Hydrothermal alteration, ore fluid characteristics and mechanisms for gold deposition at the Wallaby Gold Deposit, Laverton, Western Australia

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Abstract

The Wallaby Au deposit in the Laverton Greenstone Belt of the Yilgarn Craton is a magmatic – hydrothermal system with extensive pyrite-bearing mafic conglomerates that host a series of vertically stacked shear zone gold lodes, with 2010 year end published reserves of 3.62Mt at 5.20g/t for 0.61Moz, plus measured, indicated, and inferred resources (exclusive of reserves) of 6.8Mt at 7.7g/t for 1.69Moz. Categorising the deposit as an orogenic system or an intrusion-related system has been a topic of debate. Fluid inclusions and pyrite studies have indicated four separate fluid stages responsible for the genesis of the deposit, with sulfidation (and redox) the main driver for gold deposition. They were (1) an oxidised pervasive hematite alteration event; (2) a widespread magnetite – actinolite alteration of the conglomerate; (3) emplacement an igneous alkaline suite comprised mostly of syenite followed by (4) the high grade gold event associated with an As-rich reduced fluid.

Several pyrite varieties are present within the different alteration types in mafic conglomerate and form in equilibrium with hematite and magnetite at different stages of its genesis. Pyrite in the conglomerate and syenite show epitaxial overgrowths indicating pyrite generations as younging outwards. In situ $\delta^{34}S$ analyses across pyrite grains indicate a range of 20‰, with progression from an oxidised fluid (-10.5‰) associated with pervasive hematite alteration in event one to a reduced fluid (+11‰) associated with high grade gold pyrite + sericite + dolomite + albite + quartz in event four. Detailed in situ laser ablation inductively coupled plasma mass spectrometry (LA ICP-MS) of pyrite revealed that the gold is intimately associated with the last hydrothermal event, as invisible gold in the pyrite, and crosscuts the earlier alteration events. A decrease in granophile elements; W, Pb, Zn, and Ni and an increase in Sb and As from event one to four reveals an evolving suite of fluids. Fluid inclusion microthermometry reveal two fluid compositions – one saline and the other H_2O – CO_2 rich, typical of other orogenic gold deposits in the Eastern Goldfields Province. The saline fluid is interpreted as magmatic-hydrothermal while the CO_2 – H_2O fluid is seen as typical shear zone Au fluid.

Detailed pyrite analysis and fluid inclusions indicate that the Wallaby deposit was characterised by the evolution of one fluid with time, from oxidised (high SO_4^{2-}) to reduced fluids (high H_2S). The entire fluid history of Wallaby can be seen through pyrite zoning of $\delta^{34}S$ and trace elements. The final event was gold-bearing and is responsible for the widespread bleaching of the mafic conglomerate. The deposition mechanisms for gold are sulfidation, with redox reactions amongst fluid wall rock interactions.