



## **A multi-component model for partial melting in presence of CO<sub>2</sub> and other volatiles in the mantle.**

Malcolm Massuyeau (1), Yann Morizet (2), and Fabrice Gaillard (1)

(1) ISTO, UMR 7327 CNRS-Université d'Orléans, 1a rue de la Ferrollerie, 45071 Orléans, France, (2) Université de Nantes, Nantes Atlantique Universités, Laboratoire de Planétologie et Géodynamique de Nantes (LPGN), UMR CNRS 6112, 2 rue de la Houssinière, 44322 Nantes, France

The link between volatiles and mantle melting has so far been illuminated by experiments revealing punctually, at a given P-T condition and under a specific chemical system, properties such as solubility laws, redox equilibria, and phase equilibria. The aim we are pursuing here is to establish a multi-component model describing the Gibbs free energy of melt produced by mantle melting in presence of CO<sub>2</sub>-H<sub>2</sub>O: Carbonatite-carbonated melt and basalts.

The generated low melt fractions are often dominated by carbonate-rich compositions, whereas with increasing temperature, the melts evolve towards basaltic compositions. However, the transition between carbonate-dominated and silicate-dominated melts is complex and poorly constrained: it is characterized by a continuous evolution between a carbonated melt and a silicated melt, or show, under specific conditions, immiscibility between these two types of liquids. Several studies emphasize the role of alkalis in the immiscibility between a carbonate-dominated melt and a silicate-dominated melt. Consequently, we performed experiments in simplified systems to better understand the influence of each (K and Na) on this immiscibility. In addition, specific experiments on more complex compositions have been performed, in order to give first insights on the role of various volatiles present in the melts: water, chlorine.

From a thermodynamic point of view, the carbonate-silicate transition is defined by the activity of the component SiO<sub>2</sub> in the liquid and is calculated from experimental data (2-10 GPa, 1100-1600°C) using crystal-liquid and liquid-liquid equilibria. This silicate-carbonate immiscibility constitutes a powerful tool defining the mixing properties of the liquid. The miscibility gap defines equilibrium melts with different compositions, but the melt components are characterized by similar activities. This can be inverted to derive activity-composition relationships that are strictly independent of standard state properties. We will present a parameterization of the mixing properties allowing the complex activity-composition relationships for multi-component carbonated melts to be accounted for.

Graphite-liquid and fluid-liquid data allow, for the first time, to constrain the standard state properties of CO<sub>2</sub> dissolved in liquid, and its activity.

Activity-composition relationships for CO<sub>2</sub> are strongly non-ideal in carbonated melts, but the presence of water apparently tends to minimize this non-ideality. We suggest that water may have a role on the redox stability of C relative to CO<sub>3</sub><sup>2-</sup>, and consequently on the distribution of graphite/diamond vs. carbonate species and on the onset of melting in C-O-H-bearing mantle.

We propose several applications allowing the composition of incipient melts to be calculated as a function of depth underneath Mid-Ocean-Ridges and underneath Hot-Spots.

In the oceanic mantle, the top of the Lithosphere-Asthenosphere boundary is identified by seismic data as a discontinuity at an average depth of 65 km. This observation correlates with the onset of peridotite melting in presence of both H<sub>2</sub>O and CO<sub>2</sub>. Therefore, partial melting must occur at 65 km, implying production of H<sub>2</sub>O-rich carbonatitic melts as shown by our present model, and which are to the origin of the weakening.

This thermodynamic study, supported by experimental investigation, constitutes an essential step in modeling the distribution and fate of volatiles, especially carbon, in the Earth's mantle.