonates are associated with maximum lake expansions, and are laterally interfingering with fan deltas, as indicated by abundant clastic grains in the intercalations of the skeletal stromatolites. The Bernburg Formation microbial buildups reflect changes in lake level, hydrodynamics and grain supply, and therefore offer insights for the paleoenvironmental interpretation of lacustrine microbialites elsewhere.

Diagenesis of carbonate sedimentary breccias formed during Late Jurassic extension, Bas Agly syncline (Pyrenees, France)

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This study focuses on carbonate sedimentary breccias, the so-called "Brèche limite", widely developed in the Bas Agly syncline at the Late Jurassic/Early Cretaceous boundary. It has been clearly demonstrated in a previous study that these sedimentary breccias of significant thickness (several tens to hundreds of meters), formed during extensional tectonics are spatially associated with large-throw normal faults. They result from the creation of a steep topography that becomes unstable, producing major rockfalls and eventual debris flow. However, the heterogeneity and complexity of the structure of carbonate breccias requires a detailed characterization of both their petrographic evolution and diagenetic paleoenvironment.

The aim of this study is to understand the origin and timing of the early mineral phases that can occlude the interclastic space and that characterize the diagenetic paleoenvironments of the formation of these breccias. Moreover, the subaerial and/or subaqueous character of these breccias is one of the major objectives of this study. For this reason, thin sections of these breccia facies were analyzed by the Alizarin – Potassium Ferricyanide mixture, cathodoluminescence, confocal and Scanning Electron Microscopy (S.E.M.). In addition, sampling of matrix and cement were carried out using a Dremel micro-drill to analyze their composition in stable isotopes of carbon ($\delta 13C$) and oxygen ($\delta 18O$).

Based on observations under S.E.M, polarized-light and fluorescence microscopy a detailed inventory of the diagenetic phases has been performed. From these analyses, a diagenetic sequence and a chronology of the cements be reconstructed, by using principles of overlapping, superposition, and inclusion. The occurrence of metamorphic minerals overprinting the latest phase of calcite cementation strongly suggests that the breccia deposited prior to the Albo-Cenomanian regional metamorphic phase and support our interpretation of an interstratified sedimentary breccia of Late Jurassic age.

Finally, the present work provides a set of petrographic criteria which allows discriminating the nature of carbonate breccia (sedimentary vs tectonic) and interpreting the physical processes leading to their formation and their depositional environment.

Keywords: breccias, sedimentary, extension, diagenesis, geochemistry, S.E.M, Late Jurassic, Pyrenees.

Impact of Depositional Environment on the Evolution of Shale Lithofacies

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The Es3x shale of the Eocene Shahejie Formation is one of the target prospects for shale oil exploration in the Bohai Bay Basin, Eastern China. Thin section analysis, X-ray diffraction (XRD), X-ray fluorescence (XRF), total organic carbon (TOC) analysis, and field emission scanning electron microscope (FE-SEM) coupled with energy dispersive spectrometer (EDS) are used to observe the characteristics of the depositional environment and their effect on the evolution of shale lithofacies of Es3x member of Eocene Shahejie Formation in the Zhanhua Sag, Bohai Bay Basin. The Es3x shale has high carbonate minerals concentration (average of 67.3%), low siliceous and clay minerals concentration (averages of 9.6% and 20%, respectively), low pyrite (average of 3.2%), high TOC content (average of 3.49%), and also has well-developed laminations. Based on TOC content, mineralogy, and sedimentary structures, six different types of shale lithofacies including Organic-rich laminated clay-bearing aragonitic shale (ORLCBAS), Organic-rich non-laminated clay-bearing calcareous shale (ORNLCBCS), Organic-fair non-laminated calcite-bearing argillaceous shale (OFNLCBAS), Organic-rich laminated clay-bearing calcareous shale (ORLCBCS), Organic-poor laminated clay-bearing calcareous shale (OPLCBCS), and Organic-poor laminated quartz-bearing calcareous shale (OPLQBCS) have been established. To confirm the primary factors in the development of Es3x shale lithofacies in the Zhanhua Sag, numerous groups of elements were selected as geochemical proxies (Rb/Sr, Ca/(Ca+Fe), Ti/Al, Al/Ca, Al/Ti, Zr/Rb, Si/Al, Fe/(Ca+Mg)) to monitor the variations in the characteristics of the depositional environment including paleoclimate, paleosalinity, detrital influx and provenance, paleohydrodynamic conditions, sediment maturity, and water depth. The sedimentary setting during the Es3x deposition had a warm and humid climatic condition, higher salinity, restricted detrital influx, intermediate igneous provenance, high paleohydrodynamic conditions, least sediment maturity, and strongly reducing conditions. As a result of these factors, the lithofacies of Es3x shale are characterized by high TOC content, higher carbonate minerals, low clay and siliceous minerals.

Characteristics and Distribution of Pyrite in the Es3x Shale (Shahejie Formation), Zhanhua Sag, East China

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Pyrite is a common mineral in sedimentary rocks and is widely distributed in a variety of different morphologies and sizes. A combined geochemical and petrographic methodology is applied to address the characteristics and the distribution of pyrite in the Es3x shale of the Eocene Shahejie Formation in the Zhanhua Sag, Bohai Bay Basin, East China. The methods include thin section analysis to identify the representative samples of the shale containing pyrite, LECO carbon/sulfur analyzer for determining the total organic carbon (TOC) and total sulphur (TS) contents, X-ray fluorescence (XRF) for the investigation of elemental geochemistry, X-ray diffraction (XRD) to identify the mineralogical composition, and field emission scanning electron microscopy (FE-SEM) coupled with energy dispersive spectrometer (EDS) to observe the characteristics and morphological behavior of pyrite in the lacustrine shale. The concentration of pyrite in the Es3x shale is ranging from 1.4% to 11.2% with an average concentration of 3.42%. TOC content is ranging from 1.12 wt.% to 6.56 wt.% with an average concentration of 3.48 wt.%, while TS content is ranging from 0.98 wt.% to 5.46 wt.% (average of 2.53 wt.%). Two types of pyrite are observed during the detailed FE-SEM investigations, pyrite framboids and euhedral crystals of pyrite. Pyrite framboids are abundantly present and are densely packed in spherical aggregates of sub-micron sized pyrite crystals with sub-ordinate large-sized euhedral crystals of pyrite. The presence of pyrite, especially the abundance of pyrite framboids suggests that the sedimentary environment during the deposition of Es3x shale in the lacustrine basin was anoxic, while their dominant smaller size suggests the precipitation from a euxinic (anoxic and sulfidic) water body, which is consistent with the lack of in-place biota and the high TOC content.

The effect of redox conditions on the chemical behavior of uranium in the Bazhenov Formation

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The content of uranium considerably varies in marine source rocks depending on conditions of uranium accumulation at the sedimentation stage and chemical behavior of uranium during diagenesis and catagenesis stages. Today the borehole logging data on uranium content are widely applied for identification of source rocks in geological cross-sections and for well-to-well correlation. However, potentially these data could also be applied for detailed analysis of oil forming processes and assessment of oil products, but such constraints are considerably restricted by the insufficiency of knowledge on the chemical behavior of uranium in source rocks.

The objective of this study was to analyze the effect of redox conditions during marine sedimentation on the accumulation of uranium in source rocks. We studied content and chemical behavior of uranium in modern marine sediments and compared obtained results with the data on uranium content in the Bazhenov Formation (Western Siberia).

The behavior of uranium in oxic conditions was studied for more than 100 samples of bottom sediment sampled in the White Sea. The data on the concentration of uranium, thorium, and other metals were measured by ICP-MS, the content of carbon, hydrogen, nitrogen, and sulfur – by CHNS analyzer, isotope compositions of carbon, sulfur, and nitrogen – by IRMS. The behavior of uranium during sedimentation at anoxic conditions has been studied using data published in the literature for the Black Sea sediments. We have shown that uranium concentration in sediments of the Black Sea (anoxic conditions) is in one order of magnitude higher than in the White Sea (oxic conditions). The obtained results have been interpreted using thermodynamic modeling of the system seawater – bottom sediments at different Eh and pH. It has been shown that in oxic conditions, most part of uranium is in the water phase in soluble form, whereas in anoxic conditions, most part of uranium is in the forms of insoluble oxides.

The data on uranium content and U/TOC ratio have been analyzed for the Bazhenov Formation jointly with lithological, petrophysical, and isotope-geochemical data. From the comparison of obtained results on the Bazhenov Formation and modern bottom sediments, and we made a conclusion that redox conditions were also the most important factor for the accumulation of uranium in the Bazhenov Formation. The results of the study have been applied for evaluation of sedimentation conditions from the borehole logging data on uranium content for several wells, located in the central, North, and South regions of the Bazhenov Formation.

Sedimentological analysis of the Pokur Formation deposits in the north of West Siberia, Russia

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Upper Cretaceous Cenomanian deposits in West Siberia are the main gas production targets in Russia. The Pokur formation in the Tazov-Urengoy lithofacies subregion is divided into the upper, middle and lower subformations. It overlies the Ereyama formation and is overlain by the Turonian Kuznetsov formation. One of the main objectives is to locate the planned wells based on the updated facies model. Sedimentological analysis was conducted on cores from four wells in PK1 (Cenomanian top). The PK1 is 40 to 60 m thick in the area of interest. The stratigraphic depth is 980–1050 m. The sediments are represented by uneven interbedding of sandstones, siltstones, and clays formed in various depositional environments. As it can be observed the facies change from continental to marginal marine bottom up the section.

The fluvial channel facies is represented by medium fine-grained to fine-grained sandstones, medium sorted, with cross-bedding and cross-lamination, containing plant detritus and carbonized wooden chunks, mud intraclasts, with erosion surface at the base. Floodplain deposits are represented by thin-layered siltstones and clays with interbeds of coal and carbonaceous plant roots.

The tidal channel facies is composed of medium-fine-grained to fine-grained sandstones, with bidirectional cross-bedding, sigmoidal bedding, double mud drapes, inclined heterolithic stratification, plant detritus, and with low diversity (Cylindrichnus, Skolithos) and density of trace fossils. The rocks permeability reaches 6500 mD and porosity 40%. The facies thickness is 5–10 m. The tidal flat facies is characterized by irregular interbedding of sandstones, siltstones, and clays. Bedding is striped, flaser, and wavy-lenticular, with low diversity of trace fossils (Skolithos, Planolites, Cylindrichnus, Arenicolites), low to intense bioturbation, syneresis cracks are typical. The march facies is composed of siltstones and clays with of coal interbeds, carbonaceous detritus, roots, trace fossils such as occasional Planolites, siderite nodules.

The lower shoreface facies is represented by fine-grained to medium-fine-grained well-sorted sandstones and coarse-grained siltstones, intensely bioturbated (Skolithos, Diplocraterion, Arenicolites, Cylindrichnus, Planolites, Chondrites, Asterosoma), with rare, up to 3 cm thick storm beds. Sandstones contain shell fragments, belemnite rostra, glauconite. Permeability reaches 1000 mD, porosity reaches 32%. The facies thickness up to 10 m.

Based on core analysis and well logging data, four IV-order sequences were identified, upward: PK1-4, PK1-3, PK1-2, PK1-1. The sequences are 5–20 m thick. PK1-4 is composed of fluvial channel sandstones, siltstones and floodplain clays. The PK1-3 and PK1-2 were formed in the tidal flat environment. Spectral decomposition maps show the shape of river and tidal channels from slightly meandering to straight. The sediments were transported from the east and northeast to the west. A further rise in sea level resulted in the formation of sheet bioturbated sandstones of the shoreface (PK1-1). The medium fine grained sandstones of river and tidal channels including shoreface sandstones are characterized by best reservoir properties. Reservoir properties deteriorate due to calcite cement, grain size reduction, and bioturbation increase. Among clay minerals in the Pokur, an increased content of montmorillonite is observed which must be accounted during field development.

Early Permian ichnofossils assemblage from Bieganów quarry and surrounding localities, Słupiec Fm – Intrasudetic Basin

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The Early Permian (Lower Rotliegend) terrestrial trace fossils assemblages from the Intra-Sudetic Basin correspond well with the Variscan sedimentary basins of the NE Czech Republic and Germany (e.g. Boskovice Basin, Thuringian Forest basins and Saar-Nahe Basin) as well as Autunian Basins (e.g. Ledeve France).

The systematics of the terrestrial trace fossils encounters serious difficulties due to the lack of sufficiently transparent criteria in the description and determination of their individual ichnospecies. Most of the determinations originate in the past from marine ichnocoenoses, which in many cases do not have their exact counterparts in terrestrial conditions. Additionally, many of the traces described contain diagnostic features that classify them simultaneously into various taxonomic groups. For this reason, some designations are approximate and reduced to their taxonomic level, if possible ichnogenus, or more specifically to ichnospecies. Additionally, terrestrial assemblage contains arthropod trace fossils (larvae and mature forms) often creating traces similar to invertebrates.

Intramontane Intra-Sudetic Basin is filled by red bed type sediments (sandstones, mudstones and conglomerates) alternating with periodic deposits of extensive, relatively shallow lakes represented by bituminous black shales interbedded with carbonate rock units (occasionally tuff layers) and having a vast "red bed" type lacustrine coastal zone. The sedimentary deposition was strongly controlled by seasonal climatic conditions.

An assemblage of trace fossils, as well traces of plant remains, is described from the red bed sandstones assigned to the Lower Rotliegend Słupiec Fm, containing mainly coarse- to fine-grained fluvial dominated facies (channel and flood plain sediments), deposited by predominantly ephemeral flows within an transitional humid to semi-arid environment.

Trace fossils represent traces left by organism living in high-energy sedimentary environments characteristic with rapid burial or erosion, as fluvial channels and floods, and rapid changes in water level. These organisms represent an opportunistic group adapted to difficult and changing living conditions. The adaptation consisted in rapid colonization of the newly deposited sediment. Relatively short, frequent and variable colonization of the sediment explains the absence of dwelling traces (domichnia) (i.e. chambers).

The ichnofauna is dominated by an extensive, but low diversity Scoyenia ichnofacies. The record of invertebrate trace fossils is represented by ichnogenus Planolites, Palaeophycus, Taenidium, and Skolithos. Depending on the condition of the preserved vertical or horizontal surface of the rock slab, the observed trace fossils can be assigned to a different ichnospecies, although they are made by one, the same creator.

Rare traces as arthropod trackways or insect larvae burrows have also been observed. In addition to frequently found locomotion traces of vertebrates, enigmatic or controversial traces of vertebrate resting or nesting were found. There are occasional imprints of accumulated, washed branches of Walchia piniformis and fossil root traces. There was no association between the flora remains and traces of infauna.

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Sedimentology of late Quaternary periglacial slope sediments in the western approaches of northwest Europe

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Periglacial slope sediments are found regionally across the western approaches of northwest Europe including southwest England, southern Ireland and northwest France. These areas are located outside of late Quaternary glacier margins and were therefore not affected by direct glacial erosion and deposition. Slope sediments have therefore potentially accumulated over long periods of time in response to subtle changes in climate forcing. Although slope sediments have been identified and described from several locations regionally, sediment properties and stratigraphy are not well constrained or correlated across the region. This study reviews past and integrates new data from sites across the western approaches in order to identify typical slope stratigraphies and sediment types, including loess, and constrained by radiocarbon and luminescence dating control. This evidence shows the regional-scale context of periglacial environments and sedimentary processes during MIS3 and 2, and their major climatic controls.

Paraglacial coasts – different sedimentary and geomorphic processes during the paraglacial response cycle

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Paraglacial relaxation of sediment systems and therefore their landform dynamics is an important characteristic of deglaciating coasts globally. Models of paraglacial landscape change tend to focus on the dynamics of mountain systems, and little has been done on equivalent systems of paraglacial coasts which can be considered to have more open boundaries and subject to significant external forcing by sea-level change. Thus, previous ideas of paraglacial relaxation responses may not be applicable to paraglacial coasts. This study compares and contrasts the sediment and geomorphic systems and dynamics of coasts that have experienced recent (Svalbard) and late Pleistocene ice retreat (Ireland), with the aim of identifying the major controls on sediment and geomorphic changes at different points in the paraglacial response cycle. The combination of glacially-induced changes in sediment supply, land surface instability, sea-level change and coastal geography results in significant geomorphic and sediment system changes that can be established by mapping, monitoring and sediment dating methods. Results show that these different coasts experience different styles of response that reflect changing sediment sources and the most dominant mechanism of coastal forcing. Feedback processes, e.g. through the development of aggradational coastal plains or by estuary infilling, can variously reduce or amplify sediment system responses through the paraglacial relaxation cycle. This questions the assumption that paraglacial sediment yield simply declines exponentially over time, with implications for the predictive behaviour and management of paraglacial coastal systems.

Sedimentology and ichnology of the Satavadoskhevi section (the eastern segment of the Trialeti Ridge, Georgia)

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The Achara-Trialeti Fold-and-Thrust belt is located in the northernmost part of the Lesser Caucasus and is associated with the Arabian and Eurasian plate convergence. It is E–W trending, 360 km long, 60–45 km wide, and extends from the Black Sea coast towards its end near Tbilisi, where it submerges under young sediments of the foreland Kura Basin. During Cretaceous–Palaeogene, great thicknesses of shallow marine to deep sea sediments accumulated in the basin.

The study area is situated in the northern part of the Trialeti Ridge where a complete sedimentary succession of Paleocene–Lower Eocene turbidites of the "Borjomi Flysh" is exposed. These deposits are involved in folds, which cross section is key for the eastern segment of the Achara-Trialeti Fold-and-Thrust Belt.

Paleocene–Lower Ecocene deposits of the study section (1000–1100 m thick) are mainly represented by fine-grained, locally medium-grained sandstones and siltstones. The section starts with 3–4 m thick package of alternation of medium (20–25 cm) and thick (40–50 cm) beds of fine-grained sandstones. Upwards in the cross-section, they are overlain by intercalations of medium (10–15, 20–25 cm), thick (80 cm and 50 cm) and thin-bedded sandstones (8–10 cm), which contain dark grey plant detritus. In medium–bedded sandstones, Chondrites intricatus, Ophiomorpha plana, Gyrophylites isp. are observed. Further upsection, alternation of medium (10–25 cm), thin (3–10 cm) and very thin-bedded (1–3 cm), fine-grained sandstones are exposed. The mentioned deposits are overlain by interbedded thin (7–10 cm), thick (40–50 cm) and locally medium-bedded sandstones with intercalations of siltstones (5–10 cm). In the medium-bedded sandstones, Chondrites targionii, Scolicia vertebraris, Cardioichnus isp. occur. The cross section ends with alternation of thick (50 cm) and thin (8–10 cm) sandstones interbedded with siltstones (5–10 cm). The bedding planes are sharp; sandstones are calcareous with rare calcite veins. Abundant trace fossils (Scolicia isp., Helmintopsis isp., Paleodictyon minimum, Ophiomorpha isp., Chondrites intricatus, Lorenzinia?) are present in sandstone slabs in the debris.

The ichnological and sedimentological data collected from the studied deposits strongly support an assumption that the Paleocene–Lower Eocene Achara-Trialeti extensional basin/rift was the area of deep-sea turbiditic sedimentation. Although there are many open questions on the more precise correlation of the sedimentary succession, the information presented here will be used for interpretation of palaeoecological and depositional environments, sedimentary dynamics and basin analysis in the Paleocene–Lower Eocene interval.

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Termination of dolostone bodies: ancient reaction fronts record the demise of dolomitization

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Dolomitization has been studied extensively for decades and there have been numerous conceptual models proposed to explain its occurrence. The termination of dolostone bodies – dolomitization fronts – are paleo-reaction fronts, and should provide information on how individual dolostone bodies formed and evolved. The processes controlling dolomite body termination have been remarkably understudied, however, and therefore very little is known about why dolomitization terminates laterally and vertically.

This study focused on the characterisation of dolomitization fronts on a suite of high temperature dolostone bodies formed around faults in extensional basins in the West Canada Sedimentary Basin (Canada, Cambrian), Pennine Basin (UK, Carboniferous) and Essaouira-Agadir Basin (Morocco, Jurassic). Its primary aim was to compare and contrast how dolostone bodies terminated, and the importance of structural, sedimentological and chemical controls on the position of the reaction front. High resolution sampling across the reaction fronts provided information on the textural and geochemical changes that take place at dolostone-limestone boundaries. The principle results arising from this work are:

- The top and basal contacts of dolostone bodies are typically lithologically controlled, and related to contrasts in permeability between the dolomitized limestone and bounding beds. Even a thin (<< 1 metre thick) bounding bed or surface can lead to termination of a dolostone body that is many times thicker (>> 10 meters thick).
- The lateral termination of dolostone bodies is often scalloped or finger shaped depending on the heterogeneity of the host rocks. Dolostone bodies can terminate against fractures, but in some cases these fractures form after dolomitization as a result of contrasting geomechanical properties at the dolostone-limestone contact.
- Although dolomitization fronts appear sharp in outcrop, petrographical analysis reveals a gradation from dolostone to limestone. Changes in stoichiometry and pore volume at the reaction front indicate that a decrease in Mg/Ca ratio of the dolomitizing fluid likely led to the termination of dolomitization.
- Petrographical and geochemical changes across reaction fronts indicate that multiple phases of dolomitization occur, and can result in a back-stepping of the reaction front – towards the fluid source – through time as overdolomitization progressively reduced the effective porosity of the dolostone body. This back-stepping phenomenon also led to the preservation of early-formed porosity on the margin of dolostone bodies.

Redox geochemistry of the Baltoscandia's red orthoceratite limestones: Possible linkage to mid Ordovician palaeoceanographic changes

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Red-coloured marine carbonates, shales and silicites, or marine red beds (MRB), are distinct facies of the Phanerozoic. Their colour is usually implied by iron oxyhydroxides and thus they represent important indicators of synsedimentary, or diagenetic redox conditions. MRB are found in many stratigraphic levels of the Phanerozoic but they are abundant in typically greenhouse or greenhouse-to-icehouse transitional climatic periods such as middle Ordovician, Devonian, late Triassic, Jurassic, Cretaceous, and Palaeogene. Owing to this stratigraphic occurrence and frequent alternation with important anoxic intervals which are characteristic for the above-mentioned period, MRB are considered time-specific facies reflecting the global climatic evolution.

A characteristic example of MRB is the mid-Ordovician (upper Floian to middle Darriwillian) red 'orthoceratite limestone' of Baltoscandia. which is the subject of this study. We sampled about 45m-thick section of the Hällekis quarry, an equally thick succession from the nearby drill core, and a few samples from the Thorsberg quarry, all in the Kinnekulle area, Västergotland, Sweden. The aim was to make an insight into the redox changes in marine mid-Ordovician sedimentary record, and to find possible links to the global climate changes, using microfacies analysis, outcrop gamma-ray logging, diffuse reflectance spectroscopy (DRS), optical and BSE microscopy, electron microprobe analysis, bulk-rock, and in-situ element geochemistry (LA-ICP-MS) of rock samples and thin sections, and molybdene isotopes.

DRS data from the MRB report a prominent absorbance peak at 560–570 nm wavelength which corresponds to hematite as the main carrier of the red colour. The red colouration is carried by submicronic platy grains of hematite dispersed in the mixed clay-micrite matrix, skeletal interiors (echinoderm stereoms) and grain coatings. Hematite inclusions in detrital Fe-Mg phyllosilicates were observed. Early-diagenetic authigenic origin of hematite is indicated by hematite inclusions in the echinoderm stereom and red-grey colour changes associated with Thalassinoides trace fossils. Insignificant correlation was observed between redox sensitive elements (Fe, Mn, Cu, As, Mo, and U) and Al (<0.42), which suggests that their concentrations are unrelated to the detrital input. The MRB are characterized by low U/Th, TOC values (<0.4 %) and low enrichment factors of Mo, U, and V (~ 0.5–5) indicating oxic- to suboxic conditions. The LA-ICP-MS data show that most of the red-coloured samples are enriched in Mn, Fe, As, P, and Mo, and depleted in U, as compared to their grey counterparts. These patterns are associated with diagenetic features (bioturbation and red nodules in grey matrix) suggesting mobilization of these redox-sensitive elements over a short distance during early diagenesis. Stratigraphic trends in the red colouration and geochemical redox proxies are further discussed in the context of Dapingian to Darriwilian regressive-to-transgressive trends indicated by facies stacking patterns, and climatic trends inferred from the published oxygen-, and carbon stable isotope trends including the global Mid-Darriwillian Carbon Isotope Excursion (MDICE).

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Simple polycyclic aromatic hydrocarbons separation procedures: Main controlling factors

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This present study was aimed at identifying and providing more details on the main factors controlling the separation of PAHs according to their number of rings. Two new reliable separation procedures were developed and applied using alumina column and silica-alumina column (1:1) to elute monoaromatics, diaromatics, triaromatics and compounds with more than 3 rings, respectively. Indeed, our results from GC-MS analyses showed that alumina and silica-alumina columns allow a gradual and proper elution of aromatic compounds whereas chromatogram obtained using silica column gave a disorganised distribution of eluted aromatic compounds. Our conclusion was that for a proper separation of aromatic compounds, the column to be used should not contain more silica than alumina. Thus, according to the size of column (cm) used in the laboratory for all the tests, four types of column comprising silica: alumina were designed in order to ensure a reliable separation results regardless of the separation procedure and its related volume of solvent mixture used. These column types are the type 1 (0 cm: 6 cm), type 2 (1 cm: 5 cm), type 3 (2 cm: 4 cm) and type 4 (3 cm: 3 cm) with alumina always on the top. However, there are little differences in using these two chromatographic columns. Our results also showed that alumina column use more solvent (90:10, 40ml) than silica-alumina column (90:10, 30ml) in order to elute diaromatic compounds successfully. This means that the same ratio of the mixture of solvents can be used in these two different columns but not the same volume. Thus, this demonstrates that the type of column and the volume of the solvent mixtures are the main controlling factors for a proper separation of aromatic compounds into different ring classes. The two new separation procedures of PAHs proposed are as accurate and reliable as the related isotopic measurements of individual PAH. In addition, this study provides for the first time a detailed PAH separation guide that will allow to anyone else to carry out these two different separation procedures without difficulties and ambiguity. This research will make easier coming geochemical experiments and useful for the petroleum exploration field.

Keywords: Factors, polycyclic aromatic hydrocarbons, separation procedures, sub-fractions, aromatic fraction, crude oil.

The Eocene-Oligocene transition in Pindos Foreland Basin (western Greece)

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The Eocene-Oligocene transition is a very important time interval due to the environmental and climate changes that are observed. This transition characterized by a dramatic worldwide fall of surface temperature while low oxygen conditions were identified. These low oxygen conditions probably related to the stratification of severe water mass which prevent mixing and ventilation of bottom waters. Calcareous nannofossils and planktonic foraminifera are a useful tool for the paleoenvironmental and paleoclimate analysis but are also used for the age determination at Pindos Foreland basin. The Ionian thrust and the Pindos Thrust demarcated the basin to the west and to the east respectively. Additional, the basin is also affected by smaller thrust faults (Gavrovo, internal and middle Ionian thrusts). The system exhibits a progradational character, with inner fan deposits sitting over outer fan sediments. The studied deposits are dating to Eocene/Oligocene epoch. However the exact stratigraphic position of the Eocene-Oligocene boundary is still uncertain because it has not been conducted any detailed biostratigraphic analysis to define their time span. Thus, qualitative calcareous nannofossil and planktonic foraminifera analysis has been conducted, constraining the depositional age of the studied deposits and documenting the EOT in Pindos Foreland basin.

For calcareous nannofossil analysis, the preparation of samples was made using standard smear slide techniques. Smear slides were analyzed with an optical Optica Italy B-1000POL microscope at 1250× magnification. For the planktonic foraminifera, the disaggregation of the samples was achieved using hydrogen peroxide or/and acetic acid as appropriate, then washed through a 63-μm sieve and were dried at 50°C. An Otto microsplitter was used for the spit of the dry material and the analysis was performed with an Optica SZM-1 stereoscope at 80× magnification. The late Eocene to early Oligocene time interval is corroborated at two different locations in outer fan deposits. The Eocene-Oligocene boundary is determined to the lower part of the turbiditic system. More specifically, the presence of calcareous nannofossils Discoaster barbadiensis, Discoaster saipanensis, Ericsonia formosa, Cyclicargolithus floridanus, Reticulofenestra floridana, Sphenolithus predistentus and planktonic foraminifera Dentoglobigerina sp., Globigerina officinalis, Turborotalia sp. suggests late Eocene. The absence of D. barbadiensis, D. saipanensis in combination with the presence of C. floridanus, Reticulophenestra bisecta, R. floridana, S. predistentus, Sphenolithus distentus, Sphenolithus ciperoensis and the presence of planktonic foraminifera Dentoglobigerina sp., Globigerina officinalis, Turborotalia sp., Catapsydrax unicavus, Dipsidripella liqianyui, Paragloborotalia opima in the middle/upper part of outer fan deposits, confirms the early Oligocene epoch. C. floridanus, R. bisecta, R. floridana, S. predistentus, S. distentus and S. ciperoensis also suggest the early Oligocene time interval in the inner fan deposits.

Further investigation is continued for the biostratigraphic analysis and the foraminiferal analysis of outer and inner fan deposits because of the palaeoenvironmental, palaeoecological and palaeoclimatological interest of Eocene-Oligocene time interval.

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Detrital heavy minerals from Albian sands as a tool in provenance study, Glanów-Stroniczki, southern Poland

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During the Albian a significant marine transgression began across the expanse of epicontinental Europe. The southern, marginal part of the large epicontinental marine basin experienced shallow siliciclastic sedimentation. The Glanów area, southern Poland, was located on the peripheral part of that basin. The source areas for the sands at Glanów have not yet been precisely indicated. The Bohemian Massif (I), a hypothetical Holy Cross Mountain–Dobruja Land, (II) and/or crystalline rocks from the Eastern European Platform (III) are considered to be the most probable source area(s) of detrital material for the Albian sands at Glanów.

Detrital heavy minerals constitute less than 1% vol. of the sample. Detrital tourmaline, monazite, rutile and spinel were analyzed. Tourmaline is one of the dominant mineral in the heavy mineral assemblage. The examined grains (EPMA data) mainly dravite and schorl with avg. XMg values >0.6. The chemical composition of the tourmalines is not an independent and precise indicator of the origin of the detrital material; however, the compositions are similar to that of tourmalines from the eastern part of the Bohemian Massif (Čopáková et al. 2009, J. Geosci. 54, 221-243).

Monazite is found in small quantities in the analyzed samples. It often contains significant amounts of Pb, Th and U and thus can be used for geochronological dating. The CHIME method was used for determining the age of detrital monazites (Suzuki and Kato 2008, Gond. Res. 14, 569–586). Most monazite grains are unzoned and yield CHIME ages between 350 and 380 Ma with only a few grains ranging from 400 to 550 Ma. The ages coincide with the final stage of the Variscan collision, well documented by metamorphic rocks from the eastern part of the Bohemian Massif (Mazur et al. 2010, Przegl. Geol. 58, 133-145).

Rutile is one of the most resistant mineral to chemical weathering and is an abundant component of the heavy mineral assemblage. Using the Zr content in rutile it was possible to determine its crystallization temperatures (Watson et al. 2006, Contrib. Mineral. Petrol. 151, 413–433). The temperature histogram for rutile from Glanów is bimodal. Most grains tend to fall into eclogite-granulite facies conditions (~850°C) and the others crystallized during amphibolite facies condition (<750°C). Using a Nb-Cr discrimination diagram (Meinhold et al. 2008, Sediment. Geol. 2003, 98–111) it was possible to determine that 73% of all rutile grains are of metapelitic origin.

Chromium spinel is relatively rare in the Glanów sands. The chemical composition shows a more predominant peridotitic than picritic trend, implying a mantle origin. Only three grains of gahnite (Zn-spinel) were found. Although not abundant this mineral also gives important information of the source rock lithology. Chemical composition of detrital gahnite grains indicate a Fe–Al-rich metasedimentary and/or metavolcanic source rock (Heimann et al. 2005, Canad. Mineral. 43, 601–622).

The chemical composition of tourmaline, spinel, rutile and the calculated Variscan ages of the detrital monazites support the hypothesis that the Bohemian Massif could be the main source area for the Albian marine sands outcropping in Glanów-Stroniczki in southern Poland.

Forced or normal regression signals in a lacustrine basin? Insights from 3D stratigraphic forward modelling

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The overall architecture of a sedimentary basin is driven by a complex interplay between subsidence, water-level variations, and sediment influx rates. Several studies have been carried out in continental margin settings to analyse the effect of these forcing factors. However, in deep lacustrine settings, where temporally and laterally variable subsidence and uplift rates occur along with different climatic controls, and multiple sediment sources much less is known. Moreover, their distinct effects are usually overwritten by post-sedimentary processes. Our main aim is to describe and discuss the influence of these internal and external forcing factors and demonstrate their sedimentary response, particularly the related unconformities and clinoform geometries in deep lacustrine settings. For this purpose, the DionisosFlow stratigraphic modelling software was used to carry out 3D numerical simulations. A series of numerical models were constrained and calibrated by observations from the southwestern margin of the Pannonian Basin of Central Europe. The results have implications on the local tectono-stratigraphic evolution. Our modelling infers that paleo-water depth could have been much larger than previously anticipated, reached 1300 m in the deepest part of the basin. Furthermore, we show that post-depositional processes, such as compaction and subsidence could create apparently descending shelf-edge trajectories and onlap surfaces, that are often misinterpreted as proofs of base-level drops. Therefore, we strengthen the argument that without restoring the original offlap geometry base-level drops higher than the seismic resolution cannot be identified and specifically did not occur in the area during the late Miocene. Modelling also infers that autoretreat and autocyclic variations are more effective at low sediment supply and higher amplitude lake-level variations. At locations of high sediment supply normal regression is continued, while between sediment entry points transgression occurs, highlighting that lateral variation needs to be considered during interpretation. Our numerical model is applicable to similar lacustrine sedimentary basins, but also provides insights to high-supply siliciclastic dominated marine shelf-margin systems.

Depositional evolution of successive confining basins – inferences from observations and numerical modelling

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Several theoretical models exist to illustrate the large-scale stratigraphic architecture of successive confining basins. This phenomenon occurs in different spatial and temporal scales independent of the substantially different tectonic styles. Noteworthy examples are the salt withdrawal slope minibasins in the Gulf of Mexico, or the extension related Pannonian and Tyrrhenian Basin Systems in the Mediterranean and Central Europe, respectively. Confinement has a significant role in controlling sediment pathways, temporal relations of up- and downstream basin fills and sediment distribution. However, there is still no clear understanding about the driving mechanisms and the timing of the sequential infill. To this aim, a diffusion based numerical modelling software, DionisosFlow is used, to test different theoretical models (i.e. fill and spill, flow stripping, silled basin and tortuous corridor). The model accounts for subsidence and uplift, water-level variations, sediment influx changes, erosion and syn- and post sedimentary deformation and compaction. Our preliminary results imply that a diffusion-based model is capable of simulating the infill of successive confining basins with the fill-and-spill and tortuous-corridor mechanisms both in slope-related basins and in a chain of basins at equal topography. The internal architecture of the basins and the phases of the depositional evolution (i.e. ponding, bypass, backfilling) are reconstructed. Our conceptual model results are compared to natural examples from the Gulf of Mexico, the French Alpine foreland basin and the Pannonian Basin. This quantitative approach enables us to capture the age relationship between basin fills and study the process of trapping in source to sink systems.

Paleosols in the Old Red succession of Podolia (Ukraine)

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Three types of paleosols have been recognized in the red siliciclastic Old Red succession, which outcrops extensively in the valley of the Dniester River in Podolia, in Ukraine (Kozłowska 2019). Regionally, this succession of the late Lochkovian to Pragian age, is defined as the Dniester Formation. It is composed of isolated fluvial channel sandbodies in strongly pedogenized floodplain mudrocks.

The occurence of pedogenic, calcic nodules, illuvial clay horizon and slickensides suggest that the two of described paleosols belong to vertisols group. They have a characteristic pseudo-anticlinal and gilgai microrelief, which is formed as a result of the intensive swelling and shrinking of soils in semi-arid to sub-humid (monsoonal) climates with seasonal precipitation. Moreover, the gleyed/calcic vertisols contain rhizoliths with yellow-brownish/gray depletion zones and barite accumulations in the topsoil, which suggest the development of gleying processes and reduction conditions in water-logged soils. Both, gleyed/calcic and calcic, vertisols show the high maturity and a relation to distal floodplain facies. Their occurrence document stable and long-term weathering processes. The calcic protosols, which also represent the third type of described paleosols, are characterized by the accumulation of calcite nodules, small and irregularly dispersed within the matrix. They represent less mature, multi-storey, stacked paleosols which indicate formation during short-term episodes of landscape stability, interrupted by rapid aggradation of mud after flood events. These vertically stacked paleosols are typical of proximal floodplain facies – crevasse splays and sheetflow deposits.

The portable multi-channel gamma ray spectrometer with a Na(I)Tl detector was used to measure of natural gamma radiation of paleosols. The field measurements have revealed thorium anomalies (even 20.8 ppm) in the base of illuvial zone of paleosols and generally high potassium content. The positive thorium anomalies were recorded at different depths; generally in the case of gleyed/calcic vertisols the peaks are located around 20 cm below the top of pedogenic profiles, close to the maximum of the rhizolith penetration zone. The Th-enrichment is correlated with high maturity of paleosols and it strongly depends on the intensity of weathering processes and humidity of climate. The accumulations of thorium is being the effect of rainwater-induced downward transport of small grains of Th-bearing heavy minerals into the cracks and micropores during wet seasons. The unusual high content of potassium in vertisols, confirmed by the XRD analysis, is effected by strongly diagenesis of smectite and micaceous minerals. The composition of the soils is monotonous with the domination of quartz and the K-rich minerals as well as illite, mica, and with some admixture of illite-smectite mixed layers.

The sedimentological studies of Dniester Fm have allowed the recognition of sedimentary setting of paleosols and their relative distance to the fluvial channels. The comprehensive analysis of variability of paleosols – their characteristic features and maturity -was a key for reconstructing the landscape architecture and hydrological regime in the basin.

Kozłowska M. 2019. Paleosols and their sedimentary setting in the Old Red succession of Podolia, Ukraine. Palaeogeography, Palaeoclimatology, Palaeoecology, 514, 45–64.

Depositional and diagenesis control on the conglomerate reservoir quality of the ES4 member of Lijin

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The conglomerate reservoir of the Lijin, deposited under the lake level's influence, and the adjacent fault was studied to understand the depositional impact and the high-quality reservoir distribution. This study was conducted using integrated methods, including seismic analysis, well log, core observation, thin-section analysis, cathodoluminescence, scanning electron microscopy, and fluid inclusion. Seismic profile, well log, and core observation indicate that the fan delta conglomerate body is well connected and deposited during the HST and the nearshore subaqueous weak connected fan conglomerate in the TST. The conglomerates are mainly classified into lithic arkose and feldspathic litharenite. The fan delta porosity and permeability range from 0.1% to 17.4% (average 8.11%) and 0.007 mD to 457.596 mD (average 6.45mD), respectively. The nearshore subaqueous fan's porosity and permeability vary from 2.02% to 16.2 % (average 8.41%) and 0.02 mD to 237.158 mD (average 22.62 mD) respectively. The different microfacies present various petrophysical proprieties and reservoir quality indexes reflecting the degree of diagenetic alteration. Compaction, cementation, and dissolution are the significant diagenetic processes in the study area. Compaction is the critical factor in reducing porosity; cementation has a destructive effect, while dissolution tends to improve the reservoir quality. The braided channel of the nearshore subaqueous fan is the best reservoir developing during the TST, while the distributary channel of the fan delta represents the best reservoir in the HST. High-quality reservoirs are mainly attributed to the sedimentary environment, strong compaction resistance ability, dissolution process, and early hydrocarbon charging. This study demonstrated that, for an effective assessment of conglomerate reservoirs in the North of the Lijin area and similar reservoirs elsewhere, reservoirs detailed characterization must link lithofacies, sequence stratigraphy, and diagenesis to understand the high-quality reservoir distribution to support the predrill evaluation of reservoir quality.

From the continent to the ocean: a basin-scale snapshot on the early Toarcian environmental perturbation

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The end Pliensbachian–Toarcian is characterized by several disturbances of the carbon-cycle and faunal turnovers (e.g., ammonite or foraminifera communities), most likely triggered by pulses of the Karoo–Ferrar-Chon Aike large igneous province. Most of the studied sites upon which our knowledge of this perturbed time interval is based on were deposited in deep-water setting, leaving vast uncertainties about the concomitant development and potential perturbations of shallow-marine ecosystems. Here, we present a first basin-scale assessment of paleoclimatic impacts on neritic depositional environments from the latest Pliensbachian–middle Toarcian in the central High Atlas Basin, Morocco. Correlations between sections are based on bio-, chemo- and lithostratigraphy.

In Morocco, two episodes of carbonate production demises are observed, spanning the Pliensbachian–Toarcian boundary and the Polymorphum/Levisoni transition. Each of them correlates accurately with the well-documented environmental disturbances of the end Pliensbachian–middle Toarcian interval, including the Toarcian oceanic anoxic event (T-OAE). Moreover, each episode of carbonate factory demise coincides with a time interval of significant increase of coarse siliciclastic input the basin, further demonstrating the link between global warming, increased continental weathering, and ecosystem turnovers. Furthermore, these two episodes of carbonate factory demises are each followed by episodes of renewed carbonate production, showing the resilience of neritic carbonate factory in this region. The first recovery interval, occurring during the late Polymorphum zone, is associated with a mixed siliciclastic-carbonate system. The second episode of carbonate recovery quickly follows the demise associated with the onset of the T-OAE. It is associated with an abiotic carbonate production mode dominated by ooid production. A full recovery of biotic carbonate production only occurs in the late stage of the T-OAE. In this study, it is suggested that from a shallow-marine perspective, the major biotic and abiotic crisis occurred at the Pliensbachian–Toarcian and not during the T-OAE as often inferred from studies focused on deep-marine record. An enhanced hydrological cycle and the subsequent increase of continental nutrient shedding might have triggered the most severe changes of the carbonate productivity at the Pliensbachian–Toarcian transition, whereas ocean acidification and increased storm activity might have played a significant role at the onset of the T-OAE.

Carbonate sedimentation along southern margin of the Tethys with Lithiotis-type bivalves – similarities and differences

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During Early Jurassic (Pliensbachian – Early Toarcian) times along southern margin of the Tethys Ocean, including peri-Gondwanan parts, Lithiotis-facies bivalves-bearing carbonates belt occur. The most characteristic bivalves which belong to this facies are: Lithiotis, Cochlearites, Lithioperna, Mytiloperna and Opisoma. This carbonate belt had very long distance, about 4000–5000 km, from Morocco trough south European up to Asian countries. Palaeogeographic distribution of this Lithiotis-facies generally occcupied mentioned similar palaeoenvironments but in more detail reconstructions we can see some differentiation. Using comparative analysis between selected sections/regions, interpretation of these palaeoenvironments is the based on the: (i) Maroccan High Atlas sections, (ii) Albanian Alps section, (iii) southeastern Peloponnesus and Evvoia Island in Greece and (iv) Himalayan Nepalese Kali Gandaki valley.

(i) Lithiotis-bivalves bioconstructions in the High Atlas Mountains we studied in Assemsouk section in Jebel Azourki range. The Pliensbachian carbonate-clastic deposits is represented by record of regression manifested by continuous transition from shallow-water full marine limestones with corals trough lagoon-type calcareous-marly deposits with numerous bivalves mentioned above, up to nearshore clastic-carbonate deposits, with cross-bedding structures, and with plants which represent lagoonal-paralic environments.

(ii) In the Albanian Alps (N of Shkodra), within continuous section of the Late Triassic – Early Jurassic sequence the Early Jurassic part is represented by limestone-dominated deposits with several episodes of emersions marked by calcretes, fossil karst phenomena and extremally shallow-water environments (fenestrate limestones and/or tempestites). Overlying Lithiotis-type bivalves are represented both by parauthochthonous and authochthonous concentration, including lens-shape bivalve biostromes (Pliensbachian in age). Bivalve-rich limetsones/marls are intercalated by oolitic/oncolitic leyers. Several coal-bearing intercalations between intertidal carbonate rocks of full-marine–lagoonal–land transitional lithofacies occur with two aired roots horizons confirm occurrence of mangrove(?) palaeoenvironments of swamp formation.

(iii) The analyzed carbonate rocks occur in the southeastern Peloponnesus in Greece (Gavrovo-Tripolitza unit) and Evvoia island of the External and Internal Hellenides respectively. Lower part of these sequences comprises dolomites, dolomitic limestones and limestones representing subtidal and/or intertidal-supratidal facies in a shallowing-upward cyclic development. At a higher position there are exclusively open-marine subtidal limestones mainly represented by megalodontids (constructed sometimes storm-generated tempestites) and Lithiotis-type bivalves intercalated by ooid/oncoid-rich limestones.

(iv) Recently discovered Lithiotis-type bivalves in the Thakkhola region (northern central Nepal) occur here as a part of the so-called Kioto carbonate platform. In continuous section of clastic-carbonate formations of the Triassic/Jurassic transition is a record of a transgressive sequence of extremely shallow-marine – lagoon paleoenvironments with oolitic (with cross-bedding structures) and oncolitic limestones of the Pliensbachian/Early Toarcian Jomosom (= Kioto) Formation.

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Sedimentary conditions of the Early Jurassic Lithiotis-type bivalves facies in the Himalayan Tethys (Nepal)

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The Early Jurassic (Pliensbachian – Early Toarcian) Lithiotis buildups located in many places in the world on both sides of the Pangea continent, have been mainly connected with the southern part of the Tethys Ocean. In Europe, they are known from the Alpine-Adriatic-Dinaridic-Hellenic carbonate platforms (Spain, Italy, Slovenia, Croatia, Albania, Greece) that were developed in extremely shallow coastal palaeoenvironments. This happened just after great palaeobiological crisis at the Triassic/Jurassic transition that was one of the „Big Five" mass extinction events. By this reason, during the Early Jurassic time, organisms inhabiting reef and reef-like biostructures were eagerly recovering their biocoenoses. One of the first groups of marine invertebrates inhabiting free ecological niches were bivalves of so-called Lithiotis-type facies with the most characteristic representatives: Lithiotis, Cochlearites, Lithioperna, Gervileioperna and Mytiloperna. Recently discovered Lithiotis-type bivalves in the Thakkhola region (northern central Nepal) fit perfectly into the record of these biostructures along the southern shelf of the Tethys (here part of the so-called Kioto carbonate platform). Excellent exposed along the upper part of the Kali Gandaki valley in the Thakkhola region, the continuous section of clastic-carbonate formations is a record of a transgressive sequence of which the Late Triassic land-coastal sedimentation episode gently passes into the Early Jurassic, extremely shallow-marine – lagoon paleoenvironments. Surrounding facies very well evidence such type of regimes by co-occurrence of oolitic (with cross-bedding structures of high-energy sedimentation conditions) and oncolitic limestones, birdseye-structure limestones and/or pedogenic carbonate formations. This Nepalese region is very well known by the famous Spiti shales, which is known for the richness of the Late Jurassic ammonites. Currently, these are included in the Nupra Formation, which lies directly on the Middle Jurassic (Bajocian – lowermost Callovian) carbonate deposits of the Bagung Formation (full of tempestites) and older, Pliensbachian – Early Toarcian Jomosom (= Kioto) Formation with Lithiotis-bivalves–bearing horizones. These formations are a small fragment of the Late Triassic – Early Cretaceous sedimentary sequence of the highest tectonic unit of the Himalayas, the so-called "Series (zone) of the Himalayan Tethys" (= „Tibetan Tethys"/"Tibetan sediment zone"). This Jomosom Formation contains unique Lithiotis-type bivalves biostromes, which have been discovered recently in three sections along Kali Gandaki valley. They indicate probably either lagoonal-type palaeoenvironments or marginal part of such lagoons between nearshore regions and open marine conditions and palaeobiogeographically represent eastern Tethys Lithiotis-facies bivalves belt which occur along peri-Gondwanan margin during Pliensbachian – Early Toarcian times. The continuous, deepening upward sedimentary sequence of the uppermost Triassic – Middle Jurassic units constitute a fluvial-paralic of the latest Triassic, the carbonate platform of the Early and Middle Jurassic deposits, and the Late Jurassic black organic shales with abundant ammonites (Spiti Shales = Nupra Formation) of the northern Peri-Gondwana margin.

Late Cretaceous syn-inversion sedimentation within the Polish Basin based on analysis of seismic data

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Late Cretaceous was a period of a widespread basin inversion tectonics affecting large parts of W and central Europe. It was associated with uplift of basement blocks and compressional reactivation of salt structures. All these processed led to formation of local elevations within the Late Cretaceous epicontinental sea, often associated with localized erosion and formation of syn-kinematic strata. Field examples include, but are not limited to, the outskirts of the Harz Mts. in S Germany, of the Bohemian Massif in Czechia and SW Poland, and of the Holy Cross Mts. in SE Poland. However, vast areas affected by inversion tectonics are entirely hidden beneath the Cenozoic sedimentary cover so seismic data with good imaging at shallow depths is needed in order to depict syn-inversion strata that provide information on mode and timing of inversion tectonics and its relationship to syn-tectonic deposition. Recently acquired and/or reprocessed seismic data within the Polish Basin provided important information on inversion of this sedimentary basin and its influence on depositional systems. Offshore part of the Polish Basin located with the S Baltic Sea has been recently covered by 850 km of high-resolution multichannel seismic reflection data of the BALTEC survey. This data, together with legacy shallow high-resolution and selected industry seismic data and several deep and shallow wells, was used to construct new model of the Late Cretaceous evolution of the offshore part of the Polish Basin. Seismic data from SW Baltic Sea revealed that offshore segments of the Kamień-Adler, Trzebiatów and Koszalin – Chojnice fault zones developed as thick-skinned structures and were associated with substantial syn-inversion erosion and sedimentation. Within the SE Baltic Sea Precambrian basement together with its Cambro-Silurian sedimentary cover is dissected by a system of steep, mostly reverse faults regarded so far as having been formed mostly in Paleozoic times, due to the Caledonian orogeny. Analysis of seismic data proved that some of these faults were active in Late Cretaceous as a reverse faults and significantly modified local depositional systems characterized by local thickness changes, erosional incision, and local prograding wedges. This proves that inversion tectonics affected large areas located much farther towards the East than previously assumed. Seismic data from central Poland characterized by excellent shallow imaging revealed that Szamotuły salt diapir underwent compressional reactivation in Late Cretaceous. It formed local morphological barrier that focused the flow of bottom currents to localized routes as in its vicinity syn-inversion succession containing contourite drifts have been recognized. Contourites have been recognized using legacy and recently acquired seismic data also in SE Poland, along the NE edge of the inverted Polish Basin. In this part of the basin their development was related to a slope formed during progressive uplift of basin's axial part where currently Holy Cross Mts. are located. All these findings confirm that Late Cretaceous deposition within the Polish Basin was strongly and directly controlled by regional inversion tectonics.

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Volcanic trigger a mid-tournaisian anoxic event in carnic alps (austria)

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The mid-Tournaisian Event (also called a Lower Alum Shale Event; LASE) is connected with drastic facies changes from pelagic carbonate sedimentation to widespread black organic-rich siliceous shales and radiolarites in many parts of the world. The LASE significantly affected pelagic organisms such as goniatites. Many other benthic groups lite brachiopods, bivalves, trilobites, and gastropods were decimated, what is important on the regional scale the extinction of these groups was entire. These significant facies changes and biotic turnover are connected with global transgression, anoxic conditions development, and stopped carbonate production caused by eutrophication and increase productivity. Here we report for the first time very large anomalous Hg spikes (with maximum values reaching 3650 ppb) in mid-Tournaisian deep-water marine succession in the Carnic Alps, supporting volcanism as a trigger of the mid-Tournaisian anoxic event. The most likely candidate for the observed Hg anomalous contents is arc-volcanism connected with collision Gondwana with Laurussia as well as peri-Gondwanan terranes during the early phase of the Variscan orogeny.

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Precambrian lateritic paleosols from Aravalli Supergroup, Rajasthan: Implications for weathering and early life on Earth

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In this study, a well-developed lateritic profile has been studied from the Aravalli Supergroup (2200 Ma-1850 Ma) sediments of Rajasthan, Western India. The lateritic paleosol exposed in a 60 m query was studied for field characteristics, micromorphology, and clay mineralogical features to assess weathering and paleoclimatic conditions during the continental evolution of the Earth. The paleosol is marked by intense weathering with orange to deep-red color, pisolitic concretions of mm to cm-scale, massive to friable blocky structure in the upper ~ 30 m of the query, which progressively grades down to less altered to unaltered dolomite in the lowermost part. Microscopic study of the weathered dolomite/lateritic paleosol is characterized by (i) concentric laminations of dark red iron-oxide and light-colored partially weathered dolomite in the pisolitic concretions, (ii) fine textured iron-oxide laths/grains and dolomitic grains as the and pore-filling groundmass of the concretions, (iii) iron-oxide coatings along the conations and the dolomitic fragments.

Most of the dolomitic and iron-oxide grains show spindle-shaped spherulitic features that were possibly caused by bacterial or microbial activity during laterization of the dolomite. The XRD studies of total the clay (<2 μm) and the fine clay (<0.2 μm) fractions of these paleosols are characterized by 7A°, 4.4 A°, 4.1A°, 3.03A° mineral assemblage with a bulk of kaolinite. Other clay minerals occurring in small amounts but more common in the fine clay fraction include kaolinite-halloysite mixed layers, halloysite, and calcite-vaterite. The pisolitic concretions with spherulitic-crystals with calcite-vaterite suggest hot-humid weathering conditions with a strong possibility of bacterial action during lateralization of the dolomite during Precambrian, that is related to oxygenation and evolution of early life on our planet Earth.

An aerobic and non-motile bacteria of the genus Sinomonas and member of the Micrococcaceae has been identified in the laterite sample by 16S rRNA amplification and sequencing.

Keywords: Precambrian, Laterite, Weathering, Clay mineral, Pisolites

850 kyrs of paleoclimate evolution from magnetic and granulometric data of the Pleven loess-paleosol sequence

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Terrestrial climate archives like loess-paleosol sequences (LPSs) located in Eastern Europe are known to cover long periods of time and record climate fluctuations over the last hundreds of thousands of years (e.g. 1). Glacial cold and dry conditions, leading to loess accumulation, alternate with interglacial, warm and humid episodes, leading to the formation of paleosols. LPSs are seldomly sampled and analyzed at a continuous high-resolution with a broad variety of room-temperature rock magnetic and granulometric properties. At the lower Danube plain in Bulgaria near the city of Pleven, a LPS, spanning 27 m, was sampled at a 2-cm continuous resolution resulting in 1370 bulk samples. An initial age model, based on an indicator for pedogenic intensity (ratio of saturation magnetization and ferrimagnetic susceptibility) correlated to the global ice volume stack (2) suggests that the Pleven LPS archives 850 kyrs of quasi-continuous dust deposition (3), spanning the time from marine oxygen isotope stage (MIS) 19 to present.

In this contribution we focus on interglacial paleosols and compare granulometry-derived and magnetism-derived pedogenic intensity proxies. Clay content is a widely accepted indicator for pedogenesis. Therefore, the < 6 μm grain size fraction defining clay % is compared to a neighboring (75 km to the NW) LPS Harletz (4) spanning the last ~ 200 kyrs. Comparison is made with magnetism-derived proxies of pedogenic intensity quantifying relative or absolute concentrations of superparamagnetic (SP) to fine single-domain ferrimagnetic particles known to be mineralized in-situ during soil formation. Fluctuations in rock-magnetic parameters display three different behaviors across the presumed MIS 19 – 13, MIS 12 – 10, and MIS 9 – 1 glacial – interglacial cycles, where the amplitude of fluctuations is low for the oldest cycles and is high for the most recent cycles. Two hypotheses are tested: (i) Diagenetic alteration of the primary pedogenic signal with increasing time and burial depth; (ii) Preservation of primary signal in response to different climate regimes (Mediterranean versus continental) similarly to interpretations published on LPSs spanning shorter time intervals (5, 6).

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350 kyrs of increasing aridity reflected by geophysical proxies from the LPS of Zmajevac, Croatia

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Loess-paleosol sequences (LPSs) are aeolian terrestrial paleoclimate archives able to conserve several hundreds of thousands years of climate history. Loess deposits cover at least 10 % of the northern hemisphere continental masses (Pécsi, 1990) and provide adequate properties to conserve climate changes imprinted in the stratigraphically analyzable rock-magnetic, granulometric, and colorimetric properties (e.g. Schaetzl et al., 2018). LPSs are seldomly investigated a) at a very high (2 cm) and continuous resolution as conducted at Zmajevac and b) with multi-disciplinary proxy parameters as acquired here: rock-magnetic, granulometric and colorimetric properties. The Zmajevac LPS spans 22 m and archives a quasi-non-disturbed depositional history, with only three erosional layers observed in the field. We use the postIR IRSL290 luminescence signal of feldspar to provide reliable time controls (Wacha et al., in review) enabling an independently dated correlative age model based on magnetic susceptibility derived parameters. Granulometric and colorimetric parameters are thus incorporated into the derived age model. In this contribution we show first results detecting precise changes of interglacial / glacial conditions for the last three eccentricity cycles (~ 300 kyrs). Furthermore, rock-magnetic parameters across the Zmajevac LPS are interpreted as a precipitation indicator and compared to observations from other LPSs located several hundreds of kilometers away. The combination of two different age determinations (correlative, compared to global climate models and stacks (e.g., LR04 stack, Lisiecki & Raymo, 2005) and postIR-IRSL290 dating) allows further implications for millennial scale climate variability.

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Deep-water heterolithic deposits – their varieties and significance (examples from the Skole Nappe, Polish Carpathians)

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Deep-sea sedimentary environments involve a wide range of depositional processes and their products: from turbidites deposited by turbulent turbidity currents to debrites and slump deposits formed by non-turbulent, shear strength-controlled sediment gravity flows, and to the pelagites or hemipelagites deposited by sediment suspension fallout from the water column. The origin and palaeoenvironmental significance of these sedimentary facies is now well established (e.g., Hüeneke & Mulder 2011). The global research on deep-sea deposits in the last two decades has focused on the products of 'hybrid' or 'transitional' sediment gravity flows, combining features of both turbulent and laminar behaviour (e.g., Lowe & Guy 2000; Baas et al. 2009). Still, the most puzzling are deep-sea heterolithic deposits – the lithofacies composed of thinly intercalated of sandstone, siltstone and mudstone. They resemble tidal deposits known from littoral tidal flats and estuaries, and have been attributed to the deep-water action of tidal currents (e.g., Dykstra 2012). But in general, this kind of deep-sea heterolithic deposits can be attributed to: (1) turbidity currents with highly fluctuating velocity, (2) turbidity currents reflected from a topographic obstacle in the basin or (3) an alternation of thin pinch-out turbidites and hemipelagites. Laboratory experiments with rapidly decelerating cohesive flow indicate series of small-scale repetitive sand-silt-clay bedforms (Baas et al. 2016), compatible with observations from outcrops. The present study concurs with this latter possibility, postulating that a heterolithic facies unit can be formed as a single depositional event of an unsteady and rapidly decelerating turbidity current. The flysch deposits of the Ropianka Formation (Upper Cretaceous–Paleocene) are a part of the deep-sea sedimentary succession of the Skole Nappe, one of the main Outer Carpathian tectonic units. The heterolithic deposits discussed occur randomly both stratigraphically and spatially in this formation. They occur within a mudstone and marlstone background, and show thin intercalations of siltstone and fine- to very fine-grained sandstone, often in the form of lenticular, wavy and flaser bedding. The thickness these heterolithic units varies laterally, which suggests a diversified morphology of the basin floor. Abundant are sedimentary structures such as plane-parallel lamination, low-amplitude bedwave features, ripple cross-lamination, large ripple cross-sets (sensu Baas et al. 2016), mud drapes, and various sole marks. Instead of lumping all the heterolithic flysch facies into one genetic category, their various possible modes of deposition are considered.

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The sedimentary dynamics of Apulian sandy beaches through a multidisciplinary approach

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Beaches constitute extremely variable environments where different natural processes act simultaneously with many human activities due to the increase of density population along many coasts of the world. Consequently, numerous problems have materialized along many of the world's coasts through a destabilization of ecosystems, sedimentary budgets and processes that originally kept a complex system such as that of a beach in balance. A better knowledge of the way beaches work is fundamental to provide possible remedies aimed to correct the imbalances caused by human activities. This is particularly true for a country like Italy which has a significant developed coastal system and for some regions such as Apulia (southern Italy) which has a coastal sandy stretch of about 650 km where the growth of the urbanization in the last decade, coupled with the concentration of the economic and tourist facilities, have led these coastal areas to be affected by erosional processes. With this aim we investigated few Apulian beaches through a multidisciplinary approach, in order to build a standard procedure for monitoring their morpho-sedimentary processes by analyzing the textural and compositional characteristics of the sands and quantifying the volumes involved in the coastal dynamics during a period of time of three years. In particular, sedimentological and ecological investigations allowed us to describe the textural and compositional characteristics of the beach sands by interpreting their sand provenance and the physical/biological interactions within the beach. We used these data to establish the erosive or stable-prograding tendency of these beaches, the peculiar compositional sediment features, consisting mainly of bioclastic debris, being the Apulia Region almost characterize by the absence of watercourses that could supply the coastal sectors. Topographic surveys were carried out with a Terrestrial Laser Scanner and an Optical Total Station, aimed to quantify the variations of sediment volume of the beaches, whereas the Delft3d software was applied to analyse the effects of the dominant wave motion on the sedimentary dynamics. Geophysical techniques which included sub bottom profiler procedures, ground penetrating radar investigation and resistivity models enabled us to see the geometry and the thickness of the coastal wedges and their stratigraphic relationships with the underlying bedrock in the light of their most recent Holocene evolution.

Entobia ichnofacies from the Middle Miocene of Szydłów (Carpathian Foredeep, Poland)

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The Heterostagina Sand of the Langhian Pińczów Formation (Orbulina suturalis Zone) represents the oldest marine Miocene deposits in the northern margin of the Carpathian Foredeep, Central Poland.

The deposits are in fact represented by mixed siliciclastic-carbonate silt with intercalations and nests of red algal limestone. It contains abundant large foraminifera, other foraminifera, pectenids, echinoids, bryozoans and red algae Sporolithon sp. and ?Lithotamnion sp. The fossils assemblage indicate normal saline, shallow marine environment with moderate energy. Moreover, the fossils are typical of moderate or moderate-subtropical zone of the rhodalgal biolithofacies (Randazzo et al., 1999; Studencki, 1999) .

The dominant coarse component of limestone are red algae, commonly present in form of rhodoliths developed around gastropod shell nuclei, mostly Turitella, preserved as internal molds. Turitella contains borings produced by sponges (Entobia ?geometrica Bromley and D'Alessandro, 1984; Entobia isp.) and annelids (Caulostrepsis taeniola Clarke, 1908; Maeandropolydora ?sulcans Voigt, 1965; Maeandropolydora isp.). The encrusted red algae (rhodoliths) are also affected by borings produced by bivalves (G. dijugus Kelly and Bromley, 1984; G. turbinatus Kelly and Bromley, 1984; Gastrochaenolites isp.) and in minor contribution by annelids (Maeandropolydora isp.). The borings are preserved as very detailed positive casts showing even minute elements of their morphology. They are dwelling structures (domichnia) produced by suspension-feeders and detritivores. The trace fossils assemblage is similar to assemblages reported from carbonate rocky shores of Europe, Australia and North America (e.g., Radwański, 1965; Bromley and Asgaard, 1993) and can be ascribed to Entobia ichnofacies. It is typical for rocky shores and gravel beaches characterized by low sedimentation rate enabling colonization of the substrate.

The presence of borings within rhodoliths overgrowing the bored gastropods suggests several stages of successive colonization. First, in shallow marine water with low sedimentation rate, the long exposure of Turitella shells allowed its colonization by endobionts (sponges and polychaetes). After death of endobionts some empty borings were passively filled with loose, fine-grained carbonate matrix allowing their great preservation. At the second stage the gastropod shells at the sea bottom were rolled by waves and gradually encrusted by red algae. The colonization of rhodoliths by boring bivalves was the final stage before its final burial and passive infill of bivalve borings by surrounding sediment. The early cementation that took place after burial led to preservation of detailed casts of borings while a subsequent dissolution of the originally aragonitic shells formed gastropods molds.

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Complex development of a 300-million-year old subglacial unconformity in southern Namibia

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The expansion of ice masses across southern Africa during the Late Palaeozoic Ice Age (LPIA) at about 300 Ma has been recognised in the literature for over a century, including the distribution of upland areas in controlling the configuration of ice masses (Davis, 1908). In Namibia, increasing attention has focussed on long and deep palaeovalley networks in the north, but comparatively little work has been attempted in the topographically subdued plains of the south. The desert terrain of the Mariental area exposes diamictites of the Dwyka Formation discontinuously over about 300 km, extending further south to the Noordoewer area at the Namibian-South African border along the Orange River. Whilst previously examined at a stratigraphic level, the nature of the contact between the Dwyka glacial rocks and underlying lithologies has not been systematically investigated. This paper presents some preliminary results from fieldwork in austral winter 2019, in which we describe a highly varying basal contact that records the processes of growth, flow and expansion of ice masses across this part of Gondwana. Subglacially-produced unconformities may exhibit classic glacially-striated pavements at basin margins, which substitute for soft-sediment striated surfaces in comparatively more "basinal" areas. Where these features are absent, additional criteria may be sought. In Mariental, spectacular soft-sediment shear zones exhibit a combination of brittle and ductile end products are recognised, overprinted by shear bands. This type of subglacial unconformity developed over well differentiated, unconsolidated, siliciclastic materials. Where ice advanced over more poorly sorted material or cannibalised pre-existing diamictites, "boulder-pavements" formed in which in single clast-thick boulder-dominated intervals were facetted and striated in situ by overriding ice. By integrating measurements of striation orientations, fold vergence and palaeocurrent information, former ice flow pathways can potentially be reconstructed over a wide area, which is suspected to have been dominated by Piedmont glaciers.

The use of mineral interfaces in sand-sized volcanic rock fragments to infer mechanical durability

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The use of mineral interfaces in sand-sized rock fragments, to infer the influence exerted by durability on the generation of sediments, for volcaniclastic sand, has received little attention. To our knowledge, this is the first attempt to make use of the volcaniclastic interfacial modal mineralogy of epiclastic sandy fragments, to infer mechanical durability control at modern beach environment. Volcaniclastic sand was collected along five beaches developed on five islands of the Aeolian Archipelago, located in the southern Tyrrhenian Sea. The beach sediment has been sampled from Alicudi, Filicudi, Salina, Panarea and Stromboli islands, whereas one sample has been collected near the crateric centre of the Stromboli volcano. Each sample was sieved in order to obtain the grain-size distributions of these sand-dominated sedimentary environments and to fabricate standard thin sections for petrographic analysis. The modal mineralogy of the very coarse, coarse and medium sand fractions was determined by point-counting, through the optical microscope, of the interfacial boundaries discriminating 38 types of interfaces categories, both not-isomineralic and/or not iso-structural (e.g., phenocryst/glassy groundmass) and isomineralic, inside volcanic lithic fragments with lathwork and porphyric textures. A total of 47386 interfacial boundaries have been counted and, the most representative series of interfaces, from the highest to the lowest durability, can be grouped as follows: not-isostructural glass-rich>>glass-poor interfaces and not-isomineralic>>isomineralic interfaces. Moreover, four transport-controlled interfaces groups can be distinguished as: ultrastable not-isostructural glass-rich interfaces, stable glass-poor interfaces, moderately stable not-isomineralic interfaces, and unstable iso-mineralic interfaces.

As regards interfaces deforming style associated with transport stress fields, acting on interface categories, the not-isostructural interfaces types subjected to abrasive shear stress survive and preserve their compositional volcanic signature. Abrasion produce mainly smoothing and rounding of edges which preserve the original detrital composite signature and major portion of the entire volcanic grain area. By contrast, comminution process of the isomineralic interfaces is controlled by tensile stress promoting fracturing, both along the intercrystalline interface and through intracrystals weakeness planes, such as cleavage, zonation and twinning, producing monomineralic grains, similar to breakage process of glacial sand during grain saltation. In this latter case, provenance signal may be overprinted by the transport processes. The grains eroded from the volcanic bedrock, if affected solely by abrasion, develop a rounded and smoothed shape with prevailing not-isostructural interfaces such as Plagioclase/Glassy groundmass, Pyroxene/Glassy groundmass and Olivine/Glassy groundmass interfaces. The grains that during transport suffered fracturing and percussion have a sharp and angular shape: this combined transport mechanisms produce mainly iso-structural interfaces such as Plagioclase/Plagioclase, Pyroxene/Pyroxene, Hornblende/Hornblende, and to a lesser extent, Biotite/Opaque and Biotite/Glassy groundmass interfaces. The approach of using interfacial mineralogy data to quantitatively analyze beach environment control is sound only if we are aware that, especially for the volcaniclastic particles of the stratigraphic record, the abundance of the interface types and their diversity determine the survival potential of these detrital grains, during the pre-depositional history and that are controlled by pre-burial transport processes, that could bias compositions towards more abundant glassy-rich volcaniclastic interfaces, and with an underestimation of the isomineralic ones.

Experimental tidal channel evolution in aggradational vs. degradational settings

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The vast majority of the world's coasts are affected by the action of tides to at least some degree. These landscapes are ecologically and economically important as they support large populations and host highly productive ecosystems, providing diverse habitats for a number of plant and animal species and delivering valuable ecosystem services. The morphodynamics of these landscapes are intimately connected to the evolution of the tide-influenced channel networks they host, which represent the main conduits for the exchange of sediments, nutrients and biota between the inner land and the open sea.

However, worldwide-increasing anthropogenic pressures on coastal areas, combined with the continued rise in relative sea-level, threaten the sustainability of these landforms and calls for new insights on their morphological response. Here we present a suite of physical laboratory experiments aimed to investigate the evolution of channel networks both in aggradational and degradational tidally-influenced coasts.

In a first series of experiments, we show that distributary-channel mobility can be dramatically reduced in fluvio-deltaic systems affected by tides in comparison to an identical system with no tides, and that the mobility of distributary-channels decreases as the ratio of tidal to fluvial energy increases. This effect occurs even if new accommodation space is created by rising relative sea level. By analyzing synthetic stratigraphy derived from both digital elevation data and time-lapse photography, we also demonstrate that the reduction of channel mobility in tidal deltas increases channel stacking and connectivity in the stratigraphic record.

The net morphological effect of tidal action is to enhance seaward transfer of bedload sediment, resulting in greater shoreline transgression as compared to identical, yet purely fluvial, deltaic systems that exhibit static or even regressive shorelines. We also show that stronger tidal forcing can create composite deltas where distinct land forming processes dominate different areas of the delta plain, shaping characteristic morphological features.

A second set of experiments looked at assessing the influence of different initial basin morphologies and tidal ranges on the inception and morphodynamic evolution of tidal channel networks. The system was purely erosional, because no sediment supply was provided. All the experimental tidal channel networks exhibited an initial, relatively rapid, growing stage followed by a period of slow morphological adaptation toward a final quasi-equilibrium configuration. Continuous monitoring of the basin hypsometry indicated that the evolution of tidal channel networks occurred more rapidly in the presence of a sloped basin and for higher tidal ranges. Flat basins (i.e. 0% slope) and sustained tidal ranges favoured the development of more branching networks, while channel sinuosity was enhanced when wide breaches (manmade in this case) heightened the initial flooding of the basin. Conversely, the evolution of the network and its final branching character appeared to be quite insensitive to the initial number of breaches along the shoreline, thus suggesting an autogenic behaviour that depends primarily on the characteristics of the tidal forcing.

Determination and quantification of salt marsh sedimentation using end-member modelling of grain-size data

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It is shown that end-member modelling of grain-size data provides a method to distinguish and quantify the sedimentary processes contributing to vertical salt-marsh growth in different energetic settings. Data allow for a semi-quantitative estimation of the contribution of land reclamation measures (ditching) to marsh accretion (sedimentation rates). Two sediment cores were retrieved from marshes at the southern North Sea coast. One core originates from a natural back-barrier marsh (island of Sylt); the other from a reinstated, former managed marsh (Eiderstedt peninsula). Whereas the marsh in Sylt is a low-energy, back-barrier marsh, the marsh in Eiderstedt is exposed to storm waves from the open North Sea.

Sediment grain-size distributions were analysed using the end-member modelling R package EMMAgeo (Dietze & Dietze, 2019, E&G Quaternary Sci. J). In addition, geochemical data were used, as well as sediment accretion rates determined by means of 210Pb and 137Cs.

Sedimentation rates reach 18.4 mm yr-1 in the exposed setting and 5.3 mm yr-1 in the sheltered back-barrier setting. Data show that marsh growth in lagoonal back-barrier settings is controlled by inundation events during storm surges, as well as significant aeolian input from active dunes on the barrier. Sediment grain-size distributions show two sub-populations, with fine-grained deposits (mode 28 µm) attributed to marsh inundation, and coarse-grained sands (390 µm) originating from aeolian transport. Data show a significant amount of up to 29 % of aeolian input, a decrease in the course of dune stabilization measures in the second half of the 20th century.

By contrast, marsh growth in exposed settings is primarily controlled by high-energetic inundation events with two sediment transport processes: On the seaward edge of the marsh, coarse grained (57 µm) traction load is deposited, whereas towards the landward salt-marsh margin, settling of fine-grained (20 µm) suspension load prevails due to reduced flow velocities. Grain-size data show a third sub-population (93 µm) which is attributed to anthropogenic land reclamation measures, mainly ditching. The contribution of this sub-population to sedimentation rate reaches 39 % and drops at the same time as land reclamation measures were terminated.

Reservoir characteristics and influence factors of chang6 reservoir in xiaojiahe area of Ordos basin

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As the poor reservoir property, strong heterogeneity and high water content of the chang6 oil formation in xiaojiahe area of Ordos basin, the later development of the oilfield has been restricted.This paper will study the petrographic characteristics, pore structure characteristics, diagenesis and reservoir influence factors of chang6 reservoir in this area by using core observation, thin section identification, scanning electron microscope, cathode luminescence, physical property test and mercury injection analysis comprehensively.Results show that the XiaoJiaHe area chang6 reservoir is dominated by fine-grained feldspar sandstone, with low compositional maturity and high structural maturity and separability better characteristics. The pore types are mainly intergranular pore, besides feldspar dissolved pore and intergranular micropores. The pore structure is mainly to I class (small pore fine throat type) and II class (small pore micro throat type), III class (fine pore micro throat type) weakly development. Reservoir performance for low porosity (average porosity of 8.36%), low permeability and ultra-low permeability (average permeability of 1.24×10–3μm^2) characteristics. A set of reservoir belts with relatively high porosity and permeability were developed in the 650~680m depth section. The formation conditions include:(1)The maturity of sandstone composition has a good positive correlation with the reservoir physical properties, the rigid component is conducive to the preservation of porosity, and the plastic component has a significant impact on permeability; (2)Sedimentary microfacies control the distribution of sand body, and the development of massive structures and parallel bedding in diversion channel is obviously better than the development of horizontal bedding in natural embankment to the reservoir physical property; (3)Compaction has a strong destructive effect on the original porosity, though the formation of ring edges in early thin-film chlorite can weaken the destruction of compaction, in middle and late chlorite can affect the connectivity of the throat and reduce permeability. The closed environment with high chlorine content is conducive to the formation of organic acid, which has a strong dissolution effect on feldspar and a large number of carbonate cementants formed in the early stage, and improves the permeability of the reservoir; (4)The maximum permeability contribution radius, sorting coefficient, maximum pore throat radius and mean value of the pore throat structure have the most significant influence on the permeability, which determines the microscopic characteristics of the reservoir. In general, the macroscopic characterization and microevolution of reservoirs are controlled by sedimentation and diagenesis, and the differential effects are the original cause of the formation of relatively high permeability reservoirs.

The development and demise of an early Cambrian shallow-water carbonate factory in South China

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The development of carbonate factories has potential importance in studies of paleoenvironment, sedimentology, and reservoir geology, but the controlling mechanisms for the growth and demise of the large amount of carbonate sedimentation have not been broadly investigated, especially in deep-time sedimentary records. Here, we provide a case study on the development and collapse of a shallow-water carbonate factory during early Cambrian (Age 3) in the Hannan-Micangshan area of the South China Block. Different from modern shallow-water carbonates, the major builders of the early Cambrian factory contain non-skeletal ooids and beneath microbial communities (calcified microbes are common), with a minor contribution of metazoans (e.g., archaeocyaths). Ooid shoals generally develop in shelf margin conditions; microbial mounds (thrombolites) are identified in the shelf interior and the deep subtidal settings. Meanwhile, the association of archaeocyaths and calcified microbes can also form mound-like bioherms in the shelf interior, which appears to be closer to the source area than other factory builders due to the common admixture of siliciclastic particles in the archaeocyath-microbial bioherms. The mixed siliciclastic-carbonate system and the episodic input of high-volume siliciclastics in study area do not seem to significantly affect the development of early Cambrian shallow-water carbonate factory. Alternatively, the increasing terrigenous supply may provide adequate nutrients (e.g., P and Fe) and elevated carbonate alkalinity conditions (for higher carbonate saturation state) in the near-shore surface ocean, which likely facilitated to the development of carbonate factories during early Cambrian. The shallow-water carbonate successions are replaced by large quantalities of clastic sediments that are interpreted as a deltaic depositional environment in the Hannan-Micangshan area. Marked sea-level fluctuations, ocean acidification, tectonic activity, biotic crisis, and other factors are unlikely to cause the demise of this early Cambrian shallow-water carbonate factory based on a series of petrological, sedimentological, and element geochemical evidence in this study. Instead, the transition from carbonate-dominated to siliciclastic-dominated depositional system may be responsible for the collapse of the shallow-water carbonate factory in Hannan-Micangshan area (South China) during early Cambrian. This study provides a clue for understanding the growth and demise of deep-time carbonate factories and would be a valuable reference for studies in other regions and periods.

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Analysis of genetic mechanism and main controlling factors of lacustrine multicomponent mixed sediments

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Mixed deposition was considered to be a minority sedimentary type in the early stage. After many scholars' researches, mixed sediments are widely distributed in marine, continental, transitional sedimentary environments, which indicates that the mixed sediments and siliciclastic rocks and carbonate rocks belong to the same continuum, and mixed deposition is a kind of widely existed sedimentary type. There are less studies on the characteristics, genetic mechanism, sedimentary process and the main controlling factors of the formation and distribution of the multicomponent mixed sediments containing pyroclastic component than mixed siliciclastic-carbonate sediments. A case study of the Permian Lucaogou Formation in Jimusar sag, the mineral components of mixed sediments are identified and the types of mixed sediments are classified by the methods of outcrop and core observation, rock thin section and whole rock mineral and X-diffraction clay mineral analysis. Mixing of different types and scales are identified, including massive compositional mixing, laminated compositional mixing and lithofacies-stratigraphic scale strata mixing. The palaeoenvironment was a free-flowing lacustrine environment in the early stage, and a closed saline lacustrine environment in the late stage by the geochemical analysis methods of carbon and oxygen isotopes, principal and trace elements of core samples. Palaeoclimate was a hot and arid climate, intermittent warm and humid climate. The formation of mixing is controlled by many factors, such as climate, structure, relative change of lake level, hydrodynamics, wind field and so on. Climate affects the production of carbonate rocks and the supply of siliciclastic sediments. Lacustrine sedimentary environment is more obviously affected by climate. For example, there are many alternating light and dark laminas in the study area, which are formed due to the stratification of lake water influenced by seasons. Tectonic factors control the provenance supply, deposition process and scale of the mixed deposition to some extent. In the Permian period of Junggar Basin, strong tectonic activities and frequent volcanic eruptions brought pyroclastic components for mixed sediments and nutrients for the growth of algae in lacustrine sedimentation. Algae adsorbed fine grains in water by algal bonding and formed in situ mixing. Tectonic activities caused gravity flow and formed punctuated mixing. The relative changes of lake level and hydrodynamic changes have obvious effects on the mixed deposition in shallow water environment. Wind is an important geological agent as a form of large flow field activity. The coastal current and storm current produced by wind can form punctuated mixing and facies mixing. Wind is also an important propagation medium for the formation of mixed sediments containing pyroclastic components.

Prediction of Porosity and Analysis of the Relationship between Compaction and Accumulationof Tight Reservoir

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Large-scale tight oil have been discovered in Triassic Yanchang Formation of Ordos basin Recently. In order to effectively promote exploration and mining, the pre-drilling reservoir porosity prediction was carried out in research area. Porosity of clastic reservoirs is affected by sedimentary facies and diagenesis, the reservoirs diagenesis is first quantified, and then the quantitative parameters including paleotemperature T ,vitrinite reflectance Ro The decane isomerization index SI (C29 decane S/S+T), the smectite content S% in Y/M mixed layers of the clay mineral and the authigenic quartz content Vq% which are sensitive to diagenetic field and can be used for diagenetic stage division are selected, These five parameters are used as comprehensive calculation parameters for the diagenesis process. The diagenetic index ID is calculated by calculating these five parameters' changes. Based on the measured porosity of 30 wells in the work area, by analyzing the sedimentary subfacies of each well, the diagenetic index of the target layer Chang7 is calculated, and the relationship between porosity and diagenesis index is established under a single sedimentary subfacie. The results show that with the diagenesis index increases, the porosity shows a downward trend. This trend is expressed as an index, and the fitted relationship is $\Phi = \exp(b\text{-}ID)/a$. The error analysis found that the prediction used a total of 487 sets of data, the correlation between the predicted value and the measured value was good, the correlation coefficient R2=0.805, and the average absolute error of the predicted value and the measured value of the porosity was 1.25%. This method of prediction meets the internationally required standard for absolute error less than 2%. In order to study the relationship between reservoir compaction and hydrocarbon accumulation, we first use the fluid inclusion homogenization temperature to determine the absolute age of hydrocarbon accumulation of the Ordos Basin, and the start time of hydrocarbon filling is 146 Ma of the Chang 72 of Bai 261 well. The Chang 71 of the Cheng 75 Well is 142.1 Ma. The determined oil and gas filling time was calibrated on the single well porosity evolution history map, then the porosity which oil and gas began to fill is obtained. The Bai 261 well is 9.28%, and the Cheng 75 well is 8%, all less than 10% (The narrow margin of oil and gas) can be determined to be first compaction then accumulation.

Lacustrine varves formation in Eocene Jiyang Depression, East China

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In muds sedimentary records, laminae components, paired laminations types and their combination pattern in vertical show frequent and rapid changes, especially in the lacustrine basin, which reflects more complex and sensitive depositional system than the marine environment. The rapid change of vertical combination pattern reflects the high-frequency evolution of paleolimnology conditions. Understanding the sedimentation of these shales is essential to the study of depositional processes, paleoenvironment, and paleoclimate reconstruction. This study investigates the laminae characteristics and formation mechanisms of lacustrine shales in the upper fourth member of the Eocene Shahejie Formation (Es4s) within the Dongying Depression based on thin sections and field emission scanning electron microscope (FESEM) observations of well cores combined with X-ray diffraction and geochemical indicators (macroscale samples analysis and electron probe line scanning analysis). In the laminated shale, seven lamina units can be identified: micritic calcite laminae (MCL), sparry calcite laminae (SCL), quartz-feldspar-clay mixed laminae (SL), organic-rich clay laminae (OCL), organic matter laminae (OL), dolomite laminae (DL) and anhydrite laminae (AL). These lamina units can form different stacking manners: SCL+OL, MCL+SL, SL+CL, MCL +OL+CL, DL+OCL, DL+GL, DL+AL. Sr/Ba, Th/U and other geochemical elements show that es4s-es3x shale was deposited in the hypoxic saline lake. Different paired lamina sets have different geochemistry records in Th/K, Sr/Ba, Co, Cr and Ti content, which index suggesting different sedimentary conditions. In order to better understand the formation of these laminae and laminae combinations, we performed an electron probe line scan of the elements composed of seven laminae combinations.The deposition model has been established to interpret the origin of different laminae units. In the model, the development of laminae units sets is controlled by the hydrological conditions, paleoclimate, terrigenous supply and deposition process. The “key point” is halocline locations in the lake, which limits the boundary of terrigenous material effects, because as the terrigenous material will desalination of lake water in the area that it can reach. Thus the halocline control the differences of upper and lower halocline on composition and interface of laminae units to some extent. And the halocline is controlled by the balance of water depth versus terrigenous input.

Genesis and distribution of dolomite reservoirs in the qixia formation in northwestern sichuan basin

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In recent years, the Dolomite of the Lower Permian Qixia Formation in the northwestern Sichuan Basin has obtained industrial gas flow. This set of reservoirs has also become a focus of attention and research. Since the reservoir type and reservoir distribution are unclear in this area, the origin of the dolomite is controversial, and the previous people's understanding of the control factors of the reservoir is insufficient, this study analyzed the sequence, lithofacies, reservoir space, dolomite genesis and reservoir distribution of the Qixia Formation in Shuangyushi area by researching outcrops, cores, thin sections, logging data and the results of geochemical tests. The results show that the Qixia Formation from the bottom to the top includes a three-level base level falling cycle (SQ1) and a three-level base level rising cycle (SQ2). SQ1 includes four fourth-level base level falling cycles (C1-C4). Inside each of the fourth-level base level falling cycles, the dolomite content increases upward, and the lower part develops micrite and wackstone, and dolomitized limestones and fine-grained dolomite are developed in the upper part. SQ2 contains three fourth-level base level rising cycles (C5-C7). Inside each of the fourth-level base level rising cycles, the dolomite content decreases upwards, from bottom to top medium-grained and coarse-grained dolomite gradually becomes lime-dolomite and dolomitized wackstone. The Qixia Formation mainly develops shoal facies on edge of platform, and the shoals gradually migrate from the southwest and southeast to the northeast and northwest. High-quality reservoirs are mainly developed in the grain dolomites at the top of the third-level base level falling cycle (C4) and the bottom of the third-level base level rising cycle (C5-C6). The reservoir space of dolomite is mainly intercrystalline pores and intercrystalline solution pores, followed by solution cavities distributed in layers. Only intergranular pores and intergranular pores are developed in dolomitic limestone, and no solution cavities are developed. According to the analysis of the test results, it can be concluded that the dolomitization caused by the increase in the salinity and the Mg / Ca ratio of the original sedimentary pore water during the shallow-medium burial stage and the organic acid dissolution in the late burial period are the main reasons for the formation of the dolomite reservoir. Shoal facies reservoirs of the Qixia Formation are controlled by tectonic movements and sea-level changes. Reservoirs are most developed in the late decrease and early rise of sea level, and dolomite reservoirs regularly migrate in the direction of structural uplift.

The impact of authigenic clay on porosity evolution and reservoir quality of gas-bearing sandstone

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The Upper Huagang Formation tight gas sandstones in North-central region of Xihu Depression are various in clay cement, and the corresponding reservoir quality shows a large difference, although the target area has the same provenance system and similar detrital composition. The Y gas field and N gas field are selected as typical study areas to investigate the relationships among different clay cement, pore type and reservoir quality. The study shows that the Y gas field mainly consists of authigenic kaolinite characterized by single euhedral pseudohexagonal shapes and generally as pore-filling book-like aggregates or replaced unstable feldspar and rock fragment. While the N gas field tend to develop chlorite grain-coat, mainly comprise euhedral plate crystals oriented perpendicular to the grain surface. Both authigenic kaolinite and chlorite grain-coating developed after intense compaction (at least line-contact). Relatively shallow buried depth (3000–3200m) and long period acidic environment result in abundance of dissolved pores and kaolinite intercrystalline pore in the Y gas field. While in the N gas field, the study sandstone intervals have entered into weakly alkaline or alkaline diagenetic environment, deeper buried depth (3500–3800) and relatively weak acidic fluid leaching were responsible for the development of thin chlorite grain-coat and more primary pores and a few secondary pores reserved. By comparison, a composed and structurally similar sandstone shows higher porosity and lower permeability in the Y gas field than that in the X gas field due to difference in pore type and connectivity.

Crystallinity characteristics and controls of different origin silica in marine shale of the Sichuan Basin

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During diagenesis, the initial silica classified as opal-A will gradually transform to opal-CT, and finally to quartz at higher temperature, regardless of its initial origin, such as dissolution of biogenic opal (diatoms, radiolarians, silicoflagellates, sponge spicules), hydrothermal fluids, or smectite illitization. In sandstone interbedded with mudrocks, opal gradually recrystallized into cryptocrystalline quartz and continuously developed into ordered microquartz at the end of early diagenesis, and then grew into quartz mountains, and finally macroquartz under the premise of no hydrocarbon introduction and random microquartz coating at the late diagenesis. However, in the most common mudrocks, little available space existed for quartz crystal growth. The opal-A, such as radiolarian tests transformed to opal-CT at the early diagenesis-A stage, and then to microcrystalline quartz at the early diagenesis-B stage.

Although the types and crystal morphology of quartz in different types of mudrocks under every diagenesis stage have been comprehensively and meticulously researched with the help of the application of high-resolution scanning electron microscope (SEM) combined with cathodoluminescene (CL) techniques, the intrinsic property changes of silica in mudrocks with diagenesis enhancement did not draw much attention, especially the changes after the formation of microcrystalline quartz. The marine shale in the Sichuan Basin provided an opportunity to research these changes because of including shale samples in a large range of diagenetic stages, which can be reflected by vitrinite reflectance varying from 1.3% to 3.5%, even larger.

The quartz crystallinity index (QCI) was applied to quantitatively characterise the crystallinity features changes of silica within the marine shale of the Sichuan Basin. A total of 67 samples, including 63 shale samples, 3 quartz vein samples, and one artificial quartz sample as reference, were analysed using X-ray diffraction (XRD) in order to calculate the QCI values. Based on the identification and classification of graptolite biozones, a series of experimental analyses, including the total organic carbon (TOC) content, bitumen reflectance, and elemental composition, were conducted to determine the origin of silica and factors controlling its crystallinity. The results indicated that biogenic silica in marine shale intervals had an obviously poorer crystallinity than silica of other origins. The quartz vein samples from shale intervals presented the highest silica crystallinity. The silica that experienced a low diagenesis intensity exhibited the lowest crystallinity, which gradually increased with the diagenesis enhancement. Furthermore, under the similar diagenesis intensity, biogenic silica in high-yielding wells had much lower crystallinity than biogenic silica in low-yielding wells and outcrops, which was due to it still being in a state of overpressure. The crystallinity of silica contained within the marine shale of the Sichuan Basin is affected by origin, diagenesis intensity, and constant overpressure state.

Thin bed prediction derived from an interbedded substrate: a revised seismic sedimentological method

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Predicting the presence of thin beds ($<\lambda/4$ in thickness, where λ is the length of waveform) from within an interbedded succession can be challenging for seismic interpreters. We propose a new workflow that leverages seismic sedimentological analyses to predict the presence of thin beds. Building on the approach of Zeng et al. (2012), which was based on stratal slicing and 90°phase rotation, we propose a workflow comprising: 1) palaeogeomorphological analyses incorporating differential compaction correction associated with variable lithologies, 2) interference suppression associated with neighboring beds, 3) analysis of stratal slices tied closely to well-logs, and 4) analysis of proportional stratal slices where appropriate. The evaluation of higher-frequency sequences benefits from analysis of subdivision thicknesses coupled with precise ties with well data. The quantitative assessment of thin bed thickness follows on this with the application of some commonly-used techniques, 1) analysis of amplitude tuning , 2) peak frequency, 3) amplitude-frequency blending and 4) genetic neural network analysis.

Seismic geomorphology of a Cretaceous lacustrine deep-water basin- Songliao basin, China

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The Songliao Basin is a Mesozoic to Cenozoic lacustrine synrift basin on Northeast China. With excellent quality 3D seismic data clearly images coastal plain and deltaic channel complexes, shoreface deposits, and deep-water gravity flow deposits have been identified in the upper Cretaceous Nengjiang Formation. Coastal plain deposits are characterized by a complex network of single-threaded meandering channels characterized by a narrow range of azimuths trending N-S. Typical meander wavelength of 1–1.5km is observed suggesting individual fluvial channel-fill deposits less than 3m thick. The coastal plain channels grade into multiple small, less than 6km wide deltaic systems characterized by extensive bifurcation. No clearly delineated shoreline is imaged, suggesting a fluvial-dominated system. Outboard of the coastal/delta plain, isolated channels are observed. These channels, 15–20m wide, constitute slope and basin floor gravity flow channels and are characterized by both swing and sweep. Some of these channels are observed to feed fans characterized by significantly narrower channels and a bifurcating map pattern. Core data suggests a hyperpycnal origin for these deep-water channel-fill deposits. The longer-duration, continuous flow associated with hyperpycnal flow has not resulted in morphologically different deep-water deposits compared with those associated with classical turbidites.

Just above the gravity-flow dominated section, the seismic data clearly images a pattern indicative of a wave-dominated environment. A pattern of curvilinear parallel lineaments approximately orthogonal to the coastal plain channel trend below, is observed to cover much of this part of the basin. These deposits represent a filling of the basin and is associated with a shallowing up of the section. These deposits also highlight the dynamic nature of basin morphology ranging from fluvial-dominated to wave-dominated shorelines.

Top calcareous cementation layers in the Zhujiang Formation reservoirs in the Panyu-A Oilfield, China

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Top calcareous cementation layers (TCCLs) are common types of carbonate cements that cap reservoir sandstone units, forming local seals or low permeability inter-layers. There is no consensus on the genetic mechanism of TCCLs at present, thus hindering effective prediction of their occurrences. A suit of analytical techniques was employed to investigate the genesis and distribution of TCCLs within the Zhujiang Formation reservoir units in the Panyu-A Oilfield, Pearl River Mouth Basin, South China Sea, including core and log analysis, XRF Scanning, casting thin section, scanning electron microscopy, cathodoluminescence, electron microprobe, stable carbon and oxygen isotopes. This has enabled us to systematically study the petrologic characteristics, material source and genesis, distribution patterns and distribution model of TCCLs. TCCLs in the study area comprise mainly gravel-bearing sandstone and medium-coarse sandstone, and the carbonate cements consist mostly of ferrocalcite. The microscopic characteristics and carbon and oxygen isotope signatures indicate that the material source of TCCLs is mainly derived from endogenous biological debris, and its precipitation temperature was inferred to be between 55.9 °C and 72°C, indicating an early diagenetic (stage A) precipitation. The thickness of TCCLs mainly ranges from 0.4 m to 1.2 m, and the width-to-thickness ratios of TCCLs are mostly between 150–750 with strong variabilities among different oil-bearing reservoir beds. The distribution of TCCLs is strongly affected by sedimentary microfacies and high-frequency sequence stratigraphy surfaces. TCCLs are more often developed in the estuary bar facies and more likely to be immediately below the high-frequency marine-flooding surfaces. A genetic model of TCCLs and their distribution in the study area is established. Different from the classical "top calcareous cementation layers" model, which invokes diagenesis with mass transfer of material sources from adjacent mudstone units, the genesis and distribution of TCCLs in the study area is primarily controlled by the enrichment of bio-debris within the sandstone units during marine transgression. Therefore, the spatial distribution of TCCLs can be readily predicted through the analysis of high-frequency sequence stratigraphy and detailed microfacies characterization.

Quantitative Characterization of Pore Structure of Dolostones in the Lower Cambrian Reservoirs of Tarim Basin

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Dolostones have inherently complex multiscale pore structures due to the diversity in depositional environments and subsequent diagenetic processes. In the Lower Cambrian Xiaoerbulake Formation of Tarim Basin, dolostone reservoirs with distinct pore types in different intervals were identified by casting thin section observation and SEM observation. According to the pore types and scales recognized by above observations, the pore structure parameters such as pore size distribution, pore roughness and pore flow property were quantitatively characterized by micro-CT, high pressure mercury injection and spontaneous permeation and absorption. The results show that:

(1) There are pore types of different sizes in three rock structures. Grain-dolostones can be divided into four scales of pore structure types: the first scale is microcrystalline intergranular pores and intragranular pores, and the pore throat is distributed in the range of 20–200 nm; the second is fine dolomite intergranular pores, and the pore throat is distributed in the range of 5–30 um; The third is dolomite intergranular pores with pore diameter distribution ranging from 100–500 um, and the fourth is dissolution-enlarged pores with pore diameter distribution ranging from 1.5–4 mm. There are three types of pore structure in the stromatolitic dolostones: the first scale is algal microcrystalline dolomite intergranular pores, and the pore throat is distributed in the range of 0.8–2 um; the second is algal lattice pores, and the pore throat is distributed in the range of 6–30 um; the third is algal lattice pores, the pore diameter distribution is in the range of 100–700 um. Thrombolitic dolostones have three types of pore structures: the first scale is microcrystalline dolomite intergranular pores and intragranular pores, and the pore throat is distributed in the range of 80–600 nm; the second is intercrystalline pores, and the pore throat is distributed in the range of 5–30 um; the third is dissolution-enlarged pores, and the pore diameter distribution is in the range of 1500–5000 um.

(2) In the grain-dolostones, the fractal dimension of microcrystalline intergranular pores and intragranular pores is 2.27, which indicates better homogeneity and less roughness; The fractal dimension of the intergranular pores of fine dolomite is 2.78, which has relatively poor homogeneity and greater roughness. In the stromatolitic dolostones, both the intercrystalline pore of algae microcrystalline dolomite and the algal lattice pore have relatively poor homogeneity and greater roughness, with a fractal dimension of 2.71. In the thrombolitic dolostones, the fractal dimension of microcrystalline intergranular pores and intragranular pores is 2.67, which suggests poor homogeneity and greater roughness; the fractal dimension of intergranular pores is 2.85, which has relatively poor homogeneity and greater roughness.

Impact of paleogeomorphy on diagenesis of the qixia formation in the northwestern sichuan basin

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The dolomite reservoir of the Lower Permian Qixia Formation in the northwest of the Sichuan Basin has developed, becoming a importment layer of oil and gas exploration and development in the Sichuan Basin in recent years. Evidence from the strata thickness of Qixia Formation and denudation intensity of underlying strata of Qixia Formation indicates that the area had paleomorphic features of the southwestern high, northeast and southeast low in the Early Permian, and the intensity of the dolomitization of the Qixia Formation was obviously controlled by the paleogeomorphy, dolomite reservoirs are thick in the west and thin in the east. In the early sedimentary period of Qixia Formation, due to the influence of large-scale transgression in the early Permian, the study area was generally an open platform facies dominated by wackstones; In the late sedimentation period of the Qixia Formation, sea level began to decline. Based on the earlier low-energy beaches, platform margin began to develop in the southwest and northwest of the study area, which are mainly composed of packstones and grainstones. During sea level descent, in the marginal area of the platform with relatively high landforms, the beaches are frequently exposed to the sea surface. On the one hand, it is affected by the freshwater, and the dissolved pores develop during the syngenetic or paragenetic period; On the other hand, due to the relatively shallow water at high altitudes, the evaporation is faster and the salinity is relatively high,these high-salinity seawaters are “imprisoned” between the particles in the pore development, as the strata continues to bury, the temperature and pressure increase, and the surrounding limestone particles are continuously replaced, resulting in a strong dolomitization. In the northeast and southeast of the study area, due to the relatively deep water and smooth communication with the open sea, evaporation is slow, salinity is normal, and only weak dolomitization occurs. Therefore, the paleogeomorphy has an important controlling effect on the development of dolomite reservoirs in the Qixia Formation of the study area. It not only controls the distribution of high-energy beach facies, but also affects the dolomitization in the later period.

Baer knolls as non-aeolian landforms of the Northern Caspian lowland

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Baer knolls, elongated ridges are widespread in the Northern Caspian lowland. These ridges are not found in this region anywhere above 0 m a.s.l. Several hypotheses on the origin of knolls exist. Studying these landforms is very important for restoring the history of the Caspian Sea and environments that existed on its shores during the Late Pleistocene – Holocene transition. The objective is detailed in describing the internal structure of knolls and their lithological features for a more reliable genesis interpretation. The main issue is incomplete and often ambiguous data. For the first time, X-ray fluorescence analysis results are performed for sediments from several knolls in the Volga Delta (Russia) Deposits of knolls refer to an interval of 18–11 cal. ka BP. Knolls usually consist of two lithological formations lying above the so-called chocolate clays. Chocolate clays, Volga and Ural alluvium were significant sources of material for knoll formation. Baer knolls were formed during the Late Khvalynian – Early Holocene transition.

The aeolian origin of these landforms is prevalent among the scientific community. It contradicts several statements: high cementation of the knoll strata, variety of lamination types, interlayers and lenses rich in shell detritus, erosional contacts between strata, clay and silt prevalence, ripple marks in silty clay. If the Aeolian origin was relevant and the wind carried the clay particles, the question arises as to where such amount of deposit would come from. However, we are not aware of the simultaneous aeolian transport of clay, silt, and sand mixture with shell fragments and detritus. Aeolian transport from the surface of a takyr is low because of the very firm texture due to the high density and cementation. If it occurs, elementary dunes are forming, approximately 1 – 1.5 m high. We consider such aeolian transport of whole shells and debris is impossible in the formation of detritus layers in baer knolls. Flakes and clay pellets in knoll strata often appear in brackish water due to particle coagulation.

Thus, the knoll's material cannot be attributed to the aeolian genesis because of sedimentological features. Simultaneously with the accumulation of sandy material and interlayers of redeposited shells, there was a background deposition of clay particles in a lagoon. These landforms are analogues of river bedforms appearing as a result of turbulent flow, like ripples and antidunes.

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Carbonate sedimentation in volcanic settings – you can't keep a good carbonate down!

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Carbonate sediments have been produced and deposited in areas of active volcanism since, at least, the Paleoarchean. Despite early recognition of a significant relationship between volcanism and carbonate systems, research in this field has been sporadic at best. With increasing recognition of the accelerating effects and significance of anthropogenically-driven climate change on the ocean-atmosphere system, the time is now ripe for studying volcanism-influenced carbonates as a natural laboratory for understanding potential future environmental scenarios.

Volcanism imposes a complex and diverse range of direct and indirect controls on carbonate sedimentation. The study of these systems, in tandem with analysis of ancient mixed volcanic-carbonate sequences, provides temporally and environmentally constrained data to build predictive models to be deployed under future climate and ocean change scenarios.

On concluding our detailed assessment of the state-of-the-science, we establish that one of the largest challenges to our understanding of these complex systems is, potentially, one of the easiest to address. There is a considerable disconnect between studies that have originated from the geological community and those that have been approached from a biological perspective. This disengagement is clearly evidenced in the relative paucity of cross referencing of studies between these two disciplines. With studies from one community often positing hypothesis that may be considered as in the realm of 'common knowledge' of the other. The relative neglect of the study of volcanic-carbonate interactions within the geological community may be attributed to the traditional, long standing, divisions between the fields of sedimentology and volcanism – with each group believing that the study of these mixed systems lies in the remit of the other. Indeed, even within the field of sedimentology, the strong division between the studies of carbonate and siliciclastic sediments again results in these systems, as with other mixed carbonate-siliciclastic systems, 'falling-between-two-stools'. All communities need to pool their combined expertise. It is only through a collaborative, integrative, holistic approach – calling on the expertise of all stakeholders – that we shall be able to progress our understanding of the complex interactions within these fascinating systems.

Another important consideration is that observations of recent volcanic-carbonate interactions are 'challenging' to say the least. Long periods of volcanic quiescence are punctuated by brief episodes of violent activity. Recent developments in robust remotely deployable instrumentation offer the potential to safely undertake sustained monitoring of these systems before, during and after eruptions.

Cross-beds and sedimentary facies: The applicability of OSL as a sedimentological proxy in aeolianites

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Cemented beach or dune sands are found in a wide range of coastal sedimentary and climatic settings and are largely Pleistocene in age. Their preservation is rather a function of favourable conditions rather than formation, showcasing magnificent and often enormous exposures. Diagnostic depositional elements are their internal sedimentary structures, when preserved. Cross-stratification, the most striking feature, often reflects changes in transport directionality and evolution of the palaeo-dune, resulting in spatiotemporal variations of sedimentary facies and creation of bounding surfaces.

Since the mid-90s, Optically Stimulated Luminescence (OSL) has proven to be one of the best dating methods to establish aeolianite chronologies. Nonetheless, its value as a sedimentological proxy still requires investigation. The uniqueness of OSL relays on its capacity to date the last time a mineral grain was effectively exposed to sunlight, just prior to burial, hence reflecting the completeness and efficiency of the OSL signal resetting (i.e., zeroing process). This homogeneity is evidenced by the normality and modality of the Equivalent Dose (DE) distribution. The over-dispersion (OD) of DE values is used as a measure of the heterogeneity in the natural palaeo-dose of the grains of sand. This can be caused by an array of effects, including insufficient zeroing during transport and deposition, turbation processes after burial or other post-depositional changes. Hence, this scatter factor could be used to differentiate depositional mechanism variances, changes in sedimentary facies or even differences between a succession of cross-beds.

For this study, we selected a 100x80x60 cm block exposing different, pristinely preserved aeolianite phases showcasing at least 4 beds, with visually identifiable mm- to cm-thick cross-stratification (20o-40o dipping angles), providing easily recognizable depositional directions. The sandstone block was part of a cemented palaeo-beach/dune deposit outcropping along Spain's Northern Mediterranean Coast, North of the Ebro Delta.

In this study, we compare the different sedimentary facies present in this thick upper section of this once siliciclastic coastal dune. To our knowledge, this is the first time a comparison between juxtaposed yet distinctly individual aeolian beds is achieved using OSL signal analysis, more precisely DE OD, a parameter not commonly used to quantify the degree of sedimentary chaos (López et al., 2018) during transport and deposition. A detailed analysis of each facies OSL age was also achieved. This pilot experiment is part of a larger study that aims to further understand the effects of post-depositional changes in the OSL signal of windborne sands due to diagenetic, dosimetric, or even textural variations overtime.

References:

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Travertine deposition and diagenesis in Ca-deficiency perched hot spring systems: Insights from Shihuadong, China

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Travertines are carbonate deposits around hot springs, irrespective of the Ca concentration in spring water. However, previous studies mostly focused on travertines formed in Ca-rich hot springs, which generally laterally extend tens of meters to several kilometers. Here, we studied a fossil platform-like travertine build-up produced by a perched Ca-deficiency hot spring system. Its genesis and diagenesis were enclosed basing on detailed hydrochemical, petrological, mineralogical, and C-O-Sr isotopic analyses.

Hydrochemical analyses show active springs at the studied area discharge near natural, high-temperature (about 65 °C) water characterized with much low Ca concentrations (approximate to 15 mg/L). The calculated paleo-temperatures of the fossil travertines and the δ13C of their parent CO2 (i.e. δ13CCO2) dominantly range from 45 °C to 55 °C, and −13.58 to −10.84‰, respectively. The latter falls into the δ13C range of C4 plant-derived CO2 range (−20 to −10‰) and slightly lower than CO2 gas released from the spring vents (−8.5‰) and the magmatic CO2 (−7 to −5‰), but C4 plants are rarely developed in Tengchong, indicating the adding of some cold groundwater which contains some C3 plant-derived CO2 before the deposition of the travertines, like the present condition. The 87Sr/86Sr of fossil travertines show the strong interaction between paleo-fluids and underground Gaoligong Group metamorphic rocks.

Travertines in this perched spring system were mainly manifested in its steep frontal area and consisted predominantly of filamentous microbial boundstone and clotted microbial boundstone. In contrast, its top flat area only developed a small perched channel with two slightly protruded edges composed of compacted platy crystalline crusts, dendritic crystalline crusts, granular crystalline crusts. The travertine distribution difference might be controlled by the substrate morphology and hydrochemistry. The flat top surface and Ca-deficiency water impeded the CaCO3 precipitation. However, when the water arrived the frontal area, it had experienced long-time CO2 degassing. Meanwhile, the steep surface of the frontal area furtherly accelerated CO2 degassing and water flow speed, promoting the travertine deposition. Water scattering/dispersion might exist in the frontal area, forming fan-like discharging areas with thin water layers, unlike the perched channel environment, where the water was confined in a narrow channel, but can also fall down rapidly. This effect might be the main factor affecting the lithofacies distinction between the frontal waterfall/slope and top perched channel. After the travertine deposition, underground thermal water, meteoric water, and microbial activity progressively altered the primary fabrics, forming mosaic and need fiber calcite cements, dissolution pores, microborings, and dissolution-induced and microbe-induced micritization.

Overall, the studied perched spring system is small build-up with notable progradation and slight aggradation, and lacks distal autochthonous travertines, unlike the Ca-rich hot spring products, which might extend widely and produce striking distal travertine deposits away from the frontal slope/waterfall. These suggest the important influence of water chemistry and local topography on travertine morphology and might also be used to differentiate fossil Ca-deficiency spring systems from Ca-rich spring systems.

Characteristics of Chlorite of Uranium Deposits and Its Geological Significance in Northeastern Ordos Basin

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The formation of chlorite is related to hydrothermal fluid action, which is an important mineral alteration type of uranium deposits in the northeastern Ordos Basin, and is closely related to uranium mineralization. It is generally believed that chlorite is formed mainly in two mechanisms: one is that the fluid metasomatism minerals precipitate around the minerals and recrystallize to form chlorite. In the study area, biotite is usually metasomatism to form chlorite, showing an obvious metasomatism dissolution phenomenon. Therefore, chlorite formed under this mechanism is generally not brought in by Fe and Mg components, and is mainly converted from iron and magnesium silicate minerals. At the same time, this part of chlorite often has uranium produced along its joints; The other is chlorite formed by precipitation and crystallization in different places after fluid metasomatism. In the study area, chlorite is in the form of interstitial material between sandstone particles and is distributed on the surface of particles. The Fe and Mg components needed in the formation process are mainly brought in by hydrothermal solution.

Uranium occurs in biotite joints in the form of independent minerals or adsorption in the uranium deposits in the northern Ordos Basin, and this biotite is usually chloritized. It is considered that in the process of hydrothermal action, chlorite formed by biotite alteration will retain uranium in uranium-bearing accessory minerals, and due to the adsorption of chlorite, it will absorb part of the uranium released in the process of biotite metasomatism to form chlorite. It can be seen that the chloritization process not only changes the occurrence state of uranium in the original rock, but also preenriches the uranium released in the process, which provides some help for uranium mineralization in the later stage. In addition, during the formation of chlorite by hydrothermal fluid, not only Fe and Mg components are brought in, but also some uranium are brought in. Chlorite is formed in a reducing environment and has certain adsorbability. In the process of hydrothermal fluid migration, with the change of physical and chemical properties in the sand body, the external conditions for the existence of uranium-containing hydrothermal fluid change, and uranium is finally fixed by precipitation.

To sum up, a relationship between chlorite and uranium mineralization in sandstone-type uranium deposits is described. The characteristics, formation process, and genetic mechanism of chlorite in sandstone are emphatically expounded. In the process of formation, it is influenced by fluid, which belongs to the process of metasomatism and dissolution in sedimentary geology.

Reservoir characterization and modeling of tidal delta reservoir in halfaya oilfield, Iraq

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Cretaceous Nahr Umr clastic reservoir is important production formation for several giant oil fields in southern Iraq, including the Halfaya Oilfield. In the Halfaya Oilfield, the Nahr Umr Formation develops tidal delta sediments. It has the characteristics of poor continuity of sand bodies, rapid changes in reservoir quality, and strong heterogeneity, which challenges reservoir characterization and modeling. This study is based on data from core experiments, logging interpretation, seismic interpretation and inversion, and production performance. It has mainly completed three aspects of research: 1. The facies model of tidal deltas under the sequence stratigraphic framework in this area is proposed, which describes the distribution characteristics of different types of sand bodies; 2. The controlling effects of sedimentation and diagenesis on reservoir properties was discussed, and four different rock types were obtained; 3. With the understanding of geological research, the "loop process" of geological modeling is used to understand the uncertainty in structure, reservoir distribution, reservoir properties and fluid distribution, and to reduce uncertainty through multidisciplinary data analysis. The results show that: 1. The distribution of the Nahr Umr tidal delta clastic reservoirs in the Halfaya oil field is controlled alternately by river sedimentation and tidal sedimentation during sequence evolution; 2. Sedimentation and diagenesis have significant control over pore structure and pore size, thus affecting reservoir quality; 3. For the modeling of such highly heterogeneous clastic reservoirs, the full use of sensitivity analysis can effectively reduce the uncertainty of the geological model.

Linkage of isolated and coherent syndepositional faults: Insight for sedimentation pattern in lacustrine rift basin

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The influence exerted by the linkage and growth of syndepositional fault segments on the sedimentation pattern in a lacustrine rift subbasin, the northern Bonan Sag in the Jiyang Depression in the Bohai Bay Basin, is studied by integrating drilling cores, wireline logs and 3D seismic data. The NW-trending Guxi Fault formed through the linkage of three fault segments. They display a roughly en echelon arrangement in map view, and are probably related to early-stage regional transtensional and slip-strike stress. Between the vertical displacement troughs of normal faults, two narrow relay ramps, attributed to the coherent fault linkage-and-growth model, formed through the linkage of the three fault segments. A relative wide relay ramp, attributed to the isolated fault linkage-and-growth model, also developed due to the linkage of the NW-trending Guxi Fault and E-W-oriented segmented Chengnan Fault. The sedimentation pattern was strongly controlled by the geometry and evolution of the relay ramps. The sediment routing system was dominated by the relay zone, and the fan-delta and sublacustrine fan depositional systems developed in the early-stage of relay ramp formation. Lateral breaching of the relay ramps through extensive faulting and rifting probably caused an increasing in the vertical throw, and resulted in deposition of coarse-grained nearshore subaqueous fan in front of the normal faults. The relay zone that formed from the linkage of independent faults (the Chengnan and Guxi faults) is associated with a broad drainage area and fan-delta and sublacustrine fan deposits, which contain the most effective hydrocarbon reservoirs in this deeply-buried setting.

Seismic analysis of the Orange Basin; from a deepwater fold-and-thrust-belt to Cenozoic mass transport systems

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Traditionally, deepwater fold-and-thrust belts (DWFTBs) have been of great importance to the petroleum industry as vast reserves of hydrocarbons are associated with their anticlines. Well-preserved DWFTB systems are found in the South Atlantic with several occurring off the western coast of South Africa in the Orange Basin. Previous studies have mainly focussed on the 2D seismic interpretation of the Orange Basin, which is naturally limited or confined to shallow waters. In this study, the availability of high-resolution, 3D seismic reflection data has allowed us to constrain the strato-structural architecture of the deepwater Orange Basin from a Cretaceous DWFTB system to the overlying Cenozoic deposits.

The 3D seismic data show the imaging of the structurally complex transitional domain and a portion of the compressional domain, containing the fold-and-thrust belt system, upon a main, seaward-dipping, basal shale detachment surface. The strong seismic marker forms the oldest of the seven seismic reflections observed in the study area, identified at the base of lithological units. These are the: Turonian, Santonian and Maastrichtian Cretaceous horizons; and the Palaeocene, Oligocene and Miocene Cenozoic horizons, including the seafloor. Multiple shale detachment surfaces partially accommodate slip in the DWFTB system. Gravitational slip initially occurs along the main Turonian shale detachment surface until the DWFTB system becomes locked. Stress in the system is then redistributed through the downward propagation of thrust faults onto a lower shale detachment accommodating further slip and essentially creating a younger, underlying set of folds and thrusts. With progressive sediment deposition, stress and strain are constantly redistributed in the basin to give rise to a complex range of geometries. This affects the timing and locus of sedimentation as evidenced through the complicated fault networking system, which are possible conduits for hydrocarbon migration. Some of these faults have been reactivated, extending from the main Turonian shale detachment surface in the transitional domain and terminating between the Oligocene and Miocene stratigraphic horizons which are unconformity surfaces. These two horizons correspond with the major Oligocene and lesser Miocene sea-level lowstands, previously described in great detail for southwestern Africa's shallow marine to coastal settings, and are characterised by: one large submarine canyon truncating the base of the Palaeocene on its seaward trajectory; and a smaller series of concentrated incipient canyons, respectively. The Cenozoic mass transport system and deposits are thus strongly influenced not only by relative sea-level fluctuations but also by the underlying geometry of the Cretaceous DWFTB system. The present morphology of the seafloor indicates that slumping still occurs due to sediment instability along the seaward-dipping continental slope.

Paleoclimatic control of the upper Jurassic deposits in the central Saharan atlas, Algeria

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The palaeogeographic position of the Saharan Central Atlas was on the western margin of the Tethys in an epicontinental shallow area between a continental domain in the west and a deeper oceanic domain in the east. The Late Jurassic is a time of pronounced climate perturbations, and in the studied area in Algeria several carbonate platforms developed during this time, interrupted by fluvial clastic deposits. During the Bathonian to Oxfordian deltaic sediments have been deposited, overlain by middle Oxfordian shallow-water carbonates, again overlain by fluvial successions followed by shallow inter- to supratidal carbonates sometimes with intercalated gypsum-bearing marls overlain again by fluvial sediments, this interval is from ? upper Oxfordian-lower Kimmeridgian age. In the upper Kimmeridgian high-energy shallow-water carbonates have been deposited. The aim of this study is to disentangle whether this cyclicity of shallow-marine and fluvial deposits result from regional factors (e.g. tectonic), or from global climatic/sea-level changes. The timespan from the Bathonian to the lower Tithonian is characterised by a long-term global sea-level rise. However, the overall change from greenish clays and sandstones (Bathonian to Oxfordian) to reddish clays (sometimes with gypsum) and shallow-water carbonates (middle Oxfordian to upper Kimmeridgian) argues for a strong climatic influence on the facies development

Allocyclic controls on shoreface deposits of the Gippsland Basin, SE Australia: 70 Ma of deposition

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Shoreline depositional systems form in highly dynamic settings at the interface of marine and terrestrial environments, and are particularly susceptible to changes in relative sea level, tectonics, and climate. For this reason they are excellent record keepers of basin evolution. The Gippsland Basin contains a well developed, continuous succession of amalgamated clastic shoreline deposits from the Cretaceous to present day. During this time the basin has experienced significant changes in tectonic regime, ocean chemistry, and fluctuations in palaeoclimate.

Using 2D and 3D seismic and well data, we have described 23 stacked coastal units within the Latrobe and Seaspray Groups. These coastal units are composed of lower coastal plain swamps responsible for significant coal accumulations, and progradational and backstepping shoreface deposits dominated by strandplains, indicating significant wave influence. These units are discrete, and many exhibit exceptional preservation as a result of in-place drowning. Shoreface deposits are interpreted to include a range of depositional styles, including prograding beach, barrier island, and transgressive beach.

Palaeoshorelines of these coastal units display up to 123 km of transgression from the Late Cretaceous to the Miocene. Eustatic changes are evident by flooding surfaces punctuating unit deposition, however overall backstepping of the Late Cretaceous to early Miocene units indicate basin subsidence is a dominating allocyclic process. Compressional tectonics and glacioeustatic fluctuations are recorded by unconformities in the Oligocene and Miocene deposits. Despite fluctuations in palaeoclimate and tectonic regime, basin subsidence appears to be the dominant allocyclic driver for shoreline location.

Replicating channel bottom morphology of meandering fluvial channels: an experimental approach

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Understanding morphodynamic evolution of meandering fluvial systems, along with internal architecture of related deposits have remarkable implication for landscape management and subsurface exploration. Laboratory experiments provided remarkable insights to these research issues, by contributing to understand hydrodynamics of meander bends along with controls on their initiation, planform evolution and abandonment. Experimental studies were mainly structured in order to have a fixed-bed, which have non-erodible boundaries and no sediment transport, or movable-bed where the substrate can be remobilized by a flow. Fixed- and movable-bed experiments contributed mainly to hydrodynamic and morphodynamic investigations, respectively.

Mobile sediment in fixed meander planforms has been sporadically used in laboratory experiments. In this work, we explore the effectiveness of this approach to reproduce channel bottom morphologies, including spatial distribution of pool and riffle zones. In order to achieve this goal, we planned a comparison between bottom morphology of two meander bends of the Wabash River (Illinois, USA), and experimental topographies obtained through a number of experiments at the Department of Geoscience, University of Padova. The two meander bends of the Wabash River are sited ca. 6 km upstream from Grayville, where the river is ca. 300 m wide and up to 10–12 m deep. Channel-bottom morphology of these two bends was depicted by Konsoer et al. (2016). The experimental scaled model of this reach of the Wabash River occupied a tiltable platform, that was 3.0 m long and 1.5 m wide. The experimental channel belt included a total of four bends, named 1 to for moving downstream. Bends 2 and 4 were used for the comparison. The width of experimental channels was scaled at 0.08 m, and the total length of the channel reach to ~7 m. Meander bend planforms were milled in wood with a pantograph on the base of the CAD-extrapolated Wabash River centerline. The river banks were made by two 0.1 m high metal sheets which were placed vertically, screwed to the pantographed wooden path and sealed to it by smeared silicone. This apparatus was located on top of the platform. Experimental channel was filled with sediment up to 6 cm from its bottom, and water and sediment were supplied to the upstream termination of the channels. Water was fed through recirculating system, and sediment was delivered by means of an adjustable sediment feeder.

Eight experiments were performed with grain sizes varying from fine to very coarse sand and lasted from 1 to 5 hours according to the run suites. Sediment supply rate was defined in accordance with water discharge and basin slope by applying the solid transport laws as revised by Bathurst et al. (1987), which proved to better suit the boundary conditions of our experimental setup. Preliminary results highlight that experimental channel bottom morphology is comparable with that of the study prototype, especially in relation with spatial distribution of pool erosional depressions and riffle topographic highs in the bend inflection zones.

Possible changes in carbon fixation in the southern ocean indicated by salps fecal pellets

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Salps fecal pellets are sediments rich in organic matter produced by the excretion of salps. There has been an increase in the population of salps during recent years in the Southern Ocean as a result of warmer shallow water, where they have replaced krill as principal grazers of phytoplankton. Salps are marine invertebrates and their fecal pellets are well-known for their high content in organic matter and high sedimentation velocities, compared to other fecal pellets, it is expected, then, that an increase in salp abundance, in response to higher water temperatures, will favor the particulate organic carbon (POC) export, that is, the fixation of carbon in marine sediments.

There are three different types of pellets, classified according to their morphology, they show differences in both form and organic matter content, the type 1 fecal pellets are the most compact, fresh looking and richest in organic matter content, type 2 fecal pellets are loosely packed fecal pellets, possibly broken or partly degraded and type 3 fecal pellets are thin and mainly consisting of the mucous filter with only a few particles inside.

However, salps fecal pellets have a weaker structure than krill fecal pellets, and are more likely to be destructed or consumed by either zooplankton or by microbial action in the water column before reaching seafloor, liberating organic matter to the mixed layer and decreasing the capability of carbon fixation by salp fecal pellets sedimentation. It is believed that type 2 and 3 fecal pellets are a result of the losing of organic matter content of the fecal pellets.

Our analysis shows that there is a substantial difference in the sedimentation velocities between the three fecal pellets types, being the type 1 the fastest and the type 3 the slowest, however we found that the size of the fecal pellet particle is not directly proportional to the sedimentation velocities. Sinking velocities are, rather, related to the fecal pellet types, for example, type 1 fecal pellets are richer in organic matter, and therefore, denser than type 2 and 3 fecal pellets. In fact, while the results show that type 3 fecal pellets average size is bigger, they have notably lower sedimentation velocities compared to type 1 fecal pellets, which are smaller but faster.

Low sedimentation velocities imply that organic carbon expends more time in the water column before reaching seafloor, and, giving the weak nature of the mucous filter that protects the salps fecal pellets, it is likely that POC export is not as high as it was expected.

Epicontinental ironstone accumulation during the end-Ordovician glaciation and extinction events

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Late Ordovician ironstone of the Neda Formation, midwestern USA, contains an underappreciated record of environmental change during the end-Ordovician extinction event and glaciation. Various ironstone facies cap the Maquoketa Formation, which is composed of interbedded dolomitic shale, limestone, and dolostone containing a diverse assemblage of heterozoan carbonate-producers. The lower contact of the Neda Formation is conformable and marked by a transitional Fe-rich mudstone that contains rare Fe-coated grains. Coated grain abundance and size increase up section to form a coated grain grainstone at the top. A thin, organic-rich, carbonate fluorapatite- and pyrite-bearing bed containing large flat phosphatic clasts mantles this grainstone. Where not eroded, a hematitic crust interpreted as a subaerial ferricrete is developed over underlying units. The upper contact of the Neda Formation is the Ordovician-Silurian unconformity, which has over one meter of erosional relief.

The transition from a carbonate-producing factory to one precipitating authigenic Fe-oxyhydroxides was complicated by paleoceanography and antecedent topography. The Fe-rich mudstone of the lower Neda Formation suggests accumulation in a low-energy offshore environment below storm wave base. Trough and low-angle cross stratification in overlying coated grain rich-facies suggest ironstone accumulated in a storm-dominated middle platform environment. Cortical layers forming coated grains are interpreted to have precipitated authigenically beneath the sediment-seawater interface. Grain cortices with internal discordances probably record periods of exhumation and abrasion. The precipitation of Fe-oxyhydroxide grains and cements occurred in ferruginous pore water and was likely aided by Fe-redox pumping below the seafloor. Variability with respect to siliciclastic content can be attributed to proximity to major siliciclastic sources within the basin, as the most siliciclastic-rich deposits occur nearest the Kankakee Arch, a regional topographic high at the time of deposition. The pyritiferous and phosphatic upper Neda Formation is interpreted to record a change from ferruginous to euxinic sea water conditions. This change was probably the consequence of a landward shift in location of the upwelling front during marine transgression coincident with Hirnantian interglaciation.

The Neda Formation marks a key interval in Earth history. With glacial cooling an increase in the equator-to-pole temperature gradient is interpreted to have intensified atmospheric circulation, which strengthened oceanic upwelling. Upwelling could now tap and deliver ferruginous bottom water to the Michigan Basin and facilitate the precipitation of ironstone. Transgression during the Hirnantian interglaciation shifted the ironstone factory landward and forced the impingement of a deeper euxinic water mass on the shelf. Results of this study support the existence of a redox stratified water column with anoxic to euxinic conditions at depth within Late Ordovician Laurentian epeiric seas.

Environmental and tectonic controls on the Norian-Jurassic sedimentary succession in the Northern Calcareous Alps (Stumpfmauer-Austria)

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The Upper Triassic-Jurassic succession of the Western Tethys was affected by major climatic and environmental changes, the end Triassic biotic crisis and Jurassic extensional tectonics related to the opening of the Alpine Tethys. These global and regional events are recorded in Norian-Upper Jurassic successions of the eastern Northern Calcareous Alps (Stumpfmauer, Austria), exposed in the Königsberg and Oisberg synclines. The transition from the Norian early-dolomitized peritidal facies of the Hauptdolomit to the Rhaetian mixed limestone-siliciclastic succession (Kössen Formation) marks a rapid siliciclastic input from the European hinterland, reflecting a switch from arid to humid climate. The studied sedimentary succession was divided from base to top in eight sedimentary units labelled from A to H. Unit A (40–50 m thick; upper Norian, Hochalm Member of the Kössen Formation) consists of peritidal facies organized in shallowing-upward cycles capped by subaerial exposures overlain by claystone beds, passing to a 50 m thick fossiliferous succession of claystone and marlstone, with phaceloid corals, bivalves and brachiopods (Unit B; uppermost Norian-lowermost Rhaetian, Hochalm Member). Unit C (10 m thick, lower Rhaetian, Hochalm Member) corresponds to a massive coral limestone, representing a regional marker bed. Unit C is overlain by shallow-marine skeletal peloidal packstone/wackestone and coated-grain grainstone forming subtidal, shallowing-upward cyclothems capped by subaerial exposures followed by claystone (Unit D, 80–110 m thick, middle to upper Rhaetian; Upper Rhaetian Limestone time-equivalent to Eiberg Member of the Kössen Formation). Unit E is characterized by a basal transgressive lag with crinoidal lithoclastic rudstone overlain by nearly 45 m thick progradational cross-bedded high-energy coated grain-ooidal grainstone (Upper Rhaetian Limestone time equivalent to Eiberg Member). Unit F records a sharp change in deposition with 40 m of bivalve and ostracod wackestone/floatstone overlain by microbial boundstone with Cayeuxia associated with peloidal packstone/grainstone, likely reflecting the extinction event close to the Triassic-Jurassic boundary. Unit G (34 m thick, lower Jurassic, Kalksburg Fm.) consists of cross-laminated crinoidal coated grain grainstone with detrital quartz, passing upward to deep pelagic red colour crinoidal, thin-shelled bivalves packstone/rudstone with ammonites and radiolaria wackestone, suggesting the drowning of the shelf (Unit H, Lower to Upper Jurassic, Hierlatz Member, Adnet, Klaus, Ruhpolding formations).

The Königsberg and Oisberg synclines show different stratigraphic evolution: in the Königsberg syncline the succession is continuous from Unit A to H, whereas in the Oisberg syncline Unit A is sharply overlain by Unit H Middle Jurassic limestone. The existence of this Rhaetian-Lower Jurassic stratigraphic gap in the Oisberg syncline suggests local uplift and erosion of the Rhaetian succession before the regional Middle Jurassic drowning, whereas sedimentation persisted in nearby areas.

The investigated sedimentary evolution and facies distribution reflect a major climate change (Kössen Formation) followed by early-middle Jurassic extensional tectonics driven by the opening of the Alpine Tethys, controlling the formation of structural highs, where part of the Rhaetian succession was eroded, and lows where the succession was continuous. The observed stratigraphic setting can be framed in the regional evolution of the Alpine Tethys, which can be traced in the different palaeogeographic domains of the Alps.

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Low and High Discharge Variability Fluvial Styles: example of the Jaicós Formation, Parnaíba Basin, Brazil

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Pre-vegetated fluvial systems are frequently considered as dominated by sheet-braided to poorly channelised sand bodies. However, conventional classification based on fluvial planforms limits significantly fluvial dynamics interpretation, grouping in the same terminology channel deposits generated by distinct hydrodynamics contexts. The Jaicós Formation, Middle Silurian-Early Devonian of the Parnaíba Basin, NE Brazil, comprises exceptionally well preserved fluvial deposits that lack high-resolution facies and architectural analyses. Its stratigraphic framework is analysed in terms of the depositional nature of constituent bedforms, related to subcritical, transcritical, and supercritical flow regimes. Throughout a detailed facies and architectural analysis, eight lithofacies are recognised, and make up eight architectural elements. These elements fit into two distinctive fluvial styles: (1) the low discharge variability fluvial style – dominated by straight- to sinuous-crested bedforms as constituents of simple and compound downstream accretion bars and subcritical, aggradational dunes. These elements suggest deposition under subcritical flows, in conditions of low discharge variability, where bedforms migrate during seasonal peak-discharge events. This fluvial style assigns a steady, perennial system; (2) the high discharge variability fluvial style – consists of small- to large-scale sigmoidal bedforms and antidunes deposits, with complex vertical stacked patterns and morphologies. These bedforms are deposited by unstable, transcritical to supercritical flows. This fluvial style reveals an ephemeral system, linked to non-periodic, multi-stage peak-discharge events. The high discharge variability deposits overlay abruptly the low discharge variability ones and mark an abrupt change within the fluvial architecture of the Jaicós Formation. This hinterland braided fluvial system was deposited during an interval marked by very oscillatory climatic-oceanic conditions. This architectural shift results from large-scale discharge variability due to climate changes, varying from warm, humid climatic conditions to cooler, semi-arid conditions.

Earth system changes during the cooling hothouse phase of the Late Cretaceous:Newresults on the Coniacian-SantonianOAE3subevents

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Several competent ecological disruptions along with consequent mass extinctions have been associated with widespread anoxic settings in Earth history. The Coniacian-Santonian (C/S) was a time of strongly antagonistic oceanic sedimentation patterns, which distinguished organic carbon (OC)-rich black shales that thought to be accumulated during the last oceanic anoxic event (OAE)3, versus OC-poor white/red limestone and clay known as Cretaceous Oceanic Red Beds (CORBs), and the eponymous chalk deposits. Evidence for widespread bottom water anoxia was regionally restricted, based on elemental geochemistry, sulfur, and foraminifers, to the equatorial Atlantic, off west Africa, epeiric and shelf seas of the Maracaibo, Western Interior Seaway (WIS), Arctic Canada, and Otway basins, and the Songliao lake basin. However, a general consensus of temporal distribution of OC-rich facies and timing of the OAE3 is still a matter of debate. Here, we focus on the C/S global processes based on compiled geochemical and isotope proxy data of more than 95 study sites and areas. We constructed two global curves for the C/S carbonate and organic matter (OM) carbon isotopes and discriminated three main levels of short amplitude, yet global, carbon isotope excursions based on statistical analysis. These levels are consistent with the development of regional benthic anoxia and sea level highstand that best explain the long-term OM accumulation defined herein as OAE3a, OAE3b, and OAE3c.

The OAE3a subevent is proposed herein to occur during the late mid-Coniacian and equivalent to the Kingsdown event. It developed directly above the White Fall event and is characterized by a positive δ13C excursion of ca. 0.4‰ and occasionally reached up to 1‰ in some localities. The OAEb corresponds to the Horseshoe Bay event that occurred during the late mid-Santonian. Like the Kingsdown event, the Horseshoe Bay OAE3b represent a medium-term δ13C maxima. The OAE3c represent a regional long-term δ13C positive excursion (0.6–0.95‰) that developed directly after the latest Santonian Foreness negative excursion event up to the Santonian-Campanian boundary event. According to our C/S global carbon isotope compilations, these three subevents can be documented on a global scale. This reveals that intercontinental basins, oceans, shelf seas and realms were not isolated during these subevents and a slight perturbation in the global carbon cycle may be occurred. Throughout the equatorial Atlantic and adjoining epicontinental seas, the three subevents were accompanied by enhanced OC and sulfur accumulation, significantly high contents of redox-sensitive trace elements such as Mo, V, Cr, Zn, Cd, and benthic foraminifers become either extinct or subjected to a strong turnover compared to OC-poor contents in the Boreal, Tethys, Indian and Pacific. Differences in OC contents can be attributed mainly to water column conditions, and paleoceanographic and circulation patterns that triggered enhanced oxic bottom water within the former regions.

The Structural measurements of bertakari and bneliKhevi deposite area (Bolnisi ore field southern Georgia)

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The Study area (Bertakari-Bneli Khevi deposits) is located in Bolnisi ore field in southern Georgia which is part of the globally significant Tethyan-Eurasian Metallogenic Belt.

The Bolnisi ore field is well known for the existence of both Kuroko-type volcanogenic massive sulphide and volcanogenic epithermal ore deposits primarily associated with hydrothermal processes. Despite the economic and strategic importance of such occurrences, the detailed geology of this particular region is poorly known and it obviously lacks geological mapping at an adequate scale.

The Bertakari and Bneli Khevi deposits are host by Upper Cretaceous Gasandami suite which in the Bertakari area is subdivided into two – the lower Gasandami and upper Gasandami subsuites. Gold-base metals mineralization within the lower Gasandami subsuite is related to pervasively hydrothermally altered rocks – hydrothermal breccias. The upper Gasandami subsuite postdates mineralization and does not contain any of significance ore occurrences. It is introduced by volcanogenic, magmatic and normal marine rocks.

The lower subsuite of the Gasandami suite, (K2gn1) is constituted by the altered rocks with diverse textures, chemical and mineralogical compositions and mechanic properties mainly formed after rhyolite-dacitic lavas, volcaniclastic and extrusives rocks. The upper Gasandami subsuite breccia-conglomerates are affected by quartz-sericite, adularia, argillic and propylitic alteration.

A main NNW-SSE orientation is recognized at the regional scale in the Bolnisi mining district. Structural measurements realized on fractures of the host of the mineralization suggest the same orientation pattern. Important normal faulting are also affecting the entire unit, this feature bring both the silicified rhyodacite and the argillic alteration side-by-side. Measurement of the bedding in this hydrothermally altered rhyodacite distinct two populations of dipping plane, a major one dipping toward the northeast and another one dipping southwest. This brittle deformation style can probably be associated to the general strain during the closure of the Neothetys between the SAB and the Eurasian margin.

Mixing of continental water masses during MECO (Hampshire Basin): new insight from Carbonate Clumped isotopes

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Delineating the response of different environments to changes in temperatures is crucial to predict the impact of future climate warming. The hydrological cycle is of particular importance, as it influences rates of erosion and impact freshwater discharges on continental margins. Here, we present clumped isotopes (Δ47) and stable isotopes (∂18O and ∂13C) data from 14 well-preserved, aragonitic molluscs and gastropods samples from the Middle Eocene Barton Clay Formation (Hampshire Basin, Barton on the sea, UK). The Hampshire Basin is the northwesterly component of the larger Anglo-Paris-Belgium Basin and represent one of the best preserved Paleogene sequence worldwide. The Barton Clay Formation has been studied to assess variation on the paleoshoreline as well as in temperatures during Middle Eocene: our interest is to understand the link between climate, and the oxygen isotope composition of seawater in this basin (a proxy for input of continental freshwater).

Carbonate Clumped isotopes is based on the temperature-dependent abundance of 13C-18O bonds in CO2 (expressed as Δ47), a measure directly correlated to the temperature of precipitation of carbonates. Using clumped isotope data and the ∂18O of the sample, the isotopic water composition (∂18Ow) can be directly calculated. In continental margins, the seawater ∂18O composition is influenced by the mixing of riverine and marine waters in addition to environment temperatures. Clumped-isotopes, unlike oxygen isotopes, are not sensitive to changes in the water oxygen composition and thus allow to disentangle this temperature from water composition.

Our preliminary results confirm the presence of the Middle Eocene Climatic Optimum (MECO) event (a 2‰ negative ∂13C excursion starting ~20m upsection). The MECO is a global warming anomaly that has been recorded worldwide and dated to ~40Ma. Data from the base of the section (pre-MECO) suggest more brackish conditions (∂18Ow of -5.50‰ ± 0.5), associated with relatively low-temperature of 13°C ± 2°C. Up section, at the base of the Middle Barton Beds, more marine ∂18Ow values are recorded. A general increase of temperature is also observed (max T of 32±5°C), interspersed with a few cold events with temperature of 13°C ± 3°C. During the MECO event, clumped-isotopes analyses record temperature of 27± 1°C, and normal marine ∂18Ow values. Our quantitative benthic fauna analysis (i.e. ostracods, molluscs and gastropods) shows very low species richness index (SRI) in the lower part of the outcrop (in the brackish conditions), followed by a drastic increase in SRI up section, where our reconstructed oxygen isotope values of seawater suggest more marine conditions. This increase in marine values could be indicating a deepening of water depth in the basin starting from the middle of the Middle Barton Beds and up into the MECO event. We conclude that clumped isotopes data successfully recorded changes in temperature and input of continental freshwater into the basin: this approach thus has tremendous potential in reconstructing paleoclimate on continental margins.

Karoo palaeosols at the end-Capitanian extinction event suggest increasing landscape stability

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The mid-Permian (end-Capitanian) mass extinction event is now recognised in both the marine and terrestrial realms. Evidence for the event originally came mainly from marine carbonate invertebrate biostratigraphy but more recently an extensive study of mid-Permian tetrapod assemblage zones from the main Karoo Basin of South Africa has revealed a distinct change in tetrapod diversity at around 260 Ma. Dinocephalian therapsids characterise the mid-Permian tetrapod assemblages but they are absent from late-Permian (Wuchiapingian) assemblages. This stratigraphic interval is constrained by CA-TIMS geochronology and contains the boundary between the Abrahamskraal and the Teekloof formations. The two lowermost biozones of the Beaufort Group, the Eodicynodon and Tapinocephalus assemblage zones, are found within the Abrahamskraal Formation and are renowned for their diversity of basal therapsids, which has contributed to the understanding of the distant origins of mammals. The fossiliferous sedimentary rocks of the lower Beaufort Group provide a record not only of the dinocephalian extinction event, but also of environmental change at the end-Capitanian. Specifically, these rocks, which were deposited in vast fluvial distributary systems, show changes in ancient channel sinuosity patterns.

Environmental and climate changes associated with the dinocephalian extinction event have not yet been extensively investigated. Isotopic evidence from tetrapod tooth enamel and bone suggests aridification without warming between the upper Abrahamskraal and lower Teekloof formations. Sedimentological work has revealed a slight change in alluvial architecture across this same interval but the resolution of these facies studies prevented a fine-scale examination of the palaeo-climate proxies.

This new study investigates palaeosols from the Abrahamskraal and Teekloof formations, and presents climate proxies derived from geochemical and microfacies analysis data. The sedimentary geochemical analyses were obtained via X-Ray spectroscopy (X-Ray fluorescence and diffraction) for assessing the mineralogical and major element composition of the palaeosols and associated rock samples. Microfacies analysis of thin sections was employed to examine palaeosol fabrics.

Our initial weathering trends and aridity indicators suggest that chemical weathering at the time of deposition was insignificant, and that there was little difference in mean annual temperature, although some of the palaeosols indicate wetter intervals. Palaeosol fabric analysis shows that soils were better developed in the Teekloof Formation, indicating a more stable land surface.

Environmental engineering in the Pragian?

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Social insects are key environmental engineers in a range of ecosystems today and understanding when these groups began modifying their environment is a critical step to a better understanding of how ancient terrestrial ecosystems evolved. Finding actual remains (body fossils) rarely occurs, though traces of likely social organisation can be preserved in nests. These are complex interconnected structures made by solitary and social invertebrates and reveal their strategies for life in the terrestrial environment. Nests of insect societies tend to be more elaborate than those of solitary organisms and preserve evidence of adaptations to disturbance (e.g. from flooding and predation), low oxygen levels and feeding strategies (food hoarding, farming). Structures within nests vary depending on local substrate and climate conditions. Although construction methods and architecture converge and overlap, there are basic styles unique to particular social insects and these differences help to identify the tracemakers.

Despite the body-fossil record of social insects (ants and termites) going back only to the Lower Cretaceous, there are many published descriptions of complex burrow systems from older strata although their association with social insects is disputed because associated body fossils are absent. However, given the 'ichnocomplexity criterion' complex behaviour indicated by particular traces can be compared with extant systems made by known organisms and inferences made about the nature and makers of pre-Cretaceous structures. Recently, complex trace fossils that are similar to the nests of social insects have been discovered in Pragian (Devonian) palaeosols and this could indicate that social behaviour evolved much earlier.

These complex traces appear to meet many of the criteria for social organisation of soil organisms. This not only suggests that unknown organisms had reached a degree of social organisation much earlier than previously thought (270 million years) but also raises the issue of why such a high level of organization appeared so early in the development of terrestrial ecosystems, and in one with a trophic structure so different from modern systems.

Origin and diagenesis of microbial fabrics in cave pearls and moonmilk deposits

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Cave pearls are unattached rounded carbonate concretions usually appearing in pools or depressions in caves. Traditionally considered the product of purely physicochemical processes, recent research points toward a possible contribution of microbes in their formation. In Koševelka, a karstic cave in central Slovenia, extremely porous botryoidal cave pearls form 30 cm-thick accumulations below a big, bottom-flat inactive moonmilk stalactite, suggesting a genetic relationship between both cave deposits.

The cave pearls are very heterogeneous in shape, size, and internal structure. They measure from 1 to 10 cm and can be flat or spheroidal. Most of them display an external crystalline cortex, but internally they either present a concentric arrangement of laminae around a nucleus, or consist of grape-like aggregates of different types of coated grains weakly cemented. A detailed petrography of the grains and laminae has shown an extremely wide array of calcite microfabrics, ranging from peloidal, dense, clotted, shrubby and laminated micrite, to alveolar septal structures and microsparite. The most porous areas of the pearls consist of aggregates of needle fiber calcite (NFC) forming very open and ordered dendritic structures.

Many of these textures, specially the alveolar septal structures and the NFC dendrites are characteristic of moonmilk speleothems: porous, distinctively soft and plastic cave deposits composed of fibrous micro-crystalline calcite, mineralised and non-mineralised microbial features, microbial exopolymeric substances (EPS) and water contents up to 94 wt%. Although most research suggests that microbes are involved in the precipitation of calcite in moonmilk, questions remain open regarding the specific role of microorganisms on the fibrous habit of calcite and the precise environmental conditions required for moonmilk precipitation.

Our hypothesis is that the cave pearls and the overlying moonmilk stalactite formed simultaneously in a moment of higher discharge of water into the cave, when small fragments of soft moonmilk were detached from the stalactite constituting the nucleus for further growth of the cave pearls. While the predominance of micritic fabrics typical of microbialites suggest a contribution of microbes in cave pearls formation further work is needed to understand all the factors involved in the process during the early stages of precipitation and further diagenesis. Based on the analysis of the variety of microfabrics, we will try to discuss here the relative importance of the physical, chemical and biological parameters in the final micromorphology of the moonmilk and the cave pearls.

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An Early Eocene carbon-cycle perturbation on the North Iberian turbiditic continental margin

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Multivariate analysis of the elemental composition of hemipelagic sedimentary successions has provided invaluable information about paleoenvironmental evolution, including records of short-lived Eocene hyperthermal events. However, few studies have analysed the sedimentary record of these climatic events in turbidite-rich continental margin successions. In order to test the usefulness of multivariate statistical techniques (factor and cluster analysis) in the paleonvironmental and paleoclimatic analysis of turbiditic successions, the lowermost Eocene Solondota section, which accumulated on the North Iberian continental margin, was studied.

High-resolution sedimentological, geochemical (stable isotopes, major and trace elements) and mineralogical (general and clay mineralogy) data show that multivariate statistical analysis of turbiditic successions helps to manage large-sized quantitative datasets objectively, avoiding arbitrary choice of representative elements and identifying environmental factors (virtual variables) that may not be evident otherwise. Variations in major and minor elements of hemipelagic carbonates from a negative carbon isotope excursion (CIE) of Solondota suggest a temporarily warmer and more humid continental climate, which caused increased terrigenous material input into the marine environment. The finer grained fraction boosted hemipelagic carbonate dilution, whereas the increase incoarser grained sediment t resulted in more abundant and thicker turbiditic deposits. Thus, the results from the Solondota CIE revealed similarities with deep marine records of early Eocene minor hyperthermal events. The available chronostratigraphic data allow potential correlation of the Solondota CIE with the early Eocene minor hyperthermal event J (also known as C24n.2rH1). This study demonstrates the validity of deep-marine turbiditic successions for providing reliable sedimentological, mineralogical and geochemical records of global paleoclimatic significance, thus complementing the information obtained from other sedimentary environments. Furthermore, the generally expanded nature of turbiditic successions can potentially provide paleoclimatic information at very high resolution, thus enriching, and perhaps improving, the commonly condensed and sometimes discontinuous record of hemipelagic-only successions.

Lithiotis-type bivalves in the Lower Jurassic carbonates of the Central and Southern Velebit Mt., Croatia

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Lithiotis-type bivalves are characteristic faunal element of many Lower Jurassic successions in southern Europe, western Arabia, western and central Asia, as well as western margin of the North and South America. These large bivalves were most significant buildup-makers in Early Jurassic shallow-marine environments of many Tethyan carbonate platforms.

The study of carbonates with Lithiotis-type bivalves was carried out in the Central Velebit Mt. (Kubus section) and Southern Velebit Mt. area (Libinje and Mali Alan sections), which are 50 km apart. Benthic foraminifera assemblage (Lituosepta recoarensis, Paleomayncina termieri, Lituosepta compressa, Orbitopsella primaeva, O. praecursor, Pseudocyclammina liassica, Socotraina serpentina) indicates Late Sinemurian to earliest Toarcian age. The thickness of sections with Lithiotis-type bivalves varies from 210 m on Kubus, to 171 m on Libinje and 145 m on Mali Alan. The oldest Lithiotis-type bivalves were found in the lowermost Upper Sinemurian beds at Kubus and youngest in the Lower Toarcian beds in all studied sections.

Lithiotis-type bivalve shells mostly occur in micritic limestones indicating growth on muddy substrates, as typical mud-stickers fauna, within low- to moderate-energy shallow-marine lagoonal environments of the inner carbonate platform. Shells are typically reworked, only sporadically preserved in their primary life position. All studied sections were characterized by similar shallow-marine environments during the Late Sinemurian and beginning of the Early Pliensbachian. Relative deepening started in late Early Pliensbachian in the Kubus section (as indicated by occurrence of coarser-grained limestones with slumps), while in Southern Velebit sections shallow-marine environments persisted until the latest Pliensbachian. The Pliensbachian–Toarcian transition and earliest Toarcian were characterized by deposition of dark grey micritic limestones with Lithiotis-type bivalves and clayey limestones with thin marly beds. Intensely bioturbated micritic limestones, known as “spotted limestones” sharply overlay the last beds with Lithiotis-type bivalves and S. serpentina indicating middle Early Toarcian age.

Lithiotis-type bivalves are most abundant in the Upper Pliensbachian and lowermost Toarcian deposits in all sections and are generally more frequent in Southern Velebit Mt. Preliminary results show that Lithioperna scutata occurred as the first among Lithiotis-type bivalves, and is the most common species in the Upper Sinemurian and Lower Pliensbachian beds. First occurrence of Cochlearites loppianus can be noticed in the middle Lower Pliensbachian beds, while L. scutata and C. loppianus were equally frequent during the Late Pliensbachian. Lithiotis problematica was certainly determined only in the Lower Toarcian beds of the Kubus section. However, most of the Early Toarcian Lithiotis-type bivalves cannot be determined on generic level. The trend of increasing shell size is clearly seen in all Lithiotis-type bivalves from the Late Sinemurian to the Early Toarcian.

Rapid development and wide diversity of these unique bivalves during the Early Jurassic indicate recovery of optimal conditions within shallow-marine environments before their final demise caused by the worldwide recorded early Toarcian Oceanic Anoxic Event (T-OAE).

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Coupled early Paleozoic ferruginous water masses, ironstone deposition, and extinction events

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Ironstone is a Phanerozoic marine biochemical sedimentary rock with syndepositional Fe enrichment that has been traditionally viewed as a geologic curio. Building on a contemporary understanding of the Fe biogeochemical cycle, recent re-evaluation of North American and European ironstone has highlighted the relationship between ironstone accumulation, global ocean-climate perturbations, and biologic events in the early Paleozoic.

To further investigate this connection, ironstone in the Silurian (Wenlockian) Clinton Group of the Appalachian Basin was reexamined through detailed sedimentology, stratigraphy, petrography, and mineralogic and geochemical analyses (XRD, SEM, EMPA, in situ LA-ICP-MS). The deposition of Clinton ironstone coincided with the Ireviken Event, one of a number of globally recognizable Silurian minor extinctions and related positive δ13C excursions.

In its type area, the Clinton contains three ironstone beds. Lowest in the stratigraphy is a granular ironstone, containing hematite and chamosite coated grains (“ooids”) with quartz nuclei. The others are fossiliferous ironstone with Fe-coated and cemented calcareous skeletal grains. Each is mappable across 35–60+ km of depositional strike, with both stratigraphic and geographic facies and mineralogic variance. All three formed during transgression and are interbedded with fluvial to storm wave base non-ferruginous shale, quartz sandstone, and fossiliferous dolostone.

Observations support Fe-enrichment through authigenic redox aggradation in the shallow seafloor. Mineralogic and facies trends coupled with paleogeographic considerations suggest Fe was sourced from a basin center water mass that originated in Rheic Ocean deep water upwelled along the Laurentian margin. The ferruginous water was transported into the Appalachian Basin and mixed with shallow oxygenated water. Particulate ferric oxyhydroxide precipitated in the mixing zone, accumulating across a sediment starved seafloor during transgression. Its burial and subsequent reduction formed an ‘ironstone factory’, a zone of authigenic Fe oxyhydroxide and silicate precipitation beneath the seafloor. This zone migrated vertically due to shifts in organic matter rainout and pore water oxygenation coupled with sediment bioturbation and periods of storm reworking. Together, these processes were time-averaged during transgressive sediment starvation to produce the thick ironstone beds.

These results reinforce the emerging view that the Paleozoic oceans were not completely ventilated, with hydrothermally derived ferruginous deep-water present in more restricted seaways. The origin of these waters is hypothesized to have been related to unique changes in mantle plume dynamics and mid-ocean spreading during the early Paleozoic. Periodic shifts in ocean circulation, likely driven by global climate and eustasy, were responsible for introducing the toxic deep waters into neritic environments. This led to both ironstone deposition and the expansion of anoxia on continental shelves. The latter contributed to global carbon cycle perturbations and extinctions, as in the case of the Ireviken extinction event that occurred coincident with Clinton ironstone accumulation. This model is increasingly supported by a wealth of independent geochemical proxies from early Paleozoic successions worldwide. These results further emphasize the unsettled nature of the early Paleozoic oceans and the intertwined role of tectonic and oceanic evolution in biotic change. They also demonstrate that ironstone is not just a geologic curio but an underutilized record of the early Paleozoic Earth system.

Provenance and diagenesis of the Upper Miocene sandstones from the Pannonian Basin System

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This work demonstrates the current status and research plan on provenance and diagenesis of the Upper Miocene sandstones from the Sava and Drava depressions in northern Croatia, SW part of the Pannonian Basin System. The sandstones represent the largest oil and gas reservoirs discovered in Croatia and are of significant interest to the industry. They appear as prograding forms of delta environments associated with turbidites that were developing in brackish and partly freshwater lake Pannon formed after the isolation of the Central Paratethys in the Late Miocene. Sandstone samples from selected exploration wells were analyzed primarily to determine their composition, indicating provenance and diagenesis – factors that influence the reservoir quality the most. Analyses were conducted using the polarizing light microscope Olympus BX51 and the scanning electron microscope JEOL JSM-6510 LV with energy dispersive spectrometry (Oxford INCA X-act). Some of the samples were impregnated with blue-dye epoxy resin to indicate types of porosity and were stained with Alizarin Red S to differentiate carbonate minerals. The sandstones are dominantly fine- and very fine-grained, well to moderately sorted, composed of angular to sub-rounded grains forming tangential, and to a lesser extent concavo-convex and sutured contacts. They are mature to submature, largely composed of quartz, rock fragments and feldspar. Quartz is monocrystalline and polycrystalline; among rock fragments, sedimentary and metamorphic fragments dominate – mostly in the form of carbonates and schists; feldspars include alkali feldspar and plagioclase. The amount of phyllosilicates (mica) and heavy minerals varies. Heavy mineral associations to the greatest extent include garnet, tourmaline, rutile, apatite, epidote, titanite, zircon and opaque minerals. Intergranular volume of the sandstones is either filled with carbonate cement (calcite and ankerite), fine-grained matrix (combination of carbonate minerals, quartz, mica and feldspar-plagioclase, formed as a result of alteration and dissolution of main grains) or clays (kaolinite, illite, chlorite and different types of interstratified clays). Processes of compaction under the pressure caused by burial depth, chemical processes of mineral precipitation, dissolution of unstable grains, the formation of pseudomatrix and authigenesis of clays were detected as diagenetic changes formed after the sandstones' deposition within the basin. However, primary intergranular porosity is the dominant type of porosity, followed by secondary intragranular porosity, and microporosity among fine-grained matrix and differently oriented clays. Petrographic analyses enabled classification of sandstones, determination of source rocks and their tectonic settings, as well as detection of diagenetic processes, that are of utmost importance for reservoir characterization. The Upper Miocene sandstones from the North Croatian Basin correspond to feldspatho-litho-quartzose type, and less often to litho-quartzose type. They belong to the tectonic setting of recycled orogen (subduction complex or fold-thrust belt). Rock fragments point towards continental-block, recycled carbonate-clastic and axial belt metamorphic complex provenance. Composition of heavy minerals mostly implies metamorphic source rocks. Composition of the sandstones and detected diagenetic processes present the most significant impact on petrophysical parametres of reservoirs, i.e. their porosity and permeability. The research plans to include additional heavy mineral analyses, geochemistry and single grain geochronology, XRD analyses, petrophysical measurements and statistical data analyses.

A continuously exposed strongly river-dominated delta of the Focsani depression (Romania) reveals obliquity forcing

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The Focsani depression is one of the main depocenters of the Dacian Basin (Eastern Paratethys) that accumulated up to 13 km sediments since the midd"le Miocene. Several series of outcrops along rivers cutting the tilted part of its sedimentary fill provide an excellent opportunity to study facies and their temporal variability. The study is focused on the nearly continuous ~1.8 km thick Pontian (Messinian to Zanclean) interval of the Slănicul de Buzau section. Its age model is based on magnetostratigraphy, indicating a ~1.4 m/kyr sedimentation rate.

The grain-size of sediments in the section generally varies from clays to fine sandstones. There are 3 main facies associations distinguished: delta top (channel, muddy and sandy floodplain), subaqueous delta (delta front, prodelta) and lake dominated (beach-shoreface, offshore). According to absence of tide-induced and rarity of wave-induced sedimentary structures in the subaqueous delta facies and the minor thickness of wave-reworked beach-shoreface facies, the delta is identified as strongly river-dominated. This allows approximating the nearshore depth by the thickness of the subaqueous delta facies, which reaches 3–10 m. The delta model is suggestive of multiple active distributary channels.

In the investigated section, there are hundreds of 3–15 m thick parasequence cycles that are mainly represented by prodelta to delta front progradational (coarsening upwards) facies overlain by thin (<0.3 m) beach-shoreface abandonment facies. Some slowly accumulating offshore facies comprise the bottom part of thicker parasequences. Parasequences that occur in the section in proximity of delta top facies tend to be thinner. These parasequences repeat on a 2–10 kyr scale and are interpreted as autogenic delta behavior.

The facies record also shows cycles on various larger temporal scales, most of which are neither sufficiently regular, nor have the right duration to be Milankovitch cycles. As a notable exception, there are series of cycles of ~45, ~60 and ~70 m thick, distinguished by proportion of delta top facies, thickness of parasequences and proportion of offshore facies respectively. While these cycles display significant variability throughout the record, they are nevertheless regular in specific intervals of the section. They are interpreted as correlative to 41 kyr obliquity cycles assuming that, averaged over smaller intervals, sedimentation rates varied slightly from the magnetostratigraphically measured average rate and ranged between 1.1 and 1.7 m/kyr. Such variability could be explained by prominent changes in the lake-level affecting accommodation space in the Focsani depression and the observed facies.

Despite significant shredding of the climate signal by river and delta dynamics, meter-scale facies analysis thus seems the way forward to distinguish Milankovitch cyclicity in these environments. Availability of other outcrops of the studied strata in the Focsani depression gives an opportunity for facies correlation, improving the facies model. Proper decoding of the paleo-environmental signal of the delta seems to be the necessary step towards reliable identification of allogenic cycles and their utility for stratigraphic tuning.

An oceanographic and sedimentary study of mounded contourite drifts offshore Ireland: preliminary results

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The FWO-Flanders funded DynaMOD project aims to study at high-resolution the influence of the bottom currents over deep-sea sedimentation processes, and more particularly the formation of contourite drifts.

The study area is located offshore Ireland, along the eastern slope of the Porcupine Seabight (SW of Ireland). The studied contourite drift is located within the Belgica cold-water coral Mound Province (BMP; Van Rooij et al., 2003). It has an area of 50 km^2 and is comprised between 500 and 800 m water depth. The action of strong bottom currents results in the formation of this contourite drift. These currents are intensified by the presence of a complex topography (such as the cold-water coral mounds of the BMP). They are also enhanced baroclinic diurnal (K1, O1) currents due to resonance between the tide and the local seafloor slope, as well as the vertical density stratification.

The first campaign, carried out in June 2019 with the RV Belgica, allowed to collect oceanographic (mooring), reflection seismic (single channel sparker) and visual (ROV) data.

Firstly, the ‘present-day approach’ is reported. The aim of this approach is to understand and quantify the temporal and spatial variability of the present-day hydrodynamic regime, studied through a short-term seabed mooring and ROV observations. These “current state of the seabed” observations allow to assess how the hydrodynamic regime affects seabed geological processes.

Secondly, the ’past approach’ consists of performing a pseudo-3D view of the contourite drift and to study its evolution using very high-resolution acoustic profiles. This approach includes a correlation between the seismic profiles and the IODP Expedition-307 Hole U1318, which will be re-investigated at specific intervals for a detailed study of the contourite facies.

For 8 days, a current meter equipped on a mooring has been deployed at 5 m above the seafloor. It showed strong tidally forced bottom currents with a maximum velocity of 50 cm/s and a predominant flow to the SW and a second one to the NE. The interpretation of the reflection seismic profiles shows the stratigraphic embedding of the contourite drift with respect to local unconformities. The most recent unit corresponds to a mounded contourite drift deposited from the Early Pliocene to nowadays. It includes a “center of nucleation” at its base (central high energy drift deposit) and progressively displays more stratified sub-units through its evolution. The visual observations of the ROV dives (done at max 5 m above the seafloor) allowed to characterize the lithology, the bedforms and the ecosystems of the contourite drift and its surroundings.

These observations give an overview on the different spatial and temporal intensities of the local bottom currents during the past and the present time and their impact on the formation and evolution of the contourite drift.

Reference:

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MDACs of Tatar Strait: Implications for methane flux and low-salinity cap-water in MIS2

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C-13depleted authigenic carbonates, often referred as MDACs (methane derived authigenic carbonates), are considered to have been formed in shallow subsurface marine sediments by alkalinity increase due to anaerobic oxidation of methane (AOM) at around the sulfate-methane transition zone (SMT) (Bohrmann et al., 1998). Because the intensity of AOM is controlled by methane flux through shallow subsurface sediments (Borowski et al., 1999), secular variations in seafloor methane flux may be estimated by the abundance and the age of MDACs (Matsumoto et al, 2017). MDACs are also expected to provide information regarding conditions of the bottom sea-water at the time of the precipitation. A number of MDACs were collected from the eastern margin of the Tatar Strait at water depths of 301m to 1060m, where they were recovered along with glendonites (ikaite pseudomorphs) and gas hydrates, at sites with identified gas chimneys, pockmarks and methane plumes.

U-Th age of MDACs were measured at NTU, Taiwan. The ages are between 1.0 ka and 26.0 ka of MIS2 to MIS1, and are similar or a little younger than the age of the host sediments as determined by C-14 and diatom stratigraphy. Formation of MDACs was initiated in MIS2, indicating that the methane flux was accelerated in glacial low stand. Glacial sea-level drop by approximately 130 m in the Tatar Strait must have caused a shoaling of the base of gas hydrate stability (BGHS) and massive dissociation of gas hydrates right above the BGHS, resulting in an increase of both subsurface methane flux and of methane seepage at the seafloor. High methane flux has continued even during periods of rising sea-level, as recognized presently by the giant methane plumes in offshore Sakhalin.

Carbon isotopic composition of MDACs is between -52.4‰ and -9.6‰PDB and are comprised of an extremely depleted group (-52 ‰ to -46‰PDB) and a less depleted group (-36‰ to -9‰PDB), corresponding to microbial methane and thermogenic methane, respectively. Thermogenic group were collected from active gas chimneys and pockmarks associated with gigantic gas plumes (Shakirov et al., 2019).

Oxygen isotopic composition of MDACs ranges between 0.5 and 5.5‰ PDB. Assuming that the temperature of precipitation of 0.0 to 0.5 °C (e.g., Matsumoto et al., 2017), and pore water composition of present SMT zone ranges from -0.5‰ to +0.5‰SMOW (Hiruta et al., 2008), MDACs should be 3.0 ‰ to 5.0 ‰PDB. However, some MDACs are unexpectedly depleted in O-18, ranging between 0.5 ‰ and 2.5 ‰. Anomalously light oxygen MDACs (< 3.0 ‰PDB) may suggest that seawater in the Tatar Strait was capped by a few hundred meters of O-18 depleted low-salinity water during the glacial low stand of MIS2.

Spill communication: evolution of deep-water sedimentation patterns across the Hikurangi subduction margin, New Zealand

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Sedimentation on active margins often involves interaction with structures and complex sediment pathways connecting accommodation. Patterns of deep-water sediment distribution in such settings have typically been simplified into fill and spill models, with a systematic filling and spill into downstream basins or initial sediment bypass of upstream basins and subsequent back-filling. Here we document Neogene sedimentation patterns of the Hikurangi subduction margin, on and offshore eastern New Zealand to characterise depositional systems across a deep-water fold-and-thrust belt.

A network of thrust bound trench-slope basins, each tens of kilometres long by kilometres wide, have been diachronously growing, filling and deforming over the past 25 Ma. Due to ongoing convergence the innermost basins are exhumed, allowing detailed outcrop studies; whilst the offshore, actively building portion of the subduction wedge permits bathymetric, 2D and 3D seismic and well data analysis to constrain the large scale sedimentary systems. Basins are dominantly filled with deep-marine sediments, including (hemi-) pelagites, turbidites, mass-transport deposits (MTDs) and contourites. 3D seismic interpretation, utilising Paleoscan workflows, allows mapping of sediment distribution and characterisation of evolving sediment-structure interaction. Four major channel systems carried sediment to the intra-slope basins, with conduits being both axial and transverse along their profile; run-out lengths varied temporally and spatially. Coarse grained sediment was variably captured in up-dip basins, sporadically being cannibalised during major slope failures resulting in MTDs; or was bypassed to relatively distal intra-slope basins; or even completely bypassed the slope to deliver sediment into the trench. The outcropping basins permit studies of the facies, stratigraphic architecture and tectono-stratigraphic evolution of each basin, the fill of which is non-uniform along strike of individual basins. Micropaleontological and petrographic studies permit provenance and source-to-sink analysis of the dynamic sedimentation patterns. Multiple sediment input points, bypass conduits and tortuous corridors resulted in complex depositional systems, often with similar sedimentation occurring contemporaneously in proximal and distal basins, contrary to simple fill and spill models.

Inherently, sediment flux and distribution is controlled by external factors, e.g. glacio-eustacy and tectonic evolution. However, the interaction of sedimentary systems with local factors, such as evolving seafloor structures, rugose MTD topography, contourite fields, and allogenic influences (e.g. channel avulsion) are all factors contributing to the spatiotemporal variation in sedimentation. Understanding the interplay of these controls help us determine if basins were filling or spilling at various points on their evolution, or indeed a combination of these end member models, which are far more complex in nature. Constraining the controls on and ultimate distribution of sediment has implications for understanding resource distribution within basins, geohazard probability and the potential fate of pollutants in the deep-sea.

Unravelling deltaic architecture using borehole image logs in the Brasse Field, North Sea

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The Upper Jurassic Sognefjord Formation in the Northern North Sea forms a westward-prograding shallow marine clastic wedge sourced from the Norwegian mainland and it represents the main reservoir in a series of fields and discoveries along the Horda Platform margins. In the Brasse discovery, well-log correlation of three appraisal wells and corresponding sidetracks was integrated with core observations and interpretation of various borehole image logs (FMI, Quanta Geo and LithoTrak). This allowed to extrapolate traditional sedimentology and petrographic interpretation to the non-cored sections, providing insights on sediment transport directions and architecture of sedimentary bodies.

The succession is formed by stacked, 10–20 m thick fourth-order sequences, which represent deposition from distinctive river-dominated, tidally influenced delta lobes. The regressive parts of the sequences consist of outer stream mouth bars dissected by subaqueous distributary channels. The bars prograde onto heterolithic delta slopes formed by flood-induced hyperpycnites, some extending beyond the mud-prone prodelta. The direction of progradation is assessed by utilising cross-bedding azimuths measured on the borehole images. The obtained directions show considerable variation between individual lobes, reflecting a complex feeder system with branches discharging towards ~NE, ~W and ~SW. Occasional bimodal cross-bedding reflects a tidal signature, which is confirmed by the presence of cross-beds with double mud drapes in the cores. During the transgressive phases, the delta mouth bars were dissected into a series of tidal bars, which were locally storm reworked and carbonate cemented. The combined role of river, tidal and occasional storm processes is reflected in the petrography and in the paleocurrent orientations. Petrographic analysis records a transition from lithic, sub-lithic, semi-feldspatic to feldspatic arenites, the latter typically in the upper part of the transgressive cycle, attesting the cleaning-upward and tidal reworking that occur at the top of the regressive deltaic cycles. Paleocurrent orientations show bimodality and large azimuthal scatter with respect to the regressive progradational component, broadly perpendicular to the reconstructed shoreline.

There is no indication of subaerial exposure, similarly to what observed in most of the corresponding deposits of the Troll Field. However, in contrast to the near-linear subaqueous clinoforms of the Troll area, the Brasse delta has considerably more complex lobate geometry, likely due to the proximity of a main sediment entry point and the relatively weaker activity of waves and longshore currents.

The Neoproterozoic Uk Formation in the South Urals: organic geochemistry of a stromatolite reef complex

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The Neoproterozoic Uk Formation, which is widespread in South Urals, consists of the lower siliciclastic member and the upper carbonate member comprising large stromatolite reefs and associated bioclastic material and calcareous shales. Strontium isotope ratio in carbonates suggests that the Uk Formation is older than 720 Ma (Maslov et al., 2019), which is corroborated by presence of "molar tooth" structures in the carbonate rocks (Kuang, Hu, 2014; Maslov et al., 2019).

The organic matter (OM) from the upper Uk member was investigated. The analysed samples include stromatolites (5), biolaminitic limestones (2), intraclastic limestone (1) and calcareous shales (1). The total organic carbon content (TOC) is 0.01–0.05% for carbonates and 0.14% for calcareous shales. The bitumen content (bchl) and bitumen coefficient (100×bchl/(1.33*TOC)) average 0.001% and 4.9%, respectively. The bitumen mixture composition includes: saturated hydrocarbons (HCs) (19–26%); aromatic HCs (4–15%); resins and asphaltenes (64–75%). Saturated HCs were analysed using gas-liquid chromatography and gas chromatography-mass spectrometry. The chromatograms exhibit humps of an unresolved complex mixture of organic compounds, which is characteristic of Neoproterozoic dispersed OM (Peters et al., 2005).

The n-alkanes distribution pattern shows maximum at n-C17 and the presence of series of 12- and 13-monomethyl alkanes. The pristane/phytane (Pr/Ph) ratio is 0.7–1.2. The identified steranes are: cholestane C27, ergostane C28, stigmastane C29, with their ratios averaging 35%; 26%; and 39%, respectively. The values of sterane ratios are: C29 aa 20S/(20S+R) = 0.4, C29 bb/(aa+bb) = 0.44. The diasteranes/regular steranes ratio is 0.26–0.31 irrespective of the rock composition. Cheilantanes, hopanes and homohopanes, moretanes were detected among terpanes. The determined ratios are: trisnorneohopane to trisnorhopane (Ts/Tm) (around 1.0); C35/C34 homohopanes (0.8–0.9); steranes (C27-C29)/hopanes (C27-C35) (0.5–0.6).

The values of Ts/Tm and sterane C29 aa 20S/(20S+R) ratios point to thermal maturity of the OM corresponding to "oil window" (Petrov, 1984; Peters et al., 2005). This enables more accurate interpretation of the biomarkers composition. The Pr/Ph and C35/C34 ratios indicate a lack of water column stratification and hydrogen sulfide contamination of bottom waters, along with the suboxic conditions developed in the Uk marine basin. The presence of hopanes, isoprenoids, methyl branched alkanes and steranes suggests the coexistence of both eukaryotic and prokaryotic communities in this sedimentary environment (Peters et al., 2005). The sterane/hopane ratio is higher than in other pre-Cryogenian formations (Hussar, Wallara, Johny's Creek, etc.) (Brocks et al., 2017), which may be indicative of the relative abundance of eukaryotes in the Uk marine basin. This hypothesis is corroborated by the presence of stigmastane and high concentrations of cheilantanes.

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The Afam Canyon, a subsurface case of submarine dendritic pattern and multiphase infilling (Tortonian, Nigeria)

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Shelf or slope siliciclastic deposits incised by submarine canyons can provide efficient stratigraphic traps in case of muddy infilling acting as a lateral and/or top seal. Nevertheless, such sedimentary systems can provide up-dip leakage risks, if sand-prone bodies are present within the infilling and onlap the reservoir. The Afam area exhibits a major Miocene erosive surface affecting the eastern Niger Delta. It is partly filled by the "Afam Clay" member. The goal of this study is to better understand stratigraphic trapping modalities of the deltaic succession incised by the Afam Canyon. That implies to map its erosional morphology and to understand the infilling architecture of the canyon. The work is based on interpretation of a 50x40 km 3D seismic block.

Picking was made using Total CIG software™. The canyon basal incision was interpreted each 10 lines on both directions, producing a 250x250 m grid. The interpreted horizon was propagated and gridded. The resulting map superposed to coherency map allows a detailed observation of the incision morphology. Together with younger gridded horizons interpreted from well logs as flooding surfaces, thickness maps were produced within the Tortonian sedimentary infill. Finally, attribute maps computed between these key surfaces allowed us to characterize the evolution of the canyon infilling.

The Afam basal incision is locally up to 1000 ms (twt) deep, as shown by truncation of underlying reflections. It exhibits meanders, scalloped walls and knick-points. The resulting morphology is a complex dendritic drainage pattern: a main N-S pathway, 8-km wide, intercepts E-W secondary tributaries, which even capture third- and fourth-order branches. Secondary distributaries are controlled by syn-sedimentary growth-faults.

Five seismic facies were identified within the infilling: F1) chaotic facies; F2) low-amplitude well-layered reflections; F3) high-amplitude subparallel reflections; F4) low- to high-amplitude obliquely stratified reflections; F5) low- to high-amplitude chaotic facies. F1 and F2 drape the basal incision and are known as the Afam Clay member. Well logs indicate they consist of debris flows, hemipelagites, and “muddy” turbidites, they are an active seal for oil reservoir trapped below the canyon incision. F3 is entrenched within thalwegs directly drapping them or interbedded within F1 and F2; F3 is interpreted as sand-prone turbidite channels. A second local incision separates F1-F3 facies from F4 and F5. F4 shows southward prograding forsets, interpreted as a low stand delta infilling the second incision. F5 is located on local lows within the second incision and interpreted as destabilized F4.

In addition to the general meandering pattern of both the main axis and distributaries, the multiphase infilling consisting of deep-water deposits into a subsiding setting allows to interpret the 1000 ms (twt) Afam incision as a submarine morphology. Due to its location on the upper continental slope and its connection with the shelf, it can be interpreted as a mature canyon system triggered by slope failures. The dendritic pattern is more likely the consequence of the structuration by growth faults during the mid – Tortonian falling Stage, than the heritage of an incised valley, although these hypotheses do not exclude each other.

Unravelling the origin of widespread pelagic carbonate successions in the mid-Carboniferous Variscan foreland basin

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Pelagic carbonates became a major fraction of the carbonate record after the diversification of calcareous plankton since the Jurassic. Palaeozoic deep-water carbonates are scarce and generally reported from condensed successions or periplatform deposits comprising skeletal grains, from both benthic and nektonic biota, and carbonate mud and other components sourced from carbonate platforms.

During the Late Mississippian–Early Pennsylvanian, pelagic carbonate mud accumulated over very broad and relatively deep areas of the south Variscan marine foreland basin in the western Palaeotethys embayment (the remnant of the Rheic Ocean) at 10º–20º S latitude. These calci-mudstones are exposed in northern Spain and southern France forming two stratigraphic units (San Adrián Mb, Pendleian–Early Arnsbergian; and Barcaliente and Iraty Fms; Late Arnsbergian–Kinderscoutian) with a cumulative thickness between 60 and 400 m over an area >300 km wide and >1000 km long along the basin axis. They overlie a Visean red-nodular and goniatite-rich condensed limestone, 20–40 m thick, and, towards the foredeep, interfinger with orogen-sourced turbidites, which finally replaced them during Bashkirian times.

These two units consist of thinly bedded tabular to undulose limestone strata with marly interbeds. Microfacies are homogeneous and mostly consist of dark and burrowed or laminated mud- to wackestones. Petrographic studies, including SEM analyses, reveal that the main components are peloids (5–10 µm in diameter) and microsparite–sparite, while skeletal grains, including common radiolaria and very scarce benthic biota (mostly crinoids), represent generally <10% of the total rock volume. Peloids exhibit uniform sizes, consist of tightly packed submicron-sized low-magnesium calcite (LMC) crystals and sometimes display a 5–15 µm thick cortex made of radiating LMC crystals with euhedral terminations. Both the peloids and the skeletal grains are more abundant in the areas where the pelagic succession is thinner (50–100 m) and records lower sedimentation rates. Microsparite and sparite consist of neomorphic interlocking crystals of LMC, which generally exhibit abundant submicron-sized micropores (pits?) in polished etched surfaces. Pyritized tests and biomolds of radiolarians reveal that intra-stratal sediment compaction was minor, suggesting early cementation and recrystallization of carbonate mud. In addition, celestite is a common diagenetic mineral phase occurring mainly near bedding surfaces and in marly interbeds. Sr concentrations measured avoiding recognizable celestite crystals are high (Q1=980 ppm, median=1750 ppm, Q3=2427.86 ppm), with lower values in peloid-rich samples. Moreover, U concentrations are high (median=3.58 ppm) despite most of the studied samples are organic-matter lean (TOC values generally <0.2%) and show very low sulphur contents, which suggest deposition in normal marine waters.

Considering the observed petrographic features, geochemical composition and uniform thickness distribution of these calci-mudstone, and the absence of broad time-equivalent shallow-water benthic carbonate factories in the basin, it is suggested that carbonate mud consisted primarily of aragonite and/or high Mg calcite? mud precipitated within the water column, and of LMC peloids precipitated either in microbial mats at the sea bottom or within the water column.

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The Bréche à Micmacca limestones:A unique window to biota of the lower–middle Cambrian boundary interval

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The lower–middle Cambrian boundary interval in Morocco is characterized by shallow marine siliciclastics with multiple intercalations of thin carbonate horizons that record high-frequency sea-level changes. A considerable amount of these carbonates are developed as bioclastic limestone beds that were originally termed “Bréche à Micmacca” by Bondon and Neltner (1933). These limestone beds characterize the lower, Bréche à Micmacca Member of the Jbel Wawrmast Formation in the High Atlas and Anti-Atlas ranges.

The spatial and stratigraphic distribution and microfacies as well as the faunal composition of the limestone beds offer a wide range of variability. They occur in the Hupeolenus, Morocconus notabilis and Ornamentaspis frequens biozones with often the trilobite index fossils found as bioclasts. However, the fossil spectrum shows an enormous range with more than 60 different species registered to date, which belong to the trilobites, acrotretoid and articulate brachiopods, helcionelloids, hyoliths, different groups of echinoderms, chancelloriids and other systematic groups. Even the preservation of fossil sclerites varies occasionally within a single bed indicating a mild condensation.

Our present studies attempts to investigate these different aspects of the Bréche à Micmacca limestone beds. The studies concentrate on the taxonomy and composition of the faunal elements. However, they also analyse taphonomic characters and the ecology of the biota with emphasis on a semiquantitative analysis of the different systematic groups and its implications for the specific depositional circumstances. Collected data will serve to indicate the amount of changes in the biotic composition during the three biozones from which the samples originate, but also decipher the spatial and temporal changes in depositional environments during the lower—middle Cambrian boundary interval in the Souss Basin.

Source-to-Sink: Regional Grain Size Trends to Reconstruct Sediment Volumetric Budgets and Catchment Areas

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This paper outlines a method to reconstruct and correct sediment volumetric budgets in ancient routing systems based on regional grain size trends. Existing approaches for ancient sediment routing analysis capture only parts of sediment fairways, which are included in the area of interest and have been preserved in its stratigraphic record. Because of these limitations, sediment budget estimates are seriously underestimated. Resulting estimates of catchment denudation rates and catchment size are incomplete.

Reconstruction of regional average grain size curves and mass balance of sediment volume are integrated to overcome these two limitations. Mass balance represents the fraction of volumetric distance from source entry points for the stratigraphic interval of interest. Regional grain size curves represent a compilation of data from different intervals that are along the same routing system and depositional environment, and represent different parts of the basin (proximal or distant). Mass balancing and grain size trends are used to reconstruct the maximum possible extent of the sedimentary basin beyond the original area of interest. The comparison of grain size trends to the regional grain size data provide an estimate of the fraction of the sedimentary budget is included and preserved in the actual data set for a specific subbasin or exploration prospect/field.

This approach was applied on four sedimentary fairways from two units of a continental to marine delta system at subbasin scale (200 by 200 km each). Results show that only 40% of the total sediment volume was captured at any given time slice per fairway in the area of interest. In total, only a maximum of 70% of the basin-wide sediment volume was reconstructed. This has a profound impact on the sediment budget estimates, which range between a median of 1,000 km3/Myr in the uncorrected scenarios, to a median of 2,500 km3/Myr, in reconstructed scenarios. The new approach leads to major changes in catchment size and denudation rate estimates for clastic depositional systems. Catchment size estimates were found to be up to three times higher than in previous approaches. The new method has major implications for hydrocarbon exploration, because the volume and fraction of coarse sediment transported to the basin leads to a revision of net:gross distribution maps and risk assessment.

Upper Jurassic – Lower Cretaceous carbonates from the Postăvaru Massif (Romania). Microfacies and microfossils

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The Postăvaru Massif represents the main mountainous unit bordering the Brașov Depression towards its southern part. Săndulescu (1964) described in detail the geology and tectonics of this mountainous unit. The sedimentary succession from this area is unevenly distributed within four main tectonic units which are represented by the Postăvaru, Brașov, Cristian, and Râșnov compartments (Săndulescu, 1964).

We collected approximately 600 limestone samples from the following sections: Groapa Dracului, Vanga Mică, Cheile Râșnoavei, Drumul Roșu, Pietrele lui Solomon, Poiana Cristianului, Valea Dracului-Stejeriș, Poiana Mare-Stejeriș, Tâmpa and Cariera Cristian.

Microfacies analysis indicates that these carbonates were deposited in a wide range of depositional environments ranging from basin areas to reef slope and paltform margin or peritidal depositional settings. The following facies were identified: bioclastic intraclastic rudstone, boundstone with wackestone type internal sediment, calpionellid bearing packstone/floatstone, coarse bioclastic grainstone, intraclastic bioclastic packstone-grainstone, fenestral wackestone-packstone and non-fossiliferous mudstone. The rudstone facies contain coral fragments, sponges and encrusting organisms. These facies are interbedded with coral-microbial bioconstructions and calpionellid bearing wackestone-floatstone.

Coarse bioclastic grainstone and bioclastic intraclastic grainstone characterize the platform margin deposits. They contain abundant gastropods, coral fragments and other centimeter scale bioclasts. The inner platform deposits consist of non-fossiliferous mudstone and fenestral wackestone-packstone with meniscus cement.

The micropaleontological association contains dasycladalean algae [Salpingoporella pygmea (Gümbel), Griphoporella jurassica (Dragastan), Petrascula bursiformis Etallon, Aloisalthella sulcata (Alth), encrusting organisms [Bacinella type structures, Crescentiella morronensis (Crescenti), Iberopora bodeuri Granier & Berthou, Koskinobulina socialis Cherchi & Schröder, Pseudorothpletzella schmidi Schlagintweit & Gawlick, Radiomura cautica Senowbari-Daryan & Schäfer, Perturbatacrusta leini Schlagintweit & Gawlick, Taumathoporella parvovesiculifera (Raineri)], foraminifera [Bramkampella arabica Redmond, Bulbobaculites felixi Pleș et al., Coscinoconus alpinus (Leupold), Coscinoconus cherchiae (Arnaud-Vanneau et al.), Coscinoconus delphinensis (Arnaud-Vanneau et al.), Coscinoconus sagittarius (Arnaud-Vanneau et al.), Coscinoconus campanellus (Arnaud-Vanneau et al.), Frentzenella involuta (Mantsurova), Meandrospira favrei (Charollais et al.), Nautiloculina brönimanni Arnaud-Vanneau & Peybernès, Protopeneroplis striata Weynschenk, Protopeneroplis ultragranulata Gorbatchik] and pelagic microorganisms (Calpionella alpina Lorenz, Crasicollaria parvula Remane, Crasicollaria intermedia Durand-Delga).

This micropaleontological association is typical for the Kimmeridgian – ? lower Valanginian interval.

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Source-to-sink pathways of clay minerals in the Cadiz contourite system over the last 25 kyrs

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The northern continental margin of the Gulf of Cadiz, located between the Iberian Peninsula and Morocco, west of the Strait of Gibraltar, is characterized by a singular continental slope. The middle slope sedimentation is strongly infuenced by along-slope processes driven by the Mediterranean Ouflow Water (MOW). The interaction between the intermediate bottom current from Mediterranea and the seafloor since the early Pliocene generates a complex Contourite Depositional System. For several years, great effort has been devoted to the study of the deposition processes of the middle slope of the Gulf of Cadiz but few studies have focussed on the nature and sources of fine particles over the Contourite Depositional System.

This work presents a detailed sedimentological study of sediment cores collected over the middle slope of the Gulf of Cadiz as part of the Integrated Ocean Drilling Program Expedition 339 and the CADISAR cruise. We performed high-resolution clay mineral and grain-size analyses in order to reconstruct the pathways of fine-grained particles from their sources to their deposition along the contourite depositional system of the Gulf of Cadiz (source-to-sink approach). The clay mineral associations reflect the major contribution of the Guadalquivir River and North African rivers and dusts to fine particles settling over the middle slope. Our results suggest that size segregation deposition processes along the path of the Mediterranean Outflow Water (MOW) are responsible for the contrasted clay mineral associations between sites located under the upper MOW and the lower MOW. We observed drastic changes of sedimentation rates over the contourite depositional system throughout the last 25 kyrs. We assume that these changes are due to temporal variations in the vertical distribution of the upper and the lower MOW whose concentrations in suspended particulate matter are supposed to be drastically different. Sea-level as well as large scale (ITCZ migration) atmospheric changes over this time period induced major variations in the distance of river mouths to the CDS, and in the amount of Northwest African dust delivered to this depositional system, respectively. Climate changes therefore modified fine particle sources and pathways, which considerably influenced clay minerals settling in the middle slope of the Gulf of Cadiz since the Last Glacial Maximum.

The record of the end-Triassic mass extinction in the Southern Apennines carbonate platform (Italy)

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The end-Triassic mass extinction is one of the big five of the Phanerozoic. It is associated with severe perturbations of the global carbon cycle, recorded by the worldwide occurrence of a series of negative carbon isotope excursions (CIE) in both the inorganic and organic marine carbon record. The massive injection of isotopically light CO2 into the atmosphere/ocean system from the paroxysmal volcanic activity of the (CAMP) has been invoked as the cause of the CIEs, of abrupt climate change, ocean acidification and mass extinction.

In many areas of the Tethyan ocean, carbonate platform sedimentation was terminated around the T-J boundary, a case in point being the well-known Dachstein Platform of the Calcareous Alps and Transdanubian range. Other platforms were able to survive the crisis. In these resilient carbonate platforms, fossiliferous Upper Triassic limestones with corals, sponges, chetetids, large megalodontid bivalves and rich benthic foraminiferal associations change abruptly into unfossiliferous peritidal and/or oolitic limestones around the T-J boundary. This pattern is well represented in the carbonate platforms of the southern Apennines and Sicily (southern Italy), in the Pelagonian Platform (Greece) and in the Middle East. An intermediate pattern is shown by the carbonate platform of the Lombardy Basin, where a drop in carbonate productivity, marked by the shift from the fossiliferous Zu Limestone to the thin-bedded micritic carbonate ramp facies of the Malanotte Fm around the T/J boundary, is followed by the recovery of carbonate platform sedimentation in the Early Jurassic.

We have sampled in detail a carbonate platform section exposed near the village of Valle Agricola, in the Matese Mts of southern Apennines, about 65 km north of Naples (southern Italy). The section is about 250m thick. The lower interval (0–205m) is made up of peritidal cycles, with wackestone-packstone with benthic foraminifers and dasycladalean algae and wackestone to floatstone with large megalodontids, corals and chetetids, capped by microbial laminites and supratidal facies with microkarstic cavities. The upper interval (205–244m) is entirely made up of unfossiliferous grainstone-rudstone with ooids, oncoids and intraclasts, with no evidence of cyclicity.

We use carbon isotope stratigraphy, tied to benthic foraminifera biostratigraphy (i.e. the first and last occurrence of Triasina hantkeni), to correlate the Valle Agricola section with other previously studied sections in the southern Apennines, including the Monte Cefalo carbonate platform section and the Pignola-Abriola section in the Lagonegro basin, which has been recently proposed as the GSSP candidate for the base of the Rhaetian. The correlation allows us to elucidate the sedimentary dynamics of the southern Apennine carbonate platform and of the adjoining Lagonegro Basin across the latest Norian to earliest Hettangian time interval.

We then attempt a high-resolution correlation with the classical Val Adrara/Italcementi quarry section in the Lombardy Basin, and with other T/J boundary reference sections like the base of Hettangian GSSP of Kuhjoch (Austria) and the St Audrie's Bay section (UK).

Large benthic foraminifers-corals facies transition during the middle Eocene: Tremiti Islands (Italy)

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During the middle and upper Eocene significant changes in the benthic communities occurred. The general dominance of large benthic foraminifers (LBF) in shallow-marine environments decreases sharply through the early-late Bartonian boundary (SBZ16–18a), and an abrupt shift to zooxanthellate corals-rich facies is observed, marked by a gradual increase in size, number, and diversity of coral-buildup ecosystems.

The Tremiti Islands are located in the Adriatic Sea, less than 20 km northward the Gargano Promontory along the Italian coast and both belongs to the well-known Apulia Carbonate Platform. In this study, middle to upper Eocene LBF and coral facies of the San Domino Formation have been analyzed from sedimentologic, paleoclimatic and paleoecological significance, and finally compared to coeval facies of Monte Saraceno Formation cropping out mainland in the Gargano Promontory.

The lower and middle San Domino Fm consists of porous massive, whitish and brownish limestones rich in skeletal floatstone to rudstone mainly dominated by LBF (nummulitids, orthofragminids), echinoids, red algae, bryozoan, small benthic foraminifera and acervulinids (Gypsina). According to the biota assemblage, this stratigraphic interval is indicative of the upper Lutetian to Bartonian p.p. (SBZ 14-16). Instead, the upper part consists of a coral boundstone with corals colonies (Favites, Montastrea, Astrocoenia, Astreopora, Alveopora, Antiguastrea, Actinacis sp., Goniopora sp.) and some solitary corals. They are also associated with scattered orthofragminids (Discocyclina, Orbitoclypeus). The skeletal components and the occurrence of Chapmanina gassinensis in this coral facies, seems to indicate the Bartonian–Priabonian boundary (SBZ 18a). A similar situation is also visible in the Monte Saraceno Fm (Gargano), where LBF are abruptly covered by coral-rich facies. On the contrary of the Tremiti Island, the coral facies have a less pronounced biodiversity and seems to be a little bit younger, as the presence of Heterostegina suggest (SBZ 17-18a middle-upper Bartonian).

The stratigraphic and facies architecture in Tremiti Islands and Gargano Promontory suggest as a drastic change in carbonate factory occurs during the upper Lutetian and the Bartonian time interval. At the base LBF dominate, with big and very abundant Nummulites until the early Bartonian, abruptly covered by coral-rich facies, not present before, during the early-late Bartonian and at transition with the Priabonian.

We interpret this fast switch in carbonate production types as the result of paleoclimatic changes, from warmer interval during the Lutetian and early Bartonian, where LBF were dominant, culminating at ca. 40.1 Ma with the MECO event, and the progressive cooling, after this hyperthermal event, when corals start to thrive in more favorable conditions.

Deep-marine sedimentation in the northwest side of the Stromboli volcano (southern Tyrrhenian sea)

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Volcaniclastic material forms an important part of the deep-sea sedimentary successions, particularly along volcanic arc islands. Subaereal volcanic activity at Stromboli (Aeolian islands) leads to several types of eruptive and non-eruptive processes that generate large volumes of pyroclastic and epiclastic sediments deposited in the deep-sea. This work presents a description of volcaniclastic detritus and deposits that characterized a deep-marine core in the north-west side of the Stromboli volcano recovered during the TIR-2000 oceanographic cruise. Their texture and composition can help to identify the subaerial source of the volcanic component and the possible correlation between deep-sea sedimentation and/or sin-eruptive eruption or sector collapse of the volcanic edifice at Stromboli. Moreover, it is possible to reconstruct the pathways of the sediment and the transport-type such as fallout or some type of sediment gravity flow. The studied core is located 38° 59' 00"N of latitude and 14° 58' 00"E of longitude, about 30 km northwest of Stromboli at a depth of 3000 m. It is 95 cm in length and consists of six main depositional horizons composed of a sequence of alternating silt/clay and sand beds. Nineteen samples were selected at different depth. Grain-size analyses indicate that the first centimeters consist of more than 60% of silt and clay whereas the remaining beds are dominated by sands. The silt/clay samples show a high percentage of bioclast and pumice grains with minor amount of monomineralic grains of biotite, muscovite, quartz, plagioclase and pyroxene. Rare granitic rock-fragments have been identified. In some samples volcanic glass shards and porphyritic glassy fragments with phenocryst of pyroxene and plagioclase have been also distinguished. On the medium-sand fraction modal analyses were carried out and changes in grain roundness were assessed to evaluate grain durability during the transport. The major components are represented by monomineralic and polymineralic grains. Monomineralic grains are crystals of plagioclase, pyroxene, with minor olivine; polymineralic grains are porphyritic, microlitic and aphyric blocky volcanic fragments with black/brown color and low vesicularity. Minor amount of granitic, metamorphic and sedimentary rock fragments are also present. The relative proportion between components is similar in all samples. The highest percentage is given by crystals in microlitic or glassy groundmass (CF) (from 49% to 78%) followed by single crystals (from 9% to 32%) and aphyric and microlitic fragments (from 10% to 23%). Blocky volcanic fragments prevail over vesicular ones (more than 67%). The fragments of probably pyroclastic origin are more than 68% with respect to those of epiclastic origin. The most common roundness category is sub-angular. The roundness degree increases in the deepest sample of the core. Our preliminary data suggest a dual source area for sediments such as Lipari island where the pumice grains can be considered as source-sensitive grains as well as the black/brown shards and CF act as provenance indicators from Stromboli. A subordinate source is represented by the Calabrian granitic and sedimentary rocks. Two different transport processes allowed the deposition of the volcanic component: fall out for the finer sediment and turbidity current for the sandy ones.

Compositional and textural study of modern sands in the volcanic area of Campania region (Italy)

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The association among volcanism, tectonics and sedimentation may be critical for interpreting the paleogeographic and plate tectonic settings of the past. In modern and ancient sedimentary systems, volcaniclastic fragment classes have been distinguished on the basis of texture and composition. Criteria adopted for their temporal and spatial correlation with source volcanic areas, in terms of type of volcanism and particle-forming processes are still not well constrained and often a topic of controversy and misinterpretation. Here, we present data for volcaniclastic fragments occurring in modern beach sands of the Campanian coast of southern Italy, where there are two active volcanic areas, the Phlegrean Fields and Mt. Vesuvius. Despite their geographical proximity, these volcanoes are characterized by different magma compositions and eruptive mechanisms. We set out to test whether this translates into different textural and compositional characteristics of their associated volcaniclastic detritus in order to better constrain the criteria relating the type of volcanism to the nature of volcaniclastic sand fragments in the sedimentary record. Along 100 km coastal stretch, from the Volturno River mouth to Sorrento, 72 sand samples were collected mainly in beach berm environments. Detrital modes were defined for the medium sand fraction of each sample, where monocrystalline and lithic grains are easily identified. The analyzed samples show a mixed sedimentary and volcanic provenance. Samples from the northernmost coastal stretch showa sedimentary petrofacies at the Volturno River mouth. Bacoli marks the transition between the Apennine sedimentary and Phlegrean volcanic petrofacies. Along the Portici-Sorrento coastal stretch, volcanic lithic fragments dominate. Leucite and sanidine crystal components indicate that detritus from the Phlegrean Fields extends south from Licola to Naples Bay, whereas the Vesuvius provenance extends from Naples/Portici south to Castellammare di Stabia. Phlegrean Fields and Mt. Vesuvius volcaniclastic petrofacies have been discriminated through a different distribution of both compositions of the volcanic lithic fragments, leucite and K-feldspars content. Volcanic lithics with lathwork texture and leucite, are Mt. Vesuvius provenance source sensitive detrital grains, whereas volcanic lithics with vitric texture and K-feldspars marks the transition to the Phlegrean Fields petrofacies. The results formalize three different sandy petrofacies which were mapped from north to south as Sedimentary, Phlegrean (volcanic) and Vesuvius (volcanic) petrofacies.

Carbonate factory changes associated with the Middle Eocene Climatic Optimum: Apulia Carbonate Platform, Gargano, Italy

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The Middle Eocene Climatic Optimum (MECO) is a well-recognized paleoenvironmental perturbation. This event occurred ca. 40.1 Ma and lasted approximately 500 kyr. It has been recognized in cores and outcrops of deep-water successions around the world. Few examples have been studied in detail in shallow-marine carbonate successions and it remains unknown whether or not widespread facies and biotic changes occurred in carbonate systems of that time. However, the Lutetian-Bartonian transition appears to be marked by a sudden decline in size and abundance of large benthic foraminifera (LBF) (i.e., Nummulites and Discocyclina). LBF dominate the Lutetian interval, whereas coral-rich facies begin to occur during the Bartonian and Priabonian of the Tethyan realm.

The Middle Eocene Monte Saraceno sequence that crops out along the eastern margin of the Apulia Carbonate Platform (Gargano Promontory, southern Italy) displays a sharp transition from a Nummulites-dominated carbonate factory to a coral-rich interval lacking Nummulites in a well-exposed section. The lower interval consists of clinostratified rudstone to floatstone, with Nummulites of both A and B forms of various sizes (0.5 to 4 cm). The upper interval consists of rudstone and floatstone, rich in branching corals in a packstone matrix, with very few and small LBF. Some platy corals are also present in life position. The sharp transition between these two distinct carbonate factories, and the absence of coral fragments in the clinostratified Nummulites facies, rules out a simple facies shift between the two facies associations. Rather, the transition appears to have been triggered by important paleoenvironmental changes, with a consequent shift between the two types of carbonate factories. We relate the flourishing Nummulites within the lower interval to the MECO warming and attribute establishment of the coral-dominated carbonate factory to the subsequent cooling trend that characterized the Bartonian and Priabonian.

Diagenesis investigation: A Case Study from Early Miocene Carbonate Succession, Sawadi Islands, Northeast Oman, Oman

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A Diagenesis outline of the Early Miocene Sawadi Islands at its exposure at the Sawadi islands, Barka is presented. This study offers the first petrographic and geochemistry analysis of the Early Miocene Sawadi islands by measuring two sections with total thickness of about 100 m and collecting 36 samples for petrography and geochemistry analysis. Based on samples analyzed for petrography and geochemistry, the Sawadi Island facies can be subdivided into three diagenetic events; 1) syndepositional diagenesis including micritization, and isopachous fibrous cements, 2) Intermediate diagenesis characterized by dissolution, blocky calcite cement, physical compaction, type one (D1) and type two (D2) dolomites, and 3) Early burial diagenesis with pore-filling blocky and drusy dolomite cements (type three (D3) dolomite) and fracturing. D1 is very fine- to fine-crystalline (≤50 μm crystal diameter) and preserve depositional fabric well. D2 is coarse crystalline dolomite (about 100 to 300 μm crystal diameter) that destroyed the depositional fabric. D3 is a coarse to very coarse dolomite that formed in a shallow burial environment. This diagenetic analyses indicates: 1) the Sawadi islands experienced early marine syndepositional, meteoric and early burial cements; 2) dolomite formation ranges from early to late diagenesis stages.

Assessing the impact of multiple fault zone overprint on Devonian carbonates (Rhenish Massif, Germany)

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Dolomitic rock (dolostone) is a major topic in carbonate research and a complex archive of its palaeoenvironment and diagenetic pathways. Combining field and laboratory techniques (transmitted light- and cathodoluminescence microscopy, fluid inclusion- and clumped isotope thermometry, δ13C, δ18O), we assess the complex diagenetic succession and subsequent tectonic, hydrothermal and meteoric overprint of Paleozoic carbonates of the Middle-Late Devonian Massenkalk in Western Germany. The well-known geological and tectonic framework of the Massenkalk allows for an in-depth study of different alteration types in directly comparable lithologies. The aim is to better understand the impact of tectonic, hydrothermal and meteoric alteration events (Variscan and Post-Variscan) on multiple generations of hydrothermal dolostones and their precursors. A section was sampled which reflects increasing degrees of diagenetic overprint. Cathodoluminescence microscopy documents a complex paragenetic sequence ranging from marine calcite cements to multiple hydrothermal dolomites and meteoric/vadose calcites in partly dedolomitized carbonates. Fluid inclusion and clumped isotope analyses reveal temperatures between 20 and 230 °C. Patterns in oxygen and carbon isotope data suggest a conservative behavior of precursor limestones and early hydrothermal dolomites during burial diagenesis. Later hydrothermal dolomites were altered by meteoric dedolomitization.

Influence of basement rocks on fluid chemistry during deformation. An example from the Pyrenees

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Rocks from the Pyrenean basement have a different chemical composition with respect to those from the sedimentary cover, and thereby, the fluids migrating through basement or cover units have a different geochemical signature. For this reason, calcite cements, precipitated in fractures from these fluids, record information about the rocks through which they circulated. In the same way, the comparison between different generations of fracture-filling cements, developed under either compressional or extensional regimes, may evidence that the related fluids have different origins and have circulated through different reservoirs. The present study is focused on unraveling the influence of crystalline basement rocks on the chemistry of fluids circulating during deformation. For this purpose, we have selected a Variscan thrust (the Estamariu thrust), which was reactivated during two main regional tectonic events. The first event, related to the Alpine compression, is responsible of the migration of a deep-sourced fluid that precipitated calcite cements Cc1 and Cc2. The second event, associated with the Neogene extension, is associated with the formation of normal faults and fractures in which calcite cements Cc3, Cc4 and Cc5 precipitated. Cc3 and Cc4 precipitated from topographically-driven meteoric fluids interacting with crystalline basement rocks before ascending along normal fault zones, whereas Cc5 precipitated from surface meteoric fluids percolating through small fractures. In this contribution, we show that, regardless of the origin of the fluids and the tectonic context, basement rocks have a significant influence on the fluid chemistry that is recorded in the vein cements, particularly in their 87Sr/86Sr ratios. This means that the cements precipitated from fluids that have interacted with the Paleozoic basement have significantly high 87Sr/86Sr ratios (> 0.710), reflecting the interaction between the vein-forming fluids with Rb-rich source rocks. By contrast, vein cements precipitated from fluids that have only interacted with the Mesozoic and Cenozoic cover, have lower 87Sr/86Sr ratios (< 0.710). These lower ratios may be similar to Phanerozoic seawater values, when fluids circulated through marine carbonate units, or higher, when fluids interacted with siliciclastic rocks.

Late Paleozoic–Mesozoic tectonosedimentary evolution of the northern Bohemian Massif: state-of-the-art

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During Permian to Late Cretaceous times, the northern Bohemian Massif (BM) experienced a complex intraplate tectonosedimentary evolution that had a substantial impact on local paleogeography. Processes that led to current basin configuration have recently been explored through facies analysis, lithostratigraphic correlation of various sedimentary formations, and provenance analysis using the U–Pb detrital zircon geochronology and heavy minerals. The provenance data point to multiple sources, including local and distant sources within the BM or exotic sources originating from Baltica. The temporal and spatial evolution of source areas and stratigraphic juxtaposition of preserved basin fills suggest that at least four generations of sedimentary basins developed in the study area. The early Permian development of the Krkonoše Piedmont Basin (KPB) is characterized by reactivation of marginal as well as intrabasinal normal faults controlling subsidence of two lacustrine sub-basins fed by N/NE-trending low-sinuosity fluvial system. Dominance of clastic material came from units south of the basin including distant sources in the southern BM. Only minor clastic material from northern basin had a local source (Krkonoše–Jizera Massif), which is consistent with half-graben setting of the basin. The deposits of the KPB correlate to those of the Česká Kamenice Basin, which in turn do not correlate with the adjacent Permian deposits preserved as tectonic slivers along the Lusatian Fault. The latter differ in depositional pattern and are lithologically similar to the Döhlen Basin. We interpret them as remnants of a small pull-apart basin(s) formed within a transtensional basin system governed by NW–SE (Sudetic) faults. Together with similar basins present on the western margin of the BM they formed by reactivation of strike-slip faults parallel to the Tornquist Zone.

The absence of Middle Triassic–Lower Jurassic strata is likely due to non-deposition/erosion as a result of tectonic upwarping of the entire area. Provenance of the Upper Jurassic and Upper Cretaceous strata indicates at least two-stage deposition, interrupted by tectonic reactivation of basement faults and shift of depositional and sources areas. The Middle–Upper Jurassic deposits preserved in tectonic slivers along the Lusatian Fault are interpreted as a trace of now completely eroded Late Jurassic–Early Cretaceous basin that once covered the Lusatian Block. It received a substantial portion of Baltica-derived siliciclastic material as evidenced by the presence of Mesoproterozoic zircons. The fill of the basin was recycled into the Bohemian Cretaceous Basin (Late Cretaceous) during progressive unroofing of the Lusatian–Krkonoše–Jizera Block.

A time-slice reconstruction of tectonosedimentary evolution and paleogeography of the northern BM show that phases of basin development and deposition (Early Permian, late Early Permian–Early Triassic, Middle Jurassic–Early Cretaceous, Late Cretaceous) were interrupted by major non-depositional intervals (Middle Triassic–Early Jurassic, mid-Cretaceous, post-early Campanian). During the early Permian, a shift from extension to transtension was caused by far-field stress transfer from the Uralian Orogeny. The Mesozoic depositional episodes resulted from reactivation of major NW–SE strike-slip fault zones due to stress transfer from the North Atlantic Rift during the Jurassic to Early Cretaceous, which was overridden by the far-field effect of convergence of Iberia, Africa and Europe during Late Cretaceous times.

Quaternary shelf-margin clinoforms in the southern Song Hong-Yinggehai Basin, offshore Vietnam

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The Song Hong-Yinggehai Basin is a pull apart basin that developed obliquely across the continental shelf of Vietnam and China between splays branching off southeastwards from the Red River Fault. The basin fill spans the Eocene–Recent and is 15–17 km thick. In this study, we adopted a seismostratigraphic approach calibrated locally with biostratigraphic and core data from two wells (B1 and B4) in order to unravel the stratigraphic architecture of Quaternary shelf margin in the southern part of Song Hong-Yinggehai basin, offshore Vietnam. The Quaternary strata attain 2.4 km in thickness in the study area and are based by a prominent, near-top Pliocene unconformity. Updip and laterally away off the axial depocentrum, they onlap the unconformity and form a flat-bedded succession intercalated locally with delta-scale clinoforms and incised-valley fills. Downdip (to the SE), this shelf prism reveals a well-developed clinoformed margin, which descends through a series of apparent onlapping terminations (ascending downlap) onto the basal unconformity that is bent towards the margin due to active uplift to the SE and NE. The height of individual clinoform bundles increases generally from initially several tens of meters to several hundreds of meters, and the modern (outermost) clinoforms display the shelf-to-slope rollovers and toes located at water depth of ca. 180–230 m and 380–820 m, respectively.

A number of erosional unconformities were recognized in the shelf topset and mapped out basinwards into the shelf-margin clinoform toes. Six biostratigraphically-constrained unconformities occur in the lower Pleistocene–lowest middle Pleistocene strata (ca. 1.93–0.75 Ma). At the shelf margin, these unconformities are manifested by either offlapping stratal termination below or deep incisions, both documenting relative sea-level falls close to or below the shelf edge. Clinoform geometries together with a clinoform rollover trajectory provide clues for assessing the relative importance of progradation versus aggradation in the evolution of the shelf margin. The oldest clinoform bundles of the shelf margin display updip pinch-outs and a low-angle shingled geometry. They are followed upwards by oblique tangential forms capped with toplap truncations. These forms tend to be strongly offset downdip and stacked vertically across thin, low-resistivity drapes possibly reflecting transgressive phases. Such geometries documenting the prevalence of progradation over aggradation dominate in the lower part of the shelf margin (ca. 1.93–1.0 Ma). Complex oblique-sigmoidal clinoforms that begin to prevail upwards record prolonged periods of the margin growth through normal regression to nearly pure upstepping. This reflects a high sediment supply that exceeded the overall rising accommodation albeit punctuated by sea-level falls. All this resulted in a strong increase of the clinoform height so that the common chaotic to mounded seismic signatures at the clinoform toes are likely to record sediment accumulations laid down from sediment gravity flows supported by the extended slopes.

Gravel laminae in inland dune sediments: new data on the aeolian transport capabilities

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According to almost all sedimentology textbooks, grains larger than 2–3 mm are not involved in dune-forming processes, being left out on the deflation lag surfaces. So far, occurrences of pebble-sized siliciclastic material within the dune sediments were only reported from Antarctica.

Presented data from sixteen inland dunes deposited during the Late Glacial – Holocene, show occurrences of laminae and lenses containing extremely large grains, up to 20.5x12.5x11 mm. The studied sites are dispersed throughout three distinct physiographic regions of northern and central Poland: the Biebrza Basin, Central Poland Lowlands and the western part of the Małopolska Upland.

An aeolian genesis of the sediment is determined both on the basis of sedimentary features of deposits bearing them, as well as the morphology of the particular landforms. Extra-large grains are composed of erratic crystalline rocks and local marlstones. The grains are prevalently non-spheroidal and varying from angular to rounded. They occur at various heights above the base of the dune, on both lee and stoss sides. In a few cases, accumulations of the pebbles are interpreted as fillings of burrows. Several sites display up to seven layers of extra-large grains in vertical profile, indicating a few episodes of extremely strong and relatively steady wind during the dune-forming period. An aeolian transport of gravel in periglacial conditions could have been facilitated by several factors, such as low temperatures resulting in relatively high air density and the low humidity.

On the basis of measured dimensions and volumes of particular pebbles, a Principal Component Analysis has been carried out. The results demonstrate that distribution of grain dimensions is clearly heterogeneous between the three physiographic regions. The dispersion of values from the Central Poland Lowlands dataset is definitely minor in comparison to the other two regions. The phenomenon might have been caused by the lack of wind-flow terrain constraints in the mostly flat, vast area of the Central Poland Lowlands. In contrast, relatively high variance of grain dimension parameters could have been caused by the inconstancy of wind velocity and direction over the undulated morphology of the other two regions.

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Sometimes planar, sometimes irregular: a bipartite bed interface dilemma

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Deep marine matrix-rich (> 20% detrital clay and silt content) strata that are unlike classical turbidites or debrites have been increasingly recognized in both modern and ancient turbidite systems. Included in these matrix-rich strata are two-part beds consisting of a "clean" sandstone overlain sharply by a "muddier", clast-rich, poorly sorted layer that as a single unit have been variously termed linked debrites, co-genetic debrite-turbidite beds, hybrid event beds, transitional flow deposits and bipartite beds. In all cases, deposition of these two superimposed layers is interpreted to be genetically related but differently interpreted, including: flows consisting of two discrete and mechanistically different parts (turbidite overlain by debrite); longitudinal flow transformation; vertical stratification effects and turbulence suppression in a high-concentration suspension; particle settling in a negligibly sheared mixed mud-sand suspension. In part, these differences can be attributed to the interpretation of the contact that separates the two distinctively different lithologies. In basin-floor rocks of the Ordovician Cloridorme Formation, Quebec, Canada the contact is planar, irregular, or segments of one followed by the other, and therein provides an excellent opportunity to investigate the origin of these enigmatic strata.

In bipartite bed-planar (Bb-planar), the interface separating the basal sandy and upper muddy parts is flat, whereas in bipartite bed-irregular (Bb-irregular) the interface consists of cm-scale synform and antiforms with local overhangs and sand injections of the sand-rich basal part into the overlying mud-rich part. Despite differences in interface morphology, Bb-planar and irregular have similar texture and composition, and also occur in the same position in a 100s m long depositional continuum, which in a downflow direction consists of matrix-poor sandstone (< 20% matrix) to muddy sandstone (20 – 50% matrix) to bipartite bed with basal sandy (30 – 60% matrix) part overlain sharply by (40 – 80% matrix) upper muddier part and then sandy mudstone (50 – 90% matrix). The depositional continuum is interpreted to reflect particle settling in a rapidly but systematically evolving, negligibly-sheared sand-mud suspension that formed at the downflow terminus of a high-energy avulsion jet. More specifically, the Bb part of the continuum is the result of the settling of coarse sediment and concomitant upward flux of more slowly settling, finer-grained particles into the upper part of the suspension. With the exhaustion of settling particles, and accordingly the termination of the sand-rich lower layer, the mud-rich upper part of the flow continues to move, but only for a few decameters beyond the sand-rich pinch-out, and forms the sharp planar contact that separates the two parts of the bed. Irregular contacts, on the other hand, are interpreted to be a consequence of post-depositional deformation caused by variations in water saturation and pore fluid pressure. These conditions set up local Rayleigh-Taylor instabilities between the more dense, less permeable, mud-rich upper part and sandy, less dense basal part that ultimately results in gravity-driven deformation of the previously planar interface.

A Neoichnological Approach to Interpreting Bird and other Trace Fossils

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Detailed sedimentological analysis of an outcrop in Sandakan, eastern Sabah, Malaysia has yielded previously unreported bird related traces. The Lower Miocene Sandakan Formation outcrops in a large quarry exposing interbedded sandstone and mudstone beds. The overall depositional setting is interpreted as ancient mangrove deposits, based on highly carbonaceous, rooted mudstone beds, small steep sided creek sandbodies and a mangrove dominated invertebrate fauna. The fauna includes gastropods, bivalves and the mangrove lobster Thalassina anomala.

Several trace fossils have been identified through the sedimentological logged section including a bedding plane with bird footprints. The footprints are small and lack hallux impressions, and are attributed to small, plover like, shorebirds. Associated small, subrounded traces may indicate probe marks, but in the absence of paired bill impressions, as seen in modern probe marks, this is not certain. Of greater significance are a series of linear traces comprising highly sinuous, meandriform structures with a width of around 10 mm. These traces occur on a bedding plane deeper in the section. Comparison with modern plover feeding traces (Blacksmith and Semi-Palmated Plovers) strongly suggests that these are first "back and forth sweep" style, bird foraging traces reported in the fossil record. A further bedding plane exposure marking an interpreted abandonment surface at the top of a channel sandstone bed exposes numerous crustacean footprints. There are also casts of fossil leaves and a series of deeply incised, steep sided pits that may indicate either the probe marks of a large bird or possibly mammalian tracks.

Neoichnogical examples of the traces described above were used as analogues to confirm the interpretations. A variety of other modern behavioural traces have been observed in the field, including landing and resting traces made by geese, ducks and magpies. It was possible to observe many of these traces in the process of being made, confirming the mode of their formation. In addition, many other bird foraging and nesting strategies have been described in the literature but not recognised in the fossil record. Recommendations are provided on what to look for to identify ancient versions of such modern traces, and to use this information to interpret and confirm depositional settings and the birds that inhabit them.

Limestone-marl alternation formation: detecting original variations in aragonite and calcite

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The origin of carbonate rhythmites, i.e. limestone-marl alternations (LMA), is a lively debated topic. They are used for high-resolution cyclostratigraphic and palaeoenvironmental studies, but several studies indicate not all LMA reflect genuine differences in the original sediment composition driven by changes in the depositional environment. Differences between limestones and marls in the ratio of diagenetically inert trace elements, i.e. Aluminium and Titanium, indicate environmental changes that affected the terrigenous compound of the precursor sediment. Contrarily, LMA without these differences can be the product of (1) variations in CaCO3 input (aragonite, calcite) distorted by diagenetic CaCO3 redistribution, or of (2) diagenetic CaCO3 redistribution in a homogenised precursor sediment. The question is, how can the composition of the original CaCO3 compound (aragonite, calcite) of the precursor sediment be detected? This study provides a new approach to answer this question. The model of differential diagenesis assumes the concentration of diagenetically inert elements is inversely proportional to the amount of redistributed CaCO3. Thus, the difference between ratios of diagenetically inert elements, e.g. Aluminium and Titanium, can be used as a measure for CaCO3 redistribution. This is done by calculating the vector lengths between trace element ratios for two adjacent beds. This new approach is applied to 75 contiguous limestone and marl beds from the Högklint Formation (Silurian) on Gotland, Sweden. To test this new method, trace elements were compared according to their solubility during diagenesis. All trace elements that are bound to clay minerals or fit into the calcite lattice show the same pattern of vector lengths. In contrast, the vector lengths of trace elements which fit into the aragonite lattice and are soluble, like Strontium, differ from this pattern in vector lengths. The results support differential diagenesis as the driving mechanism for the formation of this LMA. Furthermore, phases of variations in aragonite and calcite as well as phases of without variation can be detected. This approach provides a tool to test the diagenetic origin of a LMA, to identify original variations in CaCO3 in the precursor sediment, and to test a LMA's suitability for cyclostratigraphic analyses.

Active deposition of sieve deposits on alluvial fans in Alpine environment (Planica Valley, NW Slovenia)

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The Planica Valley is located in the Julian Alps in northwest Slovenia and is a typical post-glacial Alpine valley. The valley is bounded by steep slopes, which consist mainly of Upper Triassic carbonates. After the last glacial retreat, the valley floor has been continuously filled with various Holocene sediments, deposited by rock falls, fluvial flows, debris-flows, and debris floods. All these sediments are forming distinct sedimentary bodies, of which alluvial fans are the most numerous and have the most complex sedimentary structure. The fans have an average radius of a few hundred metres and an approximate area of up to 25 ha with a corresponding catchment area of up to 45 ha. Since the fans lack permanent surface water streams the sediments are only transported onto the fan surfaces during sporadic precipitation events during debris floods and torrential events. The sediment is typically deposited on the surface of the fan either in the form of fan-shaped lobes or as sieve deposits.

At this stage of research, we have performed (i) a preliminary sedimentological analysis, (ii) clast fabric analysis by measuring the clast orientations with the standard geological compass, and (iii) an aerial surveying using Small Unmanned Aircraft (SAM) and photogrammetric modelling of the geometry of the deposits. To ensure cm-level precision for modelling and monitoring future changes in morphology, we installed a network of permanent ground control points and obtained their coordinates with precise GNSS survey. For monitoring precipitation, we use data from a permanent meteorological station five kilometres away from the research area.

Sieve deposits are one to several tens of meters long and up to ten metres wide. They consist of angular to sub-angular, open framework, clast-supported, well-sorted gravels. The clast size varies depending on the size of the individual sieve deposit. Larger sieve deposits of up to a few tens of metres in length have fine to coarse cobble size clasts, whereas smaller sieve deposits of about one metre in length have clast size of medium to coarse gravel. On thirteen individual sieve deposits we measured the clast orientation to altogether 750 clasts, which gave us a general overview of the current direction of sediment distribution on the investigated alluvial fan.

We found that sieve deposits are subject to changes in surface morphology caused by the transport and deposition of new sediments during debris flooding events. Such events occur with a frequency of two to five years. Deposition events seem to correlate well with meteorological data, particularly with intensive rainfall events. In the future, we aim to monitor changes in the surface morphology of the deposits with SAM surveying and photogrammetry, to better link sediment deposition and redistribution with intense precipitation events.

High-quality black shales in the low prospective Zaysan basin, Kazakhstan: A viable unconventional resource?

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The Zaysan Basin, located in eastern Kazakhstan contains a 1.5 km thick succession of Permian deposits. The accommodation space was formed by the Kazakhstan and Siberia plates convergence, which caused subduction, strike-slip faulting, compressional faulting, mantle intrusions, and volcanism. The Permian strata are superbly exposed in the Altai Mountains and buried to depths of up to 6 km. While existing literature lacks interpretations of depositional systems, lithological descriptions of outcrops and cores suggest that all units are predominantly comprised of clastic continental deposits, including numerous coal and organic-rich strata and sporadic volcanoclastic interbeds. The paleogeographic reconstruction suggests that the basin was filled by locally sourced sediments, while the accommodation space was maintained by tectonic subsidence. Laterally extensive coals suggest the historic presence of shallow continental fresh water environments such as delta and fluvial plains.

Pyrolysis results of 50 black shale samples collected from depths of 2424–2457m (33m thick), characterized by high hydrogen (>600) and very low oxygen (3–34) index are interpreted as lipid-rich organofacies C (Type I kerogen), characteristic for lacustrine deposits. These organofacies are likely responsible for high oil yields (6–16% of oil measured by Fisher Analysis) of the age-equivalent outcrop exposures and/or near surface deposits that were previously evaluated for mining and retorting. Numerous interbeds of sandstone, shale, coal, and organic-rich strata can be explained by frequent, tectonically driven base-level changes. An average TOC of 5.8% indicates high paleobioproductivity, probably enhanced by warm climate, inferred alkaline waters associated with terranes of basic rocks, and algal blooms caused by nutrient rich volcanic ashfalls. The high preservation potential is attributed to anoxic conditions typical for a stratified water columns in lakes and/or oxygen depletion caused by algal blooms.

Although the overlying Triassic, Jurassic and Cenozoic strata contain hydrocarbon shows and host several oil and gas fields (believed to be sourced by Permian black shales), the Zaisan basin petroleum potential is considered to be low. The reasons may include: i) forced thermal maturation by syn- and post-depositional intrusions; ii) petroleum leakage along numerous faults; and iii) copious amounts of oil retained within the source rocks. Retained oil is of primary interest in this research.

The studied interval (2424–2457m) has a calculated ultimate expulsion potential of 20.26 MMboe/km2 and ranks among the best known source rocks. However, T max values of 423 to 432 °C indicates thermally immature source rocks. Nevertheless, seismic data suggests that the same unit dips southeastwards and 16 km away reaches a depth of 4200m, indicating that the unit has passed through the oil and gas windows. The ongoing investigation aims to identify and map multiple black shale units, their organic content, organofacies, and oil- and gas windows to delineate the areas with potential unconventional petroleum resources. Sedimentological, geochemical, and geomechanical studies will allow for assessing the feasibility of their development.

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Does a unique geochemical signature of lime mud formation persist in the recent geological record?

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The origin of whitings on Great Bahama Bank has been widely debated for more than eight decades. Constraining the enigmatic trigger for tropical marine whitings will aid not only the development of sedimentary budgets for lime mud through geological time, but also the interpretation of their geochemical signatures. For instance, the elemental concentration and stable isotope composition of whitings formed via abrasion and resuspension would likely record a culmination of environmental signals, vital fractionation effects, and traces of the environment of original grain deposition. Alternatively, if whitings are precipitated in the water column, their geochemical signatures could more reliably be interpreted as a 'snapshot' of ambient water chemistry. In this study, we analyze the mineralogy, elemental concentrations, and stable carbon and oxygen isotope composition of the <63 micron sized carbonate sediments from more than 300 surficial sediment samples collected in a grid across Great Bahama Bank. Observation of significant variance between the geochemical signatures of these fine-grained fractions and published data on their counterpart bulk samples might suggest a different formation mechanism for fine-grained, lime muds on Great Bahama Bank in contrast with grainier bulk sediments. Finally, geochemical signatures of the mud-sized fraction will be compared with results of a high-resolution SLIM hydrodynamic model of the platform top. Results from the SLIM model suggest that physical mixing of on-platform and off-platform waters with a large temperature differential may explain the observation of increased whiting frequency during winter months in contrast to thermodynamic expectation of water column precipitation.

Paleoclimate evaluation during the mid-Cretaceous in Zhejiang Province, southeast China

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The Cretaceous period is known as one of the warmest intervals in the Phanerozoic, providing crucial information to reconstruct the Earth system which operated under an extreme greenhouse condition. Many studies reported that low to mid latitude regions of Asia experienced a severe aridification in mid-Cretaceous. However, geographical extent and the northern limit of the mid-Cretaceous arid climate zone is poorly constrained. In addition, paleoclimate studies of continental margin basins in China are scarce compared to inland-basins. We thus investigate the paleoclimate of coastal region in Zhejiang Province, southeast China, through analyzing chemical compositions and clay mineral compositions of mid-Cretaceous mudstones (the Chaochuan and Laijia formations).

Studied sediments are mostly fluvial to lacustrine deposits, and the depositional age is mid-Cretaceous (Albian-Coniacian). Red to purplish red deposits and calcareous nodules are prominently developed in the Chaochuan Formation (late Albian), and lower division of the Laijia Formation (early Cenomanian), which directly implies an arid paleoclimate. Chemical weathering indexes (W values and Rb/Sr) show a significant decrease in hinterland weathering from early Albian (W=75) to late Albian (W=25), and recovery in Cenomanian (W=72). The low W value detected in late Albian is comparable to the W values of modern soils developed in arid climate zones. This geochemical result is concordant with sedimentary facies, which also suggests an arid depositional environment. Therefore, we conclude that the coastal region of southeast China (Zhejiang area) experienced a severe aridification in late Albian. In comparison with the paleoclimate analyses conducted in inland-basins in Asia, the present result demonstrates shorter interval and smaller scale of aridification. However, we speculate that inland-basins could undergo an intensified aridification than continental margin basins due to the enhancement of inland dry climate and/or the orographic rain shadow effects. In addition, the present result reveals that study area (c.a. 30°N) was the possible northern limit of dry paleoclimate zone. This geographic constrain will contribute in reconstructing the spatial-temporal evolution and transition of paleoclimate that emerged in the mid-Cretaceous.

The palaeoenvironmental reconstruction of the lower toarcian (lower jurassic) lower sulphur band, cleveland basin, UK

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In the Cleveland Basin, Yorkshire, the early Toarcian Grey Shales Member was deposited under oxic conditions, but it contains three decimetre-scale black shale units that may presage later reduced oxygen events in overlying units. Here, we present an ongoing study of the earliest of these units: the Lower Sulphur Band (LSB). The LSB is lithologically heterogeneous, containing bituminous, siliciclastic, cross-stratified, and intensely bioturbated fabrics. Based on the iron speciation redox proxy, the whole of the LSB was deposited under anoxic conditions, despite the presence of Chrondrites and Rhizocorallium traces at the base and top of the unit. Trace metal analysis shows that the LSB is also enriched in Mn, implying a stratified water column, in a basin subject to a rapid transgression. Episodic enrichments in K/Rb and the presence of two sources of organic matter suggest that episodes of enhanced fluvial flux from surrounding hinterlands also took place. Our study highlights the importance of a multiproxy approach to palaeoenvironmental studies, and how a proper understanding of the biogeochemical dynamics in any studied basin is crucial for an accurate appraisal of Fe redox proxy data.

Tectonic setting of the modern straits: lessons for interpretations of ancient systems

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The tectonic settings of straits occurrence and variable oceanographic conditions suggest complex sedimentary architectures related to strait types that likely change with tectonics or climate conditions.

Modern straits, gateways and seaways tend to follow structural lineaments, in both compressional and extensional areas between tectonic plates, and as such they can record, in fossil examples, a complex interplay of tectonic, climatic, and oceanographic signals. In extensional settings, at the extremities of rift basins, straits tend to be narrow and long, mirroring the large-scale tectonic trends, and in some cases form a series of tortuous interconnected straits and seas. Another scenario in extensional settings is where the continental rifting initially forms lacustrine basins that eventually connect with the ocean through a strait before turning into a gulf or a seaway. In these cases, straits are fundamental in controlling water, sediment and biota exchange with the open sea, and the connection of a lake basin with the ocean is a process that can occur abruptly or gradually/intermittently over a long-time interval.

In convergent margins, straits can be formed between two large landmasses forming a wide range of possible morphologies such as narrow gateways (Gibraltar), long and narrow straits (Bosporus, Dardanelles) or more complex morphologies (Straits of Georgia by Vancouver Island in BC, Canada). Strait morphologies can be even more variable in complex subduction zone areas, such as in SE Asia, where a series of microplates between Australia and Eurasia and multiple volcanic arcs are separated by tens of straits.

Straits can also form in relative stable tectonic areas such as the Canadian or Scandinavian shields. In this case, straits and gateways are formed by flooding of previous topography caused by relative high sea level. Similarly, the relative high sea level and flooding of an erosional landscape can create straits or seaways, such is the case of the straits and seaways around the British Islands.

Straits hydrodynamic is controlled by its shape and connecting basins conditions. Current convergence and amplification is caused by the restriction of the cross-sectional area while the currents are triggered by water density differences (temperature or salinity driven) tidal phase opposition or to winds and storms between the interconnected basins. However, complex interactions between different hydrodynamic processes can occur both in space and in time. For example, it is quite common to observe a segregation of tidal and wave dominance between the deeper part of a strait and the shoreline, such as in the Dover Strait.

Despite not present in the modern settings, seaways, like the Cretaceous Western Interior Seaway of North America or Putumayo-Oriente-Marañón basins of South America, formed in areas of relatively gentle tectonic subsidence, where small changes in subsidence or sea level can have a vast impact in the shoreline morphologies, position and process domination. Such shallow but wide and long basins that connected larger bodies of water had variable water circulation patterns and complex sedimentary deposits.

Sedimentation modeling vs seismic facies analyses

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The subject of this research is a new approach based on the integration of seismic facies analysis with modeling of sedimentation system – submarine fan – a potential lithological trap is of interest for petroleum experts in the context of hydrocarbon accumulations exploration and development. The new approach allows introducing sedimentation systems modeling into the traditional process of seismic data interpretation.

The developed approach was tested on data of the target interval in Cherkashin formation (West Siberia, Priobskoye-Salym region, Neocomian progradation complex, Achimov sequence). In the West Siberian basin, more than 200 hydrocarbon accumulations are associated with turbidite deposits.

At the beginning of Neocomian time, the West Siberian basin was an epicontinental, rather shallow-marine starved basin (first hundred meters deep). The bulk of Neocomian formations is composed of terrigenous formations of accumulative slope, which were formed between the relatively shallow-marine shelf and deep-water zones. Sand and sand-aleuritic layers at the foot of Neocomian clay-siltstone slopes are everywhere identified as potential traps for hydrocarbon reservoirs. Their occurrence is associated with sand material supply in the form of varied-density turbidite flows and landslides. These processes have a genetic and spatial association with the discharge areas of sediments being transported within delta fronts and shelf areas. Gentle muddy slopes had the assumed inclination of 0.5° to 1.5°, rarely up to 3°; slope feet was in 20 to 50 km away from the conditional shelf edge (bench). Feeding and supply channels are up to 25 m thick, distribution channels rarely exceed 5 to 7 m with the width of 100 to 300 m. Lobe thickness varies from 20–30 m in proximal part to 2–4 m in distal part. Thickness of single frontal lobes rarely reaches 10 m. Areal size of small single lobes makes first tens of square km, while complicated fans can reach first hundreds of square km.

Lithofacies analysis of core from the Achimov formations confirms deepwater origin of the deposits and their formation in the area of subsea accumulative slope. Fine- and short-grained sand fractions and extremely inhomogeneous structure suggests their accumulation by turbidite systems with mixed sand-clay feeding (E.Zhukovskaia at all, 2018, 2019).

The presence of submarine fans selected as test-subjects for modeling is confirmed by lithofacial analysis, distribution of effective thicknesses over the area according to drilling results, seismic facies analysis. Two criteria were used to evaluate the simulation results: compare the shape of the model with the results of seismic facies analysis and comparison of the parameters describing the geological process and selected in the modeling process with modern data on turbidite systems. Modeling of submarine fan sedimentation was carried out in the Geological Process Modeling (GPM) module of the Petrel software (Schlumberger), Seismic Facies Analysis – in Stratimagic software (Emerson).

The developed approach can be recommended for studying of deep-water deposits; predicting the development of the distal parts of the submarine fan, not evident in the seismic data; the internal architecture of the potential lithological traps, the degree of its heterogeneity.

Psilonichnus upsilon ichnofosssils as a tool of environmental study in Albian sands, Glanów-Stroniczki, southern Poland

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The southern, marginal part of the large basin of epicontinental Europe experienced shallow siliciclastic sedimentation over a large area during the Albian (late Early Cretaceous) marine transgression. The sea transgressed directly onto an Oxfordian (Upper Jurassic) limestone substrate (Marcinowski 1974, Acta Geol. Pol. 24, 117–217). The Glanów area, southern Poland, was located in the peripherial part of that basin during the Late Albian. The deposits are primarily composed of quartz sands, with accessory glauconite and muscovite. Their sedimentary structures indicate a nearshore depositional setting, although the locations of the adjacent land and paleoshoreline are not clearly defined.

Natural, large, enigmatic cemented forms composed of burrows infilled by sandstone/pebblestone and/or mixed pebbly sandstone discovered in loose sands exposed near Glanów (Glanów-Stroniczki outcrop) are assigned to the ichnofossil Psilonichnus upsilon Frey et al., 1984 (Frey et al. 1984, J. Paleontol. 58, 333–350). Such burrows seem to be a crucial tool in the interpretation of basin bathymetry, indicating a foreshore to backshore (beach) facies and probably recording a temporary break in sedimentation. At Glanów, the large burrows preserved as concretions are situated at a single horizon. The lateral extent of the horizon is short, c. 25 m and it passes westwards into a large-scale bedded structure terminated by erosional canal from the east.

The Glanów horst, composed of Jurassic biohermal limestones during the Albian, was probably emergent element (Marcinowski and Radwański 2009, Acta Geol. Pol. 59, 505–521), neighbored, or surrounded, by a sandy beach with active fauna. The Psilonichnus upsilon burrows in Glanów-Stroniczki closely resemble burrows of the modern ghost crab Ocypode. In modern settings, representatives of Ocypode are encountered in extremely shallow marine (foreshore/intratidal and backshore/supratidal) to dune environments. A comparison of the burrow diameter of Ocypode quadrata measurements from three types of beach in Sapelo Island, Georgia, USA (Frey and Mayou 1971, Maritima 3, 53–57) with burrow diameter measurements of P. upsilon from Glanów-Stroniczki (Olszewska-Nejbert et al. 2020, Palaeogeogr. Palaeoclimatol. Palaeoecol. 538, 109388), suggests that the Albian progenitors of the large enigmatic burrows in Glanów-Stroniczki most probably inhabited the lower/upper backshore on a broad, very gently sloping beach with a broad backshore. It is worthy of note that this is the first record of Frey et al.'s ichnotaxon from pre-Cenozoic deposits in Poland, and probably in the world. The oldest body fossils of Ocypode, and fossil burrows assigned to Ocypode, were described from Miocene deposits (c. 15 Ma). The presence of silicified forms of burrows in the Albian Glanów-Stroniczki sands very similar to the modern Ocypode, may indirectly suggest that semi-terrestrial brachyuran crabs and/or forms with behavior identical to modern ocypoids appeared earlier than 100.5 Ma on Albian broad sandy beaches. Additionally, it worthy of note that ichnofossil P. upsilon could be used as a precise tool in sedimentary study to indicate a paleoshoreline, especially when the primary sedimentary structures are not well preserved or have been obliterated.

Holocene evolution of Lake Ulaan basin, southern Mongolia

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Lake Ulaan located in the northern margin of the Govi region, southern Mongolia has rapidly shifted into a playa lake condition due to warming and drying, and human impact. Lake Ulaan has evolved from a deep lake water in the early Holocene to a shallow playa lake in the Anthropocene. Lake Ulaan started to decrease its area, and the drop of the lake level intensified since the middle Holocene. Prevalence of humid climate in the lake basin at ~6.0 cal. ka BP and arid climate since 3.2 cal. ka BP were reflected in sedimentation rates in the lake. The sedimentation dynamics in the Lake Ulaan basin show high sedimentation rates of 11.8–22.7 cm/ka in the eastern part of the basin, and low rates of 3.3–5.8 cm/ka in the western part during the late Holocene. Both the western and eastern parts of the lake have been strongly influenced by fluvial and aeolian activities since the arid late Holocene, however fluvial sediment input was more significantly recorded in the eastern part. The eastern and western parts of the lake were initially exposed to wind deflation at 2.7–3.2 cal. ka BP and the aerial exposition continued at 0.6–1.3 cal. ka BP. The aeolian deflation has been prevailing throughout the lake bank recently.

Effects of microscopic characteristics of tight sandstone on permeability and mobile fluid distribution

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Matrix pores in tight sandstone reservoirs play an important role in oil and gas production, the parameters of micro characteristics are key data that could affect the permeability and fluid mobility that deserved to be studied. The experimental methods used to characterize the pore-throat structure have their own advantages and limitations. The eight samples of this paper are taken from Upper Triassic Yanchang formation in the Ordos Basin, China. Calibration was carried out through the more accurate information on the results of nuclear magnetic resonance (NMR) experiments and constant-rate mercury injection tests. Then, a quite comprehensive and precise distribution of throat radius and distribution of pore space controlled by throats with different radius came out. Meanwhile, the radius parameters were extracted from this: the radius of the throat which control pores at first , the radius of the throat which control the largest pore volume, the radius of the largest throat volume, the volume of the throat which control pores, the volume of the throat which control no pores, the volume of the total throat. The structural parameters of the rock such as the content of the interstitial material were obtained by scanning electron microscopy, casting thin sections, and X-ray diffraction experiments. Comparison of repeatedly centrifugal NMR experiments and pore-throat distribution results shows that:The distribution of movable fluid is affected by the radius of the throat and the film bound water, therefore, repeatedly centrifugation experiments cannot determine the distribution of movable fluid controlled by different radius ranges. The correlation between the above parameters and permeability and porosity of the mobile fluid indicates that: Both the throat volume and throat radius which control pores play important roles in permeability. Gas permeability is more affected by throat radius than liquid permeability. The higher the illite contents in the clay ore, the greater the relative difference between the gas permeability and the liquid permeability. Calcite cementation and laumontite cementation are the main reasons of the decrease in permeability for some samples.The movable fluid is mainly concentrated in the spaces of the throat which control pores and the pore spaces it controls. The total content of interstitial material has little effect on the porosity of the mobile fluid, but the higher the illite content, the lower the saturation of the mobile fluid, what is more, this correlation is significant. Finally, two formulas for predicting the porosity of mobile fluids are proposed through data fitting. One is the prediction method using the liquid permeability, and the other is the method using predict gas permeability and illite content.

Pore structure characteristics of organic-rich laminated carbonate rock reservoirs affected by tephra, Santanghu Basin, China

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The carbonate rock reservoirs in the Lucaogou Formation in the Santanghu Basin are dominated by laminated structures, with extremely heterogeneous pore structure. In this paper, the mineral composition and pore types of the reservoir were analyzed by using casting thin sections, fluorescent thin sections, and whole rock X-ray diffraction, cathodoluminescence analysis, scanning electron microscopy and QEMSCAN; combined with high-pressure mercury injection, nuclear magnetic resonance (NMR) and nano-CT scanning techniques to quantitatively characterize the microscopic pore structure of the reservoir. The results show that the laminated carbonate rock reservoir is dominated by dolomicrite, with light-colored lamination containing carbonates and dark-colored one containing tephra materials, constituting a volcanic eruption cycle longitudinally. The tephra enters the lacustrine basin and the caused the propagation of algae and other organisms, resulting in high organic matter abundance, which is at a low maturity (TOC = 2.0 %-5.0 %, with Tmax averaging 441.2 °C). The physical properties of reservoir are poor, with porosity ranging in 2% -8% and permeability less than 0.1mD mostly. The types of storage space are dominated by micro- and nano-scale intercrystalline pores of dolomite, dissolved pore, and micro-fractures which are frequently associated with dissolved pores. The NMR T2 spectrums have evident bimodal characteristics. The secondary peaks are located at 0.01ms-1ms and the major peaks are located at 1ms-100ms. They correspond to micropores (<100nm) and mesopores and macropores (>100 nm), of which the proportion of macropores (>100 nm) accounts for more than 50%. The high-pressure mercury injection curves have a higher entry pressure, which is generally greater than 5 MPa, with poor sortness. The pore throat radius is mainly between 0.025 μm-0.16 μm, and the contribution of the pore throat to the reservoir permeability can reach more than 60%, the mercury extrusion efficiency is moderately low (<50%), indicating poor pore-throat connectivity. Based on the combined results of NMR experiment, high-pressure mercury injection measurement and nano-CT scan, the cutoff of pore-throat radius of fine-grained carbonate reservoirs is defined about 60 nm, with an average saturation of mobile fluid of 50 %. Organic matter abundance and dolomite content are the major controls to the development of matrix pores, and microfractures are the key mechanisms affecting the percolation of fluid in the reservoir. For the reservoir characterized by higher dolomite content and moderate organic matter abundance, the matrix pores and microfractures are more developed, showing better pore structure and higher fluid mobility.

Dolomite origin and sedimentary environment characteristics of mixed siliciclastic-carbonate sediments affected by volcanism, Santanghu Basin, China

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Lacustrine fine-grained mixed siliciclastic-carbonate sediments dominated by carbonate rocks and volcanic ash were widespread in the second member of the Lucaogou Formation (P2l2) in the Santanghu Basin. However, due to frequent volcanic activities around the basin, the sedimentary environment of the P2l2 was extremely complex and still unclear. Therefore, in this paper, qualitative or semi-quantitative reconstruction and analysis of the sedimentary environment and the origin of the P2l2 dolomite was performed through technical methods such as cores analysis, casting thin sections, whole-rock X-ray diffraction, fluorescent thin sections, major/trace elements, carbon and oxygen isotopes, dolomite order degree, cathodoluminescence, and biomarker analysis. The results show that the P2l2 mainly develops four types of rocks: dolomite, tuffaceous dolomite, dolomitic tuff, and tuff, which are mainly charactered by light-dark colored interstitial laminated structures. Comprehensive paleo-salinity index (Sr/Ba, Rb/K, Gammacerane index), redox condition index (V/Cr, Ni/Co, Pr/Ph), paleoclimate index (Sr/Cu, C-value), and paleowater depth indicators (Mn/Fe) analysis showed that the P2l2 were charactered by a high salt, a suboxic to anoxic condition, an arid paleoclimate, and a low terrigenous input. Due to the impact of volcanic ash, the mixed siliciclastic-carbonate sediments contain a high abundance of thermally mature Type I and II1 kerogen, have excellent original hydrocarbon generative potential. In addition, there is an obvious response relationship between volcanic activity and sedimentary environment. When volcanism was intense, tuff and dolomitic tuff were developed, with high abundance of organic matter (TOC > 5%), relatively humid climate, decreased salinity, and weakened water reducibility. However, when volcanism was weak, dolomite and tuffaceous dolomite were developed, with low abundance of organic matter, hot and dry climate, increased salinity, and enhanced water reduction. The P2l2 dolomite mainly had the origin of penecontemporaneous-burial metasomatism, and the evidence were as follows: 1) A large number of dolomites had obvious zonal structure, indicating the existence of metasomatism. Besides, the P2l2 had some evaporite minerals and low-order degree of the dolomite (0.4–0.6), which suggested that the dolomite was formed by penecontemporaneous rapid crystallization; 2) Part of the dolomites were characterized by a high content of Fe2+ and Mn2+, a moderately positive excursion of δ13CV-PDB values (2–12‰, avg. 7.4‰), a negative excursion of δ18OV-PDB values (-18.3 – -2.3‰, avg. -10.6‰), a high-order degree (0.7–0.8), a positive anomaly of Eu, and a certain enrichment of light rare earth elements (LREEs), indicating that it was caused by burial dolomitization; 3) Most of the dolomites were ankerite, and the speckled dolomite and veins were mostly developed near the tectonic fault zone, with a lower value of δ18OV-PDB (< -8‰), an obvious positive anomaly of Eu (1.01–1.68, avg. 1.28), and an obvious enrichment of LREEs, indicating a higher formation temperature.

Internal architecture of coarse-grained barriers in hypertidal environments (France and Argentina): A GPR study

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Barrier spits and beach ridges are different types of coastal barriers controlled predominantly by wave dynamics. They represent the two end members of a continuum of wave-built features reflecting varying orientations of net sediment transport (longshore vs. cross-shore). In hypertidal environments, high amplitude tide-induced sea-level changes as well as strong tidal currents necessarily combine with wave action in the construction of spits and beach ridges. In this study, we image the internal architecture of two coarse-grained coastal barriers, both located in hypertidal environments: the mixed sand-and-gravel spit at the mouth of the hypertidal Somme estuary in the English Channel (Northern France), and the sand-and-gravel barrier systems at the inlet of the hypertidal Santa Cruz estuary in Southern Patagonia (Southern Argentina). Maximum tidal ranges are 9 and 11 m in the French and Argentinian sites respectively. A great variety of morphologies compose the two systems, from simple spits and barrier spits to beach ridges. Both sites were investigated using ground-penetrating radar (400 MHz GSSI antenna), along with the analysis of aerial photographs and digital elevation models. Cross-shore and long-shore profiles, with a penetration depth between 2 and 4 meters, show a large range of radar facies attributed to erosional surfaces, beachface progradation, along-drift elongation, hooks and spit terminus development, and washover deposits. The in-depth analysis of radar architecture allows reconstructing the development of individual morphology in the two systems, and helps to differentiate the influence of wave- and tide-related processes. The most open-sea barrier-spit systems (Somme estuary and Santa Cruz external mouth) show a classic development controlled by the wave-related littoral drift, probably enhanced due to shore parallel flood currents. In contrast, the most internal systems, located along the northern edge of the Santa Cruz inner inlet, feature contrasting morphologies, structures and directions of elongation, either landward or seaward, reflecting a complex balance between wave- and tide-dominated dynamics on their construction.

Evolution and internal architecture of an active mixed sand-gravel barrier spit (Somme Bay, Northern France)

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Interest on coastal barriers is closely related to the strong anthropogenic pressure on coastal environments. Nevertheless, morphodynamic evolution of coastal barriers and the way it is recorded in the internal structure are still revealing many uncertainties. Coastal spits have a high potential of preservation due to their fast elongation under littoral drift, and are thus suitable for this kind of study. Compared to sandy spits, gravel and mixed spits are understudied. Yet these coarse-grained coastal barriers are sensitive sedimentary bodies due to the high energy conditions they are usually associated with and to often scarce sediment supply. The present study focus on the relationships between multi-decadal morphological evolution of a mixed sand and gravel spit in the bay of Somme (Northern France) and its sedimentary architecture. A geophysical survey using a 400 MHz GPR antenna have been performed on the Molliere spit, a fast-growing secondary spit developing along the main 15 km-long Somme barrier spit. The development of this sedimentary body starts in the 1950s and allows a morpho-stratigraphical approach, thanks to the cross analysis of aerial photographs and GPR profiles. The spit is 5 km long and is composed of several ridges, sometimes with hooks at the tip. It is supplied by flint pebbles originating from the erosion of Cretaceous chalk cliffs south of the bay, and transported by a northward longshore drift. A synthetic depositional and stratigraphical model specific to gravel spits is proposed, based on radar profiles and aerial photographs analysis, differentiating three contrasting morpho-sedimentary units. The first unit at the spit root is characterized by mainly prograding structures that can be assimilated to a beach ridge. The second unit in the central part of the spit is characterized by individual ridges with a core structure reflecting a longshore development, topped by an aggrading unit associated to a cross-shore-dominated dynamics. At the spit terminus, the third unit is also mainly characterized by longshore dynamics, but interfering with sand bank dynamics due to the proximity of the Somme estuary and the development of the spit platform. A detailed 3D stratigraphical analysis of a hook inflexion point gives a first insight into the processes of reactivation of a recurved terminus, leading to a new phase of longshore elongation. Larger-scale GPR prospecting, especially in older coast sections, will be necessary to understand how this fast secondary spit development (decadal to centennial time scale) is integrated into the longer-term (millennial) construction dynamics of the main Somme spit.

Cyclic dominant depositional processes on a mixed turbidite-contourite system in northern Campos Basin, SE Brazil

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A new mixed turbidite-contourite system is described in the northern Campos Basin, southeastern Brazilian margin. This system is developed in a middle slope setting, and was formed through non-synchronous interaction between the turbidity current and a contour current in the same stratigraphic interval (Miocene). Based on seismic attributes, seismic facies, and isochron maps, diagnostic features on alternating cycles of downslope and alongslope processes were identified in the study area, along with an intermediate stage with features from both processes also referred to as a mixed system. Seismic units were then associated with the dominant type of current responsible for their depositional process. The two main currents activity and processes, along- and downslope, can be distinguished through the acoustic characteristics (root-mean-square (RMS) amplitude values), internal architecture, and external geometry pattern of their deposits. While alongslope currents deposits consist of mainly low RMS amplitude values clinoforms with an alongslope trend; the downslope gravity deposits present high-amplitude or chaotic seismic facies, usually higher values of RMS amplitude, channel or channel-lobe features, erosive surfaces, and a basinward depositional trend. The first and oldest seismic unit, S1, was interpreted as a dominantly alongslope system, with low-amplitude aggrading sigmoidal clinoforms, commonly associated with fine-grained deposits and interpreted as a plastered drift. Basinward, mass transport deposit derived from previous drift instability are identified. Seismic unit S2 represents the intermediate stage where both gravity-driven and along-slope currents act asynchronously. It is referred to as a mixed turbidite-contourite sequence that shows high-amplitude sediment waves migrating upslope and a moat feature carved in its upslope front. The interfingering between high- and low-amplitude reflectors, distal chaotic facies, together with sediment waves and a channel moat, points to a sand-rich deposit that was reworked by northward-flowing contour currents. Seismic units S3 and S4 show downslope features with chaotic facies (S3) and paleochannels with coarse basal lag deposits interpreted after the high RMS amplitude values (S4). In S4, a series of long-lived submarine channels formed. The last seismic unit, S5, referred to as the second plastered drift sequence, is marked by a terraced and low-amplitude clinoforms that thin basinward. Important information on the paleocurrents' direction was also made based on the final deposits display (e.g. terraces, sediment waves and paleochannels). Research on alternating dominant processes and transitional stages or mixed depositional systems may provide a better understanding of deep-water depositional processes. Because these processes do not always fit previous depositional models that are mainly described for synchronous systems, new insights on cyclic non-synchronous mixed systems can improve our understanding of how mixed systems are organized through time and space. Through these systems we can also determine which were the dominant processes that controlled the sedimentation by indicating periods where the margin was mostly submitted to sediment transfer from continent to the basin and periods where the oceanic currents prevailed by redistributing sediments along the isobaths. Setting new models on cyclic deposits and intermediate stages can have a future economic impact on potential hydrocarbon reservoir architecture.

Channel-lobes in lacustrine turbidite fan: Insight from Triassic Yanchang Formation, Ordos Basin, China

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Key words: lithofacies association; lacustrine turbidite;late Triassic; Ordos basin; China

Deep water turbidity current is an important medium for delivering sediment to deep marine (lacustrine) and created some of the largest and thickest sediment accumulations on earth in modern sea/lake floor and in ancient rock record, and becomes a hotspot and frontier area in sedimentology, a plenty of examples on hydrocarbon exploration show that turbidite sandstone are favorable petroleum reservoirs worldwide whereas they are mainly aimed at at marine deposits, rare at lacustrine deposits.

In relation to marine environments, in lacustrine systems, tidal processes are negligible, wave activity is commonly limited, seasonal fluctuations in water chemistry and biogenic productivity may be common, and the rate, frequency and magnitude of oscillations in lake level may be higher. and water salinity can be considerably lower, thus criteria for the identification of lacustrine turbidite relevant to marine environments are only partially applicable. Collectively, these factors contribute to making the differentiation of various originated turbidite and different subenvironments of lacustrine turbidite fan difficult in successions of the Ordos Basin. Yet the establishment of effective criteria with which to make such distinction is important for palaeogeographic restorations and for petroleum exploration and exploitation.

Ordos Basin formed a lake during the late Triassic, resulted from the rapid uplift of Qinling Mountain associated with a rapid subsidence of the southern Ordos basin.Yanchang Formation(Fm), composed mainly of the unit of fluvial-delta-lacustrine clastic rock, which can be further subdivided into 10 Members. In which the deep lake turbidite primarily found in members Ch-7 ,Ch-6 and Ch-1.

Variou opinions have been proposed on the origin and the resulting depositional models of the extensively distributed thick sandbodies in southweast Ordos Yanchang setting which is the main targeted aim, for example, origins of delta front, deep water sediment gravity flow (collapsed turbidite or hyperpycnite of sporadic floods) or superimposition of both of them.

Based on the database of wellcores, outcrop observation and well-log signatures, the main aims of this paper are:(1) to provide a classification scheme of lithofacies and lithofacies associations on lacustrine turbidite fan of Yanchang Formation,(2) to analyse and identify different deposits deposited in different subenvironments of channel-lobes in deep lake,vertically and lateraly, based on observation,(3) to construct a depositional model including distribution and evolution of lacustrine turbidite fan during late Triassic, Ordos Basin.

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Jungang Pang, born in 1978, associate prof. He focused his studies on sedimentology ,lacustrine system and turbidite for 17 years, with more than 40 publications.

Sedimentary structures and deposit geometries recorded after large-scale experimental subaqueous turbidity and debris flows

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This work presents bedform characteristics and depositional geometries obtained performing a set of experimental subaqueous gravity flows. Experiments were run in a large-scale (35 m long, 7 m wide and 4 m deep) tank resembling a `canyon to basin` setting. A total of 18 turbidity currents and 4 debris flows/slumps were generated using a grain-size range from clay to fine sand. The flows produced a series of stacked deposits with thickness ranging from 5 cm to approximately 1.6 m. Stacked deposits in the canyon area can be separated based on the spontaneous occurrence of debris flows (slump). Turbidite deposits pre-dating the first large-scale debris flow exhibit ripples and parallel stratification and were significantly deformed by the debris flow occurrence. Gravity flows created after slump occurrence were affected by post-slump scour topography and are characterized by scour-and-fill structures and bedforms such as backset bedding, planar and cross-stratification. The latter deposits also exhibit lenticular geometries, which fade away near the canyon´s end. Turbidite deposits at the basin area are characterized by the presence of large-scale climbing ripples close to canyon mouth, possibly produced by flow expansion and deceleration, and by plane-parallel lamination at the distal basin area. Basin deposits also exhibit compensation geometries at the proximal part of the basin and tabular, laterally extensive geometries at the distal basin area. Turbidites inside the canyon were characterized by large Froude numbers (>1). Thus, observations of this work can allow comparisons between deposit bedforms and geometries produced by supercritical versus subcritical flows at canyon to basin transition settings. Useful information is also retrieved based on observations regarding the effects of debris flow deposits on pre-existing stratigraphy and subsequent deposit geometries.

The carbonate platform record of Mesozoic OAEs and ocean acidification: noisy, incomplete, invaluable!

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Compared to the deep-water record of pelagic and hemipelagic successions, the shallow-water carbonate archive of Mesozoic OAEs and ocean acidification is inherently incomplete, noisy, often severely overprinted by meteoric diagenesis, generally plagued by low stratigraphic resolution. But still carbonate platforms are the only place where to look for learning something about the response of neritic subtropical biologic communities to crisis triggered by the rapid and massive injection of CO2 into the atmosphere-ocean system.

For many years the general implication has been that palaeoenvironmental disturbance associated with OAEs and other perturbations of the global carbon cycle led to the demise and drowning of carbonate platforms. However, some platforms did not drown, or recovered very rapidly after a short crisis. These resilient platforms often show remarkable changes of facies and fossil assemblages across the crisis intervals, revealing a much more informative pattern than the simple switch-off record of drowning platforms.

The Apennine Carbonate Platform (ACP) of Southern Italy is one of these resilient platforms. Its >4500m thick succession records more than 150 my (Late Triassic to Late Cretaceous) of carbonate production and neritic ecosystems evolution at the southern margin of the Tethyan Ocean.

The end-Triassic event, one of the big five mass extinctions and a strong candidate for ocean acidification, is recorded in the ACP by the abrupt disappearance of the rich and diverse assemblage of massive hypercalcifiers (corals, sponges, chetetids, large megalodontid bivalves) and aulotortid foraminifera of the Rhaetian Dachstein-type facies. The post-extinction interval is represented by unfossiliferous oolitic limestones and/or by microbial laminites. This pattern is suggestive of a biocalcification crisis triggered by a decrease of carbonate saturation.

A very similar pattern has been documented for the early Toarcian OAE: Lithiotid bivalves and dasycladalean algae, the most prolific carbonate producers of Pliensbachian carbonate platforms, are abruptly wiped out at the onset of the T-OAE. Unfossiliferous oolitic carbonates are again the typical expression of the post-crisis carbonate factory.

The record of the early Aptian OAE1a in the ACP is not a tale of abrupt mass extinction or carbonate factory change. Recurring transient episodes of mass occurrences of flat-conical orbitolinids and supposedly microbial Lithocodium/Bacinella consortia have been commonly interpreted as a signal of increased nutrient input, which caused the shift from the Urgonian-type photozoan carbonate factory to the heterozoan and microbial carbonate production mode.

Sharp changes in the diversity and abundance of the main carbonate producers are quite remarkable across the Cenomanian-Turonian boundary OAE2. These include a two-step pattern of selective extinction of larger benthic foraminifera, which has been interpreted as a nutrient signal, and a change in rudist assemblages from aragonite-dominated caprinids to calcite-dominated radiolitids and hippuritids, which is suggestive of changes in carbonate saturation.

All in all, resilient Mesozoic carbonate platforms tell an intricate story of climate, nutrients and ocean saturation changes triggered by massive and rapid input of CO2 in the atmosphere- ocean system. As Karl often put it, stratigraphy is the key to unlock their unvaluable archive of global change in the deep geological past.

The black shales of the Cambrian Kuonamka complex of the Siberian platform: chemofossils, microbio-community, facies

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In the Lower and Middle Cambrian, anomalously organic-rich sediments accumulated in the north and east of the Siberian Platform. They formed carbonaceous rocks of the Kuonamka complex (Shumnaya, Kuonamka, Inikan, Sekten, and Sinyaya Formations). The most of lipid matter of Cambrian black shales has been derived from remains of lower plants and bacteria. The contribution of macrofauna is much less. The known research results have been taken as a basis of diagnostics of microbiocommunity: steranes are biomarkers of eukaryotes, tricyclanes are biomarkers of leiosphaeridias (acritarchs) and algaes (prasinophyseaes) and hopanes are biomarkers of prokaryotes. Based on steranes/terpanes and tricyclenes/hopanes ratios, the communities have been divided into predominance of planktonic-algal microbiocenosis, community with predominance of bacterial organisms, and planktonic-bacterial microbiocenosis. The composition, distributions, and ratios of biomarkers from bitumen extracts of the Kuonamka, Sekten, Inikan, and Sinyaya Formations were studied by chromatography-mass spectrometry system Agilent 5973N.

The first biological community is characterized by the following parameters: steranes/terpanes ratio is higher or equal to 0.3; tricyclanes/hopanes ratio is higher than 1; steranes are generally dominated by cholestane and ethylcholestane; C29/C30 hopane ratio is less than 1. The C35/C34 homohopane index is lower than 1. This suggests that there was no anomalous hydrogen sulfide contamination of bottom water and sediments, from which the examined highly carbonaceous black shales formed. These characteristics are peculiar to the organic matter (OM) rocks of the Kuonamka Formation. The content of the total organic carbon (TOC) is more than 10%.

The molecular parameters of the second bio-community are as follows: steranes/terpanes ratio is lower or equal to 0.1–0.2; tricyclanes/hopanes ratio is lower than 1; steranes are dominated by ethylcholestane; C29/C30 hopane ratio is higher than 1. The homohopane index is higher than 1, which is indicative of hydrogen sulfide contamination of sediments and, possibly, bottom waters. These characteristics are peculiar to the OM of the Inikan Formation (TOC is lower than 10%).

The third bio-community: steranes/terpanes are at the level of 0.3; tricyclanes/hopanes are at the level of 1; steranes are dominated by ethylcholestane; C29/C30 hopane ratio is lower than 1. The homohopane index is lower than 1. These parameters are typical of the OM of the Kuonamka and Inikan Formations.

The fourth microbiocommunity: generally, steranes/terpanes ratio is equal to 0.1–0.2, and tricyclanes/hopanes ratio is lower than 0.1; steranes are generally dominated by ethylcholestane; lanostanes and 28,30-bisnorhopane have been identified; C29/C30 hopane ratio is less than 1. The homohopane index is greater than 1. These characteristics are typical of the OM of the Sinyaya Formation (TOC, generally, is lower than 5%).

The study of hydrocarbons from the shales of the Kuonamka complex has made it possible to identify four chemobiofacies in the Lower and Middle Cambrian deposits. It was established that amounts of the OM and the composition of hydrocarbons are controlled by the bio-productivity of diverse bio-communities and redox conditions characterized by lateral variability and temporal changes both in aquatic environments and sediments.

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Deposition of black shales of the Ediacaran Khatyspyt Formation in Siberia

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Terminal Ediacaran Khatyspyt Formation (556–544 Ma) of northeastern Siberia, specifically the palaeobiology, sedimentology, and geochemistry have been in the focus of attention. This primarily carbonate succession has been known to comprise black shales with total organic carbon (TOC) content up to 12–14%, that have been considered as the source rock for the flanks of the Anabar anteclise; however, the mineral and organic matter (OM) geochemistry of the black shales have been poorly studied. We have filled this gap, studied geochemical characteristics of the black shales and OM and attempted a reconstruction of the origin of the black shales and the diversity of the biota that provided the source for the fossil OM. The origin of black shales in general is far from clearly understood, with two possible scenarios emerging: either decreased oxygen supply or increased oxygen demand. The Khatyspyt black shales occur as 10–15-cm-thick intervals interstratified with thin-bedded limestones at the base of thick transgressive systems track. Composition of the two analysed black shale samples collected from outcrops along Khorbusuonka River comprises carbonates (25–27%), TOC (9.7–10.2%), sulphur (1.1–1.2%), and bitumen (0.32–0.39%). The bitumens in turn consist of 14% of saturated hydrocarbons (HCs), 19–28% of aromatic HCs, 57–65% of resins, 0.7–1.5% of asphaltenes. Both saturated and aromatic HCs were analyzed by gas-liquid chromatography and gas chromatography-mass spectrometry.

Alkane n-C17 dominates among normal ones, pristane (Pr) and phytane (Ph) dominate among isoprenoid alkanes. Pr/Ph ratio is 0.95–1.06. Carbon preference index is 1.1 on average. Low concentrations of 12- and 13-monomethylalkanes are established. Stigmastane (C29/C27 = 2.5–2.6) prevails among the identified C27–C29 steranes; 4-methylstigmastane is found as well. Hopanes and homohopanes prevail among terpanes (69–71%). The content of cheilantanes is 24–25%, moretanes is 4%, tetracyclanes is 2%. Sterane/hopane ratio (0.1) is less compared to that earlier established for the Khatyspyt Formation (0.2–0.5). Homohopane ratio C35/C34 is 0.82–0.85, Ts/Tm ratio is 0.5, moretanes C32S/C32R ratio is 1.4–1.5. Gammacerane concentration is anomalously low (<0.1%) compared to Khatyspyt carbonate rocks in general (0.7–9.9%). Dibenzotiophene, methyl- and dimethyldibenzotiophenes are identified in aromatic fractions, along with phenantrenes and aromatic steroids.

Comparative analyses of the biomarkers leads to the following conclusions. Bitumens from the black shale are depleted in saturated HCs. The Pr/Ph ratio, both low homohopane C35/C34 ratio and gammacerane concentration speak against water stratification and bottom-water hydrogen sulfide contamination during the black shales deposition, which is in agreement with the overall transgressive trend in sedimentary basin development. The black shales most likely resulted from basin expansion (an increase in accommodation space), coupled with sediment starvation and local rise in bioproductivity. The high sulphur content in carbonates and in sulphur-associated HCs suggest bacterial sulfate reduction during diagenesis. Archaea, eukaryotes and prokaryotes were the source of OM in the sediment. The dominance of hopanes and homohopanes over tri- and tetracyclanes as well as terpanes over steranes imply that microbial communities (possibly cyanobacteria) were the main source during formation of the black shales.

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Anthropized beach nourishing sieving the Posidonia oceanica organic berms

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Most of modern marine beaches are strongly affected by human impact because of tourism. It has been demonstrated that those beaches loss some of the main parts present in the idealized beach sequence; such as the dunes, the back-shore.

Main effect of this anthropization is the beach erosion. It is worldwide documented that touristic beaches need continuous artificial nourishment to be maintained.

We will present the state of art of one of the main touristic beach of Sardinia (Italy) underlining, which could be best practice to maintain it in equilibrium.

The studied beach is located in Alghero one of the main touristic center of N-Sardinia. People come on holiday on this beach because of the 2km white sandy beach. Recent studies have underlined that the beach is almost in equilibrium although this is related to the deposition of the Posidonia oceanica seaweed on the beach (banquettes). Consequence of this is the protection to the beach from storm erosion during winter time.

This natural beach protection, however, causes uncomfortableness to tourist users of the beach. Banquettes may rise up to 5 meters and could cover almost completely the sand of the emerged beach (from shoreline to the dune foot). The municipality in the last twenty years has yearly removed the beached biomasses using heavy tractors and excavators able to remove 10 to 15.000 tons/y of beached Posidonia. This implies deeply dig of the beach and the removing of leaves, sand and marine litter. Studies have documented that associated to the seaweed leaves there are sand grains in proportion of 3 up to 10% of the weight; that is, between 300 and 1500 ton/y of uncontaminated sand is yearly removed from the emerged beach. Collected leaves and sand are stored in temporary sites that in few years become dumps (also due to mixing with urban waste eventually collected). In the past, regulation indicated that leaves had to be replaced on the beach they come from at the end of the summer, but this did not occurred. The reason is that in Alghero, the beached biomasses are so much that no replacement of the older is possible. Therefore this is not done.

Remediation of two of these dumps have revealed the possibility to recover part (or in some cases all) the sand present on the leaves. The recovery has been successful because the stored leaves were dry sieved on the beach with a pit machine able to separate organic material from the sand. In one of the two cases, the recovered sand was almost the 80% in weight. This was directly replenished on the beach. In the other, the recovery was of the 50%. A second sieving in a waste treatment plant allowed recovering the 100% of the sand, but the sustainability of this approach is largely debated at moment. Thanks to the results of the present research we suggest to carry out beach sieving for the all collected Posidonia oceanica leaves to, at least, recover the 50% of the associated sand.

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Digital pore scale assessment of potential subsurface carbon storage reservoirs

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The growing importance of subsurface carbon storage for tackling anthropogenic carbon emissions requires effective characterisation of potential reservoirs to understand their capabilities. We use micro-computed tomographic imaging to characterise a variety of sandstones at the micro scale. We investigate how pore and grain geometries control crucial features of a suitable reservoir such as porosity and permeability. We chose study samples from sites located in suitable geographic locations which could be beneficial to the growth of CCS in the UK. These include (i) the UK Geoenergy Observatories (UKGEOS) Glasgow observatory from the Upper Carboniferous Scottish Middle Coal Measures formation, (ii) the laterally equivalent facies of the Sherwood Sandstone Group to the UKGEOS Cheshire observatory from drilling at Sellafield, Cumbria and (iii) core material from offshore basins. We find a range of porosities between 0.04 and 26.4% and permeabilities of up to 6000 mD across our sample suites. Consequently, we are able to make recommendation for further study at sites which show favourable characteristics for subsurface storage. We also identify and constrain a percolation threshold of ca. 10% total porosity, which is shared between sites, above which near full pore connectivity is observed. This can be used as a measure of reservoir suitability when making initial assessments of storage reservoirs without the need for expensive and time-consuming analyses.

Diagenetic variation of aragonite material and controlling factors

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The alteration of carbonate minerals is well-known, and widespread throughout the geologic record. Past studies have shown diagenetic alteration to be ubiquitous throughout depositional environments, sediment types, chemical compositions, and burial conditions. More recent studies indicate alteration to be initiated as early as during deposition, and continue throughout the burial history. Variations in the diagenetic response of carbonate minerals pose a challenge to those using these sediments as indicators for past environmental conditions. This work investigates some of these variations in the alteration response of different aragonitic sediments during experimental diagenesis to understand the controlling factors. The primary tools utilized here include isotope geochemistry, concentrations and distributions of elements and organics, and crystallographic features. A multitude of factors lead to different reactivities and responses of the given aragonite archive, and may provide insight to the meaning of diagenetically altered material in the rock record. This study compares a range of samples, from relatively organic-rich bioclast (corals and molluscs) to organic-poor inorganic samples (speleothems and single crystals). The initial observed diagenetic response seems to be recorded in depletions and redistributions of organic constituents, as well as clumped isotopes. Textural alteration, mineral transformation, crystallographic restructuring, and stable C and O isotope proxies are primarily recorder later in the diagenetic progression. Between experimentally treated samples, variations are observed between secondary mineralogy, crystal shape and size, and isotopic equilibration with the experimental fluids. Possible controls on the variation in response likely include: organic content, internal fluids (organic bound and fluid inclusions), Mg/Ca ratios (and amount of other substitution ions), and physical characteristics (porosity, permeability, and surface area). These controls result in variations of diagenetic susceptibility and alteration responses.

Reservoir characteristics and its controlling factors of the T2l3 formation in the northwestern sichuan basin, China

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Based on field outcrops, core observations, thin-sections, logging and experimental analysis data, the reservior characteristics and its controlling factors of the third member of the Leikoupo formation in the northwestern Sichuan Basin, China, were summarized. Results demonstrate that grain-bank and tidal flat deposit on the restricted platform background during the T2l3 Fm in the study area. Mainly rock types of the reservior consist of grain dolomite, algae dolomite and micro-crystalline dolomite. Meanwhile, secondary dissolved pores contribute mostly to the favorable reservior with intergranular / intercrystalline pores as supplements. It is shown that the T2l3 Fm is fracture–pore reservoir with low porosity and low permeability. Both sedimentary facies and diagenesis have significant influences on the quality of the T2l3 reservoir. 1) High-energy grain-bank facies have the best physical properties and they are the physical basis for reservior development; 2) Early seepage refluction dolomitization forms the massive dolomite, not only increasing porosity but also improving rock anti-compression; 3) Syngenetic karstification controls the formation of early reservoir, which lateral distribution limited by intermittent exposed grain-bank facies, providing the preferential seepage channel for subsequent corrosion; 4) Superficial karstification in the late Middle Triassic strengthens and consolidates the previous pores especially in the Zhongba area, which is located on the karst slope with the best dissolution effect; 5) Organic acids dissolution caused by oil and gas filling through the faults and thermochemical sulfate reduction(TSR) during the burial stage (>120 °C) play a key role to expand the reservoir space.

Localisation of environmental responses to global climate change during the Frasnian-Famennian (Late Devonian) mass extinction

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The Late Devonian was marked by numerous episodes of environmental degradation and biotic crises over a 20-million-year time period, collectively considered one of the 'Big Five' mass extinctions of animal life in the Phanerozoic Aeon. The most severe of the Late Devonian extinction/environmental-perturbation events is recorded at the Frasnian-Famennian (FF: ~372 Ma) Stage boundary, and is marked by globally recorded positive excursions in carbon- and oxygen-isotope compositions, as well as the abrupt appearance of organic-rich shales in many parts of Europe, North Africa, and North America. From these observations, it has been deduced that climate cooling and widespread marine anoxia both occurred during (and likely contributed to) the FF extinction, but what initiated these perturbations remains unknown. One (or more) meteorite impacts, large-scale volcanism, enhanced weathering rates due to mountain building and/or expansion of vascular-rooted land plants, changes in nutrient runoff/cycling, and the Earth's orbital configuration all suggested as possible triggers/contributors towards the environmental degradation. Recently, a new timescale for the Frasnian-Famennian interval has been constructed, highlighting that the onset of the carbon-isotope excursion associated with the FF boundary is recorded in sediments approximately 150 kyr older than the boundary, pinpointing the timing of the global carbon-cycle perturbation that took place during the extinction. However, the timing and duration of local environmental responses to this carbon-cycle change remain unconstrained, and it is not clear whether individual areas showed homogenous and coeval reactions to the global climate change, or responded heterogeneously and/or asynchronously.

This study presents nitrogen-isotope data from a number of well-studied Frasnian–Famennian records, all of which have been previously calibrated to the new timescale, in order to determine whether nitrogen-cycling in individual geographic areas was perturbed synchronously with the carbon cycle 150 kyr before the boundary event, or varied across the different locations. Marine nitrogen cycling is highly sensitive to biogeochemical disturbances: processes such as nitrification/denitrification and nitrogen fixation potentially vary in response to redox/nutrient changes and can cause a change in the isotopic composition of deposited sediments, as can an increased influx of terrestrial organic matter (which is relatively isotopically light with respect to nitrogen). When stratigraphic carbon- and nitrogen-isotope trends across the FF boundary are calibrated to the timescale for that interval, excursions in nitrogen isotopes are seen to vary considerably across the different studied locations. In some areas, nitrogen-cycle perturbations are recorded as occurring up to 50 kyr prior to the carbon-cycle disturbance; in others they take place more than 50 kyr later. Moreover, the type of change in nitrogen cycling varies across the studied records, with positive excursions indicative of denitrification in anoxic conditions recorded at some locations (e.g., South China), whilst negative excursions suggestive of oligotrophic conditions and cyanobacterial blooming are observed in others (e.g., Laurentia). The variability in the timing and style of nitrogen-cycle perturbations across the Late Devonian world highlights the importance of considering local-scale environmental degradation as well as global-scale climate changes when interpreting records of this major Palaeozoic event.

Intermittent mass-occurrences of microbial carbonates during the late Aptian (Basque-Cantabrian Basin, Northern Spain)

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Aptian-Albian shallow-marine limestones are best known for being rich in rudists, corals and orbitolinids. However, Lower Cretaceous carbonate platforms were sporadically punctuated by Lithocodium-Bacinella bloom episodes in different geographical locations worldwide. This biotic replacement is generally attributed to a disruption in the equilibrium of shallow-marine ecosystems as a response to intermittent palaeoenvironmental perturbations. Previous investigations have focused on establishing correlations between these biotic turnovers and time-equivalent basinal black shales deposited during Oceanic Anoxic Events (OAEs). The dominance of bacinellid microencrusters in the early Aptian has been further documented and related to the OAE 1a. Nonetheless, a gap in knowledge still exists regarding microbial proliferation periods during other Cretaceous OAEs, particularly in the upper Aptian – lower Albian interval coeval with the multi-event OAE 1b. The northwestern region of the Basque-Cantabrian Basin (northern Spain) provides an excellent opportunity to study upper Aptian Lithocodium-Bacinella stratigraphic units. These facies were deposited at the top of tilted fault blocks in a subtropical carbonate platform affected by synsedimentary tectonic activity during the opening of the Bay of Biscay. Differential subsidence controlled the thickness of the stratigraphic record as well as sea water depth. As a result, microbial carbonate production took place in lagoonal settings with diverse paleobathymetric conditions, which in turn strongly influenced Lithocodium-Bacinella growth patterns. The development of distinctive microbial morphotypes on two differentially subsiding fault blocks is reported herein. The northern Punta del Dichoso structural palaeohigh comprises two levels (0.4 m and 5 m thick, respectively) of Lithocodium-Bacinella oncoidal limestones with densely packed oncoids showing diameters up to 3–4 cm. Southwards, a slightly deeper and more subsident Cuchía block encompasses two main bacinellid units of 13 and 40 metres thick (respectively). The latter two intervals predominantly contain irregular-shaped patchy growth forms interspersed with Chondrodonta boundstones up to 3.3 metres thick. Determining both the spatial extent and chronostratigraphic range of Lithocodium-Bacinella proliferation phases is a key element to assess the role of major palaeoceanographic and palaeoclimatic variations in shallow-marine neritic systems.

Foraminiferal, palynofacies and dinoflagellate records of environmental changes at the Badenian/Sarmatian boundary in Central Paratethys

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The Badenian/Sarmatian boundary in the Central Paratethys is a major turnover in faunal elements and the development of extremely stressed environments related to mesohaline salinity, elevated alkalinity and eutrophic conditions, basin, that marks the transition from normal marine to restricted semi-marine conditions due to isolation of the basin from the world ocean at the onset of Sarmatian time, is still far away from full understanding. The Kreminna section is located at the northeastern margin of the Carpathian foreland basin (Central Paratethys) in the Medobory Hills region, ca. 70 km south-east to the town of Ternopil (western Ukraine). The Miocene deposits that overlie here the Upper Cretaceous substratum comprise the 3 m thick upper Badenian clays and marly clays passing upwards into 5 m thick Sarmatian marls and clays with limestone intercalations and 2 m-thick limestones in the uppermost part. Benthic foraminiferal assemblages are composed almost exclusively of calcareous forms; agglutinated ones are practically lacking. Elphidium spp., hauerinids, Lobatula lobatula and Ammonia spp. are the most common calcareous benthic foraminifera in the studied material. Planktonic ones represented only by the Globigerina species occur rarely in the lowermost part of the section. The analysis of foraminiferal assemblages based on the requirements of present-day representatives of the recorded taxa suggests cold water, inner shelf depths with short-term fluctuations in depth and salinity. A characteristic feature of palynofacies from the studied section is very low proportion of land-derived elements – sporomorphs and cuticles, what suggests a sedimentary setting without terrestrial influx. Another characteristic feature is taxonomical impoverishment of dinoflagellate cyst assemblages, which are either monospecific or they consist mainly of two to three species. Some changes of palynofacies composition correlated with taxonomical variations in dinoflagellate cyst assemblages may reflect some minor environmental fluctuations. A characteristic feature of palynofacies is very low proportion of land-derived elements – sporomorphs and cuticles, what suggests a sedimentary setting without terrestrial influx. Another characteristic feature is taxonomical impoverishment of dinoflagellate cyst assemblages, which are either monospecific or they consist mainly of two to three species. Monospecific assemblages of Polysphaeridium zoharyi, which occur in majority of samples, suggest stress conditions, most likely related to increased salinity. Some changes of palynofacies composition correlated with taxonomical variations in dinoflagellate cyst assemblages may reflect some minor environmental fluctuations.

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Marine transgression(s) to Middle Miocene (Badenian) evaporite basin of Central Paratethys (SE Poland)

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The Paratethys existed between Early Oligocene and late Middle Miocene times and constituted a system of marine basins extending from the Alpine-Carpathian region to the modern Aral Sea. Water circulation in the Paratethys was strongly controlled by two shallow and narrow gateways: the Slovenian (Trans-Tethyan Trench) corridor and the Bârlad Strait in Romania (Palcu et al., 2015), located in tectonically active regions. The Middle Miocene Badenian evaporite basin of the Carpathian Foredeep Basin was a saline lake located in a depression in which the brine top level occurred below the contemporaneous sea level, and it could be subject to rapid flooding when the sea level rose or when the physical barrier blocking this basin from the Tethys/Paratethys reservoir was temporarily removed. Such transgressions could leave behind marine microfossils in marly clay intercalations contained in the sulphate sequences. One of them (2.3 m thick) occurs in the uppermost part of the gypsum sequence in the Babczyn 2 borehole section in SE Poland. This intercalation of the Babczyn 2 borehole was previously interpreted by Śliwiński et al. (2012) as karst cavity infilling but the composition of the micropalaeontological assemblages differs both from those recorded in the Pecten beds in the borehole and in the strata overlying gypsum deposits in the Ukraine (Shchyrets). t contains marine palynomorphs (dinoflagellate cysts) and foraminifera assemblages indicating a marine environment. The low-diversity benthic foraminiferal assemblages are dominated by opportunistic, shallow infaunally living species, preferring muddy or clayey substrate for thriving, brackish to normal marine salinity, and inner shelf depths. Dinoflagellate cyst assemblages, although taxonomically impoverished, consist of marine species; euryhaline forms that tolerate increased salinity are missing. The connection of the Carpathian Foredeep Basin with the marine reservoir was short-lived. After such environmental change, benthic foraminifers started to colonize a new, previously defaunated niche, and the pattern of benthic foraminiferal colonization is similar in each case to that related to the reflooding terminating the Badenian Salinity Crisis. Relatively common microfossils found in clay intercalations within gypsum have important palaeogeographical implications: they strongly suggest that there existed an additional inflow channel supplying the Polish Carpathian Basin from the south during the evaporite deposition and afterwards, probably in the 300 ky following, during the generally low global sea-level (de Leeuw et al., 2018).

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Application of mass spectrometry methods in coral reef science

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In coral reef studies, mass spectrometry methods are widely applied to determine geochemical proxies in corals as a tool to evaluate seawater changes. As the coral grows, its skeleton forms annual bands similar to the growth rings found in trees. The density of the calcium carbonate skeletons changes as the water temperature, light, and nutrient conditions change. The elements stored within these bands can provide insight into the changing conditions of seawater over the entire lifetime of the coral, and serve as useful environmental records. Corals incorporate trace elements that can be precisely measured using high-resolution techniques, such as Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS). This analytical tool offers high levels of precision to determine the distribution of trace elements along the annual bands of coral skeletons. This approach can serve to monitor fixed-point time-series for water quality research, as well as large-scale observations in ocean science. Ultimately, this procedure can be applied to reconstruct past climate oscillation episodes and/or to quantify the impacts of marine pollution on coral reefs. The benefits of techno-scientific aspects of new and established mass spectrometry applications in coral reef research hold great promise that may continue to be improved in future studies. Given the current climate crisis, this issue requires accurate measurements to increase our understanding on the impacts that have become more frequent and intense.

Carbonate megabeds of Istrian Flysch (Dinaric foreland basin, Croatia)

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According to the results of extensive geological mapping of the area of central and northern Istria, several sections characterized by coarse carbonate material are selected and investigated in details: Hum, Ripenda, Plomin, Kaldir, Šublentica, Gračišće, Koromačno and Šćurak. The megabeds of Istrian flysch are distinguished from other turbidite beds in succession by their thickness, composition and internal structure. Megabeds are bipartite beds, composed of two divisions: basal breccia or conglomerate (Division I) and normally graded calcirudite/calcarenite (Division II). Two main types of facies of basal division (Division I) are recognized: Facies A – clast supported conglomerate/breccia with sparse carbonate or marl matrix, and Facies B – marl dominated, matrix supported breccia with rip-up clasts and greater total thickness than the Facies A. The lower bedding surface of both types is sharp and erosive. The overlaying Division II is clast supported and normally graded calcirudite, and can be up to 10 m thick. Clasts are composed of various Foraminiferal limestones, large benthic foraminifera, coralline algae and biogenic carbonate detritus. The transition from basal breccia (Division I) to calcirudite can be gradual or sharp. Towards the top of the interval, clast size becomes smaller and there is usually a gradual transition to arenite grain size, and eventually to silt grain size. On the uppermost part of this division, horizontal and cross lamination can be found. The topmost part of the Division II is overlain by massive marl interval. The carbonate material is derived from a carbonate-ramp located in the distal part of the foreland basin (forebulge) and re-deposited in relatively deep-water distal foredeep as wedge-shaped carbonate aprons. The content of marl, in matrix and as rip-up (intra)clasts, implies that the density/debris flow reworked previously deposited flysch sediments, and in places some megabeds directly overlay the carbonate pre-orogenic basement.

Surface sediment distribution and reworking processes on Al Wajh carbonate platform, N-Red Sea, Saudi Arabia

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Lateral facies variations within carbonate reservoirs, such as Dunham texture changes, can lead to significant reservoir quality alterations. The prediction of these facies heterogeneities, especially on interwell-scale, is still a challenging task during exploration and field development of hydrocarbon and geothermal reservoirs. As a consequence, lateral sediment distribution on modern carbonate platforms and associated controlling mechanisms were intensively investigated during the last decades. Several studies have documented that facies distribution dependent on multiple environmental factors. For instance, studies on isolated platforms, such as the Great Bahama Bank and in the Maldives Archipelago, and ramps, such as Abu Dhabi and Kuwait ramp, indicate water energy (wave- and tidal-currents) and morphology as dominant mechanisms controlling grain size distribution. Moreover alterations in mineralogy are associated with biota assemblages and seawater chemistry.

Al Wajh is the largest, land-attached carbonate platform in the Red Sea and represents a modern analogue for carbonate reservoirs situated in rift basin settings. The platform extends over an area of more than 2200 km² and is almost completely framed by a 115 km reef-shoal belt. Al Wajh interior is characterized by dozens of pinnacle reefs, several small islands and a lagoon with a maximum water depth (mwd) of around 42 m, which is dominantly connected with the Red Sea via three shallow channels (mwd 16 m). In order to investigate the lateral surface sediment distribution and its controlling mechanisms within Al Wajh platform, grain size and facies analyses, XRD and TOC measurements were performed on around 200 seafloor samples. Moreover, sea floor images were recorded and 16 CTDs measurements were collected to study the oceanographic conditions in the platform interior

Results reveal a platform interior that is dominated by overall poorly sorted sediments with low TOC content, consisting of ooids and skeletal particles, shells and shell fragments of different biota, such as bivalves, gastropods, foraminifera and echinoderms. Grain sizes range from very coarse silt to coarser sand. Images of the central lagoon seafloor present a bioturbated, marine desert-like environment. Despite the presence of wind- and tidal-induced surface currents, grain size distribution maps and CTD data point to a flow system likely driven by deep-lagoonal density currents. Moreover, analyzed grain size distribution suggests no distinct relationship between increasing water depth and higher mud-contents. Mineralogy is dominated by aragonite and high-Mg calcite, with low-Mg calcite a minor component. However, aragonite content is higher in the SE lagoon, whereas low- and high-Mg calcite content is relatively higher in the NW lagoon indicating differences in components and later diagenetic potential. Siliciclastic minerals occur in the entire lagoon and show no prominent proximal to distal trend, except an increase very near shore.

The outcome of this study presents novel insights in the surface sediment distribution and associated reworking by currents on modern rimmed, land-attached carbonate platforms situated in arid climate zones. Besides improving fundamental understanding of carbonate systems, results may also improve strategies for hydrocarbon exploration and field development for reservoirs in similar carbonate platforms in the subsurface where only low-resolution subsurface data are available

Characterizing hemipelagites and homogenites using grain-size analysis: Examples from offshore SW Taiwan

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Marine sediments may serve as archives of extreme events, including earthquakes, typhoons, submarine landslides, etc. Homogenites are one of the many event beds. They are very fine-grained sediments, initiated from sediment gravity flows, and are likely transported and deposited from suspension fall-out. Homogenites are likely to develop in enclosed basins where suspended sediment clouds are trapped and deposited. Three short length gravity cores, namely OR1-1138-16G (2.2 m), OR1-1138-18G (2.04 m) and OR1-1138-PC1G (0.97 m), and two giant piston cores, MD18-3547 (35.27 m) and MD18-3548 (20.07 m), were collected from offshore SW Taiwan. Sediment cores of MD18-3547, MD18-3548 and OR1-1138-16G are located in the perched basins of the Taiwan accretionary wedge, and OR1-1138-18G in the South China Sea west of the deformation front, and OR1-1138-PC1G in the Penghu Canyon. Detailed grain-size analysis (1 cm resolution) of the above-mentioned cores was performed using a laser particle-size analyzer. The main objective is to provide a qualitative way of distinguishing hemipelagites from homogenites. For the short cores, the thickest homogenites are about 1 m or less and ~2.5 m for the long cores (multiple layers of homogenites). CHIRP data depicts homogenites as thick, reflection-free, and transparent layers, showing wedging out reflectors at the margin if seen. Grain size parameters like mean, mode, and median are highly constant (between 6 and 8 μm) and showing uniform unimodal type distribution, indicative of homogenites. By contrast, hemipelagites show varying and irregular vertical grain sizes with unimodal or bimodal distributions. Both hemipelagite and homogenite are poorly sorted with homogenites displaying a uniform sorting throughout the unit. Our result indicates that grain size data accompanied by high-resolution CHIRP data can be used to characterize and distinguish hemipelagites from homogenites.

Depositional and diagenetic evolution of carbonate slope reservoir facies, Tengiz Field, Republic of Kazakhstan

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Tengiz is a super-giant oil field located in western Republic of Kazakhstan. The reservoir structure is a largely undeformed Devonian-Carboniferous isolated carbonate platform with steep (up to ~40 degrees) depositional slopes and almost 1 kilometer of shelf-to-basin relief. The margin and slope settings of the reservoir are volumetrically-significant and known for prolific oil production. Integration of seismic, core, log, and dynamic datasets has led to depositional and diagenetic conceptual models that describe the stratigraphic evolution of the carbonate system and the diagenetic overprints that control reservoir quality and production.

The Tengiz carbonate platform underwent sustained backstepping and aggradation throughout the Devonian and early Lower Carboniferous (Late Visean), after which margins began to prograde. The onset of progradation over the steep, high-relief relict slope profiles generated during backstepping resulted in instability, large-scale margin failure, and onlapping wedges (aprons) of sediment in the lower slope. Also during this time, former grain-dominated margins evolved into deep microbial boundstone systems that extended down the upper slope and provided an extensive source of debris (boundstone breccia) to the more distal lower slope aprons. Once the apron deposits had sufficiently infilled the relict shelf-to-basin relief, stable progradation of the deep boundstone margins, and foreslopes composed largely of their resedimented debris, persisted throughout the remainder of the Lower Carboniferous (end Serpukhovian). Finally, the Tengiz carbonate platform drowned in the early Upper Carboniferous (Bashkirian) and was subsequently buried and charged with oil. Approximately one half of the Tengiz oil-saturated rock volume resides in slope deposits, of which most are carbonate breccias that reflect extensive shedding of the deep in situ microbial boundstone margin and upper slope.

The Tengiz margin and slopes also underwent a complex diagenetic history, spanning from syn-depositional to deep burial processes, that ultimately govern the producibility of the reservoir. During Serpukhovian progradation, syn-depositional fractures formed in margin and upper slope settings from gravitational and compactional stresses. Significant subaerial exposure events (e.g., top Serpukhovian; Lower-Upper Carboniferous boundary) resulted in flank-margin cave systems (meteoric karst), that, together with syn-depositional fractures, established an early-formed high-permeability network concentrated in the margin and upper slope. As Tengiz was buried, further fracturing occurred from overburden loading and differential compaction that extended across all settings from the margin to the distal slope. Also during burial of the structure, but prior to the present-day oil charge, multiple stages of deep brine flow modified the fracture network and matrix pore systems, including both the enhancement of fracture and matrix properties from net-dissolution in some settings, and the degradation of reservoir properties from net-cementation in others. The production characteristics of Tengiz strongly reflect diagenetically-controlled spatial patterns within a more regional depositional framework that is largely driven by resedimentation processes (i.e., margin collapse).

The story of the Tengiz reservoir involves a complicated stratigraphic evolution followed by perhaps an even more complex diagenetic history. Resedimentation of carbonate -in particular the process of margin failure- was a fundamental process that emplaced much of the reservoir rock volume and dictated subsequent diagenetic patterns that drive oil production.

Fossil and modern microbialites from where everything starts: Lake de Los Cisnes (southernmost Chile)

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Microbialites are organo-sedimentary deposits formed by the activity of most often a microbial consortia. Appeared more than 3.5 billion years ago, they represent the oldest forms of life on Earth discovered to date. Currently, these structures are developing all over the world mainly at low latitudes in both lacustrine and marine settings (e.g., Australia, Argentina, Brazil, The Bahamas). However, the paucity of detailed studies of modern examples still prevent our complete understanding of the different factors ruling their formation, especially in regions under extreme environmental conditions. Lake de los Cisnes located at 53° 25' S and 70° 40' W in Chilean Tierra del Fuego, Patagonia, provides us with a unique site to fill this gap. This basin is part of a set of lakes formed during the retreat of the ice following the last glaciation about 10,000 years ago. Subsequently, Lake de los Cisnes was densely colonized by microbial mats that developed the presently living and fossil microbialites. Conversely, the very close lakes Verde and La Larga do not show microbialites most probably due to a different water chemistry. We present here the preliminary results of the first detailed geomorphological, geochemical and geomicrobiological study obtained during a field campaign carried out in early February 2020. These organo-sedimentary deposits have an extension of almost 8 km^2 encompassing several macro-morphologies exceptionally large with maximum heights and widths of 1.5 m and 5.0 m, respectively. Crater-like shapes are dominant, displaying a spherical to elongated character most frequently unfilled. This particular macro-morphology seems clearly controlled by the prevailing environmental conditions as shown by a systematic orientation of their elongated shapes perpendicular to the current coastline. In addition, there is also a relational increase in the height of the microbialites with water depth most probably to adapt to reducing light conditions during increasing bathymetry. To better constrain this phenomenon, the study of the former coastlines allows to follow the amplitude and the frequency of the variations in the lake water level through time which seem to coincide with the cyclicity of the El-Niño Southern Oscillation (ENSO). Finally, preliminary observations of the microbialite microstructures as well as of the living microbial communities show that they both are quite uniform. An underlying dense lamellar carbonate appears to be associated with sulphate-reducing bacteria on top of which microbialites further develop with a shrub-like fabric. The latter is most probably due to the escape of bubbles resulting from cyanobacteria photosynthetic activity.

The occurrence of extraordinary well-preserved fossil outcrops along with living microbialites allows the development of a formation model. This model could be further applied not only to this exceptional site but also to other microbialites outcropping at different geographical and temporal scales.

Vertical variation in the muddy deposit offshore Tagus mouth: an imprint of tsunami backwash?

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Several studies recognized the presence of onshore tsunami sedimentary deposits along the coastal area of the Iberian Peninsula, identifying sources and reconstructing inundations paths, based on sediment characterization. However, the backwash record of these events is still poorly understood, probably due to the limited access to offshore (shelf) sedimentary archives, weak preservation conditions of their signatures and the impact of human activities in the nearshore area. Nevertheless, the continental shelf adjacent to the Tagus estuary, due to the high sedimentation input, is a unique place to investigate for look for imprints of processes with similar magnitude.

In this study, we describe an uncanny sedimentary layer recognized in the continental middle shelf off the Tagus river mouth, and discuss its probable linkage with storm-surge deposits originated by catastrophic events or tsunami like the one of the 1755 earthquake. The study is carried out on a 443 cm long core, collected in the muddy deposit present in this sector of the Portuguese margin. The deposit is quite homogeneous, composed by a sandy silt with clay-dominated sequence, but 62 cm below the surface, the studied sample intersected a 97 cm thick gravelly sand layer with sharp limits and contrasting characteristics.

The grain size analysis performed along the corer show that this layer is a gravelly sand, moderately calibrated with a negative skewness, whilst the top and underlying units are fine sandy silt with interbedded clayey silt layers, with poor calibration and positive skewness.

The elemental and mineralogical analyses (XRD and XRF) also showed distinct compositions between the coarse sandy layer and the surroundings sedimentary sequences. In those ones, the ratios Si/Ca, Sr/Ca, Br/Cl and Ti/Ca have the same trends and are generally higher than in the coarse sand layer. Concerning the mineralogy content, the coarser unit is dominated by aragonite and calcite, probably linked to the coarser biogenic particles (reworked shell fragments). Concerning dating results, a gastropod clast found at the base of the core (441 cm) was dated by the AMS – C14 method, allowing to conclude that the entire sedimentary column was deposited after year 1710 AD.

The sedimentological and geochemical results, the presence of an erosive base and the sharp top contact, as well as the occurrence of a rip-up clast near the top of this gravelly sand layer, strongly suggests that this coarser level was the result of an unique and catastrophic high-energy event, disturbing the low energy sedimentation conditions over the offshore Tagus river area, occurred after 1710 AD.

Considering the medium seismic activity observed in the Iberian Margin and the associated historical record of tsunamis, the most promising working hypothesis, which is able to explain the presence of such a layer, is the action of a major singular discharge associated with the backwash process, such the one occurred in the 1755 tsunami.

Human impact induces formation and preservation of varves: case studies from northern Poland

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Recent environmental changes are strongly correlated with human activity and climate change. Lacustrine environments are especially affected by those indicators as their functioning depends on processes and changes occurring in the catchment as well as inside the water body. Most of those changes in recent decades led to increasing primary production in lakes and worsening oxygen conditions in the water column, simultaneously affecting the sedimentation processes.

In this study, we analyzed one-meter-long surface sediment cores from three lakes in northern Poland – Dubie (surface 12.5 ha, maximum depth 27.5 m), Salno (34.9 ha, 45.2 m) and Wąsoskie (58.4 ha, 27 m). These lakes differ in terms of basin morphology, as well as catchment conditions. In each core we observed significant change in the sediment structure from homogeneous to laminated towards the topmost part of the cores. To investigate causes and effects of such transition we analyzed sediment composition (XRF, CNS), historical maps and documentary data. The timing of observed changes was determined using varve chronology, Pb-210 and Cs-137 dating methods.

The sediment core from Lake Dubie shows clear transition from homogeneous and highly organic rich, dark-brown sediment (1 – 0.6 m), through faintly laminated and more minerogenic part to distinctly varved topmost 0.2 m representing last ca. 70 years. This characteristic transition in the sediment structure is most probably connected with land use changes in the catchment, i.e. deforestation, agricultural activity and meliorations. In the sediments from Lake Salno, formation and preservation of varves started around 60 years ago (ca. topmost 0.5 m of the core) and was probably related to changes in agricultural techniques, what led to increase in lake productivity and hypolimnetic anoxia. In the sediment core from Lake Wąsoskie we observed gradual appearance of laminae that started at around 0.45 m sediment depth (ca. 130 years ago). Change in the sedimentation can be connected with the land use transition into more agricultural and development of drainage ditches network.

Different timing of varve deposition onset in these lakes highlights the role of local conditions, e.g. changes in land use of the catchments and trophic status of the lakes, and indicate human impact as a major driver of changes in the sedimentation.

Multi-scale influence of topography on shallow-marine successions associated with long-term transgressions

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Thick shallow-marine successions associated with long-term transgressions are less well known than their thin, well-sorted counterparts, widely studied due to their potential to form good reservoirs. In these successions, particularly in storm-dominated examples, bioturbation can obliterate primary sedimentary characteristics, making stacking patterns and sequences difficult to define, and challenging our understanding of the main controls in their resulting depositional architecture. This study presents an example from the Jurassic of the Neuquén Basin (Argentina), with the aim to: a) refine the depositional model of a thick, shallow-marine succession associated with a long-term, early post-rift transgression, b) constrain multi-scale controls on stratigraphic architecture and lateral facies variability, and c) discuss their preservation and response to post-depositional processes. To do this, a <300 m-thick succession has been studied along a >10 km continuous exposure, with mapping, sedimentary logging and correlation of stratigraphic units, integrated with subsurface, biostratigraphic and ichnological data. The succession shows an overall retrogradational-aggradational-retrogradational stacking pattern, with several higher frequency regressive units (parasequences and parasequence sets, PSS). The lower part (PSS I) comprises laterally-discontinuous (10's of m) mouth-bars and distributary channel fills, dominated by several m-thick coarsening- and fining-up sandstone packages and m-scale erosive conglomeratic lenses. Above these, the succession (PSS II-IV) is composed by laterally-continuous (>100's of m) storm-dominated lower-shoreface to upper-offshore deposits, dominated by <1m-thick fine-grained and highly bioturbated tabular muddy sandstones and sandy mudstones, with rarely-preserved HCS and bioclastic-rich limestones; their internal characteristics and bed boundaries are diffuse due to pervasive bioturbation, suggesting overall low sedimentation rates and recurrent periods of colonization. The coarse-grained nature and lithology of the mouth bars and channel fills in the lower succession (PSS I) are consistent with a proximal sediment source, associated with erosion of intra-basinal highs. Its variable thickness, lateral distribution and onlap against underlying syn-rift deposits demonstrates partial infill of localized higher-accommodation areas. The well-sorted and finer-grained nature of the shoreface-offshore strata the middle and upper succession (PSS II-IV) indicates a more mature, distal source, with sediment redistributed by longshore currents, and then intensely bioturbated. These deposits display well-defined parasequences internally composed of laterally-continuous bedsets (<5 m-thick). They extend along the entire study area, but show a significant vertical thickness variability. The integration of outcrop and subsurface data mapping (well and seismic) reveals this variability records the stratigraphic response of transgression over a complex, regional-scale ramp-step and underfilled rift topography, which controlled the location of main thickness and facies changes, and promoted areas of favored biogenic reworking. This study offers new insights in how to interpret thick transgressive successions based on primary depositional mechanisms and postdepositional processes, and provides useful tools to understand and predict the nature and potential preservation of these deposits in limited subsurface datasets.

A down-delta hydraulic geometry model and its application to the rock record

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Interpreting paleodischarge from ancient fluvial-deltaic deposits is an important element of source-to-sink studies, hydrocarbon reservoir volumetric assessments, and paleoclimate and tectonic reconstructions. Several models have been developed from which fluvial paleodischarge can be reconstructed based on deposit geometry and sedimentology (e.g. trunk-river-based model, 'BQART' model, 'Fulcrum' model, and regional hydraulic geometries). Channel geometry changes systematically down-delta, but there are no climate-classified hydraulic geometry models specifically for deltas. The rapid growth of globally-available satellite images and discharge datasets enables us to produce such a model using empirical relationships between channel width and discharge. Here we propose novel hydraulic geometry models specifically for deltaic systems, the 'down-delta hydraulic geometry', by adopting the empirical approach of classical hydraulic geometry (regime theory). A compilation from 85 globally-distributed modern deltas of river discharge and ~5000 measurements of channel width covering arid to polar climate region was used to compute the statistical relationships between channel width and discharge. The relationships developed from the modern deltas were then applied to three well-constrained Cretaceous outcrops from North America and Canada where six paleodischarge measurements are already available from the literature. Well-exposed Ferron Sandstone has been thought to be developed during the "greenhouse" period along with the abundance of coal, gleysols, and lack of aridisols and evaporites. This formation was most likely to be deposited in a humid, subtropical climate. While paleoclimate studies from the Dunvegan and McMurray formations generally conclude that these formations were deposited in a humid and temperate region. The hydraulic geometry models developed in this study showed consistent paleodischarge estimation with other models over a factor of 3 across these two paleoclimate regions. Furthermore, these comparisons suggest ways to improve the models' performance for each climate region, and the limitations and pragmatic sampling criteria in using the proposed models. Compared to published approaches, our proposed models use information that is more readily available in the rock record (i.e. channel width rather than paleoslope, wetted perimeter, bankfull duration, etc.), so that fewer assumptions are involved and the results are applicable across different climate belts. These climate-classified models bring more details in terms of palaeoclimate impact on their consecutive hydrology system due to its climate classification and are tailored for sedimentologists dealing with the rock records by using fewer parameters. These results show how the hydraulic geometry concept can be adapted for delta systems, and hence suggest the applicability of channel morphological properties to infer behavior in other sedimentary systems (e.g. estuaries, tidal creeks, etc.).

Assessing the role of depositional environment on the geochemistry of atoll sediments from French Polynesia

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Depositional environment has been shown to influence the carbon isotope composition of marine carbonate sediments and organic matter in many shallow marine settings. Depositional modes, skeletal or non-skeletal, influence the carbon isotopic values recorded in the carbonate due to vital effects on fractionation and various oceanographic conditions. To constrain the modern geochemical composition of atoll depositional environments, surface sediments collected during the Khaled bin Sultan Living Oceans Foundations' Global Reef Expedition (GRE) from Rangiroa and Fakarava atolls in the Tuamotu Archipelago, French Polynesia were analyzed in this study. Bulk sediment samples were analyzed for carbonate carbon and oxygen isotope values, organic carbon and nitrogen isotope values, and sediment mineralogy. In addition, sedimentary constituents were analyzed for carbon and oxygen isotope values, and all geochemical data collected in this study was synthesized with grain size data produced by the GRE. Comparison of surface sediments from Rangiroa and Fakarava showed a similar range of carbon (-0.1 permille to 4.0 permille) and oxygen (-3.0 to -0.8 permille) isotope values. Major sedimentary constituents were identified, and the bulk sediment composition was predominantly contributed by Halimeda, bryozoans, crustose coralline algae, and foraminifera at both locations. All sediments were primarily composed of aragonite and high-Mg calcite, with negligible contributions of low-Mg calcite and dolomite. Preliminary analyses of sedimentary organic matter show a similar wide range in organic carbon isotope composition (-20 to -16 permille). Compared to the published geochemical composition of globally distributed skeletal carbonate platforms including Bermuda, Heron Island, Enewetak Atoll, Lighthouse Reef, Glovers Reef, and non-skeletal Great Bahama Bank, skeletal platforms had a significantly wider range of carbon values than non-skeletal platforms, and Pacific environments had lower overall carbon isotope values than their Atlantic and Caribbean counterparts. Such differences in geochemical composition are interpreted to reflect the role of depositional environment and the diversity of sedimentary constituents in photozoan carbonate factories, highlighting their potential influence upon reconstructions of global carbon cycling conducted on ancient atoll settings.

Diagenetic differentiation and reservoir quality of saline lacustrine carbonate sediments as response to lake-level fluctuations

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The saline lacustrine basin has special paleoclimate and paleo-water media conditions, which makes carbonate reservoirs of this origin show more complexity and uniqueness in the process of sedimentation and diagenesis. And the water volume of the saline lake basin is much smaller than that of the marine counterparts, which makes the lake-level more susceptible to climate and frequent fluctuations. At the end of high-frequency lake-level decline, subaerial exposure and meteoric diagenesis of carbonate rocks in the top of the upward-shallowing sequence contribute to form a large number of dissolution pores-cavities. After entering the burial stage, primary pores and dissolution pores of different sizes constitute a complex porous media system, leading to selective precipitation. This diagenetic differentiation determines the development trend of carbonate reservoir quality in the burial stage. Therefore, it is difficult to understand the diagenesis process of carbonate reservoirs in the saline lake basin as response to lake-level fluctuation. This study mainly focuses on shallow-middle buried strata in the northwestern Qaidam basin, NW China. Based on the analysis of petrography, X-ray diffraction, organic geochemistry, mercury injection curve and reservoir physical properties, the effect of lake-level fluctuations on diagenetic process and reservoir quality of saline lacustrine carbonate rocks were revealed. The results show that the saline lacustrine carbonate rocks are mainly developed in low-frequency regressive hemicycle. At the end of a high-frequency lake-level decline, the primary pores of the grain shoals, algae mounds, and partial lime flat in top of the upward-shallowing sequence had undergone karstification, which easily enlarged into dissolved pores-cavities, resulting in high-quality reservoirs to repeatedly appear in the low-frequency cycle. In the shallow burial stage, upper parts of an upward-shallowing sequence are prone to the cement filling of macropores and preservation of small pores. In a case, diagenetic minerals are preferentially filled in large dissolution pores, nearby where a large number of residual small pores are rarely affected. After entering the middle burial stage, a large amount of organic acid is generated. Therefore, the residual matrix and intercrystalline dissolution micropores can be used as channels for the migration of organic acids that can enlarged pores to form a new storage space. The measured data of core physical properties and mercury intrusion curve data confirmed that the algal limestone and micrite had undergone karstifcation in top of the high-frequency upward-shallowing sequence eventually became the most favorable exploration target in the middle burial stage. The research results can provide carbonate reservoir evolution models and favorable reservoir prediction ideas for other saline lacustrine basins of the same origin in the world.

Sequence, facies and reservoir characteristics of lower Cretaceous Yamama formation in main oilfields, southeast Iraq

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Yamama is a well developed formation with high hydrocarbon potential which have been proved in several oilfields in southeast Iraq (West Qurna, Majnoon, Halfaya, etc). Deep depth, high pressure, high temperature and H2S content confined Yamama formation's exploration and development. Integrated 3D/2D seismic data, logging data, core data and testing data to comprehensive characterize the stratigraphy, sedimentation, reservoir quality in SE southeast is important for the successful exploration and development.

The sequence of Yamama formation are studied base on the interpretation of 1921 km2 3D seismic data, 45 lines 2D seismic data (total length is about 500 km) and several deep exploration wells. Yamama is located in the bottom of AP8 sequence (super sequence of Ariba Plate) and can be divided into two progradation-retrogradation third order sequence. The barrier units YB-1 and YB-2 are correlated with MFSs of K20 and K30 in Ariba Plate sequence, they are identified in wells and seismic which separated three reservoir units: YR-A, YR-B and YR-C. The seismic reflection of YR-C is characteristic by hummocky and progradation which indicated the uncomformable contact with bottom Sulaiy formation. Top of YR-B had weak onlap reflection which may revealed expose of top YR-B. YR-A is characteristic by parallel reflection which indicated stable carbonate slope depositional environment.

Carbonate ramp is the dominated sedimentary environment of Yamama formation and it can be divided into inner ramp, middle ramp and outer ramp. From bottom to top, YR-C dominated by middle or outer carbonate ramp with mudstone and mound developed, YR-B dominated by inner or middle ramp which indicated the progradation of the ramp, YR-A dominated by middle ramp with wackestone developed. From southeast to northwest (the direction from Ratawi oilfield to Halfaya oilfield), the sediment environment changed from inner ramp to outer ramp with the basin ward progradation. Ramp crest developed oolite and reef with the best reservoir quality which is also the hydrocarbon potential area. Top of YR-B in the southeast area developed shoal with exposed environment also developed good quality reservoir. The proved oilfields mainly located in the ramp crest and shoal. Top of YR-B in the southeast and ramp crest in YR-A are the potential area for hydrocarbon exploration.

Comparative analysis of different lithofacies and shales in continental facies of the Sichuan Basin

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Continental shales in China are rich in gas resources, and show similar enrichment conditions to those of marine shales, while their geological conditions are greatly different. Compared with marine shales, which are rich in organic matter, continental mud shales feature rapid changes in sedimentary facies, diverse facies types (e.g., interbed and interlayer), low abundance of organic matter, and a significant difference in storage capability, among others. In this study, the Lower Jurassic continental shales in the Sichuan Basin were taken as an example, and based on different lacustrine sedimentation models and facies types, the lacustrine mud shales were divided into four major types and eight specific types of shale facies, including shales laminated with thin layers and shale interbeds and interlayers. Methods and technologies including organic geochemistry, high-pressure Hg injection, and gas adsorption were adopted to study the hydrocarbon generation, storage, and compressible characteristics of shales according to each facies type, and shales in the Longmaxi Formation of marine facies in the Sichuan Basin were introduced for comparison. The results indicated that the shales deposited in carbonate lakes with clastic limestone interbeds showed favorable hydrocarbon generation, storage, and compressible abilities, which were beneficial for the formation of shale gas, thereby making it the ideal type of lacustrine facies shale. The shales deposited in carbonate lakes with shell limestone interlayers and shales deposited in lakes containing terrigenous clasts with sandstone interbeds had hydrocarbon generation and shale gas storage abilities with moderate compressibility, which made them relatively favorable shale types.

Analysis of Transitional Facies Shale Micro-Pore Structure and Influence Factors of Reservoir Capacity

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Transitional facies shales are mainly distributed in the northwest, northeast, Sichuan Basin and its peripheral regions in China, where carboniferous and Permian development horizons are preferable, but the study and exploration of transitional facies shale gas are still in an initial phase. According to predecessors' studies, transitional facies shale is of particularity in the aspects of deposition, construction, lithology, reservoir characteristics and gas content and it is greatly different from marine facies and continental facies shales. Most of the current studies regarding transitional facies shale have focused on macro-analysis and test as well as shale gas reservoir forming and preservation conditions, but the micro-pore structural characteristics and reservoir capacity of transitional facies shale remain unclear. Therefore, transitional facies shale in Longtan Formation of Xiangzhong Depression taken as an example, lithofacies characteristics and reservoir characteristics of this type of shale were mainly investigated by means of shale outcrop observation, rock core observation, sample collection and test analysis. This study will be of significant theoretical and practical significance to evaluation of transitional facies shale reservoir capacity, prediction of interval rich in shale gas and optimal selection of target area. The results showed that clay mineral content was high in transitional facies shale in Longtan Formation of Xiangzhong Depression with average content exceeding 55%, followed by quartz (average content: 30 wt%), while the contents of feldspar and carbonatite were low, so the shale in this formation was mainly developed with two pore types: pores between clay minerals and organic matter pores; According to the marine facies shale correlation analysis by predecessors, it's found that traditional comparative elements used for reservoir capacity division of marine facies shale are inapplicable to transitional facies shale in Longtan Formation. A lithofacies division scheme applicable to transitional facies shale was established based on Si element correction and lamina development degree, and then transitional facies shale in Longtan Formation was divided into lamellar argillaceous shale rich in organic matters and silicon, lamellar Si-rich argillaceous shale containing organic maters, massive argillaceous shale rich in organic matters and silicon, massive Si-rich argillaceous shale containing organic matters and lamellar Si-rich argillaceous shale lacking organic maters; through a comparative analysis of reservoir capacity, shale reservoir capacity in Longtan Formation was greatly influenced by organic carbon content and lamina development degree, and high organic carbon content was good for the development of organic matter pores and enlargement of total specific surface area of pores; a certain lamina development contributed to formation of siliceous clastic lamina and lamina rich in organic matters; a favorable reservoir space was provided for free gas and adsorbed gas; terrigenous organic matters were usually damaged and the single-layer thickness of the formed siliceous clastic lamina was large due to intense lamina development, and as a result, total specific surface area of pores in shale was far smaller than that in shale with the same mineral composition under weak effect of terrestrial sources.

The genetic mechanism of overpressure in Funing Formation in Gaoyou Sag, Subei basin

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Abnormal high-pressure reservoir promoted a new domain for the sustainable development of oilfield in Funing Formation of Gaoyou Sag, Subei Basin. The overpressure is limited to the inner slope area with slightly amplitude and emerged from middle part of E1f4 to the top of E1f1 vertical direction. According to the fluid inclusions and PeotreMod soft, we calculated the paleofluid pressure and simulated its evolution history. The origin of the overpressure were investigated based on the multiple-logging combination method, Bowers' method and velocity–density cross-plot method. The results indicate that abnormal high-pressure was occurred as early as Eocene in the Funing Formation. And it experienced rapidly increase before 37 Ma, followed by rapidly reduction during 37 Ma ~ 23 Ma, and then slowly rise in 23 Ma ~ 0 Ma. Present pressure, however, was not restored to the geological history level. Overpressure was owing to fluid expansion in the mudstone section of E1f4 and E1f2, which is not caused by the disequilibrium compaction. In E1f1 and E1f3 reservoirs, overpressure is formed by pressure transfer. This research provide a significant theoretical basis for expanding the hydrocarbon exploration in the inner slope of Gaoyou Sag.

Lithological prediction in contourites and bottom-current reworked sands: the link between geometry, process and facies

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The role of bottom-currents in the reworking and redistribution of sediments has been clearly underestimated. The diagnostic criteria at the facies and seismic scales to discriminate contouritic deposits from downstream sediment gravity flows deposits need to be improved. Transport by vigorous bottom currents or in-situ winnowing of the sediments can result in reworking of turbiditic overspill material in both the canyons and channels and inter-channel areas, and the deposition of potential clean sands. This has renewed the interest and attention from both the academia and the O&G industry in search of new exploration opportunities.

Although standard facies models for contourites and bottom-current reworked sands (BCRS) are published (e.g. Gonthier et al., 1984; Stow & Faugeres 2008; Viana et al., 2002; Shanmugam 2006, De Castro et al. 2020), major uncertainties remain yet regarding the location of sands, their quality and thickness, and their distance of transport from source.

Contourites and bottom-current reworked sands have the potential to provide reservoirs and seals. First keys for lithological prediction are 1) the depositional environment defined by its hydrological conditions, and 2) the type of sediment input (detrital system fed from the continent or the shelf, or pelagic particles sorted and winnowed by bottom currents).

Our attempt is to define models of contourites and BCRS that include:

1) A typology of deposits based on geometry and internal architecture

2) The associated facies association

3) The associated sedimentary processes

4) Links with the different geological contexts and environments (e.g. strait, terrace)

5) The reservoir or seal potential of these objects

6) Metrics about the main parameters when possible (water depth, geometry, thickness, sand content, bottom current velocity).

We base our analysis on either modern or ancient calibrated cases. For all the cases presently exposed on sea floor, the data set includes seismic and cores or dredge samples, with possibly multibeam bathymetry and seafloor reflectivity. Ancient examples can be outcropping or buried objects that are penetrated by cored wells, and described in term of grain size and lithology at least. Most cases derive from recent published studies.

The reviewed objects include outer shelf BCRS, drifts associated to a strait, contourite channels, BCRS deposited in contouritic terraces and drowned carbonate terraces, pelagic carbonate sands, slope plastered and elongate mounded drifts, mixed turbidite/contourite systems and sheeted abyssal drifts.

Our objective is to have keys for prediction and qualification of reservoir & seal potential in contourites. The analysis of representative study cases allows us to propose a classification in relation with the main drivers identified, and to define types qualified as best, moderate or low reservoir potential with specific issues regarding reservoir continuity or diagenesis associated to burial (cementation concerns for carbonates). Fine-grained dominated types have a seal potential depending on occurrence of thin coarse-grained layers or waste zones that may jeopardize the seal quality.

Volcanic related methylmercury poisoning as the possible driver of the end-devonian mass extinction

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The end-Devonian mass extinction (Hangenberg Crisis, 359 Ma) was identified as a first-order mass extinction, albeit not one of the "Big Five" events. Many marine and terrestrial organisms were affected by this crisis, especially severely affected were pelagic predatory biotas such as placoderm fish, which were totally eliminated. The postulated factors responsible for this global event, such as high productivity and anoxia, a calcification crisis caused by ocean acidification, perturbation of the global carbon cycle, glacio-eustatic sea-level changes driven by orbital forcing, volcanic and hydrothermal activity, and evolution of land plants, are still vividly discussed. Recently, many pieces of evidence for extensive volcanic eruptions and submarine hydrothermal activity are documented by Hg anomalies in the different palaeogeographic domains at the D-C boundary. Extensive volcanism has been implicated in all 'big five' mass extinctions and other biotic crises in the Phanerozoic, including the Hangenberg crisis. Here we show substantial Hg anomalies in the Hangenberg Black Shales in the Carnic Alps (Austria and Italy) with maxima of 20216 and 9758 ppb in Kronhofgraben and Plan di Zermula, respectively. Furthermore, at the same levels we also detected methylmercury (MeHg), a strong neurotoxin that bioaccumulates in the food chain. This is the first evidence of MeHg found in sedimentary rocks. The organic form of mercury is a dangerous neurotoxin because it is bioconcentrated in aquatic food chains and is able to cross the blood–brain barrier. Hence, this form of Hg is much more toxic to living organisms than inorganic Hg. In modern environments, MeHg is generated predominantly by anaerobic microorganisms, such as sulfate-reducing bacteria. Therefore widespread Late Devonian anoxic water masses were ideal environments for bacterial biomethylation of a volcanically derived, large concentration of inorganic Hg supplied to the ocean. Thus, we claim that volcanic-driven methylmercury poisoning in otherwise anoxic seas could be another proximate kill mechanism of the end-Devonian Hangenberg extinction, which affected predatory fish and other organisms.

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Facies heterogeneity along a tectonically-controlled carbonate slope (Western Sicily Cretaceous Escarpment, Italy)

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Cretaceous limestones deposited in a slope setting occur in several thrust sheets of the Maghrebian chain in north-western Sicily (Capo San Vito Peninsula). These limestones are exploited as ornamental stones (Perlato di Sicilia) and well-exposed along the wire-cut walls of hundreds of quarries. Over 250 km2 are covered with these limestone series reaching ca. 500 m in thickness, thus creating favourable exposure conditions to perform detailed macro- and micro-facies analyses of the depositional system (Western Sicily Cretaceous Escarpment, WSCE). Detailed logging and correlations of selected sections exposed in several tectonic units enabled the reconstruction of the depositional architecture of the WSCE and define its sedimentary evolution throughout the whole Cretaceous. Eleven different facies types grouped into four facies associations have been differentiated reflecting specific depositional environments, from platform margin/slope transition to the talus, toe-of-slope, and basin. The features observed in the oldest Cretaceous facies (Berriasian) suggest a carbonate ramp setting. The predominant facies types show well-bedded or massive and chaotic megabreccia bodies whose matrix consists of skeletal packstone to rudstone with rudist fragments. Gravity-flow deposits alternate with volcanic intercalations that consist of tuffites and pillow basalts, hence representing a peculiar feature within this depositional system. The high TiO_2 content of the volcanites suggests the ascent of magma through deep-rooted crustal shears. Chaotic megabreccia bodies overlying and/or underlying the volcanic intercalations and strongly suggest a tight relation between this facies type and seismo-tectonic processes. Moreover, some extraclasts in the gravity-flow deposits imply the exposure of the Jurassic sedimentary substrate along the footwall of normal faults, thus providing further evidence of tectonic deformations. Therefore, repeated seismic shocks appear as the most likely trigger for the emplacement of the gravity-flow and collapse deposits constituting the WSCE, though the influx of sea-level variations cannot be totally ruled out. In this respect, the study provides new insights into the understanding of sedimentary dynamics along tectonically-controlled carbonate slopes. The intra- and extra-clastic carbonates feeding the WSCE were provided by the Panormide Carbonate Platform, a well-known paleogeographic unit of the Central Mediterranean area. During Senonian times the WSCE recorded a progressive decrease of clastic transfer which probably relates to a tectonic retreat of this platform up to the definitive shut down of the carbonate factory during the Maastrichtian. The Cretaceous tectonic evolution of the Panormide/WSCE carbonate system shows tight relationships to the geodynamic evolution of the Central Mediterranean area, influenced by the convergence between Africa and Adria and the tectonic subsidence in the Sirt Basin.

Sedimentary architecture of a turbidite channel-levée complex from the Taza-Guercif Basin (upper Miocene, NE Morocco)

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Turbidite channel deposits show a wide range of architectural styles resulting from a variety of controls on channel belt development. Even though 3D-seismic today provides unprecedented imaging of subsurface examples which greatly helps understanding how channels evolve and are subsequently filled up with sediments, studying channelized turbidites at outcrop remains fundamental to appreciate the sedimentary heterogeneity associated to channel belt development.

In this contribution, we detail the depositional architecture of one (Complex 4) of the nine turbidite channel-levée complexes belonging to the marl-prone late Miocene Melloulou Formation of the Taza-Guercif Basin (NE Morocco). Thanks to an exceptionally well-exposed outcrop belt of c. 4 km largely oblique to mean paleoflow, we were able to acquire and physically correlate eighty-four closely-spaced (ca. 50 m on average) sedimentary logs across both the sand-prone channel fills and the coeval levées of the approximately 30 m-thick Complex 4. The thus obtained cross-sectional views enabled to track vertical and lateral changes of sedimentary architecture, which provide insights into the dynamics of turbidite channel-belt development.

The studied channel-levée complex begins with five single-story sand-prone channel fills having widths in the order of a few hundred metres and thicknesses in the range of few metres associated, and laterally associated to mud-prone levées. Within these storeys, channel forms are filled up in an aggradational manner suggesting relatively short-lived channels with minor lateral migrations.

Up-section, it follows a composite channel fill composed of several single-storey sandy channel fills, which are locally amalgamated and are internally made of lateral accreted bedsets. These stack to form an up to 3.60 m-thick sand-prone body with overall tabular geometry and minimum lateral continuity of 947 m.

Higher in the stratigraphy, a swift westward shift of the channel belt is recorded, which is accompanied with deposition of four more composite channel fills to the west and deep incision in the south-east and is suggestive of up-dip avulsion. Today cut by modern incision, the youngest channel fills appear to stack vertically in an aggradational manner and develop a relatively thick high-relief levée to the east, which gently taper away from the channel belt. Here, in-channel deposits are represented by alternations of laterally accreted amalgamated sandstone bedsets and thin-bedded fine-grained turbidite sandstone-mudstone couplets, which the latter recording phases of reduced sediment input.

The depositional model of complex 4 is one encompassing a channel-belt inception phase with vertically stacked isolated single-channel fills, a middle phase in which high-sinuosity channels might have migrated laterally , and a last phase recording a stark aggradation of the channel belt.

Our results contribute to better understanding of how turbidite channel belts establish and develop and provide sub-seismic scale lithological calibration for analogue subsurface deposits.

Upper Jurassic large-scale distributive fluvial system in Paraná Basin, Western Gondwana: a quantitative approach

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Understanding fluvial system complexity requires basin-scale studies to investigate the spatial variations in fluvial features and relations with other depositional systems. This study integrates data from 62 outcrops and 2 well cores to evaluate depositional trends over a 1050 km long NE-SW section of the Guará Formation, Upper Jurassic of Paraná Basin, South America. This study only considered the outcrops and wells with thickness of at least 25% of the estimated thickness of Guará Formation to ensure a representative overview, leaving 781.9 m of columnar sections for analysis. Paleocurrents readings from the SW quadrant determined that the outcrops and well logs were being analysed in a downstream transect. Facies association of perennial (low discharge variability fluvial) are dominant in the proximal portion of the system, reducing its importance downstrem. Ephemeral (high discharge variability) fluvial facies association starts to appear in the medial to distal zones. Sheetflood facies association is almost absent in the proximal to medial zones, becoming significant towards the final portion of the distal zone. Aeolian facies association have more importance in the first half of the distal zone. The average grain size of channel deposits decreases downstream, from coarse to fine sand. The average thickness of the channel bodies appears to reduce from more than 10 m thick to less than 5 m, following the increase of ephemeral fluvial proportion downstream. The number of storeys per channel body is between 7 and 5 in the proximal portion, reducing to 2 or less in the medial to the distal zone. Storey and bar thicknesses remain largely unchanged downstream. The distribution of facies associations shows a downstream tendency of deconfinement and greater influence of variable peak discharge. The increase in aeolian and floodplain deposits could be due to higher accommodation space in the distal zone, increasing the preservation potential of interchannel deposits. Evidence of non-contemporaneity of fluvial and aeolian deposits in the distal zone of the Guará System suggests a distributive fluvial system that switches between fluvial and eolian deposits in time and space, reflecting both intense nodal avulsion or advance and retreat of the fluvial over eolian systems. The influence of climate on the architecture and nature of deposits is explored. Almost absent downstream changes in storey and bar thicknesses show that the scale of each channel kept constant from proximal to distal domains, while the size of channel belts and general discharge tend to reduce downstream. All these characteristics demonstrate a downstream zonation that classifies the Guará Formation as a distributive fluvial system of continental-scale in Western Gondwana during the Late Jurassic.

Structural characteristics of the botryoidal structures of Sinian Dengying formation in Sichuan basin

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The botryoidal structures of Sinian Dengying formation in Sichuan basin feature botryoidal bulges on the upper surface. On the longitudinal section they comprise discontinuous bulged basement and continuous curved superimposed lamina inside. In essence they are composed of bulges and superimposed lamina as shown on the longitudinal section.

Fine analysis of a large number of the botryoidal structures there revealed that the bulged basement in the middle of the botryoidal structures constitutes the basis for the formation of the botryoidal structures. There are two different types. In the first, the bedrock layer on which the botryoidal structures developed is a discontinuous basement. This type of basement bulging occurred when the bedrock layer on which the botryoidal structures developed had received dissolution before the formation of these structures. Heterogenous dissolution had given rise to a discontinuous bulged basement. Subsequently multiple superimposition with similar single lamina thickness occurred on the inherited basement, creating a continuous curving that finally shaped the botryoidal morphology. In the second, a bulged basement was consturcted over the bedrock layer. Subsequently multiple superimposition with similar single lamina thickness occurred on the inherited basement, creating a continuous curving that finally shaped the botryoidal morphology.

The rhythmic lamination in the Sinian Dengying formation botryoidal structures of Sichuan basin characterizes two different types of microstructure. The first consists of dolostones arranged in parallel to the surface of the laminae along their major axis in a "short and thick" profile. Cyanobacteria have quite a high level of enrichment in this type and all of them feature bedding development. This type of microstructure occurs in bright laminae and it must have formed in a context wherein the water body was relatively quiet. The second consists of older dolostones occurring in vertical contact with the laminae and younger dolostones distributed perpendicular to the sides of the tip of the older dolostones, resulting in a deflection in the development direction of the younger dolostones. Among dolostones of the same age, there is also a deflection in the development direction, attributable to the reduced development spaces between adjacent dolostones and, consequently, compressed development spaces for these dolostones. This has resulted in a "long and thin" fibrous profile. This type of microstructure occurs in dark laminae wherein cyanobacteria are rarely found and any cyanobacteria present are virtually in the form of small spheres. Hence, this type of microstructure must have formed in a relatively turbulent water body.

The sedimentary record of sea-level change and near seafloor diagenesis on a subtropical carbonate ramp

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In the last decades our understanding of temperate carbonate systems has improved considerably, but their development over glacial-interglacial timescales and their early diagenesis is still understudied in comparison to their tropical counterparts. The Carnarvon Ramp on the SW Shelf of Australia is situated at the transition between cool and warm water environments, and its depositional history since the early Pliocene was recovered at IODP Site U1460. The origin and composition of the sediments in the upper 25 m CSF-A were investigated using scanning electron microscopy and X-ray diffraction. The aragonite content reaches up to 36 % and originates mainly from gastropods, bivalves, cheilostomes bryozoans, ascidian spicules and some azooxanthellate corals. The high-Mg calcite contributes ~ 44 % to the bulk sediments and is mainly produced by bryozoan, echinoderms, benthic foraminifers and some serpulids worms. The Middle Pleistocene to Holocene sequence at IODP Site U1460 contains a record of sea-level controlled sedimentary cycles. Carbonate sediments deposited during sea-level highstands are fine grained and dominated by low-Mg calcite. The lowstand intervals, instead are coarser-grained and relatively rich in aragonite and high-Mg calcite. The preservation of pteropod shells shows significant aragonite dissolution within the sediment below a depth of around 6 m CSF-A. The degree of dissolution generally increases with depth but seems to be higher in organic matter (alkenone) rich interglacials compared to glacials. A comparison to geochemical porewater profiles indicates that the extend of aragonite dissolution is controlled by organic matter limited sulphate reduction. Dolomite cement forms preferentially in the interglacial deposits, due to sulphate reduction related increases in alkalinity. Overall the more intense diagenetic alteration in the interglacials amplifies the primary mineralogical differences in the sedimentary cycles.

Facies and evolution of a mixed carbonate-volcaniclastic ramp: the Toqui Formation (Lower Cretaceous), Chile (45°S)

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The Toqui Formation (Tithonian-Hauterivian?) in the Aysén-Río Mayo Basin of Northern Patagonia (43°-49°S) is a mixed volcaniclastic-calcareous unit and basal member of the transgressive-regressive succession known as Coyhaique Group. The Coyhaique Group represents the Aysén Basin fill of Late Jurassic-Early Cretaceous (Tithonian-Aptian) age, and it comprehends the Toqui Fm. (mixed), the Katterfeld Fm. (pelitic-siliciclastic) and the Apeleg Fm. (sandy-siliciclastic). In order to explain the interaction between volcaniclastic and calcareous sedimentation observed in the Toqui Formation, a detailed facies model is presented, based on sedimentogical and petrographic analysis of two outcrops and four drill cores in its type locality, the El Toqui Mine, Southern Chile (45°S).

At its type locality, the Toqui Fm. is here redefined as formed by a mixed calcareous-volcaniclastic member, overlain by a volcaniclastic member, and settled during the early marine transgression. Mixed calcareous-volcaniclastic rocks are interbedded with- and underlain by volcanic breccia and tuff of the Ibáñez Formation (Kimmeridgian-Valanginian), local source of the volcanic sediments. The mixed calcareous member is formed by sandy float-wackestone alternating with bioclast-bearing volcanic sandstone, and gryphaeid oyster biostromes settled in a storm-influenced, mixed-carbonate mid- to outer-ramp. Thin layers of pebble-sized, lithic-rich fallout deposits are occasionally intercalated in this unit and reflect periodic explosive volcanism. Carbonate sedimentation was controlled by the growth of patch-reefs and their shallow-marine reworking (parabiostromes), developed during a quiescent volcanic period. The biostromes are abruptly covered by fine-grained, laminated water-lain tuffs representing fallout deposits and prodeltaic ash-turbidites of the volcaniclastic member. This member also includes wavy-and cross-bedded volcanic sandstone, sandy conglomerates, and parallel- and cross-laminated tuffaceous sandstones-mudstones, interpreted as the syn-eruptive progradation of a wave- and storm-reworked delta front. Upsection, the succession grades to massive, laminated and normally-graded volcanic sandstone and mudstone, interpreted as eruption-fed turbidity currents from a distal delta-front to delta-slope. To the top, this fining-upwards trend continues to hemipelagic mudstone of the Katterfeld Formation, i.e. the middle member of the Coyhaique Group, settled in an outer-shelf environment.

The Toqui Formation settled over flooded continental, intra-arc volcanic terrains, during the early marine transgression in the Aysén Basin, linked to a relative sea-level rise caused by tectonic subsidence. Carbonate platforms aggraded in the shallower areas during periods of tectono-volcanic quiescence. The platforms drowned after a relative sea-level rise, and were covered by prograding fan delta deposits from a reactivated volcanism. Upwards, the succession displays a transgressive system tract dominated by hemipelagic sedimentation, likely related to “post-rift” thermal subsidence. Deposition of the Toqui Formation thus reflects a complex interaction between tectonic subsidence, coastal volcanism, and patch-reef growth.

Reconstruction of hypoxia on the Black Sea shelf over the Holocene with a multi-proxy approach

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Coastal hypoxia is a growing worldwide concern. Since the 1970's, seasonal hypoxia has been reported on the north-western Black Sea shelf. However, little is known about oxygenation in this area over the Holocene. This work aimed to detect potential hypoxic events recorded in two gravity cores retrieved at less than 5 km from the coast, at 20 m water depth. The GC7 core (2.15 m long) is located in front of the Danube mouth and the GC15 core (2.97 m long) is situated in the Odessa Bay. Several proxies for past hypoxia were tested.

First, the Ammonia-Elphidium index was tested, as these two benthic foraminifera genera are abundant in the Black Sea. However, only a few foraminifera species and individuals were found in GC7. Since foraminifera are also sensitive to salinity changes, this observation may reflect the dilution of saline waters by freshwater inputs from the Danube. The low number of Elphidium (0 to 11 on 200 individuals) in GC15 might also be due to the low salinity rather than due to oxygenation restriction. In the case of the Black Sea coastal area, the Ammonia-Elphidium index appears to be inappropriate.

Secondly, different geochemical proxies were used. Among redox-sensitive elements, vanadium behaves as a detrital element in both cores (high correlation with aluminum) and cannot be used as a hypoxia proxy. In GC15, the slight uranium enrichment might indicate reducing condition. The average low molybdenum concentration (~ 1 ppm) suggests the absence of euxinic conditions.

Based on sequential extraction, pyrite corresponds to only 6 ± 2% of reactive iron in the whole GC7 core. In contrast, GC15 shows an increase in pyrite downwards (from 20% up to 80% of reactive iron) and a decrease in the hematite and goethite fraction (from 20% to 3%) and in the FeS, siderite, ferrihydrite, akaganeite and lepidocrocite fraction (from 50% to 11%). This iron reduction with depth is linked to the decomposition of organic matter within the sediment during diagenesis. However, it provides no clear indication concerning the water column oxygenation.

Finally, the last proxy was the size distribution of framboidal pyrites. In GC7, the absence of framboidal pyrites is attributed to oxic bottom waters. On the contrary, in GC15, two groups of framboidal pyrites were identified: 1) mean diameter between 3 and 6 µm with a narrow standard deviation (1 or 2 µm) and 2) larger mean diameter (from 6 to 10 µm) with a wider standard deviation (3 to 5 µm). The first group would form in an anoxic water column, while the second one is assumed to grow within the sediment under dysoxic (i.e. low oxygen content, considered here as a synonym of hypoxic) or oxic bottom waters.

In conclusion, oxygenation conditions are not similar in the two coastal studied sites. Near the Danube mouth (GC7), the absence of framboidal pyrites suggests oxic conditions. On the contrary, in the Odessa Bay (GC15), the framboidal pyrite proxy records an alternation between anoxic and hypoxic/oxic bottom waters.

A modern study of dynamic mud deposition: Waihou River, New Zealand

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Insights about dynamic mud deposition have fundamentally changed the way sedimentologists interpret muddy strata. Mud deposits were considered to be diagnostic of low energy environments prior to the understanding that entrained sediment and flocculation can significantly alter hydrodynamic conditions. Muds deposited at high flow velocities have now been well documented both in flume studies and in the rock record; however, studies of modern sedimentary systems remain scarce. This study bridges the gap between the well-controlled environment of the laboratory and the interpretive nature of rock record studies by quantifying, in situ, the flow parameters and sedimentological characteristics of mud deposited in a modern estuary. The Waihou River on the North Island of New Zealand drains both farmland and forested mountainous areas, and carries a large suspended sediment load, which is transported into the mesotidal Firth of Thames. Hence, we focussed our study on the fluvial to marine transition (FMT) of the Waihou River where tides, river flow, and marine water interact.

Five sites along a longitudinal transect extending 14 km inland from the mouth of the river were studied. At each site, oceanographic instrumentation was deployed for approximately one neap-spring cycle (~14 days). A range of oceanographic instruments were deployed which provided us with information about flow velocities, salinity conditions, and suspended sediment concentration, allowing us to assess the relative importance of tides and river flow at each site. Immediately following instrument deployment, co-located vibracores and sediment samples were collected. The vibracores contained interspersed beds of mud and sand with relative proportions that varied along the transect. A number of styles of mud beds were recorded, including those documented from the rock record by Mackay and Dalrymple (2011). The four main mud types observed in the Waihou River represent flow conditions ranging from slack water through to plug flow. The microstructure of key mud beds was determined by sediment imaging to provide insight into the process-response relationships between flow conditions and deposition.

Although the precise linking of mud beds to individual flow events was not possible, we broadly determined the flow conditions associated with each bed type. We aimed to identify changes in the average flow conditions through time associated with shifts in the location of a turbidity maximum zone. The results will allow us to determine 1) if muds are deposited under the same flow velocities as sand, further contradicting the idea that mud deposition can only occur under low energy conditions; 2) criteria to help constrain depositional position along the FMT which will improve paleoenvironmental reconstructions; and, 3) if depositional style is related to organic carbon characteristics, and therefore can be used to determine accurate global carbon budgets as well as the nature of hydrocarbon source rocks. Workers in modern and ancient nearshore depositional systems will benefit from these improved insights into the detailed characteristics of mud beds.

Advances in understanding calcite varve formation from a dual lake monitoring in the southern Baltic

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Varved lake sediments are valuable archives for reconstructing climate and environmental change in the human habitat at seasonal resolution. However, it is still not fully understood which factors control varve thickness and, consequently, varve proxy records are differently interpreted with respect to their climatic significance. Here we present, for the first time, a dual lake monitoring in two lakes forming calcite varves to provide new insights into the seasonal depositional processes forming these varves. The study lakes, Tiefer See (TSK) in NE Germany and Czechowskie (JC) in N Poland, are located a few hundred km away from each other in the southern Baltic lowlands. This is an ideal test region for this investigation because it holds the major known geographical cluster of calcite varve producing lakes. The lake basins are different in morphology and bathymetry and, therefore, are ideal to investigate common processes and local differences of seasonal deposition. The monitoring setup in both lakes is largely identical and included instrumental observation of (1) meteorological parameters, (2) chemical profiling of the lake water column including water sampling and analyses, and, (3) sediment trapping at both bi-weekly and monthly intervals. Finally, we compared our six-year monitoring time series with varve micro-facies of sediments deposited during this time at the lake bottom. Based on this robust data-set, we present and discuss new findings with respect to the seasonal deposition of endogenic calcite varves, as well as their limnologic control factors.

Phanerozoic glendonite occurrences and their significance for palaeotemperature reconstruction

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For more than 40 years glendonites (calcite pseudomorphs after metastable ikaite) were considered as a good palaeoclimate indicator. Firstly such suggestions were made on the base of glendonite distribution in space and time, and later these were confirmed by the study of ikaite, which stability is restricted by the cold-temperature environment. However, recently numerous additional factors, such as presence of methane, bacterial activity and concentrations of Na, P or Mg became involved for an explanation of ikaites and/or glendonites occurrences.

Here the preliminary results of glendonite distribution based on a comprehensive database are represented. The database including information about more than 630 glendonite and ikaite-bearing localities, dated from the early Cambrian to recent. When possible, or these localities were plotted to palaeolatitudes (through paleolatitude.org online facility). The following conclusions can be done on the base of analysis of these data:

1) Glendonite distribution in space and time is strongly irregular. Some stratigraphic intervals are very rich in glendonites, while other lacking glendonites. Significant asymmetry between the Northern and Southern Hemispheres is also very typical, along with Western and Eastern Hemisphere irregularity in glendonite records;
2) Low latitude (near-Equatorial) glendonite occurrences are known from the times of major glaciations only;
3) Some intervals of supposed glaciations (such as late Ordovician or late Devonian) are glendonite-free;
4) Early Cretaceous is the only ice-free epoch characterized by bipolar glendonite occurrence;
5) Different types of glendonites ('rosettes' or 'blade-like' pseudomorphs) are nearly equally distributed throughout the Phanerozoic, but there are few types of glendonites which are typical for some stratigraphic intervals only. These are giant glendonites (more than 30 cm in size), which occurred in Permian, Middle Jurassic, Paleogene and Neogene, while plates which consists from glendonites were reported from the Late Cambrian and Early Ordovician marine deposits and Quaternary lacustrine settings;
6) Glendonites and ikaites occurred mainly in the marine environments (although their Quaternary records are also known from lakes, hypersaline springs, and caves), ranged from inter-tidal to deep abyssal (more than 4 km deep). Their records have no relationship with sedimentation rate and type of the basin;
7) Glendonites are always found in cold-water environments, but their presence across the localities and stratigraphic intervals controlled by poorly understood additional factors or their combinations;
8) Although the whole set of factors controlling glendonite / ikaite distribution still disputable, cold-water environments seem to be obligatory, and glendonite finds can be used for recognition of cooling events

Review of the Upper Jurassic black shales of the Russian Platform

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Black shales generated by OAE are most studied Phanerozoic facies because of their linkage to major environmental perturbations and importance as the source rocks. However, black shales with high TOC also known from the non-OAE intervals and still not fully understood.

During Late Jurassic, the Russian Platform (RP) was flooded by the shallow epeiric sea, connected to the oceanic basins in the north and south, and to the shallow European sea in the west. The numerous black shales, accumulated here present at many stratigraphical levels, but their thickness and lateral extension are strongly varied.

As well as in other Subboreal areas (Polish Lowlands, NW France, Dorset and Yorkshire coasts and northern Scotland) the black shales of RP are characterized by elevated TOC (10–40%) and are intercalated by sediments with low organic carbon such as clays, marls or mudstones, and more rarely sands and sandstones.

The oldest Middle Oxfordian black shale is very thin and not widespread due to the later burrowing, and better-preserved black shale bed (0.15–0.2 m) present near the base of the Upper Oxfordian and traced through ~ 100000 square km.

Kimmeridgian organic-rich shales, ranging from 0.02–0.1 to 1 m in thickness, present within Bauhini, Mutabilis and Eudoxus zones, and their occurrence is limited mainly by Middle Volga area. Lower Volgian black shales are characterized by greater geographic range, comparable with the Upper Oxfordian level.

The Middle Volgian black shales, belonging to Panderi zone are significantly different. It is thick (varying from 3–4 m to 100 m), consists of 5–10 beds of black shale and traced from the Caspian sea to the Pechora sea basin, covering an area more than 1 million square km. Its characteristic structure, formed due to alternation of the black shale and clayey beds maintains throughout all the area, despite significant variations in thickness. Therefore, this could not be due to factors depending on accommodation space and rates of sedimentation.

Very thin, but extremely enriched (up to 40% TOC) black shales beds present within the upper Middle Volgian–Ryazanian interval, cropped near Samara city. The sequence is strongly condensed; fine-grained sandstones with abundant glauconite and sponge spicules. The lower black shale (5 см) corresponds to Nikitini Zone, and thicker (10–15 cm) lies at the base of Ryazanian.

In the listed black shale beds ammonites (both juvenile and adult) are very common, while benthonic mollusks mainly represented by opportunistic taxa tolerant to oxygen-depleted environments. The black shales contain coleoids with fossilized soft tissues and articulated skeletons of vertebrates, preserved due to anoxia.

By their mode of occurrence, the Upper Jurassic black shales of the RP are similar to coeval ones from other Subboreal areas, but the onsets of their deposition are not well-coincide. However, taken together, they can be considered as a record of prolonged “shelf dysoxic-anoxic event (SDAE)”, stepping from the west to the east and gradually involving all Subboreal basins.

The proposed Late Jurassic “SDAE” is not associated with prominent C-isotopes excursions or severe climate changes. These patterns clearly distinguish it from OAEs.

Permo-Triassic paleoenvironmental perturbations in northern Pangea: case study from the Barents Sea

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The period including the end of the Permian and the Early Triassic was characterized by vast changes including a climate change from icehouse to greenhouse conditions, a dramatic mass extinction, phases of anoxic and stratified water column in the world's oceans and the delivery of huge volumes of siliciclastic sediments in all Arctic basins. One of the main driver for all of these changes and perturbations is likely the emplacement of the Siberian Traps Large Igneous Province.

We will show a multidisciplinary study that tackles some of the paleoenvironmental perturbations in the Greater Barents Sea Basin (GBSB) during the Early Triassic. From a sedimentological perspective, the deposition of the Havert Formation records the first progradation of hundreds of meters thick shelf-margin clinoforms with sediments sourced from the Ural Mountains in the southeast and, to a lesser extent, from Fennoscandia in the south. Seismic images, cores and well logs clearly show shelf-margin clinoforms up to 500 m thick, and provide insights into their evolution and sub-environments. Sediment budget analysis has been performed using an empirical method (BQART) coupled with Monte Carlo simulation for uncertainty assessment, and it has been compared with subsurface sediment volume estimates present in the GBSB. Our results reveal that the source area for the Havert Formation could have been big enough to include the Siberian Traps Province in the Siberian craton, making this linked source-to-sink systems much bigger than any modern analogue.

Palynological and geochemical high-resolution analyses from a well in the Barents Sea spanning the Permo-Triassic boundary reveal an abrupt increase in the levels of various volcanically-derived heavy metals, including As, Co, Hg, and Ni. This perturbation caused a transient disruption of plant communities, and even though there was no significant turnover in species or decrease in diversity, the abrupt appearance and high abundance of aberrant spores and pollen is interpreted as the first evidence for heavy metal-induced mutagenesis during the end-Permian extinction. This multidisciplinary study sheds new light on the paleoenvironmental characteristics and source-to-sink development of the Barents Sea in the Triassic Period.

Holocene environmental dynamics of microtidal paralic systems: a multi-proxy record from the Po coastal plain

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Deltas, coastal lagoons, estuaries and adjacent areas, including freshwater swamp/marshes and beach barriers, are considered valuable environments and ecosystems that play a strategic role in lowlands protection and natural resources management. However, the transitional state between terrestrial and marine realms associated to the nearly flat morphologies make these paralic areas extremely susceptible to even subtle changes in Relative Sea Level (RSL) and fluvial activity, enhancing the difficulty to develop reliable projections of future evolution. Stratigraphic-based, multi-proxy studies can provide a long-term view, useful for conservation and restoration strategies, furnishing data about environmental dynamics, depositional processes and associated forcing factors. We combined high-resolution stratigraphic and chronological data with multivariate data analysis undertaken on the Holocene palaeobiological record of Po coastal plain (NE Italy), including pollen, benthic foraminifers and ostracods. This approach allowed to investigate the variability of sedimentary environments and driving parameters during the last 11.5 kyr along a 35 km land-sea transect. Millennial-scale shifts typified the coastal landscape, documenting that coeval changes in the meiofauna reflect variations in organic matter-water depth (shallow-marine environments) and degree of confinement-salinity (back-barrier settings). Onland, in-phase shifts of vegetation communities track unsteady water-table levels and river dynamics in the freshwater palustrine areas. Five key stages of evolution followed one another through the passing of four tipping points dated around 8000 cal yr BP, 7000 cal yr BP, 4800 cal yr BP and 800 cal yr BP. These thresholds are associated with changes in RSL, climate conditions and/or fluvial regime. A marked phase of peatlands growth (up to 0.6 cm yr-1) occurred within the Po estuary at the acme of RSL rise (ca. 8000 cal yr BP), which reasonably induced high water-table conditions dozens of kms inland. Simultaneously, a low confined lagoon subject to predominant meteo-marine processes (wave currents and storms) and an open-shelf environment typified by low accumulation rates (ca. 0.1 cm yr-1) developed seaward. At the turnaround from transgression to regression (ca. 7000 cal yr BP), the estuary turned into a delta plain hosting tidally-influenced interdistributary bays. This shift was triggered by the northward switching of the Po delta lobes, while the long-term persistence of the bays was favoured by relatively stable climate-optimum, humid conditions and high sea levels. After the end of the climate optimum (ca. 4800 cal yr BP), variable climate conditions likely determined the closing of the bays via changes in river flow regime and longshore sediment transport, leading to the widespread development of brackish wetlands surrounded by wooded peatlands. The youngest threshold (ca. 800 cal yr BP), which led to the modern delta plain, is connected with a major avulsion of the Po River that also promoted a marked increase in accumulation rates (ca. 3 cm yr-1) on the shelf.

Understanding the subsidence of the Volturno River alluvial plain by combining geological and geotechnical modelling

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Most of the world's major river deltas and related alluvial coastal plain are affected by subsidence. During the 21th century the space-based techniques allowed to quantify the phenomenon. Studies were carried to figure out the potential drivers of subsidence, along with tectonics, reduced aggradation, volcanism and fluid extraction. By a sedimentological point of view, it must be taken into account that most of the world river delta formed during the Holocene and the related stratigraphic architecture is characterized by sands, silts, clays and peats compacting under their own weight. Recent studies confirm that natural compaction can drive subsidence of several millimeters for years, especially in coastal organic-rich deposits.

Detailed and quantitative evaluations of the state of subsidence processes require to gain a comprehensive knowledge of the mechanism controlling such processes, especially for the purposes of prediction and assessment of future expected events.

In this study we focused on the investigation of relationships between the subsidence process and geological and geotechnical features to characterize the lower Volturno River alluvial and delta plain (southern Italy) in order to shed light onto the expected future evolution of the instability process, thus supporting sustainable management.

We first reconstructed a detailed stratigraphic model by analyzing more than 300 shallow borehole stratigraphies. Sedimentological analyses coupled with radiocarbon dating were performed on boreholes drilled on the delta plain. Assessment of subsidence trends was previously based on SAR (Synthetic Aperture Radar) interferometry techniques.

The spatial intersection of the deformation data with the geological data showed a net overlap of the subsiding areas with a paleovalley morphology recognized in the subsoil, inferred to the Last Glacial Maximum sea level drop. The resulting Incised Valley was subsequently filled by fluvial-lacustrine, transitional and coastal deposits.

To assess the role of the Holocene sedimentary sequences in determining ground subsidence, we have compared: a) the ratio between the lithologies characterized by high compressibility and low resistance and the whole thickness of the Holocene sequence estimated for each stratigraphic log; b) the thickness of the whole Holocene sequence for each log; c) data from cone penetration tests and piezocone tests in order to establish the mechanical behaviour of the sedimentary facies; d) the ground displacement data.

The investigations carried out confirm that higher subsidence rates affect areas characterized by thicker Holocene sedimentary sequences and in particular where silt, clayey silt, clay and peat are the main lithologies. Nevertheless, the inclusion of a significant amount of peat and organic matter is reflected in high values of secondary consolidation coefficient resulting in higher vertical ground displacement even when the Holocene deposit thickness is reduced. In this case a key role is played by the age of the deposits.

All this suggests that if anthropic activities can be the cause of a generalized process of primary consolidation, a key role is played by the stratigraphic structure and in particular by distribution and thickness of Holocene deposits, whose characteristics are at the origin of secondary consolidation and of the variability observed among subsidence rates.

How the Corinth rift is connected or not with the Mediterranean sea?

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Straits are crucial in the evolution of the sedimentary basins when they are controlling a connection between an isolated basin and the open sea. Depending on the depth of the sill, the isolated-basin is experiencing dramatic changes in its environment in terms of water, sediment, and biotas, due to glacio-eustatic variations. Moreover, the sill depth is sensitive to vertical motions by faults or regional uplift. In the case of rift basins, it is almost impossible to preserve these areas due to the tectonic activity and important erosions. Location and persistence of these connections are often suggested in basin evolutions but are rarely documented due to their ephemeral persistence, and their sedimentological processes are under characterized.

We present here the case of a strait connecting an active rift isolated basin with the open sea: the Rion-Antirion strait located between the Corinth and Patras Gulfs in Greece. The Corinth Gulf is occupied by a fast opening rift (up to 1.5 cm/yr), but its sedimentary evolution is established on the hypothesis of a stable sill depth of 60 m during the last 240 kyr. A change in sediment facies and micropaleontological assemblages documents the last transition from lacustrine to marine deposits at ~12ka. This Holocene transgression in the Corinth gulf is associated locally with bottom currents deposits.

To document the last transgression, we conduct the first oceanographic survey in the Rion straight with a CHIRP sub-bottom profiler and seismic sparker profiles combined with multibeam echosounder and Acoustic Doppler Current Profiler. Additionally, some sites have been imaged by underwater videos.

The high-resolution bathymetry shows several morphologies, some triggered by fault activity and then ubiquitous shaped by active bottom currents. At the strait location, erosion is prevailing and forms both stepped terraces and straight channels with a grain sized ranging from coarse-grained to pebbles. In both sides of the strait (~60 m), the bathymetry is deeper (~90m) and formed sub-rounded pools limited by crests. This morphology is link with eddies and inherited structures. The currents are two-way with velocities up to 1 m/s. They are primary controlled by the tides: during ebb tide the currents are getting in (from the sea to the Corinth Gulf) contrary to the rising tide showing an outflow current.

Focusing on the erosional surfaces and the seismic facies, we characterized the erosion typologies: by bottom currents during highstand; or by aerial and fluviatile erosion during lowstand. Then we establish the relative stratigraphy and purpose thickness maps of fluviatile, lacustrine, deltaic, and bottom current deposits which support that beneath the strait more than 80 m of sediments are present. To complete the evolution of the strait we mapped the active fault network mainly located on the North, and identified an active diapirism on the West.

These results established the Rion strait evolution and constrained how to connect the Corinth rift with the Mediterranean Sea. We suggest to integrate the new constrains in the rift evolution and to consider the bottom current processes.

A new C-isotope (δ13Ccarb) reference for global correlations in the Aptian: The Cau-core, westermost Tethys

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The Aptian (121.4 to 113.2 Ma) was characterized by a variable greenhouse climate and was affected by profound perturbations in the carbon cycle resulting in global changes in climate and environmental conditions, both in continental and marine realms. The most remarkable environmental changes recorded in the sedimentary successions include early Aptian Oceanic Anoxic Event (OAE 1a) with global organic-matter burial in oxygen-depleted oceans, a nannoconid crisis, the growth and demise of carbonate platforms, and dramatic cooling events. Causes of these perturbations include episodes of increased atmospheric CO_2 concentrations derived from volcanogenic and/or methanogenic sources; OAE 1a may have been triggered by the emplacement of the Ontong Java Plateau in the central Pacific Ocean.

The hemipelagic section at Cau (Prebetic Zone, Betic Cordillera, SE Spain) has been selected to provide a new high-resolution reference section for the Aptian. A continuous and expanded succession accumulated in a highly subsiding distal ramp setting located in the westernmost Tethys, at the corridor between the Tethys and mid-Atlantic domains. A robust archive of biostratigraphic data includes ammonites, planktonic foraminifera and calcareous nannofossils, and TOC content, C-isotope stratigraphy and biomarkers from previous studies. Also, a pCO_2 reconstruction has been developed based on biomarker specific C-isotope values, and from that, carbon-cycle modelling has been used to understand the onset of OAE 1a better. These studies supported the selection of Cau for a research drilling project, started in 2015 to study the Cau Aptian record at a high to ultra-high-resolution scale. Here, we present a high-resolution carbonate carbon isotope (δ13Ccarb) curve, calibrated directly to planktonic foraminifera and calcareous nannofossils, and indirectly to ammonite data. Thirteen C-isotope segments (Ap2 to Ap14) have been identified and correlated and further subdivisions are presented. Correlation with other sections worldwide demonstrates the robustness of the C-isotope stratigraphy of the Cau core. The studied succession includes a continuous record of the OAE 1a. Its onset has been analyzed at an ultra-high-resolution scale (0.2–0.5 kyr spacing), revealing a succession of sharp δ13Ccarb negative spikes, interpreted as pulses' record in volcanism and methane emissions. The largest spike was rapid (< 10 kyr) and marks the base of OAE 1a, which occurs within a longer-term falling δ13Ccarb trend. The C-isotope profile across OAE 1a perfectly records the negative (C3/Ap3), positive (C4/Ap4), steady (C5/Ap5) and positive (C6/Ap6) segments that were defined from Cismon (Italy) and subsequently identified worldwide. The Ap7 to Ap11 segments record a C-isotope negative excursion and then positive (Ap12 to Ap14), coupled with high TOC contents, probably related to regional paleogeography. The links with global environmental changes and episodes of widespread deposition of organic matter are also discussed. We propose the Cau core as a new reference section for the Aptian, specifically for OAE 1a, based on its expanded and well-preserved sedimentary, geochemical, and biotic archives further insights into the environmental and biotic changes that occurred during this time interval.

Stratigraphic architecture and characterization of a Neoproterozoic continental slope system, Windermere Supergroup, British Columbia, Canada

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The deep sea is host to the largest depositional elements on earth, termed turbidite systems, that are built up as sediment is transported down the continental slope by sediment-gravity flows, principally turbidity currents. However, the inaccessibility (i.e. extreme water depths), unpredictable timing, and destructive nature of turbidity currents in modern systems has resulted in a poorly developed understanding of their internal stratigraphy and how these systems change in time and space. To bridge this gap, ancient turbidite deposits provide valuable insight into the formative processes and stratal architectures that shape these systems.

At the Castle Creek study area in the Cariboo Mountains of western Canada, the 1 km-wide and 600 m-thick Hill Section outcrop is exceptionally well-exposed due to rapid deglaciation over the last ~100 years. This remarkable exposure along with vertically dipping strata allows for detailed analyses of lithology, composition, and stratigraphic architecture. Additionally, this study correlates strata at the Hill Section with strata reported in earlier studies in the greater Castle Creek area that crop out further along depositional strike, thereby expanding the study area to about 4 km wide. At the Hill Section outcrop continental slope deposits of the Isaac Formation (Neoproterozoic Windermere Supergroup) crop out and consist of three main architectural elements: mass transport deposits (MTDs), channel, and levee deposits. MTDs range up to 90 m thick and because of their wide areal extent form excellent stratigraphic markers. Commonly, but not exclusively, associated with sea level fall, their presence in the sedimentary record offers insight into the state of gravitational stability on the slope at the time of deposition. MTDs are always in direct contact with channel elements that consist of two end-member types: aggradational and laterally accreting channel fills. These channel fills stack to form channel complexes that typically exhibit an upward change from aggradation to lateral accretion. In this way, channel evolution reflects changes in sediment supply and sea level and are integral to understanding the temporal evolution of the system. Levee deposits are commonly adjacent to or overlie channel fills and are exceptionally well-exposed, allowing for detailed description of both lateral and vertical trends. Together, the presence of MTDs, channel fill evolution, and levee strata illustrates periodic forcing on the system, likely related to long-term changes in sea level and sediment supply to the deep-marine system.

Understanding these systematic stacking patterns in ancient slope systems, the conditions under which they formed, and their depositional processes are important for assessing regional and potentially global changes in ancient climate and eustacy. This knowledge has direct application to hydrocarbon reservoir modelling in slope systems at the sub-seismic scale, where lateral and vertical variability in stratal elements can affect reservoir distribution and quality.

Investigating plastic as a sediment

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Plastic has become an almost ubiquitous component of Earth's sedimentary systems being recorded from diverse environments ranging from desert plains through to ocean trenches. It is both abundant and durable over hundreds of years (perhaps even millennia), so we need to consider plastic as part of the sedimentary cycle. To date, many investigations have recorded occurrence, type and concentration of plastic in different environmental settings, though there has been little focus on contextualising plastic distribution within the sedimentary cycle. This is not surprising because plastic is a highly diverse sedimentary material. Plastic varies in size from nano-and micron-sized particles through to meter-sized macro plastic. It has an array of compositions and can be composite with metal, rubber and other anthropogenic materials. It can be formed in almost any shape imaginable, from thin sheets through to robust spheres. As such, understanding plastic within a sedimentological framework and examining the interactions of plastics within the sedimentary cycle is highly challenging. Here we outline a scheme that provides a conceptual and unifying framework for future studies and indicates that plastic can be considered as a 'new' sedimentary component of our planet. Our scheme is supported through evidence collected globally from the modern environment and experimental data, footage of which will be presented. Our data demonstrate that whilst plastic is highly heterogeneous in many of its characteristics, there are common transport mechanisms and depositional behaviours that occur across the spectrum. This information can be used for practical application such as understanding and predicting where plastic builds up in the natural environment in order to inform where environmental clean up may be necessary and most effective.

The Depositional Setting and Astronomical Tuning of the East Georgia Konkian

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Although the Konkian sediments of the Black Sea region contain marine fossils, their position on the global stratigraphic scale still raises some questions (Nevesskaya et al., 2004). The presence of nannoplankton of undifferentiated NN6-NN7 zones in these sediments suggests that the Konkian regional stage of the Middle Miocene in the Eastern Paratethys corresponds to the lower part of the Serravallian of the Mediterranean and to the Upper Badenian (Kosovian) in the Central Paratethys (Nevesskaya et al., 2004; Popov et al., 2013). The age boundaries of the Konkian are not defined precisely. It was assumed that accumulation of Konkian sediments could have occurred from 13.8–13.4 to 13.0–12.1 Ma (Nevesskaya et al., 2004; Palcu et al., 2017; Popov et al., 2013). According to V.M. Tribukhin (Nevesskaya et al.,2004), the Sartaganian and Veselyankian beds of the Konkian correspond to Chron C5An (the time interval of ca. 425000 years: from 12.474 to 12.049 Ma) on the geologic time scale. According to the new data (Palcu et al., 2017), the upper and lower boundaries of the Konkian stage (including the Kartvelian sediments) date to 12.65 and 13.4 Ma, respectively. The Sartaganian and Veselyankian beds had been accumulating over ~240000 years (approximately from 12.89 to 12.65 Ma). In order to estimate the duration of accumulation of sediments, it is necessary to take into account the peculiarities of sedimentation conditions, the analysis of which allows determining the completeness of the geological record, as well as calculating the sedimentation rates. The aim of this research was to restore sedimentation regimes of the Konkian sediments exposed in the Ujarma section of the East Georgia between Karaganian and Sarmatian rocks and represented by clayey and clastic sediments without visible signs of significant gaps.

The Ujarma section, where the Konkian sediments are exposed, is located in East Georgia near the Ujarma village (41°77'62.24"N, 45°14'95.65"E). Here, Konkian sediments with a thickness of approximately 68 m are presented by clays that contain individual layers of sandstones (up to 1.5–2.0 m). During the field study, a detailed bed-by-bed description of the studied succession was compiled and the magnetic susceptibility of the rocks was measured every 20 cm across the strike of the layers using a KT-5 portable magnetic susceptibility meter (Geofyzika BRNO, Czech Republic). The magnetic susceptibility (K) of the rocks of the Konkian sediments varies within the range from 0.103 to 0.387 × 10–3 SI units. Based on statistical methods, using the Lomb-Scargle and REDFIT periodograms, cycles related to long-period insolation oscillations (precession of the Earth's orbit) were revealed. The sedimentation rate was approximately 8.8–13.8 cm/kyr. Konkian sediments were accumulated in shallow-water marine environment.

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Depositional styles in the underfilled phase of the Miocene Carpathian Foreland Basin fill, SE Poland

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The Serravalian Machów Formation of the eastern Carpathian Foreland Basin is known as a gas prolific province. The formation consists of deep-water and deltaic deposits recording a passive filling of an irregular and morphologically complex basement in front of the rising Carpathian thrust-fold belt. Much of sediment supply to the proximal (southern) part of the basin was controlled by tectonically driven cycles and probably also by hyperpycnal feeders. A deep-water fan complex near the base of slope were documented by Polish Oil & Gas Company during exploration phases centered around the Carpathian Frontal Thrust (CT). Thickness maps of upper Badenian sequence show a clear evidence of transverse sediment supply into an elongated basinal turbidite setting. This sequence is dominated by series of finning upward cyclothems that can be easily recognized on well logs and core data. The lower part of each cyclothem is composed of thick-bedded, massive sandstones, which fine upwards into thin to medium-bedded sandstones showing subhorizontal or ripple cross-lamination. The upper part consists of very thin to thin-bedded heterolithic deposits showing no distinctive grading trends and having the sand content of 20–30%. Seismic geomorphology analysis showed that heterolithic strata originated in extensive levee complexes developed around low-tortuosity and mud-rich channels. It is well known that basement morphology can play a key role in terms of turbidity current evolution and differentiation of the resultant turbidites. Such basement control appears particularly pronounced in the underfilled period of basin evolution. The Badenian/Sarmatian boundary marks transition to the development of more symmetrical to coarsening-up cyclothems, which probably reflect a tendency for increased sediment flux during periods of decelerated rate in tectonic subsidence. This trend can be linked to the reduction of flexural tectonics, rapid uplift and increased erosion of the Carpathian orogenic wedge, which was also associated with a change from the transversal to longitudinal sediment distribution in the basin.

Constraining the onset and migration of the central-southern Apennine foreland basin (Italy) by Sr-isotope stratigraphy

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In fold and thrust belts developing at convergent margins, the migration of the advancing wedge is accompanied by bulging of the downgoing plate, followed by the development of a foreland basin floored by a forebulge unconformity and filled by a thick succession of synorogenic sediments. The transition from forebulge to foredeep marks a key moment in the evolution of the orogenic system. In deep-water environments, the record of this transition is typically complete and progressive. Conversely, in the shallow-water/subaerial environment of many collisional systems, the uplift of the forebulge area can imply emersion and erosion, obliterating the stratigraphic record of key steps of the evolution of the orogenic system. The central-southern Apennines developed as a collisional system driven by the retreating subduction of the Alpine Tethys, which caused the migration of the orogenic belt and foreland basin system and the opening of the Liguro-Provençal and Tyrrhenian back-arc basins, along with the rotation and translation of the Sardinia-Corsica and Calabria blocks. In such a context, the central-southern Apennines represent one of those collisional fold and thrust belts where the forebulge stage has implied emersion and erosion, with the development of a regional forebulge erosional unconformity, followed by a trinity of diachronous lithostratigraphic units: (i) shallow-water carbonates, (ii) hemipelagic marls, and (iii) siliciclastic turbidites. Typically, for reconstructing the evolutive model of the Apennine orogenic-foreland basin system, several studies have used the paleomagnetic rotation data along with the age of the siliciclastic synorogenic deposits filling the foredeep and wedge-top depozones and the age of the late-orogenic extensional basins. In this study, we alternatively reveal the importance of investigating the timing and style of development of the forebulge unconformity and the age of the first synorogenic deposits at the base of the foreland basin megasequence. In particular, we have dated with high precision the onset of the foreland flexural subsidence through Sr-isotope stratigraphy applied to the shallow- water carbonates overlying the forebulge unconformity along a transect extending from the inner to the outer sectors of the central-southern Apennines. Our results show progressive rejuvenation of the base of the synorogenic carbonate deposits in the foreland basin toward the outer portions of the belt. Integration of our results with those of previous studies indicates, at the regional scale, a younging trend toward the foreland of the first synorogenic deposits sealing the forebulge unconformity. This result points to four main pulses of flexural subsidence and migration of the foreland basin: i) late Aquitanian, ii) middle Burdigalian, iii) late Tortonian-early Messinian, and iv) Zanclean-Calabrian. We associate this pattern with the differential retreat of the slab in front of the spreading back-arc basins.

The Ségure basin (Corbières, France) compared to the Stephanian basin of Saint-Etienne (French Massif Central)

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The intramontaneous (or limnic) basins of Stephanian age are well-known in the internal zones of the French Variscides (Christophoul et al., 2019). The most famous of those basins is that of Saint-Etienne (see synthesis of Doubinger et al., 1995), where the name of the latest Carboniferous regional substage originated from. Those basins are often called intramontaneous basins related to the collapse of the Variscan orogenic belt (e.g. Faure et al., 2009). The Ségure basin in the Corbières (Southern France) is one of the few basins documented in the external zones of the orogen. Its basin infill has been studied by Cazetien (1982) and Saillol et al. (2019). The aim of the study is to compare those two basins in terms of morphological, palaeontological and sedimentological features.

The Ségure basin is one of the smallest Stephanian basin, with 3 km length and 1 km width. It is a small elliptic, NNE-SSW orientated syncline, very dissymmetric, as its axis is situated near its western border. Laying on a highly metamorphized Lower Ordovician substratum, the basin infill starts with volcanosedimentary deposits, characterized by abundant detritic clasts originated from the local substratum, deposited into a calm lacustrine environment. Volcanic activities are also shown by the formation of pillow-lavas near the basin's eastern border. The second stage of the basin fill shows a flood-plain characterised by very fine-grained sediments, which is dissected by meandering rivers. This formation contains coal-bearing environments. The last stage of the basin fill shows the highest dynamics with coarser deposits of alluvial fans bordering an alluvial plain. Their internal organisation shows the distance to the sediment sources increase gradually. The coal bearing Ségure Formation contains almost all flora, which has been used to attribute a middle to upper Stephanian age for the basin (Vetter in Cazetien, 1982).

The Saint-Etienne basin is the largest of the Stephanian basin in the French Massif Central with a total surface of 207km², orientated NE-SW. The basin infill is more complex but generally present coarse deposits from near sources at the borders of the basin. The first stage of the infill is characterised by alluvial cones and an alluvial plain in the centre of the basin. In the second stage, the sedimentation became finer, and flood plains intersected by rivers developed. Numerous volcanic ash layers in the flood plain deposits illustrates contemporaneous volcanic activity not far from the basin. In the last stage, the deposits in the basin centre are similar to the previous stage, but the basin borders are clearly marked by coarse grained deposits of the alluvial fans.

Despite their different sizes, both basins present a similar evolution of the basin fill. The sources are local at first and in both case, transport is getting longer. The sedimentary dynamics are highly similar for both and the paleoflora found in the same paleoenvironments indicate not different altitudes between the internal and external parts of the orogen.

Depositional setting of Triassic turbidites deposits in Semanggol and Semantan basins across Suture, Peninsular Malaysia

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This study provides systematic characterization of Triassic turbidites associated deposits of Semanggol-SgF and Semantan formations are extensively distributed in NW part of Western Belt and throughout the Central Belt, Peninsular Malaysia. 24-localities (eight for Semanggol Formation-SgF and fourteen for Semantan Formation-SF) have been studied for detailed lithofacies analysis.

14-lithofacies (9-lithofacies from SgF and 14-lithofacies from SF) have been identified which constitute 4-facies groups: I) Conglomerate dominant facies (F1-F4) includes massive clast-supported conglomerate(F1), massive matrix-supported conglomerate(F2), pebbly coarse grained sandstone(F3), normal graded sandstone enriched in mud clasts(F4) and F2 is not observed in SgF, deposited by debris flow/concentrated high density turbidites and formed only minor part of the SgF and SF, II) Sand dominant facies (F5-F10) includes thin bedded Coarse grained sandstone with floating clasts(F5), Classical Bouma Ta-Tb facies (F6), thick- medium bedded sandstone(F7), “CCC” turbidites facies (F8) Heterolithic interbedded medium grained sandstone and mudstone(F9), alternate laminae of sand (light grey) and mud(dark grey)(F10) but F5,F8,F10 lithofacies are not identified in SgF, contains high-low density turbidites which form distinctive part of both formations, III) Choatic unit of mudstone/siltstone-coarse grained sandstone dominant facies (F11-12) includes Sand dominate debrite(F11), major slump/ mass transport deposit (MTD)(F12) and F11 is not observed in SgF, which form a secondary but highly distinctive part of the both formations, IV) Mud dominant facies (F13-F14), includes silt laminated mudstone(F13) and Light pink to brick red, in parts pale yellow, thinly bedded, tuffaceous very fine sandstone-silstone and mudstone, parallel laminated with volcanoclastics(F14), representing a major part of the both formations but 14 are not identified in SgF.

Analysis of the vertical facies successions from (from distal to proximal), has resulted in recognition of four major genetic units: (1) channel-fill complex including sub-channel elements (channel axis – channel off axis – channel margin); characterized by thick-thin and fining upward facies succession (10–12m) and dominated in its lower part by massive-thick bedded debris to sandy high-density turbidites (1–6 m), while the upper part is dominated by high-low density turbidites (4–6 m). (2) Levees or over-bank deposits; characterized by 10–15m thick, finning upward successions which are dominated by low-high density turbidites, (3) Distal lobes; represented by mudstone-dominated intervals mainly thinly bedded (few mm-20cm) low-density turbidites and occasional volcanoclastic sediments dominate at certain horizons. (4) Mass transport complexes (MTCs); characterized by highly deformed debrite and slumped units (29–32m). These four genetic units were deposited within three proposed laterally contiguous depositional environments which are: (1) inner fan channel-fill complex; (2) mid fan levee or over bank complex and (3) outer fan distal lobes.

The submarine fan of both formations is interpreted as a multiple-sourced, shelf-fed, Type III, high-low efficiency, mixed sand-mud rich depositional system. The major difference in both turbidites deposits of two wide separated basins across suture zone is lithofacies and intensity of deformation. Therefore, this work demonstrates how structural confined mini-basins i.e., rift/graben basin configuration directly impacts the behavior of gravity-driven flows.

Healed speleothems: testimony of neotectonic activity of karst areas

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The term 'healed speleothems' refers to the speleothems that were subjected to fracturing as a result of brittle deformations. The originated fractures were subsequently filled by calcite. So far, such a phenomenon has not been described in details. The studies were carried out to characterize the healed speleothems and recognize the mechanisms responsible for their formation.

The healed speleothems have been noticed in the Čarovná chodba – one of the side passages of Demänovská Cave of Liberty (Demänovská jaskyňa slobody; the Low Tatra Mts, northern Slovakia). The passage richly decorated with speleothems is developed along the rejuvenated normal fault dipping toward NW. There are numerous damaged speleothems, including fractured and subsequently healed columns, in this passage. The fractures form a polygonal pattern on the column surfaces. The measured orientation of the fractures corresponds to the strike of the fault that guides the passage. The width of the fractures ranges from 0.02 mm to 0.4 mm.

The fractures are filled with calcite healings. The distribution and the internal structure allowed to distinguish three end-member types of the healings:

type 1 – the internal part of the fracture is filled with calcite that has a continuation as a ridge on the speleothem surface,

type 2 – the internal part of the fracture remains empty; however, the ridge occurs on the speleothem surface,

type 3 – the healing occurs mainly near the fracture mouth and has an asymmetric structure.

Additional attention is attracted by helictites that cap some ridges or grow directly on the fractures. The first and the second types of the healings occur within the subvertical or vertical fractures. The third type usually occurs in the wider fractures with lower dip.

Dominant parts of the ridges are built of the columnar microcrystalline microfacies; however, the microsparite and mosaic calcite occur as well. The calcite occurring within the fractures healing is usually developed as microsparite. The helictites are usually built of elongated, fan-shaped crystals of columnar microfacies. The ratio of oxygen and carbon stable isotopes of the healings fall in the same range as calcite that form columns.

The healings of the 1 and 2 types were fed by the water seeping down the open fractures in speleothems. Precipitation of calcite proceeds near the fracture mouth where degassing of CO2 out of the water is possible. The formation of the 3 type results from gravitational flow of water down the column surface and its temporal stagnation over the fracture upper lip, which allows efficient degassing of CO2. Helictites are formed when the permeability of the fracture is diminished by growing calcite, which builds the hydrostatic pressure of feeding water.

The healed speleothems are a record of seismotectonic fracturing of speleothems during their growth. In the studied case the most probable factor is movement along the fault which guides the passage since the columns are exceptionally sensitive to any movements of the ceiling and floor of the cave.

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The influence of channel planform and slope topography on turbidity current overbank processes

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Turbidity currents can be deflected, reflected, or constricted, depending on the geometry of the bounding slope and the angle of incidence of the current. The aim of this paper is to understand how the interaction of different types of flow with seafloor morphology affects depositional processes and the distribution of small-scale bedforms. Our case study is the Acquarone Fan, located in the intraslope Gioia Basin in the south-eastern Tyrrhenian Sea. The research is carried out through multibeam bathymetry and high-resolution chirp subbottom profiles. The study area has a complex physiography, mainly controlled by the presence of the Acquarone structural ridge, that results in the confinement of the left side of the channel-levee system. Seven units (Unit I-VII) record the recent depositional history of the fan; their thickness in the overbank area has been mapped. The analysis of seismic facies shows that Unit IV and V are relatively coarser-grained than Unit I, II, III and VI while Unit VII presents an intermediate facies. Extensive bedform fields develop in specific tracts of the right levee along the channel path. The first bedform field is located in the outer side of a bend in the channel and consists of elements that are parallel to the curvature of the channel. Further downslope, in a straight tract of the channel, confined to the left by the Acquarone high, a second train develops on the right levee with a trend oblique to the channel direction. Finally, along the distal straight unconfined channel segment, a third train of bedforms begins in coincidence to an abrupt knickpoint, which occupies the channel axis and trends subparallel/oblique to the channel axis. According to unit thickness maps, two main patterns of deposition are recognized on the overbank area. The first pattern (belonging to coarser-grained units) has depocentres in correspondence of the first and third bedform fields while the second pattern (belonging to finer-grained units) in coincidence of the second field. We suggest that the location of the depocentres is controlled by the prevalent flow-type and by its interaction with the surrounding morphology. In particular, the first thickness trend results from the deposition of high-density bipartite turbidity currents, with spillover of their lower portion mainly reflecting variation in the channel path. The second thickness pattern is connected with low-density turbidity currents, more conditioned by the extent of flow confinement.

Volcanically-induced, extremely-high sedimentation rates preserved tidal channel morphology in hypertidal Miocene estuaries of Patagonia

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The late Miocene beds of the Puerto Madryn Formation (Chubut, Argentina) are mostly formed by volcaniclastic sediments accumulated in shallow marine and estuarine settings. In spite of the general volcaniclastic composition of that unit, the type and amount of the volcaniclastic components is highly variable. Very high content of fine-grained volcanic glass particles is detected in some intervals, which are thought to be synchronous to bimodal volcanism 200 km to the west of the area of final sedimentation. The upper part of the Puerto Madryn Formation is often composed of vitric tuffs, accumulated in estuarine and shallow marine settings, particularly in fluvio-tidal channels of macrotidal to hypertidal estuaries, which are well exposed on the cliffy coasts of Peninsula Valdés. These channels show an about 10 m thick (on average) fining-upward infilling starting with intraformational lag conglomerates above deeply erosional surfaces interpreted as fluvial ravinement surfaces overlain, and eventually truncated (and suppressed), by tidal ravinement surfaces, which extended upstream to the inner part of the estuary during long periods of low sedimentation rates, extended channel migration and sediment bypass. These are in turn covered with high-energy, bioclastic conglomerates with negligible volcaniclastic contribution, mostly formed in the “tidally dominated/fluvially influenced” part of an estuary representing the “normal” sedimentation in the channels. Above, large point bars with tuffaceous sandy/muddy seasonal heterolithic beds and varying content of trace and body fossils were deposited from the freshwater fluvially dominated to saline-water tidally dominated part of the estuary. The upper channel infill is formed by cross-bedded sands with thick mud drapes and seaward-directed paleocurrents, together with barren, volcaniclastic sandy to muddy heterolithic seasonal rhythmites, both deposited in the fluvially dominated part of the estuary. Currents reworked the ash in the channels and selectively sorted the sediments. Most of the light glass was concentrated in the fine sediments. Direct fallout ash deposits are rare in the column but thick intervals dominated by reworked ash are common. After large explosive volcanic eruptions on land, on the headwaters of the drainage basin, the ash was firstly driven by the rivers from locations close to the volcanoes to more distal coastal locations, that underwent a (geologically) instantaneous input of volcaniclastic sediments. This resulted in sedimentation rates as high as 0.9 m per year recorded in tidal rhythmites. All the accommodation space available for sediments was swifty filled preserving morphological features, like steep walls of paleochannels in entrenched meanders or of ravines cut by the rivers during lowstands, which are normally not recorded because of smoothing by erosion during or after channel migration.

Early Permian fluvial-lacustrine system interaction in the Krkonoše Piedmont Basin, NE Czech Republic

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The Krkonoše Piedmont Basin (KPB) is located in the eastern region of an extensive basin system that spans from western Bohemia to the central Sudetes. The KPB formed as a result of extension/transtension during early post-Variscan (c. 310–280 Ma) times and comprises up to 1800 m thick Upper Carboniferous (Moscovian/Kasimovian) to Lower Triassic non-marine deposits. The KPB probably originated as a half-graben with maximum subsidence adjacent to a major NE-SW trending normal fault that constituted the northern basin margin during late Carboniferous and early Permian (Asselian) times. This study focuses on the Vrchlabí Fm. (Asselian, up to 300 m thick) in the southern part of the basin and comprises a sedimentological and architectural element analysis of a fluvial system, which flowed into an extensive lake that occupied the northern region of the KPB. The lake deposits record frequent drying up and periodic shallowing/deepening. Fluvial arkosic sandstones and conglomerates, interpreted as multi-storey or single channel fills, were deposited by braided river system. The coarse-grained channel-related facies are interbedded with fine-grained floodplain facies that occur with different preservation potential in the vertical profile. Successive channel fills are arranged into three architectural units, where unit 1 and 3 are characterized by multi-storey channel bodies that incised thick (> 1 m) floodplain sediments, while unit 2 does not contain floodplain deposits and typically exhibits single channel bodies that show higher cementation rates than units 1 and 3. To understand better the main factors controlling the fluvial system evolution and its interaction with an extensive lake in the northern KPB (e.g., if base level changes were controlled by lake level changes), we focused on 'transitional' facies consisting of alternating grey parallel- to ripple-laminated sandstones and up to 10's of cm thick dark grey mudstones. These facies are interpreted as bottomsets of lacustrine microdelta/mouth bars deposited by traction and recurrent gravity currents that were triggered by seasonal floods supplying turbid suspension from fluvial feeder system to the lake. Further, a detailed correlation of existing well-logs and newly acquired outcrop gamma-ray logs revealed complex lateral and vertical relationships between the fluvial, the 'transitional' and the lake facies in the southern and central parts of the KPB. Our study illustrates the usefulness of an interdisciplinary approach to reconstruct a basin's history in a region with sparse outcrops and very limited fossil record.

The sedimentary record of contamination in modern oxbow lakes; Ostrava urban agglomeration area, Czech Republic

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The aim of this contribution is to describe the contamination history and evaluate an impact of highly industrial Ostrava urban agglomeration to sensitive oxbow lake systems along the Odra River. The study is focused on the oxbow lake located directly downstream of the Ostrava city (near Bohumín city) on the border between the Czech Republic and Poland, providing a high sediment preservation potential, and hence contamination record since the cut-off event in 1966. Four oxbow lakes, located in the Poodří protected landscape area (upstream of Ostrava city), were selected for the comparison of contamination levels. There, the natural river reach of the Odra River is preserved. Two of oxbow lakes were created after the flood in 2010 by a rupture of the meander neck. Another two oxbow lakes were formed artificially due to shortening of the Odra River course in the 1960s.

Oxbow lake's infill, retrieved from shallow sediment cores, shows distinct proximal-to-distal trends associated with the varying sedimentation rates and sedimentation processes. More coarse-grained silty sands or sandy silts prevail in the plug bars, and in the proximal parts, while silts or clayey silts prevail in the central and distal parts of the oxbow lakes. The petrophysical proxies (especially spectral reflectance and magnetic susceptibility logs) show certain variability, which can indicate seasonal variations in sedimentary conditions. In general, sediment accumulation rates were fastest during the first years and decades after the formation of oxbow lakes and later slowly decelerated due to ongoing isolation. Depth trends in 137Cs mass activity, DDT metabolites and hexachlorobenzene were used as additional date levels.

The Bohumín oxbow lake was highly impacted by coal mining activities, documented by the presence of coal-rich layers. The vertical distribution of pollutants reflects industrial development over the last 50 years in the region. Heavy metal concentrations (Ni, Cu, Zn and Pb) are very low in the Poodří protected landscape area (at the level of the lithogenic background), while the Bohumín oxbow lake is heavily polluted, implying a pollution source within Ostrava agglomeration. Main inorganic pollutants are Zn and Pb, showing maximum enrichment factor of 20.6 and 12.9, respectively. In addition, organic pollutants were investigated (polycyclic aromatic hydrocarbons, polychlorinated biphenyls and organochlorine pesticides) in the Bohumín oxbow lake. An anomalous peak of polycyclic aromatic hydrocarbons was detected in the coal-rich strata due to secondary sorption. Maximum concentrations of all pollutants were attained during the 1970s and 1980s, which was also the maximum of coal production. A general decrease of both organic and inorganic pollutants in the upper strata is related to the decline of heavy and other industry after the fall of the Iron curtain in 1989.

Resultant contamination levels depend on the oxbow lake position and distance from contamination source, the extent of permanent connection, flooding frequency, oxbow lake's size, geometry, and the distance and elevation difference from the river. Oxbow lakes were also more vulnerable to contamination in the initial stages of their evolution due to the possibility of frequent flooding.

Factors controlling oncoid distribution in a shallow carbonate ramp (Kimmeridgian, NE Spain)

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The characterization of the different oncoid types and their distribution in the shallow domains of a latest Kimmeridgian (Late Jurassic) carbonate ramp was accomplished by the detailed sedimentological and petrographic analysis of the lower 30 to 50 m-thick succession of the Higueruelas Formation outcropping south of the city of Zaragoza (NE Spain). This characterization allowed recognizing six types of oncoids on the basis of the internal structure of the cortex, which show a preferential distribution on the carbonate ramp, recording deposition from inner- (lagoon, backshoal, shoal-sand blanket) to mid-ramp domains (foreshoal, offshore). Type I oncoids are well rounded and micrite-dominated, and occur in all the subenvironments in low proportions. Type II oncoids are also well rounded and micrite-dominated, but include discontinuous organism-bearing laminae of mostly Bacinella irregularis, and predominate in the high-energy shoal-sand blanket domain. Type III oncoids are irregular to well rounded, and show alternating micritic and organism-bearing laminae of mostly Bacinella irregularis-Lithocodium aggregatum association. Variations in thickness of the micritic and organism-bearing laminae allowed recognizing two varieties for this oncoid type: type IIIa oncoids, where both micritic and organism-bearing laminae show similar thickness; and type IIIb oncoids, which show thinner micritic laminae. Fluctuating higher- and lower-energy conditions controlled the generation of type IIIa and IIIb oncoids, being type IIIa oncoids characteristics of the backshoal and foreshoal domains, particularly abundant in the latter; and type IIIb oncoids commonly found in a low-energy sheltered lagoon, with longer periods of calm conditions. Microbial activity controlled the generation of the irregular and microbial-dominated type IV oncoids, which also encompass to varieties: type IVa oncoids, which are entirely formed by a microbial meshwork mainly of Bacinella-Lithocodium association, occur abundantly in the lagoon; and less abundant type IVb oncoids, which are composed of continuous organism-bearing laminae of Lithocodium, are found in the mid-ramp domain. The preferential distribution of these oncoids across this shallow carbonate ramp is the result of the interplay of water energy and microbial activity, being also the high-diversity of light-dependent micro-encrusters in type III and IV oncoids reflect of normal-marine waters and oligotrophic conditions. The oncoid classification proposed here updates previous nomenclatures for marine carbonate oncoids, reporting in further details about their internal characteristics, and their preferential distribution across the studied shallow carbonate ramp provides additional information about the internal processes and depositional topography.

Keywords: shallow carbonate ramp, Kimmeridgian, Higueruelas Formation, marine carbonate oncoids

Aptian anoxic basin of the Russian Platform: recognizing a responses to global and regional controls

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Early Aptian anoxic basin of the Russian Platform (RP) is one of two currently known epicratonic paleobasins (second is situated in Northern Germany) where the onset of anoxia coincides with global OAE1a. This was recorded in thinly laminated, almost non-bioturbated "bituminous shale" (3–10 m) containing 4–9% TOC, with scarce benthonic fauna and ammonites of Deshayesites volgensis (=forbesi) Zone. The lack of calcareous microfauna and poor calcareous nannoplankton (Rhagodiscus angustus Zone, NC7) contributing only 5–10% CaCO3, limit recognizing of characteristic C-isotope excursions for the onset and duration of OAE1a. Thus, it is a problem to conclude whether the anoxia occurrence in the Early Aptian basin of RP a response to OAE1a. New integrated study, carried out in the Central Russia enables to get more dense arrangement of representative sections and provide new insight about the facies distribution and molluscian paleoecology, to apply C-isotopic chemostratigraphic curve, obtained from the aragonitic ammonite shells.

The Early Aptian anoxic paleobasin had a mud-depocenter with a radius ~200 km around the modern Ulyanovsk City, and the finely laminated "bituminouse shale" occurred in its central part (60–100 km in radius). The shoreface sand-dominated lithofacies, with rare bivalves, are recognized at a distance 300 km to the west, and alluvial cross-stratified sands are observed at 500–600 km, in the Moscow area. Southerly, about 300 км from the mud-depocenter, the heterolithic 5–10 cm-scale sand-silt-mudstone alternation, with unimodal cross-laminated small ripple were met and interpreted as deltaic facies. The wide (150–200 km) transitional belt surrounded anoxic depression. The shale with silty laminations, flattened sandy lenses (20–25 cm in length) and 1–5 cm-intercalations of well-sorted coarse silt were accumulated within the belt under the strengthened paleodelta influence. Additionally, the belemnites Oxyteuthis are totally disappear in the "bituminous shale", and ammonites Deshayesites demonstrate an obvious shell size reduction.

C-isotopic curve, measured in aragonite of well-preserved ammonite shells (17 specimens of Deshayesites volgensis), shows distinct positive excursion at the base of the "bituminous shale", which is in agreement with the C3-C4 segment of the global C-isotopic OAE1a-curve, measuring in planktonic carbonates of the oceanic sections. However, the following shift to the negative values deviates from the next segment C4-C5 showing long positive excursion during OAE1a. This disagreement could indicate the major influence of local factors (fluctuations in bio-productivity and/or salinity) on the C-isotopic composition in the ammonite shells. The O-isotopes negative values, giving with sedimentological, paleoecological and C-isotopic data, can support a freshening of surface waters in the Early Aptian paleobasin, that could generated by a large river systems. So, the "Moscow fluvial paleosystem" recognized in the north-west, and the "Voronezh fluvial paleosystem" in the south-west of Russian midlands. Periodically (seasonally) generated hypopycnal plumes of muddy fresh-water rich in nutrients led to unfavorable conditions for normal marine plankton in the surface waters due to opacity, abnormal salinity, and high buoyancy prevented mixing and contributed to stratification. Such condition in upper photic zone caused a rapid growth of highly tolerant organic-walled plankton, such as green algae, whose remains are numerous within the "bituminous shale".

Sedimentary controls on animal behaviour during the Siluro-Devonian colonization of the continents

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Throughout the history of life on Earth, sedimentary environments have placed significant controls on the trajectory of evolutionary innovations. To survive and thrive in newly-colonized sedimentary environments, organisms have needed to develop novel behaviours: often evidenced in the rock record as architectural innovation and diversification in trace fossil morphology. This study focuses on ichnological diversification as a response to sedimentary pressures during the late Silurian to early Devonian colonization of the continents by invertebrate life. The diversity and disparity of trace fossils from this interval reveals details of the biological response to newly-adopted sedimentary and environmental conditions. Extensive fieldwork, supported by a review of the wider literature, has identified trends in trace fossil record which can now begin to answer how the physical nature of non-marine sedimentary landscapes imparted first order controls on their pioneer colonizers, before they in turn irrevocably changed the operation of non-marine sedimentary environments.

This presentation will 1) describe which specific ichnotaxa and broader architectural designs became abundant in non-marine strata during the Siluro-Devonian; 2) discuss the implications of this ichnological diversification for understanding the biological challenges, main tracemakers and ecosystem engineering during the terrestrialization process; and 3) emphasise how substrate composition was a fundamental control on ichnoassemblages, and how these physical sedimentary properties affected the radiation of animals into different environments. New field data from Europe, North America, South Africa, and Australia is presented to support these findings, which shed new light on a crucial interval in the co-evolution of life and the planet.

The Neoproterozoic Oxygenation Event and the Cryogenian-Ediacaran Bambui Group, central Brazil

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The Bambui Group is an ca. 2,000 m-thick Cryogenian-Ediacaran (ca. 635–560Ma) mixed biochemical-siliciclastic sedimentary succession that accumulated in the Sao Francisco Basin, central Brazil. It is composed of six stratigraphic sequences recording the depositional evolution of this epeiric sea from the Marinoan (ca. 635Ma) to the Gaskiers (ca. 580Ma) snowball glaciations. This interpretation differs significantly from longstanding ideas regarding the stratigraphic architecture of the Bambui Group. Collectively, these sequences constitute one of the most complete records through the apex of the Neoproterozoic Oxygenation Event (NOE).

Sequence 1 rests on older basement rocks and is comprised of Marinoan glacial deposits and overlying cap carbonate. High barite contents in the cap carbonate suggest persistently euxinic conditions accompanied glacial retreat. Sequence 2 is composed of lime-mudstone with terrigenous siltstone. These basinal sedimentary rocks change laterally into peritidal phosphorites, which indicate oxygen stratification in shallow paleoenvironments. Sequence 3 is a carbonate succession dominated by stromatolites, implying widespread photosynthetic oxygen production. The top of Sequence 3 is marked by a regional unconformity interpreted to have developed during the onset of the Brasiliano-Pan African Orogeny. Sequence 4 signals a return to siliciclastic deposition. Loess derived basinal deposits are organic matter-rich and contain abundant framboidal pyrite with δ34S values between +10 and +24‰, reflecting bacterial sulfate reduction in low sulfate Ediacaran porewater. Sequence 5 is the only sequence composed of well-developed parasequences, which are formed of deep subtidal organic-rich siltstones that aggrade upwards into shallow-water stromatolites and carbonate grainstone. Such well-defined cyclicity is a hallmark of glacioeustacy and thus interpreted to record the onset of the Gaskiers Glaciation. As in Sequence 3, the ubiquity of stromatolites suggests an oxygen-stratified water column. Sequence 6 marks the change from an epeiric sea to foreland basin. This sequence is characterized by interbedded basinal glauconitic siltstone and loess-rich shale that are correlative in shallower environments to shoreface sandstones. Because authigenic glauconite requires suboxic bottom waters to precipitate, it reflects oxygenation of distal settings. Deposition ended by ca. 560 Ma when the entire Bambui Group was deformed during the assembly of Gondwana.

When compared to other Neoproterozoic successions, the Bambui Group is unique because it hosts a diverse array of redox-sensitive, authigenic lithofacies. This novel record of seawater oxygenation reflects the establishment and deepening of an oxygen chemocline through the Cryogenian and Ediacaran. Such progressive ventilation is observed elsewhere and paved the way for the evolution of multicellular animals. Periodic loess accumulation suggests the establishment of a major mid-latitude eolian system before and after the Gaskiers Glaciation. These interpretations redefine what is known about the development of the Sao Francisco Basin, and highlight the significance of the Bambui Group for understanding late Neoproterozoic Earth history.

Advanced statistics of grain-size, petrophysical and geochemical data: a tool in loess-paleosol sequences paleoenvironmental interpretations

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Loess-paleosol sequences (LPS) represent an important paleoenvironmental and paleoclimatic archive in terrestrial settings. Alternation of loess and soil horizons reflects the Quaternary climatic oscillations, because windblown dust is typically deposited during dry and cold periods, while warmer and humid periods are more suitable for chemical weathering and pedogenic alteration of loess. Climatic cyclicity is also reflected in changes of grain size distribution and chemical composition of LPS, which is traditionally used for paleoclimatic and paleoenvironmental reconstructions. Apart from climate, source area geology, transportation processes and post-depositional changes affect the geochemical and grain size characteristics of LPS.

The study is focused on three poorly studied LPS sections (Rozvadovice, Brodek u Prostějova, Dobšice u Znojma) recording the last Quaternary glacial-interglacial cycle. Selected localities represent lowland areas in the Czech Republic with the prominent loess accumulation. The unique position of the Czech Republic, where oceanic and continental macro-climate meet and close to the margins of both continental and alpine glaciations is the main reason why LPS research in this area is necessary for better understanding of European climatic oscillations during the Quaternary.

Field observations and subsequent laboratory characteristics (granulometry, colorimetry, magnetic susceptibility) were the core methods for description of loess and paleosols. Sections were sampled in regular 10 cm interval. Granulometric analysis of 188 samples was performed by a laser diffraction method (FRITSCH NanoTec Analysette 22 Particle Size Analyzer operating in 0.08 to 2000 μm range). Concentrations of major and trace elements (Al, Si, K, Ca, Ti, V, Mn, Fe, Cu, Zn, Rb, Sr, Zr, Pb) were determined by energy-dispersive X-ray fluorescence method (Delta Premium EDXRF spectrometer) in 297 samples. Each sample was manually powdered in agate mortar. EDXRF data were calibrated using 44 samples analyzed also by ICP-MS.

In this study, we apply standard bivariate and multivariate statistics and advanced statistical methods (log-ratio methodology for compositional data analysis, Bayes spaces for processing of particle size distributions, weight pivot coordinates to automatize the selection of elements for grain-size correction) to effectively separate the geochemical and grain-size signals of provenance, transport mechanisms, weathering and diagenesis in the LPS. Since the LPS represent extremely useful terrestrial archives, the proper understanding of these controls is a prerequisite for correct paleoclimatic interpretation. The separation of the provenance signal from the paleoclimatic signal is a challenge due to varied local geology.

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Volcaniclastic deposits within Late Cretaceous Deccan basalt, India and their implications on Martian weathering conditions

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The Cretaceous Deccan basalt in western and central India contains several volcaniclastic deposits, which are commonly known as bole beds. Although several studies provided chemical characteristics of these deposits, a detailed mineralogical and petrographical characterization is yet to be carried out. This study presents a combined field, petrographical and geochemical characterization of bole beds to highlight the origin of volcanogenic clay minerals. Field investigation reveals the variable color of these bole beds including red, orange, brown and green, with thickness varying from few centimeters to meters. These beds may exhibit either fine laminae or they may be massive, having sharp upper and gradational lower contacts. Mineralogical and petrographical study of bole beds reveals basaltic fragments, altered glass shards of black, brown and orange color as predominant constituents of these coarse tuffs. The basaltic fragments exhibit microlitic and lathwork texture containing microlites and laths of plagioclase, pyroxenes and opaques. Hematite, altered and fresh plagioclase, pyroxene and iddingsite are moderately abundant, while olivine, iddingsite, brown amphibole, zircons, Fe-Ti opaque phases like ilmenite and magnetite occur as accessory phases. Mineral chemical investigation by electron probe micro-analyzer identifies the pyroxene as augite, plagioclase as labradorite and andesite, opaque phases as Ti-magnetite and ilmenite and clay as Fe-montmorillonite. The green boles consist primarily of celadonite, plagioclase, pyroxene, altered volcanic glasses and Fe-Mg-rich clay minerals. Celadonite occurs as infillings within vesicles and as alteration rinds around plagioclase, pyroxene and glasses. Zeolite and silica occur either as pore-filling authigenic phases and as altered volcanic glasses in both red and green boles. Extensive zeolitization and replacement by smectites have obliterated the original texture and color of glass shards. The study of clay mineralogy using X-ray powder diffraction reveals the presence of montmorillonite as the dominant clay mineral with mixed layer smectites in red bole. While celadonite, Illite, montmorillonite is dominant clay mineral in green boles. Visible to near-infrared spectroscopy using contact probe Spectroradiometer confirms the mineralogy of clays. Incipiently developed palaeosol horizon with root traces in places indicate the formation of red boles by the alteration of the basalt during a relatively long period of quiescence in oxic conditions. The presence of fresh olivine and pyroxene in a few red boles indicates the arid climatic condition for those bole beds. Iddingsite occurs as an alteration product of ferromagnesian minerals in red boles and supports the oxidative weathering condition. The presence of zircon within a few bole beds is intriguing, but relates to an external source. Celadonite formation is facilitated by the dissolution of volcanic glass and pyroxene that supplies K and Fe-Mg. Green bole containing celadonite as dominant constituent indicates the dys-oxic condition. The study of bole beds within Deccan basalt is significant to infer Physico-chemical conditions on the Martian surface containing clay minerals such as Fe-Mg smectites, Al-phyllosilicates, celadonite.

Facies of deep-water sand-prone fan lobes at Klęczany, the Cergowa Beds (Oligocene), Polish Outer Carpathians

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In the Klęczany Quarry, almost 200 m thick section of the Cergowa Beds deep-water succession documents vertical and lateral facies changes in the sand-prone lobe complex over a lateral distance of 900 m. Three main facies associations have been distinguished: (A) very thick- and extremely thick-bedded, amalgamated, massive, normally graded or subordinately plane-stratified and plane-parallel laminated medium-, fine- or coarse-grained sandstones and pebbly sandstones, which form composed beds, up to 9 m thick; locally with mudstone clasts or rafted fragments of mudstone beds and associated slumped beds; (B) thick-, very thick- to medium-bedded, massive, normally graded fine-, medium- or coarse-grained sandstones, often topped with thin, laminated siltstones or silty mudstones, commonly rich in coalified plant detritus; plane-parallel or ripple-cross lamination is occasionally found at the bed top, and, less frequently, in the basal part of bed; mudstone clasts are present, especially in upper part of beds; (C) thick- to thin-bedded, plane-parallel, wavy or ripple cross-laminated, subordinately massive and plane-stratified fine- and very fine-grained sandstones topped with laminated siltstone and massive/graded mudstones, intercalated with thin- and very thin-bedded rippled siltstones coupled with mudstones; single medium-bedded hybrid sandstones and debrites occur; laminated sand beds are interbedded with packages of very thin- and thin-bedded ripple cross- or parallel-laminated siltstones coupled with mudstones (C1), up to 25 beds in one set.

These facies cover a wide range of density flow deposits. The thick- and very thick-bedded, massive and normally graded sandstones represent the product of high density turbidity currents (or in some instances – sandy debris flows). Complexes of amalgamated sandstones may overlie scour surfaces or deformed sandstone and mudstone beds, suggesting high energy of the overriding high-density flows. The thick- and medium-bedded, graded to laminated sand beds were deposited from high- to moderate-density turbidity currents and diluted, residual turbidity currents. The wide range of laminated fine-grained sandstones and siltstones coupled with mudstones are the product of moderate- to low density waning or quasi-steady turbidity currents.

It can be inferred that the succession at Klęczany represents a part of basin-floor lobe system of turbidite fan developed in the Fore-Magura Basin. The section reflects gradual transition from: 1) lobe axis channels filled with amalgamated, massive and normally graded sandstones (facies associations A and B) representing 4 or 5 stacked lobes separated with 1–7 m thick complexes of heterogeneous associations which may represent lobe off-axis (facies association B), and lobe fringe or lobe distal fringe settings (facies associations C and C1), to 2) lobe fringe settings with laminated sandstones intercalated with silt-mud bedsets (facies associations C and C1) stacked in positive sequences, and with single outcrop-scale, lenticular, up to 11m thick sand bodies of thick-bedded amalgamated sandstones. The whole succession may represent the retrogradational stacking pattern beginning with the fan related to the initial uplift of the basin and source area activation followed by the subsequent gradual subsidence and source area drowning and decline in sediment supply, which correspond to the pattern of evolution of the Carpathian subbasins during early Oligocene.

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Textures and structures of Oligocene-age mixed siliciclastic-carbonate turbidites in Szczawa Tectonic Window, Polish Outer Carpathians

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The Szczawa Tectonic Window is located in Western Polish Outer Carpathians, 60 km south of Kraków, Poland. The studied section is a 90 m thick part of a succession comprising lower Oligocene strata classified as the Grybów Beds succeeded by the Cergowa Beds of the Grybów Tectonic Unit. The succession is composed of turbiditic Bouma-type sequences, which form very thin to very thick beds intercalated with characteristic depositional rhythms composed of thin-bedded marlstones, and solitary extremely thick sandstone-marlstone couplets. The Bouma-type sequences constitute 78% of studied succession and form beds 5–315 cm thick. The lowermost parts of these beds are developed as laminated sandstones and siltstones, and can attain 45 cm in thickness. They pass into laminated to graded/massive or, less frequently, into massive calcareous mudstones or marlstones. Thickness of muddy subdivisions varies from a few centimetres to as much as 275 cm.

Two types of mixing are recognized in the succession: (i) strata mixing, i.e. interbedding of siliciclastic and carbonate beds, and (ii) compositional mixing, which occurs when siliciclastic and carbonate particles are mixed and deposited simultaneously to form millimeter- to meter-scale beds. Compositional mixing is the major type of mixing observed in the Szczawa section. Almost the entire succession contains carbonates as: (i) framework grains (lithoclasts and bioclasts) and matrix/cements or (ii) almost only matrix/cements with subordinate proportion of carbonate grains. Most of sandstones and siltstones developed as divisions of Bouma-type sequences contain relatively high proportion of carbonates, varying from 15% to 58%. The proportion of carbonate framework grains in total framework grain population changes from 1–2% to as much as 90%. Carbonate grains occur as bioclasts (foraminifera, fragments of red algae and bryozoa), abraded lithoclasts of micrite or sparite, and squashed carbonate mud grains.

Vertical variations of carbonate components in turbidite beds show several different patterns. Generally, carbonates content: (i) increases towards bed top so that laminated intervals usually contain their relatively high proportion (20–40% of total weight) and grade into marlstones with 35 – 50% of carbonates; (ii) is highest in laminated intervals (some plane-parallel and ripple cross-laminated intervals contain more than 50% of carbonates, as much as 58%), and either decreases, reaches minimum and again increases, or constantly decreases upward; (iii) fluctuates over the bed profile with no specific pattern. Such patterns may be owing to: (i) segregation of carbonate grains and pelitic carbonate matrix within sediment gravity flows; (ii) high proportion of carbonate grains in sand-/silt-sized laminated basal intervals; (iii) postdepositional precipitation of carbonates in pore spaces of sand- and silt-sized laminated intervals.

Microscopic observations of laminated intervals reveal two regularities: (i) segregation of components within single plane-parallel or cross laminae; (ii) alternating of silt laminae enriched in carbonates and laminae depleted of carbonates. It is inferred that the structures and textures of laminated intervals, especially segregation of components, resulted from hydraulic separation of fractions of different physical properties. The most effective hydraulic sorting was recorded in plane-parallel laminae, namely heavy siliciclastic sand-sized grains are separated from lighter and coarser bioclasts.

Fractionation of skeletal carbonate deposits due to shape-dependent settling velocity

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Particle settling velocity is a fundamental parameter in sedimentology and engineering, and has accordingly received much attention in the literature. Despite the global importance of resedimented carbonates, both modern and ancient, the field of particle hydraulics is strongly biased towards terrigenous sediments. The mechanisms that affect terminal settling velocity in part also control the threshold of initiation of motion and sediment entrainment into suspension. Terminal settling velocity may therefore provide insight into the sediment dynamics of systems largely affected by bedload transport as well. Terminal settling velocity depends on sediment properties, including particle size, density and shape. In this study, we investigated the effect of particle shape on the settling velocity of natural irregular carbonate grains of heterozoan composition using settling tube and flume experiments. Grains were binned into half-phi grain-size intervals obtained by sieving. High-resolution particle shapes have been determined using computed tomography (CT) scanning at a resolution of ca. 10 micrometres, constraining particle shape in terms of flatness (spheroidal to disc-shaped) and elongation (spheroidal to rod-shaped). First, the influence of particle shape on the terminal settling velocity of individual grains was tested. Second, it was investigated whether the observed trends hold for the vertical bulk settling of suspension clouds. Third, low-concentration carbonate turbidity currents were generated. The experiments revealed that shape fractionation occurred in all three setups. Terminal settling velocity of individual grains was up to three times larger for spheroidal shapes than for some of the flat and elongated carbonate particles. In the bulk-settling experiments, the largest differences between particle shapes was observed between the bottom and top of the deposits. Up to 10% is reported for shifts in particle flatness, i.e. from spheroidal (higher settling velocity) to disc-shaped (lower settling velocity). Smaller differences are documented for changes in particle elongation, i.e. from spheroidal (higher settling velocity) to rod-shaped (lower settling velocity). Similar trends were observed for the deposits of the low-concentration carbonate turbidity current experiments. For all experiments, fractionation became more important as grain size increased. Because the shape of carbonate grains is to a large extent a function of biological composition, the experimental deposits have also been investigated for shifts in microfacies. Although the experiments demonstrated that shape-dependent settling velocities exert an influence on vertical (bulk settling) and longitudinal (turbidity currents) trends in associated deposits, the first control on settling velocity remains grain size. The effect of shape-dependent fractionation in carbonates and associated microfacies in wider grain-size distributions as encountered in natural suspended-load-dominated (calciturbidites) and bedload-dominated (neritic skeletal carbonates) depositional systems remains to be explored further.

Carbonate fabric diversity and preservation influenced by clastic deposition archived in Neoproterozoic mixed successions

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The sedimentary record of the Pahrump Group in Death Valley comprises massive, well-exposed successions of carbonate and clastic deposits. The Tonian to Cryogenian strata represent world-class examples of microbial carbonates deposited in the lead up to, and during Earth's emergence from, Snowball Earth events, thus chronicling one of the most debated and arguably important events in Earth History. Whilst there has been significant focus on the establishment of regional stratigraphy, there has been less focus on reconstructing and explaining the high-frequency, rapid environmental changes recorded within Tonian strata. In the Horse Thief Springs Formation, large-scale carbonate – clastic sequences consisting of stromatolitic dolostone beds are sandwiched between cross-bedded strata featuring ripple marks, trough-cross beds, and chertified ooid horizons. These observations suggest a rapid switch between clastic sediment supply, sediment cut-off, and (re)-establishment of microbial communities. The Horsethief Springs Formation represents an unusual case of mixed carbonate – clastic sequences related to tectonically-induced delivery of clastics onto a shallow marine shelf. This case study offers new insights into the dynamics of carbonate vs clastic deposition in the Proterozoic in terms of rapid reproliferation of the microbial carbonate factory after clastic deposition. The efficiency of the microbial carbonate factory, indicated by abundant stromatolite growth in the face of significant clastic sedimentation, is characterized by stromatolite size and morphology. Additionally, repeated clastic deposition has an observable influence on (1) carbonate fabric diversity, (2) the presence or absence of diagenetic cements, as well as on (3) carbonate preservation, and is documented from these exceptionally well exposed Proterozoic strata for the first time. New high resolution lithostratigraphic and petrographic data suggest that tectonically-induced, repeated clastic sedimentation has a profound influence on carbonate deposition and on post-depositional preservation, and may be key in interpreting similar mixed carbonate – clastic Proterozoic, as well as Phanerozoic successions.

Deep-time paleoclimate events preserved in Svalbard's rock record – a review

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The Svalbard archipelago offers access to a near complete succession of sedimentary rocks spanning the last 650 million years, interrupted be only some few notable hiatuses (e.g. the Late Cretaceous and Neogene unconformities). The preserved sedimentary succession record several global climate and eustatic sea-level changes contemporaneously with Svalbard's drift from the southern hemisphere in pre-Devonian times to its current position at 78°N. Evidence of past climatic variations include the Late Proterozoic Snowball Earth glacial conditions, the Late Paleozoic tropical to sub-tropical climates and eustatic sea-level fluctuations caused by the Gondwana glaciations, the dramatic impacts of the End Permian Mass Extinction (EPME) on all the Panthalassic sedimentary basins, Mesozoic climate fluctuations, Paleogene warming including the Paleocene-Eocene Thermal maximum (PETM), and finally Quaternary to Holocene glaciations.

The well-exposed outcrops provide excellent targets for analyses of past climate changes at regional to local-scale. In addition, 18 petroleum exploration boreholes, several research wells, and hundreds of coal exploration boreholes were drilled within various parts of the sedimentary succession. The wells offer the possibility of mm- to cm-scale sampling. For examples, some of fully cored coal exploration boreholes provide high-resolution data across the PETM. In addition, eight fully cored research boreholes drilled as part of a CO2 storage project offer a total of 4.5 km of Triassic–Cretaceous core material, along with supplementary wireline logs. In combination with nearby outcrop data, this dataset have formed the basis of numerous spin-off studies including a re-definitions of the global stratigraphic timescale. During research drilling targeting the Permian-Triassic (P-T) boundary in 2014, two cores of almost 100 m each were recovered. These cores have allowed for multidisciplinary analyses of the paleo-climatic conditions across the P-T boundary and the accompanying EPME at a resolution not yet undertaken elsewhere in the High Arctic. The drilling operation were conducted with minimal environmental impact at relatively low cost, thus providing a role model for future stratigraphic drillings in Svalbard.

In this contribution, we synthesize past and ongoing studies of deep-time paleoclimatic studies in Svalbard. We also present an overview of geological material from Svalbard available for such studies, including existing core material available from research and selected coal exploration boreholes.

Landscape and depositional controls on palaeosols of a distributive fluvial system (Upper Cretaceous, Brazil)

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The stratigraphic record of distributive fluvial systems is commonly characterised by frequent and complex interstratification of palaeosols among channel and overbank deposits. However, current models focus primarily on sedimentation and pay only limited attention to palaeopedogenesis, thereby failing to incorporate important palaeoenvironmental and stratigraphic information. This study proposes a pedosedimentary model for distributive fluvial systems that depicts and accounts for two palaeopedogenetic trends: one downdip, in relation to distality from the fan apex, and one along-strike, in relation to distance from active channel belts. Palaeosols are reported in detail from an Upper Cretaceous succession of the Bauru Basin, southeastern Brazil, through the application of macro-, micromorphological and geochemical studies, combined with facies and architectural-element analyses of sediments. In the downdip palaeopedogenetic trend, the proximal zone of the depositional system is characterised by a dominance of well-drained Inceptisols that develop on amalgamated channel fills; in the medial zone, Inceptisols occur interlayered with overbank deposits containing Entisols and poorly drained Vertisols. The distal zone preserves more mature and poorly drained Inceptisols developed on deposits of overbank and sporadic distal channel fills. These pedotypes show an increase in maturity and hydromorphism, moving away from the apex to the fan toe. This is likely linked to (i) the progressive approach of the topographic surface to the water table, and (ii) the average increase in distance to an active channel belt in distal locations. The along-strike palaeopedogenetic trend culminates in poorly developed palaeosols in floodplain regions that correspond to topographic depressions located between channel belts and which were subject to recurrent floods. Because palaeopedogenesis in the floodplain region is penecontemporaneous to sedimentation, pedotypes show an increase in maturity, bioinduced calcification and hydromorphism with distance from the active channels; they pass laterally from Entisols and Inceptisols near active channels, to Vertisols away from active channels. Conversely, following avulsion, abandoned channel belts remain as topographically elevated alluvial ridges located at some distance from the newly active channels and positioned above the water table and this leads to the development of better drained and better developed Inceptisols relative to pedotypes of the floodplain region. Overall, both palaeopedogenetic trends demonstrate the overriding controls of topography, sedimentation rate and parent material on pedogenesis, with only minor climatic influence. This work offers a novel pedosedimentary model for distributive fluvial systems and highlights the palaeoenvironmental significance of palaeosol trends, providing new constraints for the recognition of distributive fluvial systems in the rock record.

Palaeosol-landscape relationships in the Late Cretaceous Bauru Basin, Brazil

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Palaeosols are the product of ever-changing and rapidly adjusting past soils that were highly sensitive to autogenic and allogenic processes. They carry a "soil memory" of past environments that can be accessed from a careful and combined examination of their macroscopic features, micromorphology and geochemical signature. Because palaeosols are ubiquitous features in most continental basins, they can be used as proxies to reconstruct past landscapes and past climatic conditions throughout a sedimentary basin. This work examines the Upper Cretaceous alluvial-aeolian succession of the Bauru Basin (SE Brazil) that formed in highly varied landscapes, producing different types of palaeosols at different portions of the basin, allowing the assessment of the effects of external and local factors on pedogenesis, sedimentation and landscape evolution throughout the basin. The northwestern portion of the basin corresponds to a flat area where rapid episodes of aeolian sedimentation alternated cyclically with long-term periods of surface stability and pedogenesis. Palaeosols at this location were mainly governed by climate and long periods of stability produced polygenetic successions with a 65% palaeosol frequency including well-developed Aridisols, Alfisols, Entisols and Vertisols that vary from 0.7 to 20 m thick. At the northeastern portion of the basin, poorly-developed Inceptisols, Entisols and Vertisols developed in aggrading fluvial fans. Pedogenesis was penecontemporaneous with fluvial sedimentation at the part of the basin where the mobility of avulsive channel belts determined an ever-changing depositional landscape. A close palaeosol-landscape relationship can be depicted in this area where pedotypes distribution reflects downdip and along-strike changes in the fan morphology, with minor climatic influence on pedogenesis. The southeastern portion of the basin shows the highest palaeosol frequency, where Inceptisols and Aridisols occupy up to 95% of the sedimentary record and alternate with scarce unconfined hyperconcentrated flow and wind ripple deposits. This location was marked by the lowest rates of sedimentation and the highest landscape stability of the basin. The palaeosols encountered in the different portions of the Bauru Basin reveal that soil formation was majorly controlled by local factors (e.g., sedimentation rates, avulsion, topography, water table level, parent material) whilst climate played a minor influence on pedogenesis and were in fact key controllers of the sedimentary architecture of the basin.

Sedimentary environment and depositional evolution of a Cambrian-Ordovician ramp from the Zagros Basin (Southwestern Iran)

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Lower Palaeozoic stratigraphic sequences are well distributed in all the Iranian territory, from the Alborz mountains to the Zagros Basin, being the latter one of the main hydrocarbon province in the world. For this reason, most of the geological investigations in this area focused on the more accessible Mesozoic and Cenozoic successions, while Palaeozoic units lack a detailed sedimentological characterization, essential for palaeogeographic reconstructions. This study, carried out through multiple approaches including the analysis of facies, microfacies and palynofacies aims to a palaeoenviromental assessment of a Cambrian-Ordovician stratigraphic section cropping out in Darreh-Yas location (Southwestern Iran) in order to give a contribution on the paleogeographic and paleoenvironmental evolution of the Zagros Basin during this time interval. The continue studied succession comprises the Member C of the Mila Formation (261 m thick) and the Siyahoo Formation (181 m), attributed by well preserved and diversified acritarch assemblages to middle and late Cambrian and to Early Ordovician, respectively. The lower part of the Mila C Member is characterized by medium to thick-bedded grainstones and packstones with brachiopods, trilobites and crinoids. Erosive based channel lag deposits, fining upward cycles sequences and ripple cross lamination with reactivation surfaces are present. The upper part of the Mila C Member consists of thin bedded fossiliferous packstones and wackestones grading upward to stromatolite boundstones with marl and shale intercalations. The palynofacies of the stromatolite layers are dominated by amorphous organic matter (AOM) with few acritarchs. The overlying Siyahoo Formation is characterized by dark grey shales with sandstone and siltstone intercalations. The relatively thin sandstone and siltstone beds show cross lamination and hummocky cross stratification. The total amount of the organic matter increases in the shaly intervals. It mostly consists of abundant and well diversified acritarchs and relatively lower amount of AOM. Accordingly to facies, microfacies and palynofacies analysis, the depositional environment of Mila C Member and Siyahoo Formation (of Darreh-Yas succession) is interpreted as a mixed carbonate siliciclastic ramp spanning from inner to outer zone and dated from middle and late Cambrian to Early Ordovician. The Mila C Member deposited in the subtidal to intertidal part of a mostly carbonate ramp as documented by sedimentary structures varying from channel lag deposits grading to fining upward cycles and microbialites. Differently from other coheval key sections of the Zagros basin (e.g. Zardkuh, Chalisheh, Oshtorankuh and Ghalikuh) represented during uppermost Cambrian by the siliciclastic Ilbeyk Formation, the carbonate deposition in Darreh-Yas area lasted until the Cambrian-Ordovician transition. The sedimentary structures and organic content of the Siyahoo Formation point to a siliciclastic middle-outer ramp affected by relative sea level fluctuations generating cyclic progradation and retrogradation of the coastline. In this view the coarse sandstones represent the shoreface facies while the siltstones and the thick shaly intervals, richer in organic matter and particularly in acritarchs, the outer ramp deposits. This paleoenvironmental evolution to a deeper and outer siliciclastic ramp during the Early Ordovician fits with other adjacent palaeogeographic areas in southwestern Iran, Syria and southeastern Turkey.

Seasonal Miocene precipitation pattern recognized in marginal marine deposits of Mt. Medvednica (Croatia)

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Depositional sequence from a small abandoned quarry near the Veternica cave (Mt. Medvednica, vicinity of Zagreb) bears evidence of temporary freshwater input to the marginal Miocene marine environment of the Central Paratethys (Šeparović, 2019 and references therein).

Succession, ca. 5 m thick, comprises nine horizons characterized by interchange of highly fossiliferous layers with dominantly stenohaline biota (mostly foraminifera, ostracods, bryozoans, neritic and pelagic fishes) and those with less diverse euryhaline taxa (e.g. foraminifera Elphidium, small oyster Pycnodonte, gobiid fishes). Abundant gadilid scaphopods and serpulid Ditrupa occur in all horizons. Life flourished in a shallow inner shelf environment, rich in nutrients derived from the river flows. Periods of intensive flooding can be additionally recognized from the decrease of total carbonate content, e.g. from layer 2 with 62.18% to layer 5 with 53.7 %. Amount of carbonates reaches 74.83% in the uppermost layer 9, pointing to the possible drought or diminished erosion of the hinterland. Although the pelagic taxa in the studied samples are scarce and not indicative enough, benthic fauna (foraminifera, ostracods) point to the Langhian (Middle Badenian) Spirorutilus carinatus Zone.

Significant seasonal precipitation pattern was recorded by several authors for the proposed time interval (e.g. Prista et al., 2015).

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New Upper Cretaceous depositional architecture above the cratonic edge in central Poland

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The Polish Basin formed the eastern part of the Permian–Mesozoic system of epicontinental basins of western and central Europe. Its axial most subsiding part, the Mid-Polish Trough, was superimposed onto the Teisseyre-Tornquist Zone, located within the thinned, marginal edge of the East European Craton. Following Permian rifting, the Polish Basin experienced long-term Mesozoic thermal subsidence punctuated by pulses of accelerated tectonic subsidence in Zechstein–Scythian, Oxfordian–Kimmeridgian, and early Cenomanian. It was filled with a thick siliciclastic-carbonate succession, underlain by basal Zechstein (Upper Permian) evaporites. Late Cretaceous-Palaeogene inversion of the Polish Basin was associated with substantial uplift of its axial part that led to formation of a regional anticlinal structure referred to as the Mid-Polish Anticlinorium (Swell). Inversion tectonics was associated with widespread syn-tectonic sedimentation related to localized uplift and erosion of basement blocks and salt structures. This is particularly true for the central and Western parts of the basin. Its Eastern part, located above the East European Craton, has been always regarded as characterized by mostly flat-laying, "layer cake" sedimentary cover. Well data indicated presence within the Upper Cretaceous succession of only minor stratigraphic gaps associated with localized tectonic movements of inversion structures developed along the NE flank of the Mid-Polish Anticlinorium. Interpretation of the regional high-resolution seismic data of the PolandSPAN survey in the Grudziądz-Polik area revealed completely new depositional architecture of the Upper Cretaceous succession that fundamentally differs from the previously assumed layer-cake model. A previously unrecognized regional unconformity, stretching for more than 200 km NW-SE and dividing the Upper Cretaceous succession into two regional mega-units, characterized by very different internal geometries, was identified and mapped. The lower unit, with a generally layered-cake internal pattern, is overlain by an upper unit, composed of a regionally low-angle succession that pinches-out toward the south. At the base of the upper unit subtle erosional features such as incised channels have been superbly imaged by PolandSPAN seismic data. The formation of this regional unconformity discovered above the East European Craton within the Upper Cretaceous succession has been tentatively associated with regional buckling of the cratonic plate during Late Cretaceous inversion of the Polish Basin.

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Evidence for Tithonian unroofing from the Eastern Alps

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Bauxites are interpreted as high-grade weathering products of Al-bearing rocks in a tropical monsoonal climate forming in time intervals of at least 1 million years. Karst bauxites formed on, but not out of pure platform carbonates – their formation would necessitate the dissolution of at least 1 km carbonate rock, which can be excluded in most cases. In the Late Jurassic to Early Cretaceous carbonate platforms in the Eastern Alps, intercalated bauxites of Tithonian age have not yet been reported. The emergence intervals for weathering of volcanic ashes as source material provided by the well-known Tithonian volcanic activity were too short for bauxitisation. However, in the central Northern Calcareous Alps, an occurrence of a Late Kimmeridgian to Early Tithonian bauxite with boehmite, berthierine, hematite, and kaolinite, as determined by XRD, has been discovered. The whole-rock chemical analysis yielded 12.8 % SiO2, 45.5 % Al2O3, 25.5 % Fe2O3, 2.2 % TiO2, ~ 3000 ppm Cr, ~ 800 ppm Ni, and ~ 500 ppm Zr; the occurrence of detrital chromian spinel was proven by SEM-EDX measurements. This specific chemical and mineralogical composition can neither be provided by the volcanic ashes, nor by hypothetical siliciclastic components in the carbonate platforms. Actual geodynamic reconstructions of the W Tethyan realm show W to NW directed ophiolite obduction and propagation. These ophiolites would provide ideal source materials for bauxites. Unfortunately, carbonate platforms grew on top of the ophiolite nappes and shielded them from weathering. One model for the Jurassic mountain building process explains new tectonic motions after a period of tectonic quiescence during the time span from latest Oxfordian to earliest Tithonian with the onset of mountain uplift in the Early Tithonian. This caused unroofing (Lateral Tectonic Extrusion) enabling fluviatile transport of weathering products from the ophiolites into the lagoons. During emergence – whether caused by sea-level changes or by local uplift, this pre-weathered material could have facilitated bauxite formation. Continuing gravitational collapse forced down gliding, the exposed blocks were flooded again and the platforms continued to grow. This model is confirmed by our results: the geochemical composition of the bauxites plots into the lower right corner of the FMW diagram with basaltic to mafic parent rocks, which is in concordance with the high Cr content. Detrital chromites and Al-chromites plot into the field of supra-subduction (SSZ) ophiolites. In addition, heavy minerals, i.e., zircon, rutile, and REE-bearing minerals point to higher fractionated sources. Therefore, the source of the bauxites may have constituted of an obducted island-arc and back-arc (SSZ) ophiolites, as to be expected in the highest nappe position of obducted ophiolites. Below the bauxite, ooidal grainstones are exposed, whereas in the hanging-wall transgression starts with a sandy horizon followed by platform margin carbonates of the Plassen formation of Late Kimmeridgian to Early Tithonian age.

The Anisian continental-marine transition in Sardinia (Italy): new palynological data and regional chronostratigraphic correlation

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Little evidence of paleontological record between the Upper Permian and the Anisian (Middle Triassic) of W Europe could either reflect 1) large stratigraphic gaps in the continental successions and/or 2) the persistence of disturbed conditions after the PTB extinction event and the succession of ecological crises occurred during the Early Triassic. In this frame, the study of the palynological associations, integrated with the stratigraphical and sedimentological data, plays a key role in dating and correlating the successions of the Western European domain and provides a better understanding of environmental and paleoclimatic conditions. In some cases, paleontological evidence is lacking, as in Sardinia (Italy), where a long gap encompasses the Middle Permian (pars) to late Lower Triassic successions.

Although fragmented and disseminated, the continental Lower-Middle Triassic successions (Buntsandstein) have been proven to be fundamental to understand the evolution of the southern edge of the Paleo-Europe and the different timing of the Tethys (Muschelkalk facies) transgression in some of these areas. Various paleogeographic reconstructions were attempted in previous works showing no consensus in the precise position of Sardinia and its surrounding seaways in the Western Tethys domain. Nowadays in fact, the detailed configuration and distribution of the subsiding and emerging landmasses and the temporal development of the transgressions of the Western Tethys during the Middle Triassic remains unclear. The present work focuses on the stratigraphical, sedimentological and palynological aspects of three Middle Triassic successions of Sardinia, with particular attention to the analysis of the microfloristic associations sampled there, and a detailed review of all the previous palynological publications on Sardinian Anisian. The sections studied are: Su Passu Malu section (Campumari, SW Sardinia), the Arcu is Fronestas section and Escalaplano section (Escalaplano, Central Sardinia). These sections were correlated also to other significant ones in SW (Scivu Is Arenas) and NW (Nurra) part of the Island.

The aim of this work is to provide up to date information based on a detailed stratigraphical, sedimentological and palynological examination, to improve the knowledge on the palynostratigraphical zonation of these successions and thus to define with accuracy the age of such sediments and the beginning of both continental and marine Triassic deposition in this sector of the Western Peri-Tethys.

Where are rivers forced to flow? Revision of differential subsidence effects on alluvial facies distribution

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The ratio of channel belt to overbank deposits in alluvial sequences and the variability in channel belt distribution are the most important characteristics of alluvial stratigraphic architecture. The ratio of floodplain facies to channel fills is determined by the sediment supply to accommodation rate ratio, yet the relation is probably more complex than previously thought, since aggradation rate and channel-deposit density do not exhibit a simple negative dependence. Examples of experimental and depositional research reveal that a decrease of sediment supply to accommodation ratio along the drainage axis increases the preservation of floodplain facies and decreases channel belt amalgamation.

The evolution of ideas explaining the changes in the sediment supply to accommodation ratio perpendicular to the basin drainage axis has proven very complex (Nádor & Sztanó, 2011: SEPM Spec. Pub.). A review of published research points to the existence of several factors which interact in resulting location of channel belts in an alluvial depositional system under conditions of differential accommodation, for example topographic gradient, substrate erodibility, avulsion rate or dominant grain-size of transported sediment (e.g., Hickson et al., 2005: J. Sediment. Res.; Nádor and Sztanó, 2011). The pioneering “LAB models” established that variable lateral accommodation rate results in attracting the channels to area within the drainage basin where maximum subsidence is found (e.g. Bridge & Leeder, 1979: Sedimentology; Alexander & Leeder, 1987: SEPM Spec. Pub.). Following research implied, that interplay of slopes parallel and perpendicular to the drainage axis has major control over channel location, and differential subsidence might not affect lateral distribution of channel belts (Mackey & Bridge, 1995: J. Sediment. Res.; Hickson et al., 2005).

A case study of Nádor & Sztanó (2011) showed that only up to double times higher spatial difference in accommodation documented in the Quaternary succession of the southern Pannonian Basin System resulted in location of main channel belts in the marginal part of the depocenter. In contrary, Hickson et al. (2005) showed experimentally that ca. three times higher spatial difference in accommodation rate is associated by homogeneous distribution of channel deposits in a distributary fluvial system regardless the position within the system. The same magnitude of differential accommodation caused dominant channel belt deposition on the margin of a depocenter in the sequence documented by Foix et al. (2013: Sed. Geol.).

Our case study is based on depositional record of the late Miocene alluvial Volkovce Fm. in the northern Pannonian Basin System (Slovakia) (Šujan et al., 2020: Sed. Geol.). The results indicate that the up to four times higher accommodation rate affects the drainage network by capturing the channel belts into the area of maximum subsidence. This is most likely due to topographic confinement which prevents basin-scale avulsion from relocating the channels in a lower accommodation rate area. Hence, our study show that the four times higher accommodation rate might be close to boundary conditions needed to relocate the channel belts to the area of maximum subsidence.

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Calcite cementation in a folded and fractured fluvial succession: the Puig-reig anticline (South-eastern Pyrenees)

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Cementation in clastic rocks exerts significant effects on fluid flow and reservoir properties. The Puig-reig anticline, located in the south-eastern Pyrenees, exposes fluvial sedimentary deposits hosting fracture networks, which are mainly filled with calcite cement. This anticline constitutes an excellent case study to investigate the origin and distribution of calcite cement within fracture networks and variable host rocks in fluvial facies. Five generations of calcite cement have been identified. The first generation (Cc0) precipitated in interparticle pores, featuring growth zonation with the alternation of non-luminescent and luminescent zones. It precipitated before intense folding and fracturing during the anticline growth. The second generation (Cc1) precipitated in both fractures and interparticle pores, with bright yellow luminescence and blocky crystal morphology. The third generation (Cc2) precipitated mainly in fractures and rarely in interparticle pores, with dull orange luminescence and blocky crystal morphology. The fourth generation (Cc3) only precipitated in fractures, presenting very dull luminescence and large euhedral and blocky crystals. Cc1 to Cc3 formed during folding or thrusting. The fifth generation (Cc4) precipitated in fractures, and it is non-luminescent and presents elongated crystal morphology and a palisade structure of bladed crystals. It formed after the anticline growth. As the predominant calcite cement, Cc1 filled interparticle pores and fractures throughout the anticline, resulting in the overall low matrix porosity and sealed fractures, whose distribution is affected by the host sedimentary facies and lithofacies. Channel filling sandstones in the medial fluvial fan present higher contents of calcite cement than overbank deposits and proximal fluvial deposits. Large and thick conglomerate bodies and coarse sandstones host larger calcite veins compared to fine sandstones and clay deposits. The study of outcrop analogues like the Puig-reig case is key for establishing predictive models of calcite cementation in the subsurface.

Fracture distribution in a folded fluvial succession: the Puig-reig anticline (south-eastern Pyrenees)

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Fractures play a fundamental role in controlling both fluid migration and reservoir quality, especially in low-permeability and tight reservoirs, including those in foreland fold-and-thrust belts. However, systematic fracture assessment in subsurface rocks is limited by the inability of sampling subseismic-scale fractures and large fractures that exceed the dimensions of boreholes. A common strategy is to use outcrop analogues to understand the controlling factors of 3D fracture distributions and thus reduce uncertainties in their subsurface prediction. The Puig-reig anticline, located in the SE Pyrenees, exposes fluvial sedimentary deposits that host fracture networks. The linear scanline method has been used to systematically collect fracture data, allowing the investigation of fracture distributions and their depositional and structural controlling factors. The results indicate that fracture attributes are strongly influenced both by their position within the anticline and by the depositional characteristics of their host sedimentary rocks. Relatively high-strain zones, such as the anticline crest and nearby areas, feature relatively small fracture spacing and high intensity. Besides, channel filling sandstone layers present higher fracture intensity than channel lag conglomerate bodies due to smaller bedding thickness. In the two fold limbs, where strain was lower, fracture intensity is overall lower. In the anticline, conglomerate bodies tend to present relatively large fracture length and aperture compared to thin sandstone layers, especially in the proximal fluvial fan in the north limb. This is mainly because the thick and massive conglomerate bodies can accommodate strain by the propagation and re-opening of existing fractures apart from the formation of new fractures during fold growth. The Puig-reig anticline case study can be used as a reservoir analogue to explore the fracture distribution pattern and reservoir potential in folded fluvial clastic sediments.

Establishing the depositional environment of the Viga Conglomerate, Catanduanes, Philippines using sedimentological analysis

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Viga Conglomerate is the youngest formational unit in Catanduanes Island, eastern Philippines. The formation is extensively exposed in the northeastern part of the island, and was presumed to be Pliocene-Pleistocene in age based on stratigraphic position and because of its poorly indurated character. The conglomerates appear channelized in some portions, exhibit a wide range of sedimentary structures, and are often intercalated with mudstones and sandstones. Lack of detailed sedimentological analyses, however, limits the interpretation of its depositional environment. The present study, therefore, aims to determine the depositional setting and provenance of the conglomerate deposits using (1) granulometric, (2) morphometric, and (3) lithologic clast analyses.

Granulometric analysis of sandstones within the formation shows that the samples are composed of coarse sand to very fine sand (0.77 to 3.66 phi), moderately sorted to very poorly sorted (0.78 to 2.11 phi), strongly negative skewed to strongly positive skewed (-0.89 to 0.33 phi). Using various bivariate plots such as (a) skewness vs sorting (Friedman, 1961; Moiola and Weiser, 1968), and (b) mean vs sorting (Friedman, 1961; Moiola and Weiser, 1968; Tanner, 1991), the sandstone samples were interpreted to have been deposited in a fluvial setting. The result of the granulometric analysis is supported by morphometric analysis data. Morphometric parameters such as flatness ratio, elongation ratio, maximum projection sphericity and oblate-prolate index have mean values of 0.51, 0.72, 0.71 and 0.35, respectively. In the study of Luttig (1962), Sneed and Folk (1958), and Dobkins and Folk (1970) these parameters indicate a fluvial setting. Morphometric analysis of gravels indicates the dominance of bladed, compact-bladed, elongate, and compact elongate forms (Sneed and Folk, 1958; Zingg, 1935). Along with various discrimination diagrams (Dobkins and Folk, 1970; Stratten, 1974), these gravel morphologies also suggest the same depositional setting.

Clast analysis of the conglomerates suggests differences in the composition of clasts which might be useful in the elucidating the unroofing history of the island. Sandstone, mudstone and andesite/diorite clasts dominate the conglomerates with mean values of 70.46%, 17.27%, and 10.32%, respectively. These clasts are possibly derived from the Cretaceous Yop Formation, Early Eocene- Early Miocene Payo Formation, and Early Oligocene Batalay Diorite. Paleontological analysis of limestone clasts from the conglomerate reveal two ages/sources of limestones: Late Cretaceous (based on Globotruncana) and Middle to Late Eocene (based on Nummulites, Assilina, Discocyclina, and Pellatispira). The mudstones from Viga Conglomerate, however, are barren of microfossils and therefore were not dated in the present study.

A 600-year Record of the Atlantic Multi-Decadal Oscillation in the Skeleton of a Sclerosponge

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Sea surface temperature (SST) variations in the Atlantic Ocean shows strong multidecadal variability over the past 150 years, variations that have come to be known as the Atlantic Multidecadal Oscillation, or AMO. There is considerable debate as to the causes of this variability. A large number of previous studies have argued for a role for changes in the Atlantic Meridional Overturning Circulation (AMOC) that are internal to the climate system, whilst others have suggested that external forcing (greenhouse gases, aerosols, and volcanic eruptions) set the pace and amplitude of the 20th century AMO. Here we present a new record of ocean water temperature (1380–1993), calculated using the Sr/Ca ratios measured in the aragonitic skeleton of a sclerosponge collected from a depth of 133 m in the Bahamas. The organism, dated using U/Th, records a warming of ~2.5 degrees from the peak of the little Ice Age to time of collection in 1993. The residual deviations in temperature from the long-term trends show a high degree of covariance with indices of the AMO during the period of instrumental record and a strong multi-decadal periodicity that is present throughout the record. While prior to the instrumental record there is rather poor agreement with the various proposed proxies of the AMO measured in corals and tree rings, our data show remarkably similarity to change in oceanic temperature produced from models driven by natural and anthropogenic atmospheric forcing. Despite this strong association, the persistent periodicity of signals in the record with frequencies between 60–80 years, not evident in the model data, suggest that changes in oceanic circulation cannot be ruled out as a secondary control on the AMO.

Basin evolution during incipient rifting of ribbon terranes: an example from the bohemian massif

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Protracted oceanic subduction and accretion along the northern Gondwana margin in the late Ediacaran to early Cambrian was replaced by diachronous rifting and variable separation of the Avalonian–Cadomian ribbon terranes from the continental margin. The initial stage of rifting generated a series of sedimentary basins that developed on the folded Cadomian basement. An outstanding, superbly preserved example is the Příbram–Jince Basin in the Teplá–Barrandian unit, Bohemian Massif, filled by a several km thick succession of continental and later also by marine siliciclastic deposits, mostly polymictic and monomictic conglomerates, sandstones, and shales. The depositional mechanisms and depocenters were strongly controlled by syn-sedimentary normal faulting that produced NE–SW horsts and grabens within the basin. The depositional mechanisms involved debris flows in alluvial fans along fault scarps and streamflows within fluvial distributary systems on alluvial plains that filled the grabens. A paleocurrent analysis based on planar cross-stratification and anisotropy of magnetic susceptibility (AMS) in sandstones indicates an up-sequence change in the paleocurrent directions from towards the NW (at an angle to the basin axis) to towards the NE (basin axis-parallel). This paleocurrent change is in concert with a change in clast compositions from unstable to mature quartz-dominated. We suggest that the basin became overfilled and sourced from the SW late during its evolution, perhaps in response to short-lived tectonic quiescence and cessation of normal faulting.

Building realistic models of meandering rivers and submarine channels: Implications for fluid flow

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Meandering rivers and submarine channels are among the most important depositional systems on Earth. Understanding the distribution of sediment types and of heterogeneities in these systems is important in hydrocarbon exploration and production, CO2 sequestration, and fluid flow and contaminant movement in aquifers. We have adapted a simple kinematic model of meandering to build geologically realistic models of both fluvial and submarine systems. Time-lapse satellite imagery can be used to validate and calibrate the fluvial models; modern seafloor morphology and reflection seismic data play the same role for submarine systems. Submarine channels can be – and often are – more aggradational than rivers; however, their planform behavior is similar. A fundamental aspect of this planform behavior is downstream translation of meanders, which results in deposition of finer-grained and more heterogeneous sediment in river bends. The three-dimensional stratigraphic complexity of these systems is best understood through 3D visualizations and animations. The implications for pore space distribution and fluid flow are best explored using simple flow simulations that are visualized in a geologic context; we use a flow diagnostic tool to illustrate the impact of stratigraphic architecture and well placement on sweep efficiency.

Infill dynamics and depositional patterns in gravel-bed chute cutoffs channels: the Ain River, France

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Abandoned channels are efficient sediment sinks whose closure phase is dominated by bedload deposition forming a channel plug, before being later infilled with finely-grained, impermeable sediment. Although the early bedload deposits can form connectivity bridges in abandoned channels, enhancing the connectivity of fluvial reservoirs, their presence, geometry and architecture remain overlooked. In particular, the various deposition processes of the bedload sediments and their control on the bedload plug final geometry need to be identified on the field. This study focuses on gravel-bed channels of the Ain River, France with the mapping and characterization of the bedload deposits associated with the closure phase of three abandoned channels and the monitoring of a fourth channel within which the gravel infill is ongoing. We find that bedload accumulates mainly through (i) the initiation of a bar at the mouth of the abandoned channel in the flow separation zone, which reduces water discharge, (ii) lateral accretion of coarse-grained bars resulting in channel narrowing downstream of the initial upstream bar and (iii) amalgamation of coarse-grained longitudinal bars -anchored to the initial plug bar- that fine upward as they migrate downstream. The channel plug grows downstream until it reaches its maximum length and then starts thickening. Channel plug final geometry is controlled by the channel initial geomorphic parameters and river course evolution, in relation with variable sediment fluxes and rate of channel disconnection along the studied reach.

State transition dynamics in a coastal wetland: Case study of the Venice lagoon

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Coastal wetlands represent complex ecosystems prone to continuous changes. These changes are especially standing out nowadays due to the existing feedback loop between the impact of climate change and anthropic activities, ecosystem degradation and the increased risk of natural disaster. Coastal wetlands represent particularly valuable natural resources, characterized by the interaction between their geomorphological and biological components. Their adaptation to the changing conditions depends on the rate and extent of spatial and temporal processes and their response is still not fully understood.

This work aims at improving the understanding of the transition dynamics in the evolution of eco-geomorphological structures in a coastal wetland ecosystem using fractional abundance maps derived from Landsat satellite imagery to delineate the spatial patterns of the main vegetation and sediment typologies and their variation over time (1991–2011). The selected case study is the Venice lagoon, particularly its North-Eastern part: The Lido basin.

The analysis allows identifying ecosystem-level indicators to assess the state transition dynamics, as well as the existence of naturally and anthropically-derived external drivers that increase the non-linearity of the patch size frequency distribution over time. Based on spatial and temporal analyses, a conceptual model that link the sedimentology, the biology and the hydrodynamics acting within the Venice Lagoon shows how vegetation can influence the sediment stability during the exposure of the intertidal mudflat and how morpho-biological changes, caused by both natural and anthropogenic processes, can be detected by using open satellite data.

Source Rock Potential of the Upper Cretaceous Abu Roash Formation, East Beni Suef Basin, Egypt

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The Abu Roash Formation comprises the main petroleum system elements (e.i. source, reservoir, and seal rocks) within the East Beni Suef Basin, which is a relatively under-explored rift basin in the north Eastern Desert of Egypt. The basin acquires a NW whole-graben geometry and experienced three main tectonic deformations through its evolution; Early Cretaceous rifting, Senonian transtensional tectonic regime, and Eocene, and post-Eocene extensional tectonics. The sedimentary sequence extends from the Albian Kharita Formation through the Upper Cretaceous Bahariya, Abu Roash, and Khoman formations up to the Early to Middle Eocene Apollonia carbonates. The Upper Cretaceous Abu Roash formation is mainly composed of a carbonate sequence intercalated with clastic sediments and is divided into seven members from “A” to “G” according to the clastic/carbonate ratios. Generally, the members “B”, “D”, and “F” are carbonate dominated while the other members are largely fine-grained clastics with an age from the Late Cenomanian to Early Senonian. This work aims to investigate the source potential of the whole formation in terms of kerogen type and maturity to supplement the Rock-Eval pyrolysis data, and to shed light in particular on the lithostratigraphy and depositional conditions of the Abu Roash “F” Member, which represents the main source rock in the study area.

Forty-three cutting samples collected from three wells (Gharibon-1x, Gharibon NE-1x, and Tareef-1x) were microscopically screened for spore coloration, kerogen typing, and vitrinite reflectance measurements. Furthermore, twenty-five cutting samples covering the Abu Roash “F” source rock were selected for further petrographic studies including transmitted light microscope, Scanning Electron Microscope (SEM), Energy Dispersive X-ray Spectrometer (EDS), and X-ray diffraction (XRD).

The organic petrography revealed that the Abu Roash “A” and “F” members consist mainly of immature unstructured lipids with some vitrinite particles indicating oil-prone kerogen type II, while the Abu Roash “E” Member is marginally mature and rich in vitrinite macerals with gas-prone kerogen type III, and the Abu Roash “G” Member shows immature to marginally mature mixture of macerals. The petrographic analysis showed that Abu Roash “F” source rock consists of argillaceous limestones with abundant planktonic foraminifera, local dolomitic wackstones, and residual hydrocarbon along the laminae planes in a micritized detrital clay matrix. Backscattered scanning electron micrographs of the thin sections showed foraminifera filled with clay minerals mainly kaolinite and illite, abundant pyrite in a clay matrix, and amorphous organic matter. The sediments are rich in glauconite, suggesting a continental shelf marine depositional environment and low sedimentation rates under reducing conditions. Based on this work, we could conclude that the Abu Roash Formation contains three kerogen types (Type II, III, and mix II/III) indicating variation in depositional environments through alternative cycles of transgression and regression, where the Abu Roash “F” Member consists of marine organofacies and suggested to be deposited under slightly outer shelf marine environment.

How mass-transport deposits and knickpoint-zones build the stratigraphy of the deep-water Hikurangi Channel

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Repeat bathymetric surveys of active deep-water channels have shown how features such as cyclic steps and knickpoints can generate and erode stratigraphy. However, to date, the preserved subsurface manifestation of these features at large architectural scales is poorly understood. The Hikurangi Channel, offshore New Zealand, provides an ideal opportunity to bridge this gap as the presently active channel provides a direct analogue for the immediate subsurface.

Here, we integrate high-resolution bathymetry and three-dimensional seismic data to link seafloor features to subsurface deposits and surfaces. Knickpoints, knickzones, Mass-Transport Deposits (MTDs) derived from channel-wall collapse, and terraces are widely observed in the modern channel. In the subsurface, the identification of ten seismofacies and five seismic surface types allowed the categorisation of channelised deposits into four depositional elements: channel-fill, sheet or terrace deposits, levee deposits, and MTDs. Three-dimensional correlation and interpretation of relative ages were performed using MTDs as chronostratigraphic markers. Linking depositional elements and internal reflector variability to corresponding seafloor features revealed potential formative mechanisms of deposits and surfaces commonly observed in channelised stratigraphy. Upstream-migrating knickpoints generated and filled, high-amplitude reflector package (HARP)-bounding surfaces that are concave-up in cross-section and longitudinally continuous for tens of kilometres in their downstream wake. Multiple, closely spaced knickpoints form knickzones. Knickzones generate channelform surfaces, which are composite surfaces formed by multiple HARP-bounding surfaces.

The response to MTD emplacement fundamentally controls channel deposit architecture in the Hikurangi Channel. After the collapse of a channel-wall, flow perturbation by channel damming MTDs causes deposition upstream of the MTD and formation of an upstream-migrating knickzone downstream. The knickzone incises first the MTD and then the weakly confined deposits formed upstream of it, leaving in its wake a filled channelform surface bound by a newly formed terrace. This mechanism provide an alternative to conventional models of channel deposit formation and may aid subsurface interpretation in systems lacking a contemporary analogue or with poor data coverage.

Investigating autogenic responses to allogenic control on the evolution of the llucmajor platform

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The sensitivity of sedimentary systems to environmental changes is key in understanding the cyclic response of the sedimentary architecture to changing parameters. The changes observed in the preserved stratigraphic architecture in a basin indicate the environmental changes dominant during the evolution of a given sedimentary system. Stratigraphic forward modelling (SFM) may provide insights to the stratal responses of the sedimentary units to changing paleo-environmental conditions. In order to investigate the capability of SFM, we applied this method to a carbonate system with known sedimentary dynamics. The Miocene Llucmajor platform of Mallorca in the western Mediterranean is an ideal location for this investigation due to its well understood sedimentary system and the amount of available data from previous studies. The evolution of the Llucmajor carbonate platform displays a complex relationship between autogenic processes and environmental factors. The aim of the study was to model the platform geometry and facies distribution in relation to the high-frequency sea level changes as preserved in the stratigraphic record of the platform.

This was achieved by developing several numerical forward models of the platform, based on outcrop observations, well data and modern analogues. The resulting models were subsequently compared with the observed platform architecture and facies distribution to determine the model's consistency. The uncertainty associated with the input parameters were studied and incorporated into the study by building several scenarios with changing initial bathymetry, carbonate production and wave impacts. The model presents four facies classes as observed on the Llucmajor platform: the reefal facies, simulated by high productivity of wave-resistant massive coral assemblage, the forereef slope, simulated by the high productivity of branching corals and carbonate grains, the backreef lagoon simulated by high productivity of carbonate muds in a quiescent backreef environment and an open shelf facies of red algae and transported carbonate sediments.

We developed the base case model based on trial and error runs to establish a platform model consistent with Llucmajor platform architecture. Sensitivity runs were subsequently compared to the base case model to evaluate the impact of parameter variation. The simulations show that the strongest impact on platform architecture and facies distribution is the inherited topography upon which platform development is initiated. This is in conjunction with high-frequency sea level changes as physical and ecological accommodation space is generated through the interplay of bathymetry and sea level changes. Varying the initial topography by 20% of its original depth resulted in significant changes in the in the amount of progradation of the simulated platform. Minor changes in the frequency of the sea level curves produced progradation/aggradation patterns that deviate significantly from observed patterns on the Llucmajor platform and disrupts the response of the carbonate producers to water depths. The study shows that forward models can provide a methodology to understand basinal responses to environmental dynamics while also providing an avenue to evaluate the parameters controlling the architecture and distribution of facies on the platform.

Sedimentary evidence (and oral legends) of a prehistorical giant tsunami in northern Kiribati, central Pacific

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Sedimentary evidence exists for a prehistorical giant tsunami on remote Makin Island (3°20.2'N 172°58.8') in the central Pacific Ocean. Makin is the most northerly of the Gilbert Islands in the Republic of Kiribati. Three large coral blocks, weighing up to 174 t have been deposited by a past extreme wave (or waves) 83–135 m from the seaward edge of the reef platform in the south of the island. At least one additional large block lies in shallow water just below sea level. The size of the largest reef block reaches megaclast dimensions (10.3 × 5.6 × 3.3 m).

The near-equatorial latitude of Makin means that tropical cyclone waves were unlikely to have been responsible for transporting the reef blocks towards the shore. A tsunami arriving from the west or south west seems the most probable explanation for the deposits. The concept of a prehistorical tsunami is supported by traditional geomyths (in this case, legends of giant waves) that severely impacted island in the past. Uranium-series dating provides a youngest age of fossil corals in the blocks as AD 1400–1600.

As the Gilbert islands form a linear chain of atolls located in an intraplate position, a far-field tsunami generated by plate boundary seismic activity is less compelling. Instead, we propose that a local tsunami was generated by a submarine landslide on the flank of the volcanic edifice beneath Makin's carbonate atoll, or another neighbouring atoll. Other possibilities are the AD 1420 ocean-wide tsunamigenic event produced by a Chilean super-cycle earthquake or the AD 1452 caldera collapse of Kuwae volcano in Vanuatu.

Palynofacies as sea-level proxy in Early Cretaceous marine mudstones – a critical evaluation

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Stratigraphic distribution patterns of particulate organic matter (POM) within sediments have been widely used for facies recognition and paleoenvironmental interpretation as well as to decipher proximal to distal trends within fine-grained sediments. The Lower Cretaceous mudstone-dominated succession in the eastern Lower Saxony Basin (LSB) offers an excellent opportunity to critically evaluate palynofacies parameters which have been commonly used to identify transgressive-regressive (T-R) cycles in marine sediments. For the seemingly monotonous succession, a robust sequence stratigraphic framework has been established by integrating high-resolution elemental intensity data from XRF-core scanning with organic carbon isotope chemostratigraphy and biostratigraphic information from four drill cores. Stratigraphic trends in Si/Al ratios are interpreted to reflect grain size variations and enable identification of six T-R cycles during the Berriasian to Aptian interval in the LSB. The composition and distribution of the POM has been assessed by analysis of 220 strew mounts using transmitted-light microscopy. POM is dominated by opaque and translucent phytoclasts (avg. = 49.3 %) with amorphous organic matter (avg. = 13.2 %) being mostly of subordinate importance. Marine and terrestrial palynomorphs account for roughly similar fractions with 21.1 % and 16.3 %, respectively. Overall, the POM composition indicates deposition in a mud-dominated distal to proximal shelf setting. The ratio of opaque versus translucent phytoclasts (OP/TR ratio) shows a distinct long-term increase from the Berriasian onwards with maximum values during the Lower Hauterivian, followed by a subsequent decrease in OP/TR ratio. This trend broadly reflects the overall transgressive-regressive evolution of the succession interpreted from Si/Al changes. On the other hand, the ratio of terrestrial versus marine palynomorphs (T/M ratio), often applied as indicator of proximal to distal trends and distances from the coastline, shows no correlation with the T-R cycles inferred from XRF-core-scanning data. Interestingly, systematic long- and short-term trends visible in T/M ratio correspond to variations in the XRF-derived Ca/Ti stratigraphic trend, which is interpreted to reflect variations in carbonate content. This may indicate that the T/M ratio in the LSB is largely controlled by variations in marine palynomorph flux, probably related to productivity changes of the organic-walled microplankton. In summary, the comparison of the palynofacies parameters with the independently derived T-R cycle framework for the Early Cretaceous mudstone-dominated succession in the LSB shows an overall good correspondence with the OP/TR ratio. In contrast, application of the T/M ratio must be used with caution since other factors (e.g. productivity) may exert a significant influence on this ratio.

Microbial and metal enrichment in the Dead Sea shores

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While the Dead Sea is an extreme environment challenging the development of life forms in its hypersaline water and sediments, freshwater springs at its shores have formed networks of pools of diluted waters where microbial mats develop intensely. We hypothesize that these environments share similarities with those that have allowed the formation of stromatolites along ancient Holocene to Pleistocene shorelines of the lake. These stromatolite are formed of aragonite lamina and sometimes enriched in metals like manganese (Buchbinder, 1981; Druckman, 1981). While they are used to reconstruct paleoshorelines (Lisker et al., 2009), the processes of formation of these stromatolites remain largely unknown, preventing strong support for paleoenvironmental reconstructions.

In order tackle this issue, we have targeted a system at the shore of the lake where mineralizing and non-mineralizing microbial mats have developed. They emerge from ponds and sinkholes formed by the dissolution of salt by circulating freshwater. The salinity of these ponds vary from 28 to 47 g.L of total dissolved salt (ten times less saline than the Dead Sea). Thick exopolymeric substances develop in some of them. We have characterized the biological, sedimentological and chemical compositions of the pools, EPS and mats to try to evidence emerging features supporting the development of mineralized and preservable microbialites-like structures. By combining imaging techniques (confocal epi-fluorescence microscopy, SEM) with chemical and mineralogical mapping (EDX, µXRF and EPMA), we identified patterns of transformation of EPS into Mg-Si-rich matrix and finally CaCO3. We also highlight a localized enrichment of arsenic in one of the mats, suggesting its microbial cycling possibly coupled to anoxygenic photosynthesis. This would be the first occurrence of such a process in the extreme Dead Sea realm. We also suspect that the combination of anoxygenic and oxygenic photosynthesis drives the transformation of EPS into aragonite, therefore providing a biological process for the mineralization of microbial mats into stromatolites in the Dead Sea.

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Evidences of a biodiversity crisis from a Rhaetian peritidal carbonate succession from westernmost tethys (sicily)

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A biodiversity crisis was observed in the latest Triassic Megalodontoid community from a western Tethyan carbonate platform. The studied succession, named Mt Sparagio section, consists of a continuous Upper Triassic to Lower Jurassic peritidal limestone organized in shallowing upward cycles. The subtidal facies in the lower part of this section (Unit A) contain very abundant and high diverse Megalodontoid assemblages consisting of very large specimens (up to 40 cm in diameter). The upper part of Unit A shows a decrease of the Megalodontoid diversity (disappeareance of representatives of the genus Dicerocardium) and a thinning of the shell thickness. Upward, only rare and small Megalodontoids (up to 10 cm) belonging to a monospecific assemblage occur (Unit B). The microfossil assemblages and, in particular the foraminifers, do not show significant variations in both Units that can be assigned to the Rhaetian on the base of the common occurrence of large (up to 1000 μm) specimens of Triasina hantkeni. However, a possible upper Norian age of the lowermost beds of Unit A cannot be excluded.

We analysed the δ18Ocarb from bulk rock samples (after testing the absence of diagenetic alterations) and we observed significant excursions within the Rhaetian horizons. In particular, a positive excursion of δ18Ocarb correlates to the drastic reduction in biodiversity of bivalves between Unit A and Unit B. Moreover, the correlation of the δ18Ocarb curve with the δ13Ccarb curve, previously published for this section, seems to tie the Megalodontoid biodiversity crisis to the Initial CIE and, in turn, to the first pulse of the CAMP volcanic activity. The observed sharp decrease in the mollusc biodiversity can be interpreted as a precursor of the biocalcification crisis that caused the End Triassic Extinction.

Faciological architecture of tempestites from the Teresina formation, southern Parana basin

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Despite the wide use of classic processes to understand high-energy elements' formation, the comprehension of the full formative process of tempestites and hummocky cross-stratification (HCS) still lacks analysis and information. Recent investigations have shown wide configuration possibilities for HCS, both for classic and simple to more complex and composite models. The major difficulty on tempestites and HCS interpretation is given mainly due to limited field and sample observation. Because it is generally restricted to vertical and lateral visualization of outcrops, lacking a regional basin perspective that evidences the relationship of distal and proximal facies of these deposits. Besides that, small-scale flow model experiments do not allow a faithful reproduction of depositional processes and bed configurations. Another issue that impacts interpretation is the lack of HCS-like structures in the modern record. Therefore, analogs for such big bedforms of tempestites and HCS successions are nearly non-existent. Also, the current bed morphologies are generally too small to make a solid conclusion regarding HCS identification. Usually, the description of intra-facies variability of HCS is neglected, which hinders the development of a new depositional model. This fact, coupled with the hypothesis that HCS structures are probably products of more than one depositional mechanism, makes the process even harder to evaluate. Thus, this work proposes the study of the control processes of tempestites and HCS, aiming to comprehend the mechanisms involved in the genesis and faciology of these. With this purpose, it is intended an orthophotography interpretation of lateral exposures and a detailed faciological analysis using outcrops from the Teresina Formation (Upper Permian) located in the southern Parana basin. Which is included in the Passa Dois Group, and it is frequently related to a continentalization interval due to the restriction to water incursions between the inner Parana basin and the Panthalassa ocean. It is expected from this work that it will be possible to differentiate and characterize the depositional dynamics of storms, adding to the discussion about the deposits of the Teresina Formation and the understanding of the filling of the Parana basin.

Stromatolites of the Yacoraite Formation (Tres Cruces, Salta Basin, Argentina)

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Stromatolites encompass a wide diversity of morphologies and fabrics that are often used as a proxy to infer environmental factors, biological communities and formation processes. Nevertheless, the complex suite of environmental characteristics and their interactions with the microbial communities make this task not straightforward. The stromatolites recorded in the mixed carbonate-siliciclastic succession of the Yacoraite Formation (Maastrichtian-Danian) in the Tres Cruces sub-basin (Salta Rift Basin) offer a good opportunity to investigate the heterogeneity of fabrics in a lacustrine setting. Intense research has been done in microbialites of the southern regions of the Salta Basin (Metán-Alemania sub-basins) but those of the northern part (Tres Cruces sub-basin) have received little attention. Here, we present new data on the characteristics of the stromatolites and relationships with their associated facies in the Tres Cruces sub-basin. The samples were collected in several sections (each approximately 200 m-thick) along a W to E transect of 10 kilometres. Previous and ongoing stratigraphic and sedimentological studies, show that the Yacoraite Fm. in the Tres Cruces area can be subdivided in two main parts. The lower part (circa 90–100 m in thickness) consists of thick-bedded oolitic and bioclastic grainstones, stromatolites and fine-grained siliciclastics, which represent a marginal lacustrine setting. The upper part (from 100 to 200 m) consists mainly of fine-grained siliciclastics, with intercalations of thin-bedded oolitic-bioclastic grainstones and stromatolites. Subaerial exposure features are also frequent. This part corresponds to a shallow-water (ephemeral) lake. The morphology, size and lateral continuity of the stromatolites, as well as the relationship with their associated facies show marked differences. In the lower part, the stromatolites exhibit planar to domal morphologies, up to 1 m-thick, and overlie the grainy facies. The domes are closely-spaced to coalescent forming levels that can be traced laterally for several kilometres. In the upper part, the stromatolites are planar (dm-scale thick) and rarely low-relief dome-shaped. They form discontinuous levels that extend up to hundreds of meters and pass laterally into the oolites. Internally, the stromatolites are heterogeneous and complex. Mostly, they have fine-grained and hybrid fabrics. Coarse-grained agglutinated fabrics are subordinate. The fine-grained forms exhibit micritic, peloidal, clotted and/or filamentous textures and can include fenestrae. The hybrid stromatolites are formed by in situ combinations of micritic layers and sparry layers; the latter show a wide range of textures from fibrous calcite crusts to calcite spherulites and/or shrubs.

The shift from metre-thick planar and domal stromatolites forming laterally continuous levels to decimetre-thick planar stromatolites that pass laterally into oolites may be related to a decrease in accommodation and water energy in a shallower setting. Further work will intend to better understand the spatial and temporal distribution of the stromatolite fabrics along the Yacoraite Formation and explore the environmental and biotic factors controlling the development of the stromatolites and their specific fabrics.

Modeling the dynamic of shell burial, exhumation, and disintegration in Holocene-Anthropocene cores

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Skeletal remains disintegrate rapidly in the taphonomically active zone (TAZ) but a subset of older shells remains preserved within the mixed layer, contributing to time-averaged mixtures of young and old shells. This sequestration can reflect burial-exhumation cycles driven by bioturbators and physical reworking that require significant slowdown in shell disintegration. Testing this dynamic requires analyses of downcore shell age data: does disintegration decline with sediment depth; (2) do shells revert to rapid disintegration upon exhumation to the TAZ; and (3) does disintegration vary positively with burial/exhumation, so that the temporal resolution and distinctness of assemblages increases with increasing sedimentation rate and declining bioturbation? We evaluate the effects of disintegration, burial, and exhumation on the sequestration with stochastic transition matrices , using postmortem age-frequency distributions (AFDs) of bivalve assemblages in Holocene-Anthropocene sediment cores on the southern California shelf (at 50–75 m water depths). These cores were collected along an anthropogenic gradient in sedimentation and bioturbation driven by variation in wastewater contamination. We show that, first, death assemblages in the surface mixed layer shift with increasing sedimentation and declining bioturbation from (1) strongly right-skewed distributions with millennial time averaging, with identical AFDs throughout the age-homogenized SML, to (2) simple exponential distributions with decadal averaging. Second, disintegration rate declines downcore at all sites, from yearly and decadal scales in the SML to millennial scales in deeper increments. Third, at sites with deep bioturbation (>30–40 cm), the frequency of old shells in the SML is ultimately determined by having a rate of shell exhumation that is equal to or greater than the rate of burial. In contrast, a low frequency of exhumation relative to burial at a site with limited bioturbation reduces time averaging of AFDs and preserves stratigraphic order. The gradient in the burial/exhumation dynamic is thus driven by a decline in bioturbation rate and depth rather than by a gradient in disintegration, which proceeds at a similar rate in the SML everywhere.

Coastal muddy flats to rudist-dominated lagoons in a ramp-type platform (latest Cretaceous, Iberian Basin)

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During the Late Cretaceous, coastal to shallow marine environments developed in wide areas of the Iberian Basin (NE Spain). The sedimentological analysis performed in this work focusses on the limestones and marls of the La Cañadilla Formation (upper Santonian-early Campanian). This unit has particular interest to understand the complex distribution of facies and depositional subenvironments in the south-eastern marginal areas of the shallow seaway with low-gradient depositional topography (ramp-type platform) that covered most of the basin. Field exposures of this unit in a 40 x 80 km area allow a precise palaeoenvironmental reconstruction of coastal muddy flats to rudist-dominated lagoons. A low energy wave regimen and an attenuated tidal range are assumed is this low-gradient Iberian seaway.

Based on the bed-by-bed analysis of 11 (up to 70 m thick) logs a total of 13 facies, grouped into 3 main facies associations, have been identified. Lagoon facies association A encompasses 4 facies: rudist boundstones (A1) and rudist rudstones (A2), both with grain- to mud-supported matrix and mainly Radiolitidae rudists and foraminifera (mainly milliolids); marls to wackestones rich in miliolids (A3); and miliolid packstones (A4). General low-energy conditions are indicated by predominance of muddy textures, although rudist rudstones and miliolid packstones would reflect episodic wave high energy events.

The lagoon gradually changes onshore to a belt formed by emerged muddy mounds surrounded by very shallow ponds or channels where the facies association B was deposited. Skeletal grainstones/packstones rich in foraminifera with fenestral porosity (B1) accumulated in local beaches around those emerged mounds close to the lagoon. Emerged mounds were the site of accumulation of mudstones/wackestones with fenestral porosity (B2) including scarce skeletal grains such as miliolids and characean algae. Two facies are representative of pond or channels, each showing a preferential distribution within this belt: marls and wackestones/packstones rich in skeletal grains similar to those recorded in the emerged mounds (B3) accumulated in ponds or channels adjacent to the lagoon, whereas ponds located onshore were the sites of deposition of gastropod and characean wackestones (B4).

A muddy emerged coastal plain with small ponds (facies association C) was located onshore the belt of emerged mounds and ponds. Marls to mudstones/wackestones with root traces and scarce skeletal grains (C1) formed in marshy areas with vegetation cover. Marls to wackestones/packstones rich in fragmented debris of terrestrial gastropods (C2) accumulated in shallow ponds. Desiccation and root bioturbation in emerged areas with vegetation cover also generated intraclasts, that were transported and accumulated in the plain by high-energy (storm) events forming intraclasts floatstones (C3) and breccias (C4) with fenestral porosity. Locally intraclasts remained in situ and along with pisoids, formed pisolitics breccias (C5).

The described depositional subenviroments have some similarities with modern analogues like the ten thousand island system in northwest Florida Bay, including the low gradient depositional topography, the low energy wave/tidal regime, the patchy distribution of facies and the vegetation cover of the coastal plain, thus representing one of the few ancient equivalents of this modern sedimentary system.

Integrated study and stratigraphic implications of Miocene volcaniclastic deposits on Mt. Medvednica (North Croatian Basin)

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The North Croatian Basin (NCB) evolved during the Miocene as a part of the SW margin of the Pannonian Basin (Carpathian-Pannonian Region, CPR). A major transgressive-regressive sedimentary cycle in the NCB is represented by an initial deposition in alluvial and lacustrine environments, followed by Central Paratethyan marine environments, and a subsequent return to lacustrine and alluvial depositional environments (Pavelić & Kovačić, 2018). Indications for these variable depositional conditions that are linked to the marine flooding of the NCB are preserved in sediments on Mt. Medvednica (Pavelić and Kovačić, 2018; Avanić, 1997). Due to the intensive and long-lasting CPR magmatic activity, numerous referent volcaniclastic layers are preserved in stratigraphically and environmentally different sedimentary facies. We applied an integrated stratigraphic, compositional and geochronological approach on the three volcaniclastic horizons (ČUČ-1, ČUČ-6, PL) intercalated within the marine sediments on Mt. Medvednica to determine the flooding history and the timing of the initial Miocene Central Paratethys transgression of the western part of NCB, as well as to enable the correlation of the volcaniclastic layers.

Volcaniclastic deposits ČUČ-1 and ČUČ-6 are fine to coarse tuffs intercalated with massive marls. The sequence of calcarenite, tuff, and calcisiltites recorded at site PL indicate a gradual deepening of the marine environment. The composition of volcaniclastic samples from all three sites is similar, with dominantly > 50% vitric juvenile particles (pumice and volcanic shards) with subordinate magmatic minerals (feldspar, biotite, quartz, and amphiboles). The samples are well preserved, with rarely visible volcanic glass alteration. Rhyolitic glass compositions (>77% wt. SiO_2; ranging from rhyolites to high-K rhyolites) from all 3 volcaniclastic horizons suggest an origin from major silicic eruptive events of the CPR. Future trace element measurements of glass shards will provide additional constraints to distinguish primary from secondary volcaniclastics.

New high-precision CA-ID-TIMS U-Pb zircon dates indicate that the ČUČ-1 volcaniclastic horizon (up to 15.44 Ma) is older than the PL horizon (14.937 ± 0.012 Ma), as suggested by Avanić (1997). Since ČUČ-1 zircon dates range from 15.44 and 15.9 Ma, it is not possible to interpret a high-precision age, however, the absence of zircons younger than ~15.44 Ma implies the existence of NCB marine deposits older than ~14.8 Ma (Marković, 2017; PL this study). This data is also indicating that the initial Middle Miocene Central Paratethys flooding of the western (Mt. Medvednica) and the eastern (Mt. Požeška gora, Brlek et al. 2020) parts of the NCB occurred earlier than the previously accepted ~15 Ma maximum flooding age.

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Greening of seasonally dry landscapes: the significance of Pennsylvanian red beds containing large woody debris

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The conquest of seasonally dry landscapes by plants represented a milestone of terrestrialization and involved considerable turnovers of continental depositional systems, the atmosphere and global geochemical cycles. Two evolutionary steps are regarded crucial for this process with the first already executed in the Devonian by the evolution of woody trunks and of the seed habit. Second, it was the diversification and spreading of gymnosperm-dominated communities during the Pennsylvanian, which preluded the predominance of this vegetation type until the rise of the angiosperms. The dispersion of gymnosperm trees was accompanied by an increasing emergence of large woody debris in river systems of tropical Pangaea — nowadays being found as voluminous fluvial successions containing fossil woods in the Carboniferous of North America and Europe. However, due to the low preservation potential of plants at seasonally dry settings and allochthony of the corresponding fossiliferous deposits, both vegetation structure and fossil provenance remained controversial. While most studies have focused on reconstructions of the forests in the source areas, the potential of large woody debris-containing red beds to enlighten the role of plants in shaping fluvial systems is still under-utilized. The talk summarizes a multidisciplinary study of the Upper Pennsylvanian Siebigerode Formation of the Kyffhäuser, Central Germany — one the most voluminous late Paleozoic occurrences of large woody debris from the Northern Hemisphere. A high-resolution lithofacies analysis of 182 outcrops is used to enlighten fluvial architectures preserving fossil woods, the corresponding large woody debris-induced sedimentary structures (LWDISS) as well as autogenic and allogenic factors governing the stratigraphic distribution of the logs. A minimum age of deposition results from U-Pb isotopic dating of a tuff at the top of the section. Besides palaeocurrent analyses and the proposed environment of deposition, the three-dimensional preservation of tissues in the silicified logs enables the source plant communities and their habitats to be reconstructed. The 670 m thick section reflects deposition by a large-scaled braided river system at the north-western margin of the intramontane Saale Basin around 299 Ma ago. Eight lithofacies associations composing the Siebigerode Fm. indicate avulsion processes, synsedimentary tectonics, tropical seasonally dry climate and a palaeorelief connected to gentle basement elevations as determining factors of deposition. Logs were recruited via cut-bank erosion and alluvial influx from slopes framing the river system. This semi-riparian vegetation consisted of sparse forests dominated by up to 40 m tall cordaitaleans and conifers recording precipitation seasonality by the formation of tree rings. Within the river bed, vegetation was limited to sparse communities of scrambling pteridosperms on elevated bartops. High but seasonally fluctuating discharge in wide channels facilitated the uncongested transport of the trunks and their subsequent burial. Based on comparisons of the Kyffhäuser with other Pennsylvanian red bed successions, we regard the formation and preservation of fluvial deposits containing large woody debris in tropical Pangaea as a result of the interference of Variscan tectonics, late Paleozoic climate change and evolutionary advances.

Gravity flows in Mesozoic sediments of Chukotka microplate margin (NE Russia)

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The region consider the part of the Arctic Alaska-Chukotka microplate (Grantz et al., 2011; Lavwer et al., 2011). In the modern structure, the region belongs to the Anyu-Chukotka folded system, which includes several terrains. The authors studied Mesozoic deposits in the Chukchi terrain. In the context of Mesozoic sediments, several stages of the development of powerful sandstone unit composed of gravitational flows.

Triassic deposits, represented mainly by turbidities, accumulated in a passive margin setting. Strengthening the role litharenite sandstones occurred in Olenekian, Upper Carnian and Norian Time and corresponds to periods of activation of tectonic movements of the continental margin. They are associated with the beginning of the formation of intra-basin elevations. Continental land was peneplenised, with low hills.

In the upper Jurassic-lower Cretaceous, sediments accumulated in an active tectonic setting in several isolated depressions with a constant change in the main sources of demolition. Sandstone dominance periods are set in Oxfordian-Kimmerigian and Valanginian Time. During these time intervals, powerful arcose sandstones formed, the source was located in the North. In the Tithonian-Berriasian period, the ensimatic Kulpolnei island arc accreted to the southern edge of the Chukotka microcontinent, and a new continental arc laid. The direction of currents of deposits has changed and occurred mainly from South to North. In the pool, which was located in the rear arc accumulated litharenite sandstones with a high content of volcanic material. At the same time, in the North, the terrain of the adjacent land being flattened, and the sources were subjected to intensive weathering.

Conclusion. Five Mesozoic episodes of sandstone dominant allowed us to regional periods of tectonic activity, and can serve for paleoreconstructions of the Amerasian basin.

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Tuchkova M.I., Vatrushkina E.V., Sokolov S.D., V.E.Verzhbitsky Gravity flows of Mesozoic deposits of Chukotka – paleogeographical and geodynamic evidences // IAS, Krakow, 22–25 June 2015

Paleopedology of the red and yellow paleosols of NW Himalaya: implications for early Oligocene seasonality

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The Himalayan orogeny has played a major role in evolution of Asian monsoon system that influenced global and regional climate over the Indian sub-continent. In view of this, the fluvial sedimentary record of the Himalayan Foreland Basin (HFB) provides an ideal platform to study interactions between sedimentation, tectonics, climate, and paleopedogenesis. In the present study we aimed to explore the fluvial sedimentary record of the north-west part of the Himalayan Foreland Basin. The detailed paleopedological investigation of the oldest fossil soils of a ~3.1 km fluvial succession from Kangra sub-basin shows lower 2 km part of the succession is characterized the red (10R hue) and the upper 1.1 km part of the succession by the yellow (2.5Y hue) palaeosols with varying degree of paleopedogenic development. Despite burial diagenesis (7–8 km), evidences for paleopedogenesis are still well-preserved in these paleosols in the form of structural elements, clay coating, rhizocretions, mottles, bioturbation, Fe-Mn concretions and pedogenic carbonates. The paleopedological evolution suggests four pedofacies with strongly developed (Type-A) paleosols analogous to modern Alfisols to Entisols with little or no pedogenesis as (Type-D) pedofacies. Thin section analysis showed 50–60% paleopedofeatures are preserved as microstructures, b-fabric, pedogenic carbonate, bioturbation and clay coatings. The pedogenic calcium carbonate as diffused micritic nodules with thin iron oxide coatings occurs predominantly in lower part of the succession that shows its dissolution and absence in upper part of the succession. In the lower part of the succession, the clay coatings along the voids occurring together with pedogenic carbonates appear to be impure in nature, whereas in the upper parts these are marked by thick to very-thick microlaminated coatings and intercalations of pure clay with no pedogenic carbonates. The clay mineralogy of the total clay (<2 μm) and fine clay (<0.2 μm) for these paleosols show strong and sharp 14 Å, 7 Å, 10 Å, 3.5 Å, 3.3 Å minerals along with interstratification and alteration of 14 Å and 10 Å minerals. It is also marked by a decrease in the smectite, and vermiculite and increase in the kaolin in upper part of the succession. The paleopedological conditions inferred through pedogenic calcium carbonate, illuvial features, and clay mineralogical characteristics of red paleosols provide a strong evidence of initiation of monsoon during ~31 Ma in early Oligocene. Whereas, yellow paleosols at ~20 Ma is marked by increased humidity in subtropical conditions. It is consistent with similar observations recorded in Dagshai paleosols form adjacent parts in Subathu sub-basin of the HFB.

Key words: Himalayan foreland basin, paleosols, monsoon, pedogenic calcium carbonate, weathering, clay minerals.

Microplastics as a sedimentary component in reefs systems

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Only recently, microplastic pollution has been reported from coral reef systems all over the tropics. Exposure to microplastics has several negative impacts on coral health, such as bleaching, tissue necrosis, or an impairment of the corals immune system. Despite this potential risk for reef systems, the controlling processes for microplastics dispersion and accumulation in reef sediments are still largely understudied. Presented here is a study of microplastics distribution in two tropic atoll reef platforms in Kepulauan Seribu, Indonesia. Sediment samples were collected with a tube to a depth of 7 cm in the reef crest, sand apron, lagoon, and intertidal beach. Microplastics were concentrated using density floatation and characterized by light and scanning electron microscopy. Some particles were identified as polypropylene using micro Fourier transform infrared (μFT-IR) spectroscopy. All recovered microplastics were classified as secondary microplastics, likely derived from marine and local sources, with fibers as the most abundant type. Microplastics are showing similar transport and accumulation behavior as fine siliciclastic grains. The abundance of microplastic is controlled by the proximity to the source area of larger plastic debris and hydrodynamic processes. Microplastics are not only present in low energy environments but also high energy settings such as e.g. the reef crest. Processes that contribute to accumulation in reef sediments are biofouling, interlocking, and the creation of compound grains. Microplastics are present in sediment close to the seafloor (0–3.5 cm) but also in a depth between 3.5 and 7 cm. Microplastic particles below 3.5 cm are unlikely to be remobilized under modal weather conditions in the studied equatorial reefs. Subtidal reef sediment therefore can be regarded as a permanent sink for microplastics. The study shows that microplastics in coral reef environments deserve careful consideration since microplastics poses an additional threat to corals and their ability as framework builders in reef systems.

Spatial distribution of grain size and isotope geochemistry in the modern Abu Dhabi lagoon

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Carbonates and their (isotope) geochemical, mineralogical and petrographic properties are commonly exploited as environmental archives, as they can provide information about the prevalent environmental conditions during their deposition. Many data sets published in the literature, however, are measured from bulk (matrix) carbonate, an approach that has both, advantages and disadvantages. Often, these data reflect a geochemical average of an unknown mixture of biogenic and abiogenic sediments, and can include both original and diagenetic phases. As such, the geochemical variability of the different components that contribute to the bulk signature are commonly poorly understood. This implies that the bulk isotope signal may or may not be affected disproportionately by one component type with more extreme isotope signatures. To improve the present understanding of particle versus bulk isotope signatures, this study documents a component-specific analysis of carbon and oxygen isotopes of sediments from various depositional environments of the Abu Dhabi lagoon. A total of ca. 50 sediment samples were separated into their main bioclastic sediment classes including: gastropods, bivalves, and foraminifera. The isotopic signatures of these components are then compared to the bulk carbonate signature. Variations in isotopic signature and grain distribution were analysed in a spatial context to determine the effects of environmental restriction. The carbonate sediments generally have a more positive $\delta^{18}O$ signature (1.67 ‰) compared to inorganic carbonate precipitated in equilibrium with seawater (0 ‰). Reasons may include the significant effects of evaporation leading to ^{18}O-enriched waters. Grain size distributions range from coarser to finer grains along a less restricted (outer open lagoon) to more restricted (inner lagoon) profile. The open lagoon is dominated by tidal currents and is typified by coarse grained bioclastic and ooidal sediments. In contrast, the more proximal portions of the Abu Dhabi lagoon are primarily dominated by finer-grained material. Overall, the isotope geochemistry of individual sedimentary components reflects the environmental conditions more reliably than bulk sediments. This is particularly apparent in samples with high proportions of skeletal components and other sediment types with biological control or influence, as it can influence isotope fractionation. This study highlights natural variations of modern carbonate systems, and sheds light on the potential and limitations of bulk isotope data sets.

High-resolution stratigraphic analysis of the Yacoraite Formation in the Tres Cruces Sub-Basin (Salta Basin, Argentina)

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The interplay between carbonate production and siliciclastic input in mixed depositional systems results in spatially complex distribution of facies. The Yacoraite Formation (Cretaceous-Paleogene) is a mixed carbonate-siliciclastic succession within the Salta Group in the intra-continental Salta rift Basin (NW Argentina), and provides an excellent case study to investigate spatial and temporal facies heterogeneity in a mixed setting. Deposition of the Yacoraite Formation occurred during the post-rift phase in a predominantly lacustrine environment, possibly subjected to marine influence in the northern part of the Salta Basin. The Yacoraite Formation has been thoroughly characterized in the southern part of the Salta Basin (Metán-Alemania sub-basins), whereas the northern sub-basin of Tres Cruces remains largely understudied. In this project we apply high-resolution stratigraphic and sedimentological analysis integrated with virtual outcrop modelling to characterize in detail the distribution of facies and sequence stratigraphic framework of the Yacoraite Formation in the Tres Cruces sub-basin. Facies are mainly represented by lacustrine marginal and littoral associations, dominated by stromatolites, oolitic and intraclastic grainstones-packstones, gastropod floatstones-rudstones, commonly intercalated with fine-grained siliciclastics, ranging from fine sandstones to siltstones and shales. These facies associations and their distribution reflect deposition in a shallow water balanced-fill lake basin type, with high energy ramp-type margins. Based on our observations we can subdivide the formation into two main parts. The lower part is mainly represented by carbonate dominated facies, and shows a marked cyclicity, with metric-scale sequences of oolitic and microbial carbonate facies overlying fine-grained siliciclastics, interpreted as shallowing-upwards cycles. These cycles are highly continuous and can be traced laterally at a kilometre scale. This lower unit is overlain by a mudstone interval (7 to 14 meters thick), extending at a regional scale, characterized by evidence of sub-aerial exposure, such as mottled textures and paleosol horizons, representing deposition in a flood-plain area. Above this interval, in the upper part, we observe an increase in siliciclastic facies with sparse and discontinuous intervals of oolitic grainstone-packstones and stromatolite boundstones. A coeval decrease in the regularity of cyclicity is also observed, albeit it is still present and characterized by shallowing-upwards cycles comparable with the ones in the lower part, but at a smaller scale. Moreover, the lateral continuity and average thicknesses of the carbonate facies in the upper interval are lower than those of the lower interval. Our observations are in line with the hypothesis that alternating phases of deposition between clastic dominated facies and carbonate dominated facies are mainly the result of climatically driven lake level fluctuations, resulting in stratigraphic mixing. We conclude that carbonate production is enhanced during drier climatic phases, whereas siliciclastic dominated facies are mainly deposited during more humid phases, coeval with an increase of water inflow and sediment input into the lake system.

Sequence stratigraphic patterns of benthic marine carbonate factories

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One of the main advances in carbonate sedimentology achieved during the last decades, is the distinction of different carbonate factories, i.e. groups of carbonate-producing organisms that operate under a specific set of environmental conditions, and as a result have a particular sedimentological and stratigraphic imprint. A carbonate factory classification system provides a set of characteristics, ranging from the micro texture to the overall construction geometries, which are predictive away from data points.

Here we will illustrate how an insight in the nature of these carbonate factories is important for sequence stratigraphic studies, and what the key differences are compared to siliciclastic systems. Focus will be on the carbonate sediment production rate, composition and sediment mobility, and how these control depositional profiles and eventually stratigraphic architecture. Typical examples will be provided of the four main benthic carbonate factories, Tropical (T), Cool water (C), Cool Water Coral (CWC), and Microbial (M) (sensu Schlager, 2005, and Reijmer, 2021), as well as transitional situations and documentation of co-eval existence in space. The mapping of the proliferation of the carbonate factories through time shows a close link to the large-scale climatic evolution of the Earth and the four main global Phanerozoic mass extinction events.

For carbonate sequence stratigraphic studies, it is thus essential to consider this significant spatiotemporal variation of the carbonate sediment flux, which makes that simpler, mostly physics based siliciclastic models, have a limited application in the carbonate domain.

Environmental control on carbonate platform stratigraphy – forward stratigraphic modelling the Neogene of the Maldives

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Carbonate platform stratigraphy is driven by the interaction between physical changes during basin formation and ecological evolution of biota. Ecological accommodation depends on a range of environmental parameters, most notably water depth and wave energy. Less constrained is the relationship between platform stratigraphy and parameters like nutrient availability, turbidity, salinity and temperature, as they are difficult to derive from the geological record.

The isolated Maldives carbonate platform forms an ideal case study to quantitatively investigate the impact of such secondary environmental parameters. The stratigraphy of the western margin exhibits a late Oligocene to Middle Miocene evolution that remarkably correlates with eustatic sea-level changes. Our conceptual model, based on recently published literature, subdivides it in four phases with distinct geometries, punctuated by stratigraphic turning points: (I) drowning and formation of a carbonate ramp, (II) ramp-to-rimmed-platform evolution, (III) aggradation, and (IV) progradation. With a forward stratigraphic model, we aimed to test if this sequence could be reproduced by simulating only physical accommodation changes combined with some well-established constraints.

The model's basin conditions are determined from global parameters such as the eustasy variation and the hydrodynamic regime; and regional parameters, such as the paleobathymetry and subsidence, reconstructed from seismic and well data. Carbonate sediment producers are identified from core descriptions and grouped into classes by common characteristics, such as transport and production. Production rates were restricted in space by (vertical) light- and (lateral) wave-energy dependence. Production potential over time, however, remained as the calibration variable and a proxy for unaccounted environmental changes. Our experimental hypothesis states that the impact of additional processes is negligible on the stratigraphic record, when an adequate model fit is achieved with continuous production rates over the entire study interval.

The calibrated carbonate production shows however two necessary deviations from a continuous curve: (1) a dip in photo-dependent carbonate production during drowning and (2) an increase in oligophotic and carbonate grain production rates during progradation. The first dip in carbonate production exemplifies how the carbonate platform is unable to drown solely by eustatic sea-level changes. The presence of sapropels supports the hampering of carbonate production by an environmental stress like nutrient upwelling or cyclic anoxia. The second change in production rates indicates a change in platform composition that enables the accumulation of fore-slope deposits and promotes progradation. The increase in oligophotic production corresponds to a global abundancy increase, while the increase in carbonate grains suggest intensified sediment reworking and platform shedding.

With the hypothesis falsified, our experiment shows how subtle environmental changes -unaccounted in the model constraints- profoundly impact the platform stratigraphy. Treating carbonate production rates as an uncertainty proves essential during periods of environmental change and provides insight in biological changes within the platform.

Sheet-like delta-front sandstone bodies in a river-dominated low-accommodation setting (Dakota Group, USA)

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Sheet-like delta-front sandstone geometries are often assigned to wave-dominated coastal settings. Results of this study suggests that similar geometries can be formed by sediment dispersion through multiple distributary channels in river-dominated low-accommodation settings. This indicates that a better understanding and reappreciation of forming mechanisms of delta front strata is needed for accurate interpretation of sheet-like sandstone bodies in low-accommodation settings.

This study utilizes the exhumed Cenomanian Mesa Rica Sandstone (Dakota Group, New Mexico, USA), which encompasses a fluvio-deltaic system along a ~450 km depositional dip-parallel profile. The study targets the fully deltaic development of the Mesa Rica depositional system in the center of the Tucumcari sub-basin (Western Interior Basin). A >20-km-long escarpment, subparallel to the main delta progradation direction, allows a detailed analysis of facies distribution, depositional architecture, and the spatial extent of stratigraphic surfaces based on 31 sedimentary logs, photo panels and drone survey imagery. Results reveal a typical coarsening-upward and shallowing-upward deltaic succession, consistently overlain by sand-filled amalgamated distributary-channel deposits, which forms a laterally extensive sheetlike sandstone throughout the study area. The delta front deposits have two different expressions; highly-bioturbated extensive tabular geometries and poorly-bioturbated subtle lensoidal internal geometries. These characteristics are typical for both river and wave processes acting on the delta front, whereas he continuity of distributary-channel deposits is a critical indicator for a strong river influence.

The sheet-like sandstone is interpreted to result from successive coalescence of mouth bars, in a river-dominated setting with multiple distributary channels. The sheet-like delta-front sandstone bodies are interpreted as the result of the combined effect of high sandy-sediment supply and low accommodation. The latter acted as an accelerator for the interrelated processes of frequent avulsion of distributaries and recurring mouth-bar depositional cycles at short time scales. After deposition, minor wave-reworking facilitated lateral sand redistribution and favored bioturbation.

The study highlights a sand-rich end-member example of deltaic deposition in a low- accommodation setting. The work demonstrates that sheet-like delta-front sandstone geometries from low-accommodation systems can be formed without the dominance of wave redistribution processes. This can be particularly relevant for subsurface studies, because it cautions against interpretations of amalgamated wave-dominated shoreline systems based solely on sandstone geometries, without taking into account the possible limited preservation potential and post-depositional modification of primary deltaic characteristics.

Saharan dust addition to interglacial paleosols of Central European loess-sequences

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Several hundred tons of windblown dust material is emitted and transported through winds every year from Saharan dust source areas towards Europe. Besides several other environmental effects, aeolian dust also plays an essential geological role as parent material of aeolian dust deposits. Substantial role of dust addition in interglacial soil formation has been reported from several sites around the Mediterranean. Here we present a comprehensive overview of interglacial Saharan dust addition to paleosols of Central European loess sequences.

According to a simplified model of aeolian dust sedimentation, dust accumulation is a result of local, dust storm-related coarse-grained (>30 µm: middle- and coarse-silt fraction with a casual presence of very fine-sand) dust deposition and additional incorporation of fine-grained background dust load (<20–30 µm: clay, fine-silt fraction). The source of the coarse-grained sub-population is local material, while the fine-grained component is primarily the result of deposition of dust particles from distant sources (and partly post-depositional alteration and disintegration of aggregates).

Estimations derived from the in-situ measurement-based adjustment of Saharan dust deposition simulations of numerical models indicated that the dust flux of North African fine-grained mineral material could be set into the range of 3.2–5.4 g/m2/y. Pleistocene mass accumulation rates calculated from stratigraphic and sedimentary data of loess-paleosol sequences allowed the determination of the relative contribution of Saharan dust to interglacial paleosol material. According to these calculations, North African exotic dust material represents 20–30% of the fine-grained component (clay and fine silt-sized fractions) of interglacial paleosols in the Carpathian Basin.

Sea level and sediment flux paced by insolation during the Early Pleistocene, Taiwan

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The Pleistocene was a phase of global cooling of the Earth through which glacial-interglacial cycles occurred, and the growth and decay of the ice-sheets resulted in quasi-cyclic sea-level fluctuations driven by orbital forcing. Despite that summer insolation is mostly controlled by precession, the records of the glacial cycles showcase a significant periodicity of ~41 kyrs during the Early Pleistocene forced by Earth's obliquity (tilt) that varies the latitudinal distribution of insolation especially in high latitudes. The dominance of obliquity over precession in marine archives is commonly attributed to the in-phase effect of obliquity-related insolation versus the opposite-phased influence of precession, which may cancel out the summer insolation signal received by the southern and northern hemispheres.

Here, we present a clastic shallow marine record from the Cholan Formation (Early Pleistocene; Taiwan). Facies analysis indicates that quasi-cyclic deposition occurred in shoreface to offshore environments in the paleo-Taiwan Strait. The magnetobiostratigraphic framework indicates that the studied section occurs in the lower part of the Matuyama subchron (1.925 – 2.595 Ma) close to the lower limit of the Olduvai (1.925 Ma) normal polarity subchron. Comparison of the stratigraphy to a δ18O isotope record of benthic foraminifera and orbital curves of precession and obliquity at the time of sediment accumulation reveals a good correlation between depositional cycles and Northern Hemisphere summer insolation, demonstrating precession dominated sea-level fluctuations during the Early Pleistocene. These results underpin recent findings suggesting that δ18O isotope records of benthic foraminifera have a more significant precession signal than previously described. This study also demonstrates that shallow-marine stratigraphic successions in high-accommodation and high-sedimentation basins can be outstanding climate archives, possibly even preserving sediment flux responding to half-precession cycles.

Ferruginous coated grains in the Lower Devonian Řeporyje Limestone (Prague Basin, Czech Republic)

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Phanerozoic ironstones represent a phenomenon that has been puzzling geologists for decades. What was the source of iron? Why is the mineralogy so specific? Why do they possess a concentric texture? To address these questions we focused on ferruginous coated grains mostly represented by microstromatolitic oncoids from the Lower Devonian (Pragian) Řeporyje Limestone employing BSE, X-Ray diffraction, and LA-ICP-MS analyses. The oncoids were firstly described by Skoček and Kukal (1998), who considered lateritic regolith of the exposed carbonate platform as the main source of iron and based on elevated vanadium concentrations interpreted microbial processes as essential in ironstone formation. The oncoids are up to 5 cm large, their cortices show distinct cyclic arrangement of hematite/chamosite and /or carbonate laminae, which are 10–40 µm thick, irregular, wavy, and with a relatively high degree of inheritance. Micro-domes and bulges are comparable to those observed in stromatolites, the laminae are continuous, deflecting, and overgrowing topographic irregularities (such as encrusters), which is suggestive of the presence of cohesive mat. Agglutinated foraminifers were fairly commonly observed within the oncoid framework. The surfaces of oncoids are wavy and often wrinkled. Although no undisputed microbial remains were recorded, we regard the above-mentioned features as indicators of biogenicity of the precipitates. Without attempting to elucidate the nature of microbial consortia that formed the oncoids, we assume that the precipitation of different redox-sensitive mineral phases could be a result of the microbially mediated coupling of Fe^{2+} oxidation and Fe^{3+} reduction within the mat. Positive Eu anomalies, Nd – Ce/Ce* crossplot, and Eu/Sm and Sm/Yb ratios suggest a certain influence of hydrothermal high-temperature fluids, which is interesting given the tectonic and volcanic calm in this area during the Pragian.

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A framework to link submarine fans morphology to turbidity current flow properties using depth-integrated simulations

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Experimental studies demonstrate that the fabric of turbidites in submarine fans is a combined function of the hydrodynamic and sediment-transport fields. At larger scales, the combined influence of the hydraulic and sediment-transport regimes on the resulting stratigraphic architecture remains unknown. We explore this question using a simulator governed by a set of depth-averaged equations that conserve fluid, sediment mass, momentum, and turbulent kinetic energy for turbidity currents. We implement a dimensionless approach for characterizing the fluid flow and sediment-transport fields by varying Froude and Rouse numbers, respectively, for turbidity currents that lose lateral confinement when entering a model domain. Simulated turbidity currents traverse an inlet channel (5km long and 500 m wide) onto a 20 km square domain that has uniform non-erodible antecedent surface. We obtained a total of 100 realizations to cover a wide range of morphodynamic conditions resulting from a spectrum of turbidity current defined by Froude ($0.4 < Fr < 2.2$) and Rouse ($0.02 < Ro < 0.2$) numbers. The simulator stores data on evolving topography, stratigraphic attributes such as the mean deposit grain size, and flow properties including velocity, height and flow concentration. We focus on morphodynamic evolution of simulated submarine fans. Results from simulations show distinct endmember morphodynamics. Subcritical ($Fr < 1$) fans are characterized by multiple active channels that are laterally mobile. The overall shapes of these fans are elongated due to the transport of sediments in multiple channels that orient themselves in the downslope direction. Conversely, supercritical ($Fr > 1$) fans are characterized by a single dominant channel that has limited lateral mobility between avulsions. This produces fans that are radially symmetric with much of their sediments deposited just downslope of the inlet channel. We measure and link the complexity of fan morphology to the inlet conditions, specifically, we are focusing on the link between fan rugosity to inlet conditions. Results from this work will aid future stratigraphic predictions from a priori knowledge of boundary conditions and the interpretation of paleo-hydraulic conditions from preserved deep-water stratigraphy.

Self-sealing characteristics and formation mechanism of the lower Silurian Longmaxi shale in the Sichuan basin, China

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The lower Silurian Longmaxi organic-rich shale is the main target horizon for the exploration and development of marine shale gas in China. Since 2012, it has been economically exploited in Fuling, Changning, Weiyuan and other areas of Sichuan basin. Good preservation condition is the important factor for the high yield of shale gas, and it is the self-sealing nature of the Longmaxi formation shale that enables the natural gas to be well preserved in high-quality shale. In order to define the self-sealing characteristics of Longmaxi shale, geological, geochemical and gas reservoir characteristics are analyzed. The results show that there is a layer of silty shale covering on the main producing layer, which is siliceous/carbonaceous organic-rich shale, creating a direct barrier to shale gas. And the inversion of carbon isotopes in shale gas indicates that kerogen pyrolysis gas was mixed with crude oil pyrolysis gas. In addition, the overpressure develops in the main producing layer and there has a transition from overpressure to atmospheric pressure near the silty shale layer, which also indicates that the Longmaxi shale is self-sealing. On the basis of the above studies, the formation mechanism of shale self-sealing was further discussed by combining physical parameters test experiments. The results show that on one hand the overlying silty shale layer is relatively tight, causing its breakthrough pressure is greater than the gas layer pressure of the main production layer, and the porosity connectivity is relatively poor, thus forming a good physical seal to the underlying high-quality shale production layer. On the other hand, the experiment shows that the large amount of methane adsorbed by the organic-rich shale in the main producing layer can block the shale pores, reduce the horizontal permeability and inhibit the loss of shale gas. Therefore, the self-sealing property of Longmaxi formation shale is an important factor of its high yield.

A fast adaptive non-local mean filtering and its application for stratum imaging improvement

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In the process of ultra-deep seismic exploration, due to the limitation of current seismic acquisition technology, the resolution and signal-to-noise ratio of ultra-deep seismic data are relatively low. One of the main factors affecting the signal-to-noise ratio of the post stack profile is that a large quantity of random noise is often mixed in the seismic data, which makes stratum fuzzy and fault structure unclear. Ultimately, the purpose of accurate interpretation and description of underground geological structure cannot be achieved. Non-local mean (NLM) filtering as an image noise attenuation method has been introduced into seismic data processing in recent years. In this paper, a fast adaptive NLM method based on centrosymmetric data integration is proposed. Based on the NLM with data integration algorithm, we use the centrosymmetric data integration algorithm to effectively reduce the calculation cost. On the foundation of the adaptive NLM method based on the minimum variance estimation, we add the standard deviation of similarity to measure the degree of homogeneity, which can protect the effective signal and further improve the noise attenuation effect. A series of seismic models were synthetized to examine the performance of the proposed method, NLM based on data integration and conventional NLM method. We constructed a series of models that consist of N traces with N=50, 60, . . . ,110 and 256 time samples per trace. From the computational time comparison of these three methods, the proposed method outperforms the NLM based on data integration method and conventional NLM method. Then, from the denoising quality for different seismic data models, we can find that the proposed method has better denoising quality. We also display the denoising results for model data with 80 traces. It can be seen from the difference profile that the proposed method is better to protect the effective signal and suppress the random noise more effectively. The method proposed in this paper is also applied to random noise attenuation of real seismic data. Compared with other methods, such as prediction filtering, rank-reduction filtering and conventional NLM method, the method presented in this paper has a better effect on suppressing random noise. Especially in the Cambrian salt-gypsum reflection layer at the bottom right corner of difference profile, it can be seen that: (1) the residual of effective signal in the difference profile of FX prediction filtering is relatively obvious; (2) although the noise attenuation effect of rank-reduction filtering and conventional NLM method is relatively obvious, it also causes damage to the effective signal; (3) the proposed method not only reduce the damage to the effective signal, but also can suppresses the random noise effectively.

Tracing paleosols in a UAV-based photogrammetry model of alluvial stratigraphy in the Bighorn Basin, Wyoming

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Strikingly-developed paleosols have been extensively reported in the alluvial stratigraphy of the Willwood Formation, Bighorn Basin, Wyoming. They result from strong pedogenesis on the floodplain fines during the long overbank phases with channel-stability. Stratigraphic alternations between the overbank phase and the avulsion phase featuring weak pedogenesis on heterolithic sandy avulsion-belt deposits, are demonstrated to be driven by orbital climate forcing based on the 1D cyclostratigraphic analysis. Given that the floodplain aggradation cycles can be influenced by both allogenic forcing and autogenic processes, it is crucial to reveal its lateral persistency and variability so as to disentangle the interaction between allogenic and autogenic factors over spatial and temporal scales. We here trace paleosol beds laterally in a 3D, fully-georeferenced UAV-based photogrammetry-model that covers an area of ~10 km2 and straddles a stratigraphy of ~300 m. This model is integrated with detailed sedimentary logs produced in trenched sections to document the lateral persistency and variability of paleosol-bounded floodplain aggradation cycles. There are a total of 44 cycles with an average thickness of 6.8 m. We comprehensively analyze seven successive cycles that show an average thickness range from 3.7 to 9.7 m and a standard deviation of 1.0 to 2.5 m. Variogram analysis reveals that the thickness of a cycle at one locality is related to that at another locality over a maximum distance of 1.1–1.6 km roughly in the paleoflow direction and 0.2–0.7 km perpendicular to the paleoflow direction. We suggest that this is related to morphodynamic features of the fluvial system that are more continuous in the paleoflow direction. Compensational stacking of vertically adjacent cycles seems to occur within the duration of three successive cycles and full compensation is achieved after more than five cycles are deposited. Relationships between paleosols and associated channel-belt deposits are to be analyzed in order to reveal the corresponding sedimentary environment and possible paleoclimate.

The hydrothermal potential of Calcalpine carbonate rocks related to a geothermal life cycle assessment

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The petrophysical properties of Calcalpine carbonate rocks offer potential reservoir properties for a geothermal utilization, especially for hydrothermal utilization. The lithofacial variations determine the distribution of reservoir rocks and sealing conditions within a Calcareous Alpine Zone. The stratigraphy and facial arrangement of a thrust slice of the Goeller Nappe in an area west of Baden (south of Vienna/Austria) exhibit an example of a geothermal zoning, from wich the geometrie of the deposit can be derived. A correlation between facial characteristics, storage capacity and cap rock properties took place. In connection with the rock properties a potential quantity of recoverable energy can be estimated for different depth levels. The data of the analysis are used in a life cycle assessment of a hydrothermal energy production in fractured carbonate rocks.

Tectonically the regarded area belongs to a thrust slice of the Goeller Nappe. This trust slice has been moved toward west of its base borderd by stike slip faults. For the geothermal zoning Upper Middle Triassic/Lower Upper Triassic formations are regarded. Hydrothermal target horizons are the Calcalpine platform carbonates. In the regarded area the Triassic platform facies consists of Wetterstein dolomite and -limestone as well as contemporary sediments of the platform rim. The underlying part of the considered section comprises Persmoskythian sediments, Reichenhall-, Gutenstein, and Reifling-Formation. The platform carbonates can be subdivided in massive Wetterstein dolomite, showing reef formation and bedded Wettersein dolomit, which can be interpreted as intraplatform fans. The type of porosity is mainly a fracture porosit. Outcrop analysis showed primary pososity, interparticle and intrapartice porosity of the reef sediments and secondary porosity by fracturing, caused by tectonic or dolomitsation.

The hydrothermal reservoir shows a structure of highly permeable reservoir rocks, minor permeable layers and cap rocks. The reservoir capacity is limited to the massive reefoidal Wetterstein dolomite and the bedded Wetterstein dolomit. Minor permeability show Wetterstein limestone, Ladinian slope facies, Reifling-Formation and Gutenstein-Reichenhall-Formation. Cap rocks are the Gießhuebl Formation, Permoskythian layers, the Ladinian basin facies and the Lunz Formation with shales and cemented sandstones. The cubature of the deposit can be derived from the teconic position and the geothermal zoning. The reservoir potential for this cubature is determined from measured thermal parameters and the storage capacity of the Wetterstein dolomite. The data for the calculation of the storage capacity originates on fracturing analysis of outcrops and comparative well data. The stratigraphic and facial arrangement of fractured carbonate rocks is related to a deposit potential. Based on the petrophysical rock properties, the storage capacity, the cubature of the reservoir body and the geodetic depth level, the continuously recoverable energy quantity and the CO2 reduction potential can be derived. The recoverable energy quantity is related to different depths of the hydrothermal reservoir. The life cycle assessment is based on the required well depth, the development of the energy source, to the energy extraction in a geothermal power plant to the reinjection of the water used. The CO2 footprint is highly dependent on the required depth of a hydrothermal development.

Lithofacies summary and depositonal setting of Namurian A mudstone, Namur Synclinorium and Campine Basin (Belgium)

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Namurian A Formation in Belgium consists of organic rich mudstone and it belongs to the Mississippian shale play. Large and potential gas reservoirs are presumed to be present in previous work. It's deposited in the Campine Basin and the Namur-Vesdre and Dinant synclinorium (Doornenbal et al., 2010). Following the Viséan disruption of the Dinantian carbonate platform and the development of a regional unconformity, the Rheno-Hercynian shelf tectonically subsided during the Namurian with sedimentation of orogeny-derived deltaic and coal-bearing clastics with sporadic marine intercalations filling in the Variscan foreland basin (Doornenbal et al., 2010). In order to reconstruct the paleoenvironment of Namurian A mudstone, samples from the Chokier, Gottignies and Epen Formation as well as the Geverik Member in the Namur Synclinorium and the Campine Basin were collected for mineralogical and organic geochemical analysis, including core and thin section description, grain size analysis, cathodoluminescence, X-ray diffraction, total organic carbon, total nitrogen, stable isotope analysis, organic petrography and Rock-Eval pyrolysis.

11 sedimentary Facies were defined, including fine argillaceous mudstone (Facies A), medium argillaceous mudstone (Facies B), silt bearing coarse to sandy argillaceous mudstone (Facies C), fine siliceous mudstone (Facies D), medium siliceous mudstone (Facies E), sandstone interbedded coarse to sandy siliceous mudstone (Facies F), silica dominated mudstone (Facies G), medium mixed mudstone (Facies H), carbonate cemented mudstone (Facies I), fossiliferous medium to sandy mudstone (Facies J), limestone (Facies K). Facies A to C are common. They have low carbonate and high clay mineral contents. Facies D to F exhibit variable composition, in general they possess high detrital quartz and bioclasts content with increased contribution of authigenic carbonates. Facies E is more common while Facies D and F occur locally. Facies G is found in the western Namur Synclinorium with highest quartz content and well developed fractures. Facies H is highly carbonate bearing, including siderite and ferroan dolomite with abundant calcite veins. It is found mainly in the Campine Basin. Facies I and J distribute locally in the Campine Basin and the eastern Namur Synclinorium. Facies I contains recrystallization carbonate which obliterated the original depositional fabrics. Facies J is characterized by densely packed shell beds with abundant bioclasts. Facies K represents limestone from mud supported to clasts supported framework and contains abundant graptolithina, sponge tests and radiolarians. It is found in the Campine Basin and the western Namur Synclinorium.

Namurian A mudstone is overmature (Ro, 1.9 to 3.5%) with higher maturity in the Campine Basin. The Gottignies Formation (averaging 5.4 wt%) and the Geverik Member (averaging 4.1 wt%) contain higher TOC with marine organic matter. The Epen Formation (averaging 2.1wt%) and the Chokier Formation (averaging 2.7 wt%) contain lower TOC with marine and terrestrial organic matter. The origin can be linked to microorganisms and continental plants. The depositional environment of Namurian A mudstone in the Campine basin and the western Namur Synclinorium are more distal from their source area than in the eastern Namur Synclinorium. Significant amount of pyrite framboids, euhedral pyrite crystals, pyritized burrows and tests reflect general anoxic-sulfidic condition.

Morphological and geochemical characterisation of seep carbonates in the southeastern Mediterranean Sea

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Methane-derived authigenic carbonates have recently been discovered in the Levant Basin and the Palmachim Disturbance (SE Mediterranean Sea). Methane-derived authigenic carbonates are important archives of past and recent methane seep activity. This study aims to reconstruct seepage activity in the Palmachim Disturbance and the adjacent Levant Basin based on sediment petrographical (SEM, CT), mineralogical (XRD) and geochemical (stable isotopes) analyses of authigenic seep carbonates collected during the EUROFLEETS 2 SEMSEEP expedition aboard the RV AEGEO in September 2016 offshore Israel.

Seep carbonates with different morphologies (chimneys, crusts and pavements) were found in three of the surveyed stations: the Palmachim Disturbance (PD), the Levant channel (LC) and the Nile deep-sea fan ~40 km to the west (NF). Petrographical investigations, combined with high resolution X-ray computed tomography, indicate recurrent cements throughout the different authigenic carbonates. X-Ray Diffraction (XRD) analyses of cements reveal the presence of aragonite, calcite, high-Mg calcite with varying magnesium content (between ~8 and ~20 mol-%) and dolomite. The chimneys consist mostly of aragonite and high-Mg calcite cements. In addition, barium sulphate crystals are present within the cements, and Fe-Mn phases at the cement boundaries. The carbonate crusts reveal high-Mg calcite cements with varying magnesium content. The carbonate pavement samples contain relatively small amounts of aragonite cement, but a high amount of micritic dolomite within matrix sediments rich in low-Mg calcite. Results indicate the presence of different cement generations and mineral phases in the studied seep carbonate samples, suggesting changing seep activity and varying geochemical conditions through time. Stable isotope data evidence the presence of three clusters, (1) one highly negative $\delta 13C$ cluster (~ -35 to -50‰), (2) one $\delta 13C$ cluster with values around 0‰, and (3) a mixing phase respectively.

Further geochemical results will help to identify the source of the methane fluids.

The Lochkovian-Pragian boundary interval of the Barrandian area – discussion of oxygen and carbon isotope data

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The Barrandian represents the type/classical area for the Lochkovian and Pragian stages with the Lochkovian-Pragian boundary Event recognized here. The Lochkovian-Pragian boundary coincides with a sea-level fall, changes in facies, faunal content, organic productivity and bottom water redox conditions. In this contribution, new oxygen and carbon stable isotope data from middle to distal carbonate ramp environments of the Prague Basin are presented. In the studied Na Branžovech section, the upper part of the Lochkov Formation (Lochkovian) is represented mainly by crinoidal calcarenites revealing a coarsening-upward trend. Instead, the overlying Praha Formation (Pragian–lower Emsian) shows fining-upward from crinoidal calcarenites/calcirudites to calcisiltites (dacryoconarid-rich wacke – /packstones) with calcareous shale/marlstone intercalations. The Požáry section shows a similar facies development.

Carbonate δ13C and δ18O data from the Na Branžovech section (109.5m, upper middle Lochkovian–lower Emsian) come from 50 polished thin-sections examined for cathdoluminescence. In total, 91 samples of powdered brachiopod calcite, fine-grained carbonate matrix and sparite obtained by microdrilling were analysed. Carbonate δ13C values range from -0.9 to 4‰ VPDB. Positive shifts in δ13C often coincide with decreasing computed gamma-ray (CGR) values interpreted as indicating regressions, whereas negative δ13C shifts are observed together with increasing CGR values interpreted as transgressions. The upper Lochkovian–lower Pragian positive δ13C excursion reported by previous authors was recorded. Carbonate δ18O values are between -6.6 and -1.3‰ VPDB and show a trend to higher values across the Lochkovian-Pragian boundary. δ18O of the fine-grained matrix and of non-luminescent/slightly luminescent brachiopod shells show comparable trends. Generally, non-luminescent/slightly luminescent brachiopod shells show higher δ18O values than luminescent brachiopod shells, fine-grained matrix and sparite in fine-grained limestones and lower values in coarse-grained crinoidal limestones.

Conodont apatite δ18O values from the Požáry section (137m, upper Silurian–lower Emsian, N= 45) reach 16.5–20.8‰ VSMOW. An increase in δ18O is documented for the Lochkovian-Pragian boundary interval. This trend starts in the middle Lochkovian (≈17‰ VSMOW, boundary of transitans – trigonicus and trigonicus – kutscheri zones) and continues to the lower Emsian (≈21‰ VSMOW, gracilis/excavatus – gronbergi Zone).

The Lochkovian-Pragian boundary interval is connected with cooling. The temperature difference between the upper middle Lochkovian and lower Emsian calculated from both, δ18O of non-luminescent/slightly luminescent brachiopod calcite as well as δ18O of conodont apatite is relatively large (14 °C). Relatively high Pragian/lower Emsian carbonate δ18O values from some Barrandian sections were ascribed to elevated salinity during temporal partial isolation of the Prague Basin by previous authors. Likewise, conodont apatite δ18O values from the Prague Basin are higher than values from Australia. Our data indicate that the complexity of the carbon and oxygen stable isotope record is a result of an interplay between temperature changes, facies variability due to relative sea-level changes, facies-dependent, marine and deep-burial diagenesis, and variation in salinity supposed by previous authors.

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Source area composition indicated by coalified tree-trunk hosted in deep-marine turbidites (Oligocene, the Outer Carpathians)

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The Cergowa Beds form an elongated lenticular lithosome interpreted as a submarine fan and as an infill of the slope troughs in the confined tectonically partitioned synorogenic deep-marine basin. Deposition at Lipowica took place during the Oligocene sea-level lowstand by a range of SE-oriented density flows rich in coalified plant fragments, including tree-trunks, and was primarily controlled by hyperpycnal effluents. The tree-trunks occur at bases of thick sandstone beds and represent three types: T1 – compacted, unfilled, found in the lower part of the outcropping succession, and only slightly deformed, filled, and located higher in the outcrop, namely T2 – silicified, and T3 hollow, arenite-filled. Organic petrography study shows that the trunks were buried fast in the source area and coalified near redox boundary below the groundwater level. The T2 and T3 trunks were mineralized/filled in the source area prior to redeposition into the deep-marine basin. The aim of this study is to test whether the sandy material filling trunks emplaced in this marine depository can serve as a proxy for derivation either directly from land or from a temporary storage within the delta.

Comparative microscopic petrographic and grain-size analysis concerns sandy infill of the tree trunk type T3 (sample W3) and a sample (S1) from the lowermost part of a very thick-bedded turbidite sandstone bed representative for the facies hosting all trunks. Both samples have very similar mineral composition rich in quartz (55% for W3, 56% for S1) and carbonate rock fragments, with distinction of non-biogenic (22% for W3, 29% for S1) and biogenic (5% for W3, 1% for S1). Feldspars, cherts and schists rock fragments account for <10% each. Grain shape within each mineral group is also very similar comparing both samples. However, a crucial petrographic difference is the presence of severely fractured quartz grains in the offshoots of the main cracks in the W3 sample (T3 trunk), which are absent from the hosting sandstone beds. Grain-size distributions of W3 and S1 are relatively symmetrical as mode, median, mean and graphic mean are within fine-grained sand class. Most grains (65% and 62% respectively) are fine- and very fine-grained sand. Negative graphic skewness (-0,09) reflects slightly coarse-tail distributions with admixture of coarse- and very coarse-grained sand (16% and 12%). This, combined with a small addition of coarse silt (ca. 4% in both samples), results in relatively high inclusive graphic standard deviation values, implying relatively poor sorting (ca. 0,99).

Minor compositional and textural differences, especially among the stable components, show little influence of transportation mechanisms on the features of clastic material. However, five times lower number of bioclasts suggest their destruction during transportation to the deeper sea. Both mineral composition and textural features of the analysed samples display such similarities that the sandy material filling the T3 trunk from Lipowica appears representative for derivation from the shelf-edge delta supplying the Cergowa basin. However, heavily fractured quartz grains occur only in the T3 trunk, therefore they may represent an earlier stage of its transport, from the source land to the delta.

Far-field effects of the Darriwillian (Mid-Ordovician) ice age: agglutinated stromatolites in a temperate epeiric platform

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The Mid–Late Ordovician was an interval when atmospheric pCO2 was declining, sea surface temperatures in the tropics had fallen to modern day equatorial levels, and eustatic sea level was lowered due to developing Ordovician glaciation on Gondwana. Previously widely developed microbialite carbonates declined globally after the Early Ordovician in response to the Great Ordovician Biodiversification Event (GOBE) where ecological changes saw increases in burrowing and grazing organisms. Surprisingly, an abundance of microbialites (agglutinated stromatolites) occurs in the Middle Ordovician (Darriwillian; Segerstad–Skärlöv interval, Aseri regional stage) orthoceratite limestones that cover 100s km2 of the Baltoscandian epeiric platform. This occurrence in a condensed cool-temperate water carbonate sequence represents one of the oldest known examples of otherwise rare Palaeozoic agglutinated stromatolites. Why did this very rare facies develop at this time, is it linked to a specific set of conditions related to the effects of glacio-eustatic changes, is it time-specific, or seen beyond Baltoscandia at other (later) Ordovician intervals?

This agglutinated stromatolite facies are particularly well-developed in the carbonate 'platform' facies of the orthoceratite limestone in Jämtland, Central Sweden, in red-grey packstone-grainstone beds and bed-sets up to ~0.75–1 m thick, over- and underlain by rhythmically bedded grey dominated mudstones-packstones. They typically cover closely spaced iron-rich discontinuity surfaces and drape protruding fossils (orthocone nautiloids) as laterally-linked flat topped hemispheroids (LLH) and more rarely, discrete, vertically stacked convex-up hemispheroids (SH). Commonly, domes are separated by 2–10 cm deep v–u-shaped grooves filled with intervening grey–pink trilobite, echinoderm, microgastropod grainstones-packstones that also form the inter-stromatolite layers. The stromatolites clearly demonstrate an agglutinated microfabric with ~0.5–1 mm thick laminae of trapped fine–medium sand grade bioclasts. Rarely, small burrows cut stromatolite laminations. The stromatolites most likely formed by the binding/trapping action of phototactic filamentous cyanobacteria, and the preservation indicates lack of grazing and a deterred burrowing infauna for most of the time. Iron-rich Frutexites-like shrubs (hematite microstromatolites) appear to have grown into intervening grainstones from stromatolitic surfaces at some horizons. These are indicative of non-phototropic growth and dysaerobic microenvironments with iron bacteria and fungi likely responsible for the red pigmentation. Rare iron-rich oncoids also occur in the grainstones.

This rare agglutinated stromatolitic facies represents the response of the carbonate system in the interior of a vast temperate epeiric platform, a true non-actualisitc setting, to glacio-eustatically driven sea level change. The switch from deeper conditions typified by rhythmically bedded grey mudstones-packstones to grain-rich stromatolites and grainstones suggests falling sea levels, commensurate with the development of Darriwilian ice across Gondwana. Biogenic carbonate production in Baltica was reduced as reflected in the abundance of iron-rich discontinuity surfaces and mobilised carbonate sediments trapped in microbially colonised parts of the seafloor. This opportunistic microbial response is recognised in other Ordovician intervals associated with cooling and sea level lowstand (e.g. Täljsten interval) and potentially later in the Ordovician for example in the Late Ordovician Pa Kae and Tha Manao formations of Thailand.

Submarine channel behaviour on structured slopes: A quantitative synthesis from the Niger Delta system

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Submarine channel systems play a crucial role in governing the delivery of sediments and pollutants from the shelf edge to deep-water. Understanding their distribution in space and time is vital to constrain the locus, magnitude and characteristics of deep-water sedimentation, and to predict stratigraphic architectures and depositional facies. Here we collate new insights into the effects of active deformation on the routing of submarine channels from shelf edge to deep water from a multi-disciplinary research team at Imperial College London, using the outer fold and thrust belt of the Niger Delta as a well-constrained natural laboratory.

Using a 3D seismic reflection data we illustrate how cumulative strain (shortening) and interval strain rates can be calculated for a large number of thrust-related folds mapped in the toe-thrust region of the southern lobe of the Niger Delta. Our analysis allows us to unravel the sequence of thrust nucleation, propagation and linkage through time and in space, giving us detailed constraints on the deformation history in the study region. Based on this analysis, we determine the distributions, pathways and characteristics of Miocene to recent channels that have crossed these structures. First, we demonstrate the morphology of young channels with bathymetric expression are highly sensitive to ongoing deformation and we use this geomorphic data to infer a likely distribution of bed shear stresses and flow velocities from the shelf edge to deep water. These results give new insights into the erosional dynamics of submarine channels and allow us to quantify the extent to which submarine channels can keep pace with growing structures. Second, we evaluate how tectonically driven changes in slope modify the evolution and characteristics of submarine channel architectures and facies across a range of spatial scales from the channel element to the scale of a channel complex set. In so doing, we show that the kinematics of channel behaviour governs the competing expression of migration and aggradation in the stratigraphic record. Finally, we use a big–data statistical approach to quantify strain and shortening rates recorded where channels have crossed structures, compared to the fault array as a whole, during the growth history of the fold and thrust belt. Our results prove statistically that in response to increasing deformation rates submarine channels are driven to locations of lower strain rates, with a marked reduction in the number of channel-fault crossings. Consequently, we demonstrate that strain analyses are an important tool to predict the temporal and spatial routing and distribution of submarine channels affected by structurally-driven topography.

Multiple pulses in lacustrine turbidites can reveal earthquake doublets

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Earthquake doublets form a particular challenge for seismic hazard assessment and can provide insights into potentially characteristic fault behaviour. However, knowledge on this type of earthquake sequences is limited to information provided by historical archives as their identification in paleoseismic records is ambiguous. The continuous sedimentation records provided by lacustrine settings might be able to resolve closely-timed earthquakes, but confident identification of earthquake doublets has, up to now, not been made. To reveal the potential of these high-resolution records, we perform a detailed analysis of a multi-pulsed turbidite that has been identified in the sedimentary infill of Lake Singkarak and that was generated by the March 2007 West Sumatra earthquake doublet (i.e. two Mw>6 shocks on adjacent fault segments at 2 hours apart). In order to distinguish non-synchronously generated pulses in this turbidite (different earthquake, same turbidite source area) from those that are potentially synchronously-generated (same earthquake, different turbidite source areas), we develop a new methodology that allows analysing paleoflow directions by using grain-size analysis, natural remanent magnetization measurements and high-resolution X-ray computed tomography. Combining these techniques allows us to reveal the absolute geographical orientation of elongated grains, which are considered to be deposited aligned to the dominant paleoflow direction. Application to the 2007 turbidite in Lake Singkarak allows identifying the presence of non-synchronously generated pulses, thus confirming that each earthquake in the 2007 West Sumatra doublet triggered separate turbidity currents in the lake. Our study thus underscores the invaluable sensitivity of lacustrine paleoseismic records and outlines a promising methodology to analyse previously-described multi-pulsed lacustrine turbidites to reveal the occurrence of, up to now, unknown earthquake doublets.

Sedimentary architecture of typical short-lived meander belts in the Rhine-Meuse delta, Netherlands

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In the unconstrained, low gradient setting of major delta plains, individual meander belts tend to function shorter due to relatively frequent periodic repositioning of channel activity, i.e. avulsions. The short-lived nature of these deltaic meander belts makes them suitable for studying the products of steady meander evolution without complicating factors such as by repeated cut-offs or continues internal reworking. The aim of this project is a dedicated internal architecture study of classic deltaic meander belt (Stuivenberg channel belt, Rhine-Meuse delta, Netherlands), with explicit attention to meander evolution in relation with stages of development (i.e. main activity and abandonment stages). We used the Stuivenberg channel belt case to i) develop a method to separate 'main activity' from 'abandonment stage' sandy facies in cross-sectional and planform architecture, ii) back track past meander migration, and iii) investigate grain size characteristics for initial, main activity and abandonment stages over a length of 5 consecutive meanders.

Planform reconstructions of the main activity and abandonment stages utilize LiDAR and coring based traditional methods to map channel belt boundaries, and top and thickness of channel, overbank and residual channel deposits. Outlining of the edges of the abandoned channel zone demanded an explorative approach, combining cross-sectional observations and empirical hydraulic geometry relationships. Back tracking of meander evolution was based on reconstructed ridge swale morphology which is largely subdued by covering younger delta plain deposits. However, local swale depressions can still be identified within the LIDAR imagery and high density borehole data (>4000 boreholes) allowed for identification of ridge-swale topography in cross-section plots.

Final reconstructions reveal that abandonment stage deposits turn out to comprise 1/3 of the width of the Stuivenberg meander belt, and have a modestly finer mean grain size and subtly lower top sand level. In the remaining 2/3rd of meander belt width, convex and concave ridge-and-swale scroll complexes were identified that disclose the translation, expansion, and rotation trajectories of the individual meanders. In initial stages, the bed sediments were relatively finer grained than in later stages of meander belt evolution. Patches of relative coarse sand at shallow depth developed in convex parts in the later stages and kept being mobilized in the abandonment stage as well. The architectural subdivision of the deposits into 'abandoned channel zone', 'active phase: convex point bar' and 'active phase: concave accretion' turns out functional in analyzing grainsize variation in heterolithic channel belts of deltaic river channels.

A ~61 m.y. astronomical time scale for the uppermost Mississippian through Early Permian

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The Naqing section in South China,a representative carbonate slope succession in the eastern Paleo-Tethyan realm, encompasses four Global Stratotype Section and Point (GSSP) candidates for the Carboniferous Period. High-resolution magnetic susceptibility measurements through the section have variations that correlate with lithological cycles of lime mudstone, wackestone, packstone and grainstone. Astronomical calibration of ~3–12 m sedimentary cycles to the 405 k.y. orbital eccentricity cycle period aligns other significant, shorter sedimentary cycles to periods recognizable as short orbital eccentricity (~100 k.y.), obliquity (31 – 33 k.y.) and precession (17 – 23 k.y.). The orbital eccentricity has long-period modulations with 2.4 m.y., 1.6 m.y. and 1.2 m.y. periods, and the obliquity has a 1.2 m.y. modulation cycle. The astronomical calibration indicates durations of 7.6 m.y., 8.1 m.y., 8.5 m.y., 2.87 m.y., 4.83 m.y., 4.67 m.y., 3.9 m.y., 0.72 m.y., and 16.5 m.y. for the Serpukhovian, Bashkirian, Moscovian, Kasimovian, Gzhelian, Asselian, Sakmarian, Artinskian and Kungurian stages, respectively. The calibrated durations of the 34 conodont zones collectively indicate a 60.8 m.y. time scale. Biochronological correlation of the Paleo-Tethyan and Euramerican records significantly refines the global chronostratigraphy for the Serpukhovian Stage and the uppermost Kungurian Stage. Our study provides an improved temporal resolution for understanding the climatic, environmental and biological evolution during late Paleozoic ice age.

Sequence stratigraphic distribution of OM in shale: Insight from the controlling factors and development process

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The sequence stratigraphic distribution of organic matter (OM) is extensive and complex. While previous studies emphasize OM enrichment, they neglect the development process and correlation analysis of controlling factors for sequence stratigraphy and OM accumulation; this makes it difficult to analyze the genetic mechanism of the sequence stratigraphic distribution of OM. Based on X-ray diffraction, petrologic observations, organic geochemistry, and inorganic geochemistry, a complete third-order sequence of the Eocene shale in the Dongying Depression has been recognized, whose development is more influenced by the tectonics and climate, compared with the sediment supply and relative lake level. Not only the total organic carbon (TOC) content but also the OM type and other organic parameters [e.g., content of initial TOC (TOCini), S1, S2, chloroform bitumen "A", OM flux, and the difference value between TOCini and TOC] co-vary with sequence stratigraphic units. Three stages were identified to analyze the controlling factors and process of OM accumulation: high primary productivity elevates the TOCini content (rather than TOC) and is beneficial to the generation stage of OM; the sedimentation rate (SR) is inversely/positively proportional to the OM flux and thus, affects the settlement stage of OM (turning point is 100 m/Myr); and reducibility plays a significant and positive role in the preservation stage of OM. A new approach is proposed to explain the intrinsic genetic mechanism of the sequence stratigraphic distribution of OM. The controlling factors for the sequence development affect the controlling factors of OM accumulation, leading to the sequence stratigraphic distribution of OM, in the following ways: (1) The warm-humid climatic conditions elevate the primary productivity by improving the living environment and causing planktonic algae to bloom, which affect the generation of OM. (2) Under the co-evolution of the tectonics and climate, the relative lake level and accommodation space vary, resulting in a change in the SR and thus, affecting the settlement of OM. (3) The elevation of the relative lake level under a warm-humid climate contributes to the formation of a long-term anoxic water body favoring the preservation of OM. This study provides new insight into the heterogeneity of OM in the sequence stratigraphic framework, which can be of significance for the evaluation of source rocks and shale oil resources.

Tectono-sedimentary pattern of the Yen Bai Basin (Red River Fault Zone, northern Vietnam

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The major strike-slip faults of East Asia are commonly considered to have formed in response to the Himalayan collision and the indentation of the rigid Indian plate into Asia. Large displacements along these faults must have resulted in localized shear deformation and lateral extrusion of coherent crustal blocks toward the E and SE since the Eocene. The Red River Fault Zone (RRFZ) is the most important of the strike-slip faults that are thought to guide lateral extrusion of SE Asia. The estimated left-lateral offset along this fault, from Eocene to Miocene, is in the range of 200–700 km. Since the beginning of Pliocene, the RRFZ kinematics have been reversed into right-lateral with the total lateral offset in localised zones between 6 km and 60 km. The end Miocene reversal of fault kinematics was associated with regional inversion of elongated sedimentary basins, as evidenced by offshore and onshore seismic data. Most of studies based on seismic and borehole data were thus far focused on the offshore section of the RRFZ and the large sedimentary basins associated. In contrast, the present knowledge on the onshore basins connected with the RRFZ, their stratigraphy and architecture is by far insufficient. To fill this gap, the detailed field work was done in the Yen Bai Basin, one of the basins that are related to the landward part of the RRFZ. The basin is directly limited from the N by the main branch of the RRFZ, separating the basin from the high-grade metamorphic Con Voi Massif. Outcrops of the lower Palaeozoic rocks make the southern frame of the Yen Bai Basin. The basin is filled with Palaeogene/Neogene clastic deposits of different type and origin. A peculiar feature of the Yen Bai Basin is an intimate coincidence of sedimentary sections representing contrasting depositional environments. In the central and SW parts of the basin chaotic coarse-grained deposits with metres-size olistoliths predominate. Typically, the bodies of coarse-grained sedimentary breccias are parallel to the trace of the RRFZ. To the NE, thick coarse-clastic series composed of pebble-size conglomerates with rare sand lenses occur. In the northernmost area, lacustrine series with turbidites prevail. They are characterised by heterolithic facies with graded bedding, convolute bedding, synsedimentary folds, tool marks, abundant coquina beds and numerous floral fragments. All clastic series are strongly tectonised and cut by series of outcrop-scale strike-slip and normal faults. In our new interpretation, contrasting sedimentary facies of the Yen Bai Basin were juxtaposed by syn- to post-depositional strike-slip movements along the RRFZ. Although the exposure is patchy, the location of fault splays cross-cutting a sedimentary succession can be traced using the combination of SRTM 3 and magnetic data. The restoration of strike-slip displacements along the fault splays allows for reconstructing the original depositional architecture of the Yen Bai Basin that is consistent with its pull-apart origin. In this part of the RRFZ last inversion-related uplift might have taken place fairly recently as evidenced by onshore seismic data that show Pliocene – Pleistocene deposits that underwent folding above inverted depocenter.

Spatial self-organization and autogenic dynamics of peritidal carbonate system: insights from stratigraphic forward modelling

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Spatial self-organization is a process in which coherent pattern emerges through interaction of system components, independent of initial conditions, and without external forcing. In depositional systems, it is possible that there is a significant link between self-organization and autogenic dynamics that can create ordered, cyclic strata. Previous numerical modelling work that partially explored self-organised cyclicity in carbonate strata is expanded, refined and tested using a different numerical model formulation that is a variant on an existing carbonate forward model CarboCAT.

Results show that cross-platform sediment transport creates a series of self-organised prograding islands and shorelines that generate upward-shallowing autocycles, defined by strong statistical evidence for ordered facies successions. A subtidal zone in front of each shoreline supplies sediment that drives shoreline progradation when the A/S ratio is less than one. Subtidal supply-zone widths are self organised such that the A/S ratio is less than but close to 1,. The resulting island progradation rate determines autocycle thickness, which is very different from the accommodation control assumed in most sequence stratigraphic and cyclostratigraphic interpretations.

Analysis suggests that this self organisation process is comparable to the reaction-diffusion morphogenesis pattern-forming process first suggested by Alan Turing. The simplest possible combination of processes that leads to this self-organization are water-depth-dependent production, straight long-distance cross-platform transport and uniform subsidence. Additional processes, such as spatially-complex sediment production, local downslope diffusional transport, and wave-topography interaction, also produce self-organisation but lead to more diverse island morphologies, less ordered autocyclic strata, and more variable facies lateral facies continuity.

Exploration of the model parameter space shows that self-organisation occurs for only a limited range of production and transport rates, where the resulting subtidal width is above a critical value that can create cyclic strata in vertical sections. We calibrate this modelling by comparison with shoreline progradation in the model to similar effects observed in the modern Peros Banhos carbonate platform in the British Indian Ocean Territory, and a Holocene Abu Dhabi shoreline. Progradation rates similar to those modelled are measured from satellite imagery and radiocarbon dating, respectively, suggesting that this process is a realistic and perhaps ubiquitous process to account for cyclicity observed in carbonate platform strata. Given the fundamental nature of processes modelled here, and the match with observed processes in modern depositional systems, it seems likely that similar autogenic, self-organising processes have operated on many carbonate platforms and had had an important influence on the stratigraphic record.

Sedimentary sequence of biological recovery in Feixianguan Formation of Lower Triassic in Northwest Sichuan

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Carbon isotope studies showed that after the extinction of the P/ T boundary, there remained an ecological gap of about 170 ka in Feixianguan Formation. While the characteristics of strontium isotopic composition showed a steady increase in the early Triassic of Sichuan Basin.

The marine sedimentary records of the Early Triassic in the western margin of the Sichuan Basin showed that the depositional environment, which was obviously in coordination with the biological recovery in the area, underwent a unique evolutionary process from Late Permian to the Middle Triassic before the massive radiation. The Lower Triassic strata in Western Sichuan Basin were continuous and integrated, mainly composed by marine carbonate rocks and clastic rocks. Such well-developed deposits could explain clearly the sedimentary sequence of multi-layer, multi-type and multi-environment changes.

A platform – slope sedimentary system was developed in the first Member of Fixianguan Formation. The sedimentary environment in the platform was stagnant, and the development of cyanobacteria and other microorganisms occurred more commonly. Meanwhile, oolitic banks developed around the platform edge, with oolite ring fuzzy and poorly rounded. And giant oolites were produced in some sections, which reflected the monsoonal turbulent environment with the participation of microorganisms under relatively low hydrodynamic conditions.

With the changes of structure and climate, the island chain in the western margin of Sichuan basin was formed during the second member of Feixianguan Formation. Therefore, the sedimentary system presented distinct characteristics. Tidal flat and platform was developed with mixed deposits of clastics and carbonate, mainly including oolitic limestone, bioclastic limeston, siltstone and silty mudstone,etc. Occurrence of mixed sediments needed both carbonate and siliciclastic sources, active hydrodynamic regimes, alternate dry and wet climates, and the fluctuation of sea level. It showed that organisms gradually recovered, weathering was enhanced, and monsoon transformation was frequent during the period.

The above sedimentary sequence of Feixianguan Formation indicated that during the process of biological recovery, the ecosystem reconstruction went through the evolution from hypoxia and hydrostatic deposition to the steady enhancement of weathering, thus the supply of terrigenous debris in the sediments increasing continuously. It was a combined result of the interaction, mutual restriction and co-evolution between organisms and the environment.

Key words: sedimentary evolution, mixed sediments, biological recovery, Feixianguan Formation, northwest Sichuan Basin

Hydrocarbon generation and accumulation of limestone organic matter in a lacustrine mixed sedimentary environment

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Some lacustrine carbonate source rocks have gradually been proven to be effective at generating hydrocarbons. The previous research mainly focused on the organic matter in mudstone and explored the mechanism of organic matter enrichment in terms of preservation conditions, productivity, and dilution. Compared with the marine sedimentary environment, the water area, depth, and water volume of the lake is relatively low. Lakes lack environmental regulation abilities and are more susceptible to the impact of paleoenvironment and terrestrial inputs than the ocean. The research on the organic matter enrichment in a lacustrine mixed sedimentary is relatively lacking. There is an obvious contradiction between oil production and organic matter abundance in the mudstone source rock of the Da'anzhai Member in the central Sichuan Basin, China, and the hydrocarbon-generating significance of lacustrine limestone is easily overlooked. Typical samples were systematically analyzed to determine the relationship between limestone organic matter and lacustrine sedimentary environment.

1. The limestone can form a complete full-rock hydrocarbon generation system with mudstone. The lacustrine limestone has a higher conversion rate of organic matter, and the hydrocarbon generation threshold of limestone organic matter is lower than that of argillaceous source rocks.

2. The enrichment of organic matter in carbonate rocks is an interactive process involving the paleoenvironment, terrestrial inputs, and productivity and mainly depends on the preservation conditions and biotic productivity. The effect of the redox conditions on the preservation of carbonate organic matter is obvious. The effects of water depth and hydrodynamics are closely related to the redox conditions. Quiet, low-energy, and deep conditions result in a reducing environment that is conducive to the preservation of organic matter but not the formation of thick carbonate rocks.

3. Terrestrial inputs can provide abundant nutrients for biological growth, but excessive terrestrial inputs can cause the strong dilution of organic matter. In other words, the promotion effect of terrestrial inputs on the accumulation of organic matter is effective within a certain range. The effects of paleoclimate and paleoweathering on organic matter are reflected in terrestrial inputs and paleoproductivity. A warm and humid climate is conducive to improving weathering, terrestrial inputs, and productivity. Lacustrine carbonate organic matter enrichment should occur in a quiet, low-energy, and relatively deep lake zone in a warm and humid climate with an appropriate supply of terrestrial inputs.

4. The Da'anzhai Member formed in a lacustrine mixed sedimentary environment, and this environment resulted in multiple organic matter enrichment types and variable forms and rock types of shell limestone. The limestone source rocks are mostly argillaceous limestone rich in organic matter that formed in a relatively low-energy environment. In the lake slope and semideep lake facies, argillaceous shelly limestone mostly coexists with mudstone and appears in the form of interlayers, but the limestone deposit thicknesses and scales are limited. The argillaceous shelly limestone deposited from the beach face to the lake slope is medium thick and has a relatively high organic matter abundance, and its effectiveness cannot be ignored.

Lithology prediction in a thin-bed mixed siliciclastic–carbonate–evaporite system in Triassic Jialingjiang Formation, Sichuan Basin, China

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High-quality three-dimensional (3D) seismic data acquired in the central Sichuan Basin, southwestern China, offer an opportunity to map complex lithologies in a mixed siliciclastic–carbonate–evaporite system in the Lower Triassic Jialingjiang (T1j) Formation. The formation consists of siliciclastics, limestone, dolostone, anhydrite, and salt. The lithologies consist several source-reservoir-cap assemblages in the area.

Lithologies in the T1j Formation change rapidly in the vertical direction, forming different interbed patterns in thin layers. In the mean time, the lateral extend of each lithology is complex. This vertical and lateral distribution makes it difficult to predict lithology by single seismic attributes. Therefore, principle component analysis (PCA) was applied to tens of seismic attributes to extract useful information. The first three components contain most (83.02–99.85%) of the lithology information preserved in seismic attributes, which were used to correlate with lithology content calculated by core-calibrated wireline logs. Correlation coefficients of the three seismic components with lithologies are significantly higher (0.37–0.79) than those of individual seismic attributes (near zero to 0.58). Different assemblies of end-member lithologies were selected from anhydrite, siliciclastics, tight dolostone, limestone, and salt to perform PCA in different sequences. Lithologic content distribution of individual end members was shown by color-blending method to map the lithology mixture. Sedimentary history in the T1j Formation was reconstructed based on lithology-mixture maps and regional geology background in the study area.

Eight 4th-order sequences were interpreted in the T1j Formation. Only the second sequence was influenced by siliciclastic input, forming a complete mixed siliciclastic–carbonate–evaporite system. Open platform and/or restricted evaporative environment dominated the other seven sequences, forming a mixed carbonate–evaporite system.

Sedimentary facies and reservoir in a deep Cambrian carbonate platform-to-basin area, Tarim Basin, China

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The LT-1 well produces oil and gas from the Lower Cambrian (Є1) dolostone reservoir at 8,203 m in Tarim Basin, northwestern China, which inspired us to apply seismic sedimentology to investigate Є1 facies and reservoir in Gucheng area located at the same platform margin. Techniques of phase rotation, frequency decomposition, seismic attribute generation, stratal slicing, and red-green-blue (RGB) blending were combined into a seismic geomorphologic workflow to qualitatively interpret facies. Landsat images of modern environments help to analyze the deep-buried Є1 sediments. Since Tarim and Yangtze Craton are nearby in Early Cambrian makes, we believe that geologic settings of Gucheng area (Tarim Craton) and Gaomo area (Yangtze Craton) are similar. Therefore, equation between seismic attributes and reservoir in Є1 Longwangmiao (LWM) Formation of Gaomo area was borrowed to calculate quantitative distribution of effective (porosity>6%) reservoir in Gucheng area. In addition, principal component analysis (PCA) and random fitting were employed to form a seismic lithologic workflow for quantitatively reservoir prediction.

Two seismic data sets were used, i.e., GCB2 and GCLP. In GCB2, three stages of eastern prograding carbonate shoals were recognized. The first and third stages are formed in an analogous environment to modern shallow carbonates in Bermuda. Reservoirs in the two stages are continuous. The second stage is depicted as a carbonate shoal modified by tidal-channels, which is similar to the Florida Keys. Reservoir in the second stage is thin in channels but thick in inter-channel areas and channel-mouth delta. The larger GCLP survey shows inner ramp, middle ramp, and outer ramp to basin, composing of a complete environment from platform to basin. The three stages of shoals in GCB2 are located in the middle ramp. Line-source slope fans are recognized in the near-end of outer ramp while point-source basin-floor fans in the far-end of outer ramp to basin. Channels providing materials to slope fans and basin-floor fans are straight, which are different from the curvy tidal channels in the middle-ramp shoal. Thick reservoir is formed in slope fan and basin-floor fan besides of inter-channel shoal and channel-mouth delta. Reservoirs are abundant in the middle ramp, minor in the outer ramp to basin, and rare in the inner ramp.

The model-driven qualitative facies reconstruction and the data-driven quantitative reservoir prediction are complementary, which together reveal huge hydrocarbon exploration potential in deep-buried Є1 in Gucheng area.

Sedimentary facies study of the Lower Cambrian Xiaoerblak Formation in Tarim Basin

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The Cambrian Xiaoerbulake Formation dolomite reservoir in Tarim Basin is an important and potential exploration target. Due to the deeper burial depth of Lower Cambrian, the number of wells encountered is relatively few, which has brought certain difficulties for exploration and reservoir prediction so it is very important to study the sedimentary facies of Tarim Basin. The target layer is the Lower Cambrian Xiaoerbulake Formation in Tarim Basin. The zones with good reservoirs are predicted by delineating the development location of the high-energy facies zone based on geological data, well logging and seismic data. It is based on sequence stratigraphy, sedimentology and geophysics.

The dolostone types of the Lower Cambrian Xiaoerbulake Formation are systematically analyzed based on the previous work. Thirteen types of sedimentary microfacies were identified though the measured sampling of three field outcropping profiles, as well as the detailed observation of core and section of more than 10 wells in Tarim Basin. The good reservoirs are mainly distributed in these sedimentary microfacies, including spongy layered dolomite, residual particles structure fine-mesocrystalline dolomite, stromatolite dolomite. It is considered that the Lower Cambrian Xiaoerbulake Formation is a set of carbonate rock gentle slope system. The Cambrian Xiaoerbulake Formation is divided into the tidal-flat facies, the lagoon facies, the depression facies, the shoal complex facies of the gentle slope, the deep gentle slope facies and basin facies. The distribution characteristics on the plane from west to east are as follows: the tidal-flat facies and lagoon facies with weak hydrodynamic force, shoal complex facies of the gentle slope with high energy, the deep gentle slope facies and basin facies. Whether studying the migration characteristics of the sedimentary facies of the Lower Cambrian Xiaoerbulake Formation from the plane or the section. It is generally clear that the sedimentary facies of the Cambrian Xiaoerbulake Formation migrated towards the basin with the decrease of sea level during the sedimentary period. It is can be found that the high energy facies zone migrates from the Xiaoerbulake Formation to the Awatage Formation from the seismic profile and the gentle slope sedimentary model of the Xiaoerbulake Formation gradually evolved into the marginal platform model.

It is found that the reservoir of the Lower Cambrian Xiaoerbulake Formation is mainly controlled by sedimentary facies, while the shoal complex facies of the gentle slope is a favorable facies zone for reservoir development. According to the drilling results under the Cambrian, the sedimentary environment during the sedimentary period of the Xiaoerbulake Formation is favorable for the development of the scale of the frame reef-bank complexes in the high energy carbonate platform and the spread of the large area.

Nature and distribution of paleosols in cenozoic fluvial succession of the ranital-kangra section, nw himalaya

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This study reports Paleopedological details of the Lower Siwalik (12 Ma to 10.9 Ma) and Middle Siwalik (10.9 Ma to 5 Ma) along one 1800 m transact from Ranital-Kangra of the Kangra sub-basin of the Himalayan Foreland. In the lower part of the succession, 12 composite paleosol profiles explored show dominance of brownish yellow (10 YR hue) color, moderate to strong development of paleopedofeatures such as rhizocretions, blocky and wedge shaped peds, pedogenic carbonates in Bw, Bt, Bss, and Bk horizons. Whereas in the middle part of the Siwaliks, 15 paleosols studied show varying colour (2.5 Y and 5 YR hue) with weakly to moderately developed paleopedofeatures in Bw, Bwk, and Bk horizons.

Thin section and clay mineralogical studies of these paleosols show critical changes at the transition (10.9 Ma) with a relative decrease in clay pedofeatures and increase of pedogenic carbonates and the alteration of 14 Aº smectite and vermiculite. In the middle part, at about 7–8 Ma, the paleosols are marked by a distinct change in colour, decrease in clay pedofeatures and a relative increase of kaolin in contrast with 14 Aº clay minerals. The nature and distribution of the paleosols in this fluvial succession suggest that weathering and paleopedogenic expression were affected by the fluctuating SW monsoonal strength and uplift of the Himalaya during 12Ma to 5 Ma.

Keywords: Paleosols, Siwalik, Macro morphology, Clay Minerals, Pedogenic carbonate.

Turonian-coniacian climate and sedimentation conditions of the north-west caucasus

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The results of a comprehensive study of the Turonian-Coniacian deposits of the North-West Caucasus, represented by a rhythmically built terrigenous -carbonate stratum, are presented. The study area is located in the valley of the Abin River and belongs to the folded-allochthonous Novorossiysk-Lazarevskaya zone of the Greater Caucasus. The purpose of this work is to reconstruct the climate and sedimentation conditions in the North-West Caucasus in the Turonian- Coniacian time on the basis of detailed bio- and chemostratigraphic studies. The use of petrographic, lithological, X-ray phase, isotopic and micropaleontological analyzes made it possible to reveal important changes in abiotic and biotic events during this interval.

The study of rocks in thin sections resulted in the identification of 4 lithotypes of rocks, differing from each other in composition, color, structure, texture, paleontological features. The deposits were distributed over 2 facies zones: moderately shallow-water and moderate-deep sea shelf. The maxima of sea level rises fall on the periods of accumulation of mudstones. Wackstone and packstone indicate a decrease in sea level. Sandy and siltstone interlayers record short-term moments of regression, activation of the feeding source, and retreat of the coastline towards the basin, which is also confirmed by micropaleontological data. Greywacke composition of sandstones indicates the influx of material from the territory of the Greater Caucasus. This is also evidenced by fragments of volcanic and metamorphic rocks. Carbonate-clay cement testifies to the humidization of the climate of that time. The presence of montmorillonite interlayers, formed during periods of volcanic activity, was established

The composition of foraminiferal assemblages from the Turonian-Coniacian deposits show that the deposits were formed in an open sea basin with a relatively high taxonomic diversity of the planktonic forms, with a periodic predominance of deep-sea taxa. By its composition, the foraminiferal assemblage is close to the associations of the central parts of the Tethyan region, but differs in less diversity.

Results based on the distribution curve of paleotemperature values showed that during the Turonian-Coniacian interval, they varied from 16 to 33 degree Celcium. The average value is 23 degree. The maximum value of paleotemperatures was observed at the end of the Late Turonian. In the Coniacian time, the number of episodes of a decrease in temperatures increased, which corresponds to the general trend of a slight decrease in temperature in this interval. In general, the excursions of the carbon 13 isotopes and oxygene 18 isotopes values are in good agreement with the lithological features of the rocks and changes in the composition of the microbiota of the host sediments. On isotopic curves for this section, it was possible to distinguish event levels that record climatic fluctuations and fluctuations in the bioproductivity of surface waters. The data obtained do not contradict the ideas of other authors about relatively high temperatures for this time. Changes in values on the paleotemperature curve reflect climate fluctuations and allow correlating these levels with other sections of the Peritethys.

Construction model of a Middle Permian Archaeolithoporella-microbial-sponge reef of the Changning-Menglian Belt, western Yunnan, China

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The studied Capitanian (Middle Permian) Archaeolithoporella-microbial-sponge reef is located 27 km south to Dai and Va Autonomous County of Gengma, western Yunnan, China, which is tectonically belongs to the Changning-Menglian Belt. The reef is composed of Archaeolithoporella-sponge boundstone, sponge boundstone, microbial boundstone and skeletal wackestone. According to the different assemblages of these lithofacies, the reef can be classified into five parts. The first, third and fifth parts are represented by the assemblage of the four lithofacies mentioned above. The lithofacies in this assemblage does not show any regular distribution, and integrate laterally and vertically with each other. By contrast, the second and fourth parts are marked by the assemblage that is almost entirely made up of Archaeolithoporella-sponge boundstone.

The Archaeolithoporella-microbial-sponge reef was constructed by the framework constructor of sponges, the encruster of Archaeolithoporella and the binder of microbes. Under a moderate-energy condition, sponges grew in clusters, and among these clusters microbes developed and constructed small domal frameworks. The sponge clusters and microbial frameworks acted as bafflers that trapped sediment. At the last stage of sponge's life, some were encrusted by Archaeolithoporella, and after death most toppled over from their life positions. The cavities in the Archaeolithoporella-sponge and sponge frameworks were filled by radial fibrous and equant cements in turn, and microbial aggregations were preserved as peloids and micritic filaments through incompletely calcification. Through repeating these four steps, the assemblage of Archaeolithoporella-sponge boundstone, sponge boundstone, microbial boundstone and skeletal wackestone was ultimately formed. Comparatively speaking, sponges flourished under a high-energy setting, and were encrusted by Archaeolithoporella at the last stage of their life, even bound together in some areas. After death, most of sponges toppled over from their life positions, some of which continued to be encrusted by Archaeolithoporella. The spaces in the Archaeolithoporella-sponge frameworks were filled by radial fibrous cement, and finally equant cement. The assemblage of Archaeolithoporella-sponge boundstone was eventually formed by repeating these three steps.

The Archaeolithoporella-microbial-sponge reef shares some characteristics of the classical Capitanian reef from Guadalupe Mountain, U.S.A. in reef-building organisms, whereas, it also shows the following unique features. 1) Most sponges are toppled. 2) Bryozoans and Shamovella are rarely observed. 3) The reef limestone here is more complex than that in the Capitanian reef from Guadalupe Mountain, U.S.A..

Key words: Sponge; Archaeolithoporella; Reef; Permian; Changning-Menglian Belt

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Seismic sedimentological response of gravity flow in Panshan depression of Bohai Bay Basin, China

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Since the 1950s, the concept and classification system of gravity flow have been updated and improved continuously, especially after the theory of turbidity flow and sandy debris flow was put forward, the research of gravity flow has been widely concerned in the world. In the continental lake basins of China, there are various types of gravity flow, which can be used as favorable sand bodies for oil and gas . It can be said that the study of lacustrine gravity flow has a broad prospect and profound research significance.

However, the lacustrine gravity flow sand body often has the characteristics of thin layer, so it is difficult to identify it by conventional methods. Therefore, using seismic sedimentology to study deep-water gravity flow has become a new idea and method. Seismic sedimentology has the technology of phase conversion, frequency division and strata slicing, which provides the possibility for us to identify the thin-layer gravity flow sand body in deep water, analyze its parameters quantitatively, and finally establish the evolution model.

Based on the above theories and methods, we studied the characteristics of lake gravity flow and its seismic sedimentology in Panshan depression of Liaohe sag in Bohai Bay Basin, Eastern China. The target layer of the study is the third member of Shahejie formation of Paleogene, with a semi-deep and deep lacustrine developed. The type of gravity flow is turbidity flow and sandy debris flow, the former is mainly characterized by the Bauma sequence, while the latter is characterized by the mud-coated intraclasts. It can be seen from the results of phase transformation, RGB fusion and strata slicing that the turbidity current in the study area is mainly red strong amplitude reflection on the seismic section, which is in the form of undercutting or long strip on the plane, and distributed along the fault trough, with an extension length of about 1.5km, while the sandy debris flow is in the form of shuttle strong reflection on the seismic section, with the phenomenon of bifurcating and merging on the plane, most of which is tongue strong reflection developed at the downdip of the fault slope break belt. At the same time, we use the frequency division technology to divide the seismic data into three frequency bands(15Hz, 25Hz, and 44Hz), which correspond to the stratum thickness of 50m, 30m, and 17m respectively. Therefore, the RGB fusion shows that the average thickness of turbidity sand body is about 24m, and the average thickness of sandy debris flow sand body is 30m.

The development of these two types of sand bodies is mainly controlled by paleogeomorphology, provenance supply, fault activity and other factors. The slope belt on both sides is mainly an independent, single provenance supply path. After entering the deep depression area, it is characterized by mixed provenance and coexistence.

Organic geochemical characteristics of Upper Post-Rift Sediments in the Orange Basin, South Africa

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The Santonian to Tertiary sediments from four wells in the Orange Basin were investigated to characterize their organic matter, paleo-redox conditions, thermal maturity as well as petroleum potential. The shales were assessed by rock-eval pyrolysis for total organic carbon (TOC) content, gas chromatography, gas chromatography mass spectrometry for n-alkane, isoprenoid and biomarker studies. TOC ranges from 0.60 to 1.50wt% signifying fair to good yield. Its average TOC value is 1.02wt% establishing sufficing petroleum potential with likely prosperous organic matter type. The source rocks exhibit fair EOM yield (averagely 965.7ppm) with 10.4–68.2wt% of the hydrocarbon fractions. Hydrogen Index is between 40.0 to 130.61mgHC/gTOC, averagely 68.59mgHC/gTOC suggesting Type III kerogen in most analyzed samples. KE-1 well sediments have HI values between 40.0 and 48.0mgHC/gTOC depicting type IV facies. A plot of HI versus Tmax has abundant type III with few Type IV organic matter. S1 values is less than 1 with lowest value at the shallowest depth. S2 yields between 0.47–1.28mgHC/g rock implying low source rock potential that is likely more gas prone. Vitrinite reflectance measurement ranges from 0.561–0.865. Based on geochemical maturity indicators by rock-eval pyrolysis, biomarker and vitrinite reflectance measurements, the organic facies contain immature to peak mature organic matter.

Paleoclimate and sedimentary evolution of Cretaceous successions in Central Pontides, Central Taurides and Arabian Platform

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Stable isotopes values (O, C) of the bulk samples are obtained from measured stratigraphic sections in Cretaceous successions (Hauterivian-Barremian, Aptian, Cenomanian-Turonian) around Central Pontides (NW Turkey), Central Taurides (S Turkey) and Arabian Platform (SE Turkey) (Yilmaz et al, 2004, 2010, 2012).

Platform carbonates belonging to Derdere Formation are generally wackestone/packstone in facies and include benthic foraminifera, dasycladacean algae, gastropod, pelecypod, echinid and whole rudist and fragments. However, Karababa Formation displays dark gray-black marls/mudstones with high organic content, and includes mainly planktonic foraminifera, echinoid, sponge spicules, fish scales and rudists. The relationship between Derdere and Karababa formations indicates a drowning of the Arabian Platform (SE Turkey) (Yilmaz et al., 2018; Mulayim, et al., 2019).

In Central Tauride platform, subtidal platform carbonates with bioclastic packstone/grainstone facies alternate with intertidal birdseye/fenestral limestone facies. And overlying supratidal carbonates display laminar stromatolite facies. Subaerial exposure features such as mudcracks, dissolution vugs and microkarstic mantling breccias (Altiner et al., 1999; Yilmaz et al., 2004) can cover the laminar stromatolites.

In Pontide Platform, subtidal facies display pelloidal grainstone/packstone, intraclastic grainstone/packstone or oncoidal wackestone/grainstone facies with partly iron encrusted/corroded surfaces around peloids, oncoids and intraclasts. Stromatolitic supratidal facies displays reddish-pinkish colored laminar and wavy features and include iron staining within the peloidal laminae (Yilmaz et al., 2016).

Hauterivian –Barremian platform carbonates of Pontides display different sedimentary evolution and present a drowning of the carbonate platform in the western part. However, the Barremian is represented by shallow-water carbonates in the north. Hauterivian platform carbonates present average paleotemperature around 16 degree Celsius and pelagic Barremian displays 26 degree Celsius. However shallow water Barremian carbonates display 35 degree Celsius in the north.

Early Aptian platform carbonates of Taurides are generally composed of an alternation of peritidal and supratidal stromatolitic facies. However, early Aptian platform carbonates of Pontides display alternation of sandy limestone and subtidal facies. The average paleotemperature data of Taurides is around 27 degree Celsius, however average paleotemperature data of Pontides is 31 degree Celsius. Early Aptian pelagic equivalents of Pontides display 24 degree Celsius on average.

Average paleotemperature value obtained in pelagic Late Cenomanian in Pontides is 24 degree Celsius and average paleotemperature of Early Turonian is 22 degree Celsius.

Average paleotemperature value in Cenomanian (Arabian Platform) is around 30.5 degree Celsius and average paleotemperature value for Turonian-Coniacian is around 28 degree Celsius.

Temperature values fit Global Cretaceous ocean values in the Mediterranean Tethys Ocean, and it has been seen that there is a clear difference between Taurides (S Turkey), Pontides (NW Turkey), and Arabian Platform (SE Turkey). Paleotemperatures of platform and equivalent pelagics displayed considerable difference and can be used in global and regional correlation.

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Oil and Gas Distribution and Tectonic Evolution of Cambrian Bottom Unconformity Surface in Tarim Basin

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Tarim Basin, the largest hydrocarbon-bearing basin in China has been a subject of exploration for more than 50 years and abundant reservoirs of marine oil and gas were recognized within the Paleozoic strata. The Lower Cambrian Yuertusi and Xiaoerbulake formations are one of the important source rocks. The facies distribution of the Xiaoerbulake Formation is controlled by the paleomorphology of the Cambrian bottom unconformity surface (CUS), which also controls the maturity of the source rocks of the Yuertusi Formation and the migration of oil and gas along unconformities.

We used the structure map, paleo-water data and the well data to reconstruct the tectonic evolution, sea-level changes history and the sedimentary depocenter changes of the Cambrian bottom unconformity surface in Tarim Basin and implications for the oil and gas research.

The CUS records the complex tectonic evolutionary history of various units in the Tarim plate, such as the Manjiaer area that experienced multiple subsidence during the end of the Ordovician period and Tazhong area, which has been uplifted during the late Ordovician.

There was no obvious change in the paleo-water depth and sedimentary facies in the Tarim Basin in the early Cambrian. Carbonate rocks were deposited in the Manjiaer area and in the southwestern part of the Tarim Basin, controlled by the CUS. During the late Cambrian to Mid-Ordovician, carbonates and black shales were deposited as a consequence of sea-level rise and the CUS was buried deep in the Manjiaer area and the southwestern part of Tarim. During the Silurian, the depocenter moved to the southern and northern part of the Tarim Basin. Due to the CUS, the differences in facies distribution between the northern and southern part of the Tarim Basin appeared. After the Devonian and especially during the Carboniferous, deep-marine sediments were deposited due to the tectonic subsidence and concomitant sea-level rise. Therefore, the Manjiaer area and northward part of the Tarim Basin has enormous oil and gas resources.

Determination of palaeotemperature trends by δ15N data (rationale of a new method)

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Four methods (O-isotopic, TEX86, clumped isotope and Ca-Mg) are known for estimating marine temperature in the geological past. The method for determining the direction of temperature changes by variations of δ15N values is offered now. The rationale is given by the example of the Permian-Triassic (PT) sections in NE Russia, where N-isotope (NI) intervals of various ranks are established. Changes in the NI-composition of the organic matter are the result of the complex effects of various processes of the global biogeochemical N-cycle (BNC), e.g., N2-fixation, denitrification and anammox. In each of the studied sections, frequent δ15N deviations from the average value (NI-signals) are observed. It was shown that N2-fixation in the ocean can be enhanced as a result of warming and increased stratification of the water column (Karl et al., 2002); the cold glacial intervals of the Neoproterozoic and Phanerozoic are characterised by relatively high δ15N values, while the warm intervals of greenhouse conditions of the Phanerozoic are low (e.g., Algeo et al., 2014); there is a direct dependence of the upwelling intensity on climate fluctuations and that enhanced upwelling corresponds to low SST (Matzias et al., 2012).

In the light of the above information, the possibility of using NI-data for paleoclimatic reconstructions becomes obvious, although the nature of the detected NI-signals is not entirely clear. It is assumed that they are most likely a reflection of events associated with the processes of denitrification and N2-fixation. Deviations in the direction of increasing δ15N values are most logical to associate with an increase in upwelling activity and the entry of cool deep waters enriched with a heavy NI due to enhanced denitrification process (represent denitrification signals). Deviations in the direction of decreasing δ15N values represent N2-fixation signals and should be associated with a slowdown or cassation of inflow of cool deep waters, thus shifting NI-signals to the N2-fixation side.

Among the possible shortcomings of the proposed method one can name the difficulty of isolating from the obtained results signs of the influence of global factors. This certainly only can be established when comparable NI-trends are identified in several sections and/or NI-signals are in good agreement with other methods. Available data on O-isotope thermometry (e.g., Joachimski et al., 2019) indicate a sharp increase in temperatures in the Early Triassic compared to the Late Permian and short cooler episodes at some of the substage boundaries. In the sections of the Boreal Superrealm, these changes at the PT boundary associated with a distinct trend towards a steady decrease in δ15N in the Lower Triassic (and, accordingly, with a stable trend towards an increase in temperature, assumed on the basis of NI-data) and short NI-excursions at the respective substage boundaries. Since the above data indicate a very likely coincidence of the direction of temperature changes caused by both regional (upwelling) and global (climatic) events determined from NI-data, the use of the results obtained for the reconstruction of temperature trends seems legitimate. This work was partly supported by the Russian Foundation for basic research (grant 20-05-00604).

87Sr/86Sr record of Barremian-Albian invertebrates: first evidence from the Caucasus and its palaeogeological significance

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Data on the Sr-isotope composition of benthic, semi-pelagic and pelagic invertebrates from 10 zones of the upper Barremian, Aptian and lower Albian of the Caucasus were obtained for the first time. The results obtained made it possible to outline the main 87Sr/86Sr trend in Early Cretaceous, which is consistent mainly with data from other regions of the world, clarify the sequence of some paleoegeological, paleooceanological and palaeoclimatological events and eliminate some errors in biostratigraphical reconstructions in some sections of Dagestan and Western Georgia. There are conflicting points of view regarding the interpretation of some Sr-isotope data for the Aptian-Albian interval. Currently, the available data believe the existence of a single negative 87Sr/86Sr excursion for the Aptian-Albian interval (Jones and Jenkyns, 2001). At the same time, data on the Caucasus and Ulyanovsk Volga region, requiring additional confirmation, allow us to speak about the legitimacy of raising the question of the possibility of the presence of two negative excursions in this interval, as suggested by Ingram et al. (1994). In addition to the known late Aptian excursion, which was reliably established within the Abichi, Nolani and Jacobi Zones in the Caucasus (with 87Sr/86Sr ratio of 0.70720–0.70723, 0.70720–0.70723 and 0.70721, respectively), a much less pronounced preceding excursion is proposed to distinguish. The latter was originally documented on limited material from the Volgensis-Schilovkensis Zone in Ulyanovsk (0.70733–0.70738; Zakharov et al., 2018a). If this point of view is confirmed, we can assume the following sequence of paleoegeological, paleooceanological and palaeoclimatological events, which took place during the Aptian-Albian time. Following Bralower et al. (1997) and Larson and Erba (1999) we associate the Aptian black shales and the low 87Sr/86Sr values with the pulses of mid-plate volcanic activity that produced apparently the Ontong Java Plateau in the Pacific. The combined 87Sr/86Sr, δ18O and OAE records, obtained in the Caucasus (Zakharov et al., 2018b), Ulyanovsk Volga region (Zakharov et al., 2018a), and western Europe suggest that the early and late Aptian negative 87Sr/86Sr excursions, reflected the see-floor hydrothermal activity, directly followed by same events: the development of anoxia (OAE-1a and OAE-1b) and the increase in temperature. The highest δ13C values in the Aptian in the Caucasus and other regions occupy an intermediate position between negative 87Sr / 86Sr excursions. This relation probably indicates that the high bio-productivity in the sea took place between the peaks of mantle basaltic volcanism. This work was partly supported by the Russian Foundation for basic research (project no. 18-17-00247).

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How thin is a thin bed? A seismic-sedimentology perspective

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One of the most important concepts in seismic interpretation is seismic resolvable limit. Sheriff (2002) defined it as "the minimum separation so that one can ascertain that more than one interface is involved." Seismic resolution depends on the dominant frequency of the data and the velocity of the sedimentary rocks. In practice, the value of resolvable limit also depends on the criteria for judging the minimum separation and what seismic character or feature of a sediment body to observe. Widess (1973) defined 0.125λ as the resolvable limit, because traveltime no longer decreases with actual thickness and becomes constant at that point. Kallweit and Wood (1982) defined the resolvable limit at peak–trough separation as 0.25λ. Normally, a maximum composite amplitude, or tuning amplitude, is also observed at 0.25λ. Most seismic interpreters use 0.25λ (10 m for a 50-Hz data of 2000 m/s rock velocity) as resolvable limit.

In many cases, seismic detectable limit, the minimum thickness for a bed visible in a seismic display, is more useful than resolvable limit. It is much smaller than resolvable limit, because identifying a sediment body is considerably easier than picking its top and bottom and measuring its thickness. Sheriff (2002) estimated it at about 0.04λ (1.6 m for above case), a practical value in many applications.

In a 3D sense, seismic interpretation of sedimentology involves imaging not only in the vertical dimension, but also in the horizontal dimension, which requires researchers to consider both vertical and horizontal resolution. For a high-quality stacked and migrated 3D seismic volume, the horizontal resolution approximately equals the vertical resolution (Lindsey, 1989). Spatial resolution can be defined as a combined status of vertical and horizontal resolution (Zeng, 2015). There are four basic statuses of the spatial resolution: resolved vertically and horizontally (type 1), resolved vertically and detected horizontally (type 2), resolved horizontally and detected vertically (type 3), and detected but not resolved vertically and horizontally (type 4). Having a large horizontal dimension (tens to thousands of meters) and a small vertical dimension (meters to tens of meters), type 3 sediment bodies are most common in nature and can be best imaged and resolved on horizontal slices. Horizontal imaging (stratal slicing) is key to improving the stratigraphic resolving power of seismic data.

To adequately evaluate the capability of seismic data to visualize a sedimentary body, one must estimate the range of thicknesses within which one can visually diagnose the geometry of the body. This thickness range is defined as the visualization range. In an -90°-phase section, the width of the seismic event as an accurate measurement of thickness of the sediment body is between 0.25λ and 0.375λ; with a frequency-fusion processing (Zeng, 2017), the range can be extended to 0.125λ and 0.75λ. if an accurate measurement of thickness is not required, the visualization range can be expanded further to the detectable limit. With a great caution, it is time to practice seismic interpretation at a scale of outcrop- and well-based sedimentology.

Seismically informed thin-bed sedimentary analysis

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In lacustrine basins, thin beds (1–10 m) are major exploration targets in many depositional systems, especially in fluvial, deltaic, and turbidite systems. There is an increasing demand for mapping the geometry and stacking patterns of these thin beds using conventional seismic data. Sedimentologists are forced to work with low signal-to-noise seismic information because the seismic signal extracted from thin reservoirs will be substantially weaker compared to the signal from thick beds. Such data are more difficult to interpret, causing great uncertainties in reservoir prediction. Reducing these uncertainties is an immense challenge.

Seismic sedimentology has the potential to help advance our thin-bed imaging capabilities to meter scale by using lithology-indicative seismic stratal slices to assist with the correlation of thin beds. It has been shown that, under favorable geologic and data conditions, sandy depositional elements as thin as one meter can be imaged with stratal slices (Zeng et al., 2011). More and more applications have demonstrated that now it is realistic to seismically image meters-scale thin beds or even sedimentary structures.

We showcase the recent progress in this exciting new capability of sedimentary analysis in three common cases. The first case is ultrathin sand bodies in lacustrine delta and fluvial systems where the thickness is significantly below the tuning thickness and seismic signal is weak. The second case is subseismic clinoforms that represent shallow-water prograding processes in shallow-water deltas or prograding carbonate shelf margin but illustrate apparent parallel to subparallel reflections on vertical seismic sections. In the third case, thickness changes dramatically, with thin features key to understanding reservoir distribution and reservoir performance, such as in a point-bar complex.

Multistage burial dolomites of the Lower Permian Qixia Formation in the Northwestern Sichuan Basin

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Layered dolomite reservoir ensues preferentially in the bank facies of the Lower Permian Qixia Formation in the northwestern Sichuan Basin. Dolomite characterized as, replacement and cement, on the basis of occurrence. Replacement dolomite include (1) fine to medium floating dolomite (Rd1); (2) fine to medium, nonplanar anhedral mosaic dolomite (Rd2); (3) medium to coarse, planar-s subhedral mosaic dolomite (Rd3). As the degree of dolomitization is relatively high, the observation of pre-existing structure of the original limestone is difficult. Two types of dolomite cement were identified: coarse euhedral dolomite cement (Cd1) and the saddle dolomite cement (Cd2). Both types of dolomite cement distributed as a pore-lining, void-filling or fracture-filling. Cement are typically coarse crystalline, sweeping extinction, and maybe overgrown by late-diagenetic calcite (Cc). The qualitative CL characteristics (emission intensity and color) of dolomite fall into three broad categories, 1st group showing almost non-luminescence (Rd1, Cc and host limestone), 2nd group appearing as dull red luminescence (Rd2 and Rd3), and the 3rd group displaying moderately bright orange-red luminescence (Cd1 and Cd2). Compositional analyses depicted that the change in CL intensity, in turn, reflects a decrease in the Fe2+/Mn2+ ratio in the dolomite crystal, therefore there is a correlation of fluorescence with mineral paragenesis. The replacement dolomite has the similar values of δ18O (-8.1 to -5.45‰ VPB), δ13C (+2.3 to +5.3‰ VPB), 87Sr/86Sr ratios (0.706–0.708) and homogenization temperature (100–145°C). While the dolomite cement yields higher δ18O (-5.80 to -4.87‰ VPB), higher δ13C (+3.81 to +4.85‰ VPB), higher 87Sr/86Sr ratios (0.710–0.719) and higher homogenization temperature (130–220°C). This data suggested that dolomite cement precipitated from higher temperature fluid after the formation of the host replacement dolomite. The petrographic and geochemical similarities between some replacement dolomite and dolomite cement suggested that replacement dolomite, formed at earlier stages, recrystallized when it exposed to dolomitizing fluid at later stage. However, the rare earth element distribution patterns of both replacement and cement dolomite are similar to the host calcite (depleted LREE, enrich HREE, negative Ce anomaly and slightly Eu anomaly), which verified that the dolomitizing fluid still remained to be the seawater preserving in pores. In combination with macroscopic distribution, the dolomite is not apparently fractured along, and there is also a lack of evidence of hydrothermal minerals. It is indicated that the dolomite formed by burial dolomitization. With the going down in the depth, the dolomitizing fluid chemical property changed, which cause the different fluorescence of replacement and cement dolomite. The kinetics barrier of dolomitization has been overcome due to an increase in burial temperature and changes in fluid property especially Mg/Ca ratio.

Applying seismic sedimentology for high-resolution anatomy of fluvial-deltaic systems in a complex strike-slip fault zone

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The complex fluvial-deltaic system in the Miocene Guantao Formation of Bohai Bay Basin, China, presents a challenge for reservoir prediction in a complex strike-slip fault zone with strong effects from the Tanlu fault system. On the basis of high-resolution three-dimensional seismic data and 12 wells drilled, we propose two different frequency-fusion (RGB color-blending) methods of three different-frequency panels/volumes from various data sets. One method is based on the stacked, migrated, -90° phase data, and the other is based on the root mean square (RMS) volume attribute extracted from the -90° data. Integrated with user-controlled linear combination analysis, we try to better quantify fluvial-deltaic sandstones of the Guantao Formation. The results show that the RGB color-blending slices based on the RMS panels have much greater ability to characterize sedimentary-facies-geometry distribution and sand-thickness quantitative analysis, which can effectively decrease disadvantageous influence of multiple fault blocks on stratal-slice view. On the vertical section, however, the linear combination and the RGB color-blending analysis based on the -90° phase data have greater utility and resolution, which can be used to characterize the sand body by width of seismic event or display the various sand thicknesses in different colors. A linear combination and two different types of RGB color-blending analysis have been successfully applied in the three third-order sequences of the Neogene Guantao Formation in both the PL19 and PL20 blocks. This integrated analysis has readjusted the thin-bed tuning effect based on -90° phased data and the RMS volumes, and exhibited a good visual match among sandstone-thickness, seismic events and RGB color. Based on these characterizing results, we can effectively predict the greatest-potential braided-river-channel and deltaic sandstones with various thickness changes (4–40 m) by exhibiting the thickness cyclicity in vertical section (depth) and displaying the thickness-related map in stratal-slice view. The comprehensive seismic-sedimentology analysis of the Guantao Formation in both PL19 and PL20 blocks can better explain why past drilling activities in the PL20 block were not successful. They also explain why exploration in PL19 block has been much more productive than in the PL20 block. The thick channel sandstones in the PL19 block, especially in R-C, are the highest-potential targets for hydrocarbon exploration in this complex strike-slip fault zone. In the PL20 block, even though the sand bed is much thinner than in PL19, we also can identify several high-potential regions for next-step exploration. The proposed integrated methods can effectively reduce the uncertain impact of manual interface interpretation within complicated zones and improve the accuracy of thickness prediction and sedimentary-facies interpretation. The high-resolution anatomy of fluvial-deltaic system in the Bohai Bay Basin not only can explain current exploration effects but also effectively predict thick sandstones with the most production potential in this complex region. This useful technique can be carried out with sparse drilled-well control and is therefore suitable for most complex areas or strata that have experienced intense tectonic evolution.

Pore throat structure characteristics of tight sandstone reservoirs and its influence on movable fluid saturation

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The image analysis and fluid injection methods were used to qualitatively and quantitatively analyze the pore throat structure characteristics of the tight reservoir and discuss the effects of different pore throat structure types on movable fluid saturation. The high pressure mercury injection (HPMI) and constant speed mercury injection (CMI) results revealed that the pore throat structure of the reservoir in the present study area can be divided into three types: Type I reservoirs have more large pore throats and fewer small-pore throats, with good connectivity, while type II reservoirs have reducing large pore throats and increasing small pore throats. Type III reservoirs have fewer large-pore throats, and have more small-pore throats. Combined with the NMR test, the characteristics and effect factors of the movable fluid saturation (Sm) of pore throat structures reservoirs were investigated. The results revealed that the mean Sm in type I, type II and type III reservoirs is 66.53%, 33.15% and 19.28%, respectively. The seepage coefficient, permeability and throat radius have the greatest influence on movable fluid saturation. Furthermore, this also reflects that Sm is mainly determined by the seepage ability and connectivity of the reservoir. The correlation between the physical property parameters and pore throat structure parameters of type I reservoirs and movable fluid saturation is better, when compared to type II and type III reservoirs. Furthermore, when the pore throat structure of reservoirs is from type III to type I, the fluidity saturation exponentially changes. Finally, combined with the HPMI and NMR tests, the lower limit of the movable throat radius of the study area was calculated as 20 nm. In classifying the throat radius based on fluid mobility, the throat radius can be divided into three types: immobile throat (<20 nm), bound throat (20–200 nm) and movable throat (>200 nm).

Effect of microscopic pore-throat heterogeneity on gas phase percolation capacity of tight sandstone reservoirs

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In the development process of tight gas reservoirs, the gas-water two phases interfere with each other, which lead to the decline of percolation capacity and the significant difference in the production with per well. The essential reasons of the phenomenon is the pore throat structure heterogeneity. However, there are few studied on the effects of pore throat heterogeneity on percolation capacity. Therefore, it is necessary to discuss the effect of pore throat heterogeneity on gas phase percolation capability when the gas-water two phases coexist. The pore-throat heterogeneity of the tight sandstone in Ordos basin was investigated for using NMR and constant velocity mercury intrusion tests (CMI). The aim is to qualitatively and quantitatively characterize the microscopic heterogeneity of pore throat by combining the advantages of the two experiments. On this basis, studying the effect of pore-throat heterogeneity on gas phase percolation capacity by using gas-water relative permeability experiment. The results show that 1) the pore radius calculated by the CMI test is too large to reflect the real situation of reservoir. So, the pore heterogeneity was characterized by of NMR test, while the throat heterogeneity was characterized by CMI test; 2) with the stronger of the pore-throat heterogeneity, the effective seepage space is smaller for gas phase and the interference in gas-water two phase gradually increases. As a result, the gas phase permeability is low, the bound water saturation is high, and the common infiltration area is small; 3) the pore-throat heterogeneity common effect gas phase percolation capacity. The stronger heterogeneity of the pore throat, the slower the gas phase permeability curve grows with the increase of gas saturation, which reflect the higher on producing water ratio of reservoir, indicating that microscopic heterogeneity of pore throat restrain the migration of the two-phase fluid and sweep area of single-phase fluid. The stronger of pore-throat heterogeneity, the worse the exchange of gas and liquid, which ultimately leads to the low development efficiency of the Shihezi reservoir

Study on Sedimentary Microfacies of Tidal-controlled Estuary in M1 of Oriente Basin

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The study area is located in the northwest of Block T of the Oriente Basin, between the Andean fold belt and the Gondwana shield. The stratum studied in this study is the M1SS. This stratum is mainly medium-fine-grained quartz sandstone, which was deposited in the Albian (K1) to Campeni (K3), and its sediment originated from the Gondwana shield in the southeast. Due to the discontinuity or denudation caused by tectonic uplifting movement, only varicolored continental and coastal mudstones of the Paleogene Tena Formation was deposited, forming a regional caprock. In 2012, the Oriente Basin exploration and development plan was adjusted to tap the remaining oil of some low-production and inefficient wells. This means that the research area urgently needs to carry out detailed microfacies research on the reservoir, which can provide guide on the changes of development plan.

Utilizing previous research results and core data, this study identified the sedimentary microfacies of M1SS layer: (a) Tidal sand bar microfacies: it is developed in the lower part of the M1 interval, which is composed of medium-fine sandstone. A variety of staggered bedding, lenticular bedding, and double clay layers are developed. GR curve shows low amplitude of box type; (b) Tidal sand flat microfacies: This microfacies is the sedimentary background of the study area, which consists of fine sandstone and siltstone with argillaceous interlayers. It mainly develops enveloping bedding and staggered beddings. GR curve shows toothed low amplitude; (c) Mixed flat microfacies: This kind of microfacies is also known as sand-mud flat, which mostly develop around the tidal sand bar microfacies.

The M1SS layer in the study area is a typical thin reservoir. It is difficult to describe this type of sand body using traditional seismic inversion methods. A relatively new inversion method, named wave phased inversion, is adopted in this study. This method eliminates the negative effects of seismic noise. The inversion results can be used to correct the distribution of sedimentary microfacies and obtain a more reliable plane distribution of sedimentary facies. This study used GR, VSH and RHOB curves to perform inversion respectively. The results show that a high muddy strip from north to south develops in the middle of the study area, which is the same as the planar distribution of sedimentary microfacies.

The M1SS layer deposition period went through three stages: (a) Initially, the hydrodynamics were much chaotic, and the sedimentary environment was mainly the tidal-controlled estuary, accompanied with the delta environment. (b) In the early period of transgression, the river environment transformed into the tidal estuary, and M1 sandstone and mudstone interlayers gradually formed, accompanied by many tidal structures. (c) In the late period of transgression, seawater gradually withdrew from the estuary, and the sedimentary environment gradually changed to the shallow sea shelf sedimentary environment, forming a good regional caprock. (d) Finally, the depositional environment of shallow sea sheds dominated, and chlorite-containing sandstones began to appear.

Quantitative characterization of architecture elements in deep-water hyperpycnal systems in lacustrine rift basins

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Hyperpycnal flow formed during flood event at a river mouth is an important process for transporting sediments into deep water, which are commonly developed in lacustrine rift basins. The paleotopography controlled by slope and ramp zone leads to deep-water hyperpycnal system with different grain-size composition and depositional model. Outcrops of the Lower Cretaceous Xiguayuan Formation in Luanping Bain are well exposed for the high-resolution measurement of the architecture elements of hyperpycnal system. Lithofacies, geometry and bounding surfaces with scale parameters of depositional unit are constructed to quantitatively characterize the architecture elements. Grain-size parameters and width/thickness of unit are used to analyze the various process of hyperpycnal flow. Ramp zone with low topographic relief developed sand-rich traction current dominated hyperpycnal system. Thin channel unit and high width/thickness ratio reflect depositional channels and lobes are the dominated architecture elements. However, gravel-rich debris flow dominated system was formed under slope zone with high topographic relief. The thick channel units with low width/thickness ratio shows incision-dominated process. This study provides an insight into the process and quantitative characteristics of depositional architecture under different tectonic unit in a lacustrine rift basin.

Seismic sedimentology characterization of thin beds in Neogene paleo-Pearl River Delta front, south-eastern China

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In Neogene, there developed a large delta system in Pearl River Mouth Basin, south-eastern China. The delta extends more than 100 km because of the level paleo-geomorphology and sufficient depositional sources supply. By wave transform, there deposited large area of thin sandstone layers in delta front which form good oil reservoirs. From the thickness tuning curve, it can determined depositional surfaces and thickness of thin beds cannot be accurately interpreted in seismic section. There are 3 problems in sedimentary facies study of thin beds: 1) recognize seismic reflection of the 4th order sequence and interpret isochronous surfaces in 3D seismic data; 2) identify thin beds with thickness less than seismic resolution and characterize their boundaries; 3) interpret distributary channels in delta front.

Seismic reflection of isochronous surfaces is recognized and interpreted with techniques of isochronous reflection analysis and frequency-decomposition analysis. With calibration of wells, seismic event has a good relationship with thin sand-layers in 90°-phase seismic data. 90°-phase seismic data is sliced from bottom to the top of target layer. Evolution of sandstone distribution from slices indicates seismic reflection of the 4th order sequence surfaces which is maximum flooding surface.

Thin beds in delta front are imaged clearly on plane with techniques of composite seismic attribute analysis and frequency division RGB fusion. With traditional seismic slicing methods, slices may extend cross geologic time surface and present incomplete channel display. The method of non-linear slicing is used to avoid such a problem and help to map distributary channels in delta front.

With the above techniques and workflow, depositional facies of thin beds is characterized and depositional evolution of delta front is reconstructed. The result supports exploration and development of lithologic reservoirs in study area.

Origin and evolution of the Late Cretaceous reworked phosphorite in the north of Saudi Arabia

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As an essential element for agriculture as a component of fertilizers, and serves as a fundamental driving force in marine productivity, phosphorus has attracted a lot of attention. The re-deposition of pristine phosphorite play an important role in phosphorus accumulation, which created reworked phosphorite widespread on the continental shelf. This paper, using geochemical analysis combined with data from petrology and diagenesis, focuses on the reconstruction of the formation processes of the Late Cretaceous Thaniyat phosphorite deposition in the northwestern Saudi Arabia, which is a part of the famous large Neo-Tethys Ocean's phosphorite deposit. The results of our study illustrate that the phosphorites are the represent the reworked products from the north closing to the edge of the Neo-Tethys Ocean's shelf, where upwelling had accreted the pristine phosphorite. The reworked phosphatic grains were redeposited near the shore in a sandstone, forming sandy phosphorite and on a carbonate platform, creating a calcareous phosphorite deposit. The phosphatic grains in sandy phosphorite are dominated by phosphatic pellets, while in calcareous phosphorite are mainly phosphatic ooids. The difference of phosphatic grains in sandy and calcareous phosphorite implies diversity of the phosphorite source. The aggregated extra-large phosphatic grains containing various phosphatic pellet and ooid, and phosphatic bio-fragment are other minor phosphatic components observed in both sandy and calcareous phosphorite. The grain size and assemblage pattern indicate fluctuation of the flow energy for erosion and physical transportation of the reworked phosphorite. Minor and trace element analysis results show that V/Cr, V/Ni, V/Mo and Ni/Co ratio varies in a wide range but has a trend of oxic condition indication in bulk rock of sandy and calcareous phosphorite. The Ce anomaly, however, suggests anoxic sedimentary environment. These may be subject to the minor element content is controlled by deposition processes, while the REE is likely derived from the phosphatic source rock, which is dominated by pristine phosphorite. The REE patterns of sandy and calcareous phosphorite are similar with that of the phosphorite from Jordan and other place in the north with a significant characteristic of rich in MREE. Early diagenesis was occurred in both sandy and calcareous phosphorite, which is evidenced by recrystallization of the phosphate minerals, geochemical depletion and C and O isotope excursion. Based on the results above, a scenario sketch was established, trying to explain the sedimentary processes of the reworked phosphorite in the north of Saudi Arabia, which supplied more detail about the formation of the phosphorite from source to sink in Neo-Tethys Ocean and Arabia peninsula.

Pore-throat structure characteristics and influencing factors of seepage capacity in tight sandstone reservoir

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With the continuous change of global energy supply pattern, tight sandstone oil and gas has become the key field of global unconventional oil and gas exploration and development. Microscopic pore-throat structure characteristics and the influencing factors of seepage capacity of tight sandstone reservoir are very complex, which play an important role in the development of tight sandstone reservoir. In this study, we use the casting thin sections, scanning electron microscopy, X-ray diffraction, high pressure mercury injection and constant velocity mercury injection method to comprehensively investigate pore-throat types, size, morphology, connectivity and clay mineral compositions within tight sandstone samples from the Triassic Yanchang Formation of the Maling Oilfield, Ordos Basin, China. And pore-throat structure can be divided into four types according to the parameters of pore and throat. On this basis, nuclear magnetic resonance and oil-water relative permeability experiments were used to study the occurrence characteristics of movable fluid and oil-water seepage characteristics of different types samples the pore structure, and further explore the controlling factors of microscopic seepage capacity. The results show that the pore types of tight sandstone samples are mainly residual intergranular pores, intergranular dissolved pores, intragranular dissolved pores, intercrystalline micropores and a few microfractures. The mainstream throat radius of the four types of pore-throat structure are significantly different, and the larger the mainstream throat radius is, the higher the permeability is. And great differences lie in the movable fluid saturation, the length of the two-phase flow zone and the water saturation at the crossing point of the samples with different types of pore-throat structure. The type and content of clay minerals, throat radius , pore-throat radius ratio are closely related to the movable fluid saturation, the length of the two-phase flow zone and the water saturation at the crossing point. This indicates that the tight sandstone reservoir is developed with various scales and types of pores and throats, and the microscopic seepage ability is heavily affected by the type and content of clay minerals and pore-throat parameters. This study is helps to clarify the relationship between clay minerals, pore-throat structure and microscopic seepage capacity of the Triassic tight sandstone reservoir in Maling Oilfield, and can provide beneficial guidance for the related researches in Ordos Basin and other basins around the world.

Sedimentary environment and distribution of source rocks in slope belt of the Xihu Depression, China

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The slope belt of Xihu depression is a typical sedimentary environment of transitional facie. There are three kinds of coal-bearing source rocks, including coals, carbonaceous mudstones and mudstones. However, the sedimentary environment of each source rock is different. Due to the lack of drilling, the enrichment rules of the source rocks are not clear. Based on the analysis of cores' geochemical data, including the total organic carbon (TOC) and pyrolysis analysis results. It is considered that coals (the HI contents ranged from 212.44 to 718.66 mg HC/g TOC (average of 346.44 mg HC/g TOC)) and carbonaceous mudstones (the HI contents ranged from 148.73 to 395.04 mg HC/g TOC (average of 243.68 mg HC/g TOC)), in comparison with mudstones(the HI contents ranged from 40.00 to 332.64 mg HC/g TOC (average of 126.76 mg HC/g TOC)) have a higher liquid hydrocarbon generation potential. Only when TOC of mudstone is more than 1.00%, can it reach the standard of effective source rock. In this article, we are based on the research about sedimentary facies, and find that coals and carbonaceous mudstones deposited in tidal flat facies and lagoon facies. Instead, Mudstones mainly deposited in delta facies. The distribution of coal-bearing source rocks is obviously controlled by the sedimentary environments. In conclusion, the coals mostly deposited in the paleo-uplift areas which are in the middle of the slope, and the thickness becoming thinner from the shallow tidal flat or lagoon environments to the eastern semi-enclosed bay. There is a symbiotic relationship between carbonaceous mudstones and coals. While the thickness of the effective mudstones (TOC > 1.00%) increase with the depth of the sedimentary water. All in all, the distribution characteristics of coal-bearing source rocks can provide scientific basis for the exploration of oil and gas fields.

Late Paleozoic siliciclastics of the Changning-Menglian Belt in western Yunnan, China and their paleogeographic indications

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The Changning-Menglian Belt in western Yunnan, China, recorded the remnants of Paleo-Tethys. Analyzing the lithological components of this belt is key to understanding the development of Paleo-Tethys in this region.

The Carboniferous-Permian Nanduan and Laba Formations developed in the east zone of this belt, are mainly consist of quartzose sandstones, silty mudstones and some shales. Sedimentary structures, petrographic indices and geochemical features indicate that these siliciclastic sequences were deposited in a neritic shelf to deep shelf environment on the passive continental margin. Detrital zircon geochronological analyses, which display significant age groups of ca. 550 Ma and ca. 950 Ma, suggest that these rocks are Gondwana-derived, and were possibly deposited on the east flank of the Baoshan-Shan Block with the metamorphosed Cambro-Ordovician siliciclastic successions in this belt.

Late Paleozoic siliciclatics with a Devonian to Early Carboniferous age distributed in the central zone, comprise lithic sandstones, silty mudstones and shales. They are identified as mainly near-source turbidity currents and continental island arc related deposits, based on their sedimentary structures, petrographic features and geochemical analyses. Detrital zircon ages of these rocks, which record remarkable age clusters of ca. 435 Ma and ca. 950 Ma, show similar distribution patterns with those from the Simao and South China Blocks. These rocks were probably deposited along the western margin of the Simao Block, and then thrust onto the east flank of the Baoshan-Shan Block together with other rock units of the accretionary wedge during the closure of Paleo-Tethys.

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Lower Ordovician sequence stratigraphy and its control on microbial rocks in Songzi area, Hubei

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By analyzing the rock types, structures and sedimentary structures of the Lower Ordovician in the study area, the sedimentary facies of the study area are divided into two types: open platform phase and limited platform phase. The open platform can be further divided into the shoal subfacies, the shoal shoal phase and the reef subfacies. The limited platform phase can be further divided into the shoal subfacies and the lagoon subfacies. According to the standard microfacies division method of carbonate rock, 11 kinds of microphases were identified in the Lower Ordovician in the study area.

Through the application of classical sequence stratigraphy theory, three sequence interfaces are identified in the study area, including erosion erosion surface, lithology transformation surface and maximum sea surface. On this basis, the Lower Ordovician in the study area is divided into six third-order sequences, and the sequence stratigraphic framework of the Middle Yangtze region is established. Using the theory of high-resolution sequence stratigraphy, 15 Quaternary sequences were identified in the Lower Ordovician strata in the Liujiachang area of Songzi City and their developmental characteristics were described. At the same time, through the cycle theory of Milankovic, the identification of the Meter level cycle of the Lower Ordovician in the study area was carried out for the first time. A total of 11 types of Meter level cycles were identified, and the Lower Ordovician was divided into 86-meter cycles.

Based on the description of the types of microbial rocks in the study area, the study on the control effects of sequence stratigraphy on different types of microbial rocks in the study area . The results show that in the stromatolite microbial rocks, the wavy stromatolite is mostly distributed in the middle stage of the Transgressive system tract and in the early stage of the highstand systems tract. The columnar stromatolite is distributedin the middle stage of the Transgressive system tract, and the mound stromatolite is in the late stage of the highstand systems tract. In the crust microbial rocks, the porphyritic thrombolite are distributed in the early stage of theTransgressive system tract, while the reticular thrombolite are in the late stage of the Transgressive system tract; the nucleus with good particle size and content is in the early stage of the highstand systems tract

The analysis of the control effect of high-frequency sequence on microorganisms suggests that the wavy stromatolite is distributed in the early stage of the rising half-cycle and the early stage of the falling half-cycle, and the columnar stromatolite is mostly developed in the upper part of the rising half-cycle, and the mound-shaped stromatolite is in the upper part of the descending half-turn; The porphyritic thrombolite is in the middle of the rising half-cycle, and the reticular thrombolite is in the late stage of the rising half-cycle. The nucleation stones with good particle size and content in the core-shaped stone are mostly distributed in the middle of the rising half-cycle, which is more suitable for the development of the nucleus.

Geochemical identification of carbonate sedimentary environment: A case study of Nanjinguan Formation in Songzi area

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Taking the Nanjinguan Formation of Early Ordovician in Liujiachang area, Songzi, Hubei as an example, this paper attempts to analyze and determine the depositional environment of carbonate rocks by using the changes in contents of geochemical elements. The results of the U/Th, V/(V+Ni) ratio method show that the Nanjinguan Formation is in astrong vertically stratified, oxygen-poor environment; in it, stromatolite microbial rocks were formed in a generally oxygen-poor environment and clotted limestone was formed in a hypoxia environment. The Sr/Ba ratio data show that the ratio of Sr/Ba in Nanjinguan Formation is greater than 1, and is between 20 and 50 for three times. Among them, microbial rocks such as stromatolite and clotstone are mostly developed in a water body with a Sr/Ba ratio of 1 to 20, that is, a higher salinity. The analysis of the Mg/Ca ratio shows that the Nanjinguan The temperature of the Nanjinguan Formation in the study area was relatively high during this period., and the appropriate climate and the high temperature were favorable for the development of organic reefs and microbial rocks. A comparison of the ground source elements Al, Ti, and V in the vertical direction and a comprehensive analysis of correlations indicate that there have been three more significant sea level rise and fall events in the Nanjinguan Formation. Laminated limestone developed during the first two sea level high water levels, and the clinker limestone developed during the third sea level change.

Bedding features from borehole images and their geological significance in shale gas reservoirs

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In recent years, major exploration breakthroughs have been made in the Taiyang anticline, Zhaotong Basin, with the discovery of large-scale shallow shale gas reserves. The main exploration target of the Taiyang anticline is the Ordovician Wufeng Formation and the lower part of the Silurian Longmaxi Formation. Through analysis of the borehole image logs, combined with conventional logs, thin section identification and core observation, the following understanding is obtained: (1) Based on the thickness of single layer, horizontal bedding can be divided into block, thick, middle, thin and page-like (fine), indicating the periodicity of hydrodynamic conditions and material composition changes during deposition, which can be used to analyze its sedimentary microfacies or sequences. With a high resolution of about 5mm, electrical imaging logging can effectively identify the above bedding types. (2) The overall vertical model is as follows: from Wufeng Formation to the middle-lower part of sub-Layer 2, sub-Member 1, Member 1 of Longmaxi Formation, thin bedding mainly developed, except Guanyinqiao Member of the top Wufeng formation with medium/ thick bedding; from the middle-upper part of the sub-Layer 2 to the sub-Layer 4, sub-Member 1, Member 1 of Longmaxi Formation, page-like bedding mainly developed. Combined with conventional logging, it can be divided into three quasi-sequence groups. From the middle-lower part to the top of sub-Layer 2, there is a transition zone from thin bedding to page-like bedding, and the large sedimentary discontinuity at the top may represent the most flooded surface. (3) As the best reservoirs, Wufeng formation and sub-Layer 1, sub-Member 1, Member 1 of Longmaxi Formation, thin bedding developed, and the lithology is silicon-rich mudstone, mainly cryptocrystalline chalcedony and clay quartz, where quartz is mostly authigenic, clay minerals are the least, and the content of organic matter is highest, corresponding to siliceous shale deep-water shelf sedimentary microfacies. Because the water body is the deepest, the reducibility is the strongest, and it is stable for a long time, page-like bedding is hardly developed, whereas the source and storage conditions are the best. The upper part of sub-Member 1, Member 1 of Longmaxi Formation, from sub-Layer 2 to sub-Layer 4 mainly developed page-like bedding, which is formed during the slow regression period. The development of the foliation indicates that the sedimentary water conditions and material composition have small periodic changes at high frequency, resulting in an inferior stability and relatively poor conditions of source and reservoir, which also acts as a sealing for the underlying reservoirs.

Thin shoal delta characterization of seismic sedimentology in the gentle slope of Dongying Sag, China

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The dongying sag is a typical faulted basin with southern slope in Bohai Bay basin. The tectonic setting is stable, climate is arid and the slope is gentle during sedimentation of Shahejie Formation (Es2 and Es1). But,there are some differences of topographic slope in southern slope of Dongying Sag, the topographic slope of eastern segment of the southern slope is 0.52°~1.29°, western segment 0.5°~1.8°. The water depth of Es2 and Es1 are 8~13m and 9.2~52m respectively. All of mentioned above provide good geological background for the formation of shoal delta in gentle slope.

The lithology of Es2 and Es1 in the southern slope of Dongying Sag is interbedding of sandstone and mudstone with the thickness of 100–300m totally, but the single thickness of sandstone and mudstone is 1–5m and 1–3m respectively. Obviously, it is very difficulty to characterize the thin sandbodies of delta based on interpretation of normal seismic data.

Seismic sedimentology can investigate sedimentary rocks and depositional processes, characterize the thin sandbodies effectively. The study of seismic lithology of Dongying Sag has demonstrated that the mudstone has low wave impedance and high GR, and the sandstone has high wave impedance and low GR, therefore it is easy to determine the sandstone and mudstone using stratal slicing of seismic sedimentology. The software Geoscope has been used for stratal slicing of Es2 and Es1, and we got 280 stratal slicings, one of which represent the sedimentary thickness of 0.5m~3m, so the thin sandbodies could be characterized. The major sandbodies of shoal delta is distributary channel (2–5m thick) which prograde towards 5–6km with lenticular in section topography.

The eastern segment of the southern slope is near to Guang uplift which provide much sediment to the Sag and form large, coarse shoal braided delta with area of 100km2; the western segment of the southern slope is far away from provenance of Lu Mountain which provide relative less material to the Sag, therefore the delta prograde only towards 2–4mk, the size is much small with area of 20km2.

Stratigraphy and anthropogenic contamination of dam-reservoir sediments from the Váh river dam cascade

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Filling up of dam reservoirs with sediments presents an important environmental and economic issue due to the loss of reservoir capacity and accumulation of pollutants in the reservoir depositional systems. There are numbers of factors, which influence the depositional architecture and accumulation rates in dams and deposition of anthropogenic substances, so it is difficult to propose a universal predictive depositional model of dam reservoirs. A sound predictive model of distribution of anthropogenic pollutants requires a deep knowledge of site-specific parameters such as the river gradient, sediment load, grain size, frequency of floods, land use in the catchment, reservoir bottom morphology, primary organic productivity, reservoir trap efficiency, etc.

The Váh River, a left-hand tributary of the Danube River, is the longest river in Slovakia, which drains a predominantly mountainous catchment with very diverse geology spreading from Slovakia to Poland and Czechia. There are 22 dams constructed along its 406 km long course (one dam per 18.5 km of river course on average!) which are known as the Váh Cascade. Owing to the frequency of dam reservoirs and the very diverse geology, the Váh River offers an excellent opportunity to study the effects of damming on the transport, accumulation, architecture and composition of the reservoir sediments. Sediments found in dams are commonly a mix of soil particles and rock fragments transported from the catchment, alternatively atmospheric depositions.

In this paper, we present the first results from two dam reservoirs, Hričov and Žilina, located on middle reaches of the river. Subsurface sediment architecture was studied in a series of 2D ground-penetrating radar scans and 11 shallow (up to 95 cm deep) cores. The cores were sampled (sampling step 1 to 2 cm) for Vis-spectral reflectance (colorimetry) measurements, mass-specific magnetic susceptibility, and laser grain-size analysis. Sediment accumulation rates were calculated from depth distribution of 137Cs mass activity and depth to pre-reservoir bottom as inferred from the above-mentioned physical parameters. Element geochemistry of the sediments was analysed by Energy Dispersive X-ray Fluorescence analysis (EDXRF) and ICP-MS with total acid digestion. Total organic carbon (TOC) was measured by ELEMENTAR LiquiTOC Vario cube; concentrations of persistent organic pollutants (PAH, pesticides, herbicides) were analysed by gas chromatography. The results show that geochemistry of the reservoir sediments rapidly changes from reservoir to reservoir, depending on the changing provenance and depositional setting. There is only a low impact by the risk elements (Cr, Ni, Cu, Zn, Pb, Hg) but relatively high impact by organic pollutants especially from agriculture (PAH, polar herbicides and pesticides).

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Thermal maturity of flysch-type Grajcarek succession based on vitrinite reflectance analysis, Poland – preliminary results

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The Grajcarek succession in Poland consists of strongly folded and thrust Jurassic-Paleogene sedimentary formations, belonging to the Northern Tethys realm. Thermal maturity analysis was done on forty-five samples representing the Jurassic-Cretaceous Grajcarek succession. Vitrinite reflectance measurements of dispersed organic matter were used as a base to obtain the coalification ranks and thus, the burial depths. Random vitrinite reflectance falls in the range from 0.58% to 1.10%, which corresponds to the high rank of bituminous coal. Such values are typical for the mature main phase of liquid petroleum generation known as peak oil window.

Calculation of the maximum temperature using the most popular kinetic equation by Sweeney and Burnham (1989) reveals that the rocks were exposed to maximum temperatures ranging from 84 to 166°C with an error of ca. 10°C resulting from an average standard deviation of vitrinite reflectance. The depth of burial was estimated for two different geothermal gradients: 19.8°C/km and 29.18°C/km reported previously in boreholes. The maximum burial depths are estimated to be between 4.2 and 8.4 km, and between 2.8 and 5.7 km respectively. Differences in coalification ranks and thus, the maximum temperatures within the Grajcarek succession may be due to several reasons: (i) at very high levels of thermal maturity, vitrinite reflectance depends not only on maximum palaeotemperature but also on the host-rock lithology resulting in differences in pressure propagation and thus deformation; (ii) higher vitrinite reflectance is observed in shear zones than in the background which is interpreted as due to frictional heating during seismic faulting; although the thermal maturity of the Grajcarek succession was resulted from tectonic subsidence developed during the Paleocene-Eocene Thermal Maximum that its tectonic features originated during two stages of deformation: first related to Jurassic-Paleogene folding and thrusting; second related to Miocene when the initial structure of the Grajcarek formations was obliterated by local thrust- and strike-slip faulting activating pre-existing tectonic structures; (iii) local additional heating by a) andesitic rocks emplaced along an “en échelon” system of second-order faults, or b) hydrothermal fluids circulation pathways along fractures and faults system evidenced by the calcite-filled open fractures in sandstones; (iv) vitrinite reflectance suppression (reduction of reflectance due to high hydrogen content in vitrinite of various origin).

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Fossil wood as indicator of palaeo-environmental scenario during the Cergowa Beds sedimentation (Outer Carpathians, Poland)

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Turbidite strata of the deep-marine Oligocene Cergowa Beds are a part of the most important hydrocarbons-prone complex in the Polish Flysch Carpathians and contain a wealth of coalified terrestrial plant matter. According to the current interpretation, the sand-rich turbidite succession at Lipowica was primarily controlled by hyperpycnal flow turbidites derived from a delta positioned at the edge of shelf adjacent to the source area elevated to the NW and formed by the Silesian Ridge during the Oligocene eustatic sea-level lowstand.

The terrestrial plant matter at Lipowica was classified into three groups based on the size of the remains, and macro-and micropetrographic features as follows: (i) coalified plant detritus, (ii) coalified plant fragments, and (iii) coalified fragments of tree trunks. Coalified plant detritus represents black and dull/lustrous particles 2–3 mm across, irregular in shape, occurring within the uppermost parts of turbidite beds, mainly in mudstones and siltstones but sometimes also in very fine-grained sandstones, parallel and convolute laminated and often containing mud clasts. Coalified plant fragments form black and lustrous irregular vitrain lenses parallel to each other, 1–5 cm long and 1–4 mm thick. They occur in fine- and very fine-grained sandstones with parallel and current ripple cross lamination, occasionally in mudstones. Coalified tree trunks fragments occur within massive medium-grained sandstone beds as two types, namely unfilled compacted/flattened or filled logs only slightly deformed by compaction. The internal parts of the filled-type tree trunk fragments occur as: (a) silicified wood structure containing a small admixture of carbonate cement surrounded by irregular, 2–6 mm thick external rims of vitrain. or (b) fine-grained quartz arenite cast with calcareous cement cut by irregular vitrain veins. The major component of coal-forming compacted tree trunks is telinite with well-preserved cellular structure, in some parts deformed and fragmented. Elongated telinite cell walls are impregnated by gelinite and mineral matter such as silica and calcite. Collotelinite is a minor component with a dense system of cracks, sometimes impregnated with framboidal pyrite. The silicified tree trunk consists of gelified plant tissue, represented by telinite. Cells of telinite are almost impregnated with gelinite and silica, and only a small part of cells are empty. Collotelinite occurs in vitrain rims, and in those trunk fragments where gelification process is more advanced. The major petrographic component in tree trunk with arenite cast is collotelinite with inclusions of well-developed framboidal pyrite. The vitrain veins consist of collotelinite laminae, which contain crushed organic maceral debris such as collotelinite, telinite and fusinite.

The three different types of coalified tree trunk preservation (compacted, with the mineral cast, and petrified) at Lipowica reflect different biochemical conditions accompanying various intensity and/or duration of humification of terrestrial plants within the source area in the subaqueous environment: (i) quick burial and compaction of slight humified tree trunk fragment causing flattening, (ii) gradual filling of the hollowed tree trunk fragment with sediment (arenite), and (iii) silicification of well-preserved internal structure in rapid buried tree trunk fragment.

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The Dolomites Genesis Of Upper Sinian In Tarim Basin

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With the development of exploration in tarim basin, the research focus has gradually shifted from shallow to deep. Based on the analysis of outcrop and core in tarim basin, the genesis of dolomites in qigebulak formation is summarized. A set of micrite-crystal powder dolomite is developed in the qigebulak formation and It's widespread. It is proved to be primary dolomite by petrological analysis. Stromatolite-dolomite and granular dolomite are developed locally, but the grain structure is also micrite structure. The geochemistry of the dolomites of the qigebulak formation is consistent with that of the seawater at the same time. Through C-O isotope, Sr isotope, Mg isotope and fluid inclusion analysis, the temperature and fluid properties of the dolomite in the formation period were determined, after the ice age, the temperature of sinian sea water can reach 57°C, which is a high temperature environment, and the fluid is rich in Mg elements.it is found that the isotopic analysis results of dolomite with different grains and structures are not clearly differentiated, indicating that the genesis of dolomite is consistent. Combined with the development of thick micritic dolomites in the qigebulak formation and the lack of metasomatism, It is proved that the dolomites developed in the qigebulak formation are primary dolomites.

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Facies changes, volcanism, and mass extinction conundrum: the Permian-Triassic boundary across the Barents Sea Shelf

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The most dramatic mass extinction the Earth has ever experienced occurred 252 million years ago, at the end of the Permian. It was likely triggered by the volcanic eruptions and magmatic intrusions associated with the Siberian Traps Large Igneous Province (LIP), leading to dramatic climatic changes, with consequences lasting well into the Early Triassic. Here, we present a summary of the findings from the study of several sedimentary successions distributed across the Barents Sea that spanned the End Permian Mass Extinction (EPME) and the Permian-Triassic boundary. The four studied successions included the renowned Festningen section in the outer part of Isfjorden, western Spitsbergen; the DD-1 core and the associated river section in Deltadalen, central Spitsbergen; a core drilled offshore Kvitøya in northern Svalbard, and a core drilled on the Horda Platform in the Barents Sea. Datasets of various research lines were collected from these sections including sedimentology, organic geochemistry, isotope, geochronology, XRF, mineralogy, ichnology, palaeontology, palynology and digital outcrop data.

Historically, the Permian-Triassic boundary exposed today in Svalbard (and at various places across the High Arctic regions) was placed at the very prominent and abrupt facies change occurring between the siliceous mudstones or spiculites of the Kapp Starostin Formation, and the overlying soft, non-siliceous mudstones and siltstones of the Vardebukta and Vikinghøgda formations. The abruptness of this facies change, which also marks the demise of sponges, led to the belief that it represented a hiatus or a gap of several million years, with the uppermost Permian strata missing from the sedimentary record, while the mudstones of the Vardebukta and Vikinghøgda formations were definitely of Lower Triassic age, based on ammonoid biostratigraphy.

Hindeodus parvus, the conodont that defines the base of the Triassic, was for the first time identified in Svalbard a few meters above the lithostratigraphic boundary, which is therefore of Upper Permian age. Additionally, our new data show that sedimentation was continuous across this lithostratigraphic boundary. This transition from the Kapp Starostin Formation to the Vardebukta and Vikinghøgda formations was accompanied by a major reorganisation/inversion of the basin(s), but its exact nature remains puzzling.

Further, all measured sections record the EPME, which is associated with a 6–8 ‰ δ13CVPDB negative excursion, and measured between the lithostratigraphic and the Permian-Triassic boundaries. These negative isotopic excursions are found in close vicinity to several tephra layers that have been precisely dated at 252.13 ± 0.62 Ma, strongly suggesting a connection to the Siberian Traps LIP event. The mass extinction is also confirmed by the very rapid decreasing of trace fossil abundance and diversity, as anoxia spread across the water from proximal and shallow water to deeper settings. Geochemical and ichnological data indicate the occurrence of several anoxic pulses, intersected by very brief episodes of improved oxygenation levels. It took ca. 145 Kyr for life to recover after the extinction event, based on sedimentation rate calculations. Data also suggest that a shift towards more arid climatic conditions and increased eutrophication on land accompanied the EPME.

A quick a robust numerical modelling method to study the propagation of tides in palaeo-seas

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Tidal dynamics in shoreline-shelf systems are dependent on the physiography (geometry and bathymetry) of a basin and its latitude. Researchers can increase their understanding of sedimentary processes in ancient shallow-marine basins, and incorporate potential variations in tidal dynamics in response to an anthropogenically-driven relative sea level change by studying the impact that changes in physiography have on tides.

In order to conduct such an analysis in the epicontinental Upper Jurassic Sundance and Curtis Seas, we developed a workflow that everyone can use to model the propagation of tides in ancient basins, to understand the evolution of tidal dynamics in a basin with respect to change in its physiography, or to test the feasibility of certain geological interpretations.

The numerical simulations of tides are run in the open-source Deltares Delft3D software, and one of the primary input that the software requires is palaeobathymetric data. Since these data might not exist for the study of ancient marine systems, we developed a simple Python code that extracts the colour-value of every pixel in a georeferenced image, before attributing it a depth value depending on how light- or dark-colour the pixel was: the lighter-coloured the pixel is, the shallower the attributed depth is (and vice-versa). Various tidal constituents can then be forced into the system, either at the same time, if the control on the different tidal constituents in the system is robust, or individually in order for example to minimise assumptions. Such a workflow can quickly test if and how tides can propagate in any given ancient seas, which allows for the testing of certain geological interpretation of the rock record.

Our Python-code allows for the very quick generation of multiple palaeobathymetries, by varying the maximum depth attributed to the darkest-coloured pixel of the image, which can then be used to study by proxy the impact of relative sea-level variations on the propagation of tides in ancient seas. The sensitivity of the models can then be tested by varying different input parameters, such as the initial open-ocean tidal forcing, or the bottom drag coefficient values.

Delft3d can notably simulate the tidal amplitude and the flow speed anywhere in the system and at any time, but the distribution of sedimentary facies can be predicted for each of the simulation, using the modelled maximum bed shear stress as a proxy. The map of the predicted distribution of sedimentary facies can then be compared to the real distribution of sedimentary facies in the rock record.

The study of the Upper Jurassic Sundance and Curtis Sea using this simple but robust workflow allowed us to identify the primary control that the physiographic configuration had on the propagation of tides in the system. This workflow also allowed quantifying how tidal dynamics would evolve with respect to change in palaeophysiographic configuration, which has highlighted the importance of considers the effects of palaeophysiographic changes related to relative sea-level variations and their associated impact on tidal dynamics, which will certainly help improving and refining models of tide-dominated basins and their evolution.

Late Abstracts

Main Ethiopian Rift landslides formed in contrasting tectonic and surface settings

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The Main Ethiopian Rift (MER), where active continental rifting creates specific conditions for landslide formation, provides a prospective area to study the influence of tectonics, lithology, geomorphology and climate on landslide formation. A multidisciplinary approach evaluating many natural factors by geostatistical methods is used to provide an interpretation of landslide formation in contrasting geological, geomorphological and climatic settings.

New structural and morphotectonic data from CMER and SMER support a model of progressive change in the regional extension from NW – SE to the recent E – W direction driven by the African and Somalian plates moving apart with the presumed contribution of the NNE(N) – SSW(S) extension controlled by the Arabic Plate. The formation and polyphase reactivation of faults in the changing regional stress-field significantly increase the rocks' tectonic anisotropy and the risk of slope instabilities forming.

Landslides in the central and southern MER occur on steep slopes, almost exclusively formed on active normal fault escarpments. Landslides are also influenced by higher annual precipitation, precipitation seasonality, vegetation density and seasonality.

A detailed study on active rift escarpment in the Arba Minch area revealed similar affinities as in MER. Landslides here are closely associated with steep, mostly faulted, slopes and a higher density of vegetation. Active tectonics and seismicity are the main triggers. The Mejo area situated on the uplifting Ethiopian Plateau 60 km east of the Rift Valley shows that landslide occurrence is strongly influenced by steep erosional slopes and deeply weathered Proterozoic metamorphic basement. Rapid headward erosion, unfavourable lithological conditions and more intense precipitation and higher precipitation seasonality are the main triggers.

Evolution of Krkonoše Piedmont Basin (Czech Republic) in Pennsylvanian – Caenozoic: extension to basin inversion.

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The Krkonoše Piedmont Basin (KPB), a Variscan late- to post-orogenic basin of the northern Bohemian Massif, has continental non-marine red bed fill spanning Westphalian D to Lower Triassic (ca. 305 – 240 Ma). The older parts of the eastern KPB underwent partial deformation during the formation of the Trutnov-Náchod sub-basin (TNSB) in late Rotliegend/late Early Permian – Triassic.

Apatite fission track data yield ages indicating Upper Permian annealing over 120°C of the Palaeozoic rocks, and Middle Triassic partial annealing (over 80°C). An overall burial is suggested deeper than 3 km, assuming thermal gradient of 30°C/km. Burial events (ca 100 – 200 m/Ma) were found in latest Pennsylvanian and Early Permian in the central and western part of the basin. Late Permian and Triassic burial events (overall burial ca 1 km) were identified only in eastern part of the KPB - in TNSB. First burial event is connected with half-graben setting of the basin while the latter burial events followed basin reactivation from extensional to strike-slip regime.

Time-temperature modelling reveals four significant cooling/uplift periods, which are generally moving through time from west to east: (I.) uplift of southwestern and southcentral basin parts in Late Triassic – Middle Jurassic (230 – 190 Ma, ca 20 – 30 m/Ma), (II.) uplift of east and northwest in Jurassic and Cretaceous (190 – 90 Ma, ca 30 – 70 m/Ma), (III.) uplift of south-east, northeast and north-center during the Late Cretaceous – Paleocene (90 – 60 Ma, ca 80 m/Ma), and (IV.) fast uplift in Miocene – Pliocene (20 – 2 Ma, ca 40 – 130 m/Ma) is a common feature for all studied samples.

Fault structures identified across the the KPB form an orthogonal system bearing two orientational maxima: (a) Prevailing dextral strike-slip or oblique-slip thrust faults dipping steeply to NNE or SES and (b) subordinate sinistral, steeply dipping faults showing NNE-SSW trend. This tectonic pattern corresponds to dextral transpression in overall N-S oriented shortening (compression) in the key period of cooling (exhumation).

These results show the importance of polyphase post-orogenic exhumation of Upper-Palaeozoic sedimentary basins, where previous studies have suggested relatively long-term stability. These preliminary data also contribute on timing of the tectonic events, previously interpreted based on indirect evidence only.

New information on the structure of the Osinsky horizon in East Siberia (Lower Cambrian, Russia)

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Reefs at the territory of the Siberian Platform were recorded, for the first time, in the Osinsky Horizon of the Cambrian period. The facies analysis was carried out using core plugs from 10 wells of Rosneft Oil Company, the total meterage of which amounted 720.77 m. Core analysis was conducted in the laboratory of Core Research Center (Tyumen). The Usolskiy horizon of the Tommot-Atdaban stages of the Lower Cambrian in the area of interest is composed of argillaceous-sulphatic-carbonate and salt rocks.

Under conditions of low stand of RSL (relative sea level), the accumulated sediments underwent subaerial diagenesis. Relative sea level increase starts the next stage of sedimentation, formation history of which has several stages on the basis of ecological succession:

Pioneer stage- the development of stromatolite buildups, while tidal brings granular material. Further increase in relative sea level creates accommodative space for the development of first nodular microbial-algal buildups. These buildups are thin (up to 3m) and serve as a source of carbonate clastic material for shallows of various thicknesses. The continuous increase in relative sea level formed a space for the development of dendrolite microbial-algal reefs.

Climax stage- the bacterial-sponge stage.

Stromatolites served as the basis for microbial-algal nodular structures. In elevated areas, dendrolite-like subvertically oriented microbial-algal reefs grow. They include zones of the reef core, marginal reef zone, granular reef plume and intra-reef lagoon.

The reef core is composed of finely branched forms of cyanogen with interskeletal zones filled with radiaxial marine and micrite cements. The microporous skeletons of cyanobacteria are leached first. Thus, a loosely bound, patchy micropore system is formed.

Under low water energy conditions of the intra-reef lagoon, micritic material is actively synthesized by cyanobacteria and is retained between their branches. Gypsum crystals precipitate, which are converted to anhydrite during the diagenesis stage. The only type of voids is lithogenetic fractures filled with anhydrite. In the marginal zone of the reef, thin-branched cyanobacteria are replaced by thick-branched ones. Under conditions of high water energy, large amounts of carbonate granular material are formed and are distributed in the matrix in the form of numerous lenses and pockets. Stylolites filled with clay-organic material are formed at the contacts of tight matrix and loose granular filling in the process of sediment compaction. The stylolites are accompanied by thin short compaction fractures. The connectivity of porous areas is increased by fractures which improves rock permeability.

The reef plume rocks are composed of carbonate granular material with rare interlayers of thick-branched boundstones. Grains are represented by fragments of boundstones, lithoclasts, phytoclasts, and peloids. Primary porous reservoirs keep and multiply the initially high capacity during diagenetic processes. The reef plumes had enough accommodation space for the growth of columnar forms of bacterial-spongy communities. In the wells where reef plumes were penetrated, a significant proportion of bacterial-sponge frameworks with marine fascicular-optical cement is found. In shallower areas with limited accommodation space, the activity of bacteria increases.

At the final climax stage of the reef development, rocks with granular and layered structures prevail.