Mineral equilibria at high PT-parameters

Zharkova E.V., Kadik A.A. Redox conditions in upper mantle: Experimental determination of intrinsic oxygen fugacity of the minerals from spinel and garnet lherzoliths, garnet pyroxenite and megacrysts from volcano Shavarin-Tsaram (Mongolia)

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Abstract. The different minerals from spinel and garnet lherzoliths, garnet pyroxenite and 5 megacrysts: garnet, pyrope, two clinopyroxenes and sanidene from volcano Shavarin-Tsaram (Mongolia) were chose for the determinations of intrinsic oxygen fugacity. The experiments which we carried out show that the values of the intrinsic oxygen fugacity of the minerals lie in the area between buffers equilibrium iron-wustite and wustitemagnetite

Key words. Intrinsic oxygen fugacity of the minerals; high temperature furnace based on two solid electrolytes, spinel and garnet lherzoliths, garnet pyroxenite, megacrysts, olivine, orthopyroxene, clinopyroxene, spinel, garnet, pyrope, sanidine.

Citation: Zharkova E.V., A.A. Kadik.(2014). Redox conditions in upper mantle: determinations of intrinsic oxygen fugacity of the minerals from spinel and garnet lherzoliths, garnet pyroxenite and megacrysts from volcano Shavarin-Tsaram (Mongolia). *Experimental Geochemistry*. V. 2, No

The different minerals from spinel and garnet lherzoliths, garnet pyroxenite and 5 megacrysts: garnet,

pyrope, two clinopyroxenes and sanidene from volcano Shavarin-Tsaram (Mongolia) were chosen for the determinations of intrinsic oxygen fugacity (fO_2).

The collection belong to academician V.I.Kovalenko

The determinations of intrinsic oxygen fugacity were carry out on the high-temperature furnace with two solid electrolytes from 800°C to 1150°C and at 1 atm.

It should be noted, that for the most of the investigated samples observed the explosion of gas-fluid inclusions at the first stage of experiment (heating), but never the less this process didn't influence on redox conditions of the samples itself. The experiments which we carried out show that the values of the intrinsic oxygen fugacity of the minerals from spinel lherzoliths lie in the area between buffers equilibrium iron-wustite (IW) and wustite-magnetite (WM) fig.1.

The formation of the minerals from garnet lherzoliths and pyroxenites (fig. 2) also occur in the area between IW-WM, but the mineral equilibrium with each other was not achieved, in contrast to the minerals from spinel lherzoliths from volcano Shavarin-Tsaram (Mongolia).

The intrinsic oxygen fugacities, measured for megacrysts from volcano Shavarin-Tsaram lies in the area of buffer equilibrium WM and higher except bubbling megacryst of clynopyroxene (Cpx Mo-7) fig. 3.



Fig. 1. The dependence $\log fO_2-10^4/T^{\circ}K$ for measured samples (ShTs 3-1): 1- Ol; 2 – Opx; 3 – Spl: 4 – Cpx. Experiment in Geosciences 2014 Volume 20 N 1



Fig. 2. .The dependence $\log fO_2 - 10^4/T^{\circ}K$ for measured samples (ShTs 4334-14): 1 – Ol; 2 – Opx; 3 – Cpx: 4 – Spl.

Sample	Α	В	n*	r**	$\log fO_2$ at
					1000°C
		Spinel lhe	erzoliths		
MPR 79-1					
Ol	13.554	35082	10	0.996	-14.00
Opx	10.242	30617	11	0.997	-13.81
Срх	11.356	31762		0.998	-13.59
MPR 79-4					
Ol	10.948	31364	11	0.987	-13.69
Opx	13.581	34165	10	0.998	-13.26
ShTs 3-1					
Ol	10.804	30887	10	0.991	-13.46
Opx	13.421	33982	11	0.996	-13.27
Срх	12.481	33190	10	0.992	-13.59
Spl	12.468	32913	11	0.998	-13.39
ShTs 3-2					
Ol	9.182	29142.1	9	0.996	-13.71
Opx	9.64	29594.7	10	0.996	-10.74
ShTs 4230-11					
Ol	9.395	29565.4	9	0.997	-13.83
ShTs 4230-12	gysth	eresis	11		
ShTs 4230-13					
Ol	12.3	33648.6	8	0.999	-14.13
ShTs 4230-16					
Ol	6.378	26931.5	10	0.991	-14.78
		Garnet lh	erzolith		
ShTs 4334-11					
Ol	7.993	28071.9	10	0.995	-14.06
Opx	10.398	32035.9	10	0.994	-14.77
Срх	11.868	33521.2	8	0.995	-14.46
		Garnet py	roxenite		
ShTs 4334-14					
Ol	11.666	33477.3	7	0.993	-14.63

Table 1. The values of coefficients "A" and "B" in the equation of $\log fO_2 = A-B/T^{\circ}K$ for the minerals from volcano Shavarin-Tsaram

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Sample	Α	В	n*	r**	$\log fO_2$ at
					1000°C
Opx	9.382	29872.1	11	0.994	-14.08
Срх	10.215	30716.1	9	0.996	-13.91
Spl	12.918	33166.8	11	0.999	-13.14
		Megacr	ysts		
Mo-1					
Срх	20.513	41643	10	0.991	-12.20
Mo-7					
Срх	11.885	33.044	9	0.999	-14.07
Gr	16.559	36562	9	0.994	-12.16
PT-11					
Ру	14.092	34675	9	0.990	-13.15
Sa	17.456	37833	8	0.995	-9.12

 $n^{\ast \text{-}}$ the quantity of experimental points, $r^{\ast\ast}$ coefficient of coorrelation.

Table 2.	Composition	of	minerals	of	spinel	lherzoliths,	garnet	lherzolith	and	garnet	pyroxenite	from	volcano
Shavarin	-Tsaram (Mo	ngol	lia)										

Sample	FM	Fo	Fa	Wo	En	Fs
		Spinel lhe	rzoliths			
MPR 79-1						
Ol	11	88.67	11.33	-	-	-
Opx	11.55	-	-	1.44	87.17	11.39
Срх	10.96	-	-	45.81	48.25	5.94
MPR 79-4						
Ol	10.15	89.53	10.47			
Opx	11.27	-	-	1.9	87.05	11.06
ShTs 3-1						
Ol	11.34	88.42	11.58	-	-	-
Opx	11.24	-	-	1.11	87.77	11.12
Срх	10.92	-	-	48.35	46.02	5.64
Spl	-	-	-	-	-	-
ShTs 3-2						
Ol	11.16	88.47	11.53	-	-	-
Opx	11.24	-	-	1.75	87.2	11.05
ShTs 4230-11						
Ol	9.98	89.64	10.36	-	-	-
ShTs 4230-12						
Ol	9.89	89.83	10.17	-	-	-
ShTs 4230-13						
Ol	10.1	89.56	10.44	-	-	-
ShTs 4230-16						
Ol	11.37	88.26	11.74	-	-	-
		Garnet lhe	erzolith			
ShTs 4334-11						
Ol	11.2	88.61	11.39	-	-	-
Opx	11.6	-	-	2.24	86.42	11.34
Срх	12.23	-	-	43.89	49.24	6.86
	1	Garnet py	roxenite	1	r	1
ShTs 4334-14						
Ol	10.51	89.26	10.74	-	-	-
Opx	9.89	-	-	2.13	88.2	9.68
Cpx	10.96	-	-	45.73	48.32	5.95
Spl	-	-	-	-	-	-

 Table 3. Composition of minerals of megacrysts from volcano Shavarin-Tsaram (Mongolia).

Mineral	Cpx (Mo-1)	Cpx (Mo-7)	Gr	Py PT-11	Sa
FM	26.32	29.37	34.12	34.57	0.00
Ab	-	-	-	-	43.28
Or	-	-	-	-	56.72

Abstracts

Mineral	Cpx (Mo-1)	Cpx (Mo-7)	Gr	Ру РТ-11	Sa
An	-	-	-	-	0.00
Alm	-	-	28.66	29.17	_
Pyr	-	-	56.86	56.65	-
Spes	-	-	0.79	0.77	-
Gross	-	-	10.16	10.53	-
Andrad	-	-	3.47	2.89	-
Uvar	-	-	0.06	0.01	-
Fo	-	-	-	-	-
Fa	-	-	-	-	-
Wo	38.75	40.66	-	-	-
En	45.13	41.91	-	-	-
FS	16.12	17.43	-	-	-



Fig. 3. The dependence $\log fO_2-10^4/T^{\circ}K$ for measured megacrysts from volcano Shavarin-Tsaram: 1 - Cpx (Mo-7); 2 - Cpx (Mo-1); 3 - Gr; 4 - Py (PT-11).

The investigation was carried out under the support of RFFI (grant $N_{2}14-05-00136a$).

Zharkova¹E.V., Kadik¹A.A., Badanina²I Yu., Malitch²K.N., Murzin²V.V. Experimental measurement of intrinsic oxygen fugacity of platinum-group minerals from the Verkh-Neivinsk and Guli massifs

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Abstract. Different platinum-group minerals (PGM) of the Ru-Os-Ir system from Verkh-Neivinsk massif were chosen for the investigation and determination of the intrinsic oxygen fugacity. The results of measurements show that the samples of investigated PGM have higher values of the intrinsic oxygen fugacity than those obtained for the minerals of osmium from the Guli massif. The log IO_2 values are plotted in close proximity to the field of buffer equilibrium wustite-magnetite or higher, whereas measured log IO_2 values of the Os-rich alloys from the Guli massif are situated between buffers equilibrium of wustite-magnetite and iron-wustite. Key words: The intrinsic oxygen fugacity, platinum-group minerals, ruthenium, osmium, iridium, wustite-magnetite, iron-wustite.

Citation. Zharkova E.V., A.A. Kadik, I.Yu. Badanina, K.N. Malitch, V.V. Murzin (2014) Experimental measurement of the intrinsic oxygen fugacity of platinum-group minerals from the Verkh-Neivinsk and Guli massifs. *Experimental geochemistry*. V. 2.

Different platinum-group minerals (PGM) of the Ru-Os-Ir system from Verkh-Neivinsk massif [Murzin V.V. et al., 1999] were chosen for the investigation and determination of the intrinsic oxygen fugacity (fO_2). The results of measurements show that the samples of investigated PGM have higher values of the intrinsic oxygen fugacity than those obtained for the minerals of osmium from the Guli massif. The log fO_2 values are plotted in close proximity to the field of buffer equilibrium wustite-magnetite or higher, whereas measured log fO_2 values of the Os-rich alloys from the Guli massif [Malitch, K.N. et al., 2011] are situated between buffers equilibrium of wustite-magnetite (*WM*) and iron-wustite (*IW*).



Fig. 1. Plot $\log fO_{2^{-1}}$ 10⁴/ $T^{\circ}K$ for the measured samples: 1 – ruthenium (Ru, Os, Ir), small grains; 2 – ruthenium (Ru, Os, Ir), large grains.

Fig. 2. Plot log fO_{2} -10⁴/T°K for the measured samples: 1 – osmium crystals (Os, Ir, Ru); 2 – osmium aggregates (Os, Ir, Ru).





Fig. 4. Plot $\log fO_2 - 10^4/T^{\circ}K$ for the measured samples: 1 – native osmium from dunite; 2 – iridian osmium from chromitite.

Sample	А	В	r	n							
Verkh-Neivinsk massif											
Rutenium (Ru, Os, Ir), large grains	15.226	36575	0.996	7							
Rutenium (Ru, Os, Ir), small grains	16.947	38502	0.994	8							
Osmium crystals (Os, Ir, Ru)	16.649	37305	0.992	8							
Osmium aggregates (Os, Ir, Ru)	17.256	37931	0.989	9							
Iridium crystals (Ir, Os)	19.876	41224	0.990	8							
Guli massif [Malitch, K.N. et al., 2011]											
Native osmium, Os	9.369	41768	0.999	8							
Iridian osmium (Os,Ir)	12.179	33284	0.973	8							

n – quantity of experimental points, r – correlation coefficient.

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Kogarko¹ L.N., Krigman L.D. Experimental modelling of larnite-normative melanephelinite crystallization

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Abstract. We investigated phase equilibria of larnite-normative nephelinite, close in composition to parent magma of ultramafic-alkaline Kugda massif (Polar Siberia).

Experiments have been carried in dry and CO_2 -bearing compositions. The runs have been done at 1 atm and 2 kbar by quenching method.Runs at the atmospheric pressure were carried out in an electric furnace with controlled oxygen fugacity. For 2 kbar experiments sealed platinum capsules lined inside with

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tungsten foil were used as containers and the runs were carried out in piston-cylinder apparatus with gas media. The order of tujaite crystallization strongly depends on the pressure. With the low pressure the order of crystallization is: olivine-melilitepyroxene, with higher pressires: olivine-clynopyroxene-melilite. On the basis of this data the difference in the order of crystallization of mineral phases and the structure of the ultramafic alkaline massives bearing melilite rocks can be explained. The absence of orthopyroxene suggests the formation of turjaite melt as result of partial melting of verhite mantle material.

Key words: Nephelinite, phase equilibria, tujaite, larnit-nornitmative rocks, Kugda massif.

Citation: Kogarko L.N., L.D. Krigman (2014). Experimental modelling of larnite-normative melanephelinite crystallization. *Experimental Gechemistry*. Vol. 2. №

Bulk composition of synthetic mixture used as a starting material in our runs corresponds to that of carbonatized melanephelinitic melt evaluated on the base of melt inclusions study in early liquidus minerals of Kugda olivinites (the composition is listed in table). We consider this melanephelinite composition to be a possible parental liquid for the whole Kugda intrusion.

Experiments have been carried out with volatile-free and CO₂-bearing compositions. In both cases we have also studied the crysallization of compositions doped with small amounts (1 wt.%) of fluorine. The runs have been done at 1 atm and 2 kbar by quenching method.Runs at the atmospheric pressure were carried out in an electric furnace with controlled oxygen fugacity. For 2 kbar experiments sealed platinum capsules lined inside with tungsten foil were used as containers and the runs were carried out in piston-cylinder apparatus with gas media.

Phases crystallizing from melanephelinitic melt are: olivine (ol), melilite (mel), perovskite (pst), clinopyroxene (cpx), F-phlogopite (in fluorine-doped runs), magnetite and nepheline-kalsilite solid slution. Crystallization sequence depends on pressure and starting composition (concentrations of fluorine and CO_2), but in all cases ol and mel are the first liquidus phases. Addition of CO_2 results in remarkable increase in cpx stability.

The order of tujaite crystallization strongly depends on the pressure. With the pressure up to 8 kbar the order of crystallization is: olivine-melilite-pyroxene, with higher pressires: olivine-clynopyroxene-melilite. On the basis of this data the difference in the order of crystallization of mineral phases and the structure of the ultramafic alkaline massives bearing melilite rocks can be explained.

Table 1.	Compositions of	f residual liquid	ls by crystallisatior	of melanefelinite	without (MN) a	nd with (MNF) fluorine
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Sample	Т	SiO_2	MgO	TiO_2	Al_2O_3	FeO	CaO	Na ₂ O	K_2O	P_2O_5
MN-5GL	1275	39.89	12.41	5.13	4.16	8.20	24.15	3.50	1.92	0.63
MN-2GL	1250	38.29	11.88	5.49	4.29	8.70	21.91	3.81	5.07	0.55
MN-1GL	1200	39.35	9.54	8.23	5.56	8.60	21.46	2.87	3.82	0.58
MN-3GL	1175	37.72	8.67	8.20	5.74	10.82	18.89	4.34	4.80	0.83
MN-4GL	1150	37.71	7.58	6.98	6.30	12.26	15.15	5.68	7.40	0.95
MN-6GL	1050	41.00	4.80	4.24	8.81	10.15	7.49	7.84	13.73	1.95
MNF-5GL	1275	38.67	12.18	4.74	3.99	8.00	24.75	3.50	3.76	0.41
MNF-2GL	1250	38.62	11.86	5.45	4.45	8.94	22.73	3.47	3.84	0.65
MNF-1GL	1200	38.87	9.88	7.67	5.45	10.18	20.13	3.00	3.98	0.83
MNF-3GL	1175	37.34	8.45	8.58	5.59	11.89	19.72	3.61	4.02	0.79
MNF-4GL	1150	37.76	7.25	7.97	5.88	14.34	18.77	3.39	3.88	0.76
MNF-6GL	1050	41.45	4.93	4.21	9.52	9.87	7.70	6.74	13.62	1.98



Fig.1. Plots temperature vs. concentrations of elements in melt by crystallisation of melanefelinite with (right) and without (left) fluorine (wt.%).

Kuzyura¹ A.V., Simonova ¹D.A.², Litvin¹ Yu.A. Experimental modeling of paragenesis of diamond and minerals of peridotites and carbonatites in the mantle chambers of parental magmas

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Abstract. There are results of experiments on studying of syngenetic crystallization of peridotite and carbonatite minerals from parental diamond-forming carbonate-silicate melt of system peridotite $Ol_{48}Opx_{16}Cpx_{16}Grt_{20}$ – carbonatite $(CaCO_3)_{20}(Na_2CO_3)_{20}(FeCO_3)_{20}(Na_2CO_3)_{20} - carbon in the work. Phase diagram of binary systems peridotite-carbon, carbonatite – carbon, pseudobinary system peridotite-carbonatite, and triple system peridotite-carbonatite – carbon that characterize physic-chemical conditions of syngenesis of paragenetic peridotite and carbonatite minerals were constructed on the results of experiments.$

Key words: the Earth's mantle, diamond-forming chambers, peridotite-carbonatite-carbon system, carbonate-silicate melt.

Citation: Kuzyura A.V., D.A. Simonova, Yu.A. Litvin (2014). Experimental modeling of paragenesis of diamond and minerals of peridotites and carbonatites in the mantle chambers of parental magmas *Experimental geochemistry*. V. 2. No.

Formation of carbonate-silicate parental medium for natural diamonds and syngenetic inclusions is a result of the upper mantle magmatic evolution marked by magmatic and metasomatic events [Boyd et al, 1994; Taylor, Anand, 2004; Klein-Ben David et al, 2007, 2009; Wallace, Green, 1988]. Chemical and phase composition of parental magmas has originally been composed by components as the mantle multicomponent multiphase peridotite so the "metasomatic agent". According to existing ideas, carbonate melts play an important role in the processes of the mantle metasomatism, as exampled in [Litvin, 1998; Yaxley et al, 1998]; by another conception, they could be formed during partial melting of the carbonatized peridotite [Dalton, Presnall, 1998]. The carbonate melts dissolve peridotite minerals and carbon, and so can form a completely miscible carbonate-silicate-carbon parental magma (at condition of complete or partial melting). Probably, this kind of magma can assimilate and create diamond-forming parental "chambers" in the mantle peridotite. During natural cooling of the chambers components of peridotite minerals dissolved in the parental carbonate-silicate-carbon magmas crystallize paragenetically in the form of mineral phases resample to minerals of the host mantle peridotite. Fragments of these "recrystallized" peridotite minerals hermetically included in the growing diamonds occur as syngenetic inclusions in them.

Data on the composition of "metasomatic agent" and carbonatite melts are in accordance with information on a composition of high dense microinclusions in fibrous diamonds. Therefore, an experimental modeling of mantle metasomatism includes a few stages: 1) an origin of the upper mantle carbonate-silicate diamond-forming melts, 2) their consolidation in magmatic chambers, and 3) an evolution under conditions of equilibrium and fractional crystallization.

Components of mineral phases valuable in composition of probable metasomatic agents, the upper

mantle peridotites, as well as syngenetic inclusions in diamonds are used as model approximations for boundary compositions of peridotite–carbonatite–carbon system researching in physico-chemical experiment at 6 GPa within the current study. Phase relations of the diamondforming system reveal the mechanisms of both, nucleation and crystallization of diamond as well as formation of paragenetic silicate and carbonate phases of peridotite paragenesises.

The goal of the study was modeling of phase relations of parental media for diamonds and peridotite and carbonatite mineral inclusions that appear within diamondforming chambers of the upper mantle in result of natural cooling of diamond-forming magmatic chamber, that is demonstration of the magmatic stage of its evolution under conditions of equilibrium and fractional crystallization.

A model peridotite with composition $Ol_{48}Opx_{16}Cpx_{16}Grt_{20}$, close to counted composition of the primitive mantle and real mantle xenoliths, complex carbonate with composition of $(CaCO_3)_{20}(Na_2CO_3)_{20}(FeCO_3)_{20}(Na_2CO_3)_{20}(K_2CO_3)_{20}$ that model a composition of fluid inclusions in natural diamonds as well as spectral pure graphite on base of isotope ¹²C as source of carbon in the system were used as a starting substance. Phase relations of boundary binary and pseudobinary systems carbonatite-carbon, peridotitecarbon, and peridotite-carbonatite were researched at 6 GPa and temperatures 1100-1750°C.

A graphite ampoule-heater with MgO-BN-insulating hub between a cell made of lithographic limestone and a graphite heater was applied for studying of the phase equilibrium. High pressures and temperatures were created within experimental cells with using of a toroidal type apparatus "anvil-with-hole" with duration of 5-60 min. After the runs experimental samples has been split, polished and researched by methods of scanning electron microscopy and microprobe analyses at IEM RAS. Phase diagram of the systems were plotted basing on the results of the experiments.

System carbonatite – carbon (figure 1) is characterized by eutectic melting and a presence of a curve of solubility of diamond in carbonate melts that distinguishes areas of melts unsaturated with carbon (on the left on the diagram) and saturated ones (on the right). The solubility curve controls conditions of diamond nucleation and crystallization. At once, it is conjugated physicochemically with phase fields of formation of associations of paragenetic carbonate minerals (iron containing Fe-Ms, sodium containing aragonite Na-Arag, and potassium carbonate (K_2CO_3) , by means of that their combined crystallization with diamonds and, correspondingly, a capture of their fragments by growing diamonds in form of syngenetic inclusions is provided. It was found that an accurate determination of appearing of carbonate phases is very difficult because of typical textures of carbonate mass and very small sizes of individual crystals, carbonates are often occur as a mix of all of five components.



Fig. 1. Phase diagram of system carbonatite (Carb) – carbon (C) with experimental points. Lcarb – carbonate melt, Diam – diamond.

Meanwhile, we managed to register an appearance of Fe-Ms, as well as "catch" a tendency of an appearance of Na-Arag and potassium carbonate (K_2CO_3) as the last phase.

Test experiments proving diamond-forming efficiency of carbonate-carbon melts oversaturated with carbon were carried out for system carbonate-carbon, the synthesized spontaneous diamond crystals in quenched carbonate melt (Lcarb) are shown on SEM images (fig.2).

It is known, that silicate melt react with diamond and graphite weakly and cannot provide diamond formation

[Borzdov et al., 1999]. That's why the boundary system peridotite – carbon (fig. 3) is notable for complete immiscibility of components of peridotite (olivine Ol, ortopyroxene Opx, clinopyroxene Cpx, garnet Grt, and peridotitic melt Lper) and carbon (diamond, graphite Graph and graphite melt Lgraph) in solid and liquid state and is a supplier of components providing a syngenesis of diamond and peridotite minerals in the base triple system peridotite – carbonatite – diamond.



Fig. 2. Diamond crystals, formed spontaneously from carbonate melt.



Fig. 3. Phase diagram peridotite-carbon with experimental points. Lper – melt of peridotitc composition.

System peridotite-carbonatite is also characterized with eutectic melting type (fig. 4a). Phase fields Ol+L, Ol + OPx+L, Ol+OPx+CPx+L, Ol+Opx+CPx+Grt+L were

experimentally determined on the diagram. Pyroxenes occur often as tight coalescences; therefore, liquidus line of clinopyroxene is marked by dashed line here. Experimental data of Bobrov A.V. with coauthors [Bobrov et al, 2011] were also used for determination of phase boundaries, they estimated an appearance of silicate minerals syngenetic to diamond in experiments for compositions Per₃₀Carb₇₀, corresponding to revealed position of concentration barrier of diamond nucleation CBDN [Bobrov, Litivn, 2009]. It is possible to trace graphically an evolution of diamond-forming carbonatesilicate chamber from complete or partial melt (depends on the temperature of its formation) up to complete subsolidus according to a diagram-section of the triple system peridotite-carbonatite-carbon, Per₇₀Carb₃₀ – C (fig. 4b). However, as it is known that studying ratio of carbonate and silicate Per70Carb30 is lower than CBDN (Per₇₀Carb₃₀), that is to the left of the kinetic level within the triple system peridotite-carbonatite-carbon (fig. 5), so, more likely, there will not be any spontaneous nucleation in the chamber of such type, in this case diamonds can grow on a seed, the studying section is within an area of metastable oversaturation (AMO).



Fig. 4. Phase diagram of peridotite-carbonatite system (a) and section of the triple system peridotite-carbonatite-carbon (b) with experimental points. Phase associations: 1 - L + Fe-Ms, 2 - L + Fe-Ms+Na-Arag, 3 - L + Ol + Fe-Ms, 4 - L + Ol + Fe-Ms+Na-Arag, 5 - L + Opx + Fe-Ms, 6 - L + Ol + Opx + Fe-Ms+Na-Arag, $7 - L + Ol + Opx + Fe-Ms+Na-Arag + K_2CO_3$, 8 - L + Ol + Opx + Fe-Ms, 9 - L + Ol + Opx + Cpx + Fe-Ms+Na-Arag, $10 - L + Ol + Opx + Cpx + Fe-Ms+Na-Arag + K_2CO_3$.



Fig. 5. A projection of liquidus surface of triple system peridotite-carbonatite-carbon combined with kinetic boundaries and fields (ALS, AMO, AUS, CBDN), the studying section Per₇₀Carb₃₀ is shown as a blue dashed line

System peridotite-carbonatite-carbon is responsible for formation of diamond (it is controlled by a curve of its solubility in carbonatite magmas) and paragenetic minerals (it is controlled by boundaries of phase fields of mineral associations at partial melting), correspondingly. Experimentally proved thermodynamic and kinetic points and fields (concentration barrier of diamond nucleation CBDN, solubility of diamond in completely miscible peridotite-carbonatite melts, areas of metastable oversaturation and area of labile solutions of peridotitecarbonatite-carbon melts, AMO and ALS, correspondingly, as well as an area of unsaturated solutions, AUS are indicated on a projection of liquidus surface of the triple system. The diagram characterizes physico-chemical conditions of syngenesis of diamond and paragenetic peridotite and carbonatite minerals.

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