Skublov S.G., Drugova G.M. Peculiarities of distribution of REE in amphiboles and their application to reconstruction of metamorphic parameters

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The highly precise methods allowing to analyze rare elements and REE in minerals, such as INAA, SIMS, PIXE, LA-ICP-MS, give a new possibilities to study petrology of polymetamorphic complexes. A common presence of amphiboles in rocks from the green-schist facies to the granulite facies makes these minerals attractive for the reconstruction of metamorphic sequences and character. Nevertheless, an application of amphiboles in the petrological modeling is very confined because of their mineralogical and crystal chemical complexity. The known amphibole-bearing mineral thermometers and barometers are empirical and often are not consistent with calculated thermodynamic data. Calcic amphiboles are characterized by high concentration of REE. In addition, a number of investigators showed that REE and rare elements were able to accommodate in different sites in amphiboles. That explains their different mobility and unambiguous behavior in petrological processes [1]. Until now, distribution of REE in metamorphic calcic amphiboles was not studied. The mostly investigated amphiboles are those of magmatic rocks and eclogites. There are just rare determinations of REE in amphiboles of the granulitic facies [2], whereas data on amphiboles from amphibolites are practically absent. The present study is based on the analysis of REE distribution in amphiboles from the polymetamorphic Nyurundukanskii Complex (N-W Cis-Baikalie). The REE concentrations were measuered by the INAA method in the Institute of Precambrian Geology and Geochronology RAS and ion microprobe (SIMS) in IMI RAS.

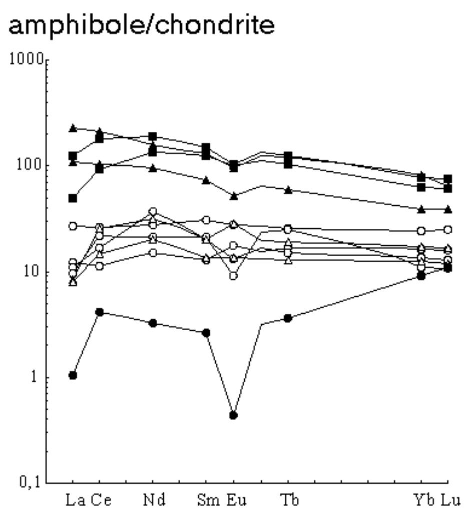

Fig. 1. Spectra of REE distribution (normalized to chondrite) of amphiboles from rocks of the Nyurundukanskii Complex (solid triangles and quadrangles – amphiboles of granulite facies, open symbols - amphiboles of amphibolite facies, solid circles – metasomatic amphibole).

The Precambrian Nyurundukanskii Complex is heterogeneous in structure. It consists of two-pyroxene cristalline schists of granulite facies (770-850^{O}C, 5-6 kbar), amphibolites, and gabbroids. The Nyurundukanskii Complex was affected by several consequent metamorphic stages with a general tendency of an decrease of temperature at different pressures in different portions of the Complex. The general feature of the Nyurundukanskii Complex is imposed low-pressure high-temperature amphibolite metamorphism (650^{O}C, 4-5 kbar). Only at the contact of the Nyurundukanskii Complex with the low-grade Olokitskii Complex, there is a shear zone, where amphibolized granulites and amphibolites are transformed to garnet amphibolites. High-pressure (580-630^{O}C, 9-10.5 kbar) metamorphism was followed by retrograde (550^{O}C, 6-7 kbar) stage accompanied by widely developed metasomatism. All metamorphic stages, from granulite to low-temperature amphibolite, were reflected in amphibole compositions, both in major components and rare elements [3, 4]. Calcic amphiboles are present practically in all rock types.

A total REE content in analyzed amphiboles distinctly depends on metamorphic grade. A average content of REE in granulitic amphiboles is 225 g/t, in amphibolitic, 34 g/t. The total REE content in metasomatic amphibole is below 11 g/t. Thus, REE content in amphiboles significantly decreases with the temperature decrease. The ion microprobing of the zoned amphibole from the Nyurundukanskii Complex showed the same regularity within the single grain [5]. The central part of amphibole is brawn hornblende with high TiO_2 content. The total REE content in the center is 4-5 higher than in the rim (green hornblende).

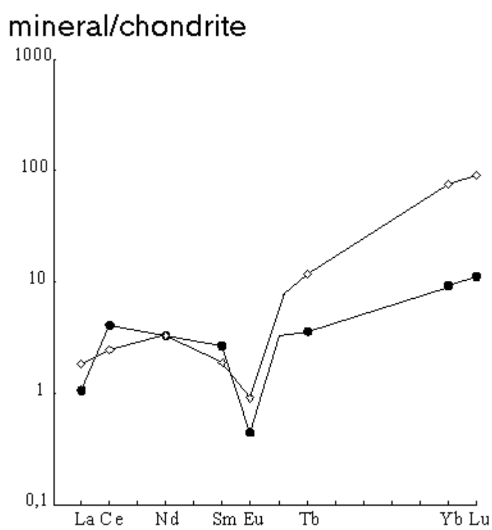

Fig. 2. Spectra of REE distribution (normalized to chondrite) in amphibole (solid circles) and garnet (open circles) from metasomatic rock.

The curves of REE distribution, normalized to chondrite [6], are different for different groups of amphiboles (Fig. 1). Granulitic amphiboles demonstrate a distinct decrease from LREE to HREE. Amphibolitic amphiboles are characterized by lower total content of REE, 10-30 times higher than chondritic, low La/Yb ratio both in the high-pressure conditions and beyond them (garnet-free assemblages). Appreciable oscillations of the REE content in these amphiboles are observed within average REE. I can be concluded that content and distribution of REE is conditioned mostly by thermal regime of metamorphism and does not depend on pressure. The REE curve in metasomatic amphibole strongly differs from amphiboles of main metamorphic stages. It is similar to the REE curve of coexisting garnet with a distinct Eu-anomaly and an increase from average REE to HREE (Fig. 2). No doubt, that such distribution is inherited from garnet. Similar inheritance of REE distribution from garnet and clinopyroxene was observed in study of the imposed metamorphism in eclogites and metamorphosed oceanic gabbro [7]. An analyses of such relationships gives a possibility to establish a sequence of mineral formation.

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