CO_2 Mineral Trapping Opportunities in Western Kazakhstan Sedimentary Basins – A Preliminary Geological Screening Results and Research Directions

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Abstract

Carbon mineral trapping is defined as a phase conversion of the injected CO2 gas into a solid phase via geochemical and/or bio-geochemical mineralization in sedimentary formations. The rate of mineralization is typically slow and occurs on geological timescales (i.e., requires a decadal time slot to start and thousands of years to convert). However, reservoirs containing an abundance of reactive minerals that contain metal ions (Mg^{2+}, Fe^{2+}, and/or Ca^{2+}), such as glaucony facies and fragments of ultramafic rocks/minerals typical for ophiolites (peridotites, serpentinite, dunite, olivine, etc.), are expected to act as geochemical traps of CO2 and precipitate as magnesite, siderite, and calcite, respectively. Both glaucony and ophiolite minerals are rare in sedimentary rock records. Glaucony is restricted since its formation in shallow marine environments requires long periods of a delicate balance between the degree of physical confinement of a particle and the amount of ionic exchange between sediments and seawater, including the availability of iron and potassium. Ultramafic rock fragments are very rare because of the scarcity of exhumed ophiolites throughout the geological history, their fast dissolution kinetics, and mechanical disintegration rates during weathering and sediment transport. The literature review of Western Kazakhstan geology documents the occurrences of glaucony facies in the Albian strata of the Mangyshlak and Pricaspian Basins and the Santonian-Campanian strata of North Tourgay basin, while the Devonian Kempersai Massif (Southern Uraltides) comprised of ophiolites that were likely exhumed since Triassic, served as a sediment source for both the Pricaspian and North Tourgay basins. The abundance of cemented (mostly ironized) trace fossils with up to 53% Fe content (measured by XRF) and carbonate (calcite and siderite) concretions (up to 3 m in diameter) found in well- sorted, very-fine to fine-grained greenish sand with up to 10% of glaucony facies (estimated by stereo- microscope) demonstrates the abundance of metal ions within the formation and their reactivity during and after sedimentation. Our preliminary paleo-drainage maps suggest that Triassic and Jurassic deposits in North Tourgay and Pricaspian should contain ophiolite rock fragments with reactive mineral assemblages. An ongoing multidisciplinary characterization of the reservoir (including the content and composition of reactive minerals as well as pore system characteristics) and formation water (pH, Eh, ionic composition) coupled with batch reaction simulation experiments aims at a better understanding of the present-day CO2 mineral trapping potential within the marine shelf deposits enriched in glaucony (Cretaceous) and fluvial deposits with the inferred presence of ultramafic rock fragments (Triassic-Jurassic). This research helps establish a robust groundwork for investors interested in climate change solutions and contributes to Kazakstan's goals to become net zero by 2050.