Contrasting Cu-complexing behaviour in vapour and liquid fluid inclusions from the Yankee Lode deposit, Mole Granite, Australia

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Synchrotron Radiation-induced X-Ray Fluorescence (SR-XRF) and X-Ray Absorption Near Edge Structure (XANES) experiments were performed on coexisting vapour and liquid inclusions from the Yankee Lode, Mole Granite, Australia. The sample analyzed is a quartz crystal from a cassiterite-quartz-vein showing a complex hydrothermal growth history characterized by successive pulses of fluid trapping from 900 to 200°C. The liquid and vapour inclusions analyzed show homogenisation temperatures around 450°C, corresponding to fluids predating cassiterite precipitation. SR-XRF mapping of the two inclusion types showed that, in vapour inclusions, Cu is associated with S together with K, Ti, Mn, Fe, Zn and As, likely in a sulphide mineral. Quantification deduced from sumspectra extracted from mapping experiments as well as quantification performed on homogenised inclusions show that Cu and to a lesser extent As, Ca and S have a strong affinity to the vapour phase. XANES experiments performed upon heating liquid and vapour inclusions demonstrated that Cl-ligand complexes dominate in both inclusion types up to 450°C. Continuous mapping during heating above apparent homogenisation revealed that the vapour inclusion was not completely homogenised at 450°C. Continuous XANES analysis at the K-edge of Cu between 450 and 500°C show that a new species forms above 450°C which is not detectable in the liquid inclusion. XANES spectra acquired at 506°C could not be identified but do not correspond to any known Cu-Cl complexes published so far in the literature. We conclude that an unknown Cl-ligand Cu^{1+}, a S-ligand Cu^{1+} or a mixture of these should account for Cu complexion at high temperature. Reversible change of the Cu local environment to a well documented Cl-Cu complex at about 409°C indicates that Cl is the main ligand for Cu transport on the cooling path. Recognition that the transition from Cl-complexing to unknown-complexing coincides with the temperature of dissolution of S-bearing daughter crystal strongly suggests, however, that sulphur plays a dominant role at higher temperature. Experimental data in the system Cu-S-Cl-CO_2-H_2O are critically needed to fully document the new XANES spectra recorded here.