Multi-isotopic constraints on the origin of carbonate cements in sandstones: A natural analogue of CO₂ mineral trapping in CCS sites

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Subsurface geological storages are considered as one of the viable mathods to reduce CO_2 emissions. Porous sedimentary rock layers with saline pore water are a prime candidate of CO_2 storages. The injected CO_2 into pore spaces will be dissolved, ionized and eventually precipitated as carbonates. The entire processes of CO_2 trapping need to be monitored to validate the effectiveness of CO_2 emission reduction. The objective of this study was to develop methods that can be used to apportion the amount of injected CO_2 precipitated as carbonate cement in storage layers based on multi-isotopic constraints.

As a possible natural analogue of mineral trapping of injected CO₂, a 1200m core was retrieved from Mesozoic sandstones in southeastern Korean peninsula. Eleven layers from different depths with distinct mineral assemblages and carbonate contents (1.7~22.5%) were sampled for detailed chemical and isotopic analyses. The powdered rock samples were analyzed for carbon and oxygen stable isotopic compositions of carbonate cements. A step-wise dissolution technique was used to extract 'exchangeable', 'carbonate', 'silicate' and 'whole rock' fractions, and Sr (87 Sr)⁸⁶Sr) and Mg (25 Mg/²⁴Mg, 26 Mg/²⁴Mg) isotopic compositions were analyzed for all fractions.

The isotopic data were used to understand the condition of cement formation. (1) The carbon isotopic composition represents mobilization of existing inorganic carbon in pore waters and mineral phases, and carbon inputs via infiltrating meteoric waters. (2) The oxygen isotopic composition indicates that of pore waters during cement formation, which can be significantly modified by the CO₂ injection due to isotopic exchanges associated with H₂O-CO₂ equilibration. (3) Sr and Mg isotopic compositions constrain the weathering and precipitation reactions occuring at the pore spaces, and therefore can be used to quantitatively estimate the proportion of carbon originated from different sources.

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