Magmatic-hydrothermal versus metamorphogenic origin of tungsten mineralization: Examples from the Eastern Alps

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The increasing demand for tungsten in the European high-tech industry is offset by an increased supply risk. Hence, this metal has been on the list of critical raw materials for the EU since 2011. Global tungsten production is primarily from ore deposit types genetically related to granitic intrusions (e.g., skarn-type, vein-type, porphyry deposits etc.) and linked with magmatic-hydrothermal processes.

Europe's largest tungsten mine is located at Felbertal in Austria in (pre-)Variscan units of the Tauern Window in the Eastern Alps. Recent studies also support a magmatic-hydrothermal model and re-interpreted the Felbertal deposit as a metamorphosed vein-stockwork scheelite deposit associated with chemically evolved, W-rich granitic melts emplaced during the Variscan orogeny (Kozlik & Raith 2017). In the Eastern Alps, however, there are still numerous smaller (sub-economic) tungsten showings that differ significantly from the Felbertal deposit in terms of their geological and mineralogical characteristics. Most of them lack a direct relation to igneous intrusions but occur proximal to large-scale tectonic structures in Paleozoic strata with metacarbonate rocks (e.g., Tux-Lanersbach, Mallnock) of the low-grade metamorphic Austroalpine units. Syngenetic/syndiagenetic sedimentary-exhalative models were suggested in the past but a metamorphogenic origin as discussed by Palmer et al. (2022) for the formation of this style of mineralization elsewhere is also plausible.

Scheelite ($CaWO_4$) is the most common tungsten mineral in the Eastern Alps and was analyzed by the combined use of cathodoluminescence, electron probe microanalysis and in-situ LA-ICP-MS analysis to determine the mineralogical-chemical signature of scheelite from different styles of tungsten mineralization. The combination of geological-mineralogical information and trace element analysis of scheelite allows to distinguish three generic mineralization styles in the Eastern Alps, i.e., 1) *intrusion-related*, 2) *polymetallic* (As, Sb, Au), and 3) *carbonate-hosted stratabound* scheelite mineralization. Mineral chemistry shows that the trace elements Na, Sr, Nb, Mo and REE+Y in particular are suitable for differentiating scheelites from these different ore forming environments.

We demonstrate that the "Felbertal" magmatic-hydrothermal signature of scheelite is distinctly different from other styles of mineralization and that these findings can be used as an indicator in future exploration to evaluate the regional tungsten potential.

Kozlik M, Raith JG (2017): Variscan metagranitoids in the central Tauern Window (Eastern Alps, Austria) and their role in the formation of the Felbertal scheelite deposit. - Lithos 278-281, 303-320

Palmer MC, Scanlan EJ, Scott JM, Farmer L, Pickering D, Wilson VJ, Oelze M, Craw D, le Roux PJ, Luo Y, Graham Pearson D, Reid MR, Stirling CH (2022): Distinct scheelite REE geochemistry and $^{87}Sr/^{86}Sr$ isotopes in proximally- and distally-sourced metamorphogenic hydrothermal systems, Otago Schist, New Zealand. - Ore Geology Reviews 144, 104800