

Mineral chemistry and evolution of niobium minerals from the Miaoya carbonatite complex, China

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The Miaoya carbonatite complex is located at the southwestern margin of the Wudang Terrane along the southern edge of South Qinling orogen. The complex composes of both carbonatite and syenite and hosts abundant REE and Nb mineralization with estimated reserve of 1.21 Mt REE₂O₃ at 1.72 wt.% and 0.93 Mt Nb₂O₅ at 0.12 wt.%. Detailed petrographic and chemical investigations of Nb-bearing minerals at Miaoya are presented with the aim to identify the distribution and evolution of Nb mineralization.

At Miaoya, Nb mineralization is predominantly hosted by carbonatite and shows a heterogeneous distribution varying from sample to sample. The main Nb-bearing minerals are columbite and Nb-rutile, with minor uranpyrochlore, betafite, fersmite, fergusonite, aeschynite and euxenite. The most dominant Nb-mineral is columbite, and both primary and secondary grains are identified. Primary columbite occur as disseminated grains or intergrow with fersmite, and have low Ta₂O₅ contents (< 1.0 wt.%). Secondary columbite are mostly pseudomorphs of the octahedral pyrochlore-group minerals, which are cavernous or atoll-like and contain pockets infilled with secondary calcite and apatite. They display variable Nb₂O₅ and FeO compositions (67.2~71.2 wt.% and 18.4~19.7 wt.%, respectively) and contain higher Ta₂O₅ contents (2.3 wt.% in average) compared to that of primary columbite. Nb-rutile grains are usually anhedral and disseminated in both carbonatite and syenite, which usually intergrow with biotite and ilmenite or occur as exsolutions of pyrochlore and betafite. Uranpyrochlore grains are subhedral to anhedral without zoning, generally inclusion-free, and may be fractured. All examined pyrochlores are characterized by a large number of A-site vacancies (up to 1.03), which are affected by late-stage hydrothermal fluids. Betafite are only identified in association with secondary columbite, which show a wide range of UO₂ contents (24.3~41.1 wt.%) and more A-site vacancies (1.07~1.27) than that for uranpyrochlore.

Based on the petrographic and geochemical results of Nb-bearing minerals, Nb mineralization has experienced magmatic and metasomatic stages similar to REE mineralization at Miaoya. It is dominantly represented by the crystallization of columbite, pyrochlore ± (Nb-rutile and betafite) during magmatism, whereas secondary columbite and Nb-rutile replace pyrochlore and betafite in the late-stage metasomatism.