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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for the degree of Doctor of Philosophy in
the Department of Geology
James Cook University of North Queensland
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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 (D1) detachment of the Staveley Formation from older units, followed by upright, north-trending, tight to isoclinal folding (D2), 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 D2 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 D3 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 D1 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 S3, but is randomly orientated from clast to clast, arguing for post-D3 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, CO₂-bearing, highly-saline (65-70 wt% salt) metamorphic or magmatic fluid containing K⁺, Na⁺, Fe²⁺, Ca²⁺, B, SiO₂, H⁺, Cl⁻ and possibly SO₂. After initial separation and loss of an immiscible CO₂-rich phase, the residual aqueous fluid became more dilute with time, probably by mixing with cooler, lower salinity (<20 wt% salt), low-CO₂ 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 D₃ “corridors” of shallowly-dipping bedding and S₂ 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, CO₂-bearing connate and prograde metamorphic fluids upwards into and along the decollement. Subsequent upright to inclined F₂ 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 F₂ 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.
TABLE OF CONTENTS

Statement on Access ......................................................................................................... (i)
Declaration (original) ....................................................................................................... (ii)
Declaration (electronic version) ...................................................................................... (iii)
Electronic Copy ............................................................................................................... (iv)
Abstract .............................................................................................................................(v)
Table of Contents ........................................................................................................... (vii)
List of Appendices ........................................................................................................ (xiii)
List of Figures .............................................................................................................. (xiv)
List of Tables ................................................................................................................ (xviii)
Acknowledgements ........................................................................................................ (xx)
Statement of curation ................................................................................................... (xxii)

CHAPTER ONE
INTRODUCTION

1.1 PREAMBLE ............................................................................................................. 1-1

1.2 THE MOUNT DORE COPPER DEPOSIT ....................................................... 1-4

1.3 AIMS AND STRUCTURE OF THE THESIS ..................................................... 1-5

CHAPTER TWO
TECTONOSTRATIGRAPHIC EVOLUTION OF THE KURIDALA-SELYWN REGION

2.1 INTRODUCTION ................................................................................................... 2-1
  2.1.1 Rationale ......................................................................................................... 2-1
  2.1.2 History of previous investigations ................................................................. 2-2
  2.1.3 Statement of the problem .............................................................................. 2-3

2.2 STRATIGRAPHY ................................................................................................. 2-6
  2.2.1 Kuridala Formation ...................................................................................... 2-6
    Prelude ..................................................................................................................... 2-6
    Note on terminology ............................................................................................... 2-7
    Meta-arkose ............................................................................................................ 2-7
    Psammites and psammopelites ............................................................................. 2-9
    Pelites, quartzites and amphibolites .................................................................. 2-11
    Carbonaceous slates and amphibolites .............................................................. 2-12
  2.2.2 Staveley Formation ..................................................................................... 2-14
    Metabasalt ........................................................................................................... 2-14
    Ironstones ........................................................................................................... 2-16
    Variably-calcareous meta-arenites and meta-lutites .................................. 2-16
  2.2.3 Double Crossing Metamorphics .................................................................. 2-18
  2.2.4 Gin Creek Granite ....................................................................................... 2-19
2.2.5 Williams Batholith ................................................................................. 2-20
2.2.6 Dolerites ...............................................................................................2-22

2.3 DISCUSSION.......................................................................................... 2-23
  2.3.1 Obsolescence of the Kuridala Formation ......................................... 2-24
  2.3.2 Regional stratigraphic relationships and absolute ages? ............... 2-25
  2.3.3 Palaeodepositional environments .................................................... 2-26
  2.3.4 The tectonostratigraphic evolution of the Kuridala-Selwyn region .... 2-29

2.4 CONCLUSIONS ......................................................................................... 2-30

CHAPTER THREE
DEFORMATION HISTORY

3.1 INTRODUCTION ....................................................................................... 3-1

3.2 PREVIOUS INVESTIGATIONS ................................................................. 3-3
  3.2.1 Deformation history ........................................................................ 3-3
  3.2.2 Metamorphic history ....................................................................... 3-4

3.3 STRUCTURE IN THE KURIDALA-SELWYN REGION .......................... 3-6
  3.3.1 Rationale.......................................................................................... 3-6
  3.3.2 D_2 - Regional north-south folding .................................................. 3-6
      Macrostructural evidence for D_1 ..........................................................3-12
      Microstructural evidence for D_1 ......................................................... 3-15
  3.3.3 D_3 - North- to northnorthwest-trending folding ............................ 3-19
  3.3.4 D_4 - Northeast-trending crenulations ............................................. 3-23
  3.3.5 Faulting............................................................................................ 3-23
      Conjugate shearing ............................................................................. 3-23
      The Mount Dore Fault Zone .............................................................. 3-24

3.4 DISCUSSION......................................................................................... 3-25
  3.4.1 The style of D_1 ............................................................................. 3-25
  3.4.2 Deformation Ages .......................................................................... 3-26
  3.4.3 Implications for tectonic modelling ..................................................3-28

3.5 CONCLUSIONS ....................................................................................... 3-30

CHAPTER FOUR
LOCAL GEOLOGIC SETTING

4.1 INTRODUCTION ...................................................................................... 4-1
4.2 LOCAL GEOLOGY ................................................................. 4-3
   4.2.1 Principal lithologies .................................................... 4-3
   4.2.2 Structure .................................................................... 4-8

4.3 BRECCIATION ................................................................. 4-9
   4.3.1 Introduction ............................................................... 4-9
   4.3.2 Angular breccias ...................................................... 4-12
   4.3.3 Rounded breccias .................................................... 4-13
   4.3.4 Granitic breccia ...................................................... 4-14
   4.3.5 Ferruginous cataclasite ........................................... 4-14

4.4 BRECCIA PETROGENESIS, FAULT PROPAGATION AND
   HYDROTHERMAL FLUIDS ................................................. 4-15

4.4 CONCLUSIONS ............................................................... 4-17

CHAPTER FIVE
HYDROTHERMAL PHASE PARAGENESES AND
GEOCHEMISTRY

5.1 INTRODUCTION ............................................................... 5-1

5.2 DISTRIBUTION AND PARAGENESES ............................. 5-2
   5.2.1 Identity and distribution of phases .............................. 5-2
   5.2.2 Alteration parageneses ............................................. 5-11
      Granite ........................................................................... 5-11
      Quartz-muscovite schist .............................................. 5-14
      Carbonaceous slate .................................................... 5-15
      Calcilutites ................................................................. 5-16
      Quartzite ....................................................................... 5-19
   5.2.3 Mineralization parageneses ...................................... 5-19

5.3 MINERAL GEOCHEMISTRY .............................................. 5-22
   5.3.1 Diopside ................................................................. 5-22
   5.3.2 Amphibole .............................................................. 5-22
   5.3.3 Scapolite ............................................................... 5-27
   5.3.4 Epidote ................................................................. 5-27
   5.3.5 Garnet ................................................................. 5-33
   5.3.6 Microcline ........................................................... 5-33
   5.3.7 White mica .......................................................... 5-37
   5.3.8 Tourmaline ............................................................ 5-42
   5.3.9 Apatite ................................................................. 5-49
   5.3.10 Biotite ................................................................. 5-54
   5.3.11 Carbonate ........................................................... 5-58
   5.3.12 Chlorite ............................................................... 5-60
   5.3.13 Sulphides ............................................................ 5-65
5.4 IMPLICATIONS OF MINERAL PARAGENESES FOR FLUID GEOCHEMISTRY

5.4.1 Potassic alteration and fluid redox .............................. 5-67
5.4.2 Calc-silicates and retrograde reactions ...................... 5-70
5.4.3 Boron and silica metasomatism .............................. 5-72
5.4.4 Carbonate alteration .............................................. 5-72
5.4.5 Sulphur fugacity and sulphide formation ...................... 5-73
5.4.6 Accessory phases ...................................................... 5-75
5.4.7 Fluid "dregs" .............................................................. 5-76

5.5 CONCLUSIONS ........................................................................ 5-76

CHAPTER SIX
FLUID GEOCHEMISTRY AND PROVENANCE

6.1 INTRODUCTION ........................................................................ 6-1

6.2 FLUID INCLUSION CHARACTERIZATION ................................. 6-2

6.2.1 Introduction ........................................................................ 6-2
6.2.2 Type I multiphase solid ....................................................... 6-4
6.2.3 Type II multiphase solid ......................................................... 6-12
6.2.4 Immiscible liquid ................................................................. 6-16
6.2.5 Type I liquid-rich, two-phase inclusions .............................. 6-17
6.2.6 Type II liquid-rich, two-phase inclusions ............................. 6-21
6.2.7 Vapour-rich, two-phase inclusions ....................................... 6-21
6.2.8 Solid inclusions ................................................................. 6-22
6.2.9 Spatial and temporal relations between inclusion populations ........................................................................ 6-22

6.3 VOLUMETRIC STUDIES .......................................................... 6-24

6.3.1 Introduction ........................................................................ 6-24
6.3.2 Solution composition at room temperature ....................... 6-25
6.3.3 Homogeneous fluid composition ........................................ 6-28

6.4 STABLE ISOTOPE RESULTS ................................................... 6-32

6.4.1 Introduction ........................................................................ 6-32
6.4.2 Fractionation equations used in this study ....................... 6-32
6.4.3 Results .............................................................................. 6-39

Oxygen .................................................................................. 6-39
Deuterium ............................................................................ 6-40
Carbon ................................................................................. 6-40
Sulphur ................................................................................. 6-41

6.5 DISCUSSION ............................................................................ 6-41

6.5.1 Primary fluid composition ................................................. 6-41
6.5.2 Evolution of fluid chemistry from fluid inclusion evidence 6-44
6.5.3 Transport and precipitation of base metals ........................................ 6-45
6.5.4 Fluid provenance ........................................................................ 6-46
   Fractionation considerations ..................................................... 6-46
   Source of oxygen ...................................................................... 6-48
   Source of deuterium ................................................................ 6-51
   Source of carbon ..................................................................... 6-51
   Source of sulphur ................................................................... 6-54
   Which means the fluid is...? ................................................... 6-56

6.6 CONCLUSIONS ............................................................................. 6-58

CHAPTER SEVEN
PETROGENESIS OF MOUNT DORE-STYLE BRECCIA-HOSTED COPPER DEPOSITS

7.1 INTRODUCTION ........................................................................ 7-1

7.2 CHARACTERISTICS OF OTHER COPPER DEPOSITS .......... 7-4
  7.2.1 Mount Elliott ................................................................. 7-4
      Local geological setting ..................................................... 7-4
      Mineralization and associated alteration ......................... 7-7
  7.2.2 Hampden Group ........................................................... 7-9
      Local geological setting ..................................................... 7-9
      Mineralization and alteration ........................................... 7-9
  7.2.3 SWAN ........................................................................ 7-12
      Local geological setting ..................................................... 7-12
      Mineralization and alteration ........................................... 7-14
  7.2.4 Some small deposits ..................................................... 7-16
      Lady Ella Mine ................................................................. 7-16
      Marilyn Mine .................................................................. 7-17
      Mariposa Prospect .......................................................... 7-17
      Stuart Mine ...................................................................... 7-17
      Labour Victory ................................................................. 7-18

7.3 COMPARISON OF CHARACTERISTICS ................................ 7-18
  7.3.1 Structural controls .......................................................... 7-18
  7.3.2 Host lithologies .............................................................. 7-19
  7.3.3 Alteration assemblages ................................................... 7-20
  7.3.4 Primary mineralization .................................................. 7-21
  7.3.5 Hydrothermal fluid ....................................................... 7-21
  7.3.6 Conclusion ..................................................................... 7-22
  7.3.7 Comparison with the Mount Isa copper deposit ............... 7-23

7.4 PETROGENESIS OF THE MOUNT DORE COPPER DEPOSIT ...... 7-24
7.5 SPECULATIONS ON REGIONAL METALLOGENY ........................................ 7-27
   7.5.1 Absolute age of alteration and mineralization .......................... 7-27
   7.5.2 Source of metals ..................................................................... 7-28
   7.5.3 Mineralizing role of granitoids ............................................. 7-31
   7.5.4 Metallogeny and tectonics ..................................................... 7-33
   7.5.5 Recommendations for further work ...................................... 7-36
   Tectonic studies ........................................................................... 7-36
   Metallogenic studies .................................................................. 7-38

7.6 SUMMARY OF RESULTS AND CONCLUSIONS ............................... 7-40

REFERENCES ...................................................................................... R1-R19
APPENDICES (VOLUME 2)

APPENDIX A: ........................................................................................................ A1-A17

The new Maronan Supergroup - some definitions and implications for stratigraphic revision in the Cloncurry Fold Belt, northwest Queensland.

APPENDIX B: ...................................................................................................... B1-B29

Rock specimens lodged at the Geology Department, James Cook University

APPENDIX C: ........................................................................................................ C1-C7

Analytical techniques used in geochemical studies

APPENDIX D: ...................................................................................................... D1-D38

Full mineral compositional data from microprobe analyses

APPENDIX E: ......................................................................................................... E1-E9

Fugacities of HCl and HF in hydrothermal fluids at Mount Dore

APPENDIX F1: ...................................................................................................... F1.1-F1.3

Tabulated aqueous fluid inclusion thermometric data

APPENDIX F2: ...................................................................................................... F2.1-F2.37

Calculation of fluid composition from fluid inclusion volumetric data

APPENDIX G: ......................................................................................................... G1-G14

Listing for the program "ISOTOPE.BAS"
LIST OF FIGURES

CHAPTER 1

FIGURE 1.1: Location of the Mount Isa Inlier, and major geographic features.

FIGURE 1.2: Summary geological map of the Cloncurry Fold Belt, showing location of mineral deposits.

CHAPTER 2

FIGURE 2.1: Comparison of the conventional interpretation of stratigraphy with that proposed in this study.

CHAPTER 3

FIGURE 3.1: Locations of some important breccia-hosted copper deposits in the Mount Isa Inlier.

FIGURE 3.2: Map showing the distribution of major regional structures in the Kuridala-Selwyn region.

FIGURE 3.3: Polar and contoured polar equal area stereoplots of foliation data.

FIGURE 3.4: Linear and contoured linear equal area stereoplots of lineation data.

FIGURE 3.5: Field and microscopic characteristics of the Selwyn Shear.

FIGURE 3.6: Microstructural features of the S₂ foliation.

FIGURE 3.7: Development of a new slaty foliation by progressive crenulation, shearing and dissolution of a previous foliation (after Bell and Rubenach, 1983).

FIGURE 3.8: Model of Bell (1986) for reactivation of an earlier foliation by antithetic shearing and decrenulation of later foliation.

FIGURE 3.9: Field and microstructural features of D₃ structures.
CHAPTER 4

FIGURE 4.1: (a) Outcrop geology map of rock types in and around the Mount Dore Prospect (after Leishman, 1983). (b) Interpretive solid geology map and cross-section of the Mount Dore Prospect.

FIGURE 4.2: Outcrop and drill core characteristics of Mount Dore breccias.

CHAPTER 5

FIGURE 5.1: Isometric block diagrams showing the distribution of main alteration phases and copper mineralization at Mount Dore.

FIGURE 5.2: Diagrammatic log of drill hole SHQ-78-35, showing relationship between lithology, brecciation, and metal grades.

FIGURE 5.3: Mineral parageneses for each major lithology at Mount Dore.

FIGURE 5.4: Selected photomicrographs of sulphide textural relationships.

FIGURE 5.5: Plot of Mount Dore diopside compositions.

FIGURE 5.6: Plot of Mount Dore amphibole compositions.

FIGURE 5.7: Plot of Mount Dore scapolite compositions.

FIGURE 5.8: Plot of Mount Dore epidote compositions.

FIGURE 5.9: Plot of Mount Dore garnet compositions.

FIGURE 5.10: Plots of Mount Dore white mica compositions, illustrating chemical differences in micas from different lithologies.

FIGURE 5.11: Plots of Mount Dore tourmaline compositions, illustrating chemical differences in tourmalines from different lithologies.

FIGURE 5.12: Chemical variations across zoned tourmaline crystals.

FIGURE 5.13: Plot of Mount Dore apatite compositions, where all three components could be estimated.

FIGURE 5.14: Chemical variations across zoned apatites.

FIGURE 5.15: Plots of Mount Dore biotite compositions, showing degree of chloritization, and also illustrating chemical differences in biotites from different lithologies.
FIGURE 5.16: Plot of Mount Dore chlorite compositions.

FIGURE 5.17: T-f_{O2} diagram for the system Fe-O-H-Si-Al at P=207 Pa, showing the stability fields of biotite and K-feldspar.

FIGURE 5.18: T-X_{CO2} diagram for P=100 MPa, showing reactions limiting the stability fields of diopside, and its minimum temperature of formation.

FIGURE 5.19: Calcite, dolomite and magnesite stability fields in terms of temperature and mole fractions of m_{Ca^{2+}}/(m_{Ca^{2+}}+m_{Mg^{2+}}) in solution in equilibrium with these phases.

CHAPTER 6

FIGURE 6.1: Photomicrographs illustrating the different populations of fluid inclusions observed at Mount Dore.

FIGURE 6.2: Photomicrographs of fluid inclusion contents observed during semi-quantitative SEM analyses of opened inclusions.

FIGURE 6.3: Examples of X-ray spectra obtained from semi-quantitative SEM analyses of daughters in opened inclusions.

FIGURE 6.4: Thermometric data for Type I multiphase solid inclusions.

FIGURE 6.5: Vapour-saturated solubility surfaces in the ternary NaCl-KCl-H_{2}O and NaCl-CaCl_{2}-H_{2}O systems, showing the interpreted possible field of fluid compositions in Type II multiphase solid inclusions.

FIGURE 6.6: Thermometric data for Type I liquid-rich two phase and vapour-rich two-phase inclusions.

FIGURE 6.7: Plan view of Mount Dore prospect showing location of drill holes and isotope samples used in this study.

FIGURE 6.8: T-X_{CO2} diagrams for the H_{2}O-CO_{2}-NaCl system for 35 wt% NaCl relative to H_{2}O+NaCl, at P=50, 100, 150 and 200 MPa, illustrating immiscibility conditions.

FIGURE 6.9: δD-δ^{18}O diagram showing deuterium and oxygen isotope results from Mount Dore, superimposed on the fields for metamorphic and magmatic H_{2}O.

FIGURE 6.10: Deviation of δ^{13}C of CO_{2} in solution from that of the bulk fluid as a function of f_{O2} and pH, for a temperature of 350°C, showing possible field of conditions for the fluid at Mount Dore.
FIGURE 6.11: Deviation of $\delta^{34}_{\text{H}_2\text{S}}$ from $\delta^{34}_{\text{fluid}}$ as a function of $\log a_{\text{O}_2}$ and temperature, at $P_{\text{H}_2\text{O}} = 100$ MPa.

CHAPTER 7

FIGURE 7.1: Geological map showing locations of mineral deposits considered in this chapter.

FIGURE 7.2: Geologic setting of the Mount Elliott deposit.

FIGURE 7.3: Geologic setting of the Hampden deposits.

FIGURE 7.4: Geologic setting of the SWAN deposit.

FIGURE 7.5: Schematic diagram of a proposed model for regional epigenetic mineralization.
LIST OF TABLES

CHAPTER 2

TABLE 2.1: Comparison of lithological characteristics of the Kuridala Formation and constituent formations of the Maronan Supergroup.

CHAPTER 3

TABLE 3.1: Characteristics of the main deformation events recognised in the Kuridala-Selwyn region.

CHAPTER 5

TABLE 5.1: Base metal sulphides identified at Mount Dore.

TABLE 5.2: Diopside compositional data, and structural formulae calculated on the basis of six oxygens per unit.

TABLE 5.3: Summary amphibole compositional data, and structural formulae calculated on the basis of 24(O+OH+F+Cl) per unit.

TABLE 5.4: Scapolite compositional data, and structural formulae calculated on the basis of 12(Si+Al) per unit.

TABLE 5.5: Epidote compositional data, and structural formulae calculated on the basis of 12 oxygens per unit, with all iron assumed to be ferric.

TABLE 5.6: Garnet compositional data, and structural formulae calculated assuming 16 cations per unit.

TABLE 5.7: Summary microcline compositional data, and structural formulae calculated on the basis of eight oxygens per unit.

TABLE 5.8: Summary white mica compositional data, and structural formulae calculated on the basis of 24(O+OH+F+Cl) per unit.

TABLE 5.9: Summary tourmaline compositional data, and structural formulae calculated assuming 31(O+OH+Cl), all Fe is FeO, Li₂O is negligible, and three boron atoms per unit.

TABLE 5.10: Summary apatite compositional data, and structural formulae calculated assuming eight cations per unit cell.
TABLE 5.11: Summary biotite compositional data, and structural formulae calculated assuming 24(O+OH+Cl+F) per unit.

TABLE 5.12: Summary carbonate compositional data, and structural formulae calculated on the basis of six oxygen atoms per unit.

TABLE 5.13: Summary chlorite compositional data, and structural formulae calculated assuming all iron is ferrous and 18(O+OH+Cl) per unit.

TABLE 5.14: Trace metal contents of base metal sulphides from Mount Dore.

CHAPTER 6

TABLE 6.1: Characteristics of different fluid inclusion populations observed at Mount Dore.

TABLE 6.2: Optical properties of identified daughter phases in Type I multiphase solid inclusions.

TABLE 6.3: List of daughter phases identified in Type I multiphase solid inclusions used in volumetric studies.

TABLE 6.4: Thermometric data for Type II multiphase solid fluid inclusions.

TABLE 6.5: Eutectic temperatures for various salt-water systems.

TABLE 6.6: Thermometric and volumetric data for CO₂-bearing fluid inclusions.

TABLE 6.7: Calculated solution compositions (wt%) and H₂O activities in equilibrium with various invariant mineral assemblages in the system NaCl-KCl-MgCl₂-CaCl₂-H₂O at 25°C.

TABLE 6.8: Volume percentages of all phases at room temperature in Type I multiphase solid inclusions used in volumetric studies.

TABLE 6.9: Calculated composition of the homogeneous hydrothermal fluid trapped in Type I multiphase solid inclusions.

TABLE 6.10: Ratios of major cationic species in fluid inclusions used in volumetric studies.

TABLE 6.11: Mineral-fluid isotope fractionation calibrations used in this study.

TABLE 6.12: Sample numbers, lithologies, alteration styles, and mineral and calculated fluid isotopic data for K-feldspar, biotite, quartz and carbonate. All values in permil.
CHAPTER 7

**TABLE 7.1:** Comparison of geological characteristics of the Mount Dore deposit with those of other breccia-hosted deposits.

**TABLE 7.2:** Concentrations of selected trace elements in "average" continental crust, and in six major lithologies.
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Finally, I dedicate this work to my immediate next of kin, particularly my
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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
trust 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.