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Experimental modeling of syngenesis of diamond and minerals of peridotite and eclogite parageneses

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Abstract. Study of physicochemical conditions of syngenesis of diamond and mineral phases of peridotite and eclogite paragenese sin changeable carbonatite parental media is started at 8 GPa and 1200–1800°C. Experimental determinations testify that the compositions of parent media for diamond and inclusins belog to the phase field "boundary carbonatite–peridotite$_{30}$carbonatite$_{70}$ - eclogite$_{35}$carbonatite$_{65}$". It is found that the processes of olivine carbonatization as well as garnetization while it reacts with jadeite component are developed at regions of complete and partial melting of the compositions rich in peridotite constituents. As the result of the processes, the stability region for the minerals of peridotite paragenesis is contracted, but that is extended in the case of eclogite paragenesis.

Introduction. Analytical mineralogy of primary ("syngenetic") inclusions is the only plausible source of information on chemical composition of the parental media for natural diamonds and phases trapped by these while growing. Along with this, physicochemical experiment permits to obtain the objective information on genetic links of diamond and phases included therein. It becomes possible if the diamond-forming systems which boundary compositions are chosen to take into account the evidence of the inclusions mineralogy. The mantle-carbonatite theory of diamond genesis [*Litvin*, 2007, 2009] is developed as a result of generalization of mineralogical and experimental data that sort of. According to the theory, the natural parental medium is basically multi-component completely miscible carbonate-silicate melt with dissolved elemental carbon (in the frames of the peridotite-eclogite-boundary carbonatite-diamond system. The composition limits for diamond-forming melts are experimentally determined using the concentration barriers of diamond nucleation (CBDN) and correspond to the values (wt.%): peridotite$_{30}$carbonatite$_{70}$ and eclogite$_{35}$carbonatite$_{65}$ [*Bobrov & Litvin*, 2009]. Generalized diagram of the parental medium composition is constructed [*Litvin,* 2010; *Litvin, et al.,* 2011]. The diagram determines the boundaries for the phase region of parental media for diamond and inclusions. It has been ascertained in this case that compositions of the natural diamond-forming media belong to the carbonatite classification interval. In this work, study of physicochemical conditions of syngenesis of diamond and mineral phases of peridotite and eclogite parageneses in carbonatite parental media is started at 8 GPa and 1200–1800°C.

Experimental study of formation of diamond and paragenetic phases. This is evident from the phase region for parental media (fig. 1) that their compositions are extremely changeable in respect tas content of silicate components ofp eridotite-pyroxenite and eclogite-grospydite parageneses so the indicators of the silicate/carbonate ratio. The value of mid-weighted composition for the parental medium is calculated for its concentration triangle «peridotite$_{30}$carbonatite$_{70}$ - eclogite$_{35}$carbonatite$_{65}$–boundary carbonatite» (composition 10 in the fig. 1 and in the table. 1). Experimental investigation of diamond and inclusions syngenesis is started within the section (wt. %) boundary carbonatite–(peridotite$_{30}$carbonatite$_{70}$)$_{50}$(eclogite$_{35}$carbonatite$_{65}$)$_{50}$ which is formally the composition triangle for the parental media onto two parts – peridotitic and eclogitic. The starting experimental compositions №№ 9, 10 and 4 are given in the table 1 together with the boundary compositions used at their calculations.

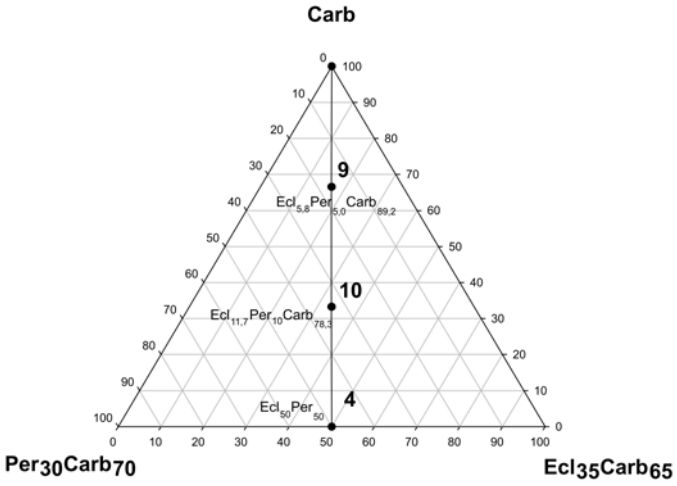

Fig. 1.

Table 1. Boundary compositions of the generalized diagram of parental media, the phase region of the parental media, and compositions of starting materials used in experiments at 8.0 GPa

Composition	Oxides (wt. %)							
	K_2O	Na_2O	MgO	FeO	CaO	Al_2O_3	SiO_2	CO_2
Boundary Per		0.52	37.12	11.35	2.49	3.48	45.04	
Boundary Ecl		3.71	8.51	15.24	9.04	15.76	47.74	
Boundary Carb	18.55	1.69	8.30	15.89	15.08			40.49
CBDN $Per_{30}Carb_{70}$	12.99	1.34	16.95	14.53	11.31	1.04	13.50	28.34
CBDN $Ecl_{35}Carb_{65}$	12.08	2.40	8.38	15.65	12.95	5.52	16.70	26.30
№ 9	16.55	1.72	9.99	15.59	14.05	0.99	5.01	36.10
№ 10	13.30	1.80	12.80	14.80	12.40	1.90	14.43	28.00
№ 4	12.54	1.87	12.67	15.09	12.13	3.28	15.10	27.32

Footnote to Table 1. Symbols: Per – peridotite ,Ecl – eclogite, Carb – carbonatite; CBDN – concentration barrier of diamond nucleation; experimental compositions expressed through boundary constituents (wt. %): № 9 – $Ecl_{5.8}Per_{5.0}Carb_{89.2}$, №10 – $Ecl_{11.7}Per_{10.0}Carb_{78.3}$, № 4 – $Ecl_{17.5}Per_{15.0}Carb_{67.5}$

Experimental studies were carried out in toroidal apparatus anvil-with-hole;the method details are characterized in the paper [*Litvin, et al.*, 2008]. The results of microprobe analyses of the experimental phases including melts formed at temperature 1600–2000 ^oC, silicate minerals (garnet and clinopyroxene) and carbonate mineral (Mg–Fe-carbonate) at temperature
1400–1600^oC, – are given in the table 2. Experimental data testify to that phases of the eclogite paragenesis are exclusively formed within the section boundary carbonatite–$(peridotite_{30}carbonatite_{70})_{50}(eclogite_{35}carbonatite_{65})_{50}$whereas phases of the peridotite paragenesis are not presented. There is important to underline that such characteristic minerals of peridotite as olivine and orthopyroxene are absent. This is evidence of reaction interaction with the other components of the system under study. In other words, reaction "eclogitization" of peridotite is observed. Carbonatization reactions of peridotite Mg-minerals which were established in experiments at lower pressures [*Wyllie, Huang,* 1976], as well as reaction between olivine and jadeite components resulting in garnetization of olivine [*Gasparik, Litvin,* 1997] reveal themselves as important factors.

Mass crystallization of diamond in melt oversaturated with dissolved elemental carbon in the sample № 10 of mid-weighted composition is demonstrated in the fig. 2 (sample № 2429, 2000^oC). In the fig.3 (sample № 2450, composition № 9, 1400^oC): eclogite assemblage Cpx + Grt with Mg-Fe-carbonate is shown, Ol andOpx are not determined. Fig. 4 (sample№ 2270, a mode lsystem Fo–Di–Jd–Dol, 1200^oC) demonstrates process of garnetization of olivine: the sample contains Grt and Cpx whereas forsterite (major component of olivine) is not detected.

Conclusion. Experimental modeling of diamond and inclusions in parental medium which contains *peridotite and eclogite minerals reveals physicochemical conditions of syngenetic crystallization of* diamond and minerals of eclogite paragenesis (Cpx, Grt). Therewith, processes of carbonatization and garnetization of olivine and orthopyroxene suppress formation of characteristic minerals of peridotite paragenesis.

Table 2. Representative compositions of phases obtained in experiments at 8.0 GPa

Sample	T,°C	Phases	Oxides (wt. %)							
			K_2O	Na_2O	MgO	FeO	CaO	Al_2O_3	SiO_2	CO_2
№ 9	1600	L	6.6–16.1	1.3–2.1	2.6–3.9	4.0–4.8	5.1–6.5	0.3–0.4	1.6–2.2	45.0–50.0
	1400	Carb	0.12	0.02	24.77	23.01	3.52		0.21	48.35
		Cpx	0.79	1.85	9.98	14.19	18.78	1.94	52.47	
		Grt		0.25	5.61	25.56	15.57	11.90	40.93	
№ 10	2000	L	4.8–8.5	0.7–1.4	2.3–3.9	3.5–4.0	3.1–4.1–	1.0–3.0	4.0–6.0	30.0–50.0
	1400	Cpx	1.45	2.31	13.41	10.47	15.49	3.05	53.82	
		Grt		0.11	10.18	19.52	7.22	21.61	41.36	
№ 4	1800	L	5.0–5.5	0.7–3.5	1.7–5.8	10.6–13.9	6.5–10.9	1.5–3.7	12.4–18.9	40.5–53.0
	1600	Carb	0.65	0.18	17.89	23.86	7.01	0.09	0.49	49.83
		Cpx	0.56	2.50	9.88	14.91	15.76	2.87	53.52	
		Grt		0.26	5.85	24.16	12.95	17.98	38.80	
	1400	Cpx	1.06	2.84	11.70	10.04	17.92	3.72	52.72	
		Grt		0.11	10.00	22.60	8.06	19.11	40.12	

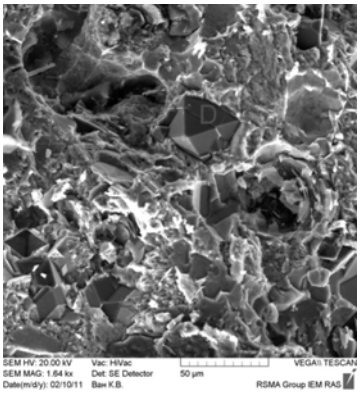

Fig. 2.

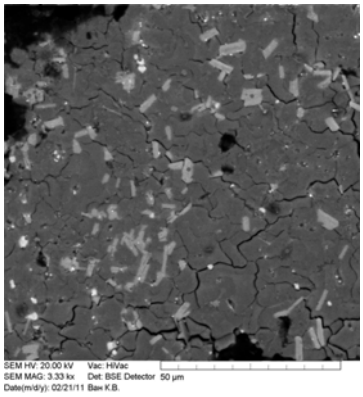

Fig. 3.

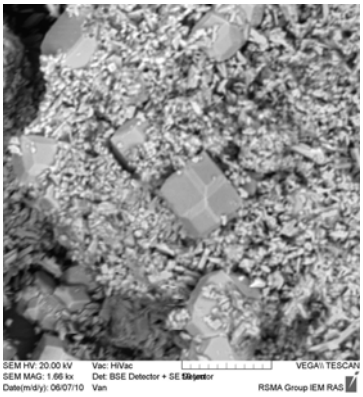

Fig. 4.

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