European Mineralogical Conference
Vol. 1, EMC2012-491, 2012
European Mineralogical Conference 2012

Towards a thermodynamic modelling of partial melting in the Earth's mantle in presence of CO_2 and other volatiles.

M. Massuyeau (1), F. Gaillard (1), Y. Morizet (2), and B. Scaillet (1)

(1) Université d'Orléans, CNRS/INSU, ISTO, UMR 7327, Orléans, France, (2) Université de Nantes, LPGN, UMR 6112, Nantes, France

Carbon and others volatiles, that are present in the Earth's mantle at ppm concentration levels, induce partial melting. A large experimental database describes equilibrium compositions of minerals and melts in function of P-T conditions. In general, low melt fractions are dominated by carbonate-rich compositions, whereas with increasing melt fractions, the melts evolve towards basaltic compositions. However, the transition between carbonate-dominated and silicate-dominated melts is complex, generally continuous, but is also showing immiscibility under specific conditions. The multiplicity of reported behaviour within this carbonate-silicate transition may indicate a lack of internal consistency of the database.

The aim of this study is to perform a thermodynamic analysis of this complex transition by considering liquid-liquid and crystal-liquid equilibria. Such quantitative approach will constitute a test of the internal consistency of the existing database and will permit the construction of a predictive model defining melt composition as a function of P and T.

We performed experiments in simplified systems to better understand the influence of chemical composition on this immiscibility at 3 GPa & 1300-1400°C. We clarified the effect of K-Na and of Ca-Mg substitutions on the size of the miscibility gap. Specific experiments were performed on more complex compositions, some giving first insights with respect to the presence of additional volatiles in the melts : water, sulphur. We used published experiments and our new constraints on liquid-liquid equilibria to define the mixing properties of multicomponent carbonate-silicate liquids.

Defining by the activity of the component SiO_2 liquid constitutes a critical thermodynamic step for modelling the carbonate-silicate transition. Coexistence of forsterite and enstatite buffers SiO_2 activity following the univariant relation:

Mg2SiO4 + SiO_2 = Mg2Si2O6

Using this equilibrium, we have calculated SiO_2 activity of existing experimental data (2-10 GPa, 1100-1600°C) in melt with compositions encompassing the transition from carbonate to silicate melts. We observed a strong non-ideality, which can be anticipated by the occurrence of immiscibility between carbonate and silicate liquids. We will present a parametrization of the mixing properties (γSiO_2) allowing the complex activity-composition relationships for SiO_2 to be accounted for.

This thermodynamic study, calibrated by experimental data, will permit to model the role of volatiles on mantle partial melting. In particular, we intend to define the nature and composition of melt as a function of P and T relevant to various geodynamics settings.