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Precambrian Research 148 (2006) 67–84
Precambrian Research
www.elsevier.com/locate/precamres

Crustal architecture of basin inversion during the Proterozoic Isan Orogeny, Eastern Mount Isa Inlier, Australia

David Giles [a,*], Laurent Ailléres [b], Dylan Jeffries [b], Peter Betts [b], Gordon Lister [c]

[a] *Centre for Mineral Exploration Under Cover, School of Earth and Environmental Sciences, The University of Adelaide, 5005 SA, Australia*
[b] *School of Geosciences, Australian Crustal Research Centre, Monash University, 3800 Vic., Australia*
[c] *Research School of Earth Sciences, Australian National University, 0200 ACT, Australia*

Received 25 July 2005; received in revised form 6 March 2006; accepted 7 March 2006

Abstract

The folded and metamorphosed supracrustal rocks of the eastern margin of the Mount Isa Inlier, NW Queensland, Australia, provide a record of basin inversion processes at high temperatures, from the foreland toward the core of a developing orogen. Deep water, turbiditic metasedimentary rocks of the lower Maronan Supergroup (ca. 1.71–1.66 Ga) occupy the hanging wall of a crustal-scale thrust, the Cloncurry Overthrust, which separates them from calc-silicate and meta-evaporitic rocks of the Doherty Formation (ca. 1.74–1.72 Ga) in the footwall. During the early stages of the Isan Orogeny (ca. 1.60–1.58 Ga) the rocks of the Maronan Supergroup were expelled from their basin and thrust to the north-northwest. Shortening was restricted to the hanging wall and produced a 10 km scale north to northwest verging nappe with a crumpled frontal zone of upright east–west trending folds. This morphology is consistent with a push-from-the-rear mechanism of nappe emplacement with the simple shear component of deformation increasingly accommodated within the hanging wall, down dip toward the core of the orogen. Metamorphism associated with this folding reached upper amphibolite facies temperatures at moderate to low pressures (4–6 kbar). Metamorphic zones in the hanging wall of the Cloncurry Overthrust were antiformally folded with continuing deformation. The relationship between faulting, folding and metamorphic zoning across the Cloncurry Overthrust are consistent with a thrust system, despite that fact that younger rocks are juxtaposed over older. Basin inversion provides the best explanation for this phenomenon. Within this context metamorphism during the early stages of orogenesis can be explained by the inheritance of elevated geothermal gradients produced by lithospheric thinning and sediment loading during formation of the basin. The overall orogenic architecture was controlled by a combination of thermal softening, which focussed early deformation within the basin, and weak zones at the base of the basin and the base of the crust. This resulted in crustal-scale thrusts of opposite vergence that partitioned upper crustal and lower crustal deformation.

Keywords: Mount Isa Inlier; Basin inversion; Structural geology; Fold nappe; metamorphism; Crustal architecture

1. Introduction

Basin inversion is a commonly observed mechanism of crustal shortening. There are numerous examples of the phenomenon in nature and there is a growing body of observational data supporting the notion that extensional basins form zones of lithospheric weakness that tend to focus strain during subsequent phases of shortening (Cooper and Williams, 1989; Ziegler et al., 1995; van Wees and Stephenson, 1995; van Wees and Beekman, 2000; Turner and Williams, 2004). This weakening effect presumably indicates that factors leading to lithospheric strengthening during extension (replacement of weak lower crust by strong mantle) are commonly overcome

* Corresponding author. Tel.: +61 3 9905 4878; fax: +61 3 9905 5062.
E-mail address: david.giles@adelaide.edu.au (D. Giles).

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doi:10.1016/j.precamres.2006.03.002

by factors leading to weakening during extension (thermal or strain softening) (Sandiford, 1999; Nielsen and Hansen, 2000; van Wees and Beekman, 2000). Thermal softening in particular, might be expected to play a major role in relatively young basins in which the thermal anomaly associated with lithospheric thinning has not yet decayed, or in older basins containing high heat-producing sediments (Sandiford, 1999). In these cases hot-mode basin inversion can be predicted to result in (and to exhume) highly deformed orogenic

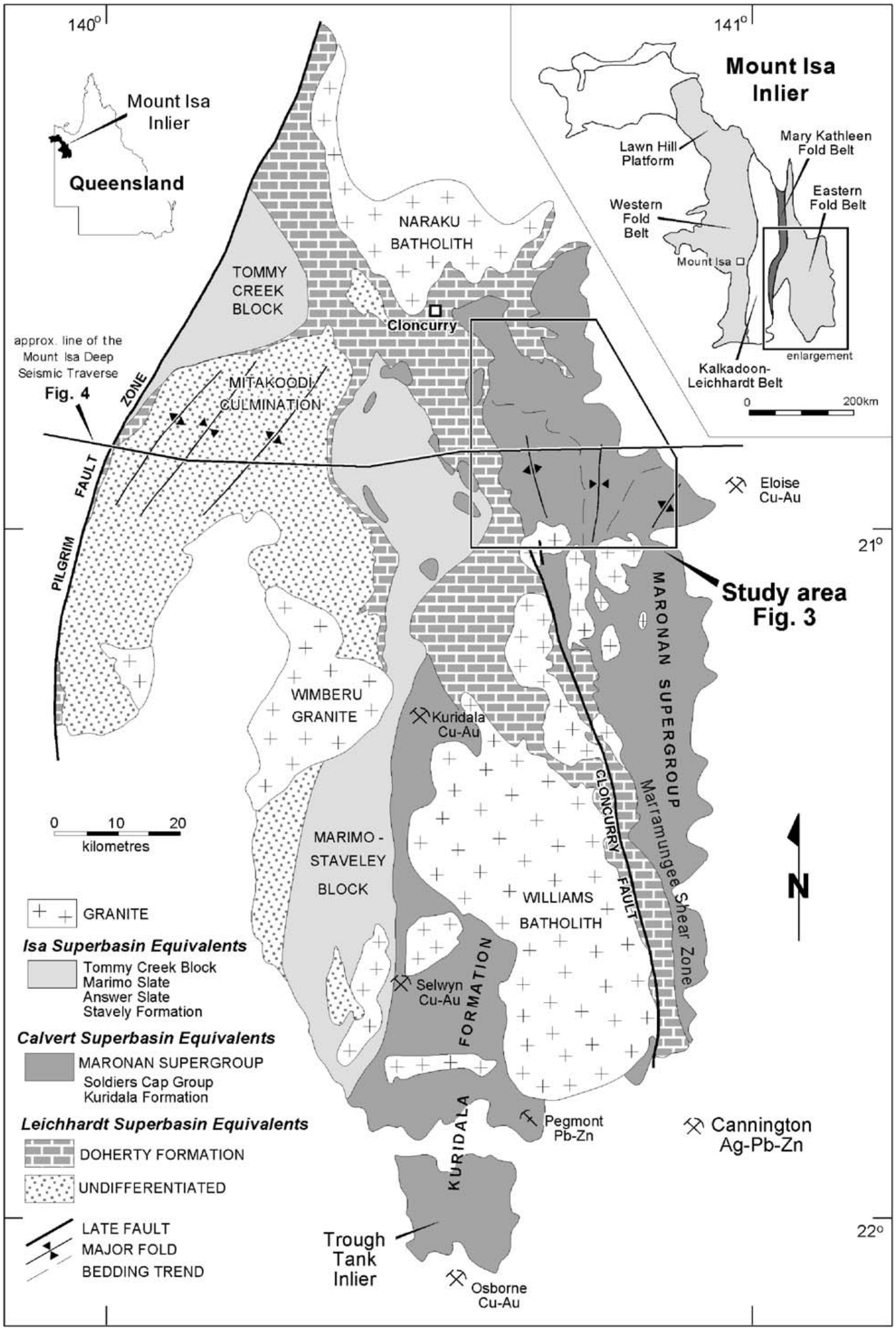

Fig. 1. Simplified geology of the eastern Mount Isa Inlier.