

Experimental study of interphase partitioning of rare elements in diamond forming eclogite-carbonatite and peridotite-carbonatite systems

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Study of geochemistry of syngenetic inclusions with growth carbonate-silicate melts and minerals that crystallized together with diamond in them are complicated, and data about trace elements partitioning numbers between mineral and melt phases of diamond forming systems of the Earth mantle are extremely low.

Earlier authors studied at high pressure phase relations and interphase participation of rare elements at melting of natural carbonatite [Kuzyura *et al.*, 2008]. Possible compositions of chemically changeable carbonate-silicate growth medium for diamond were modeled by mafic carbonatite from Chagatai complex (Uzbekistan). Their melts are highly effective for diamond nucleation [Litvin *et al.*, 2001, 2005]. At that time garnets and clinopyroxenes similar to ones associating with high calcic diamondiferous eclogites and grosspidites form syngenetically with diamonds. [Bobrov *et al.*, 2004].

Further study of participation of rare elements in diamondiferous mantle systems was relates to model eclogite-carbonatite and peridotite-carbonatite systems. In this connection series of experiments on experimental research of equilibrium participation of rare elements “mineral-melt” and “mineral-mineral” in eclogite-carbonatite and peridotite-carbonatite systems were carried out with using of apparatus “anvil-with-hole”-like (IEM RAS) at 7–8.5 GPa. Prepared in special way mixture of rare elements, mainly in oxides: Li, Rb, Cs, Ba, Th, U, Ta, Nb, La, Ce, Pb, Pr, Sr, Nd, Zr, Hf, Sm, Eu, Gd, Tb, Dy, Y, Ho, Er, Tm, Yb, Lu, Sc, и Zn was added to the systems. Starting proportions of components were $[[CPx_{40-64}Grt_{16-40}(SiO_2)_{20}]_{59,3}Carb_{39,3}]_{98,6}RE_{1,4}$ for eclogite-carbonatite system and $[[Ol_{36-60}OPx_{16}CPx_{12-24}Grt_{12-24}]_{30}Carb_{70}]_{99}RE_1$ for peridotite-carbonatite system. After quenching experimental samples were spited and polished. Electron microprobe and SEM researches were carried out on the polished surfaces with carbon covering in IEM RAS. Contents of trace elements in grains on the same samples (carbon covering has been removed from) were determined using of method of LA-ICP-MS in mineralogical department of the London Natural History Museum.

We analyzed homogeneous melt areas and isometric grains of minerals – garnet, clinopyroxene, olivine.

Quite large (more than 100 μm) garnet, clinopyroxene, and olivine crystals crystallized form melt in experiments at 7.0–8.5 GPa (fig. 1). Mostly the crystals appear surrounded by melt in quenched samples. In some cases large crystals are separated from parental carbonate-silicate quenched melt because of low viscosity of the melt and gravitation. Carbonate-silicate melt is in intergranular space in such samples. Melt of model eclogite-carbonatite and peridotite-carbonatite systems quenches as cryptocrystalline aggregate. Most cryptocrystalline areas were chosen for analyses, analyses was done on squares.

Based on results of analyses of content of rare elements in experimental phases by LA-ICP-MS-method, coefficients of interphase participation (Kd) garnet-melt, clinopyroxene-melt, and garnet-clinopyroxene were calculated. There is a diagram demonstrating participation of rare elements between garnet and carbonate-silicate melt, clinopyroxene and carbonate-silicate melt, and garnet and clinopyroxene on fig. 2. Such kind of data present for natural system with Chagatai carbonatite and for model eclogite-carbonatite system only. The main feature of the obtained picture of interphase partitioning of trace elements

is quite different behavior of light (La, Ce, Pr) in relation to medium and heavy (Nd, Zr, Hf, Sm, Eu, Gd, Tb, Dy, Y, Ho, Er, Tm, Yb, Lu) rare-earth elements. While light elements are mainly distributed in melt phase, the heavy ones go to garnet. A number of elements including LILE (Rb, Sr, Ba), Sc, as well as Zn, Ta, Pb, Th, and U Sc, V, Y, Zr, and Hf have a clearly expressed affinity to carbonate-silicate melt. A curve format on the diagram of participation garnet-melt is practically confirms a curve format for garnet-clinopyroxene participation, this testifies to that main participants of rare elements distribution are garnet and carbonate-silicate melt, clinopyroxene plays a part of Zn-concentrator in the process.

By preliminary data, garnet and clinopyroxene are main collectors of rare elements in peridotite-carbonatite system.

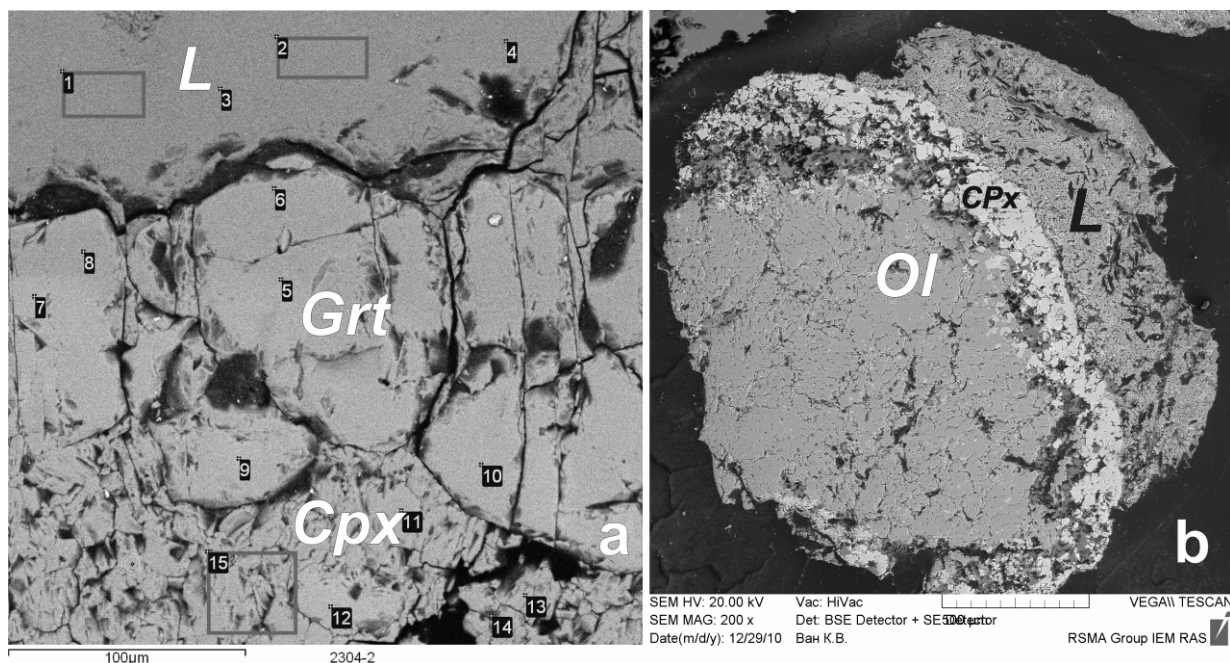


Fig. 1. SEM photograph of experimental samples: a) sample 2304, system eclogite-carbonatite [$CPx_{52}Grt_{28}(SiO_2)_{20}]_{59.3}Dol_{39.3}RE_{1.4}$, 8.5 GPa, 1600°C, duration 155 min; b) sample 2351, system peridotite-carbonatite [$Per_{30}Carb_{70}]_{99}RE_1$, 7 GPa, 1400°C, duration 180 min. *Grt* – garnet, *CPx* – clinopyroxene, *Ol* – olivine, *L* – completely miscible carbonate–silicate melt, *Dol* – dolomite, RE – mixture of rare elements, *Per* – peridotite, *Carb* - carbonate

The obtained participation pictures were compared with data of different researchers. Experimental study of interphase partitioning of trace elements between garnet and carbonatite melts and other chemically different melts were spent before for limited set of rare elements at 2.7–3.3 GPa and 1000°C [Sweeney *et al.*, 1992, 1995; Van Westrenen *et al.*, 1999; Walter *et al.*, 2008]. However those used PT -parameters were not within the area of thermodynamic stability of diamond. For comparison K_d available from literature on these researches were inserted on our graphs of participation. Thus, there were find out a similarity in contrast behavior of light and heavy REE and other RE at comparison of distribution of rare elements between garnet and carbonate-silicate melt of Chagatai carbonatite and model eclogite-carbonatite system, from one side, and garnet and model silicate melt, from other side [Van Westernen *et al.*, 1999].

Therefore, the detected similarity in tendencies of trace elements partitioning between garnet phase, on the one hand, carbonatite and silicate melts, with another, basically, hampers an identification of melt "partner" on the basis of relative contents of trace elements for garnet phase only

The results demonstrate that rare elements participation doesn't depend significantly on melt composition. Heavy RE are concentrated in a melt. Diamondiferous carbonate-silicate, carbonate, and silicate melts behave similarly in respect of participation of rare elements.

Data about trace elements partitioning numbers between mineral and melt phases of diamond forming systems of the Earth mantle were unknown until the present work. Studying of interphase trace elements partitioning patterns for mantle diamond forming processes becomes possible in connection with development of methods of physical and chemical experiment together with high-sensitivity analytical methods. These investigations have also more general geochemical value as formation of growth media for a

great bulk of natural diamonds and syngenetic minerals included in them are a part of general process of magmatic evolution of mantle substances and is integrated physico-chemically and spatially to it.

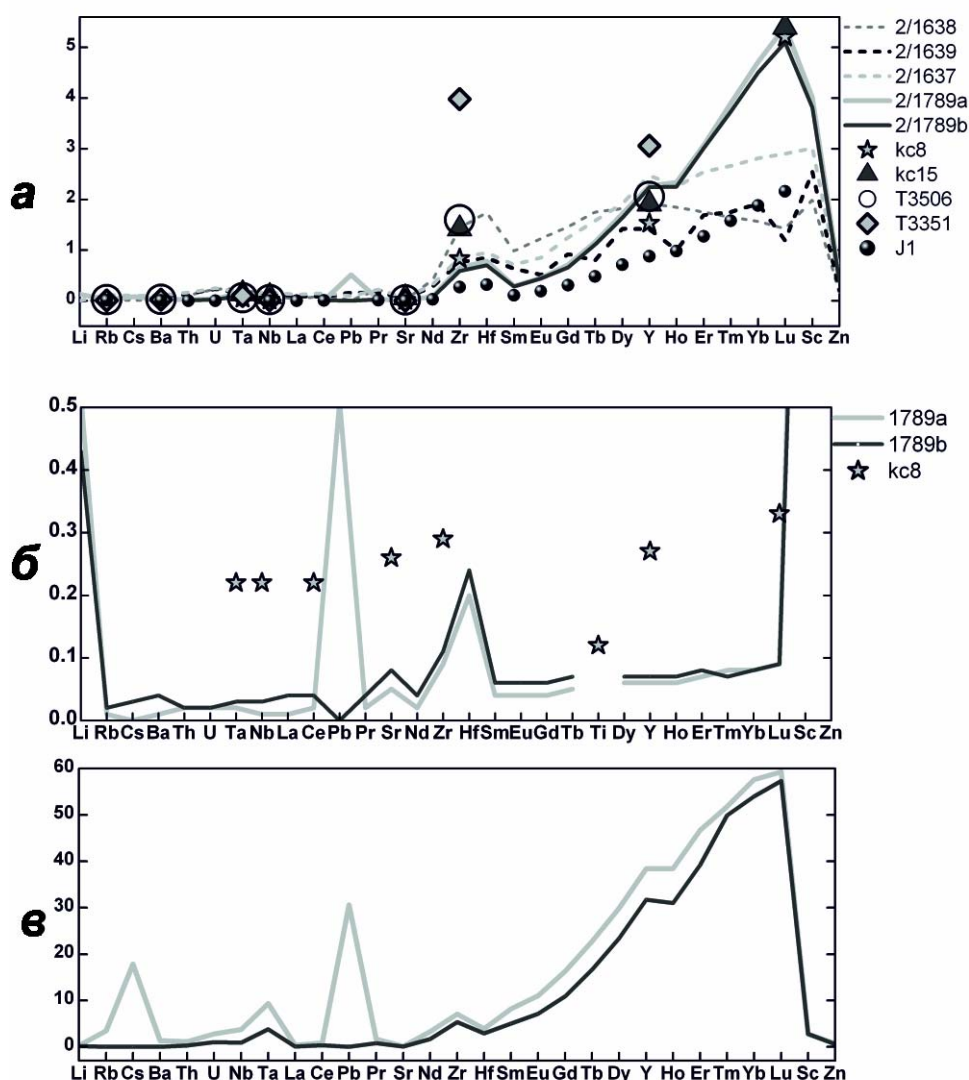


Fig. 2. Diagrams of interphase participation of rare elements between: (a) – garnet and carbonate-silicate melt; (b) – clinopyroxene and carbonate-silicate melt; (c) – garnet and clinopyroxene; kc8, kc15, T3506, T3351, J1-data from literature; 2/1638, 2/1639, 2/1637, 2/1789 – our experimental samples obtained at melting of natural Chagatai carbonatite and model system eclogite-carbonatite

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KUZYURA ET AL.: INTERPHASE PARTITIONING OF RARE ELEMENTS

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