Mineralogical and Petrogenetic Study of Gold Ore from the Boddington Gold Deposit, W.A.

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ABSTRACT

The Boddington gold mine, situated in the Saddleback greenstone belt, Yilgarn Craton, W.A., is a geologically complex and highly varied deposit. A variety of genetic models have been invoked in the past to explain the genesis of the deposit and features observed, including porphyry- and orogenic- models, as well as more recently, an intrusion-related gold system. Mineralisation occurs as veins, veinlets, shears, lenses and disseminations with host rocks of diorite, andesite and dacites. Veins and alteration are pervasive and consist of multiple stages of quartz-sericite, quartz-biotite, quartz-albite and actinolite alteration. Detailed ore mineralogical, petrographic and mineral-chemical study of representative ore samples from five of the eight domains within the deposit have given insights into the distribution of precious metals and also provided evidence for the formation of the Boddington deposit and provide evidence for its genetic evolution.

Mineralisation is characterised by a reduced assemblage, with chalcopyrite and pyrrhotite as the dominant sulphides. Pyrite (often replacing pyrrhotite), sphalerite, cubanite, cobaltite, arsenopyrite and pentlandite are minor sulphides. Molybdenite is also relatively abundant and occurs as a major mineral in localised areas throughout the deposit. The study has shown that the deposit also contains an extremely diverse array of trace minerals which can provide supporting evidence for aspects of ore genesis. Native gold and electrum are the main gold minerals; maldonite (Au_2Bi) is a minor component. LA-ICPMS analysis of pyrite and arsenopyrite revealed that these minerals are not significant Au-carriers at Boddington. In addition to maldonite, the deposit contains a suite of Bi-minerals, including native bismuth and a suite of Bi, Bi-Ag, Ag- and Pb-tellurides and selenides. These minerals are identified both in ore samples and in Cu-concentrates.

There is a strong and systematic Bi-Au signature across the deposit, reflected within individual mineral associations and in geochemical data. Aside from maldonite, melt-like droplets of Bi±Au±Te are recognised, suggesting that Au-scavenging by Bi-melts contributed to the observed gold distribution through (repeated) gold upgrading and remobilisation. Microprobe analysis of Bi-chalcogenides of the tetradymite group (Bi_xX_y, where X=Te,Se,S) shows compositions from across the full range of the series, demonstrating the multiphase character of the Boddington mineralisation and, specifically, (often incomplete) overprinting by more oxidising fluids. This dataset also includes several previously unreported and non-stoichiometric compositions of tetradymite group phases; these may represent unnamed phases, but may also be disordered at the lattice-scale. There is also a wide variety of Ni-bearing minerals present, including parkerite, $Ni_3(Bi,Pb)_2S_2$, lending weight to that mafic/ultramafic source rocks were involved in primary ore genesis. Nickel-bearing minerals are prominent components of ore remobilisates.

LA-ICPMS of molybdenite from the Boddington deposit reveal that this mineral is highly enriched in Au and Re, as well as a wide array of other elements (Bi, Te etc). High Re contents (up to 2,449 ppm) are indicative of a porphyry precursor. Re contents within molybdenite also display inhomogeneity at both the deposit and grain scales. Elevated Au (Bi,Te) contents in molybdenite are interpreted as sub-microscopic inclusions of discrete minerals within fractures and cleavage planes in the molybdenite.

Boddington is clearly not the product of a single ore-forming event but is rather a multiphase system recording successive overprinting and replacement of minerals, often very localised, and displaying strong lithological control. Boddington lacks many of the features consistent with a reduced intrusion-related gold system (RIRG), however some features observed can be explained by this model. It is believed, however, that fluids of granitic origin were probably an agent for remobilisation of existing mineralisation.