Simulating partial melting and chemical fractionation in mantle dynamics models

SYLVAINE FERRACHAT[1] AND LOUISE H. KELLOGG[2]

[1]University of California Davis, Geology Dept, Davis CA USA (ferrachat@geology.ucdavis.edu)
[2]University of California Davis, Geology Dept, Davis CA USA (kellogg@geology.ucdavis.edu)

Neither geophysical observations on mantle dynamics, nor geochemical measurements on basalt are able to constrain by themselves the long-term evolution of the Earth's mantle. However, combining both approaches is promising to restrain the set of possible mantle dynamics models, and to get a better understanding of mantle mixing. Here, we present the results of numerical mantle convection studies incorporating partial melting and chemical fractionation at ridges. We use the 2D-cartesian convective code ConMan (King et al 90) to carry out the calculations. We advect passive tracers with assigned chemical concentrations in U, Th, He, Pb and K. Partial melting at ridges is controlled by the local temperature and the mean previous degree of partial melting encountered by matter at a local scale (with a resolution of about 25 km). Reversely, latent heat consumption due to partial melting has a feedback on the temperature and velocity fields. The subsequent chemical fractionation yields a thin, highly degassed and enriched in incompatible elements oceanic crust, and a thicker residual lithospheric mantle. This process has a non-negligible impact on the global mixing properties in the system, since it generates an heterogeneous chemical distribution between crust and lithosphere, while smoothing the melt product relative to the source. In this presentation, we will focus on the effects of the petrologic parameters (such as the bulk partition coefficients) on the resulting long-term chemical evolution of the system. What are the chemical implications of some candidate models for the Earth's mantle dynamics (Hot Abyssal Layer (Kellogg et al 99), D'' crust trapping (Christensen and Hofmann 94))?

References

U. Christensen and A. W. Hofmann, (1994), *JGR* **99,** 19,867-19,884.

L. H. Kellogg, B. H. Hager and R. D. van der Hilst, (1999), *Science* **283**, 1881-1884.

S. D. King, A. Raefsky and G. H. Hager, (1990), *PEPI* **59**, 195-207.

Melt/Biotite $^{11}B/^{10}B$ Isotopic Fractionation And The Boron Local Environment In The Structure Of Volcanic Glasses

G. FERRARA[1], C. FORTE[2], R. PETRINI[3], F. SLEJKO[3] AND S. TONARINI[1]

[1]Istituto Geoscienze e Georisorse, CNR, Pisa, Italy (g.ferrara@igg.cnr.it)
[2]Istituto Processi Chimico-Fisici, CNR,Pisa, Italy
[3]Dip. Scienze Terra, Trieste University, Italy

$^{11}B/^{10}B$ isotopic compositions were determined on biotite and glass from three evolved volcanic rocks belonging to the Neogene-Quaternary magmatism of Central Italy. ^{11}B MAS NMR spectra were also performed on the same glasses. In these samples the measured boron biotite-glass partition coefficient ranges between 0.004 and 0.011 indicating that boron behaves as an incompatible element during biotite crystallization. The ^{11}B MAS NMR spectra reveal the presence of trigonal $BO_{3/2}$ units, tetrahedral $BO_{4/2}^-$ sites and three-coordinated $BO_{2/2}O^-$ species containing one non-bridging oxygen. The $^{11}B/^{10}B$ isotopic fractionation between biotite and melt/glass was observed to be large even at magmatic temperatures and was found to be between 1.0066 and 1.00279. The measured α values are significantly higher than those calculated using the Reduced Partition Function Ratio (RPFR) values for $B(OH)_3$ and $B(OH)_4^-$ as well as the abundance of trigonal and tetrahedral boron obtained by ^{11}B NMR spectra. Furthermore, a non-linear relationship is observed between the $\%BO_4$ in the glass structure and the measured $1000\ln\alpha$ suggesting that the approximation of monomeric $B(OH)_3$ and $B(OH)_4^-$ species contribution through ideal mixing in calculating the RPFR in polyanions probably does not apply to silicate glasses.