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Fractional ultrabasic-basic evolution of upper-mantle magmatism: Evidence from xenoliths in kimberlites, inclusions in diamonds and experiments

Yuriy Litvin and Anastasia Kuzyura
Institute of Experimental Mineralogy, Mantle Processes, Chernogolovka, Russian Federation (litvin@iem.ac.ru)

Ultrabasic peridotites and pyroxenites together with basic eclogites are the upper-mantle *in situ* rocks among xenoliths in kimberlites. Occasionally their diamond-bearing varieties have revealed within the xenoliths. Therewith the compositions of rock-forming minerals demonstrate features characteristic for primary diamond-included minerals of peridotite and eclogite parageneses (the elevated contents of Cr-component in peridotitic garnets and Na-jadeitic component in eclogitic clinopyroxenes). High-pressure experimental study of melting equilibria on the multicomponent peridotie-pyroxenite system olivine Ol – orthopyroxene Opx – clinopyroxene Cpx – garnet Grt showed that Opx disappeared in the peritectic reaction Opx+L→Cpx (Litvin, 1991). As a result, the invariant peritectic equilibrium Ol+Opx+Cpx+Grt+L of the ultrabasic system was found to transform into the univariant cotectic assemblage Ol+Cpx+Grt+L. Further experimental investigation showed that olivine reacts with jadeitic component (Jd) with formation of garnet at higher 4.5 GPa (Gasparik, Litvin, 1997). Study of melting relations in the multicomponent system Ol – Cpx – Jd permits to discover the peritectic point Ol+Omph+Grt+L (where Omph – omphacitic clinopyroxene) at concentration 3-4 wt.% Jd-component in the system. The reactionary loss of Opx and Ol makes it possible to transform the 4-phase garnet lherzolite ultrabasic association into the bimineral eclogite assemblage. The regime of fractional Ol, Cpx and Grt crystallization must be accompanied by increasing content of jadeitic component in residual melts that causes the complete "garnetization of olivine". In the subsequent evolution, the melts would have to fractionate for basic SiO_2-saturated compositions responsible for petrogenesis of eclogite varieties marked with accessory corundum Crn, kyanite Ky and coesite Coe. Both the peritectic mechanisms occur in regime of fractional crystallization. The sequence of the upper-mantle fractional ultrabasic-basic magmatic evolution and petrogenesis may be controlled by the following melting relations: from Ol, Opx, L field to cotectic curve Ol, Opx, Cpx, L, peritectic point Ol, Opx, Cpx, Grt, L (loss of Opx), cotectic curve Ol, (Cpx+Jd), Grt, L, peritectic point Ol, (Cpx→Omph), Grt, L (loss of Ol), divariant field Omph,Grt,L, cotectic curve Ky, Omph, Grt, L, eutectic point Ky,Coe,Omph, Grt,L, subsolidus assemblage Ky,Coe,Omph, Grt.

The fractional ultrabasic-basic evolution of the upper-mantle silicate-carbonate-carbon melts-solutions, which are responsible for genesis of diamond-and-inclusions associations and diamond-bearing peridotites and eclogites, follows the similar physico-chemical mechanisms (Litvin et al., 2016). This is illustrated by fractional syngenesis diagram for diamonds and associated minerals which construction is based on evidence from high pressure experiments.

References

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