EXPERIMENTAL MODELING OF ALKALI-CARBONATE METASOMATISME AND MELTING OF THE MANTLE: EFFECT OF TEMPERATURE ON THE PHASE RELATIONSHIP

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Key words: *metasomatoze, melting of eclogite, HPT experiment*

Both peridotite, and eclogite inclusions has a wide distribution in all types of deep magmas along with various crust xenoliths. Evidences of partial melting are widely spread in eclogite xenolites. A number of xenolites contains silicate glasses which are enriched in alkalis (up to 16 wt.%), phlogopites, carbonates, sulfides, sanidine. Formation of such exotic structures is resulted from partial melting of eclogites caused by the influence of deep alkaline fluids. We studied influence of temperature on the phase relationship at alkali-carbonate metasomatisme in temperature range from 850 to 1450°C and a pressure range from 3.6 to 4 GPa experimentally.

At the heart of research were two systems. The first (T=850-1450ºC) – carbon-saturated system, the second (T=1200-1250ºC) – "dry" system. Starting materials were composed of mixtures of picrobasalt and $(K, Na)_2CO_3$ (10 wt.%).Experiments were carried out in an anvil-with-hole apparatus by a quenching technique. The temperature is measured by a Pt30Rh/Pt6/Rh thermocouple. At high temperature, pressure is calibrated using a curve of balance quartz - coesite. Uncertainties are ± 5ºC for temperature and ± 0.1 GPa for pressure measurements. Duration of experiments was from 6 to 8 hours. Products of experiments were studied by PC-controlled scanning electron microscope Tescan VEGA TS 5130MM with detector of secondary and backscattered electron on the YAG-crystals and energy dispersive X-ray microanalyzer with semi-conductor Si(Li) detector INCA Energy 350.

Association of graphite-garnet-clinopyroxene-phlogopite with accessory chromite were formed at near-solidus (T=850°C, P=3.5GPa) alkali-carbonaceous metasomatism of eclogite in C-saturated system. This association co-exists with intergranular alkaline silicate melt (not more than 5%). Carbonate phase has not been found out. Clinopyroxenes contain 11-13 wt.% of CaO and up to 3.0 wt.% K_2O (tab.1).

Table 1

Representative phase composition of run products in C-saturated system. T=850ºC, P=3.5 GPa

	Ga	Cpx	Flog	m	Cht
SiO_2	39.6	50.7	36.2	52.54	0.2
TiO_2	0.4	0.1	0.3	0.75	0.4
Al_2O_3	19.1	7.0	18.0	13.44	31.3
Cr_2O_3	1.0	-	0.3	0.79	33.6
FeO	11.6	8.9	23.6	8.65	16.6
MgO	1.2	13.8	10.8	5.01	16.2
CaO	25.9	13.7	0.3	10.47	0.1
Na_2O	0.6	2.1	0.6	7.6	0.3
K_2O	<0.1	3.0	9.5	0.64	
Total	99.5	99.3	99.6	99.89	98.7

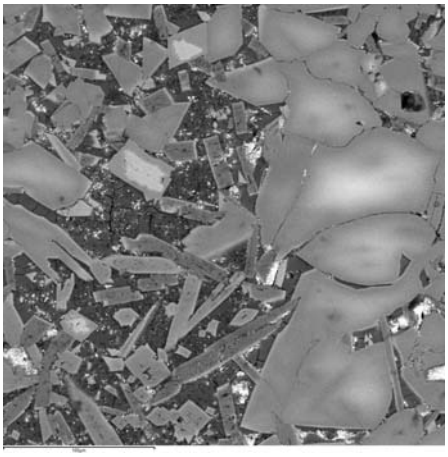

Fig.1. Backscattered electron photograph of run products. Melting of eclogite in C-saturated system at T=1300ºC, P=3.9GPa

Melting of eclogite (up to 30 % and more) increases at temperature increase up to 1300ºC (P=3.9GPa) at the same compositions in carbon-saturated system. The sample is presented by clinopyroxene, phlogopite, accessory chromite which cementing by alkaline Na-K silicate melt. However, the carbonate phase is not found out too. (fig. 1, tab. 2)

Table 2

Representative phase composition of run products in C-saturated system. T=1300ºC, P=3.9 GPa

	Cpx	Flog	Cht	m
SiO_2	46.72	41.66	0.08	46.10
TiO_2	3.60	1.55	0.4	0.37
Al_2O_3	14.44	14.61	31.26	19.87
Cr_2O_3	0.11	0.37	33.64	0.12
FeO	2.53	1.69	16.03	1.38
MnO	0.2	0.2	-	0.1
MgO	11.27	25.22	15.75	0.2
CaO	20.36	0.15	0.02	0.32
Na_2O	2.08	0.56	0.04	8.60
K_2O	<0.1	9.01	-	3.61
Total	98.24	95.13	97.39	81.50

Composition of liquidus associations in high-temperature (up to 1450°C) experiments differs from phase composition of near-solidus associations in low-temperature (850°C) experiments. At high-temperature experiments we observed only Ca-clinopyroxene (with <0.1% K_2O), garnet and K- clinopyroxene are not presented. Possible explanation of carbonate phases absence in these experiments it is low activity CO_2. Balance C-CO-CO_2 is displaced aside CO in the presence of graphite at T-P parameters of experiment. Absence of a garnet on the liquidus of alkaline silicate melts we also can explain as temperature effect.

Carbonatization of silicate melts were observed at alkali-carbonaceous metasomatism and partial melting of eclogite at T=1200°C, P=3.8GPa. Carbonatization of silicate melts occurred in C-unsaturated system with formation of immiscibility alkaline silicate and carbonate liquids. Alkaline melts (m) of phonolite composition coexist with carbonate melts (Ka), Ca-clinopyroxenes (Cpx), phlogopites (Flog) and chromites (Cht) (tabl.3, fig.2).

Table 3

Composition of coexisting phase at alkali-carbonaceous metasomatism and melting of eclogite. T=1200ºC P=3.8 GPa

	Cpx	Flog	m	Ka	Cht
SiO_2	52.1	40.1	49.0	2.4	0.65
TiO_2	0.5	1.4	0.5	0.1	0.7
Al_2O_3	7.8	12.9	14.9	1.0	21.75
Cr_2O_3	0.8	0.2	0.2	0.1	37.93
FeO	8.4	18.0	5.0	12.0	28.79
MgO	10.0	7.9	1.2	1.2	7.05
CaO	14.3	1.7	2.4	20.6	0.26
Na_2O	4.3	1.8	6.3	12.6	0.23
K_2O	0.1	6.1	6.1	1.1	0.08
Total	98.4	92.2	83.6	52.0	97.44

Experimental samples are presented by large (tens micron) the tabular form silicate minerals, which are cementing by silicate glass (quench silicate melt) with the oval form inclusions of carbonate phases (quench carbonate melt). The size of carbonate phase is about 5-10 μm. Carbonates are enriched (in recalculation on 100% oxide, without CO_2) by Ca (to 40 wt.% of CaO), Na (to 25 wt.% Na_2O), contain SiO_2 (to 5 wt.%), and characterized by high solubility of sulphur (to 3 wt.% SO_3) (fig. 2).

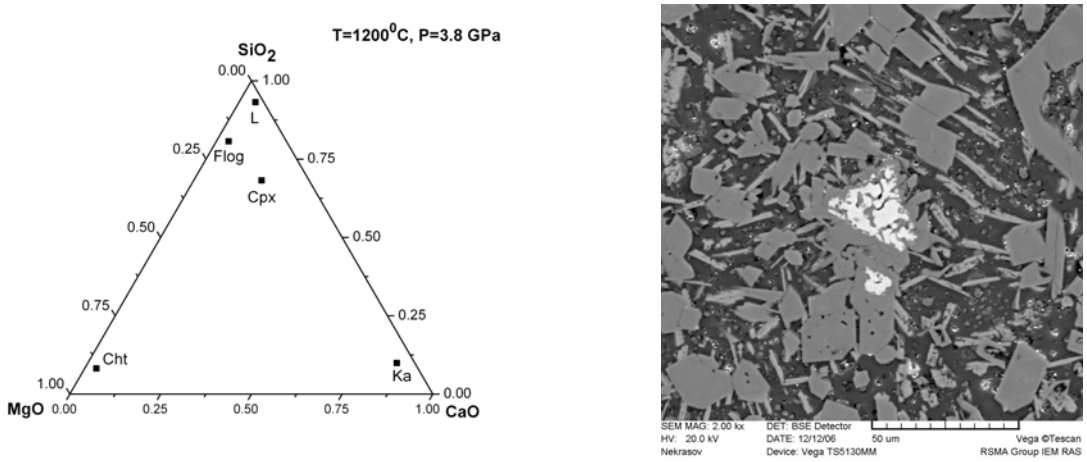

Fig.2. Melting of metasomatic eclogite, liquid silicate-carbonate immiscibility. At the left - structures of coexisting phases: m – silicate melt, Ka – carbonate melt, Cpx – clinopyroxen, Flog – phlogopite, Cht - chromite. On the right – backscattered electron photograph of run products

At the same system, at temperature increase up to 1250ºC (P=3.8 GPa), experimental samples consist of immiscibility alkali silicate, carbonate and sulfide melts which coexist with phlogopite, Ca-clinopyroxene, chromite and garnet (tabl.4, fig. 3).

Table 4

Composition of coexisting phase at alkali-carbonaceous metasomatism and melting of eclogite. T=1250ºC P=3.8 GPa

	Cpx	Ga	m	Ka	Flog
SiO_2	52.5	44.22	55.53	0.58	39.43
TiO_2	0.27	0.02	-	-	0.38
Al_2O_3	8.11	24.07	21.33	0.34	14.93
Cr_2O_3	0.11	0.71	-	-	0.14
FeO	1.32	3.18	0.66	3.95	1.5
MgO	17.87	23.47	2.18	4.64	23.46
CaO	18.76	6.03	0.63	35.77	0.1
Na_2O	1.41	0.24	10.91	1.55	5.04
K_2O	0.09	-	2.4	0.14	9.76
Total	100.4	101.94	93.64	46.97	94.74

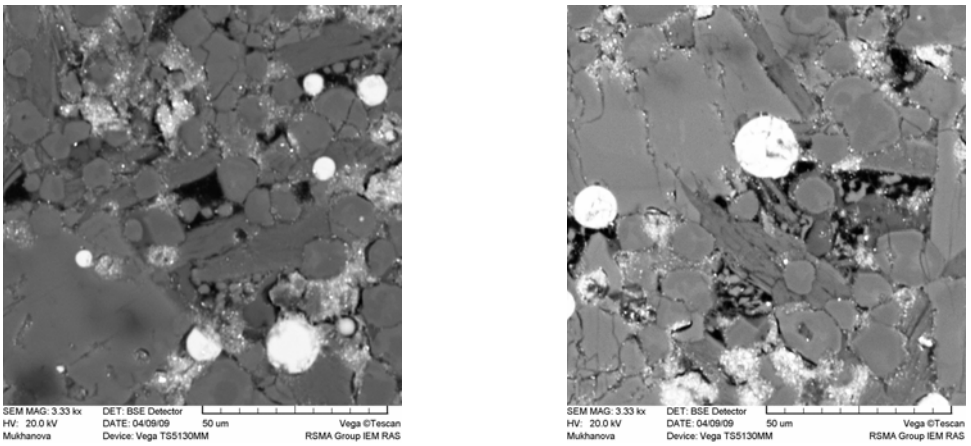

Fig.3. Backscattered electron photograph of run products

During researches has been finding out that alkali-carbonaceous metasomatism and melting of eclogite leads to formation of alkaline and carbonate melts. Features of melt composition and associations of minerals coexisting with them show efficiency of alkali-carbonate melts in metasomatic trans-

formation of the upper mantle and the important role of these processes in mantle magma-formation, including formation alkaline and carbonatite magmas. Experimental results show effective influence of temperature on phase correlation and interphase distributions of components in investigated system.

Supported by Grant RFBR 09-05-01131

Electronic Scientific Information Journal "Vestnik Otdelenia nauk o Zemle RAN" № 1(27)'2009
ISSN 1819 – 6586
Informational Bulletin of the Annual Seminar of Experimental Mineralogy, Petrology and Geochemistry – 2009
URL: http://www.scgis.ru/russian/cp1251/h_dgggms/1-2009/informbul-1_2009/magm-19e.pdf

Published on July, 1, 2009
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