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Tungsten Mineralization in the Eastern Alps – Tracking Ore-Forming Processes Using Scheelite Trace Element Chemistry and Micro-textures

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The increasing demand for raw materials used in high-technology applications, and their economic importance, is reflected in efforts by the European Union to achieve strategic autonomy on key raw materials. Tungsten is one of the prominent raw materials highlighted by EU criticality assessments. Discovery of the world-class Felbertal W-deposit (Austria) in 1967, which is still Europe’s largest producing tungsten mine, triggered substantial greenfield exploration during the 1980s. Many tungsten occurrences were discovered in the Eastern Alps and are currently being investigated with the aim to define differences in mineralization processes. The goal is to establish assessment criteria ("fingerprint") to identify regions with high potential for significant tungsten endowment that can be used in mineral exploration.

Scheelite ($CaWO_4$) is the most common tungsten mineral in the Eastern Alps, occurring in different geological settings and mineralization styles, including stratabound mineralization in metabasites, meta-carbonate and calc-silicate rocks, skarns, orogenic Au-W veins, and scheelite-bearing metamorphic veins etc. Scheelite from these different settings is studied using a combination of cathodoluminescence (CL), electron probe micro-analyzer (EPMA), SEM-based automated mineralogy (MLA), and laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) techniques.

In the metamorphosed Felbertal vein-stockwork deposit, several stages of scheelite (re)crystallization are recorded. In addition to magmatic-hydrothermal scheelite, there is metamorphic scheelite, which formed during polyphase regional metamorphic overprint. CL-documented micro-textures and in situ trace element data allow us to define individual scheelite generations and track changing conditions during ore formation. Based on the Felbertal trace element signature of scheelite, a comparison with scheelite from other ore-forming environments will be carried out.

The results of this study show that Na, Mg, Sr, Y, Nb, Mo, Ba, REE, Hf, Pb, and U are sensitive to specific mineralization processes and, hence, useful to discriminate scheelite formed in different environments. In combination with CL imaging, in situ trace element analysis of scheelite distinguishes metamorphic scheelites from those of other provenance. Metamorphic scheelite exhibits homogeneous micro-textures, whereas magmatic-hydrothermal scheelite commonly shows primary and oscillatory zoning. Secondary zoning and replacement textures develop in scheelite affected by subsequent metamorphism, resulting in formation of several generations of scheelite with different trace element signatures. Molybdenum, Sr, and, particularly, REEs experience significant redistribution between these generations. Total REE concentrations and REE patterns may vary considerably; e.g., LREE enrichment or depletion and negative or positive Eu-anomalies. Furthermore, fractionation of REE between scheelite and coprecipitating minerals (e.g., apatite, allanite-Ce, epidote, titanite, etc.) is also important.