

¹Litvin Yu.A. , ²Jones A.P., ²Beard A.D.,
³Divaev F.K. **First synthesis of diamond
and syngenetic minerals in the melts of the
Chagatai diamondiferous carbonatites.**

¹Institute of Experimental Mineralogy, Chernogolovka,
²University College London, UK, ³ Institute of Mineral Resources, Tashkent

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Findings of diamonds in magmatic carbonatites of the Chagatai trachyte-carbonatite complex, Uzbekistan, were firstly reported in [1]. The diamondiferous carbonatites are intermediate carbonate-silicate rocks kasenite and rengite. They consist of calcite (40-60 %), diopside-hedenbergite clinopyroxene (5-30 %), biotite (3-20 %), apatite (5-15 %), and magnetite (3-15 %). Firstly, diamond was identified as monocrystals and polycrystalline aggregates of 100-200 microns in size in the carbonatite concentrates. That caused doubt because of the possible “pollution” of the rocks with diamonds during concentration. Using the scanning electron microscopy and microprobe, we found *in situ* in one of carbonatite thin section diamonds of 10 microns in size, included in impurity-free calcite. That unambiguously proved the diamond presence in the Chagatai carbonate-silicate rocks.

The discovery of the diamondiferous carbonatites confirms the well-substantiated theory of diamond genesis in the Earth mantle, which assume the diamond formation from the strongly compressed carbonatite melts [3, 4].

Table 1. Compositions of carbonatite used in experiments

Sample	23	79	86	88	89
SiO ₂	22.19	18.2	12.22	27.86	11.62
TiO ₂	0.6	0.65	0.33	0.38	0.6
Al ₂ O ₃	5.36	6.24	2.68	9.64	3.67
Fe ₂ O ₃	4.97	14.37	2.93	11.04	1.23
FeO	2.87	4.2	3.95	3.52	2.87
MnO	0.25	0.23	0.34	0.28	0.85
MgO	2.8	3.65	0.81	3.58	3.5
CaO	26.64	29.4	36.73	30.14	31.8
Na ₂ O	1.62	0.29	1.3	0.32	1.15
K ₂ O	1.32	0.89	0.7	0.9	0.54
P ₂ O ₅	0.49	0.43	4.58	0.15	2.75
H ₂ O	0.26	0.46	0.2	0.34	0.08
CO ₂	18.7	20.9	21.65	10.45	7.92
SO ₃	0.01	0.13	0.1	0.12	0.03
Total	98.08	100.04	98.52	98.72	98.61

Table 2. Compositions (wt. %) of minerals syngenetic with diamond in the experiments with the Chagatai deep-seated carbonatites.

Phase	Grt	Grt	Grt	Grt	Grt*	Cpx	Cpx	Cpx	Calc	NKCC	C-L	Ap
Sample	597	600	602	599	599	599	602	602	596	602	597	596
Rock	88	79	23	86	86	86	23	23	89	23	88	89
Temp.	1550	1520	1450	1520	1520	1520	1450	1450	1535	1450	1550	1535
Duration	10	25	12	40	40	40	12	12	40	12	10	40
SiO ₂	40.51	39.44	38.56	37.04	33.27	50.17	52.55	52.39	0.24	0.49	0.44	0.69
TiO ₂	0.88	1.28	0.72	2.69	3.11	0.50	0.02	2.75	0.15	0.22	0.08	0.09
Al ₂ O ₃	20.55	19.61	19.94	14.60	11.91	5.24	4.47	3.00	0.03	2.38	0.17	0.23
Cr ₂ O ₃	0.24	0.06	0.10	0.15	0.07	-	0.07	0.01	0.05	0.06	0.05	0.03
FeO*	9.64	11.80	12.37	19.17	23.22	17.95	11.39	18.73	0.29	0.70	31.30	2.21
MnO	-	0.68	0.74	0.50	0.97	0.28	0.13	0.29	0.08	0.20	-	0.14
MgO	3.78	2.92	2.72	0.99	1.25	3.59	8.14	3.88	0.04	-	8.80	0.66
CaO	25.01	24.33	25.04	24.82	26.30	19.12	20.54	9.63	58.82	22.64	14.35	54.18
Na ₂ O	-	-	-	-	-	3.12	2.56	9.27	0.04	22.53	-	0.35
K ₂ O	-	-	-	0.05	-	-	0.13	0.08	0.04	4.79	-	0.15
P ₂ O ₅	-	-	-	-	-	-	-	-	-	0.71	-	42.55
CO ₂	-	-	-	-	-	-	-	-	(46.30)	(45.41)	(44.91)	-

Note. Sample – number of the experimental sample; Rock – number of rock sample used in the experiment; Temperature – temperature of run (°C); Duration – run duration (minutes). Abbreviations: Grt – garnet, Grt* - quenched garnet, Cpx – clinopyroxene, Calc – calcite (aragonite ?), NKCC – carbonate (Na, K)₂Ca(CO₃)₂, C-L – quenched multi-component carbonate melt, Ap – apatite. Estimated concentrations (wt. %) are shown in parentheses.

The diamond synthesis from the natural carbonatite melts was conducted at 7 GPa, 1450-1550°C, and run duration 10-40 min. Melts of natural carbonatites (SiO₂ content varies from 11.6 to 29.7 wt. %) were used as solvents for carbon (graphite). Compositions of the used

rocks are shown in table 1. Starting charges were prepared from powders of natural carbonatite (Table 1) mixed (1:1) with graphite of analytical purity and grain size of 0.5 mm. The experimental method is similar to that described in [3]: graphite capsule – heater, high-

pressure “anvil-with-hole” apparatus, and cell made of lithographic stone. The experimental samples were studied using scanning electron microscopy and microprobe (JEOL Superprobe 733).

Conditions and results of the experiments, including compositions of phases co-crystallized with diamond, are shown in table 2. Spontaneous crystallization of diamond occurred within the 1-2 minutes of experiment after reaching of the temperature of melting of the initial carbonatite-graphite mixture. Nucleation and growth of diamond crystals occurred by means of the dissolution of graphite and the formation of solutions in the carbonatite melt oversaturated with respect to diamond. The mechanism of the diamond formation in the carbonatite melts is similar to the mechanism of diamond formation in the carbonate-carbon [3] and metal-carbon [5] systems. The essence of this process relates to the growth of crystals from melt solutions. Diamonds formed octahedral monocrystals, spinel twins, and their aggregates. The quenched diamond-forming carbonatite melts were of complex multi-component composition (Table 2). Along with diamonds, diopside-hedenbergite clinopyroxenes, grossular-almandine garnets, apatite, calcite were formed (Table 2). Calcite served as a matrix for other minerals, i.e. it was crystallized later. Tiny veinlets of garnet were observed in calcite (see table 2). They were crystallized at rapid solidification of the calcite melt. That is an evidence for appreciable solubility of garnet in the carbonate melt (and in the calcite melt). Similar aggregates of coesite in solidified carbonate were also identified. It means, that coesite solubility in the carbonate melt is high as well. Relationships of experimentally produced minerals allow to surely state that carbonate constituents in natural carbonatite at high pressures are perfect solvents not only for diamond (and graphite), but oxide, silicate, phosphate, and other minerals as well. This clarifies a nature of primary solid inclusions in diamonds as phases, which are syngenetic with diamond, formed from the single mantle carbonatite (carbonate-silicate) melt.

Numerous accessories were observed in the experimental samples: pyrrhotite FeS, Fe-Cr alloy with varying chromium content (this phase forms at the contact with diamond surface, because of highly reducing properties of carbon), wüstite FeO, muassanite SiC, previously unknown Si-Al carbide (identified from spectrum), alkali carbonate $(Na, K)_2Ca(CO_3)_2$, and gold.

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