

Experimental view on mineral inclusions of “mixed” paragenesis in lithospheric diamonds

A. Shatskiy^{1,2}, K.D. Litasov^{1,2*}

¹Sobolev Institute of Geology and Mineralogy SB RAS, Novosibirsk, 630090, Russia

² Novosibirsk State University, Novosibirsk, 630090, Russia

Keywords: diamond; peridotite; eclogite; high pressures; multianvil experiment; Earth’s mantle.

*e-mail: klitasov@igm.nsc.ru

The natural diamonds could be formed during reduction of carbonatite melt [1], which can be derived by partial melting of carbonated eclogites in subducted slab [2-3]. The partial reduction of this melt should cause precipitation of silicate solutes simultaneously with diamond.

Experimental reconstruction of the composition of the deepest known melts (kimberlites) [4] has shown that the liquid coexisting with garnet lherzolite mineral assemblage in the mantle source region contains (mol%): SiO₂ = 9, FeO = 6–7, MgO = 23–26, CaO = 16, Na₂O = 4, K₂O = 1, and CO₂ = 30–35 suggesting essentially carbonatitic composition of primary kimberlite melt similar to that of kimberlite-associated diamondiferous magnesiocarbonatites [5] in terms of CaO–MgO–FeO–SiO₂–CO₂ system.

Under high-pressures (> 3 GPa) most of carbonate-silicate systems have *T-X* phase diagrams with eutectic shifted to carbonate component. Thus, under mantle pressures carbonate melts act as a solvent for refractory silicate minerals. Partial reduction of carbonate component of carbonate-silicate melt during its interaction with reduced iron saturated ambient mantle decreases the amount of solvent. As a result, carbonate-silicate melts become saturated with silicate minerals. Thus, diamond crystallization should be accompanied by nucleation and growth of silicate minerals.

Experimental results at 6.5 GPa and 1500 °C suggest that the decreasing bulk CO₂, which accompanies reduction, changes the mineral assemblage co-precipitating with diamond in following sequence: eclogite (Coe + Cpx + Grt) → pyroxenite (Cpx + Opx + Grt) → lherzolite (Ol + Opx + Cpx + Grt) → wehrlite (Ol + Cpx + Grt) [4]. This would explain the formation of diamonds from group A eclogite with mineral inclusions of “mixed” paragenesis, where two-phase coesite + clinopyroxene (Jd₇Di₈₅En₅Fs₃) inclusions and garnet (Prp₇₄Alm₁₇Grs₉) inclusions are located at the central zone and olivine (Fo₉₃) inclusions are much closer to periphery [6-7]. In our study observed clinopyroxene with close composition (Jd₁₀Di₈₃En₃Fs₄) in coexistence with coesite at bulk CO₂ of 31 wt%, whereas olivine appears at bulk CO₂ of 15–23 wt% (Fig. 1) [4].

Thus, successive decrease of bulk CO₂ during reduction of carbonate-silicate melt should change assemblage of minerals co-precipitating with diamond, from coesite-bearing eclogitic toward olivine-bearing peridotitic.

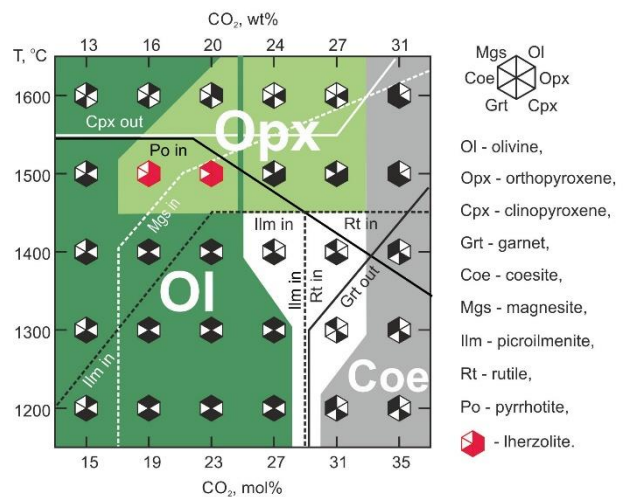


Figure 1. The temperature-bulk CO₂ plot illustrating mineral assemblages coexisting with melt during partial melting of anhydrous Udachnaya-East kimberlite at 6.5 GPa versus temperature and bulk CO₂ content.

Acknowledgments: This work was supported by Russian Science Foundation (project No 14-17-00609-P).

- [1] Y.N. Palyanov, Y.V. Bataleva, A.G. Sokol, Y.M. Borzdov, I.N. Kupriyanov et al., *PNAS* 2013, **110**, 20408.
- [2] G.M. Yaxley and G.P. Brey, *Contrib. Mineral Petrol.* 2004, **146**, 606.
- [3] K.D. Litasov, A. Shatskiy, E. Ohtani, G.M. Yaxley, *Geol.* 2013, **41**, 79.
- [4] A. Shatskiy, K.D. Litasov, I.S. Sharygin, and E. Ohtani, *Gondwana Res.* 2017, **45**, 208.
- [5] A.M. Agashev, N.P. Pokhilenko, E. Takazawa, J.A. McDonald, M.A. Vavilov et al. *Chem. Geol.* 2008, **255**, 317.
- [6] A. Ragozin, V. Shatsky, D. Zetgenizov, S. Mityukhin, *Doklady Earth Sci.* 2006, **407**, 465.
- [7] V. Shatsky, A. Ragozin, D. Zedgenizov, S. Mityukhin, *Lithos* 2008, **105**, 289.