

# Pressure-temperature-time paths from P-T pseudosections and zoned garnets: implications for microstructural and metamorphic evolution of the Eastern Succession, Mt Isa Inlier

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## Introduction

The Mt Isa Inlier of northwest Queensland contains multiply deformed and poly-metamorphosed middle Proterozoic meta-sedimentary rocks with extensive intrusive and extrusive complexes. A number of structurally-controlled Iron Oxide Copper Gold (IOCG) and Ag-Zn-Pb deposits are hosted within the inlier. It has been argued that the mineralization is controlled by discrete episodes of deformation and metamorphism (e.g., Adshead-Bell, 1998) ranging from ~1595Ma Osborne Cu-Au (Rebenach et al., 2001) to ~1505Ma Starra Au-Cu orebodies (Rotherham et al., 1998). Therefore, understanding tectonics and metamorphism is essential for prospectivity analysis and exploration for these deposits.

The Eastern Fold Belt of the Mt Isa Inlier hosts poly-metamorphic signatures of pro- and retrograde mineral assemblages. Examples of poly-metamorphic mineral assemblage include cordierite-staurolite-biotite-muscovite in the Snake Creek Anticline (Rubenach and Lewthwaite, 2002) and Rosebud Syncline of the Mary Kathleen Fold Belt (Reinhardt, 1992). The occurrence of such poly-metamorphic mineral assemblage implies that the Eastern Succession of the Mt Isa inlier has undergone discrete phases of metamorphism and associated deformation (e.g., Pattison et al., 1999).

This study seeks to understand the tectono-thermal evolution of the Eastern Succession of the Mt Isa Inlier. Detailed structural mapping and systematic sampling has been carried out in the key areas of the Eastern Succession to answer some of the fundamental and most critical questions, e.g., what is the link between the poly-metamorphic nature of the Eastern Succession with crustal-scale deformation episodes? We present our preliminary P-T results based on microstructural relationships and thermodynamic modeling from the Snake Creek Anticline, Tommy Creek Block and White Blow Formation of the Mary Kathleen Fold Belt (Fig. 1). Significantly, we have documented high-pressure estimates based on thermodynamic modeling of chemically zoned garnets, which are consistent with textural relationships and field observations, and have never been reported from any part of the Mt Isa Inlier.

## P-T pseudosections and geo-thermobarometric constraints

P-T pseudosections, that is, maps of stable mineral assemblages in P-T-X space, have been prepared using XRF bulk rock major element chemistry, using the computer program THERMOCALC and an internally consistent thermodynamic database (Powell et al., 1998). This method can reliably model the P-T conditions of garnet core growth, based on the intersection of Fe, Mn and Ca compositional isopleths (Vance and Mahar, 1998). P-T pseudosections are able to explain the observed mineral assemblages, compositions, zonations and modes in the rocks with distinct bulk compositions with respect to a petrogenetic grid.

P-T paths for five samples were calculated in a 9-component model chemical system (MnCaNaKFMASH). Three samples came from Snake Creek anticline (SC122, SC189, SC192), one

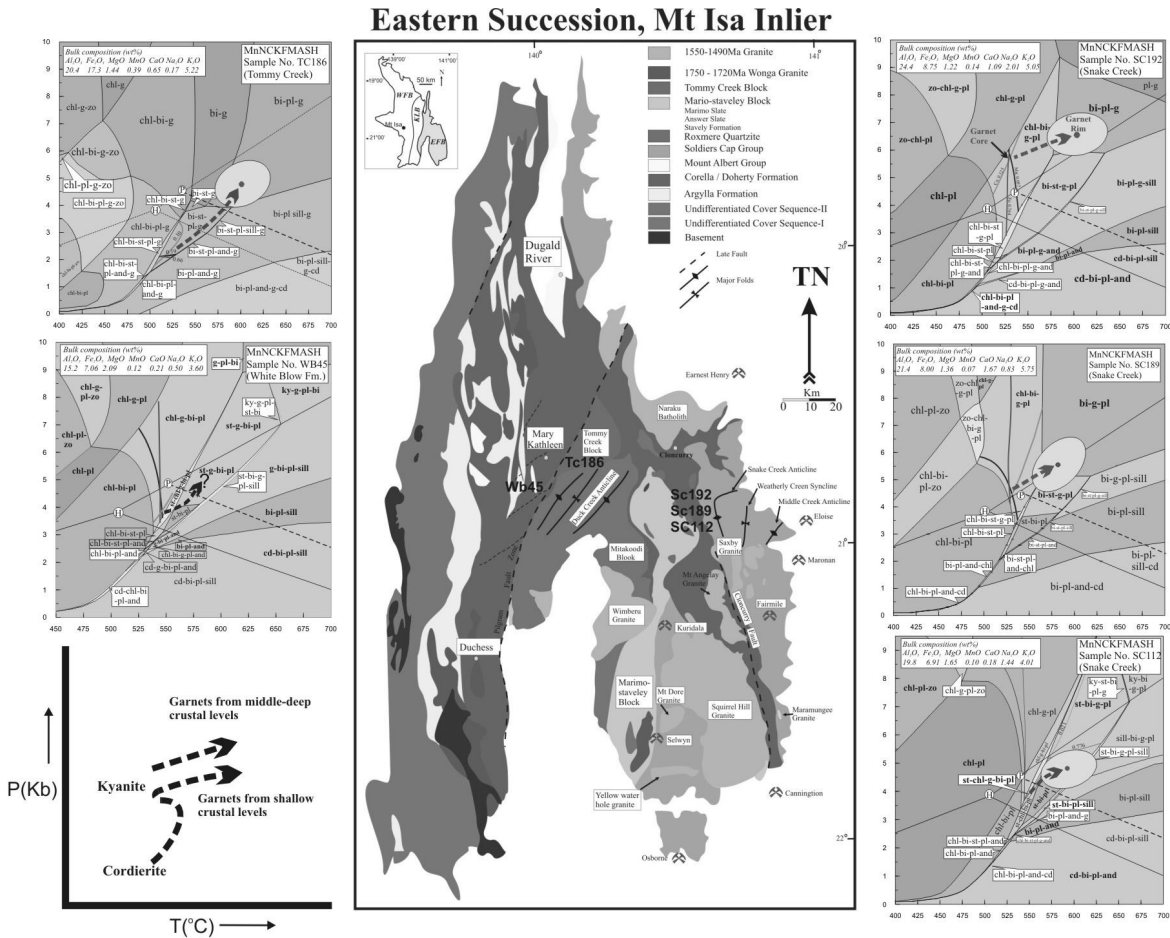


Fig.1. P-T pseudosections showing P-T paths from representative rock samples from the Eastern Succession of the Mt Isa Inlier. Sample number plus location is presented on the top right corner of the pseudosections, where XRF bulk rock composition (wt%) is on the top left.

from Tommy Creek Block (TC186) and one from White Blow Formation (WB45) (Fig. 1). To a first approximation, the pseudosections for sample SC192 and SC189 are consistent with the mineralogies of the rocks. For example, in sample SC192 chlorite and plagioclase inclusions occur in the core and median region of the garnets. No chlorite was observed in the matrix. This textural relationship has successfully been modeled, where garnet core  $X_{Mn}$ ,  $X_{Fe}$  and  $X_{Ca}$  compositional isopleths intersect uniquely in chl-bi-pl-grt stability field. Similarly, garnet rim, matrix plagioclase, biotite and muscovite geothermobarometric estimates by using the average P-T feature of THERMOCALC lies within the grt-pl-bi field, and is completely consistent with the pseudosection stability field. Texturally, the inclusion trails within the garnets are fine-grained as compared to the matrix minerals and are not continuous, i.e, the matrix foliation is strongly deflected around the porphyroblast. This suggests that the garnet growth occurred early in the deformation history (Passchier and Trouw, 1998). The core of the garnet growth occurred at 5.6-5.8kb/526°C, whereas the garnet rim with matrix phases are found to be 6.5±1.1kb/602±27°C. For sample SC189, garnet core growth occurred at 4.4-4.6kb/527-529°C, whereas garnet rim has been modeled at 5.5±1.2kb/581±26°C. These are the highest pressure estimates so far reported from any part of the Eastern Succession.

In samples SC122 and WB45, the garnet core compositional isopleths intersect at 3.7-3.9kb/548-550°C and 3.7-4.5kb/544-547°C, respectively. Garnets analyzed from these two samples were interpreted to be syntectonic, that is, inclusion trails are continuous with the matrix foliation. Both the rocks host more than 1cm size syntectonic staurolite, and it is clear from textural relationships that garnet grew first, as garnet is found inside the staurolite. For

sample SC122, garnet rim plus matrix mineral phases are modeled at  $4.8 \pm 1.3 \text{ kb} / 592 \pm 32^\circ \text{C}$ . No average P-T calculations have been made for sample WB45 as no plagioclase has been found in the matrix. However, as the pseudosection geometry and textures of WB45 are very similar to that of SC112, it is assumed that WB45 had similar paths to SC112. For sample TC189, garnet core formation is predicted to occur at  $2.1\text{-}2.2 \text{ kb} / 510\text{-}515^\circ \text{C}$ , whereas garnet rim plus matrix phases have been calculated at  $4.8 \pm 1.1 \text{ kb} / 600 \pm 29^\circ \text{C}$  (Fig. 1).

### Tectonic implications

P-T paths from sample SC112, WB45 and TC186 appear to be the part of the classic anticlockwise P-T-t path proposed by Rubenach and Lewthwaite (2002). However, the P-T paths from samples SC192 and SC189 show near-isobaric heating at elevated pressure. Significantly, the garnets displaying elevated P-T growth conditions appear to be older based on textural evidence (i.e., truncated inclusion trails) than the relatively low-pressure samples (i.e., continuous inclusion trails). One of the possible interpretations is that as these two rock samples were collected near the vicinity of Cloncurry Fault, which is interpreted as thrust fault in a number of publications. It is suggested that the garnets from sample SC189 and SC192 began to grow at elevated P-T conditions at middle crustal levels, followed by rapid exhumation and cooling along the Cloncurry Fault.

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