Partial Melting in a Metasomatized Source Region: Kimberlitic Melt Compositions derived from Forced Multiple Saturation Experiments

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The geochemistry and mineralogy of the mantle source for primary kimberlite melts is still very much debated. The primary melt is argued to be either of carbonatitic or kimberlitic nature and proposed melting mechanisms range from low-degree partial melting of a carbonated peridotite to high-degree melting of strongly metasomatized veins.

We performed forced multiple saturation experiments at 7 GPa and 1400-1650 °C mixing a modified composition of the previously proposed primitive melt from the Jericho kimberlite [1] with a peridotite. In these experiments, the peridotite's mineral mode was adjusted such that the Jericho kimberlite could saturate in olivine, opx, cpx and garnet. Volatiles varied between 5-15 wt% CO_2 and 0.23-4.7 wt% H_2O. Mineral stability is mostly controlled by the CO_2 contents of the starting materials. A lherzolitic mineral assemblage is obtained over a wide temperature range (1400-1650 °C) for a starting composition with 10 wt% CO_2 and 0.23 wt% H_2O. At <7.5 wt% CO_2 opx was absent, while at >12.5 wt% CO_2 olivine and cpx were not stable. Variable H_2O contents do not influence the mineral saturation paragenesis but lowers the range of multiple-saturation temperatures: Under near anhydrous conditions (0.23 wt% H_2O) kimberlitic melts in equilibrium with olivine, opx, cpx and garnet are obtained at >1500 °C, while at 2.5-3.5 wt% H_2O melt compositions with 18.3-24.2 wt.% SiO_2 and 23.4-24.2 wt.% MgO already occur at 1400 °C. Olivine in these melts has Mg# of 92.5-93.0 and garnets display low TiO_2 and lherzolitic CaO and Cr_2O_3 contents.

The obtained melts can be compared with previously proposed close-to-primary kimberlitic compositions in regard of their SiO_2 and MgO. However, Mg# of 83.8 to 85.5 are slightly lower and Na_2O contents of 1.8 and 2.8 wt% are much higher than for previously proposed melt compositions. These results are consistent with kimberlitic melts being produced by moderate partial melting of a strongly metasomatized (alkali- and volatiles-rich) mantle source, temperatures at 7 GPa would be 1400-1550 °C.

[1] Kopylova *et al.* (2007), *GCA*, **71**, 3616-3629