Petrography, mineralogy and trace element chemistry of Cu-Au-Mo mineralisation from Central Diorite, Boddington, W.A.

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ABSTRACT

The world-class Boddington Cu-Au-Mo deposit has a complex genetic history. The relative importance of different ore-forming processes during the period 3.0 – 2.6 Ga is debated, particularly with respect to the role played by the 2611±3 Ma Wourahming granite. LA-ICP-MS analysis of trace element concentration in molybdenite represents a valuable new metallogenetic tool to track mineralising events in deposits with protracted geologic histories. The Re content and trace-element signatures in molybdenite from diorite and granite show three distinct populations, attributed to porphyry-style (hundreds of ppm) orogenic- and granite-related systems (<1 to a few ppm, respectively). Rhenium concentrations in molybdenite are highly variable on the deposit-scale. Economic concentrations of Re occur only at shallower levels in both Central Diorite and ABreccia. The Au content correlates with high-concentrations of chalcophile elements (CE). This is seen in the association of Au-minerals and Bi-(Pb)-tellurides present as inclusions in the molybdenite from diorite and is inferred from an LA-ICP-MS element map for molybdenite in granite.

The FIB-SEM and TEM study show that visible telluride inclusions extend down to the nanoscale as coherent intergrowths with host molybdenite. Nanoporosity is accompanied by a whole range of structural defects and twinning. The telluride species identified include unnamed $Bi_4Pb_7Te_4S_9$. Analysis of stacking sequences show co-precipitation of Bi-tellurides and molybdenite under equilibrium conditions. In corroboration with EPMA data, this is the first confirmation that minerals from the aleksite series are characteristic components of the ore at Boddington. Molybdenite with high-concentration of chalcophile elements is present as the 2H polytype only, contrary to previous hypothesis that incorporation of trace elements is assisted by 3R structural modification. Instead, a new mechanism is presented in which coherent lattice-scale intergrowths between molybdenite and tellurides are reasons for the measured high CE concentrations. Knowing that Bi-(Pb)-tellurides are Au-carriers, this may also explain the observed, unusual Au-enrichment in molybdenite from Boddington. Nucleation of Au fine particles is inferred from element map correlations but further work is necessary to prove if Au nanoparticles are also present.

Petrographic, mineralogical and geochemical evidence support a three-stage model for Boddington. An early porphyry event can account for the bulk of the Cu mineralisation, as well as some of the Au and Mo. A subsequent orogenic-Au event led to shearing and remobilisation of ore components. New constraints on metamorphic conditions are offered by

chlorite and stannite-sphalerite geothermometry (200-420 °C) and the occurrence of two co-existing pyrrhotite species. The granite introduced some Au, Mo and other ‘granitic’ elements, notably Bi leading to substantial upgrading of Au grades by Bi-melt scavenging. The study concludes however that hydrothermal activity associated with granite was not the most important concentrator of ore minerals.