



Mantle origin of diamond-parent carbonatite magma: experimental approaches

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1. Diamond-parent carbonatite magma. Reliable insight into chemical and phase composition of parent medium for dominating mass of mantle-derived diamond is attained through integration of mineralogical data for diamond-hosted heterogeneous inclusions and relevant results of physicochemical experiment. Mantle-carbonatite theory of diamond genesis (Litvin, 2007), genetic classification of diamond-included materials (Litvin, 2009) and generalized composition diagram for multi-component diamond-parent medium (Litvin, 2010) are the key findings. Carbon-saturated peridotite-carbonatite and eclogite-carbonatite melts of carbonatite specialization form the basis for changeable diamond-parent magma. Some of minor components (oxides, phosphates, chlorides, C – O – H – N volatiles, etc.) are dissolved in parent melts and capable to form paragenetic accessory minerals and released volatiles. The others (sulfides, native metals, etc.), being xenogenetic immiscible and insoluble phases, are occasionally involved into diamond-parent magma and accessible for caption by diamonds.

2. Formation of chambers of diamond-parent carbonatite magma in mantle peridotite. At PT-conditions of diamond stability, Mg-Ca-carbonatite melt can result from mantle peridotite in response to chemical attack of mobile high-temperature «metasomatic agent» rich in CO₂, K, Na-alkaline carbonates and silicates, minor incompatible and REE elements (Wyllie, 1990; Litvin, 1998; Gasparik, Litvin, 2002). Productivity of source reservoir of metasomatic agents controls generation of carbonatite melts and, evidently, dimensions of chambers of diamond-parent carbonatite magma. In the making stationary chamber, primary carbonatite melts dissolve mantle peridotite minerals, solid and dispersed carbon material, minor soluble phases and involve xenogenetic ones. Important physicochemical points are carbonate congruent melting, complete carbonatite-peridotite and carbonatite-eclogite liquid miscibility, low viscosity of carbonatite magma as contributory factor for fractional crystallization, inhibitory role of silicate constituents and concentration barrier for diamond nucleation in carbonatite-silicate melts. Diamond-forming activity of mantle carbonatite chamber begins during cooling when diamond solubility concentration in carbonatite magma is attained, then carbon oversaturation in respect to diamond is reached producing nucleation and growth of diamond.

3. Peridotite-to-eclogite paragenetic transition in fractionated diamond-parent carbonatite magma. Early temperature-controlled diamond growth is accompanied by formation of paragenetic minerals similar to those of mantle peridotite for re-crystallization of dissolved before peridotite minerals is realized. Fractional crystallization causes increasing accumulation of jadeite component at residual carbonatite melts. By experimental evidence (Gasparik, Litvin, 1997; Butvina, Litvin, 2010), reaction between Ol- and Jd-components at 7 GPa is resulted in Ol disappearing and Grt formation; reaction point Ol+Jd-Cpx=Grt+L at liquidus surface of both peridotite-eclogite and peridotite-eclogite-carbonatite system controls continuous transition from ultrabasic to basic magma and, respectively, from formation of Ol-bearing peridotite assemblage to Ol-free eclogite one. Reaction mechanism of peridotite-to-eclogite paragenetic transition is effective alternative to “eclogite thermal barrier” one ([O’Hara, 1968) which bans the transition. Reaction mechanism controls continuous transition from formation of peridotite mineral paragenesis to the eclogite one in the diamond- parent carbonatite magma.

4. Diamond nucleation and growth with caption of paragenetic and xenogenetic inclusions. Melting relations of multi-component eclogite-carbonatite-sulfide-diamond system approximating by composition diamond-parent medium for eclogite paragenesis are studied at 7 GPa. «Syngensis diagram» for diamond, paragenetic and syngenetic inclusions therein is constructed. Diamond solubility curves for carbonatite and sulfide melts are determined. Phase regions for silicate, carbonate and sulfide minerals and melts are found. This offers to reveal physicochemical mechanism of origin of natural diamond, PT-conditions of formation of paragenetic silicate and carbonate minerals and their coexistence with xenogenetic sulfide minerals and melts. Thus physicochemical conditions of primary caption of paragenetic and xenogenetic phases by growing diamond are revealed. Period of diamond crystallization is commensurable to lifetime of mantle chamber of diamond-parent carbonatite magma. Support: RFBR grant 11-05-00401.

