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Jingsuiite, TiB_2, a new mineral from the Cr-11 podiform chromitite orebody, Luobusa ophiolite, Tibet, China: Implications for recycling of boron

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Abstract

The new mineral jingsuiite (TiB_2, IMA-2018-117b), together with osbornite-khamrabaevite solid solution (TiN-TiC), deltalumite, and a potential new mineral, hexagonal $Ti_{10}(Si,P,\square)_7$, constitute four inclusions up to 50 μm across in corundum recovered from the Cr-11 podiform chromitite orebody near Kangjinla, Luobusa ophiolite, Tibet, China. EELS, EDS, and 3D electron diffraction were applied to study the phases. In one inclusion, jingsuiite forms a rounded grain 40 μm across. Associated osbornite-khamrabaevite solid solution forms an irregular mass up to 10 μm across having the composition $Ti(N_{0.5}C_{0.5})$ and the $Ti_{10}(Si,P,\square)_7$ phase forms an incomplete overgrowth up to 20 μm thick around the grain of jingsuiite. In a second inclusion, jingsuiite, osbornite-khamrabaevite solid solution, $Ti_{10}(Si,P,\square)_7$ and deltalumite form a lamellar intergrowth 100 μm long composed of tablets of the four phases up to 50 μm long × 4 μm in thickness. Jingsuiite has a primitive hexagonal cell with $a = 3.04(6)$, $b = 3.04(6)$, $c = 3.22(6)$ Å, $\alpha = 90°$, $\beta = 90°$, $\gamma = 120°$, $V = 25.8$ (9) Å^3, space group $P6/mmm$, $Z = 1$. Its structure was determined ab initio and dynamically refined on the basis of three-dimensional electron diffraction data; it is equivalent to that of synthetic TiB_2. Results of EELS analyses of jingsuiite in foil no. 5357 (N = 20) gave B 61.87(1.22), C 1.53 (1.26), Ti 36.62 (1.45) at% from which an empirical formula of $Ti_{1.10}(B_{1.86}C_{0.05})_{\Sigma 1.91}$ was calculated on the basis of 3 atoms. The ideal formula is TiB_2. Our preferred scenario is that corundum with entrapped Ti-Si-P-Fe intermetallic melts was precipitated from basaltic magmas during exhumation following deep subduction. Enrichment of B in the melt pockets is attributed to the highly reducing conditions that led to the segregation of siderophile elements into intermetallic melts and to the siderophile behavior of B, thereby concentrating it in the intermetallic melts in preference to silicate melt. Experimental work on the Ti-Fe-Si system indicates that minerals enclosed in corundum grains such as Ti, $FeTiSi_2$, and $TiSi_2$ could have crystallized from alloy melts at the lowest T accessible on the liquidus, i.e., <1300 °C. The presence of TiB_2 in four inclusions in the Cr-11 orebody suggests incorporation of crustal sediments in the ophiolite followed by deep subduction to the Transition Zone where qingsongite (cubic BN) is inferred to have crystallized and subsequently exhumed to shallower levels where hexagonal BN and jingsuiite presumably crystallized.

Keywords: Boron, jingsuiite, intermetallic melts, crystal structure, transmission electron microscopy, three-dimensional electron diffraction; Lithium, Beryllium and Boron: Quintessentially Crustal