Permeability control on sub-seafloor phase separation, venting temperature and salinity in MOR hydrothermal systems

THOMAS DRIESNER[1] AND DIM COUMOU[2]

[1]Isotope Geochemistry and Mineral Resources, ETH Zurich, Switzerland (thomas.driesner@erdw.ethz.ch)
[2]Potsdam Institute for Climate Impact Research, Potsdam, Germany (coumou@pik-potsdam.de)

In a recent simulation study [1], we demonstrated that venting temperature, salinity and their temporal fluctuations mainly depend on water depth. Here we report the effect of crustal bulk permeability, *k*, on these parameters. Numerical simulations of transient fluid flow were performed for simplified across-axis MOR sections with an axial magma chamber at 1 km depth. We use accurate, realistic fluid properties including the full phase diagram of H_2O-NaCl and allow two-phase flow, salt precipitation etc. to evolve transiently during simulation. The axial magma chamber is mimicked by a Gaussian heat flux profile, equivalent to 100 to 200 MW heat input per km of ridge length.

For simulations with the seafloor at 2500 m depth, sub-seafloor phase separation and related sub-seawater salinities in vent fluid only occur when *k* is less than ~5x10^{-14} m^2. Salinities of 0.5 times seawater occur at ~5x10^{-15} m^2, and decrease to 0.05 times seawater at ~1x10^{-16} m^2.

Venting temperatures in excess of 300°C only occur in a *k* window between ~2x10^{-16} m^2 and ~3x10^{-14} m^2. At lower *k*, the increasing importance of conductive heat transfer leads to lower temperatures. At higher *k*, the flux of seawater through the hydrothermal convection cell is too high to allow for stronger heating (and, hence, significant phase separation) and rather leads to venting of low-temperature fluids of seawater salinity (e.g. ~110°C at a bulk permeability of ~1x10^{-12}). For *k* less than ~1x10^{-14} m^2, temperatures at the bottom are in excess of the MORB solidus, probably indicating that magma extrusion or diking is required in addition to hydrothermal activity to accommodate the heat flux into a mid-ocean ridge.

We conclude that 'typical' vent temperatures and salinities require axial crust to have a bulk *k* of no more than ~3x10^{-14}, substantially less than current "best estimates" [2] but very similar to continental hydrothermal systems [3].

[1] D. Coumou *et al*. (in press) *JGR*. [2] Lowell & Gemanovich (2004) *Geophysical Monograph* **148**, 219-244. [3] Hayba & Ingebritsen (1997) *JGR* **102**, B6,12235-12252

Isotopic signatures for key mineralogical reactions accompanying biostimulated uranium reduction

JENNIFER L. DRUHAN[1], MARK E. CONRAD[2], KENNETH H. WILLIAMS[2], ERIC L. SONNENTHAL[2] AND DONALD J. DEPAOLO[1,2]

[1]University of California Berkeley, Berkeley, CA 94720, USA (*correspondence: jennydruhan@berkeley.edu)
[2]Lawrence Berkeley National Laboratory, Berkeley, CA, 94720, USA

This research focuses on identification of isotopic systems useful in tracing contaminant attenuation due to stimulated subsurface bioremediation, and incorporation of these isotopes into reactive transport models. The isotopic signature associated with a fractionating reaction is preserved in both the residual reactant and product species, providing a means of detecting principal contaminant sequestration processes as well as monitoring the long-term stability of key precipitates. Acetate amendment experiments at the Integrated Field Scale Subsurface Research Challenge Site (IRFC) at Rifle, Colorado, USA have succesfully demonstrated sequestration of aqueous uranium. Removal rates are highest during iron oxide reduction and decline with the onset of sulfate reduction. Analysis of samples collected during these amendments shows sulfur isotopes to be a sensitive indicator of the onset of sulfate reduction and the transition to and from sulfate-limiting conditions. There is enrichment of up to 7‰ in $\delta^{34}S$ of sulfate and a corresponding sulfide $\delta^{34}S$ of -20‰ in down-gradient monitoring wells, followed by a transition to smaller fractionation factors as sulfate becomes less available. Preliminary $\delta^{44}Ca$ data show no variation due to calcite precipitation, probably because the effect is masked by ion exchange.

Sulfur isotope data from the Rifle site are not adequately described by mass balance considerations, suggesting these data incorporate information about the reactive transport processes of the system. Using the TOUGHREACT numerical simulation program, isotopes are modeled in this system by modifying the thermodynamic parameters of individual isotopic species for specific reaction pathways, including both biotic and abiotic processes, thus allowing associated fractionation factors for each process to be incorporated into the model. This approach allows us to test the influence of individual processes on the overall isotopic composition, and track flowpath evolution through the isotopic signatures of precipitate species.