Crystals from the scheelite-powellite solid-solution series at the nanoscale

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Scheelite ($CaWO_4$) and powellite ($CaMoO_4$) are iso-structural minerals considered as a continuous solid solution series. We have undertaken nanoscale investigation of specimens of scheelite-powellite (Sch-Pow) from the Zhibula skarn, Gangdese Belt, Tibet, China, [1] to address whether compositions straddling the Sch-Pow boundary can be attributed to nanoscale exsolution of the two end-members, or to cation exchange at the lattice-scale. Back-scatter electron (BSE) images show the presence of molybdenite (Moly) in the same areas as Sch-Pow grains (Fig. 1a). Electron probe microanalysis of single crystals shows widely variable compositions (2.70-51.86 wt.% MoO_3). HAADF-STEM imaging and STEM mapping of FIB-prepared foils from areas of highest Mo (80 mol% Pow) show this compositional change within a single crystal (Fig. 1b-d).

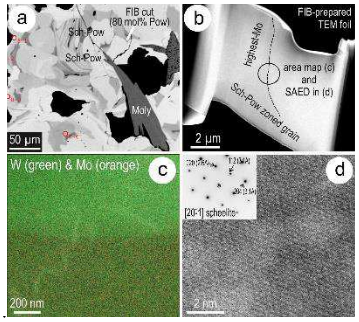

Fig. 1. (a) BSE image of oscillatory-zoned Sch-Pow crystals & location of FIB cut. (b) HAADF STEM image of FIB-foil. (c) EDX map overlapping W & Mo across boundary in (b). (d) HAADF-STEM image & SAED (inset) of scheelite on [20-1] zone axis. Bright dots correspond to W & Mo atoms. HAADF STEM images & maps at 80 kV.

This work demonstrates the utility of combined FIB-SEM and HAADF-STEM techniques to address issues of ex-solution vs. solid solution in compositionally heterogeneous crystals of this type. This has potential broad application for understanding analogous mineral series and for correct interpretation of compositional data, notably trace element LA-ICP-MS data, where there exists concern about whether elements of interest are lattice- or inclusion-hosted. It also allows redox conditions of prograde (Sch-Pow) to retrograde (Moly) stages to be constrained for the Zhibula distal skarn.

[1] Xu J. et al. (2016) Lithos 262, 213-231