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Diamond formation at reduced conditions in the lithospheric mantle: experimental data

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Conditions of graphite interaction with fluids of different compositions of C-O-H system have been studied under control of Mo-MoO_2, Fe-FeO and Fe_3O_4-Fe_2O_3 buffers. It is found that the most efficient diamond forming medium is water fluid. For extremely oxidized, almost pure CO_2 fluid, the possibility of dissolution and transport of carbon, as well as diamond and graphite crystallization have been experimentally proved. In extremely reduced methane-hydrogen fluid at 6.3 GPa and 1600˚C diamond is not formed and only metastable graphite crystallizes.

Problems of the composition of diamond crystallization media and source of carbon in reduced mantle domains are still debatable. According to experimental data the most appropriate environment for the crystallization of diamond in extremely reduced conditions are melts of transition metals – Fe, Ni, Co. We performed investigations of the effect of nitrogen impurities and H_2O content on diamond formation in metal systems. The concentration of nitrogen in the growth system was varied by adding nitrogen-containing substances to the charge; the other conditions of the growth were constant: Fe-Ni-C system, P=5.5 GPa, T=1400˚C and duration of 65 h. It was established, that with an increase in nitrogen concentration the crystallization of diamond proceeds through the following stages: single crystal → block crystal → aggregate of block crystals and twins. At nitrogen concentrations in metal melt higher than 0.4 at. % the nucleation and growth of diamond are terminated and graphite only crystallizes in the field of thermodynamic stability of diamond. As H_2O content increases the diamond growth form changes from octahedron to dodecahedron. At concentration of $H_2O \geq 0.3$ wt.% growth of diamond is blocked and metastable graphite crystallizes. These experimental data are evidence of restricted diamond-forming ability of metal-carbon melts.

Taking into account the possibility of subduction of oxidized crustal materials to considerable depths, as it is suggested in most of modern geodynamic models, interaction of subducted materials with reduced mantle rocks is very predictable (Rohrbach et al., 2007; Foley, 2010). Simplified models of this interaction are carbonate-metal reactions. Experimental study of (Ca,Mg)CO_3-Fe^0 interaction was performed at the pressure of 6.3 GPa and temperature range of 1350-1650˚C. In the experiments with duration of 20 hours, association of Mg,Fe,Ca carbonate melt, Mg-wustite and elemental carbon is formed. In the temperature range of 1350-1450˚C diamond growth on seeds and crystallization of metastable graphite is established. At 1550 and 1650˚C spontaneous crystallization of diamond takes place. In whole temperature range carbonate melt plays a role of source of carbon and diamond crystallization medium.

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