Main lessons from the complex study of Mihályi-Répcelak natural CO_2 occurrence

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Abstract

The Middle-Upper Miocene delta sedimentary sequence is widespread in the Pannonian Basin. Previous studies indicated that these sediments are suitable for industrial CO_2 geological storage, up to 10^9 tons. These sediments entrap hydrocarbons overall in the Pannonian Basin. Besides the hydrocarbon reservoirs natural CO_2 occurrences are also known from the delta sedimentary sequence. One of the best studied natural CO_2 reservoir system in the Pannonian Basin is the Mihályi-Répcelak CO_2 occurrence. The Mihályi-Répcelak area lies in western part of the Pannonian Basin. The sedimentation in the area started around 10 million years ago. The CO_2 trapped mainly in the deep basin turbiditic sandstone sediments, where the caprocks are aleurolites (Mészáros et al., 1979).

Exploration of the Mihályi-Répcelak area started in the 30's with geophysical measurements. During the first drilling CO_2 was found. The original gas in place is approximately 25 million t, from which 100-160 kt CO_2 is produced annually.

The origin of CO_2 based on stable isotope analysis in the gas phase was found to be magmatic Cornidez et al. (1985). However, results of Clayton et al. (1990) did not agree with this hypothesis, their results suggested that the origin of CO_2 may be metamorphic. Further studies (e.g., Konz and Etler 1994) could not clearly identify the origin of CO_2, however, showed that the Rába tectonic line acted as a migration pathway for the CO_2. The most recent results of traditional stable isotope analysis and noble gas measurements show that the origin of CO_2 rather magmatic (Palcsu et al., 2014). However, it is assumed that the reaction between the pore fluid and the reservoir rock caused the derogation in the stable isotope ratios (Palcsu et al. 2014).

According to the petrographic characterization, the detrital minerals of the sandstone reservoirs are quartz, metamorphic rock fragments, mica (mainly muscovite), dolomite and feldspar (K-feldspar and plagioclase). During the diagenetic processes ankerite precipitated around the dolomite, calcite and clay (mainly kaolinite) formed cement. The plagioclase transformed into albite. Furthermore, one part of quartz overgrowth may also have formed during the diagenetic processes. The result of natural CO_2 flooding is that carbonate minerals and silicates dissolved in the acidic pore water. Dissolution of carbonate minerals buffered the pore water, for this reason, when the pH increased to around neutral, the carbonate minerals could reprecipitate and dawsonite could crystallized in the system. The Al^{3+} source of dawsonite was either the dissolution of aluminium silicates, whereas the Na^+ originated from albite or from the pore water. The SiO_2 content of the Al-silicates precipitated as the

other part of the quartz overgrowth. The stable isotope composition of carbonate minerals (dawsonite and siderite) was measured.
Detailed study of the Mihályi-Répcelak area showed that some natural CO_2 fields also are present in conglomerate rock. Dawsonite is also present in the conglomerates and is texturally related to clasts composed of kaolinite.
Reservoir caprocks were also studied. The results of caprock analysis showed that dawsonite is present in some caprock samples in many cases only in trace amounts invisible for X-ray diffractometry. A new methodology applying ATR FTIR was developed so that the detection limit of dawsonite decreased to 0.1 m/m%. Later on the dawsonite was identified by SEM in these samples. The diagenetic processes and the mineral composition was similar in the caprocks and in the reservoirs, however, the modal composition is different in the two rock types.
Because the dawsonite is present in many caprocks, it is questionable that the Mihályi-Répcelak area is leak-proof. For this reason, our group not only studied the petrographic characterization of the caprock samples, but also reinterpreted the well-logs. Petrophysical parameters (effective porosity and permeability) were estimated from the self-potential and resistance sections. According to the petrophysical properties of the caprock, the area is safe. The petrophysical properties of the studied caprocks (permeability ~0.026 mD, porosity: ~4 %) are close to that of the Eau Clare Formation (permeability: 0.076–0.001 mD porosity: ~4–5 %), (KunleDare, 2005). Therefore, the lack of CO_2 leakage in the Mihályi-Répcelak area may be due to the multilayer structure of the reservoirs.

References:
Clayton, J.L., Spencer, C.W., Koncz, I. & Szalay, A. 1990. Origin and migration of hydrocarbon gasees and carbon dioxid, Békés Basin, southeastern Hungary. Organic Geochemistry 15, 3, 233-247.
Cornidez I., Takaoka N., Nagao K. & Matsuo S. 1986. Contribution of mantle-derived gases to subsurface gases in a tectonically quiscent area, the Carpathian Basin. Hungary, revealed by noble gas measurements. Geochemical Journal 20, 119-125.
Koncz, I., Etler, O., 1994. Origin of oil and gas occurrences in the Pliocene sediments of the Pannonian Basin. Organic Geochemistry 21, 1069–1080.
KunleDare MA (2005) Petrographic investigation into the development of secondary porosity in sandstones: a case study of the Cambrian Mount Simon and Galesville Sandstones, Illinois Basin. Dissertation, University of Missouri-Rolla
Mészáros L., Dallos E., Vágó L., Czupi J., Paulik D., Darabos A., Marton T., Simán Gy. & Ferenczy Z. 1979. A Mihályi kutatási terület lehetároló fázisú zárójelentése, a szén-dioxid- és a „nem éghető” kevert gáztelepek vagyonszámítása. – Országos Kőolajipari Tröszt, 116.
Palcsu, L., Vető, I., Futó, I., Vodila, G., Papp, L. & Major, Z. 2014. In-reservoir mixing of mantle-derived CO2 and metasedimentary CH4-N2 fluids – noble gas and stable isotope study of two multistacked fields (Pannonian Basin System, W-Hungary), Marine and Petroleum Geology 54, 216-227.