Anatomy of the Mount Isa Fault system: thrust exhumation of middle crustal elements of the Mount Isa Rift basement during the late Isan Orogeny

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The contractional Isan Orogeny in the Mount Isa Inlier of western Queensland, is generally regarded as a multiphase event spread episodically over a ~100 my interval from ~1600 Ma to ~1500 Ma. It terminated a protracted extensional interval in which rocks of the Haslingdon and Mount Isa Groups accumulated in the superposed Leichhardt River and Mount Isa Rifts at ~1800 Ma and ~1650 Ma, respectively. An extensive fault system, the Mount Isa Fault, separates high-grade rocks of the Haslingden Group (and older rocks) to the west from lower-grade equivalents to the east, as well as from rocks of the overlying Mount Isa Group. The complex system of faults associated with this boundary is well-defined in deep seismic imagery.

We present the results of detailed mapping and geometrical analysis (based on ~6000 field observations) of the structure across the Mount Isa Fault system ~10 Km southwest of Mount Isa in the Mica Creek area. Multiple generations of metamorphic structural fabrics associated with two discrete crustal events characterise the rocks. Many of the results simply confirm previous work but major conclusions that emerge from this study are:

1) **The existence of a low Isan strain window of middle crustal remnants of the ~1650 Ma Mount Isa Rift system**. The earliest fabric recognised is a stratigraphy-parallel (subhorizontal) foliation associated with mid-crustal emplacement of syntectonic granitoid bodies (Sybella Granite) at ~1650 Ma. We believe that these rocks represent ductilely stretching middle crust at the brittle-ductile transition immediately below the evolving brittle Mount Isa Rift system. Constrictional fabric geometry and kinematics are consistent with development in a transtensional system with dextral shear on northwesterly diverging N-S oriented rift boundaries.

2) **The Mount Isa Fault system, separating low grade rocks in the east from high grade rocks in the west, is a system of east vergent, eastwardly propagating, thrusts**. All remaining fabrics and folds are associated with the sequential eastward development of three, increasingly less ductile, fabrics, each associated with the forward propagation of an eastwardly verging, thin-skinned thrust system (and associated folds). The Mount Isa Fault system itself is a distinctly more brittle and a more thick-skinned, reverse separation structure, and may have a significant post-Precambrian displacement component.

   The oldest of the fault-related ductile fabrics (S_2) is most intensely developed around the eastern faulted margin of the Sybella Granite and overprints the early syn-intrusion fabric. We interpret this fabric as related to a local ramp in a thin-skinned east vergent thrust system. We attribute rheological problems associated with moving the 1-2 km thick Sybella granite sill through this ramp as the possible driving force for the subsequent development of kilometre-scale east-vergent asymmetric folds, and development of the step-forward imbricate thrust fault system, that becomes progressively more thick-skinned to the east. A widespread west-dipping foliation (S_3) accompanies the formation of the macroscopic fold system, which, with its associated faults, provides the dominant control on the structural grain of the area. Within 2 kilometres of the more steeply west dipping Mount Isa Fault system proper, a spaced cleavage (S_4) accompanies gentle refolding (wavelengths of 100s of metres) of the earlier faults and macroscopic folds. The surface expression of the Mount Isa Fault itself is almost entirely brittle, although weak (F_5) folds occur locally.

3) **The Pre-Isan orogeny basin geometry consisted of westerly-tilted half-grabens.** Palinspastic reconstruction of the thrusts and folds indicates that, prior to thrusting, the entire Haslingdon Group sequence dipped shallowly to the west (~20°), thus accounting for the subsequent juxtaposition of different metamorphic grades at approximately the same stratigraphic level (e.g. Eastern Creek Volcanics) across the Mt Isa fault system. We suggest that this tilting is related to the geometry of the evolving Isan rift system at ~1650 Ma. The westward tilt suggests half-graben geometry with a depocentre toward the west. Similar tilted strata are apparent in the published deep seismic transect, as are early east-dipping faults that may be the half-graben fault margins.

4) **Structures associated with Isan orogenic contraction did not appear in the western part of the Mount Isa Inlier (around Mount Isa mine) until late in the reported range of Isan ages (at ~1535Ma) and continued perhaps for an interval of ~30-40Ma.** The oldest of the fault-related ductile fabrics (S_2) correlates with both peak metamorphism and pegmatitic partial melt accumulations in the granite. Zircon ages of ~1532 Ma from this generation of peak-metamorphic pegmatite have previously been obtained by Connors & Page, 1995. Other pegmatite generations span the subsequent ductile fabric, and these authors report zircon ages as young as 1480 Ma. Our findings are consistent with these results and suggest that the brittle Mount Isa fault system is no older than this age (and may have considerably younger components of movement).

Reference:

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