Potential-field interpretation of the Kars Belt, western NSW

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SUMMARY

The Cambrian Ponto Group of the Koonenberry Belt is a suite of fore-arc rocks of the Mt Wright Arc, and includes basalts that are associated with copper mineralisation. Magnetic derivative maps allow the Ponto Group to be followed southwest under shallow cover, where they define the magnetic texture of the Kars Zone that flanks the southeastern margin of the Curnamona Craton. Shallow-sourced positive magnetic anomalies in the Kars Zone are superimposed on a longer-wavelength magnetic low; this contrasts with their equivalents along the Koonenberry Belt, which sit on broad magnetic highs. Gravity images of the Koonenberry Belt suggest that shallow dense sources associated with the Ponto Group overlie deeper mass excesses, while equivalent shallow and deep mass excesses appear to be uncoupled in the Kars Zone. Joint magnetic and gravity modelling of a profile across the Kars Zone suggests that high-susceptibility, dense bodies representing the Ponto Group have been displaced to the northwest, over-riding in their path deep magnetic sources below the Menindee Trough. Similar deep magnetic sources below the Bancannia Trough have been interpreted as very large intrusive features forming the base of the Mt Wright Arc. Together, the potential field imagery and modelling suggests very large scale, low-angle thrusting of the Mt Wright fore-arc over a rigid basement of the Mt Wright Arc.

Key words: Gravity, magnetism, geologically constrained modelling, Kars Belt, Mount Wright Arc

INTRODUCTION

With the recent completion of a program of geological mapping and geophysical interpretation and modelling of the Koonenberry Belt in northwest NSW (Figure 1), a clear picture of the tectonic setting of this part of the Delamerian Orogen has emerged (Greenfield et al., 2011). Late Neoproterozoic rifting of the Gondwana margin at the Curnamona Craton, producing the alkaline Mount Arrowsmith Volcanics and continental margin sediments (Kara Formation) was succeeded by Early to Middle Cambrian west-dipping subduction, characterised by coincident continental arc volcanism and back-arc extension. Concurrent arc volcanism and spreading resulted in the emplacement of both the calc-alkaline Mount Wright Volcanics and related very large (> 10 000 m^3) intrusives, now covered by 3–7 km of Devonian and later sediments, that are the sources of a chain of high amplitude, long-wavelength magnetic anomalies that mark the Bancannia Trough. Stacking of arc basement, fore-arc sediments and volcanics in a thrust wedge formed the Wonnaminta Zone to the east of the Bancannia Trough. Prominent linear magnetic anomalies on the eastern, frontal side of the fore-arc wedge define the Ponto Group, and result from fore-arc basalts (the Bittles Tank Volcanics), mineralised calcsilicates, and quartz-magnetite exhalative horizons set within this dominantly fine-grained marine clastic sequence. Besshi-type Cu mineralisation associated with the Bittles Tank Volcanics is known from the Grasmere deposit.

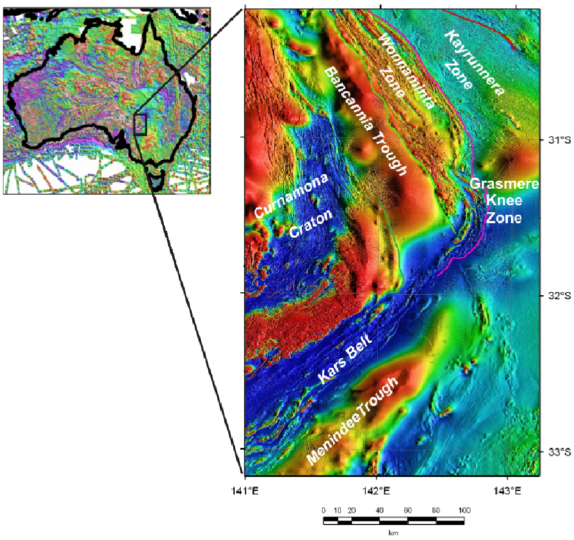

Figure 1. Total magnetic intensity (TMI) of the Koonenberry Belt, Kars Belt, Menindee Trough and eastern Curnamona Craton. The Koonenberry Belt comprises the elements of the Mount Wright Arc: volcanic arc / back-arc (Bancannia Trough), fore-arc (Wonnaminta Zone), and accretionary prism (Kayrunnera Zone).

First vertical derivative magnetic anomalies (Figure 2) allow the Ponto Group to be traced around an 80° change in strike at the Grasmere Knee Zone, cutting across the trend of more inboard elements of the Wonnaminta Zone to run parallel with the southeastern margin of the Curnamona Craton; this geophysically-defined belt was termed the Kars Zone by Sharp et al. (2006). Other roughly parallel zones of linear magnetic anomalies lie between the Kars Zone and the craton; limited outcrop and drill core suggests that these comprise other elements of the Mount Wright Arc and its rifted margin basement. Together, this suite of linear belts comprises the Kars Belt. The opposite side of the Kars Belt flanks the Menindee Trough, which appears to be a continuation of the Bancannia Trough and is floored by similar magnetic sources.

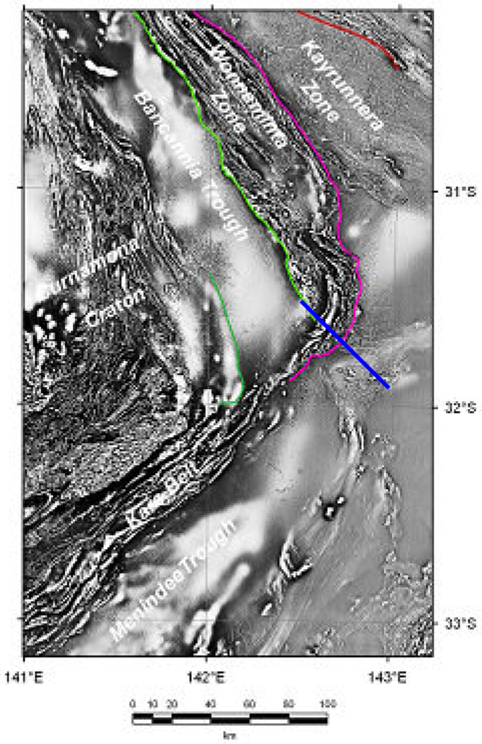

Figure 2. First vertical derivative of TMI after reduction to the pole. Blue line shows location of modelled profile in Figure 4.

The sequence craton–Kars Belt–Menindee Trough contrasts with the order craton–Bancannia Trough–Wonnaminta Zone in the Koonenberry Belt, and suggests some tectonic rearrangement of the order in the Kars Belt. Outcrop in the Kars Belt is very limited, and seismic reflection data across the Menindee Trough and Kars Belt (Gibson et al., 1998) is poorly resolved at less than 10 km depth. An existing gravity model extending across the Kars Belt (Williams et al., 2010) does not recognise the presence of Palaeozoic rocks in the Kars Belt, and was constructed without reference to recent gravity and magnetic models across the Koonenberry Belt. To resolve the mode of structural emplacement of the Kars Belt, we compared the potential field signal of the Kars Zone with its equivalent in the Koonenberry Belt, the Ponto Group, and carried out geologically constrained joint magnetic and gravity modelling of two profiles across the Kars Belt.

METHOD AND RESULTS

Density and susceptibility constraints on rocks in the Koonenberry Belt were derived from Musgrave (2010a) and Direen (1998; 1999). Additional constraints on samples from the Kars Belt were obtained from measurements on core samples held by the Geological Survey of NSW.

Gravity images over the Koonenberry Belt show a superimposition of short-wavelength (half-width < 3 km) and long-wavelength positive anomalies with a common trend, reflecting a stacked thrust geometry of shallow and deeper mass excesses inferred from geological observations and confirmed by potential field modelling (Musgrave, 2010b; Musgrave et al., 2007). Over the Kars Belt, by contrast, corresponding short- and long-wavelength anomalies are spatially separated, indicating that shallow and deep mass excesses are uncoupled (Figure 3). Similarly, shallow-sourced positive magnetic anomalies in the Koonenberry Belt are superimposed on broader magnetic highs, whereas the background to the short-wavelength magnetic anomalies in the Kars Belt is a magnetic low.

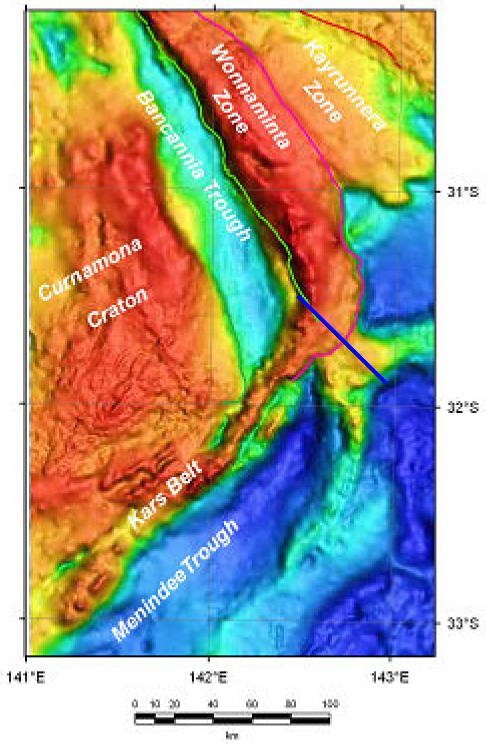

Figure 3. Isostatically reduced Bouguer gravity.

At the time of preparation of this abstract, only one profile across the Kars Belt has been fully modelled (Figure 4). This profile, close to the Grasmere Knee Zone, shows that the gravity and magnetic data can be satisfied simultaneously by a model incorporating a set of southeast dipping thrusts displacing a sheet of Ponto Group rocks to the northwest relative to the craton. Preliminary modelling of profiles further to the southwest indicates that here the thrust sheet displaced the Ponto Group about 60 km laterally on a near horizontal detachment fault, overriding rheologically competent arc intrusives of the Menindee Trough on the way, and leaving behind the roots of the thrust on the southeastern flank of the trough.

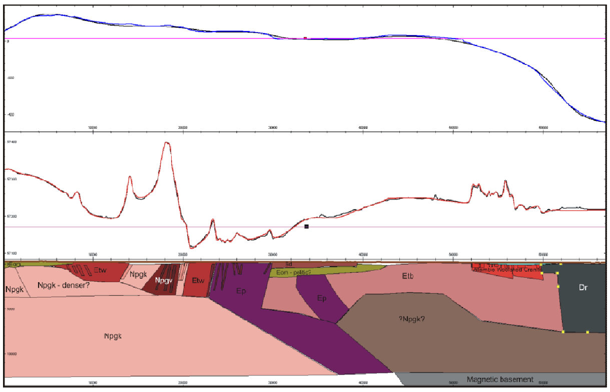

Figure 4. Potential field model of a profile across the northeastern end of the Kars Belt, close to the change of trend at the Grasmere Knee Zone. Upper panel shows gravity data (black trace) and model response (blue trace); middle panel shows TMI data (black) and model response (red). Gravity units are µms^{-2}, magnetic units are nT. Lower panel shows model profile; purple bodies are Ponto Group.

CONCLUSIONS

Image analysis and geologically constrained modelling of magnetic and gravity data indicate a higher degree of structural complexity in the setting of the Kars Belt than is determinable from the limited geological control available from outcrop and drilholes. In particular, our potential-field study suggests that the Kars Belt originally had a similar spatial relationship with the magnetic sources of the Menindee Trough to that between the fore-arc Wonnaminta Zone and the sub-volcanic arc features of the Bancannia Trough, but that deformation following the cessation of arc activity – the Delamerian Orogeny – displaced the Kars Belt on a detachment fault, and emplaced it on the flanks of the Curnamona Craton.

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