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Geochemistry of oxide minerals of Nb, Ta, Sn, and Sb in the Varuträsk granitic pegmatite, Sweden: The case of an "anomalous" columbite-tantalite trend

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ABSTRACT

The complex, petalite-subtype Varuträsk pegmatite in the Proterozoic rocks of northern Sweden is, as a whole, rather poor in Nb and Ta. The pegmatite consolidated in eight units, but the (Nb,Ta)-oxide minerals attained saturation levels only in a late albite + lepidolite-bearing unit under conditions of high activity of alkali fluorides. Consequently, the compositional trends of columbite-group minerals and cassiterite mimic those typically displayed in pegmatites of the lepidolite subtype: from ferroan manganocolumbite [with Mn/(Mn + Fe)(at.) of 0.35 and Ta/(Ta + Nb) of 0.08] through near-end-member manganocolumbite (0.95 and 0.20, respectively) to Fe-depleted manganotantalite (0.99 and 0.55, respectively), and from (Fe >> Mn, Nb > Ta)-bearing to (Mn > Fe, Ta > Nb)-enriched cassiterite. To date, rare occurrences of cassiterite with Mn > Fe are restricted solely to the lepidolite-enriched granitic pegmatites. The degree of cation order in the Varuträsk columbite-group minerals increases from early to late phases, and with decreasing amounts of heterovalent substitutions. Slower cooling of initially disordered structures in late phases, or their diminished compositional complexity may be responsible for the higher degree of order. Rare primary microinclusions of cassiterite in columbite-group minerals show consistent and systematic preference for Ta and Fe, suggesting an approach to chemical equilibrium, but columbite-group inclusions in cassiterite show in part a compositional scatter. In contrast, rare inclusions of ferrotapiolite and wodginite closely reflect the (Fe,Mn,Ta,Nb) compositional features of the host cassiterite. Stibiotantalite shows high values of Ta/(Ta + Nb) and mere traces of Bi, reflecting the relative abundance of native antimony and stibarsen in the pegmatite, and the absence of Bi-bearing minerals. Rare primary microlite is Ta- and F-rich, whereas the more widespread pyrochlore-microlite metasomatic after columbite-group minerals reflects the Ta/(Ta + Nb) values of the precursors, as does the stibiomicrolite replacing stibiotantalite. Cesium is elevated in several grains of primary and metasomatic pyrochlore-group phases that also are enriched in Sb, but not in stibiomicrolite. The array of large cations in pyrochlore-microlite metasomatic after columbite-group minerals is quite different from that typical of stibiomicrolite, suggestive of differences in the nature of the parent fluids. The lepidolite-subtype signature of the columbite-group minerals and cassiterite in the petalite-subtype Varuträsk pegmatite emphasizes the importance of specific conditions controlling stabilization of these minerals. The restriction of the columbite-group minerals to a very late lepidolite-rich unit imposes a lepidolite-subtype signature on the whole petalite-subtype pegmatite, a signature grossly different from the characteristics typical of petalite-subtype pegmatites elsewhere.