Integrating reactive transport with thermal-hydrological flow on the eastern flank of the Juan de Fuca Ridge

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Coupled flows of fluid, heat, and solutes on the flanks of mid-ocean ridges are important to a wide range of global processes, including the cycling of carbon and nutrients, which supports a vast crustal biosphere. Only a few ridge-flank sites have been studied in detail; hydrogeologic conditions and processes in the volcanic crust are best understood on the eastern flank of the Juan de Fuca Ridge. We are combining 3-D coupled (thermal-hydrological) models of crustal-scale circulation with results from the first hole-to-hole tracer transport experiment in the ocean crust. Modeling this system requires a wide range of temporal and spatial scales to assure solution stability while incorporating solute transport between boreholes. Tracer injection and extraction occurs across a length scale of kilometers; solute transport occurs at the pore scale, while the effective porosity of the rock system appears to be very low. Simulation of tracer behavior provides insight into the configuration and scaling required to model interdisciplinary reactive transport processes, such as nutrient delivery and microbial community evolution as a function of fluid flow, and potential influence of CO_2 injection as part of a sequestration program in the upper crust. Utilizing the wealth of data collected during decades of drilling, submersible, observatory, and survey expeditions and experiments from this area, we are developing the first generation of reactive transport models for this ridge-flank setting.