GARNETS FROM MEGACRYSTS AND DEFORMED XENOLITHS FROM YAKUTIAN PROVINCE: CHEMISTRY AND GEOCHEMISTRY

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The asthenospheric source is commonly accepted for the genetic interpretation of minerals in megacryst assemblages from kimberlites and deformed lherzolites. Both assemblages are regarded as highest temperature and high-pressure formations in the mantle. According to [1-3], minerals of the megacryst assemblage are products of fractional crystallization of the asthenospheric melt. At the same time, the problem of close association of the formation of megacrysts and deformed lherzolites is discussed in [6], in which the lithospheric origin of deformed peridotites is suggested and evidence of refertilization of the lower lithosphere by asthenospheric melts is presented. All these problems remain to be solved and require further investigations. The compositions of main, rare-earth elements and Sr, Nd, O isotope compositions in garnets from the megacrysts were defined in the kimberlites from Udachnaya pipe and from pipes of Verkhne-Muna field of the Yakutian Province, as well as in xenoliths of deformed peridotites of Udachnaya-Vostochnaya pipe.

Methods of studies. Trace element composition of minerals was defined via ionic micro analyzer «Cameca IMS ion probe» at the Institute of Microelectronics, RAS (Yaroslavl). Isotope studies of Rb-Sr and Sm-Nd systems were done on modernized Mass-spectrometer MI 1201-T and Finnigan MAT 262 at the Institute of Geochemistry SB RAS (Irkutsk). Oxygen isotope in garnets was analyzed at the analytical center of RAS (Vladivostok) with the help of fluoridation on MS Finnigan MAT 252. The reproducibility of $\delta^{18}O$ results for the samples amounted 0.1 ‰.

Results of investigations. The garnets from megacryst basically have low Cr contents, and high-Cr garnets from megacrysts have been recovered only in the Verhnemunsk field and in the Griba pipe. Deformed lherzolites make up two groups of xenoliths with relatively large and small grains of garnet having low and high Cr_2O_3 contents, accordingly. On the Mg-Fe-Ca diagrams the large-porphyry lherzolites display (Fig. 1) the trend parallel to the Mg-Fe axis with Ca abundance unchanged. The small-porphyry lherzolites display the trend parallel to the Mg-Ca axis with Fe abundance unchanged.

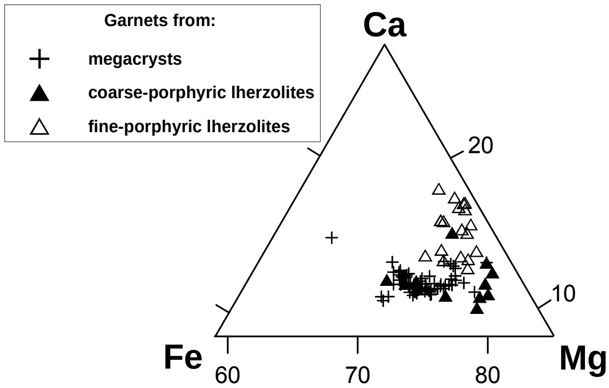
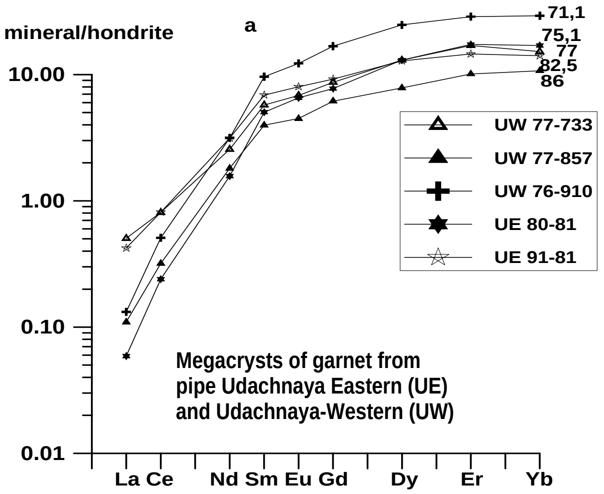
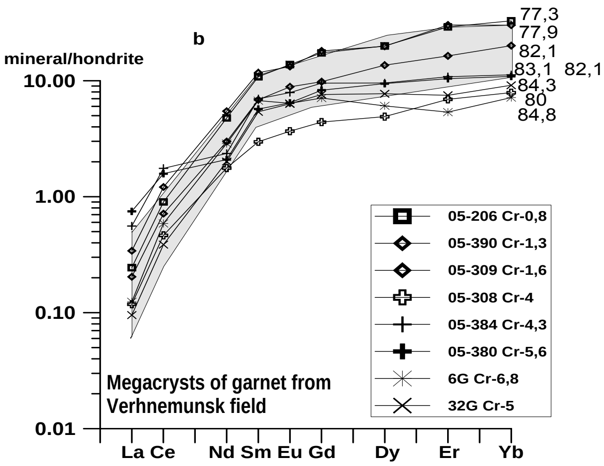


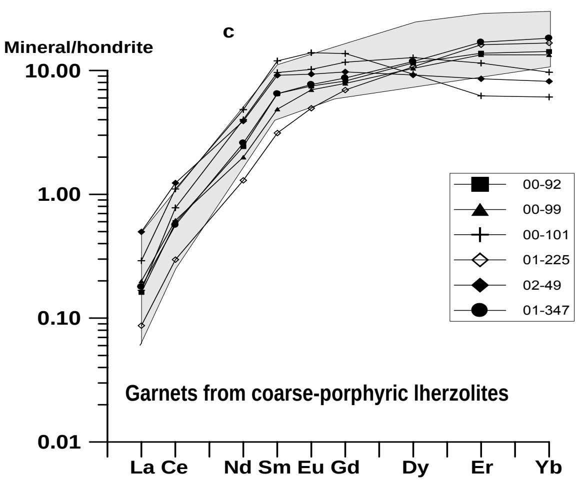
Fig. 1. Ternary diagram showing chemical compositions of garnets from megacryst assemblage and deformed lherzolite xenoliths in the Udachnaya kimberlite pipe.

It appears that different trends of garnet compositions reflect different processes of their crystallization: (i) magmatic (Mg-Fe isomorphism) and (ii) metasomatic (Mg-Ca isomorphism). The features of distribution seem to be similar for both chemical and rare earth compositions of garnet from large-porphyry deformed lherzolites and megacrysts. The spider diagram pattern of REE distribution (Fig. 2) is similar in both varieties: it depends on the Cr_2O_3 content in garnets. In case of high Cr_2O_3 in megacrysts and garnets from large-porphyry lherzolites the HREE concentration diminishes. It has been concluded that the same process proceeding in the same mantle source had derived both formations. The distribution of incompatible trace elements in the garnet shows a distinct inverse correlation between the REE content and Mg#. This relationship is characteristic of garnet megacrysts from all pipes without any exception. The REE patterns of xenoliths from the coarse- and fine-porphyric peridotites are significantly different (Fig. 2c,d). The low-Cr garnets from the coarse-porphyric lherzolites are close to low-Cr garnet megacrysts in terms of both the REE contents and REE patterns. The REE patterns of high-Cr garnets from the coarse-porphyric lherzolites (samples 00-101 and 02-49) show a distortion in the HREE region (flattening of the spidergrams similar to the high-Cr garnet megacrysts).
The hypothesis on the fractionation crystallization of garnet megacrysts has been proposed; however it contradicts the features on incompatible elements

distribution. It is proposed that the megacryst association was crystallized from the asthenosphere melt, which, when ascending produced metasomatic effect on the rocks of lithosphere mantle and evolved towards increasing the Mg and Cr abundances due to lithosphere substance contamination.







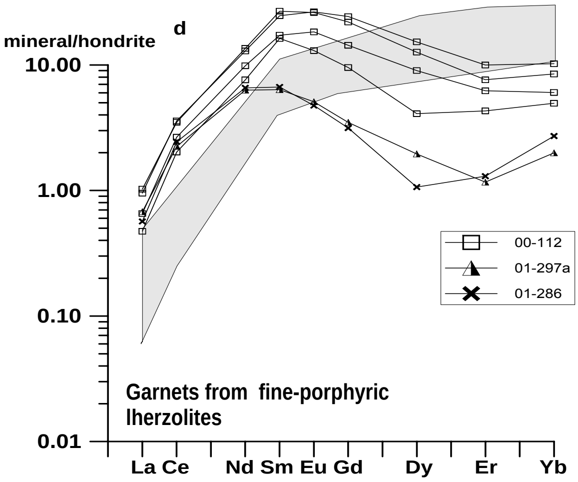


Fig. 2. Spidergrams of REE distribution in garnets from megacryst assemblage and deformed coarse-porphyric and fine-porphyric lherzolite xenoliths. The gray field corresponds to low-Cr garnet megacrysts from various kimberlite pipes of the Yakutian province. Numerals in panels (a) and (b) are Mg# values; Cr_2O_3 contents (wt %) are indicated for the Verkhnemunsk field.

Sr, Nd, and O isotopic systematic confirms conclusion about astenospheric source of megacryst formation. Age of garnet and phlogopite megacrysts (Rb-Sr isochrones) compile approximately 400 m. years. Thus, crystallization of the megacrysts occurred shortly before kimberlite intrusion.

The studies of Sr, Nd and O isotope systematics for the megacryst association of minerals from diamond-bearing pipes of the Yakutian province provided the following conclusions:

1. Oxygen isotope composition for megacryst Gar ($\delta^{18}O$ = < 5‰) is lighter as opposed to known values [4] for garnets from xenolith of the lithosphere mantle (Fig. 3.), that indicates a predominant astenospheric source for origin mineral megacryst associations. Similar correlation of O isotope composition was obtained for olivine from megacrysts and xenoliths of the lithosphere mantle (Fig. 4).

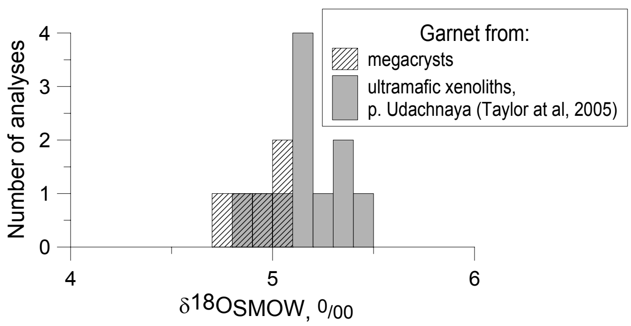


Fig. 3. Histograms of oxygen isotope composition distribution ($\delta^{18}O$) in the garnets of different paragenesis from Udachnaya-vostochnaya pipe.

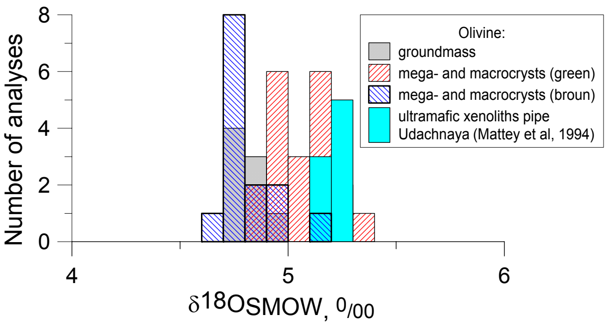


Fig. 4. Histograms of oxygen isotope composition distribution ($\delta^{18}O$) in the olivines of different paragenesis from Udachnaya-vostochnaya pipe. Groundmass olivine forms idiomorphic crystals with size 0.1-0.5 mm in the non-altered kimberlite. Mega- and macrocrysts of olivine (green color) are characterized by 92-94% Fo and belong to dunite-harzburgite paragenesis. Mega- and macrocrysts of olivine (brown color) are characterized by 86-90 Fo. We suppose, their origin is connected with kimberlites.

2. Initial isotope $^{87}Sr/^{86}Sr$ ratio for Gar megacrysts varies within 0,70355-0,70367 (εSr = -4,7 - -6,8) and corresponds to weakly depleted mantle source recalculated for the age as 400-425 Ma. Initial isotope $^{142}Nd/^{143}Nd$ ratio for garnet megacryst from pipes Udachnaya-vostochnaya and Komsomolskaya-Magnitnaya (Verhkne-Muna field) was determined as equal to 0,512589 and 0,512425 (δNd = 7,56 и 4,36) correspondingly, that corresponds to weakly depleted mantle source recalculated for the age as 400 Ma.

3. Isochronous Rb-Sr age for megacryst Phl and Gar practically coincide and amounted to 401,5±3,3 and 400,8±5,5 Ma, correspondingly. The comparison with the age of Udachnaya-vostochnaya pipe origin (367 Ma [5]) indicates that the crystallization of the major part of the megacryst association, accompanied by the metasomatic transformation of the lithosphere mantle occurred in the pre-kimberlite period from the astenospheric liquid.

The main results of investigations are obtaining new data, which contradict a widely used hypothesis concerning the origin of megacryst garnet only due to fractionation crystallization. We have arrived at the conclusion on the significance of metasomatic processes in the formation of megacrysts. The origin of low-chromium megacrysts and deformed coarse-grained lherzolites is associated with astenospheric source. In addition to the astenospheric source the contamination of rocks under the lithosphere mantle was significant in the formation of high-chromium megacrysts.

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