Tracking geothermal reservoir stimulation by Li isotope fractionation

C. WANNER*, E. L. SONNENTHAL, S. NAKAGAWA, S. T. BROWN, J. N. CHRISTENSEN, J. P. ICENHOWER AND S. NAKASHIMA

Lawrence Berkeley National Laboratory, Berkeley CA, USA (*correspondence: cwanner@lbl.gov)

Enhanced geothermal systems (EGS) do not have to rely on naturally occurring hydrothermal convection and are therefore promising for new geothermal power production. It is based on hydraulic/thermal reservoir stimulation increasing permeability and enhancing fluid flow and heat extraction. Because hydraulic stimulation can create fresh and more reactive mineral surfaces, geochemical proxies can be used to assess the efficiency of geothermal reservoir stimulation. A promising tool for tracking such increased water-rock interaction are Li isotopes. Owing to their large mass difference, the two stable Li isotopes (^{6}Li, ^{7}Li) significantly fractionate when primary silicate minerals are altered and secondary minerals are formed. Even at temperatures relevant to EGS ($\approx$250°C) reported Li isotope fractionation is on the order of 1.6‰ [1].

We present a novel reactive transport modeling approach that was used to simulate a column experiment performed at 260°C for the goal of evaluating potential chemical changes during EGS development. Li isotope fractionation was explicitly simulated during secondary mineral precipitation (e.g., chlorite) using a solid solution approach with 3 different endmembers: (i) a pure, non-Li-bearing secondary mineral endmember with known thermodynamic properties, (ii) a pure ^{6}Li-bearing mineral endmember and (iii) a pure ^{7}Li-bearing mineral endmember. The pure ^{6}Li and ^{7}Li endmembers are entirely hypothetical, but their specification allowed fitting Li concentrations and δ^{7}Li values observed at the column outlet by calibrating the corresponding log(K) values.

Simulation results show that the δ^{7}Li value observed at the column outlet is not only dependent on the Li isotope fractionation factor (i.e., temperature) but also on the amount of Li-bearing secondary minerals formed along the column. This finding is important because it shows that at higher temperatures, large amounts of secondary mineral precipitation results in observable fractionation even though fractionation effects become smaller. Moreover, it shows that in EGS systems the degree of Li isotope fractionation is also strongly dependent on the reservoir mineralogy.

[1] Vigier *et al* (2008) *GCA* **72**, 780-792.