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Lithium isotope systematics of deep-sourced pore fluids at continental margins

Florian Scholz (1), Christian Hensen (1), Gert J. De Lange (2), Matthias Haeckel (1), Volker Liebrau (1), Anette Meixner (3), Anja Reitz (1), and Rolf L. Romer (3)

(1) IFM-GEOMAR, Biogeochemistry, Kiel, Germany (fscholz@ifm-geomar.de), (2) Department of Earth Sciences, Utrecht University, The Netherlands, (3) Deutsches Geoforschungszentrum GFZ, Germany

In the past two decades, the behavior of lithium (Li) isotopes has been studied in various marine systems, including mid-ocean ridge and sediment-hosted hydrothermal systems, subduction zone settings and normal coastal and deep-sea sediments recovered by the Ocean Drilling Program (ODP). Major processes identified to cause deviations from the seawater isotopic composition are adsorption/desorption reactions, formation and transformation of silicate minerals, and leaching of Li from sediments or underlying crust at high temperature. As a result of the accomplished work, Li isotopes are considered a promising tracer for the diagenetic evolution and provenance of pore fluids in overpressured sedimentary environments.

Here, we present Li concentration and isotope data of 18 cold seep locations and reference fluids from shallow marine sediments, a sediment-hosted hydrothermal system and two Mediterranean brine basins. The new reference data and literature data of hydrothermal fluids and pore fluids from the ODP follow an empirical relationship reflecting increasing Li release and decreasing isotope fractionation during clay mineral authigenesis with increasing temperature. Lithium concentration and isotope data of cold seep fluids are mostly in agreement with this empirical relationship. Ubiquitous diagenetic signals of clay dehydration in all cold seep fluids indicate that authigenic smectite-illite is an important sink for light pore water Li in deeply buried continental margin sediments. Deviations from the general relationship are attributed to the varying proportion of weatherable (e.g. volcanogenic) components and to transport-related fractionation trends. A simple transport-reaction model was applied to simulate Li isotope fractionation during upwelling of pore fluids to the seafloor. It is demonstrated that slow pore water advection (order of mm a^{-1}) suffices to convey much of the deep-seated diagenetic Li signal into shallow sediments. If carefully applied, Li isotope systematics may, thus, provide a valuable record of fluid/mineral interaction that has been inherited several hundreds or thousands of meters below the seafloor.