

Butvina V.G.¹, Litvin Yu.A.², Spetsius Z.V.³. Diamond synthesis in sulfide melts in the eclogite-sulfide-carbonate system at P=6-8 GPa

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The problems concerning the nucleation and growth of diamond in nature are very actual. The most interesting question is a composition of a diamond-forming media. Primary carbonatite inclusions in diamonds gave rise to the carbonatite hypothesis of diamond genesis, which is described in Litvin and Zharikov (2000).

The most common solid inclusions in diamonds are sulfides, such as pyrite, pyrrhotite, and pentlandite, which also are constituents of diamondiferous mantle rocks (eclogites, clinopyroxenites, peridotites). Findings systems.

First runs were conducted in the carbon-carbonate system. A spontaneous diamond growth in the carbonate melt was observed (Fig. 1). That repeats the results of earlier experiments (Litvin, Zharikov, 2000). In the system carbon-eclogite-carbonate, diamond was crystallized from carbon, dissolved in the carbonate melt. Simultaneously, a dissolution of eclogite in the

of sulfides in the growth centers of diamonds (Bulanova et al., 1993) allowed assumption about the sulfide diamond genesis. In the present study, we attempted to experimentally model of the natural diamond-bearing eclogite system.

Number of investigators (Wentorf, 1966; Arima et al., 1993) performed experiments on the synthesis of diamond in the carbon-sulfide system. However, they obtained a negative result. Chepurov (1988) synthesized diamonds in the system Fe-Ni-S-C only in the metal-rich portion ($Me/S > 1$). As a result, a conclusion on the inhibition of diamond-forming processes with an increase of sulfur concentration has been done.

In the present study, a possibility of diamond synthesis was investigated in the media, whose composition is similar to eclogite. Starting compound is natural Yakutian diamondiferous eclogite from the Udachnaya pipe. Compositions of the starting mixtures are shown in Table 1. Along with it, simple sulfide-carbon systems with silver sulfide (argentite) were treated as well in order to support an idea that only sulfide melts is responsible for diamond growth rather than metals, i.e. Fe and Ni, which are constituents of pyrite, pyrrhotite, and pentlandite. Experiments were carried out at pressures 6-8 GPa using the high-pressure apparatus AH-13T in the laboratory of fluid-magmatic melt occurred (Fig. 2). The spontaneous nucleation of diamond proceeded after addition of sulfide into the system. Octahedral crystals and spinel twins were formed. According to optical observation, sulfides were not completely molten (crystals of sulfides were found). Therefore, carbonate melt was responsible for the diamond synthesis.

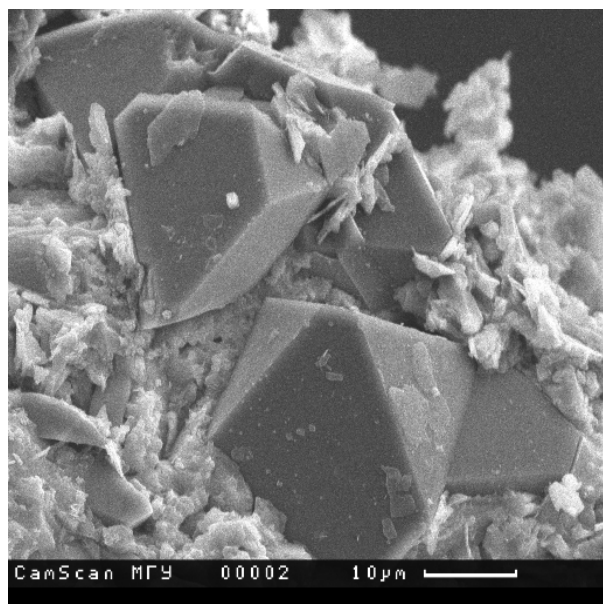


Fig. 1. The spontaneous diamond growth in the carbon-carbonic system.

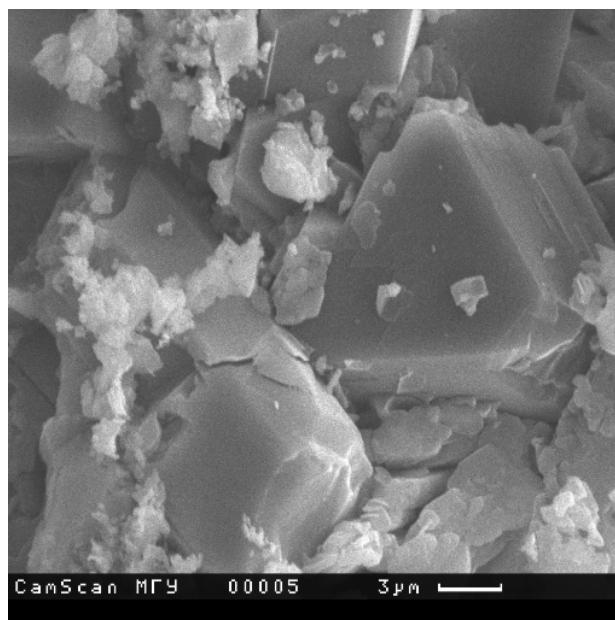


Fig. 2. Diamond crystal and garnet with dissolved faces in the carbonate melt of the carbon-eclogite-carbonic system

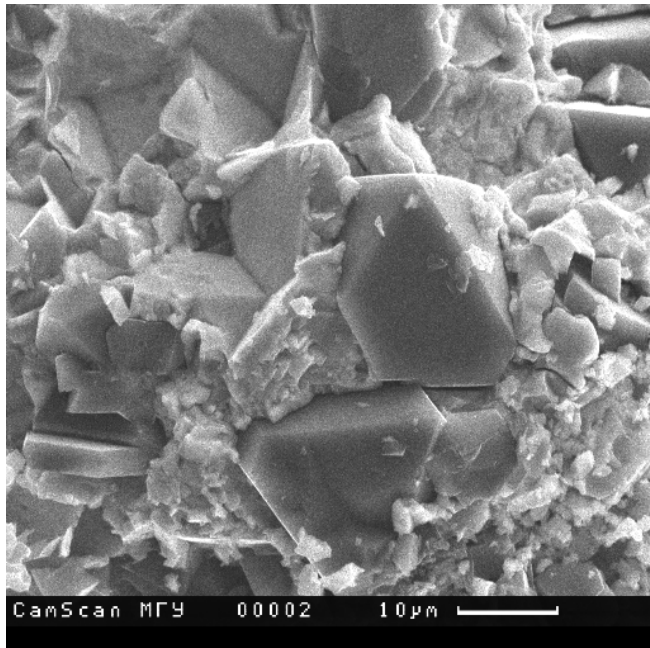


Fig. 3. The spontaneous diamond growth in the carbon-sulfide system.

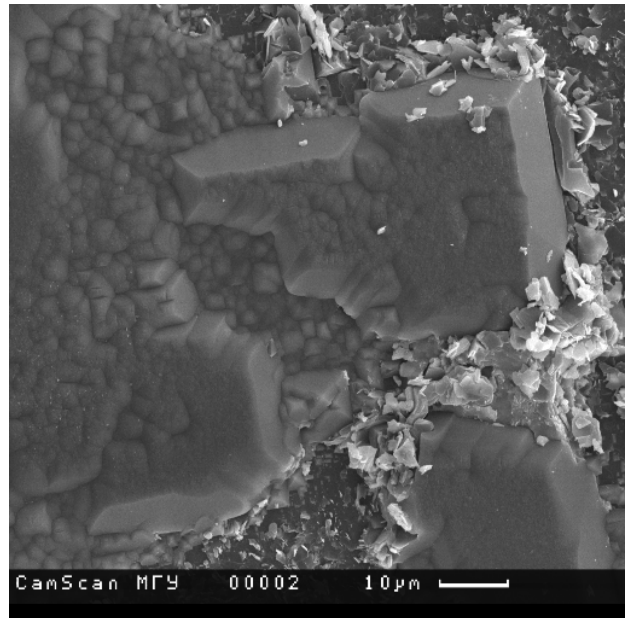


Fig. 4. The metastable diamond growth on the seed crystal in the carbon-sulfide system.

Table. 1. Compositions of the starting mixtures.			
Eclogite (garnet : clinopyroxene, wt. %), U-2340			
Component	Garnet		Clinopyroxene
	wt%		wt%
SiO ₂	39,16		54,48
TiO ₂	0,64		0,38
Al ₂ O ₃	21,05		4,90
Cr ₂ O ₃	0,03		0,01
FeO	21,86		7,42
MnO	0,44		0,04
MgO	8,55		11,52
CaO	8,50		17,72
Na ₂ O	0,09		2,45
K ₂ O	—		0,06
Total	100,32		98,98
Sulfide mixture (pyrrhotite:chalcopyrite, wt. % = 50:50 . U-2290			
Component	Pyrrhotite		Chalcopyrite
	wt%		wt.%
Fe	62,54		31,40
Ni	0,35		4,25
Co	0,04		0,28
Cu	0,02		29,44
S	35,06		31,53
Total	98,01		96,92
Carbonate mixture			
Component	wt.%	Component	wt.%
K ₂ CO ₃	27,21	MgCO ₃	17,35
Na ₂ CO ₃	2,89	FeCO ₃	25,63
CaCO ₃	26,91		

The next experiments were conducted in the carbonate-free systems. Both an active growth of diamond crystals on the seed facets and the spontaneous crystallization of cubic and octahedral crystals occurs in the system carbon-sulfide-eclogite. A composition of the eclogitic phase (garnet, in the given case) (mol. %): SiO₂ – 38.87, TiO₂ – 0.63, Al₂O₃ – 21.19, Cr₂O₃ – 0.04, FeO – 22.02, MnO – 0.34, MgO – 8.39, CaO – 8.23, Na₂O – 0.29) changes slightly. The spontaneous nucleation of octahedral diamonds occurred in the carbon-sulfide systems (Fig. 3). Growth of diamonds on the seed crystal occurred at metastable conditions (Fig. 4). According to microprobe study, a decomposition of the sulfide compounds to metallic phases did not occur. Thus, the carbon-metal system could not serve as a solvent of carbon during diamond re-crystallization from graphite. Exclusively sulfide melts were responsible for the diamond synthesis.

The experimental modeling of the diamond-bearing eclogitic system showed a leading role of the sulfide melts in the diamond synthesis. The following problem is an identification of typical features of diamonds, i.e. determination which medium, carbonate or sulfide, is responsible for diamond genesis.

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