THE WARRATTA FAULT: GEOPHYSICAL ARCHITECTURE AND LANDSCAPE EVOLUTION SIGNIFICANCE

Nicole Anderson, Nicholas G. Direen & S.M. Hill

CRC LEME, School of Earth & Environmental Sciences, University of Adelaide, SA, 5005

INTRODUCTION

The Warratta Inlier is located in northwestern New South Wales, approximately 20 km south of Tibooburra. The Inlier is bound on its northeastern side by the Warratta Fault and it has been suggested that this is an extension of the Olepoloko Fault (Stevens 1985), a major terrain boundary between the Thomson Fold Belt and the Lachlan Fold Belt of the Tasmanides. This study incorporated potential field geophysics and regolith-landform mapping to determine possible models for the landscape evolution of the area, based on reconstructing the geometry of the Fault, the basement inliers, and disrupted Cretaceous and Tertiary cover sequences that appear to have been exhumed during late movement on this structure. The primary goal of the study is to explore the subsurface geometry of the Warratta Inlier and incorporate the 'old, deep, hot' history of the area with the 'young, shallow, cool' history. The region hosted alluvial and vein-bearing Au mining in the 1880s (Thalhammer 1991) and this study contributes to developing a geological framework that will assist further mineral exploration in the region.

GEOLOGICAL SETTING

The Warratta Inlier is one of several inliers separated by several NNW trending faults between Milparinka and Tibooburra (Stevens & Etheridge 1989, Thalhammer 1991) (Figure 1). The inliers are composed of Early Palaeozoic rocks, that may have been uplifted by wrench faulting (Thalhammer 1991). Metasedimentary rocks in the Tibooburra-Milparinka area were probably deposited in a delta front or prodelta environment during the Early Cambrian (Stevens & Etheridge 1989), as they contain Cambrian to Early Ordovician trace fossils, as identified by Webby (1984). These rocks are of low metamorphic grade. Stevens & Etheridge (1989) also identified rare acidic to intermediate dykes and minor basic intrusives in the area. There have been four deformational events recognised within the Warratta Inlier, discussed in detail by Thalhammer (1991).

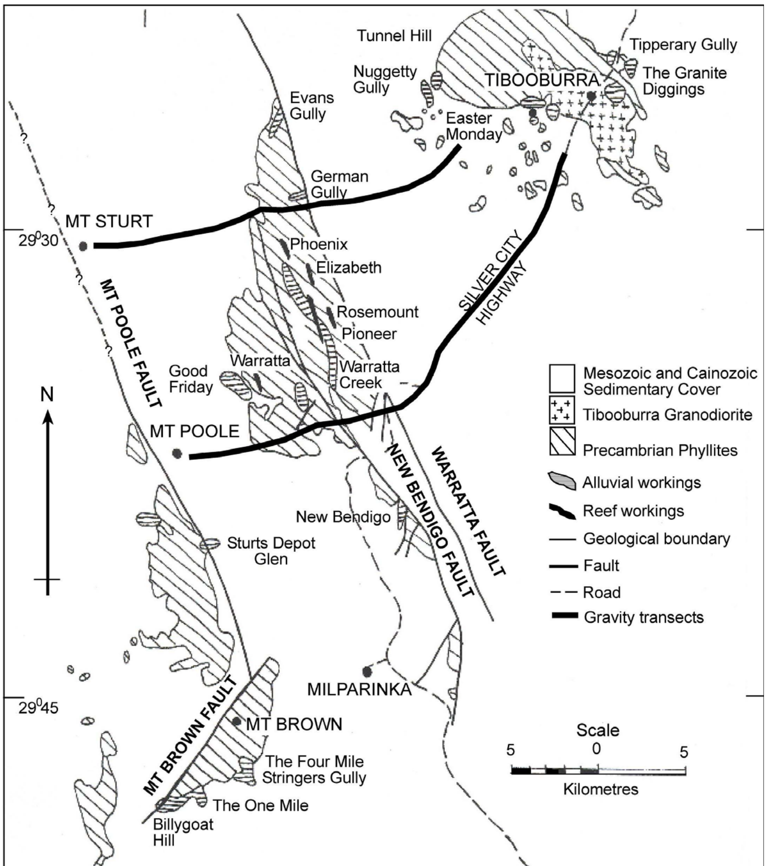

Figure 1: Generalised geological map of the Warratta Inlier and surrounding inliers, and location of the gravity transects. Adapted from Thalhammer (1991).

The Warratta Fault forms the eastern boundary of the Warratta Inlier and is a NNW-trending structure (Stevens & Etheridge 1989). The New Bendigo Fault bisects the Warratta Inlier, striking parallel to the Warratta Fault. Psammites are common along the Warratta Fault scarp. These sandstones are typically fine-grained arkoses and greywackes, becoming more quartz-rich to the west. Ripple marks are a widespread sedimentary structure in these rocks. The contact between the psammites and pelites is quite sharp (Stevens & Etheridge 1989) and is visible along some parts of the fault scarp.

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Phyllites are widespread in the Warratta Inlier and form the majority of the Warratta Rangefront. Cyclic laminations are fairly common within these rocks. It is more generally interpreted that this facies was deposited on a shallow shelf, prodelta environment which overlies the delta front where the sandstones were deposited. The Palaeozoic rocks closest to the Warratta Fault have been brecciated (Stevens & Etheridge 1989).

Quartz veins are abundant within the metasediments of the Warratta Inlier. These veins show great variations in thickness, ranging in size from centimetres to several metres. Gold is associated with cleavage-parallel quartz veins that contain small amounts of sulfides (Thalhammer 1991). These auriferous quartz veins are thought to have formed during hydraulic fracturing prior to the end of S1 cleavage formation. Gold distribution in the sediments shows an increase from unaltered to altered phyllites, with Au values of up to 45 ppb. Historically, Au has also been derived from alluvial Cretaceous and Early Tertiary conglomeratic sediments (Stevens & Etheridge 1989). Much of the surface quartz lag seen in the area is from the mechanical erosion of arrays of quartz veins throughout the Warratta Inlier. However, some of the more rounded quartz may be residual deposits of the now-eroded Tertiary Eyre Formation and other Mesozoic units, such as the Cadna-owie Formation (equivalent to the Gum Vale Beds).

The major controls on the landscape of the Warratta Inlier are thought to be the lithology of the bedrock, structures, tectonism and eustacy. The Warratta Inlier has a drainage system that generally flows to the east into the Thompson Creek catchment that joins the Bulloo River Overflow to the east of the area.

METHODS

Regolith

A regolith-landform map was constructed along the Warratta Fault range and scarp (included at rear of this paper). This was produced both with fieldwork as well as through aerial photograph and Landsat TM image interpretation. Field observations and mapping site descriptions were concentrated along the Warratta Fault and associated range-front. Landsat TM images were obtained from the Geological Survey of New South Wales' Koonenberry Geoscience Database Version 1 CD-ROM (Needham 2002). These images, as well as the reconnaissance geological maps produced by Stevens & Etheridge (1989), were used as a basemap for the final regolith-landform map. Differential Global Positioning System (DGPS) receivers were used to make accurate (± 50 cm) height measurements at closely spaced (approximately 10 m horizontally) intervals along Barton's Creek (Gum Vale Gorge) and also on some of the bevelled surfaces that parallel this drainage line. This information was used to produce longitudinal profiles of Barton's Creek and the adjacent bevelled surfaces.

Geophysics

Gravity surveys were completed along two transect lines at 500 m station spacing (Figure 1). Transect 1 runs from just south of Tibooburra, following the Silver City Highway, and then to the Mount Poole homestead. Transect 2 begins at the turn-off to Gum Vale Gorge along Fort Grey Road and continues through Gum Vale Gorge and onto Gum Vale and Mount Sturt stations. Station spacing was extended to 1000 m when the road was parallel to strike. Gravity values were tied to the Isogal 84 network using the station at Tibooburra Airfield. Heights and position data for the gravity reduction were obtained using DGPS, giving an accuracy at each station of ± 50 cm for the heights and ± 1 m for x and y. Gravity data were reduced to Free Air Anomalies for modelling, using the 1967 reference ellipsoid and a free air correction based on that described in Flis *et al.* (1998).

Total Magnetic intensity transects were extracted from TMI grids supplied by the NSW Department of Mineral Resources (NSWDMR). The grids are generated from aeromagnetic data flown in August 1995, at 200 m and 400 m line spacing and at a height of 60 m AGL. These data have all been levelled and corrected by NSWDMR. Magnetic data transects were not coincident with the gravity traverses and magnetics data taken at edge of dataset could also be affected by edge effects.

Rock samples were taken at different localities along the geophysical transects, particularly Transect 2 where there was abundant outcrop. Specific gravity values were measured on wet rock samples of minimum 0.5 kg using Archimedes principle, to be used as base values when modelling. In general all samples had low density, perhaps indicative of pervasive weathering.

RESULTS

Regolith-landforms

The regolith-landforms can be broadly subdivided into two groups, with colluvial sheet-flow deposits comprising the northeast to eastern half of the mapped area, and slightly to moderately weathered bedrock making up the southwest to western half of the area. The latter occurs mostly as rises (9-30 m relief), low hills (30-90 m relief) or hills (90-300 m relief). The sheet-flow deposits show contour banding with pebbly, sparsely vegetated bands separated by red-brown fine silt-dominated vegetated bands. The Warratta Fault closely corresponds with the sharp boundary between the depositional sheetflow deposits and erosional bedrock units. The sinuosity of the range-front associated with the fault is low, suggesting that the Warratta Fault scarp is relatively young.

Four bevelled surfaces were recognised and mapped in the Warratta Inlier area:

- Surface 4 corresponds with the present day channels and alluvial plains;
- Bevelled surface 3 is a strath terrace that in most places is several metres higher than present channels and is characterised by a low relief surface eroded across the steeply dipping bedrock cleavage;
- Bevelled surface 2 corresponds with the unconformity between the Mesozoic sediments and the underlying weathered bedrock. It is therefore interpreted to be from the Early Mesozoic or at most immediately pre-dates the Mesozoic. This surface typically has an angular and rounded quartz pebble surface lag and is closely associated with a majority of the surface exposures of vein quartz mining shafts in the district;
- Bevelled surface 1 corresponds with the summit bevels through the Warratta Hills and is interpreted to be the oldest landscape facet preserved in the area.

DGPS data down the creek line are plotted as a longitudinal section (Figure 2) showing that the present day surface 4 and surfaces 2 and 3 generally follow equivalent profiles vertically offset upstream of the position of the Warratta Fault. This suggests baselevel change, most likely associated with tectonism along the Warratta Fault.

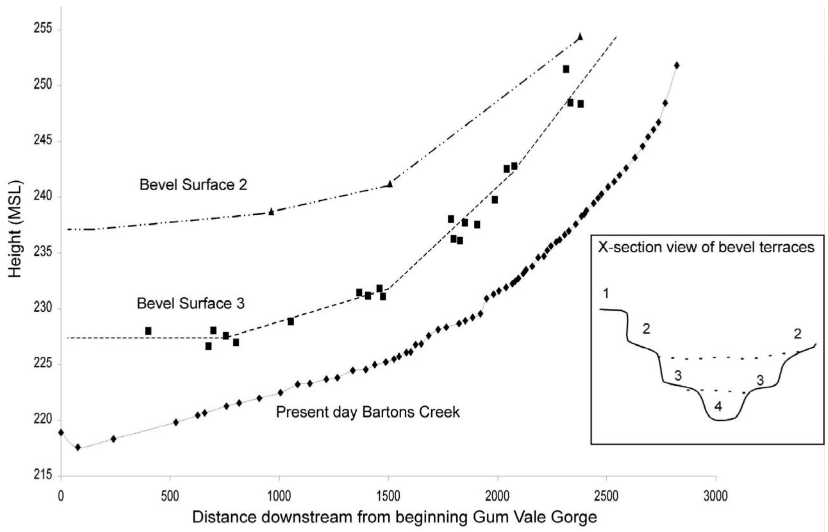

Figure 2: Longitudinal profile of present day surface (4) and bevel surfaces 3 and 2. This figure shows baselevel change, likely to be related to tectonism.

Geophysical modelling

A general model for Transect 2 is seen in Figure 3. Models of Free Air gravity data indicate metasedimentary layers of several different densities (2.65-2.75 gcm^{-3}) within the basement. These are overlain by a more complex set of weathered layers, of both Cretaceous basins (2.15-2.4 gcm^{-3}) and deeply weathered metasedimentary units (1.7-2.56 gcm^{-3}).

The lowest density layer is believed to represent highly weathered kaolinitised bedrock. Deep kaolinitic weathering is documented by Morton (1982) in a drillhole on the Warratta Fault scarp (GDA94 GR 558820 mE 6702060 mN). Significant weathering is also indicated by the differences in measured density of the samples obtained at the surface with the densities given by the final model at depth. The densities ascribed to metasedimentary rocks in the upper parts of the model match those measured in the lab, within the errors of such a small sample size. We note in passing that the densities of the measured samples are significantly lower than those that are generally expected for fresh metasedimentary rocks, however, this could be as the samples chosen in the field were at the surface and so had been exposed to much chemical weathering. Densities measured are more like those of residual regolith (Tracy & Direen 2000). Inspection of thin-sections of these rocks showed that the feldspathic matrices of the more arkosic/greywacke rocks have been severely altered to fine-grained mica and clay minerals. This would significantly reduce the densities (c.f. Tracey & Direen 2000).

In order to determine the sensitivity of the models to the ascribed dip of the Warratta Fault, a plot of dip angle versus RMS for the Warratta Fault was constructed by changing the angle of the Warratta Fault on the model and comparing the RMS. This was done for both a reverse and normal fault model. This procedure is described in Direen (1998). The curve is fairly flat and concave-up, indicating that the model is not very sensitive to the modelled angle of the fault. The general solution for the dip of the Warratta Fault at depth is anywhere between 60° to 90° to the SW, with 75° giving the lowest RMS result. The Warratta Fault is a reverse fault, as Cretaceous rocks of the footwall are vertical to overturned along some parts of the fault scarp.

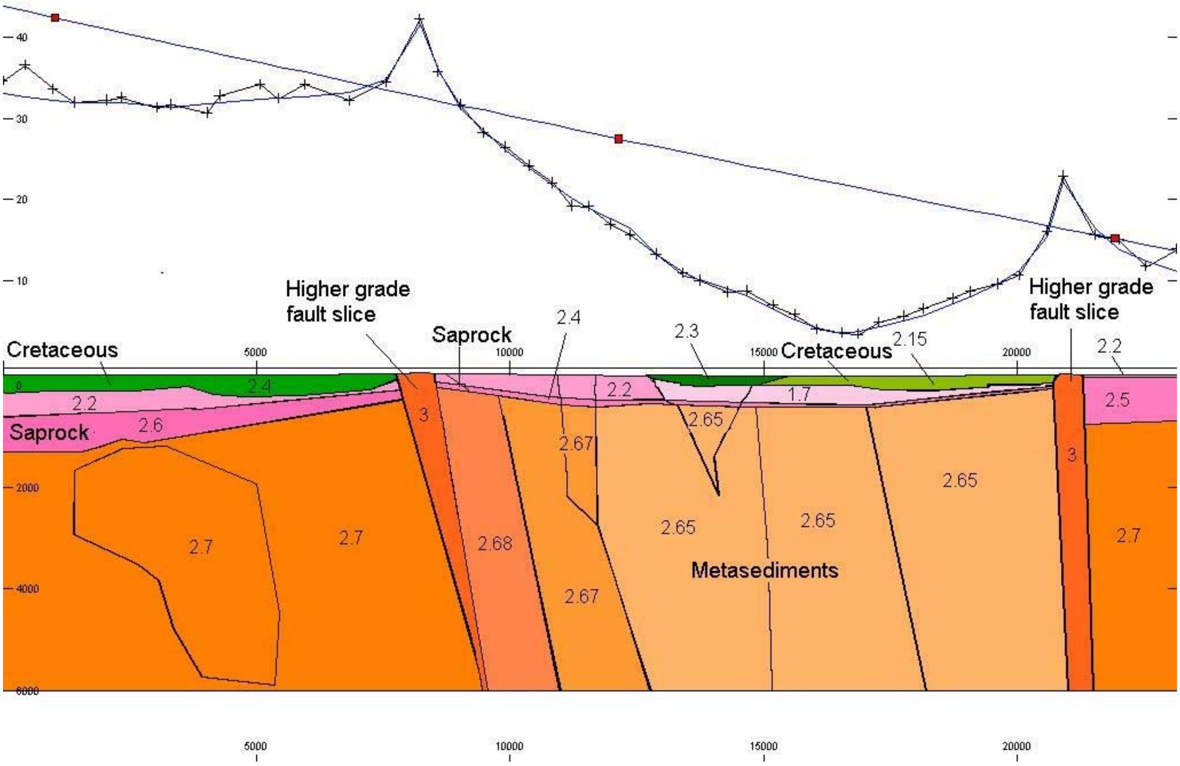

Figure 3: Gravity model of Transect 2 through the Warratta Fault showing suggested densities. This model shows that there are metasedimentary rocks at depth with a more complex metasedimentary and Cretaceous weathering profile at the surface.

Modelling of magnetic data in Transect 2 indicates the presence of a roughly spherical magnetic body at depth, required to fit the high amplitude, long wavelength magnetic anomaly between GDA94GR 584620 mE 6742272 mN and GDA94GR 582153 mE 6739183 mN. This body must have the same density of the surrounding metasedimentary rock, as it has no associated gravity anomaly. It is possible that this object could be a panel of metasediment with differing magnetic properties; an alternative possibility is that it is a blind granitoid body, as it is at the NW (Tibooburra) end of the profile.

CONCLUSION

The landscape evolution of the Warratta Inlier, as determined by potential field geophysics results and regolith-landform mapping, is expressed as a series of bevelled terraces caused by baselevel change driven by tectonism along the Warratta Fault. The vertical offset of these terraces and bevelled surfaces suggest that there have been at least four different erosional baselevels, offset by at least three episodes of tectonism, which have occurred since the Mesozoic. Gravity and magnetics along with field observations have shown that the Warratta Fault is a thrust fault. It is also seen that modelling of the Warratta Fault is not all that sensitive to dip, however gives the lowest RMS when the fault is steeply dipping at 74°.

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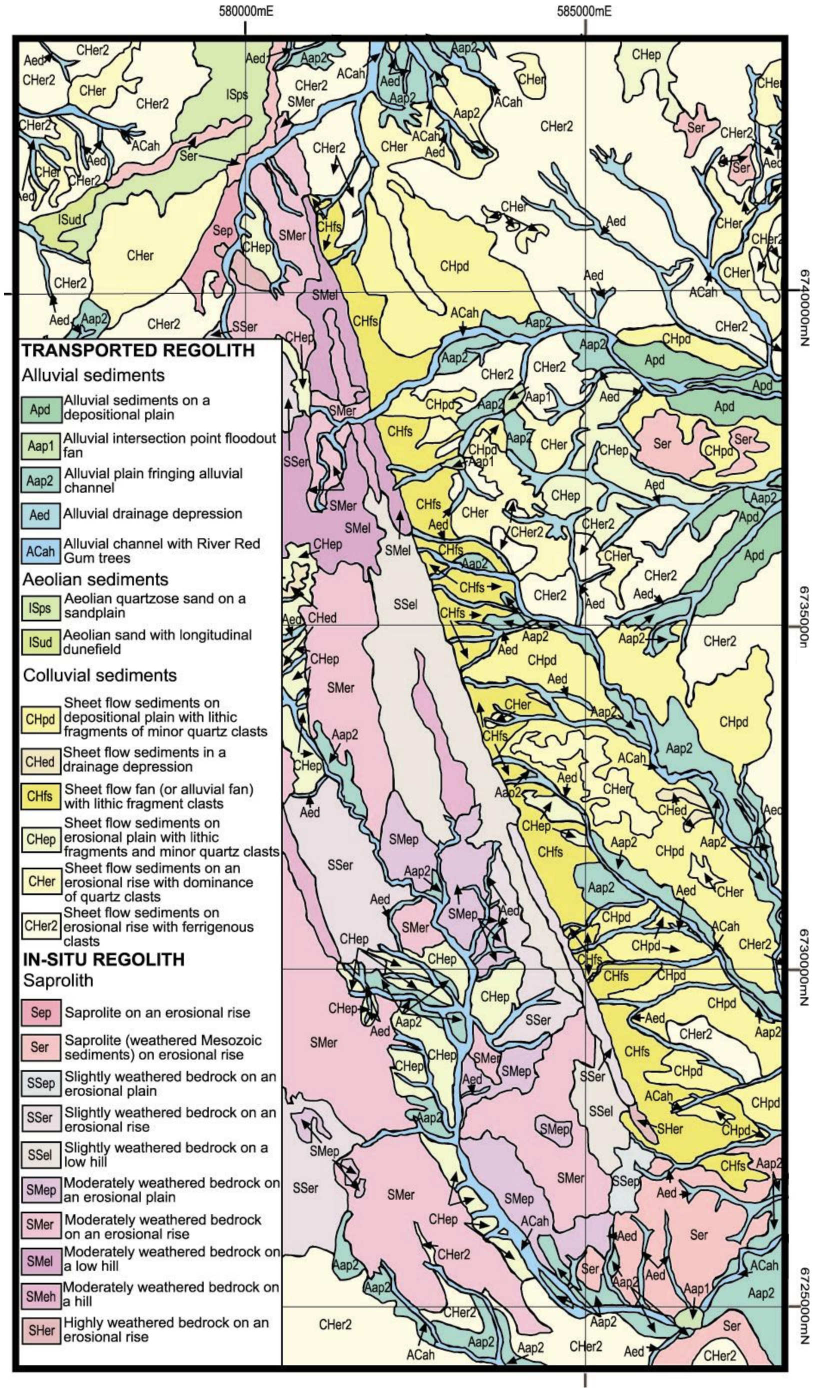

The regolith-landform map of the Warratta Fault area, near Tibooburra, NSW.