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**Author**

Garcia-Cuison, AL

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# **Geology and genesis of the Ridgeway porphyry Au-Cu deposit, NSW**

by

**Ana Liza Garcia-Cuison (Bsc)**

Submitted in fulfilment of the requirements for the degree of

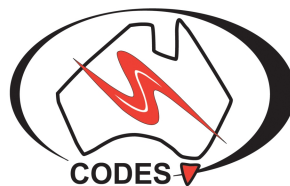
Doctor of Philosophy

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November, 2010



University of Tasmania



ARC Centre of Excellence in Ore Deposits

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# Abstract

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The Ridgeway alkalic porphyry Au–Cu deposit is located in the Molong Volcanic Belt of the Macquarie Arc, part of the Lachlan Fold Belt in eastern Australia. Ridgeway is hosted by a Middle Ordovician sequence of volcano-sedimentary rocks that were deposited in an active submarine sedimentary basin. The volcanic sequence evolved from fine grained distal volcanoclastics (Weemalla Formation) to coarse proximal breccias and sandstones (Forest Reef Volcanics). The host sequence was intruded first by pyroxene- and feldspar-phyric dikes and sills, and then by the Ridgeway intrusive complex, a cluster of subvertical porphyry pipes, dikes and stocks of monzodiorite (U–Pb<sub>zircon</sub> age:  $448.2 \pm 2.1$  Ma), mafic monzonite and quartz monzonite (U–Pb<sub>zircon</sub> age:  $444.2 \pm 1.3$  Ma). Cross-sectional shapes of the monzonite intrusions are broadly pipe-like. They swell at the contact between the Weemalla Formation and Forest Reef Volcanics.

The highest Au–Cu grades at Ridgeway are associated with quartz–magnetite–bornite vein stockworks and intense K-silicate alteration that formed during the emplacement of the mafic monzonite. These early stage veins have been truncated by the quartz monzonite porphyry and its lower grade quartz–chalcopyrite  $\pm$  molybdenite veins (Re–Os<sub>molybdenite</sub>:  $445.7 \pm 2.8$  Ma,  $442.8 \pm 2.3$  Ma) associated with less intense K-silicate alteration. A late-stage quartz monzonite cut the earlier phases, and defines the low-grade core of the deposit.

The mafic monzonite and quartz monzonite contain magnetite- and quartz-rich unidirectional solidification textures (USTs), miarolitic cavities and aplite vein-dikes. These textural features imply that magmatic-hydrothermal fluids streamed through and accumulated within the narrow pipes, which acted as a conduit to supply fluids from a deeper magma to the site of ore deposition. Mineralizing fluids were released when the carapace of the crystallizing fluids failed, and were emplaced preferentially into two subvertical vein systems that formed via hydraulic fracturing.

The older veins (set 2) strike N, WNW and NE, whereas the younger mineralized structures (set 3) strike E, NE and NW.

Cathodoluminescence imaging of quartz shows that most of the quartz (Qz-1) crystallized early in the history of vein formation. Dissolution of Qz-1 was then followed by the deposition of a second quartz generation (Qz-2). Cu–Fe sulfides were then deposited together with a later generation of darkly-luminescent quartz (Qz-3). Bright luminescence in Qz-1 correlates with elevated Al, Ti and K concentrations, whereas dull-luminescent Qz-3 is comparatively rich in Fe. High-temperature Qz-1 precipitated during vein stockwork formation at temperatures between 601° and 850°C in equilibrium with hydrothermal K-feldspar. Changes in pressure and temperature occurred during mechanical fracturing that created secondary permeability exploited by Qz-2. Further decrease in pressure and/or temperature facilitated the precipitation of Qz-3 at temperatures below 589°C, synchronous with Fe–Cu sulfides.

Sulfur isotopic compositions of sulfides from Ridgeway show increasing  $\delta^{34}\text{S}$  depletion in the sequence of pyrite (ave. -1.8 ‰), chalcopyrite (ave. -3.6 ‰) and bornite (ave. -4.9 ‰). Low  $\delta^{34}\text{S}_{\text{bornite}}$  and  $\delta^{34}\text{S}_{\text{chalcopyrite}}$  values occur in the core of the deposit. Isotopically light  $\delta^{34}\text{S}_{\text{pyrite}}$  values are also found in the core of the deposit, but these become more negative towards the top of the deposit, in the epidote–chlorite–hematite alteration zone. This is consistent with isotopic fractionation caused by cooling of the magmatic-hydrothermal fluids under oxidizing conditions during late-stage pyrite deposition.

The Ridgeway deposit was localized at the intersection of NW-trending faults and a NNW-trending monocline. The pre-existing NW-trending parallel wedge-shape faults provided the pathways for the deep-seated magma to migrate into the shallow crust. Roof-lifting within the fault wedge provided space for monzonite emplacement. At Ridgeway, there was an intimate link between magmatism and a dynamic structural environment that ultimately controlled the genesis of the high-grade orebody and provided an excellent focus for fluid flow in a well-developed vein stockwork.

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To my late father and sister.....I made it.

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