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Effect of CO2 content on melting phase relations in kimberlite group I at 6.5 GPa and 1200-1600oC

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Our understanding of kimberlite petrogenesis is significantly hampered by uncertainty about the compositions of kimberlite magma. It is generally accepted that the last equilibration of kimberlite magma with surrounding mantle (garnet lherzolite) occurred beneath cratons at 6-7 GPa prior its rapid ascent (about 70 km/h) to the surface. This conclusion is based on the following facts. The deepest (170-220 km depths) and hottest (1200-1500^{o}C) xenoliths entrapped by kimberlites are sheared garnet lherzolites originating from the lower part of lithospheric mantle. The preservation of deformation features in sheared lherzolites indicates that the rock was undergoing dynamic recrystallization just before it was picked up by the magma and that it reached the surface after less than a few days or even hours in magma rising by crack propagation (Green and Gueguen, 1983; Meyer, 1985; Sparks et al., 2006). Based on our resent study (Sharygin et al., 2013) of melting phase relations in an exceptionally fresh kimberlite group I from Udachnaya-East kimberlite (UEK) pipe at 3.0-6.5 GPa and 900-1500^{o}C, the kimberlite melt had essentially Na-K-Ca carbonatite composition $<$15 wt.% SiO_2, Na_2O + K_2O = 5-18 wt%, Na/K = 2, Cl $>$1.5 wt%, and Ca/(Ca+Mg) $>$0.5. However, the mineral assemblages obtained in these experiments differ from known mantle parageneses. This may be due to unaccounted CO_2 budget missed at shallow depth as a result of decarbonation reactions at 1.5-2.5 GPa. Therefore, in present study we examined the effect of additional CO_2 on melting phase relations in synthetic UEK kimberlite system at 6.5 GPa and 1200-1600^{o}C.

Based on obtained results mineral assemblage equilibrated with kimberlite partial melt gradually changes from peridotite to eclogite paragenesis with increasing its CO_2 content from 13 to 35 mol %. As can be seen at 6.5 GPa kimberlite partial melt (i.e. Na-K-Ca carbonatite melt) becomes equilibrium with garnet lherzolite (i.e. olivine + enstatite + diopside + garnet + FeS + ilmenite assembly) at 1500^{o}C and 23 mol % (20 wt%) CO_2. This value is 10 mol% more than natural abundance of CO_2 in the Udachnaya-East kimberlite rock (group I kimberlite). In other words, the kimberlite magma lost almost half of the CO_2 budget during the eruption.

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Figure. Melting phase relations in Udachnaya-East kimberlite (kimberlite group I) versus temperature and CO_2 content at 6.5 GPa. 13 mol % CO_2 corresponds to the natural abundance of CO_2 in UEK rock.

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