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Zircon-pyrochlore ores of the Gremiakha-Vyrmes massif, Kola Peninsula

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The Gremiakha-Vyrmes massif is the largest Early Proterozoic alkaline–ultrabasic complex of the Kola Peninsula, including four complexes (from old to young): basic-ultrabasic; foidolitic; alkaline-granites and granosyenites; alkaline metasomatic rocks and carbonatites.

This massif comprises the largest titanomagnetite-ilmenite deposits in Russia. In addition, Gremiakha-Vyrmes massif contains significant resources of Zr and Nb. Zircon–pyrochlore mineralization was discovered late in 1980 by Murmansk Geological service. We have obtained a new mineralogical and geochemical results on rare-metal ores.

The rare-metal ores are located in metasomatic rocks in the central part of the massif. The approximate area of metasomatic rocks is 10 km2. These rocks are made of albitites, aegirinites and nepheline-aegirine rocks, which occur as lenses, pegmatoids bodies and veins intersected by calcite carbonatite veins. The metasomatic rocks are composed of main minerals: albite, orthoclase, aegirine, phlogopite-annite and minor zircon, pyrochlore-group minerals, ilmenite, titanite, prehnite, calcite, REE silicates, zeolites, graphite and sulfides. Carbonatite does not contain accessory Zr-Nb minerals.

The trace element spectra for the metasomatic rocks are close to the Gremiakha-Vyrmes foidolites, which exhibit a negative Rb, K, Pb, P and Ti anomalies but albitites are enriched in U - up to 655 ppm, Zr up to 1384 ppm, Nb - up to 21712 ppm and Ta up to 330 ppm. Aegirinites are enriched in Zr up to 3450 ppm.

Trace element patterns for the Gremiakha-Vyrmes carbonatites are similar to calcite carbonatites of the globe (Woolley & Kempe, 1989); however, they are characterized by lower concentrations of Th, U, REE and higher Rb, K, Sr, Ti.

In metasomatites, zircon and pyrochlore are main rare metal minerals, which crystallized at the latest stages. Pyrochlore and zircon form two generations. The minerals of early generation are large heterogeneous metacrystals composed of inclusions of host rock and accessory minerals: calcite, prehnite, ilmenite, thorite, thorianite, coffinite, thorogummite, REE silicates, graphite and sulfides. The crystals of late generation do not contain inclusions. Central zones of pyrochlore usually consist of Ca–Na pyrochlore, rarely uranpyrochlore, intermediate zones are enriched in U, Ba, Sr. The cation-deficient hydrated and Si-rich pyrochlore are present in the rim and fractures zone. Zircon crystals are nearly stoichiometric in composition; Ca, Ce, Al, Fe, Nb, U and Ti are near their limits of determination. The chemical variations of zircon show that the intermediate zones are enriched in Pb, Y and Th, relative to the central zones, and overgrowth zones are enriched Hf only.

The rare metal minerals of early stages are crystallized in high alkaline hydrothermal environment at increased activity of U, Th and a temperature of near 600° C (according to isotopic graphite-calcite and biotite-pyroxene thermometers). The minerals of latest stages occurred under low-temperature, decrease of pH and high activity of Si, REE, Sr, Ba, Fe and Al. We suggest that carbonatites were the source of Nb, U, Th, Zr and REE. Metasomatic rocks accumulate rare metals and could be formed during the metasomatism triggered by intrusion of carbonatites into the alkaline and basic-ultrabasic complexes of the massif.