Partial Melting of carbonated peridotite to 20 GPa and Genesis of Carbonatite and Kimberlite melt

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CO2 rich alkaline magmas (carbonatite and kimberlite), play an important role in distribution of carbon in the deep Earth, are generated from melting of carbonated peridotite and eclogite in the Earth's deep mantle. For better understanding of the generation of CO2 rich magmas requires knowledge of the melting behavior of carbonated peridotite composition over a range of conditions of pressure and temperature.

In the present study we have investigated the partial melting behavior of carbonated peridotite between 10 and 20 GPa and temperature range from 1600oC to 2100oC.

The starting material was a synthetic carbonated fertile peridotite, which is close to an average mantle pyrolite composition after Ringwood (1975) except the CO2. The solidus temperature increases from ˜1380oC at 10 GPa to ˜1525oC at 15 GPa and the solidus curve becomes almost flat from 15 GPa to 20 GPa, where it is located near 1550oC. At 10 GPa, the solidus of carbonated peridotite is ˜550oC lower than the solidus of CO2-free natural anhydrous peridotite. The solidus of the present study was also ˜120oC lower than the solidus determined by Dasgupta and Hirschmann (2006) for natural carbonated peridotite. At 10 GPa, we observed small fraction of partial melting at 1600oC. Low-temperature assemblage includes olivine, majorite garnet, clinoenstatite, clinopyroxene, and magnesite. Magnesite. Liquidus phase at 10-20 GPa is majorite garnet. At 10-15 GPa, crystallization sequence with decreasing temperature is garnet, olivine and clinoenstatite. Clinopyroxene was observed only at 1400oC and clinoenstatite is stable up to 1900oC. Subsolidus phase assemblage at 1400oC includes wadsleyite, garnet, clinoenstatite, clinopyroxene, and magnesite.

At 20 GPa, lower temperature assemblage includes ringwoodite, garnet, and magnesite. Melt formed by 10-25% of the partial melting at 10-20 GPa has high MgO (26-34 wt.%) and FeO (7.0-10.4 wt.%) and low SiO2 (18-36 wt.%) and Al2O3 (0.5-1.3 wt.%) contents. It contains also 6-12 wt.% CaO, 0.6-2.0 wt.% Na2O and 0.1-0.3 wt.% K2O which is close to group II kimberlite magma. The CO2 contents in the melts determined by total deficit of electron microprobe analyses are 14-32 wt.%. The composition of partial melts is significantly different from melts observed at lower pressures (3-6 GPa), which are enriched in SiO2, CaO and Al2O3 (Hirose, 1997; Dalton and Presnall, 1998, Dasgupta et al., 2007; Brey et al., 2008).