

EXPERIMENTAL INVESTIGATION OF JOINT CRYSTALLIZATION OF DIAMOND WITH MINERALS OF ECLOGITES AND PERIDOTITES

Doroshev¹, A.M. , Pal'yanov², Yu.N., Turkin¹, A.I.,
Khokhryakov², A.F., Borzdov², Yu.M., Sokol², A.G.

1. Institute of Mineralogy and Petrography, Siberian Branch of the RAS, Universitetskii pr.3, Novosibirsk, 630090, Russia.
2. Design and Technologic Institute of Monocrystals, Siberian Branch of the RAS, ul.Russkaya, 43, Novosibirsk, 630058, Russia

Introduction. Factual data unambiguously proves that diamond is syngenetic with sulfide, silicate and oxide minerals whose investigation allowed establishment of ultrabasic and eclogitic types of diamond paragenesis (Sobolev, 1985). The process of diamond crystallization in the field of its thermodynamic stability from metal-carbonic melt is the best-studied nowadays. Treating the Me-C system as a particular case of the systems "solvent-carbon" in this paper, we made attempts to experimentally realize joint crystallization of diamonds with the minerals of eclogites and peridotites.

Experimental methods. The experiments were carried out in a split-sphere multi-anvil apparatus in the range of pressures 55-60 kbar and temperatures 1400-1550°C in the system Ni-Fe-C (Pal'yanov et al., 1990). The scheme of the reactional zone of the cell is shown in Fig.1. The mixture of Ca, Mg, Al, and Si oxides was used as "eclogite"(E) and "lherzolite" (L) additive to the metal-carbonic charge. The proportion of this mixture was set on the basis of the average value for typical samples of eclogites and lherzolites from pipe MIR (Vladimirov et al., 1976). On separate crystallization of L and E mixtures in Pt capsule at 50 kbar and 1250°C, Fo+Opx+Cpx+Gar and Gar+Cpx, respectively, were formed. In a number of experiments these phases were added to the metal-carbonic charge instead of the oxide mixture. The quantity of the additive was 0.5-5 wt %. Pellets of L- and E-mixture were additionally placed in the center of reactional zone in runs 510 and 512, respectively. The phases were identified by optical and X-ray methods. The composition of phases was determined by microprobe analyzer CAMECA MS 46.

Results and discussion. The conditions and results of experiments are given in tables 1 and 2. In the "clear" system Ni-Fe-C without oxide additives, diamond grows as flat-faced crystals of octahedra with minor faces {100} and {311}. It was established that addition of oxides leads to a decrease in mass-transport of carbon and, respectively, to a decrease in the growth rate of diamond crystals. With the quantity of additives 0.5wt%, the morphology of diamond does not change. Crystals become stressed and block-like due to formation of dispersed silicate

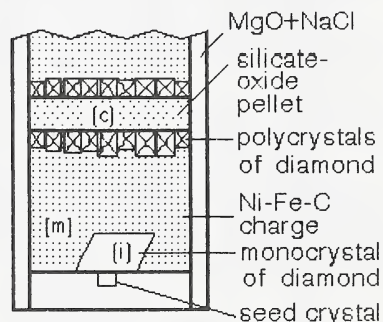


Fig.1 Scheme of reactional zone of cell. Letters designate localization sites of studied silicate-oxide phases: (c)-central pellet, (i)-inclusions in diamond, and (m)-grains in Me-C charge.

Table 1. Conditions and results of experiments (P=55-60 kbar)

Run	T, °C	Time, hours	Add(w.%)	Phases	Diamond faces		Growth rate, mg/hour
					main	minor	
496	1400	38	L(5)	Ol.Cp.Op.Cor	{111}	{110}	0.34
499	1400	38	E(5)	Gar.Cp.Cor	{100}	{111}	0.30
510	1400	39	L(0.5)	Gar.Cp.Op.Cor.Co	{111}	{100}, {311}	1.0
512	1400	39	E(0.5)	Gar.Cp.Cor	{111}	{100}, {311}	0.70
533	1400	40	Py(0.5)	Gar	{111}	{100}, {311}	0.75
539	1550	20	E*(2)	Gar.Cp	{111}	-	-

Cor.Co, Py - corund, coesite, synthetic pyrope; E.L - eclogitic or lhercolitic composition; *-crystalline phases

Table 2. Results of microprobe analysis of phases (average values)

Run	Ph	loc*	CaO	TiO2	MnO	Na2O	MgO	SiO2	Al2O3	FeO	NiO	Total
496	Ol	m	0.563	-	0.000	0.270	50.36	41.11	0.245	8.32	0.334	100.20
	Op	m	1.11	-	0.002	0.601	33.71	57.16	0.567	7.52	0.269	100.95
	Cp	m	9.39	-	0.004	3.68	20.18	57.19	4.40	5.24	0.116	100.20
	Co	m	0.033	-	0.000	0.112	0.227	0.371	97.00	0.258	0.069	98.07
499	Cpl	m	15.89	-	0.000	5.21	10.75	55.86	5.38	7.68	0.261	101.03
	Cp2	m	21.40	-	0.000	0.054	3.99	49.77	0.373	24.32	0.984	100.89
	Cor	m	0.372	-	0.000	0.000	0.272	0.192	98.05	0.848	0.033	99.77
510	Gar	c	3.75	-	0.006	0.050	27.40	43.68	23.55	0.273	0.026	98.73
	Op	c	0.792	-	0.005	0.039	38.96	58.18	1.21	0.100	0.050	99.33
	Cp	c	20.30	-	0.007	0.252	21.62	55.35	1.59	0.075	0.025	99.21
	Cor	c	0.029	0.018	-	0.023	0.229	0.254	94.65	0.039	0.014	95.26
	Cp	i	20.67	-	0.003	0.511	20.60	54.50	0.542	2.23	0.776	99.83
	Cor	i	0.132	-	0.002	0.019	0.392	0.396	96.01	0.226	0.163	97.33
	Co	i	0.014	-	0.000	0.021	0.000	97.83	0.000	0.384	0.294	98.54
512	Gar	c	5.61	0.007	-	0.061	25.73	44.19	24.22	0.021	0.009	99.85
	Cp	c	22.65	0.006	-	0.088	19.61	53.07	2.58	0.089	0.209	99.31
	Co	c	0.032	0.015	-	0.008	0.000	99.34	0.000	0.016	0.020	99.43
	Cor	c	0.060	0.000	-	0.010	0.292	0.337	94.50	0.044	0.005	95.25
	Cp	i	20.53	-	0.000	1.12	16.65	53.17	1.13	6.11	0.930	99.64
533	Gar	i	0.049	-	0.000	0.053	30.83	44.15	24.12	0.520	0.195	99.91

* loc - site of phase localization in cell (see fig.1.)

inclusions whose presence proves selective capturing of silicate and oxide inclusions by growing diamond (Pal'yanov et al., 1994). An increase in additives to 5 wt% results in formation of skeletal and block-like diamonds(+L) or aggregative intergrowths of microcrystals(+E). The diamond morphology drastically changes. In L-containing charge, diamond forms crystals of octahedron-dodecahedron series. In E-containing charge, diamonds have a cubic habit with minor{111}; flat faces{100} are absent. Surfaces{100} are represented by octahedral apexes. We analyzed silicate and oxide phases localized in three different zones of the reactional volume of cell(see Fig.1): c-in control pellet, m-segregations in metal and i-inclusions in diamond. It was optically established that the occurrence of silicate minerals in metal is possible at rather low concentrations of silicate additive (0.5 wt%). However, accumulations of grains accessible for microprobe analysis was observed when the quantity of additive was 2 wt% and more. Microprobe analysis of synthetic silicates from metal and inclusions showed the presence of iron and sodium, borrowed from the components of cell assemblage. The amount of these components

from the control pellet is small, the same as in garnet inclusions from run 533. The contents Fe, Na, and Al in the same-type silicates were heterogeneous. The phases of olivine-two-pyroxene association are compositionally similar to minerals from peridotite intergrowths with natural diamonds, except decreased contents of Ca in clinopyroxene. Cpx quantitatively dominates in eclogite association, Gar is present as relict grains substantially replaced by microcrystalline pyroxene-bearing aggregate. Cpx is distinctly divided into two types in composition. The first is similar to omphacites of eclogite paragenesis from inclusions in natural diamonds, the second - differs in drastically elevated content of iron (Fe/Fe+Mg to 0.9) and has no analogs in basic and ultrabasic rocks syngenetic with diamond. The points of clinopyroxene compositions are shown in fig.2. Preliminary results allow the following conclusions to be made: 1- Ni-Fe melt, as solvent of oxides, does not prevent crystallization of phases compositionally similar to rock-forming minerals of diamondiferous parageneses; 2 - Addition of oxides into metal melt involves a decrease in growth rate of diamond, change in its morphology, and selective capturing of inclusions.

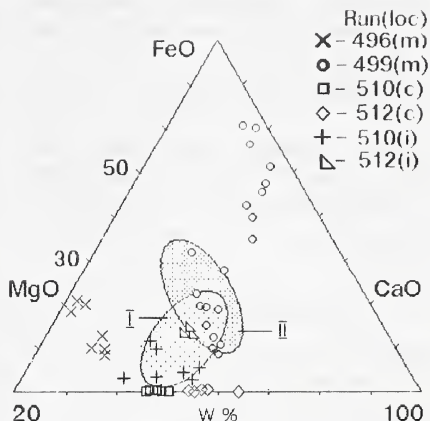


Fig.2. Diagram of synthetic clinopyroxene compositions in terms of MgO, CaO and FeO. Shaded areas are fields of natural clinopyroxenes included or intergrown with diamonds of lherzolite(I) and eclogite(II) parageneses (Sobolev, 1974; Bulanova et al., 1993).

The research described in this publication was made possible in part by Grant RCY000 from the International Science Foundation.

- Bulanova, G.P., Barashkov, Yu.P., Talnikova, S.B., and Smelova, G.B. (1993) Natural diamond-genetic aspects., 168p., Nauka, Novosibirsk.
- Pal'yanov, Yu.N., Malinovskiy, I.Yu., Borzdov, Yu.M., Khokhryakov, A.F., Chepurov, A.I., Godovikov, A.A., and Sobolev, N.V. (1990) Use of "split sphere" apparatus for growing large diamond crystals without the use of a hydraulic press. Doklady Akademii Nauk SSSR, Earth Science Section, 315, 1221-1224, (In Rus).
- Pal'yanov, Yu.N., Khokhryakov, A.F., Borzdov, Yu.M., Doroshev, A.M., Tomilenko, A.A., and Sobolev, N.V. (1994) On selective capturing of inclusions in diamond in connection with the upper mantle composition problem. Abstracts of 16th IMA General Meet., 4-9 Sept. 1994, Pisa, Italy, 314.
- Sobolev N.V. (1974) The deep seated inclusions in kimberlites and the problem of the upper mantle composition., 264p., Nauka, Novosibirsk, (In Rus).
- Sobolev, N.V. (1985) Ultramafic and eclogitic types of parageneses of diamonds. Abstr. of All-Union Conf. "Nature elements formation in the endogenic processes.", Yakutsk, June 25-28, part IV, 38-41.
- Vladimirov, B.M., Volyanyuk, H.Ya., and Ponomarenko, A.I. (1976) The deep seated inclusions from kimberlites, basaltes and kimberlite-like rocks., 284p., "Nauka", Moscow, (In Rus).