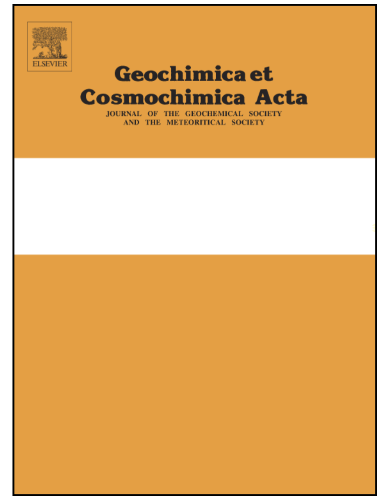

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Multiple stable isotope fronts during non-isothermal fluid flow

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Abstract

Stable isotope signatures of oxygen, hydrogen and other elements in minerals from hydrothermal veins and metasomatized host rocks are widely used to investigate fluid sources and paths. Previous theoretical studies mostly focused on analyzing stable isotope fronts developing during single-phase, isothermal fluid flow. In this study, numerical simulations were performed to assess how temperature changes, transport phenomena, kinetic vs. equilibrium isotope exchange, and isotopic source signals determine mineral oxygen isotopic compositions during fluid-rock interaction. The simulations focus on one-dimensional scenarios, with non-isothermal single- and two-phase fluid flow, and include the effects of quartz precipitation and dissolution.

If isotope exchange between fluid and mineral is fast, a previously unrecognized, significant enrichment in heavy oxygen isotopes of fluids and minerals occurs at the thermal front. The maximum enrichment depends on the initial isotopic composition of fluid and mineral, the fluid-rock ratio and the maximum change in temperature, but is independent of the isotopic composition of the incoming fluid. This thermally induced isotope front propagates faster than the signal related to the initial isotopic composition of the incoming fluid, which forms a trailing front behind the zone of