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Zircon-pyrochlore ores of Proterozoic Gremyakha–Vyrmes polyphase massif, Kola Peninsula: source and evolution

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The alkaline–ultrabasic Gremyakha–Vyrmes massif occurs within the Central Kola terrane in the northern part of the Fennoscandian Shield and consists of diverse rock complexes: basic-ultrabasic rocks, foidolites, alkaline metasomatic rocks and carbonatites, alkaline granites and granosyenites. Nb-Zr ore deposit is confined to alkaline metasomatic rocks developed over foidolites. The metasomatites are represented by albitites and aegirinites occur as submeridionally orientated zones extending up to 6-8 km and several hundred meters thickness. They are mainly composed of albite and aegirine, but amphibole, annite, microcline, fluorapatite, titanite, ilmenite, pyrochlore group minerals, zircon are present [Sorokhtina et al., 2016]. Carbonatites are developed sporadically and accessory zircon but not the pyrochlore is observed only in contact zones with albitites and aegerinites.
In metasomatites, zircon and pyrochlore are main rare metal minerals, which are formed at the latest stages of crystallization. Ca-dominant fluorcalcio- and hydroxycalciopyrochlores are the most abundant, whereas U-dominant pyrochlore, oxyuranobetafite, zero-valent-dominant (Ba, Sr-dominant) pyrochlore, hydro- or kenopyrochlore are rare. The pyrochlore-group minerals form heterogeneous metacrystals containing inclusions of host rock minerals, calcite, ilmenite, zircon, sulfides, and graphite. While pyrochlore is replaced by Si-rich “pyrochlore” (SiO_2 is up to 18 wt.%.), cation-deficient hydrated pyrochlore, Fe–Si–Nb, U–Si–Nb, and Al–Si–Nb phases along fracture zones and margins. The early generation zircon is represented by large heterogeneous metacrystals filled with inclusions of various host rock minerals, calcite, ilmenite, thorite, thorianite and sulfides, while the late zircons are empty of inclusions. Zircons are nearly stoichiometric in composition; but intermediate zones are enriched in Pb, Y and Th, and overgrowths are enriched Hf only. According to CL and ion-microprobe analysis zircon has polygenetic nature: some relics inherited from foidolite crystallized at about 800°C, whereas the newly formed – at 600°C [Watson et al., 2006].
The time interval of the magmatic massif formation may be estimated as long as 80-100 Ma only. The basic-ultrabasic rocks and foidolites were intruded consistently at 1982 ± 6 Ma and 1894±12 according to SHRIMP-II U-Pb zircon dating, but the whole-rock Sm-Nd isotope dating has resulted in 1879±99 Ma and reflects the impact of alkaline granite intrusion (1871±9 Ma). The late differentiates from alkaline magma crystallization were the main source of rare metals for zircon-pyrochlore ores of alkaline metasomatites. The metasomatic rocks (aegirinites, albitites) and carbonatites were formed as late as 1910 ± 15 Ma (SHRIMP-II U-Pb zircon, titanite, pyrochlore). While some pyrochlore grains from metasomatites are showed that U-Pb age of ore formation is 1766 ± 24 and 1764 ± 19 respectively. That can be attributed to additional source of rare metals connected with fluids formed during regional metamorphism 1750 m.y. ago [Glebovitskii et al., 2014]. The last probable source of rare-metal material and ore-deposit evolution stage (recrystallization) is established by individual pyrochlore grain Sm-Nd and U-Pb systems and evidences tectono-thermal activity at the Paleozoic plume magmatism, which was followed by structural and chemical mineral changes.
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