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Isotopic and geochemical modelling study of limestone CO_2 reservoir in the Pannonian Basin

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Subsurface porous media like sandstone and limestone play a key role for geological storage of CO_2. Late Miocene sedimentary rocks of the Pannonian Basin offer significant potential for storing large gas volumes [1], especially sandstones that are well investigated. However, limestone reservoirs had less attention until today. The assumption is that CO_2 dissolves the rock-forming carbonates, which could cause drastic changes in reservoir properties. To deepen our knowledge on the storage potential of the Pannonian Basin, a natural CO_2 occurrence in Hungary was selected, where CO_2 has been trapped safely in limestone reservoir on a geological timescale. Drilling core samples of the reservoir and caprock from 1700-1900 m depth were studied with petrographic and geochemical methods. Microdrilling of the carbonates was carried out to get insight in the carbon and oxygen isotopes of different constituents to reveal possible dissolution/recrystallization processes which may have taken place in the CO_2 reservoir. Geochemical modeling with PHREEQC was also used to simulate possible reactions in the reservoir.

Two types of cement were found in the samples with optical and CL petrography, a blocky, drusy cement and a syntaxial cement on the echinoderms (early cement). Contrary to the assumptions, dissolution features which may be related to CO_2 inflow were not observed in the rocks. The stable C and O isotope data of microfossils shows a narrow range, $\delta^{13}C$ is ranging from -1.55‰ to 2.05‰, $\delta^{18}O$ is between -7.98‰ to -0.25‰, expressed on the V-PDB scale. These data indicate no effect of magmatic CO_2, which may reside in the Ölbő reservoir [2], in agreement with the petrography. Geochemical modelling indicates only minor changes in the reservoir rock: dissolution of albite, calcite and kaolinite; and precipitation of dolomite, dawsonite.

To summarize our results, CO_2 inflow did not affect the Ölbő limestone reservoir, i.e., did not imply significant dissolution, neither was involved in cement precipitation. This limestone could be excellent physical traps for CO_2 with minor mineralization of CO_2, and its utilization in carbon capture and storage projects should be considered.

Reference:
[1] Falus et al (2025), Geol.Soc.Lond. 555, 196
[2] Cseresznyés et al (2021), Chem.Geol. 584, 120536