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Tectono-metamorphic evolution of the Eastern Fold Belt, Mount Isa, NW Queensland, Australia

Volume 1

Thesis submitted by
Ahmed Sayed Ali Ahmed (ABU SHARIB)
BSc, MSc, Cairo University (Egypt)
In September 2010

For the degree of Doctor of Philosophy
in the School of Earth and Environmental Sciences,
James Cook University, Townsville, Australia

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INTRODUCTION AND THESIS OUTLINE

The Mount Isa Inlier, which occupies the northwest corner of Queensland, Australia, contains three N-S trending tectonostratigraphic belts that are juxtaposed along major tectonic contacts (Blake, 1987; Blake and Stewart, 1992). These belts are the Western Fold Belt (WFB), the central Kalkadoon-Leichhardt Belt (KLB) and the Eastern Fold Belt (EFB). The Snake Creek anticline region is situated about 30 km southeast of Cloncurry on Roxmere Cattle Station. It lies between latitudes 140°37'23" and 140°43'47" E and longitudes 20°00'01" and 21°00'35" S and covers an area of about 300 km^2. It represents an essential part of the Soldiers Cap Group, which occupies the northeastern part of the Eastern Fold Belt of the Mount Isa province.

This thesis investigates the tectono-metamorphic evolution of the Snake Creek anticline region. This region exposes Mesoproterozoic volcano-sedimentary rocks that are metamorphosed at greenschist to upper amphibolites metamorphic facies conditions (Foster and Rubenach, 2006; Rubenach *et al*., 2008). The rocks of the study area have been affected by multiple deformation and metamorphism that accompanied the 1650– 1500 Ma Isan Orogeny (Loosveld, 1989; Bell *et al*., 1992; Lally, 1997; Lewthwaite, 2000; Giles *et al*., 2006). This region represents a key portion of the Mount Isa inlier as it hosts W–E and N–S-trending macroscopic folds whose origin and timing relationships have been debated for many years and are still controversial in the literature (Bell, 1991; Bell and Hickey, 1998; Lister *et al*., 1999; Giles *et al*., 2006). The metamorphic history of the area under investigation is complex and contains multiple overprinting metamorphic events (Rubenach and Barker, 1998; Foster and Rubenach 2006). Low-P/high-T metamorphism characterizes the Mount Isa inlier in general, and the Soldiers Cap Group rocks in particular (Reinhardt, 1992; Foster and Rubenach 2006; Rubenach *et al*., 2008).

It has been realized recently that the visible matrix foliations in complexly deformed and multiply metamorphosed orogenic belts preserve little of their complete deformation history; they rarely preserve more than 2 or 3 foliations in addition to a schistosity parallel to the compositional layering, S_0 (Bell, 2010). Little of the complete tectono-metamorphic history is preserved in the simple history suggested by the visible matrix foliations. In particular, the tendency for shearing parallel to the compositional layering during matrix reactivation to rotate and destroy pre-existing and developing foliations (Bell *et al*., 2003; Ham and Bell, 2004) dramatically hinders preservation of more than a small fraction of the deformation history. Quantitative studies on porphyroblasts over the last two decades have provided access to this lengthy history (Bell, 1981; Bell and Rubenach, 1983; Bell and Johnson, 1989; Hayward, 1992; Vernon *et al*., 1993; Aerden, 2004; Aerden and Sayab, 2008; Bell, 2010; Bell and Hobbs, 2010).

Under suitable P-T metamorphic conditions and bulk chemical composition (Spear, 1993), in the presence of coaxial deformation (Bell *et al*., 2004), porphyroblasts begin to grow in metapelitic rocks and cease growth once a differentiated crenulation cleavage develop against their margins (Bell and Bruce, 2007). Porphyroblasts entrap the matrix foliation in the form of inclusion trails, preserving the asymmetry of developing crenulation cleavages at the time the porphyroblasts grew, and locally that or the earlier matrix foliation. Inclusion trails are protected from the destructive effects of reactivation and decrenulation of the matrix foliation that accompanies later deformation events. Indeed, inclusion trails preserved within porphyroblasts commonly contain evidence of earlier deformation events that no longer exist in the surrounding matrix. They can be used as kinematic indicators of the sense of shear of the matrix foliation at the time these porphyroblast grew. The intersection between two overprinting foliations defines a Foliation Intersection/Inflection Axis within the porphyroblasts that is called a FIA. Measuring FIA trends (Bell *et al*., 1995) allows correlation of porphyroblasts of the same generation across a region or orogen. They form at right angles to the direction of bulk horizontal shortening (Cihan, 2004) and provide quantitative information on the direction of movement during orogenesis.

This thesis consists of four sections (A-D) each of which has been written in a paper format and submitted to international journals. The thesis is in two volumes; volume 1includes the text and references whereas volume 2 contains the figures, figure captions, tables and the appendices.

Section A of the thesis deals mainly with the changes in the direction of bulk horizontal shortening during the lengthy Isan orogeny. On the macroscopic and mesoscopic scales, planar and linear structural elements have been measured and dealt with geometrically to deduce the different phases of deformation. On the microscopic scale, the FIAs were measured, in all possible porphyroblasts, and their relative timing was established based on microstructural and textural relationships. The resulting macro, meso and microscopic structural data, were integrated, discussed and interpreted in terms of their significance for the tectono-metamorphic history of the Snake Creek anticline.

A new deformation scheme has been introduced (Table 1) and a new tectonic model (e.g. Fig. 19) has been introduced at the end of that section showing the tectonic history of the Snake Creek anticline area during the 1670–1590 Ma long-lived Isan Orogeny.

Section B uses mesoscopic (e.g. planar and linear fabric elements) and microscopic (e.g. FIA trends preserved in different porphyroblasts) structures to resolve the relative timing of the orthogonal N–S (Snake Creek anticline and Weatherly Creek syncline) versus W–E (Toole Creek and Davis synclines, and Mountain Home anticline) trending folds in the Soldiers Cap Group, in particular, and the Mt Isa inlier, in general, and their significance to deformation partitioning. The origin and relative timing between these orthogonal folds have been problematical for many years and a range of solutions have been suggested (Bell, 1991; Bell and Hickey, 1998; Lister *et al*., 1999; Lewthwaite, 2000; Giles *et al*., 2006).

Microstructural data including FIAs and the relationship between the inclusion trails within porphyroblasts (internal fabric) and the surrounding matrix foliation (external fabric) supported with the meso and macroscopic structures, were the keys to resolve the quandary regarding the relative timing between the orthogonal W–E and N–S folds in the Snake Creek anticline during the Isan Orogeny.

Section C uses (EPMA) dating of monazite grains entrapped within garnet, staurolite and andalusite porphyroblasts to constrain the absolute timing of the FIA succession relative to N–S- versus W–E-trending folds. Microstructural relationships, i.e. porphyroblast to matrix relationships, together with absolute age dating, were used to figure out the relative directions of motion that accompanied orogenesis and interpret it in the framework of plate tectonics.

A possible correlation between the Mount Isa, Broken Hill and Gawler provinces and between the Isa terrane and the SW Laurentia was suggested. The latter sheds light on the reconstruction of Rodinia during the 1670–1590 Ma Isan Orogeny.

Section D of the thesis represents a multi-disciplinary approach that comprised integrated microstructural and textural relationships, geochronology, phase diagram modeling (using THERMOCALC computer software) and garnet core maps to infer the P-T conditions and the metamorphic history of the Snake Creek anticline during the tectono-metamorphic events that took place during the Isan Orogeny. Light was thrown, in general, on the metamorphic history that accompanied the different periods of deformation throughout the orogeny and, in particular, on those P-T conditions that prevailed during the W–E and N–S shortening events (e.g. Fig. 17). The interrelationship between sedimentation, tectonism and metamorphism is discussed briefly.

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