Modeling biogeochemisty in an Early Ocean Analogue

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In the 590 m deep Lake Matano, Indonesia, a persistent pycnocline at 100 m depth separates the oxic epilimnion from anoxic deep waters. The resulting redox gradient drives the biogeochemical cycling of iron, manganese, methane, and other elements, producing vertical distributions that are remarkably close to being at steady state. Given the low sulfate concentrations, this lake is an excellent modern analogue of the sulfate-poor oceans of the early Earth and is therefore useful for characterizing anaerobic reactions that dominated these oceans. To quantify the rates of these reactions and vertical elemental fluxes, a geochemical model needs to be coupled to a model of physical mixing. Our previous work [1] has shown that a 1-dimensional mixing model may be insufficient. We therefore combine 3D and 1D hydrodynamic models with a geochemical reaction-diffusion model, which we use to characterize the biogeochemical transformations within the redox gradient. In particular, we test the possibility, suggested by the C isotope data and microbial ecology, that anaerobic oxidation of methane takes place in the absence of sulfate.

[1] Crowe *et al.* (2008) *Limnol. Oceanogr.* **53**, 319-331.

Mantle heterogeneity and crustal production in magma-dynamics simulations of mid-ocean ridges

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Simulations of coupled magma/mantle flow and thermal structure have great promise as a tool for connecting surface observations of lava flux, chemistry and chemical heterogeneity with physical processes of melt transport at depth. I report on progress in solving the 2D equations of magma dynamics (McKenzie 1984) coupled with two-component equilibrium thermo-chemistry via the Enthalpy Method (e.g. Alexiades & Solomon 1993). The simulations are configured to model a mid-ocean ridge. I have investigated the relationship between mantle material properties (permeability and rheology) and the efficiency of melt focusing and crustal production. The models predict the distance over which magma is focused to the ridge (Sparks & Parmentier 1991) and quantify the variation of focusing distance with key material parameters. Melting of a chemically heterogeneous mantle is also considered, with particular attention to the effect of variations in mantle fertility.