Transient Transport of Isotopic Tracers in Reactive Fluid-Rock Systems

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ABSTRACT: The isotopic compositions of fluids in natural subsurface systems are useful for characterizing flow paths, transport rates by diffusion and advection, and the rates of fluid–solid chemical exchange. More specifically, isotopic tracer data provide important information on fracture-matrix (FM) interaction, and are being heavily investigated at present in applications such as the enhanced geothermal systems (EGS) for possible estimation of FM interface area and detection of new flow paths. Isotopic effects in such evolving fluid-rock systems are different from conventional systems, largely due to the difference in geochemical transport modes between the fluids flowing in the existing and newly-created fractures and the fluids trapped in the rock matrix separating the fractures. This paper presents a mathematical model that describes the transient isotopic shifts of commonly measured elements with natural isotopic variations in fluids moving through and reacting with fractured porous rock. The objective is to better understand fluid and rock isotopic evolution in reactive fluid–rock systems, and to evaluate the relationships between isotopic effects, fluid–rock reaction rates, fracture spacing, and FM interface area.