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Early tectonic evolution of the Thomson Orogen in Queensland inferred from constrained magnetic and gravity data

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ABSTRACT

The crustal architecture as well as the kinematic evolution of the Thomson Orogen in Queensland is poorly resolved because the region is concealed under thick Phanerozoic sedimentary basins and the basement geology is known from limited drill holes. Combined potential field and seismic interpretation indicates that the Thomson Orogen is characterized by prominent regional NE- and NW-trending structural grain defined by long wavelength and low amplitude geophysical anomalies. The 'smooth' magnetic signature is interpreted to reflect deeply buried source bodies in the mid- to lower crust. Short wavelength positive magnetic features that correlate with negative gravity anomalies are interpreted to represent shallower granitic intrusions. They appear to be focused along major fault zones that might have controlled the locus for magmatism. The eastern Thomson Orogen is characterized by a prominent NE structural grain and orthogonal faults and fold interference patterns resulting in a series of troughs and highs. The western Thomson Orogen consists of a series of NW-trending structures interpreted to reflect reverse faults. Sedimentation and basin development are interpreted to have initiated in the Neoproterozoic to Early Cambrian during E–W- to ENE–WSW extension, possibly related to the Rodinia break-up. This extensional event was followed by Late Cambrian shortening recorded in the Maneroo Platform and the Diamantina River Domain which possibly correlates with the Delamerian Orogeny. Renewed deposition and volcanism occurred during the Ordovician and may have continued until Late Silurian, resulting in thinned Proterozoic basement crust and extensive basin systems that formed in a distal continental back-arc environment. Our interpretation places the Thomson Orogen to the west of the Neoproterozoic passive margin preserved in the Anakie Inlier. The region is likely to represent the internal extensional architecture during the Rodinia break-up that has been subsequently extensively modified by multiple extensional basin forming events and transient episodes of crustal shortening and basin inversion.

1. Introduction

The Thomson Orogen is the largest tectonic domain of the eastern Australian Tasmanides (Glen, 2005; Glen et al., 2006) and represents approximately one-eighth of the Australian continent (Figs. 1 and 2). The region records a protracted tectonic evolution that spans the Neoproterozoic to Triassic and is coincident with one of the largest periods of growth of the Australian continent (Glen, 2005).

The basement rocks of the Thomson Orogen are concealed under thick sedimentary basins, which have made it difficult to unravel the crustal architecture and tectonic evolution of the region (Draper, 2006; Finlayson et al., 1988; Glen et al., 2010; Murray and Kirkegaard, 1978). In this study, we use high resolution regional potential field datasets to interpret the crustal architecture of the Thomson Orogen (Figs. 1 and 2). The data have been demonstrated to be effective in determining the crustal architecture (Stewart and Betts, 2010), structural setting (Betts et al., 2003; McLean and Betts, 2003), and associated kinematics (Betts et al., 2007) in regions with little or poor geological exposure. Interpretation of potential field data is ambiguous by its nature but the ambiguity can be reduced via the incorporation of geological constraints and other geophysical datasets (Gunn et al., 1997). Nevertheless, the method is very effective at constraining crustal architecture over large areas, and is the only tool that allows 3D mapping of the architecture of geological provinces such as the Thomson Orogen, where there is limited outcrop and basement-intersecting drill holes.

The results of this study provide insights into the timing and kinematics of major tectonic events in the Thomson Orogen. Understanding the crustal architecture of the region has implications for reconstructing the evolution of the eastern Australian continent during the transition between the Neoproterozoic break-up of Rodinia and the subsequent Phanerozoic evolution of east Gondwana. Then we compare our results and evolution model with the current understanding of the Lachlan Orogen in the southern Tasmanides.

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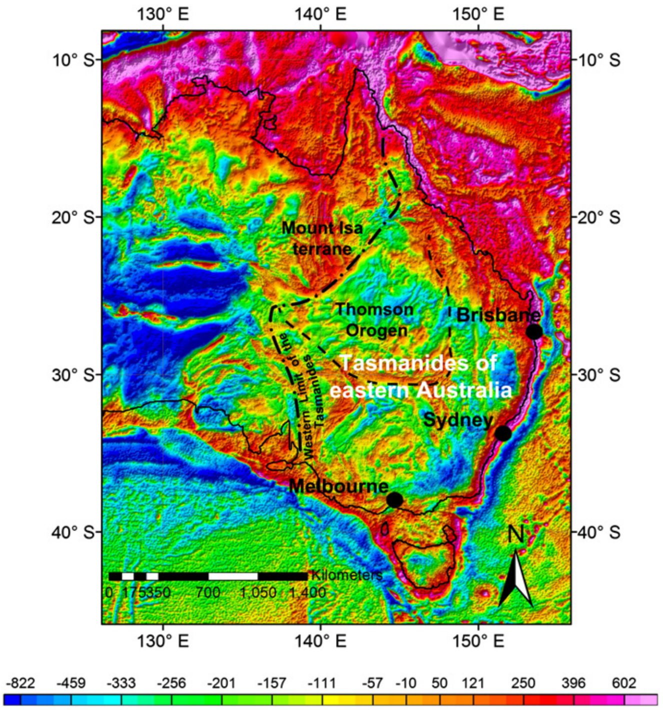

Fig. 1. Extent of the Thomson Orogen (dashed line) on a pseudocolor image of the Bouguer gravity anomaly of the Australian continent. The Thomson Orogen is juxtaposed to the southern edge of the Proterozoic Mount Isa terrane and forms part of the Tasmanides of eastern Australia; the dot-dashed line represents the western and northern margins of the Tasmanides (Glen, 2005). Values in the legend bar are in μm*s^{-2}.

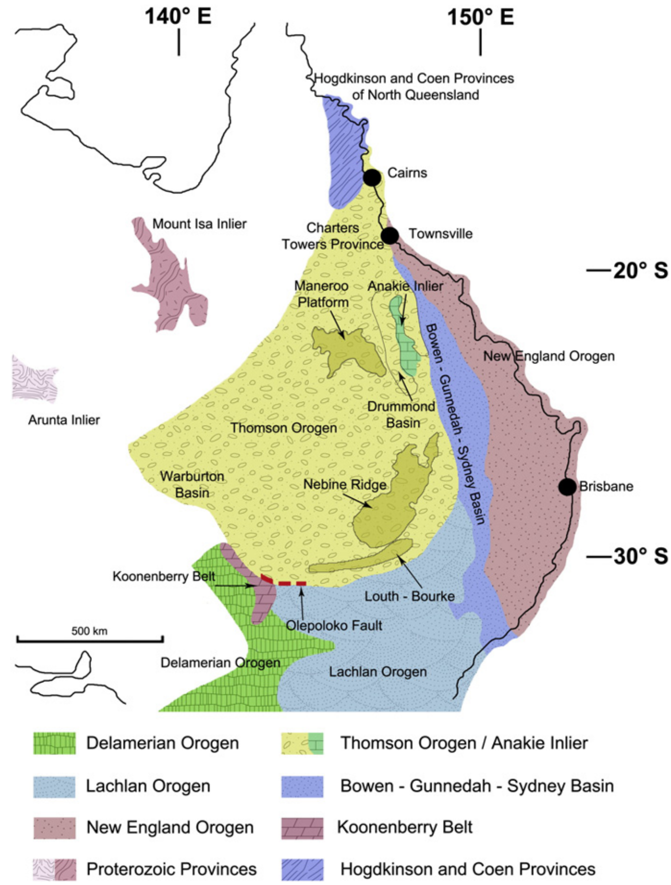

Fig. 2. Sketch showing the distribution of major geological features and the extension of the geological provinces surrounding the Thomson Orogen; modified from Kositcin et al. (2009).

2. Geological setting

The northern extent of the Thomson Orogen is defined by the prominent Cork Fault (Figs. 3 and 5), which separates the Thomson Orogen from the Proterozoic Mount Isa terrane (Wellman, 1990). The southern boundary is mostly defined by the Nebine Ridge (Finlayson and Collins, 1987; Finlayson et al., 1990b), although in the south-western part of the region, the Olepoloko Fault Zone is interpreted to mark the transition from the Thomson Orogen to the Lachlan Orogen (Fig. 2) (Glen et al., 2013). The eastern Thomson Orogen incorporates the Anakie Inlier and Charters Towers Province (Fig. 2) (Draper, 2006; Fergusson and Henderson, 2013; Fergusson et al., 2009; Kirkegaard, 1974; Withnall et al., 1995). The western boundary between the Warburton Basin and the Thomson Orogen (Figs. 2 and 3) is less well defined because it is buried beneath thick sedimentary basins (Murray and Kirkegaard, 1978).

The basement rocks of the Thomson Orogen lie beneath three stacked Middle Palaeozoic to Mesozoic sedimentary systems (Murray and Kirkegaard, 1978), which include, from top to bottom, the Early Jurassic to Late Cretaceous Eromanga Basin (Moss and Wake-Dyster, 1983), the Permian to Triassic Cooper and Galilee basins (Finlayson et al., 1988) and the Devonian Adavale Basin (Figs. 3 and 4) (Finlayson et al., 1988).

Terrestrial to shallow marine sedimentary rocks of the intra-cratonic Eromanga Basin (Wake-Dyster et al., 1983) define the upper stratigraphic unit in the area of study. The widespread Eromanga Basin extends over an area of approximately 1,200,000 km^2 (Finlayson et al., 1988; Mathur, 1983; Spence and Finlayson, 1983). This basin is unconformably underlain by the Cooper and Galilee basins (Figs. 3 and 4) (Finlayson et al., 1988).

The Cooper Basin (Fig. 3) forms an NE-trending structural depression extending for ~130,000 km^2 across South Australia and Queensland. It contains glacial, fluvial, and lacustrine sediments (Thornton, 1979). The basin architecture has been controlled by NE-trending and NW-trending pre-Permian basement structures (Apak et al., 1997; Sun, 1997). The Cooper Basin overlies also the Cambrian–Devonian Warburton Basin to the east and Carboniferous igneous rocks to the west (Battersby, 1976; Gatehouse, 1986). The Eromanga and Cooper basins have undergone inversion associated with minor Cenozoic shortening events which mostly reactivated existing faults (Leven et al., 1990; Moss and Wake-Dyster, 1983).

The Galilee Basin (Fig. 3) is a large intra-cratonic basin which is predominantly filled with fluvial sediments (Hawkins and Harrison, 1978; Jackson et al., 1981; Van Heeswijck, 2010). It overlies the Devonian Adavale Basin to the south, the Late Devonian to Early Carboniferous Drummond Basin to the east (Fig. 2) and Proterozoic to Early Palaeozoic basement rocks to the north (Van Heeswijck, 2010). The upper succession of the Galilee Basin can be correlated with the adjacent Cooper Basin in the Thomson Orogen and the Bowen Basin (Fig. 2) (Van Heeswijck, 2010). The Galilee Basin formed inboard of the New England Orogen (Fig. 2) which developed along eastern Gondwana in the Late Palaeozoic to Early Mesozoic (Van Heeswijck, 2010).

The underlying Adavale Basin (Figs. 3 and 4) (Finlayson et al., 1988) is interpreted by Evans et al. (1992) as a rift-sag basin developed during an Early Devonian intra-continental transtensional event (McKillop et al., 2007). Felsic intrusive magmatism accompanied the crustal extension event throughout the broader Thomson Orogen (Murray, 1994). Deposition was initially dominated by fluvial sedimentation followed by a marine incursion that resulted in mixed carbonate–siliciclastic deposition (McKillop et al., 2007). Middle to Late Devonian sedimentary successions define a restricted marine and fluvio-lacustrine environment (McKillop et al., 2007) that preceded Middle Carboniferous deformation (Finlayson, 1993). The Adavale Basin is interpreted to have formed in response to continent-dipping subduction to the east in the New England Orogen (McKillop et al., 2007; Murray, 1990) and thus