Ge/Si fractionation by higher plants: mechanisms and applications to biogeochemical cycles

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In the near surface environment, silica is under both mineralogical and biological control. In order to better understand the sources and cycling of silica in the critical zone we use the ratio of germanium to silicon as a tracer. Uptake by higher plants discriminates against Ge, and plant phytoliths have low Ge/Si ratios. We find consistently low Ge/Si ratios (< 0.5 μmol/mol) in biogenic silica separated from a wide variety of plant groups, including grasses, deciduous and coniferous trees, and ferns. The apparently ubiquitous occurrence of strong discrimination against Ge during uptake of silica from soil solution suggests a fundamental mechanisms common to many higher plants. Preliminary SIMS data suggest that control on Ge and Si uptake is exerted along the Casparian strip in the roots of higher plants. These data are consistent with a proposed Si transport mechanism involving aquaporin family proteins across the Casparian strip (Ma *et al.*, 2005). These proteins are known to control transport of small neutral molecules such as glycerol and water, and conformational effects could account for Ge-Si fractionation. The low Ge/Si of biogenic silica can be used to show that labile silica in shallow soils is dominated by biogenic sources. Ge/Si data from tropical sites indicate rapid and extensive cycling of silica through biomass. We find that Si is also strongly cycled seasonally in a NE USA sugar maple forest, with strong net uptake in spring and early summer coupled to transpiration, and release from litter during snowmelt season. Mass balance calculations suggest that a substantial fraction of "labile" Si in forested watersheds in tropical and temperate systems passes through the plant pool prior to export in stream water.

The mode of mantle convection: Exploring the model space and comparing with probabilistic tomography

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A growing number of seismological observations indicate that strong compositional variations are present in the Earth's mantle. Meanwhile, considerable progresses in numerical modelling of convection have been achieved in the past decade. These include thermo-chemical convection, compressibility, and spherical geometry. Still, the mode of convection of the Earth's mantle is not well constrained. Important efforts have been made to estimate values of the controlling parameters for the Earth's mantle by testing various models against available seismological information. Linking convection models and seismological data is a delicate step that requires careful modelling of the thermo-chemical properties of the mantle aggregate. Statistical approaches, which account for all reported sources of uncertainties in thermo-chemical data and modelling, provide the possible ranges of thermo-chemical structure predicted by seismology. Here, we explore the model space of thermo-chemical convection. We run new 3D models of thermo-chemical convection (Figure 1) in which we vary important parameters and properties, including the buoyancy ratio and the volume of dense material, the mode of heating, the spherical geometry, and the presence of a phase transition at the bottom of the fluid. We then test snapshots of these models at different time against existing models of probabilistic tomography (Figure 2).

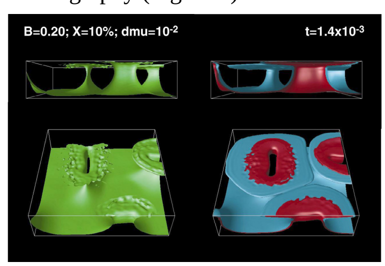

Figure 1. An example of thermo-chemical convection model. Isosurfaces represent the fraction of dense particles (green C=0.5) and the non-dimensional temperature (red and blue, contour levels T=0.0375 and T=0.0375, respectively).

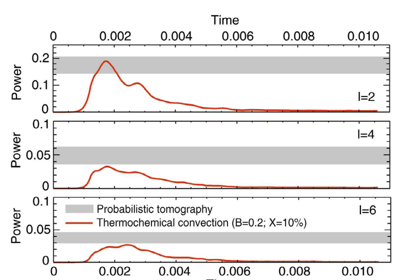

Figure 2. Comparison between spherical harmonic degrees 2, 4 and 6 of chemical density anomalies at the bottom of the mantle (2000<z<2891 km) predicted by thermo-chemical convection. (B=0.2, X=10%) and probabilistic tomography as a function of time.