Evolution of Nb,Ta-oxide mineralization in rare-metal pegmatites of the East Sayan belt, Siberia, Russia

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ABSTRACT

Variations of Nb,Ta-oxide mineral composition were studied in rare-metal pegmatites of the East Sayan belt. Nb,Ta-oxide mineralization is different in spodumene and petalite pegmatites. First of them contain mainly minerals of columbite group of different composition. Petalite pegmatites have broad scope of Nb,Ta-oxide minerals, in which Ta predominate.

Keywords: *Rare-metal pegmatites, Nb,Ta-oxide minerals.*

INTRODUCTION

The East Sayan belt of rare-metal pegmatites is located in the south-western part of the Siberian platform. It includes the largest in Russia Goltsovoye and Vishnyakovskoye pegmatite deposits of rare metals. The Nb,Ta-oxide minerals are common in these pegmatites, however their chemical composition is not enough well studied. In the light of new data this research examines evolution of the Nb-Ta mineral chemical composition.

RARE-METAL PEGMATITES

The East Sayan belt includes several pegmatite fields. In its southeast part there are the Urikskoye, the Goltsovoye, the Belskoye, the Belorechenskoye, the Belotagninskoye and the Malorechenskoye fields, which are located in the Urik-Iya graben. The Vishnyakovskoye and the Alexandrovskoye pegmatite fields lie in northwest part of the belt and are located in the Elashsky graben. The specified grabens are composed of Low Proterozoic metamorphosed effusive-sedimentary rocks and orthoamphibolites. Pegmatites of fields in the southeast part of the belt belong to spodumene subformation of rare-metal pegmatite formation (Zagorsky et al., 1999), while pegmatites of petalite subformation are located in fields of northwest end of this belt. Spodumene pegmatites usually are not differentiated, they are composed essentially of blocky albite-quartz-spodumene-microcline complex on which later muscovite-albite-quartz and albite complexes develop. Zonal bodies of these pegmatites are rare. There is one well differentiated vein in the Urikskoye field. It is composed of pegmatites of following zones (from contact to centre): 1) endocontact medium-graned quartz-plagioclase, 2) medium-graned quartz-microcline zone with ferrocolumbite, 3) blocky qurtz-microcline unit with spodumene, 4) central quartz-microcline-spodumene zone with manganocolumbite, manganotantalite, elbaite and pollucite, 5) quartz core. Petalite pegmatites compose bodies with clear asymmetrical zonality. So, pegmatitic veins of Vishnyakovskoye field have the following zones (from hanging contact to lying one): 1) the albite-muscovite-quartz margin, 2) the quartz-albite porcelaneous aggregate with sections of petalite and quartz-spodumene pegmatites, 3) the overhead zone of block potassium feldspar, 4) the zone of medium-tabular albite pegmatite, 5) the quartz core, 6) the bottom zone of block potassium feldspar, 7) the zone of fine-tabular albite pegmatite. Sections of quartz-lepidolite complex and muscovite aggregate are observed.

CHEMYSTRY OF NB,TA-OXIDE MINERALS

Electron microprobe analyses of the Nb,Ta-oxide minerals are carried out.

Columbite group. Nb,Ta-oxides of columbite group $(Fe,Mn)(Nb,Ta)_2O_6$ in veins of spodumene pegmatites mainly include ferrocolumbite, ferrotantalite, manganocolumbite and manganotantalite. Minerals of this group from differentiated spodumene pegmatites form trend of fractionation from ferrocolumbite of outer pegmatite body zone to manganocolumbite and then to manganotantalite of central zone of vein (Fig. 1 trend 1, the Urikskoye field). Points of minerals observed in blocky complex of undifferentiated bodies of the Goltsovoye field lie in central part of diagram Fig. 1. Manganotantalite is most spread in the late albite pegmatites of the Malorechenskoye and the Belotagninskoye fields, where composition of only early minerals are manganocolumbites (Fig. 1, trend 2).

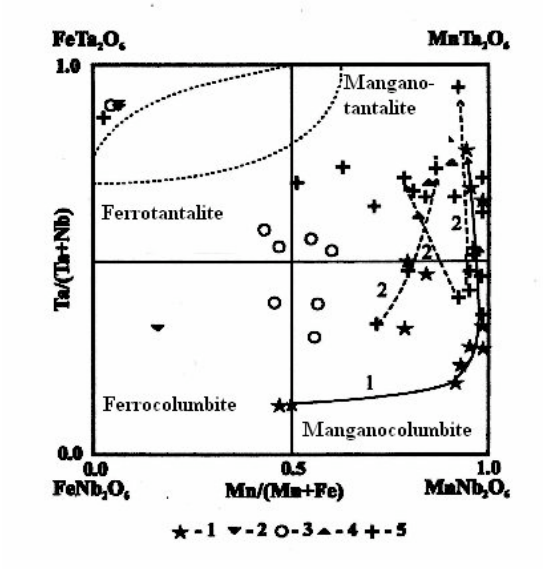

FIGURE 1. Atomic ratios Ta/Ta+Nb vs Mn/Mn+Fe diagram for minerals of columbite group. Compositional trends are explaned in the text. The Urikskoye (1), the Belskoye (2), the Goltsovoye (3), the Belotagninskoye (4) and the Malorechenskoye (5) pegmatite fields

Tapiolite is rare. Nb,Ta-oxides of columbite group in petalite pegmatites usually comprise manganotantalite, manganocolumbite is rarely observed. Trends of fractionation are rather short (Fig. 2, trends 1 and 2).

Calculated unit-cell parameters of columbite group minerals show the highly variable structural state.

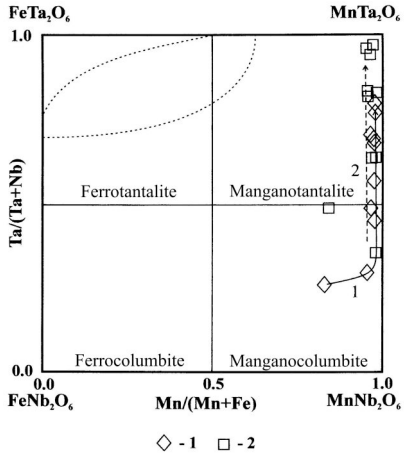

FIGURE 2. Atomic ratios Ta/Ta+Nb vs Mn/Mn+Fe diagram for minerals of columbite group. Compositional trends are explaned in the text. The Alexandrovskoye (1) and the Vishnyakovskoye (2) pegmatite fields

The manganotantalite from spodumene and petalite pegmatites have a highly ordered structural state, manganocolumbite in petalite pegmatites shows the lowest degree of order, while ferrocolumbite and manganocolumbite from spodumene pegmatites show an intermediate structural state.

Wodginite group. Wodginite, ferrowodginite, titanowodginite, lithiowodginite and tantalowodginite are included into this group, joined by formula $(Mn,Fe,Li)(Sn,Ti,Ta)(Ta,Nb)_2O_8$. Besides ixiolite refers also to stanniferous Nb,Ta-oxides. Wodginite is characterized with the ordered crystal lattice, thus it differs from ixiolite, structure of which is disordered. Wodginite is most widespread in petalite pegmatites of the Vishnyakovskoye field, there it is observed as an impregnation on boundaries of blocks of potassium feldspar and in albite-lepidolite-quartz complex or granulous masses with green muscovite in sections of a medium-tabular albite. Ixiolite is observed in an intermediate zone and an external part of the central zone.

Obtained data show a direct correlation between contents of FeO, TiO_2 and Nb_2O_5 and reverse correlation of these oxides with Ta_2O_5 amount in studied wodginites. Contents of MnO are maximum in minerals with average contents of Ta_2O_5 are lowering at minimum and maximum amounts of latter oxide. From early generation to late one contents of FeO, TiO_2 and Nb_2O_5 reduce. Presence of wodginite with high concentration of tantalum in petalite pegmatites of the Vishnyakovskoye field along with a significant amount of manganotantalite has resulted in very high Ta contents and large Ta/Nb ratio in these pegmatites.

Microlite. The chemical composition of microlite is presented by formula $A_2B_2X_7$, where A = Na, Ca; B = Ta, Nb, Ti, Sn, W; X = O, OH, F. Our data show, that the microlite of spodumene pegmatites usually contains 4-6 % of Na_2O whereas its amount in a microlite from petalite pegmatites changes in a wide interval (from 5 up to 1 %). Maximal contents of Na_2O (more than 5 %) are found only in microlite inclusion in manganotantalite of a medium-tabular albite central zone. Microlites from pegmatites of spodumene subformation are characterized with absence of SiO_2, FeO and MnO, whereas microlites from pegmatites of a petalite subformation contain these elements. Microlite inclusions in tantalite from the central blocky zone have high Ta_2O_5 contents at absence of Nb_2O_5, thus amounts of Na_2O and CaO are close to their stoichiometrical ones. On the contrary, for inclusions of microlite in tantalite from the late quartz-muscovite aggregate maximal contents of CaO and Nb_2O_5 are characteristic at lowered amounts of Na_2O and Ta_2O_5. High concentration of Nb_2O_5 in the microlite of late complex reflects the fact, that it is developed on early porcelanous albite, in which tantalite-columbite was already the owner for such inclusions.

Rynersonite and fersmite. Rynersonite $CaTa_2O_6$ is a rare mineral. It is often observed as inclusions in wodginite and manganotantalite from petalite pegmatites of the Vishnyakovskoye field. Fersmite $CaNb_2O_6$ is a very rare mineral. It is found and investigated as microinclusions in cassiterite from spodumene pegmatites of the Belskoye field where it is observed in the latest calcite-fluorite-albite-microcline complex.

CONCLUSIONS

As a result of study of Nb,Ta oxide minerals it is established, that they are presented by columbite group, tapiolite, wodginite, microlite, fersmite and rynersonite in rare-metal pegmatites of the East Sayan belt. New data on the composition of Nb,Ta-oxide minerals show that Nb-Ta mineralization is different in spodumene and petalite pegmatites. Spodumene pegmatites contain mainly minerals of columbite group, their trend of fractionation includes ferrocolumbite, manganocolumbite and manganotantalite, the latter is most spread in late albite pegmatites. For petalite pegmatites it is important that they contain broad scope of Nb,Ta-oxide minerals (manganocolumbite, manganotantalite, wodginite, ixiolite, microlite and rynersonite). These pematites formed from rich in volatiles especially F melt, differentiated in the highest degree. Ta minerals predominate in them. The late metasomatism intensively developed in these pegmatites results also in formation of Ta enriched species.

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