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# The rare-metal ore potential of the Proterozoic alkaline ultramafic massifs from eastern part of the Baltic Shield in the Kola alkaline province.

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The Kola Alkaline Province consists of intrusions of two main stages of the intraplate alkaline magmatism. The early stage of igneous activity occurred in Proterozoic 1.9 billion years ago, the next in Paleozoic at 380 million years. The Proterozoic alkaline magmatism produced Gremyakha-Vyrmes and Elet'ozero large alkaline-ultrabasic massifs, Tiksheozero carbonatite massif and numerous small syenite complexes. Paleozoic magmatism on Baltic Shield exhibited more widely, than Proterozoic. The world largest Khibiny and Lovozero alkaline intrusions, numerous alkaline-ultrabasic massifs with carbonanites, alkaline dike swarms and diatremes were formed.
It is well known that carbonatites of Paleozoic alkaline-ultrabasic massifs contain large-scale deposits of rare-metal ores (Afanasiev et al., 1998). The metasomatic rocks on foidolites and carbonatites of Gremyakha-Vyrmes are final products of differentiation of Proterozoic alkaline-ultrabasic magma enriched in incompatible elements, including Nb and Zr similar to Paleozoic carbonatites.
The massif Gremyakha-Vyrmes is one of the largest titanomagnetite-ilmenite deposits in Russia associated with ultrabasites. Our investigation showed that albite-microcline and aegirine-albite metasomatites formed rich rare-metal ores consisting of 3.2 wt. % Nb2O5 and 0.7 $ZrO_2$.
Zircon and pyrochlore-group minerals represent the main minerals of rare-metal ores.
The following evolutionary sequences of pyrochlore group minerals has been observed: betafite or U pyrochlore – Na-Ca pyrochlore – Ba-Sr pyrochlore - "silicified" pyrochlore - Fe-Nb, Al-Nb silicates. Such evolution from primary Nb oxides to secondary silicates under low temperature hydrothermal conditions is similar to the evolution of rare metal phases in Paleozoic alkaline massifs analogous to Lovozero syenites and in carbonatites.
The rare metal minerals of Gremyakha-Vyrmes crystallized in high alkaline hydrothermal environment at increased activity of Nb, Ta, Zr, U, Th and at temperature near 600-650°C (according to isotopic graphite-calcite, biotite-pyroxene and zircon-rutile thermometers). The minerals of latest stages occurred under low-temperature, decrease of pH and high activity of Si, REE, Sr, Ba, Fe and Al.
Isotope data obtained for carbonatites and metasomatites of the Gremiakha-Vyrmes massif linked to a mantle source. 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.
The nepheline-feldspathoid-aegirine pegmatoids, carbonatite veins and breccia of Elet'ozero Proterozoic alkaline-ultrabasic massif formed rare-metal ores and showed genetic similarity to final products of differentiation of the Gremyakha-Vyrmes.
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