American Mineralogist, Volume 99, pages 2292–2302, 2014

The role of water in generation of group II kimberlite magmas: Constraints from multiple saturation experiments

Alexander G. Sokol[1,2,*], Alexey N. Kruk[1] and Yury N. Palyanov[1,2]

[1]V.S. Sobolev Institute of Geology and Mineralogy, Russian Academy of Sciences, Siberian Branch, 3, Koptyug Avenue, Novosibirsk, 630090, Russian Federation
[2]Novosibirsk State University, 2, Pirogov strasse, Novosibirsk, 630090, Russian Federation

Abstract

Multiple saturation experiments have been performed in a multicomponent system at 6.3 to 7.5 GPa and 1400–1670 °C using a split-sphere multi-anvil apparatus to constrain the conditions of kimberlite magma generation. The starting bulk compositions of samples corresponded to the average group II kimberlite (orangeite), with water contents varying from 5 to 9 wt% H_2O and the $CO_2/(CO_2+H_2O)$ molar ratio from 0.37 to 0.24. The charges were placed inside graphite liners sealed in Pt capsules to avoid Fe loss. Oxygen fugacity (f_{O_2}) during the experiment was buffered by the equilibrium between graphite and a hydrous carbonate-silicate melt about EMOG/D. As water in the starting kimberlite increased from 5 to 9 wt%, the temperature of its complete melting became ~100 °C lower (relative to 1670 °C), both in the 6.3 and 7.5 GPa runs. Orthopyroxene was stable just below the liquidus at all pressures and H_2O concentrations applied in the experiments. An olivine + garnet + orthopyroxene assemblage was present at ≤100 °C below the liquidus when H_2O was 5 wt%. At 7 and 9 wt% H_2O, the same assemblage appeared at 100–150 and >200 °C below the liquidus, respectively. In no experiment was clinopyroxene observed as a run product. Olivine, garnet, and orthopyroxene stable in the multiply saturated melt were compositionally similar to mantle peridotite minerals found as xenoliths in kimberlites worldwide. Thus we infer that generation of group II kimberlite magma may occur by partial melting of carbonated (metasomatized) garnet harzburgite at pressures from 6.3 to 7.5 GPa, temperatures about 1500–1600 °C, and no more than 5 wt% H_2O in the melt. Water, in the amounts required to produce this magma, may come from interaction of K-Ca-rich carbonatite melt, infiltrating from a deeper mantle source, with a peridotite protolith containing H_2O in nominally anhydrous minerals and, possibly, also in phlogopite.

Keywords: Experiment, mantle, kimberlite, magma, water, fluid