2D Reactive transport models of mid-ocean ridge hydrothermal systems

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Water-rock interaction in mid-ocean ridge hydrothermal systems includes extensive geochemical exchange between oceanic crust and seawater that affects the chemistry of the oceans, and through subduction of oceanic crust, the chemical evolution of Earth's mantle. Insights into these systems have come from extensive study of vent fluid chemistry, heat and mass balance constraints, altered seafloor rocks, and laboratory experiments. Questions remain about the temporal evolution and spatial structure of the modern systems, as well as effects of different spreading rates and seawater chemistry through Earth history. To get additional insight we are using the TOUGHREACT code, which simulates heat transfer, fluid flow, advective-diffusive transport, and mineral-fluid reactions simultaneouly, with a dual-permeability model to represent fractured rock. We have started with 2D static (no seafloor spreading) simulations of the near-axis region where most of the high temperature chemical exchange occurs. Calculations involve 17 chemical components, 20 mineral phases, and also track Sr isotope exchange. Measured vent fluid Ca, Mg, SO_4, Na, Sr, Sr isotopes, and previous estimates of mineral reaction rates and fluid fluxes, are used as constraints on the models. Mineralogy, fracture and matrix permeability, and fracture spacing can be varied. Thermal convection is driven by a heat flux applied at the bottom of the domain to simulate a shallow axial magma chamber about 200-300m below. Initial simulations reproduce many aspects of modern vent fluid chemistry and Sr isotopes with maximum $T < 400°C$. Fluids are not in equilibrium with the rocks anywhere in the model system, and a fraction of the upflow fluids recirculate in narrow zones near the axis. Chemical and isotopic effects generated using different seawater compositions, as proposed for the Cretaceous for example, are substantial and different from modern systems (cf. Antonelli et al., *PNAS*, 2017). The model can also be applied to lower temperature off-axis circulation and hydrothermal systems in ancient oceans that may have had more extreme chemistry and/or temperature differences.