SOIL GAS MONITORING EXPERIENCE FROM ABOVE UNDERGROUND GAS STORAGE AND A PILOT CO_2 STORAGE, CZECHIA

J. Franců[1], P. Jirman[1], V. Hladík[1]

[1]Czech Geological Survey, Czechia

Introduction

Both oil and gas fields and underground gas storages require periodical check of the trap integrity and occurrence of gas leaks through the caprock. For this purpose soil gas geochemistry was used as a monitoring tool in two contrasting settings. The Zukov gas field, located in NE Czechia, was explored in the 1950[s]. In 2001 it started to work as underground gas storage. The sandstone reservoir of Langhian age is sealed by shales and the thrust plane of the Carpathian Flysch fold-and-thrust belt. Over 50 deep exploration and production boreholes were drilled in the area, some of them have been identified as risky for possible gas leakage. 41 grid points have been measured in the area of interest. The Zar-3 oil & gas field located in SE Czechia is a potential candidate for CO_2 storage pilot (CCS) project in Czechia. The field was discovered in 2001, at present it is in the final production phase. The Zar-3 reservoir of fractured Jurassic dolomites is sealed by Upper Jurassic marls and Eocene siliciclastics as well as by the thrust plane of the Carpathian Flysch belt. 95 grid points were measured 3 times a year. In both Zukov and Zar-3 fields, soil gas monitoring was carried out for more than 2 years to distinguish the natural background and leak anomalies.

The soil gas measurements were performed using the Ecoprobe-5^{TM} portable instrument from 80 cm deep monitoring holes drilled prior to the measurement. The CO_2, CH_4, O_2, and total petroleum (TP) content in soil gas was measured by infrared detectors. The sampling under-pressure was used to estimate the soil permeability. Chromatographic and isotopic analyses complement the field data.

Results

In Zukov area methane leakage is associated with poorly abandoned wells, e.g. with gas migration behind the casing. Typical soil gas pattern consists of a high methane anomaly (10-60%$_{vol}$ CH_4) associated with significant oxygen drop and CO_2 collar surrounding the high methane. The surface diameter of the methane plume around the 1.6 m deeply buried well-tops is in most cases < 10 m. CO_2 is partly from plant roots and partly from microbial oxidation of CH_4 by archea and bacteria. The position of the anomaly is in same cases deviated from the well head by downslope groundwater flow. Observed controls of the absolute CH4 and CO2 content and the areal extent of the anomalies include atmospheric pressure, ground water level, soil wetness / rainfalls and temperature. Specific seasonal periodicity is observed with highs in wet spring and autumn and lows in dry summer and frozen winter. The chemical and isotopic composition of the monitored methane gas is of thermogenic origin related to the gas in small reservoir lenses above the Zukov depleted field while CO_2 ranges from typical plant root origin to microbially oxidized methane.

Low amount of methane was detected in soil gas above the Zar-3 oil & gas field during the baseline monitoring (Fig. 1). The maximum CH_4 value (< 0.48%$_{vol}$) measured in summer 2022 was not confirmed by further measurements nearby nor in different seasons. However, strong soil gas composition variability depending on the season and related vegetation and biological activity was discovered. Permanent CO_2 probes with hourly sampling interval registered considerable seasonal variability with spring increase, the highest values in summer (< 10%$_{vol}$) and autumn decrease. The minimum CO_2 content in soil gas (< 0.5%$_{vol}$) was measured in winter. The land-use represents another crucial factor among the season and biological activity. The grasslands and forests have much stable soil gas composition compared to cultivated crop growing fields. Ploughing the fields increases the permeability and releases the soil gas to the atmosphere (Fig. 1).

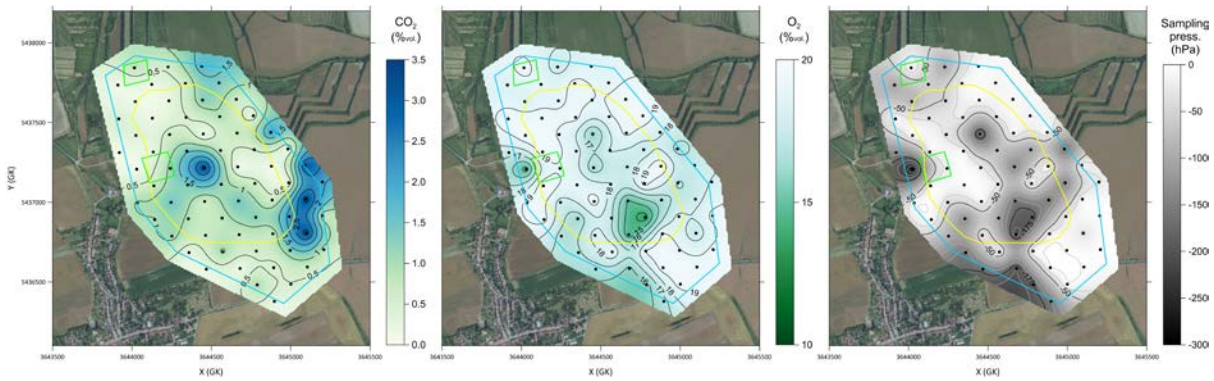

Fig. 1. Contour maps of the average CO_2 and O_2 content (%$_{vol}$) related to the soil permeability based on sampling pressure in spring 2021. The effects of field cultivation are visible in SE part of the Zar-3. Polygons: field protected area, yellow = Zar-3 oil & gas field, green = mining license (drilling platforms).

Conclusions

The results of the monitoring campaigns provide examples of methane and CO_2 anomalies in soil gas. Mapping the data show relationships to the morphology, ground water flow, atmospheric pressure and temperature, soil permeability and mainly precipitations. Rain makes the cracked dry clayey soil less permeable in the upper part of the soil profile. Combination of chemical and isotopic composition of the gas samples shows, that permanent slow methane flux generates microbial colonies oxidizing methane to carbon dioxide with very negative values of $\delta^{13}C$. The measured and interpreted data show examples of settings, where CO_2 from methane is distinguished from CO_2 of plant root origin.

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