PETROGENESIS OF MOUNT DORE-STYLE BRECCIA-HOSTED COPPER ± GOLD MINERALIZATION IN THE KURIDALA-SELWYN REGION OF NORTHWESTERN QUEENSLAND

Thesis submitted by

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ABSTRACT

"Geology has to choose between the rashness of using imperfect evidence or the sterility of uncorrelated unexplained facts."

Gregory
(cited in Wolf, 1970)

Mount Dore-style breccia-hosted copper-gold deposits define a 70 kilometre-long, north-trending lineament from Kuridala (65 kilometres south of Cloncurry), southwards. The type deposit lies 130 kilometres south of Cloncurry, and a detailed study of it was undertaken to produce a metallogenic model applicable (with suitable modifications) to all deposits having this style.

Regional geology results from a combination of **(i)** at least two cycles of ensialic rift sedimentation, **(ii)** later compressional tectonics and associated metamorphism to a maximum middle amphibolite grade, and **(iii)** intrusion of late-tectonic granitoids (Beardsmore *et al.*, 1988 and Newbery *et al.*, in prep.). Mount Dore-style deposits are largely restricted to rocks of the upper part of the Middle Proterozoic Maronan Supergroup, a newly-recognized package of rift-basin sediments. The precise age of this unit is presently unknown; it could belong to either rift episode, or be older or younger.

The Mount Dore deposit occurs within steeply east-dipping quartz-muscovite schists and carbonaceous slates of the uppermost Maronan Supergroup structurally overlying meta-calcarenites, calcilutites, marbles and metabasalts of the Staveley Formation. The structural history includes early, subhorizontal (D_1) detachment of the Staveley Formation from older units, followed by upright, north-trending, tight to isoclinal folding (D_2), accompanied by peak metamorphism in the lower to middle amphibolite facies (Jaques *et al.*, 1982). The events are tentatively dated at 1545 Ma, by analogy with D_2 and metamorphic history derived for the western part of the Mount Isa Inlier (Page and Bell, 1986). Northwest-trending corridors of open, upright folds belonging to the D_3 deformation event are scattered across the region, and one of these passes through the Mount Dore orebody. Latest tectonism produced the Mount Dore Fault Zone, a moderately- to steeply east-dipping reverse fault-zone about 250 metres wide, which passes through Mount Dore and reactivates the D_1 structure. The fault zone contains a thin sliver of uppermost Maronan Supergroup, sandwiched between footwall Staveley Formation and hangingwall (truncated) Mount Dore Granite. The granite is dated at 1510 Ma (Nisbet *et al.*, 1983).

Mount Dore displays a complex history of brecciation and alteration. Both are related to movement along the Mount Dore Fault Zone and to associated hydrothermal activity. Brecciation was a continuum process, with any particular "event" first producing angular, commonly tabular, crenulated schistose fragments. The crenulation is identified with S_3, but is randomly orientated from clast to clast, arguing for post-D_3 brecciation. Subsequent reworking of the early fragments involved tectonic and hydrothermal milling. Replacement and infill in the breccias are extensive. Early alteration produced K-feldspar (or biotite), tourmaline, sericite and quartz. Later alteration produced carbonate (dolomite and calcite), apatite and chlorite. All phases are associated with all brecciation styles, but the most pervasive alteration is associated with the intensively milled breccias.

Sulphide mineralization is associated temporally with carbonate alteration, and occurs late in the history of development of the Mount Dore deposit. Primary sulphide mineralization comprises pyrite and chalcopyrite, with minor sphalerite and galena. Pyrite is early, and is replaced by the other phases. Chalcocite also clearly replaces earlier pyrite, but is restricted to shallow depths, and probably formed by deep leaching of the deposit during Recent weathering.

Alteration, fluid inclusion and stable isotope geochemistry identify a primary deep-seated, hot (>500°C?), oxidized, CO_2-bearing, highly-saline (65-70 wt% salt) metamorphic or magmatic fluid containing K^+, Na^+, Fe^{2+}, Ca^{2+}, B, SiO_2, H^+, Cl^- and possibly SO_2. After initial separation and loss of an immiscible CO_2-rich phase, the residual aqueous fluid became more dilute with time, probably by mixing with cooler, lower salinity (<20 wt% salt), low-CO_2 fluid, possibly also of metamorphic origin. A model accounting for mineralization at Mount Dore invokes dilation and hydraulic brecciation during movement along the Mount Dore Fault Zone, where the fault intersects D_3 "corridors" of shallowly-dipping bedding and S_2 foliation. Early potassic and silicic alteration released ore metals (Cu, Pb, Zn, Ag, Co, U, Au) to the fluid from the host rocks at this time. Sulphide precipitation was controlled by sulphate reduction with carbon released from host. Pyrite scavenged most of this, and later Cu-, Pb- and Zn-sulphides formed by scavenging of S from pyrite.

Data concerning other Mount Dore-style deposits (Mount Elliott, S.W.A.N., Hampden) are limited, but suggest they may have formed by similar processes, with superficial differences arising from variations in geological setting. These deposits apparently all formed during a single metallogenic event related to late tectonism in the eastern part of the Mount Isa Inlier. A speculative regional model proposes emplacement of at least one large allochthonous slab of Maronan Supergroup over the carbonate-evaporite successions of the Mary Kathleen Group. The latter passed highly saline, CO_2-bearing connate and prograde metamorphic fluids upwards into and along the decollement. Subsequent upright to inclined F_2 antiforms may have ponded these fluids, allowing them to "stew" for some time in contact with relatively metal-rich rocks in the overriding plate. Alternatively, or additionally, the fluid may have migrated dissolved in Williams Batholith magmas, which were produced by partial melting of deep crustal material probably at the peak of regional metamorphism. Eventual release of hydrothermal fluid to higher crustal levels occurred only when vapour separation occurred in the rising plutons, and when permeable, late-tectonic reverse faults, which also controlled the solid-state emplacement of at least some of the plutons, breached F_2 structures. Passing rapidly upwards along the faults, the fluids encountered local dilatant zones, where high fluid fluxes and rapidly changing physical and chemical conditions instigated extensive alteration and sulphide precipitation. Low salinity fluids of meteoric, or more likely upper-plate metamorphic derivation also migrated into the dilatant zones when the deeply penetrating fault structures became available, and subsequently mixed with the saline fluids, perhaps initiating some styles of mineralization in the process.

Epigenetic mineralization across the Cloncurry Fold Belt (and perhaps the entire Mount Isa Inlier) appears to be the result of large-scale devolatilization of the crust during the waning stages of regional deformation and metamorphism. The characteristics of individual deposits depends on the combination of local factors such as structure and rock types available adjacent to these structures for leaching of metals.

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Various drafts of different parts of the thesis were read by Hugh Davies, Mike Rubenach, Bill Laing, Kim Dowling, Chris Wilson, and Pat Williams, and its content greatly improved thereby. Any errors of omission or commission must, however, remain my sole responsibility.

Finally, I dedicate this work to my immediate next of kin, particularly my mother, who must have despaired at times of my ever finishing.

Computer hardware and software

The wonders of modern technology have been invaluable for preparation of the document you see before you. Its making has spanned several generations of IBM-compatible (8086, 80286, and latterly 80386) computers, and four generations of the trusty word processing programme Wordperfect™ (versions 4.1, 4.2, 5.0, and 5.1). Mineral geochemical data were processed, and various cartesian and ternary plots of particular parameters were prepared using the programme MINFILE (Afifi and Essene, 1988). Plots were captured as bit-mapped .TIF graphics files using the Pizazz Plus™ screen printing utility (version 1.3). These files were then imported into Corel System Corporation's computer drawing package CorelDRAW!™ (version 2.0) and traced to produce publication quality diagrams. Calculations of fluid isotope compositions from mineral data were done using a programme written by myself using Microsoft® QuickBASIC™ version 4.5. Planar and linear structural data were processed into a series of point and contoured equal area stereographic plots using the programme QuickPlot version 1.0 (van Everdingen *et al.*, 1992). Screen images were saved as Lotus® .PIC files and imported into CorelDRAW!™ for tracing. Many of the "freehand" diagrams in the thesis were also drafted using CorelDRAW!™.

STATEMENT OF CURATION

Many hand-specimens from outcrop, and all drill-core samples are catalogued and lodged in the compactus of the Geology Department at James Cook University of North Queensland. Appendix B contains a complete listing of these specimens. Collectively, the samples are intended to provide a database for future studies on geologic and metallogenic aspects of the Kuridala-Selwyn region.