On the thermal and dynamic requirements for mantle melting

M. TIRONE* AND J. GANGULY

Department of Geosciences, Univ. of Arizona, Tucson, 85721 AZ, USA (*correspondence: max.tirone@gmail.com)

Our understanding of the petrological geodynamics of the Earth's mantle can be improved by numerical simulations supported by a comparison of the results with observable quantitites. Melting in the upper mantle is the end-product of dynamic and petrological processes. The description of these processes is usually based on several simplifying assumptions. However, a more realistic approach should consider the complex interplay among the petrological and dynamical aspects. Here we present a multistage numerical procedure to characterize the thermal and dynamic conditions of the mantle that ultimately control the melting process as a function of time and space during mantle upwelling. (1): A parameterized mantle convection model is used in conjuction with a thermodynamic approach and an optimized mineralogically dependent viscosity model to determine the thermal structure of the mantle from top to bottom using several constraints such as the melting temperature requirement to generate komatite magmatism in the Archean and plume melting in more recent time. (2): The viscosity and the thermodynamic models and the thermal state at the CMB from the thermal history study are then applied to model the geodynamic evolution of a thermal plume. (3): The thermal and dynamic evolution at shallow depth (but below the mantle solidus) is then used to constrain the melting process which is investigated using a coupled two-phase flow model and a thermodynamic formulation for melt that is modified from pMELTS.

The whole procedure illustrates the interconnection among a wide range of factors, such as thermal history, CMB temperature, mantle viscosity, thermal structure of plumes, evolution and composition of melt.

Here stage (3) is applied to the case of melting under a moving plate (e.g. Hawaii) which is discussed in some details. In particular it is shown how the thermal and dynamic interaction of the plume with the lithosphere affects the melt distribution and composition and how it is related to the various stages of magma emplacement. A source component of melt detected by the model is clearly provided by the lithospheric mantle. Pyroxenite cumulates are obtained by partial crystallization of underplated melt. Bathymetry appears to be correlated with the thermal erosion of the lithosphere.

Influence of glass composition on Si and Ca isotope measurements by SIMS

L. TISSANDIER*, C. ROLLION-BARD AND G. CARO

CRPG/CNRS, BP 20, 54501, Nancy, France (*correspondence: tix@crpg.cnrs-nancy.fr)

Isotopic data obtained by *in situ* mass-spectrometry are affected by instrumental mass fractionation effects related to the nature of the sample. This 'matrix effect' can cause large deviations from the real value and needs to be accurately evaluated in order to obtain precise stable isotope ratios. To constrain these matrix effects, we measured Ca and Si isotopes in a series of silicate glass standards spanning a wide compositional range ($7 < SiO_2 < 72$; $0 < Al_2O_3 < 56$; $0 < CaO < 50$; $0 < MgO < 32$; in wt%). Measurements were performed on a CAMECA IMS1270 at the CRPG/CNRS, Nancy France. We used a multicollection mode, and the different isotopes were measured on Faraday cups. Regardless of the composition of the glass, internal precision was better than 0.1‰, and external reproducibility ranges between 0.15 and 0.35‰ (2σ). The isotopic compositions of Ca and Si in these samples were also measured by TIMS and ICPMS, respectively.

In these different standard glasses, Ca and Si isotopic signatures show a clear compositional dependence. To a first order, instrumental mass fractionation is controlled by the silica content of the glass. However, smaller effects can also be observed for samples with identical silica content, e.g. when substituting Ca for Mg. These results show that the degree of polymerization of the glass is the key parameter for understanding these matrix effects, but it has to be completed by other factors considering the nature of the different constituing elements. Based on these results, we derived a new empirical law, linking compositional parameters to the degree of polymerization of the glass and instrumental fractionation. In Fe-free compositions, instrumental mass fractionation, spanning more than 20‰ in $\delta^{30}Si$ and $\delta^{44}Ca$, can be accurately corrected using this method. After correction, the dispersion of the results is less than 1‰ around the mean value, and this correction is much more successful than other proxies previously used (SiO_2 content, NBO/T,...). Correcting instrumental fractionation effects in glasses containing Fe is more complex since this element can occur in several oxidation states in glasses.