Melting relations in peridotite-carbonate and eclogite-carbonate melts at 7.0–8.5 GPa: application to diamond genesis

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We simulated crystallization of diamonds in melts with variable compositions of model peridotite [60 wt% olivine (Ol), 16 wt% orthopyroxene (Opx), 12 wt% clinopyroxene (Cpx), 12 wt% garnet (Grt)] and eclogite [50 wt% Grt, 50 wt% Cpx], with carbonate of dolomite composition (CaCO3•MgCO3), K2CO3, and multi-component K-Na-Ca-Mg-Fe-carbonatites. Carbonate-silicate melts in all experiments performed at PT-conditions of diamond stability are completely soluble. Concentration barriers of nucleation (CBN) were estimated at a pressure of 8.5 GPa for variable concentrations of silicate and carbonate components in parental melts: 25, 30, and 30 wt.% of peridotite components and 35, 45, and 35 wt.% of eclogite components, for CaCO3•MgCO3, K2CO3, and model carbonatite, respectively. At higher silicate concentrations in carbonate-silicate melts, diamond grows only on seed being accompanied by thermodynamically unstable graphite phase.

The appearance of peridotite minerals syngenetic to diamond in the studied diamond-forming melts was established in special run series at P = 7.0 GPa and T = 1200–1800° for the composition of peridotite30–carbonate70 (wt.%). Ol is a liquidus phase in the system with (CaCO3•MgCO3); at T < 1700°, an association of Cpx + Ol + carbonate-silicate melt (L) is stable; at 1600°, Grt is added. The prevalence of Cpx over other silicates was established for this system; none of the runs demonstrated the presence of Opx. It is assumed that in CaCO3-rich systems Opx enters into reaction like 2MgSiO3 + CaCO3 $\rightarrow$ CaMgSi2O6 + MgCO3 and practically is not presented as a proper phase. In the system of peridotite–alkali carbonate (K2CO3) the following assemblages are established: Opx(Ol) + L (1800°C); Opx + X phase + L (1500°C); Opx + Ol + carbonate + L (1300°C), Opx + Ol + wadeite + carbonate (1200°C). Crystallization of melts with model multi-component (K-Na-Ca-Mg-Fe) carbonatite proceeds with the following change of mineral parageneses as the temperature decreases: Ol + L $\rightarrow$ Ol + Cpx (Grt) + L $\rightarrow$ Ol + Cpx (Grt) + carbonate. In principle, the appearance of Opx is possible in this system, but only if initial peridotite is enriched in this component, and alkali carbonate (K2CO3) essentially prevails over CaCO3 among carbonate phases. In the eclogite-carbonate system, for the composition of [Grt50Cpx50]35Carb65 (wt%), Grt and Cpx were obtained as liquidus phases depending on the starting composition. Melt crystallization proceeds by the following scheme with a temperature decrease: L $\rightarrow$ Cpx+L (Grt+L) $\rightarrow$ Grt+Cpx+L (Grt+Carb+L) $\rightarrow$ Grt+Cpx+Carb+L $\rightarrow$ Grt+CPx+Carb.

The results obtained correspond to the carbonatite (carbonate-silicate) model of diamond genesis and point on theoretical possibility of crystallization of peridotitic and eclogitic silicate minerals syngenetic to diamond in silicate-carbonate melts under PT-conditions of diamond stability. The definite set of mineral inclusions in diamond is determined by the chemistry of carbonate-silicate systems including carbonate composition.

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