Geophysical Research Abstracts
Vol. 21, EGU2019-182, 2019
EGU General Assembly 2019

U-Pb age of pyrochlore-group minerals from the Ilmeny-Vishnevogorsk miaskite-carbonatite complex, South Urals

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U-Pb dating of the pyrochlore-group minerals from Zr-Nb deposits of the Ilmeny-Vishnevogorsk miaskite-carbonatite complex (IVC) located in the Ural Fold Region has been carried out. 12 samples and 200 grains of pyrochlore from the main types of the IVC rocks were investigated by optical microscopy, an electron probe and ion microprobe analysis (IMS-4f and CamScan-2500). The age of individual pyrochlore crystals was determined at the CIR VSEGEI (St. Petersburg) by local U-Pb isotope methods: secondary-ion mass spectrometer (SHRIMP-II); laser ablation and ICP-MS (in the case of high-U pyrochlores with $UO_2 \geq 2.5$ wt.%).

The pyrochlore-group minerals, representing U-(Ta)-rich oxycalciopyrochlores and fluorcalciopyrochlores (including Ta-, REE- and Sr-containing varieties) according to recent nomenclature [Atencio et al, 2010], have been separated from miaskite-pegmatites, different types of carbonatites (sövites I-III), and fenites. It was suggested that the formation of the pyrochlore-group minerals is related to certain evolution stage of the alkali-carbonatite magmatic system and/or to transformations of the IVC [Nedosekova et al., 2017].

U-(Ta)-rich oxycalciopyrochlore (UO_2: 15-24, Ta2O5: 1-14 wt.%) are found in the early high-temperature silicocarbonatites (sövites I) and is formed on the late-magmatic stage of crystallization, earlier than other types of pyrochlores. Fluorcalciopyrochlore with the highest Nb2O5 (65-69 wt.%) and low trace-element contents (<0.5 wt.%) commonly occurs in the calciocarbonatites (sövites II) and miaskite-hosted feldspar veins. Ta-containing fluorcalciopyrochlore (Ta2O5: 1.5-5 wt.%) is found in the miaskite-pegmatites. Sr-REE-containing fluorcalciopyrochlore ($LREE2O_3$: 3-6, SrO: 1.5-7 wt.%) is common in late carbonatites (sövites III) and fenite-hosted pyroxene-feldspar veins. It is heterogeneous in composition and often contain relics of the earlier pyrochlore. Probably, its formation is related to the final stages of the IVC.

U-Pb systems of the studied pyrochlore samples indicate a multi-stage formation of the Nb-mineralization at the IVC. The earliest stage of ore formation (378±4.9 Ma) is recorded by U-(Ta)-pyrochlore from silicocarbonatites and seems associated with the primary crystallization in the alkaline-carbonatite magmatic system. The following ore-mineralization stages are recorded by U-Pb isotope systems of fluorocalciopyrochlore from sövites II (246±5 Ma), Sr-REE- and Ta-containing fluorocalciopyrochlores of Vishnevogorsk (230±1.5 Ma) and Potanino (217±1.9 Ma) deposits. A similar age of 245±8 Ma was previously obtained by the Rb-Sr mineral isochron for IVC miaskites and it is correlated with the late collision metamorphism [Kramm et al., 1983; Puchkov, 2010]. The slightly older U-Pb ages were obtained for IVC zircons from miaskites (279±10 Ma), miaskite-pegmatites (251±6 Ma), and carbonatites (280±8 Ma) [Krasnobaev et al., 2010, 2014; Nedosekova et al., 2014, 2016]. All these data confirm the late stages of rare-metal ore formation in the IVC on the late collision and post-collision stages of the Urals Fold system.

This work was supported by the RFBR grant No. 17–05–00154.