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Fluid inclusion microthermometry in coexisting quartz and wolframite – a case study from Morococha, Peru

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In the ore deposit research, most fluid inclusion studies are conducted on transparent gangue minerals which are “co-genetic” with the mineralization according to textural evidence. However, ore-precipitating fluids can be more directly studied by analyzing fluid inclusions found in transparent ore minerals, like Fe-poor sphalerite (e.g. Simmons and Browne 1997; Bonev and Kouzmanov, 2002) or wolframite. Commonly, wolframite-hosted fluid inclusions are studied by infra-red light microscopy and microthermometry (Campbell and Robinson-Cook, 1987; Bailly et al., 2002), but some Mn-rich wolframite (huebnerite) can be transparent in visible light due to its low iron content.

In this study we present and compare microthermometric measurements of fluid inclusions in huebnerite (Mn-rich wolframite) and syn-genetic quartz from Cordilleran polymetallic veins of the Morococha district in Peru, which overprint the giant Toromocho porphyry Cu-Mo deposit (Catchpole, 2011). The huebnerite, which precipitated after enargite and other Cu-sulphosalts, occurs intergrown with pyrite and quartz. A growth zonation highlighted by reddish-orange bands is visible in transmitted light microscopy (Figs. 1 and 2a).

Electron microprobe analyses (EMPA) and X-ray mappings reveal growth banding controlled by variable Fe and Mg content (Fig. 1), which substitute for Mn in the wolframite structure (Bailly et al., 2002). Iron and Mg content in huebnerite (Fig. 1.d-f) are often below the detection limit of 0.2 mass% and 0.07 mass%, respectively, but three analyses yield compositions of 0.7 to 1.65 to mass% Fe and 0.13 mass% Mg.

Microthermometric measurements have been performed on huebnerite and quartz using a Linkam THMSG 600 heating-freezing stage mounted on a DMLB Leica microscope. Primary (along growth bands) and secondary fluid inclusion assemblages (FIAs; Goldstein and Reynolds, 1994) were found in the wolframite, while numerous secondary fluid inclusions were observed along trails in quartz crystals (Fig. 2). Both, primary and secondary fluid inclusions in wolframite are liquid-rich (30 % vapour). Post-entrapment modifications due to necking-down or leaking are common for secondary fluid inclusions in quartz and wolframite.

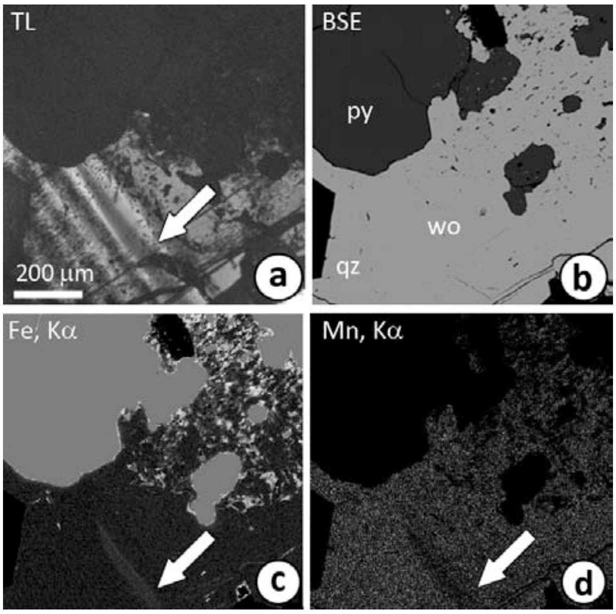

Fig. 1. Wolframite textures: a) Transmitted light photomicrograph of growth zoning in wolframite; b) BSE image showing no zonation; c-d) EMP X-ray maps of Fe and Mn. Iron and Mg are enriched in the dark growth bands (white arrows), whereas Mn is slightly depleted. Abbreviations: py - pyrite, qz – quartz, wo - wolframite.

Primary FIAs in wolframite yield homogenization temperatures of around 300 °C and low salinity (1-1.3 eq mass% NaCl) and are representative for the wolframite deposition conditions (Fig. 3). Secondary fluid inclusions in wolframite have similar or slightly lower homogenization temperatures but higher salinity reaching 4.3 eq mass% NaCl.

Secondary fluid inclusions in quartz usually yield lower homogenization temperatures between 180 to 280 °C with salinities similar to those found in the secondary FIAs in the wolframite (Fig. 3).

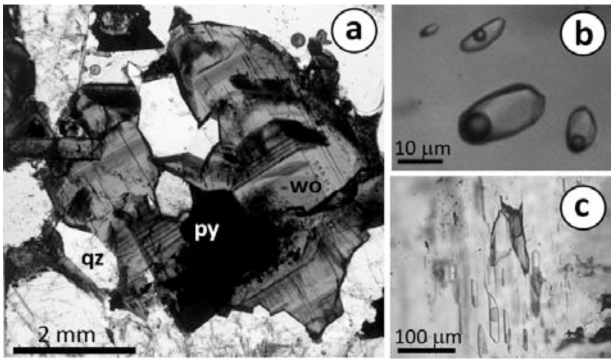

Fig. 2. *Transmitted-light photomicrograph of wolframite-quartz-pyrite vein from the Morococha district: a) Growth zones are highlighted by dark growth bands; b) Large secondary liquid-rich fluid inclusions in quartz; c) Primary fluid inclusions in wolframite.*

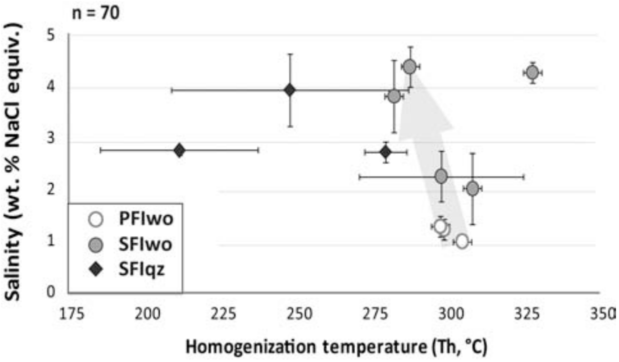

Fig. 3. Microthermometry data for fluid inclusions hosted in quartz (diamonds) and wolframite (circles). Seventy single fluid inclusion measurements have been collected from 11 FIAs. The arrow indicates the T-X evolution of the fluid from a low salinity (1 eq mass% NaCl) at 300 °C which cools with time and undergo boiling as revealed by secondary FIAs in wolframite and quartz with higher salinities. X-error bars are mostly reflecting the effect of post-entrapment re-equilibration of the fluid inclusions (e.g., necking-down). Abbreviations: PFIwo – primary fluid inclusions in wolframite, SFIwo – secondary fluid inclusions in wolframite, SFIqz – secondary fluid inclusions in quartz.

Fluid boiling could explain the evolution of the fluid salinity of wolframite-hosted inclusions from an early high-temperature low-salinity fluid (primary FIAs) to later lower temperature fluid (secondary FIAs) with a higher salinity (Fig. 3, light arrow). Finally, fluid mixing between the cooling fluid and meteoric water could explain the decrease of homogenization temperatures and salinity of the two secondary FIAs in the quartz. The data are in agreement with reported microthermometric results for Cordilleran polymetallic veins from the central Morococha district (Catchpole, 2011).

This fluid inclusion study on wolframite and quartz reveals that microthermometric measurements on ore and gangue minerals can complement each other, bringing more information concerning the fluid evolution. LA-ICP-MS analyses of the fluid inclusions will be undertaken in order to compare the metal, alkalis and sulphur content of quartz- and wolframite-hosted FIAs in the studied samples.

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REFERENCES

Bailly L., Grancea L., Kouzmanov K. (2002) *Economic Geology* 97: 415-423.

Bonev I., Kouzmanov K. (2002) *European Journal of Mineralogy* 14: 607-620.

Campbell A.R., and Robinson-Cook S. (1987) *Economic Geology* 82: 1640-1645.

Catchpole H. (2011) *PhD thesis*, University of Geneva, Switzerland.

Goldstein R.H. and Reynolds T.J. (1994) *Systematics of fluid inclusions in diagenetic minerals*. SEPM Short Course 31.

Simmons S.F. and Browne P.R.L. (1997) *Economic Geology* 92: 485–489.