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Genesis, Tectonic Setting- and Exploration Considerations for Fe-oxide Cu Au Deposits, Mount Isa Eastern Succession

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ABSTRACT

Based on the geochemistry of mafic rocks, the Palaeo-Mesoproterozoic eastern margins of the North and South Australian Cratons can be classified into the Eastern Domain (Mount Isa Eastern Succession, Curnamona Province and Georgetown Inlier) and Western Domain (Mount Isa Western Succession, Kalkadoon-Leichhardt Belt and McArthur River Basin). Basaltic magmatism of the Eastern Domain was synchronous with back arc basinal development, while Western Domain magmas were emplaced into a thicker continental crust. This difference is reflected in the metallogenic nature of the domains, whereby Fe-oxide-Cu-Au (IOCG) and Broken Hill Type (BHT-type) deposits dominates the Eastern Domain, and stratiform Pb-Zn-Ag and Mount Isa Style Cu-Pb-Zn(Ag) are found in the Western Domain. Based on the distinct evolutionary trends for mafic magmas of the domains of Mesoproterozoic Australia, we suggest that the Mount Isa Western Succession and McArthur River Basin continue to be recognised as part of the North Australian Craton. While the Mount Isa Eastern Succession, Curnamona Province and the Georgetown Inlier be referred to as the East Australian Craton. An actively or formerly subducted slab sitting in the mantle lithosphere to the east of the eastern margin of the East Australian Craton may have provided the appropriate mantle chemistry to contribute to subsequent generation, in an extended continent, of magmas and volcano-sedimentary input that led to the formation of Mesoproterozoic IOCG and BHT deposits.

In the Mount Isa Eastern Succession, mafic rocks and magmas contributed sulphur and metals to IOCG ore deposition over a protracted (~170My) period. Between 1686 Ma and 1660Ma, S and metals (Cu, Au, Zn, Fe, Ni, Co) were exsolved

from crystallising strongly fractioned back-arc tholeiitic magmas into active extensional faults, and surrounding country rocks. During Isan peak-metamorphism, at ~1600Ma-1580Ma, significant amounts of S, Cu, Au, Zn, Ni, Co and Cr were leached from mafic rocks and crustal accumulations, and led to the deposition of early IOCG and base metal deposits. Subsequent albitic alteration associated with the hydrothermal fluids of the ~1550Ma-1490Ma Williams-Naraku Batholith may also have sequestered sulphide material from mafic rocks. This study highlights the possibility that the previously held consensus that the Williams-Naraku Batholith of felsic-intermediate magmas contributed the bulk of the metals to the Eastern Succession mineral deposits, may not necessarily be the case, but rather, fluids derived from these magmas remobilised previously existing mafic derived metal accumulations.

Protracted metal and sulphur contributions to the Mount Isa Eastern Succession Iron oxide-Cu-Au (IOCG) province occurred primarily as a consequence of long-lived fluid and melt fluxes from the base of the crust, stimulated by initial back-arc emplacement of voluminous mafic magmas. The concentration of sulphur, iron, copper and gold into the presently observed mineral deposits involved a significant component of remobilisation and reworking of early initial enrichments (pre- to syn-Isan Orogeny) by later fluids (syn- to post-Isan and syn-Williams/Naraku Batholith). Osborne (eastern domain) and Eloise-type ores formed or were strongly remobilized at c. 1600 Ma by reduced, mafic-derived fluids, whereas oxidised brines released by the Williams/Naraku granitoids overprinted magnetite ± sulphides at Osborne (western domain) and Starra to produce younger (c. 1530 Ma) hematite-chalcopyrite associations. CO_2-rich, potentially mantle-derived fluid may have periodically pulsed through the system, manifest now as pyrrhotite-stable carbonate veins and pods. Exploration for Ernest Henry and Starra style deposits should focus on recognition of oxidised corridors in relation to mafic- proximal and structurally-defined targets, However, the possibility remains that large, early mafic rock related Cu-Au ± (Fe, Co, Ni, Zn) deposits are preserved distal to the oxidising effects of the Williams-Naraku hydrothermal system, and may also present exploration opportunities.

Within the southern portion of the Mount Isa Eastern Succession, mafic rocks, and faults that intersect areas of mafic rocks, exhibit the strongest spatial relationship to IOCG mineralisation than any other geological unit. In contrast, felsic rocks, of which both genetic and exploration models have relied heavily upon in the past in order to explain the final localisation controls on IOCG deposits, do not display a significant relationship to mineralisation. The results attained call for an immediate review of exploration practices in the Eastern Succession, and call upon more mafic-related models in order to achieve sustainable IOCG mineral discoveries.

CONTENTS

STATEMENT OF SOURCES

Declaration

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information dervided from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

15 June 2010

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Kris Butera Date

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PREFACE

This thesis has been written as concisely as possible in order to fulfil its objective as an industry "friendly" document, with the specific purpose of helping explorers discover unidentified Fe-oxide Cu Au mineral resources, under the philosophies and logic of the predictive mineral discovery cooperative research centre (pmd*CRC).

The thesis is written as four exclusive papers/articles with the intention of publication in relevant journals/newsletters, and as such, there may be some repetition of crucial topics from paper to paper. Each paper has been contributed to by one or more co-authors.

The papers, in individual chapters, form a logical geological progression from beginning to end:

Chapter 1:
Back-arcs, mafic rock geochemistry, metallogenesis and a reinterpretation of the Paleo- to Mesoproterozoic assembly of Northern and Eastern Australia.
Butera, K.M., Oliver, N.H.S., Foster, D.R.W., Rubenach, M.J.R., Collins, W.C. and Nortje, G.S.

This chapter sets the tectonic framework for the metallogenic studies contained further in the thesis. The geochemistry of the mafic rocks units from within the Mount Isa Inlier and surrounding Proterozoic domains was studied in order to explain the distribution of different metallogenic styles that are temporally and spatially associated with those domains.

Chapter 2:
The role of mafic rocks in the genesis of Iron oxide-Copper-Gold deposits, Mount Isa Eastern Succession, Northwest Queensland.
Butera, K.M., Oliver, N.H.S., Cleverley, J.S., Rubenach, M.J. and Collins, W.C.

Chapter 2 examines the geochemical relationships between Fe-oxide Cu Au (IOCG) deposits and mafic rocks and magmas in the Mount Isa Eastern Succession. Topics studied and discussed include both primary (fractionation) and secondary (metamorphic leaching) processes enacted upon mafic rocks/magmas that led to IOCG genesis.

Chapter 3:
A protracted multi-staged model for Fe oxide-Cu-Au mineralisation, Mount Isa Eastern Succession, NW Queensland.
Butera, K.M., Oliver, N.H.S. and Nortje, G.S.

Chapter 3 takes the data and interpretations from Chapter 2 and puts them in a broader context for overall IOCG Genesis models in the Mount Isa Eastern Succession, discussing previous models and highlighting the need to incorporate the new data into current genetic and exploration models for IOCGs. A reworked version of this paper was published in Precambrian Research, with a siginificant component of the work being contributed by Nick Oliver. This reworked paper is included in Appendix III for comparsion, outlining the various authors contributions.

Chapter 4:

Spatial Associations of mafic rocks and Fe-oxide Cu-Au deposits, southern Mount Isa Eastern Succession: implications for exploration

Butera, K.M. and Oliver, N.H.S.

This chapter examines the spatial association of geological units to IOCG deposits, and specifically the strength of the spatial relationship of mafic rocks to IOCGs. Utilising Weights of Evidence and Fractal Analysis, this work provides exploration indicators/strategies for IOCG deposits, and with the previous discussed geochemical relationships of mafics to IOCGs, adds a set of tools and greater confidence for mineral explorers to engage in IOCG mineral discovery.