NEOTECTONISM ALONG INTRACRATONIC BASIN MARGINS: REGOLITH AND LANDSCAPE EVOLUTION OF WARRATTA SOUTH – NEW BENDIGO INLIERS, NORTHWESTERN NEW SOUTH WALES

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INTRODUCTION

The Warratta South – New Bendigo inliers in far northwest New South Wales contain some dramatic examples of tectonic contributions to regolith and landscape evolution that have significant implications for Au dispersion and residence within this highly prospective region. The Warratta South – New Bendigo inliers are a series of small inliers, forming the southern extension of the Warratta Inlier (Kenny 1934; Stevens & Etheridge 1989). This area is near the boundary of the Thomson, Lachlan and Delamerian orogens (Thalhammer *et al*. 1998), in the south of the Eromanga Basin (Hill 2005), and is therefore not only geologically significant but has been a region very much under-explored in mineral exploration programmes.

Regolith mapping, supported by measurements on morphotectonic structures and key sedimentary sections, are used here to develop a regolith and landscape evolution model of the Warratta South – New Bendigo inliers. This contains evidence critical for developing a more complete regional model, including:

- The identification of at least two Cainozoic tectonic contributions to the landscape evolution, consisting of gentle folding with NE-SW axial planes and NW-SE trending reverse faults;
- Refinement of the local Mesozoic and Cainozoic stratigraphy involving the detailed re-logging of the ‘Gum Vale Formation’ type-section area;
- Discovery of a W-E trending, Cainozoic palaeodrainage (possibly Eyre Formation equivalent) valley system;
- The synthesis of a regolith and landscape evolution model for the area.

SETTING

The Warratta South – New Bendigo inliers lie to the east of Milparinka, *ca*. 40 km south of Tibooburra and *ca*. 300 km north of Broken Hill in northwestern New South Wales. They are part of the Grey Range, which forms the watershed of the Lake Eyre Basin to the west and Bullo-Bancannia Basin to the east (Hill 2005).

Little previous geological work has been undertaken in the study area, with most previous work in the region focussing on other inliers to the north and west (Stevens & Etheridge 1989; Stevens & Fanning 1998; Thalhammer *et al*. 1998; Anderson *et al*. 2004; Davey & Hill 2005; Hill *et al*. 2005). The bedrock inliers in the region are mostly composed of late Cambrian to Ordovician metasediments of the ‘Jeffreys Flat Beds’ (Stevens & Fanning 1998). This sequence consists of phyllite interbedded with phyllitic sandstones metamorphosed to greenschist facies (Stevens & Etheridge 1989; Stevens & Fanning 1998). Bedding parallel quartz veins are thought to have intruded in the late Silurian at the same time as other igneous intrusions in the area (Thalhammer *et al*. 1998).

Mesozoic and Cainozoic sediments and indurations surround the inliers. The Mesozoic sediments are part of the Eromanga Basin, and include:

- The fluvial to marginal marine, Jurassic- early Cretaceous ‘Gum Vale Formation’ (Morton 1982) which is the local stratigraphic equivalent of the Cadna-owie Formation (Hawke & Cramsie 1982);
- The Cretaceous Wittabrinna Shale (Morton 1982), which is the local equivalent of the Bulldog Shale (Hawke & Cramsie 1982).

Exposures of Palaeogene Eyre Formation (Wopfner *et al*. 1974) are significant in the wider region (such as further south around Peak Hill), but in the Warratta South – New Bendigo inliers area they are mostly limited to surface lags of silicified quartzose sediment, closely associated with E-W trending palaeovalleys, such as south of the New Bendigo Inlier. Quaternary sediments cover most of the area and include aeolian, alluvial and colluvial materials.

Climate in the Tibooburra area is arid, with an average annual rainfall of *ca*. 228 mm (Bureau of Meteorology 2006). Annual temperature ranges from above 30°C in summer to below 10°C in winter

(Bureau of Meteorology 2006). Vegetation in the area is mostly chenopod shrubland with larger trees mainly in the drainage channels.

REGOLITH-LANDFORMS

Transported Regolith

There are three main contemporary sediment types in the Warratta South – New Bendigo area:

- Alluvial sediments in ephemeral drainage channels and associated fans and plains. Sediments in the main channels include gravels and coarse sands that are locally derived from the erosion of the adjacent inliers and reworking of Mesozoic and Cainozoic sediments;
- Colluvial sediments are mainly transported in sheetwash and mantle erosional landforms as well as forming depositional plains and fans. Minor creep and rock fall colluvium occur near the fault scarps. The sheetwash sediments are mostly composed of pebbles of indurated regolith clasts (both siliceous and ferruginous), vein quartz clasts and quartz sands; and
- Aeolian sediments are at least surficial components of most regolith-landform units. Aeolian landform units include sandsheets and minor dunes, consisting of rounded, red-brown quartz sands with a small component of colluvial material.

In situ regolith

Three types of weathered bedrock exist in the Warratta South – New Bendigo inliers area:

- Weathered metasediment of the 'Jeffreys Flat Beds' mostly expressed as kaolinitic and slightly ferruginised saprock within erosional plains, rises and hills, and occasionally within the beds of drainage depressions. Regolith-landform mapping associated with this study has found an additional two inliers of weathered metasediments on the western side of the Warratta Faults centred on the following coordinates (a) 591200 mE 6716450 mN and (b) 592000 mE 6714800 mN (Figure 1) and one to the west of the New Bendigo Fault at (c) 590300 mE 6708700 mN (Figure 1);
- Weathered sandstone and siltstone of the 'Gum Vale Formation' ', which is largely covered by sheetflow sediments but has prominent exposures along rises mostly associated with escarpments along fault lines. These are mostly quartzose with kaolinite, muscovite and calcite and local ferruginous and siliceous induration. The area contains the type section for the 'Gum Vale Formation' (Morton, 1982), which has been re-logged in greater detail in this study; and
- Weathered shale and siltstone of the Wittabrinna Shale consisting of mostly kaolinitic with haematitic, goethitic and gypseous induration. These have a very subdued landscape expression, mostly within incised drainage depressions, particularly to the southeast of New Bendigo Inlier.

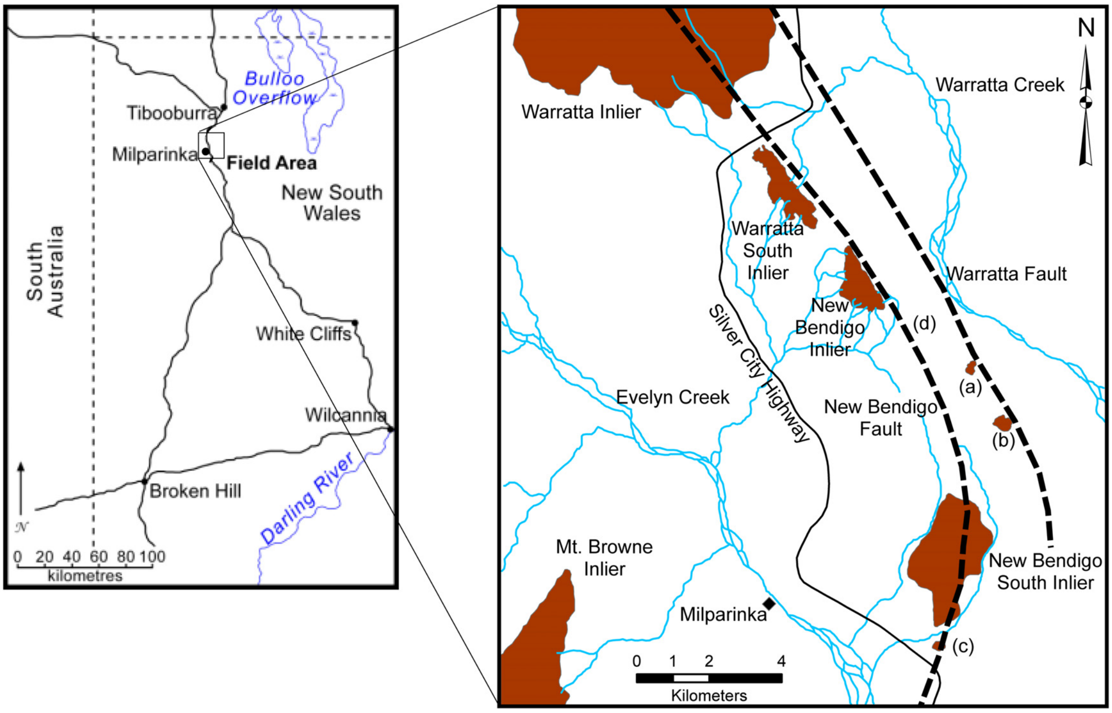

Figure 1: Location map showing Warratta South – New Bendigo inliers. Sites (a), (b) and (c) are new inliers.

Indurated regolith
Silicified material is a large component of the regolith in the area. It is mostly found as clasts in surface lags associated with sheetflow sediments, except for on and immediately adjacent to bedrock inliers. Most are nodular sediments, either derived from erosion of the Eyre Formation palaeodrainage or the 'Gum Vale Formation'. These silcretes include siliceous clasts and fossilised wood cemented in a siliceous matrix.

Ferruginous regolith mostly occurs as:

- Ferruginised metasediments with mostly haematitic liesegang bands and surface patinas, where saprolite fabrics such as cleavage planes and quartz veins are preserved;
- Ferruginous zones within the 'Gum Vale Formation' occur as goethitic and haematitic bands which overprint beds within the sedimentary sequence or infill sub-horizontal fractures and joints;
- Ferruginised 'Wittabrinna Shale', mostly as surface lag, and is typically black to dark red-brown haematitic, goethitic and maghaematitic clasts. The hardness and degree of feruginisation is highly variable, ranging from hard, cohesive masses to soft and friable clay-rich sediment; and
- Ferruginous detrital clasts within colluvium are reworked clasts and derive from any of the previously described ferruginous regolith types.

Gypseous regolith is typically in the weathered 'Wittabrinna Shale' as polycrystalline aggregates and veins, where it is probably a by-product of the weathering of pyrite in these sediments (Hill 2005).

Regolith carbonates are mainly hardpan deposits, and are mostly on exposures of 'Jeffreys Flat Beds' and 'Gum Vale Formation' that had calcareous cements (Gibbons & Hill 2005). They are associated with soil and groundwater movement through the sediments and are best developed near faults, along joints and fractures and on *in situ* exposures in drainage channels.

REGOLITH AND LANDSCAPE EVOLUTION

The regolith and landscape evolution of the area can be briefly summarised as:

1. Palaeozoic sediment deposition following the Delamerian Orogeny with subsequent deformation.
2. Pre-Mesozoic weathering of Palaeozoic bedrock and possible post-Permian glaciation (although Permian sediments are not exposed in the area).
3. Erosion of weathering profiles and limited bedrock exposures within braided fluvial and marginal marine deposition of the 'Gum Vale Beds' (Cadna-owie Fm equivalent) in the Jurassic-early Cretaceous. Quartz and kaolinitic, with minor lithic, fragments suggest a highly but variable weathered landscape. The abundance of conifer wood fragments suggests some forest. The palaeoclimate is inferred to be in a cold, high-latitude setting.
4. Marine incursion represented by deposition of 'Wittabrinna Shale' (Bulldog Shale equivalents) sediments in the Early Cretaceous. Shallow marine conditions with deposition of mostly clays and silts. These marine sediments largely covered at least the lower-lying bedrock exposures and basal Mesozoic sediments.
5. Weathering, particularly of marine sediments. This has probably been ongoing but would have commenced with the regression of the marine conditions in the mid-Cretaceous. An important feature here would have been the oxidation of pyritic, iron-rich minerals, which would have contributed to the development of an acidic weathering environment.
6. Folding into anticlines-synclines with axial planes trending approximately NE-SW.
7. Erosion of Mesozoic sediments in the crests of the anticlines, and deposition of the Eyre Fm equivalent in palaeovalley systems in the trough of the synclines. The erosion on the anticlines removed much of the Wittabrinna Shale from these areas but led to its burial and preservation in the axis of synclines.
8. Weathering and silcrete development. Eyre Formation sediments are weathered, mostly with groundwater and pedogenic silcrete development. Silicification developed during and immediately post-dating sediment deposition.
9. Block, reverse faulting, mostly along NW-SE structures (e.g. Warratta Fault and New Bendigo Fault). This faulting has offset the earlier folds as well as all of the earlier sedimentary sequences, such as the Mesozoic and Eyre Formation equivalent sediments and their weathering/induration products.
10. Increased aridity and associated aeolian activity in the Cainozoic to present day, as well as the final formation of contemporary regolith-landforms.

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