Geochemical modelling the effect of CO_2 injection on the Szolnok Sandstone Formation, Hungary

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One of our extensive environmental problems is the global climate change and its impact on Earth ecosystems that we can all feel on our own skin. Therefore, mitigation of anthropogenic greenhouse gas, most importantly CO_2, emission is one of the main challenges of humanity. Carbon capture and geological storage is considered to be an efficient technology in eliminating carbon-dioxide at large, stationary carbon-emitting industrial sources. To ensure the long-term stability of the geologically trapped CO_2, behavior of system of the CO_2 reservoir rock – pore water should be predictable on geological timescales.

In Hungary the best candidate for CO_2 storage is the mostly saline aquifer of the Great Hungarian Plain (SE-Hungary), with sandstone reservoir and clayey caprock. The Neogene basin of the Great Hungarian Plain was subsided and then filled by a prograding delta system from NW and NE during the Late Miocene, mostly in the Pannonian time. The most potential storage rock was formed as a fine-grained sandy turbidite interlayered by thin argillaceous beds in the deepest part of the basin. It has relatively high porosity, depth and more than 1000 m thickness. Providing a regional coverage for the sandy turbidite, a 400-500 m thick argillaceous succession was formed in the slope environment of the delta. The composition, thickness and low permeability is expected to make it a suitable, leakage-safe caprock of the storage system (Falus *et al*., 2011).

The major question in the CO_2 geological storage is the geochemical behavior of the potential storage rock – pore water – CO_2 system, hence the processes in the reservoir taking place in geological timescale. For this reasons, to obtain a realistic picture about the geochemical behavior of the potential CO_2 storage system, geochemical models were developed for the reservoir rocks. The PHREEQC 3.0 code (newest version from Parkhurst & Appelo, 2012) was used to derive the equilibrium and kinetic geochemical models applying the internationally accepted *llnl.dat* thermodynamic database, which is based on the data of Lawrence Livermore National Laboratory (USA). The data used in the models are actual, measured pore water compositions and an average mineral composition of the possible reservoir rocks, called Szolnok Sandstone Formation.

To determine the rock composition used in the models, drilling core samples have been collected from the potential reservoir rock in the Great Hungarian Plain. Thereafter thin sections were made to define their modal compositions, pore distributions, pore geometry and grain size. To obtain more accurate modal composition, petrographic observation, SEM analyses, XRD and Thermal Analysis (TA) measurements have also been carried out. The water compositions of the studied depth were known from well-log database. Using the information, acquired from these archive documents, we have constructed input data for geochemical modelling.

The results of the equilibrium model indicate decreasing pH during the dissolution of CO_2 into the pore water. Furthermore show complete dissolution of albite, chlorite and kaolinite and partial dissolution of calcite, K-feldspar and pyrite. In addition precipitation of the following phases also takes place: quartz, muscovite, dolomite, ankerite and as a new phase dawsonite ($NaAlCO_3(OH)_2$) (Fig. 1.). The latter plays a key role in mineral sequestration of CO_2.

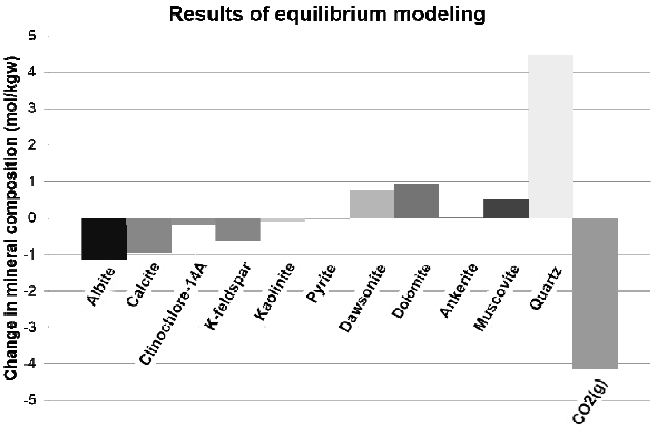

Fig. 1.: Changes in mineral composition of the potential Szolnok Sandstone Formation storage rock as a result of the injected CO_2. For further explanation see the text above.

Furthermore, the kinetic models, which provide a time/rate dimension to the observed reactions, suggest that the dissolution of calcite and precipitation of dolomite and ankerite are rapid reactions considering the time scale of CO_2 storage. Additionally, it can be assumed that the dissolution of albite plays an important role in dawsonite formation, as source of the necessary Na^+ and Al^{3+} content.

Our geochemical models can contribute to better understand the reservoir behaviour in response to future CO_2 injection, therefore more efficiently reduce geology related risks in CO_2 storage.

Parkhurst, D. L., Appelo, C. A. J. (2012): Description of input and examples for PHREEQC version 3—A computer program for speciation, batch-reaction, one-dimensional transport, and inverse geochemical calculations. U.S. Geological Survey Open-File Report, pp. 490.

Falus, Gy., Szamosfalvi, Á., Jencsel, H., Hámor-Vidó, M., Török, K. (2011): Hung Sci, 4: 450-458.