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Constraints on hydrothermal fluid pathways within Mary Kathleen Group stratigraphy of the Cloncurry iron-oxide–copper–gold District, Australia

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Abstract

Widespread brecciation and Na-(Ca) alteration in the metacarbonate-dominated Mary Kathleen Group characterise some of the district-scale host-rocks to iron-oxide–copper–gold (IOCG) mineralisation in the Proterozoic Cloncurry District of north-eastern Australia. Structural and mineralogical observations combined with stable isotope data indicate that within the Mary Kathleen Group, late- to post-metamorphism brecciation was preferentially developed in calcite-poor lithologies, while marbles and to a lesser degree calc-silicate rocks were not prone to fracturing and acted as impermeable barriers to fluid flow. These impermeable layers helped maintain high fluid pressures promoting brecciation in adjacent lithologies. Only in areas of localised high shear strain did carbonate-rich lithologies allow for appreciable fluid flow. Such carbonate-rich rocks contain isotopically and mineralogically distinct skarn-like assemblages, the recognition of which may be important in identifying high fluid flux corridors in the vicinity of major IOCG deposits.

Keywords: IOCG; Ernest Henry; Fluid flow; Permeability; Stable isotopes; Australia

1. Introduction

The Cloncurry District of the Proterozoic Mount Isa Block hosts a number of active and historically important iron-oxide–copper–gold (IOCG) deposits including the Ernest Henry, Osborne, Starra, Mt Elliott and Eloise deposits (Fig. 1). The district is characterised by widespread albite-rich Na-(Ca) alteration with many of the deposits hosted by more discrete zones of K–Fe alteration. Fluids for regional alteration and IOCG mineralisation were predominantly derived from magmatic sources (Marshall et al., 2006). Iron and potassium enriched in the ore environments was in part scavenged from regional country rocks through the albitisation process (Oliver et al., 2004), as documented by shifts in fluid isotopic and geochemical signatures from inferred fluid sources through regional alteration and Cu–Au mineralisation (Marshall and Oliver, 2006).

This contribution investigates rheologic controls on the development of hydrothermal fluid pathways within the Mary Kathleen Group of the Cloncurry District using structural and mineralogical observations and interpretation of a subset of isotopic data presented by Marshall et al. (2006). These data indicate that most marbles remained relatively impermeable during regional Na-(Ca) alteration and IOCG mineralisation, and that fluid flow was channelled predominantly through fracture and breccia networks preferentially developed in carbonate-poor lithologies.

1.1. Regional geology and tectonostratigraphic setting

Supracrustal rocks in the Mt Isa Block are subdivided by Blake (1987) into Cover Sequences 1–3 deposited at ca. 1870–1840 Ma, 1790–1720 Ma and 1680–1620 Ma, respectively (Fig. 1). Much of the Cloncurry District consists of metasedimentary and metavolcanic rocks of the Mary Kathleen Group (Cover Sequence 2), including Corella Formation marbles, calc-silicate rocks, metasiltstones and the overlying Mt Fort Constantine metavolcanic rocks. Cover Sequence 3 in the Cloncurry District is dominated by metavolcanic and pelitic rocks.

The Isan Orogeny has been interpreted as a west-vergent fold and thrust belt (e.g. O'Dea et al., 1997). D_1 deformation involved thrust reactivation of basin-bounding extensional faults, with Cover Sequence 3 rocks thrust over older Cover Sequence 2 rocks. D_2 deformation involved tight to isoclinal folding of both sequences, broadly synchronous with greenschist to amphibolite facies metamorphism, most likely within the interval of

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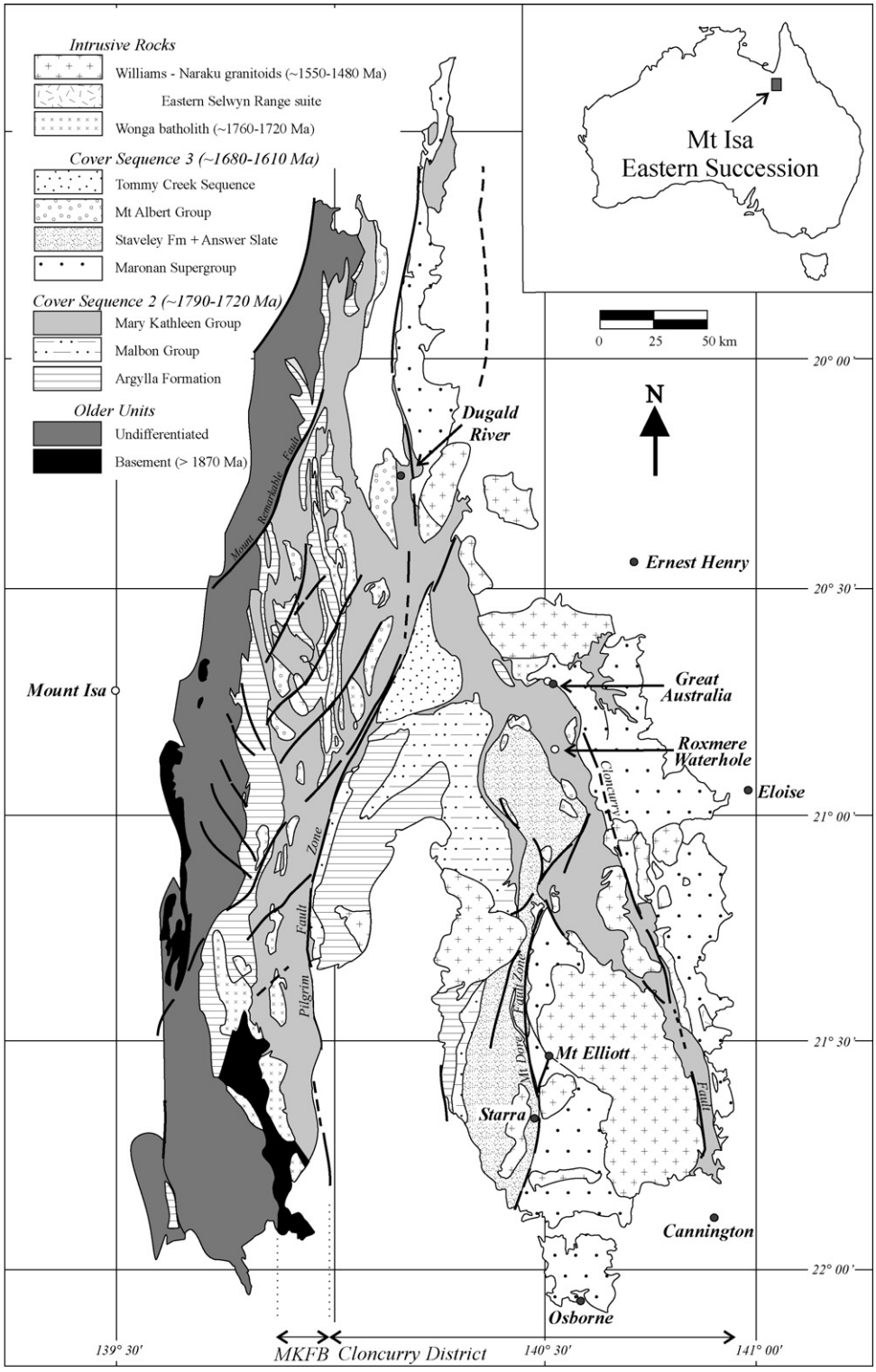

Fig. 1. Simplified geology of the Cloncurry District, northern Australia, modified after Williams (1998).

1600–1570 Ma. D_2 structures are overprinted by D_3 structures including conjugate NE- and NW-trending open folds, predominantly N–S trending shear zones and fault zones, and widespread breccias best developed within Corella Formation strata. D_3 deformation was broadly synchronous with emplacement of the Williams and Naraku Batholiths (ca. 1540–1500 Ma).

1.2. Ernest Henry Cu–Au deposit

Ernest Henry (166 Mt @ 1.1% Cu and 0.55 ppm Au; Ryan, 1998) is the largest known Cu–Au deposit in the Cloncurry District. The deposit consists of a pipe-like breccia body hosted predominantly by Mount Fort Constantine (MFC) felsic