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Cassiterite and Sn mineralization in the giant Bayan Obo Fe-Nb-REE deposit, Northern China

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Abstract

Critical rare metal deposits are strategic resources as these metals have numerous applications in high-tech industries. Among the critical rare metals, natural stannum (Sn) is mainly found in the Sn-oxide mineral cassiterite (SnO_2) and is closely associated with granite or pegmatite. Carbonatite and alkaline rocks are more likely to contain vast amounts of critical rare metals, especially REEs and niobium (Nb). Here we report the presence of abundant cassiterite (SnO_2) and evaluate potential Sn mineralization in the Bayan Obo Fe-Nb-REE deposit in northern China, the largest REE deposit worldwide. This represents the first reported evidence of Sn enrichment in a carbonatite-hosted REE deposit.

REE-Fe ores are dominantly mined in the Bayan Obo deposit. Disseminated, banded, and massive ores contain tens to hundreds of parts per million Sn, and vein-type ores are notably rich in Sn (up to 1500 ppm). In-situ micro-zonation mineralogical analyses identified two occurrences of cassiterite and several Sn-rich minerals in these REE-Fe ores. Abundant early-stage nanoscale cassiterite inclusions are present within magnetite grains in banded and massive REE-Fe ores, and ubiquitous late-stage granular cassiterite, Sn-rich rutile, titanite, and bafertisite are present in vein-type REE-Fe ores. Multiple U-Th-Pb dating of monazite and columbite-Mn in association with cassiterite yields peak ages of 425 Ma and 419 ± 18 Ma, respectively, revealing coeval Sn and Nb mineralization. We conclude that Sn was derived from carbonatitic magmas, and the dense distribution of cassiterite inclusions in magnetite marked the pre-enrichment of Sn in the Bayan Obo deposit. Subsequent Early Paleozoic hydrothermal events led to reactivation and further Sn mineralization. Similar to Nb, Sn was mineralized in the Bayan Obo deposit, possibly forming economically important resources. Our study highlights the potential of Sn mineralization associated with carbonatite-hosted REE deposits.

Keywords: Critical rare metals, cassiterite, Sn mineralization, Bayan Obo deposit, TEM, geochemical characteristics, U-Th-Pb dating, SIMS