EXPERIMENTAL STUDY OF DIAMOND CRYSTALLIZATION IN METAL – SILICATE – – CARBON SYSTEMS

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The existing mineralogical and experimental data allow to conclude, that most of the natural diamonds were formed in the ancient Earth mantle, where highly reductive conditions provided stability of the transition metals in their free state. Thus one can assume, that diamond crystallization proceeded from heterogeneous substrates of silicate-metal-carbon, silicate-sulphide-metal-carbon or more complex composition.

We have conducted experimental modeling of the process of diamond crystallization in the system metal (Fe,Ni alloy) - silicate (basalt melt or solid olivine) - carbon. The experiments were held on the multy-anvyl high-pressure apparatus "BARS" [1]. The source of carbon was placed in the central, the most high-temperature zone of the high-pressure cell; above it, the metal-silicate schist and a diamond crystal seed were put. The carbon source was represented by graphite, while for seeds, synthetic diamond crystals 0.3 mm in size served. The metallic content of the schist was a mixture of iron and nickel with the ratio Fe:Ni = 3:7. For added silicates, synthetic olivine of the following composition (wt. %): SiO_2 - 31.11; TiO_2 –0.07; Al_2O_3 -0.04; Cr_2O_3 - 0.01; FeO - 62.42; CaO - 4.70; MgO - 3.33; MnO - 0.15, and natural glass with alkaline basaltic composition: SiO_2 - 46.60; TiO_2 - 2.24; Al_2O_3 -15.27; Cr_2O_3 - 0.01; Fe_2O_3 - 4.82; FeO - 6.38; CaO - 6.68; MgO - 4.25; MnO - 0.15; Na_2O - 6.14; K_2O - 4.70; P_2O_5 - 2.34; H_2O - 0.10; CO_2 - 0.004, were used. At the P-T parameters of the experiments, olivine doesn't melt, while the basaltic glass gives the melt with its composition, close to that of eclogite. The conditions of the conducted experiments and their results are given in the table.

Table

The conditions and results of the experiments on diamond crystallization in the metal-silicate-carbon systems

No of experiment	Silicate content in schist, wt. %	Experimental parameters			Diamond formation	
		P, kbars (±2)	T, ^{0}C (±20)	τ, hrs	Conversion graphite into diamond	Diamond growth into seeds
1	Olivine – 1%	55	1450	40	Yes	Yes
2	Olivine – 2%	55	1500	40	Yes	Yes
3	Olivine – 5%	55	1500	60	Yes	Yes
4	Olivine – 15%	60	1450	70	Yes	Yes
5	Olivine – 100%	55	1500	70	No	No
6	Basalt – 2%	55	1500	60	Yes	Yes
7	Basalt – 4%	55	1500	70	Yes	Yes
8	Basalt – 4%	55	1550	90	Yes	Yes
9	Basalt – 10%	55	1500	70	Yes	Yes
10	Basalt – 17%	55	1550	90	Yes	Yes
11	Basalt – 20%	55	1500	65	Yes	No

In all the experiments with the metal-silicate-carbon schist, the transformation of graphite into diamond, along with (except No 11) the growth of a diamond seed crystal, took place. Solid silicates and silicate melt (immiscible with the metallic one) have lower density and, due to the fact, were located in the upper part of the reaction volume. In the experiment with 20 % of basalt melt relative to the weight of metal, diamond seed crystal was blocked by silicate, so its growth did not occur. Diamond synthesis and growth of seed crystal did not take place in the experiment No 5 without metal. The last fact confirms the conclusions of previous studies [1, 2], that at the pressures of 50-60 kbars and temperatures 1400-1500^{0}C in the silicate-carbon melts, diamond doesn't form.

In course of the experiments, initial olivine turned into pyroxene, garnet and newly formed olivine. The silicate melt of basaltic content at the end of the experiments crystallized into garnet and highly magnesial olivine and spinel, despite the apparent predominance of iron and nickel in the system. It was due to reductive conditions in the crystallization me-

dium, at which transition metals concentrate themselves in metallic phase.

In the synthesized diamonds, inclusions of metal, wustite and silicate phases (olivine and garnet) were established. Similar content of metallic and silicate inclusions was observed in the diamond crystal, synthesized in the experiment No 1, though its formation proceeded in the medium with the content of silicate of only 1 % from the weight of the metal. The fact points at selective incapture of silicate phases by diamond in the process of its crystallization.

Thus, the obtained results had shown, that in heterogeneous medium, consisting of metallic melt and solid or liquid silicate, diamond formation occurred at the same P-T parameters (50-60 kbars, 1400-1500°C), as in pure metal-carbon systems. That is, the presence of silicates doesn't reduce the chemical ability of metallic melts to catalyze the transformation of graphite into diamond. Yet, silicates can block some parts of crystallization cameras, preventing the penetration of metallic melts there and, consequently, diamond formation. In the metal-silicate-carbon systems, along with diamond, olivine, garnet, pyroxene, spinel - i.e. the typical minerals of natural diamond-bearing paragenesises, - crystallized.

1. Chepurov A.I., Fedorov I.I., Sonin V.M. Experimental modeling of diamond formation processes. Novosibirsk: NIC UIGGM SB RAS, 1997. 197 p.
2. Chepurov A.I., Sonin V.M. On the crystallization of carbon in silicate and metal-silicate systems at high pressure // Geologija i geophizika. 1987. № 10. P.78-81.