

Melting phase relations in anhydrous primitive mantle composition at 10 GPa

L. ARMSTRONG, S. KESHAV, A. CORGNE

Geophysical Laboratory, Carnegie Institution of Washington, USA

Numerical simulations show that the energy released by impacts during our planet's violent accretion would have been enough to melt much or all of the Earth, resulting in a global magma ocean. Subsequent cooling of this putative magma ocean from the bottom up could have led to stratification of the primitive mantle by crystal fractionation. Knowledge of the pressure-temperature stability field of mantle minerals above solidus conditions is necessary to understand the geochemical effects of magma ocean crystallization. At present, there remain large uncertainties on the phase relations in anhydrous primitive mantle composition at pressures above 7-8 GPa. Here we report new results of melting experiments at 10 GPa. Experiments were performed in Walker-type multi-anvil presses at the Geophysical Laboratory. The primitive mantle composition was prepared from shelf oxides and carbonates, following the bulk silicate Earth model composition of McDonough and Sun (Chemical Geology 1995). In order to reduce the thermal gradient in the sample chamber of the 10/5 cell assembly, Re capsules 1 mm long were used. Final sample sizes were approximately 250 x 200 μm . Our results show that the liquidus is located between 2000 and 2050 $^{\circ}\text{C}$, i.e. 50-75 $^{\circ}\text{C}$ lower than reported in earlier studies (e.g. Zhang and Herzberg, JGR 1994). Olivine is the liquidus phase followed down temperature by Ca-poor pyroxene and garnet (1950 $^{\circ}\text{C}$), and clinopyroxene (1900 $^{\circ}\text{C}$). Ca-poor pyroxene is not present in the melting interval below 1800 $^{\circ}\text{C}$ but becomes stable again just below the solidus. The solidus is located between 1700 and 1750 $^{\circ}\text{C}$, as we find very small amounts of interstitial melt at 1750 and 1800 $^{\circ}\text{C}$ but none at 1700 $^{\circ}\text{C}$. The solidus temperature is ~ 125 $^{\circ}\text{C}$ lower than reported in the early work of Takahashi (JGR 1986) and more than 170 $^{\circ}\text{C}$ lower than reported more recently (Zhang and Herzberg, JGR 1994; Herzberg et al., *G³* 2000; Hirschmann, *G³* 2000). The subsolidus assemblage consists of olivine, garnet and clinopyroxene. Near the liquidus, the melt has a Mg/Mg+Fe ratio of 0.83, a SiO₂ content of 49 wt% and CaO/Al₂O₃ ratio of 0.7. Near the solidus, the Mg/Mg+Fe ratio is 0.56, the SiO₂ content reaches 43 wt%, and the CaO/Al₂O₃ ratio increases to 3.5. Our major finding is that Ca-poor pyroxene is stable in the melting interval at 10 GPa, i.e. 3 GPa higher than previously reported (Walter, J. Petrol. 1998). In addition, unlike in earlier studies, we find at 10 GPa high-Mg melt that is in equilibrium with a garnet harzburgite residue.