THE LONG-TERM LANDSCAPE EVOLUTION AND REGOLITH GEOLOGY OF THE MT BROWNE AND MT POOLE INLIERS, NORTHWESTERN NEW SOUTH WALES

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INTRODUCTION

The Mt Browne and Mt Poole Inliers are within a poorly understood regolith-dominated region historically renowned for Au mineralization. Field evidence suggests that the contemporary form of the landscape has been evolving since at least the mid-Mesozoic with strong influences from several endogenic and exogenic geomorphological processes.

Until recently minimal studies have been conducted on the inliers, primarily due to the abundance of regolith and complexity of the landforms. Most geological studies with in the area have been confined to the Tibooburra and Warratta Inliers further north (Stevens & Etheridge 1989, Thalhammer 1998, Chamberlain 2001, Hill *et al.* 2003, Anderson 2004, Hill *et al*. 2005). Geological mapping of the bedrock in the Mt Poole inlier was conducted in 1982 and 1989, and an interpretation of the Mt Browne Inlier completed based upon a partial traverse of some of the inlier (Stevens & Etheridge 1989). While this mapping provides a general analysis of the geology within the inliers, minimal analysis and interpretation of the Eromanga Basin geology, regolith features and landscape evolution has been attempted.

The focus of this project is to develop a better understanding of the landscape by first understanding the regolith. In doing so a basis for further geochemical and geophysical analysis is created. To begin, a 1:25,000 regolith-landform map (Figure 1), a 1:50,000 geology map (Figure 2) and a 1:50,000 geomorphology map were produced for the inliers and surrounding basins.

SETTING

The Mt Browne and Mt Poole Inliers are in northwestern New South Wales, approximately 40 km from Tibooburra. They form part of the bedrock exposures in the Grey Range bordering the Thomson Orogen in the south of the Eromanga Basin, along the boundary of the Lake Eyre Basin and the Bulloo-Bancannia Basin (Hill 2005).

The inliers are comprised of the Early Ordovician metasandstones and metasiltstones of the Depot Glen Beds, which are interpreted as approximate stratigraphic equivalents of the Jeffreys Flat Beds of the Warratta Inlier and the Easter Monday beds of the Tibooburra Inlier (Stevens & Fanning 1998). This sequence is dominated by gently folded, interbedded phyllites, psammites, quartzites and slates with reworked felsic and intermediate volcanoclastics (Figure 2). The Mt Poole Inlier and the northern part of the Mt Browne Inlier have been intruded by dolerite and monzonite dykes, plugs and sills, dated at 410-417 Ma (Stevens & Fanning 1998, Thalhammer *et al*. 1998). Bedding-parallel quartz veins are also thought to have intruded around this time (Thalhammer *et al*. 1998). Surrounding the inliers are Mesozoic, Palaeogene and Quaternary sediments and indurations. Lithological equivalents of the Late Jurassic Gumvale Beds and the early Cretaceous Wittabrenna Shale lap onto the edges of the inliers and, where silicified, Eocene Eyre Formation caps topographically inverted mesas with in the Basin.

Bedrock within the area is predominantly, but not exclusively, exposed within the high points of the landscape, expressed as north-northwest trending hills and ranges. The highest points within the inliers are the Mt Browne and Mt Poole summits, with elevations of 274 m and 263 m, respectively. Surrounding these elevated areas are low undulating basins, with an approximate depth of transported cover < 10 m.

The climate is predominantly dry, being classified as semi-arid to arid, with seasonal rain slightly more prevalent in the summer months (Hill *et al*. 2003). Average annual rainfall until 2003 was approximately 230 mm (Chamberlain 2001, Hill *et al*. 2003). Vegetation within the region is highly variable with very strong geobotanical associations between the geology and the vegetation species.

REGOLITH-LANDFORM UNITS

In situ regolith

Weathered bedrock

Slightly weathered bedrock has formed from two distinct lithologies: the Early Ordovician metasediments common to the Mt Browne Inlier; and, the Late Jurassic to Early Cretaceous inter-bedded siltstones and sandstones of the Gumvale Beds. Both units have maintained their competency, with the effects of weathering only penetrating the immediately exposed surfaces of the rocks. Features typical of these exposures are slight ferruginous staining, small joints and fracture sets and white and blue-green lichen colonization.

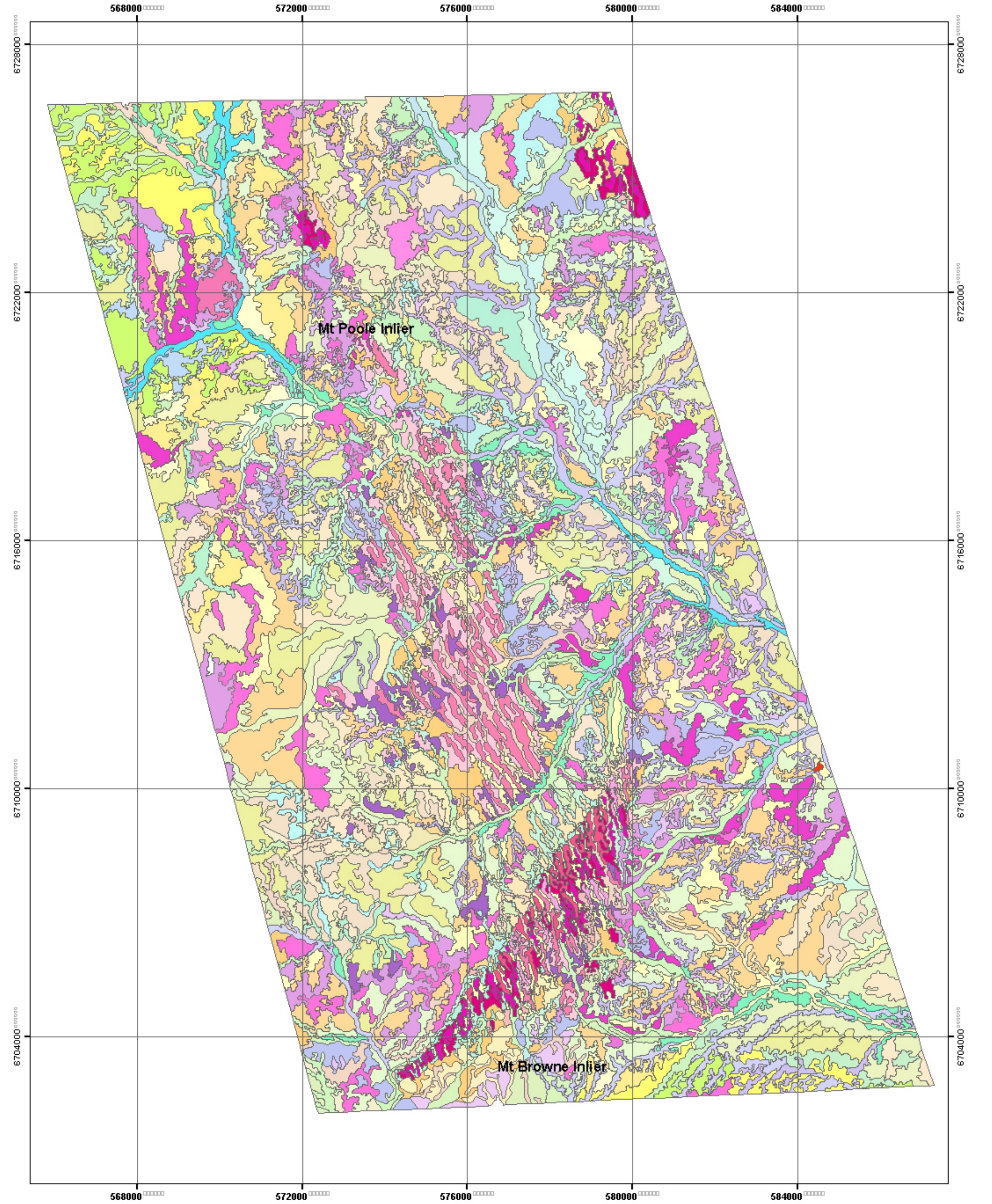

Figure 1: Regolith-landform map of the Mt Browne and Mt Poole Inliers.

Moderately weathered bedrock in the area is not as abundant and is typically restricted to the Depot Glen Beds at Mt Poole and some Gumvale Beds and Wittabrenna Shale exposures. Micro-scale structural features such as cleavage and parasitic folds in the Depot Glen Beds and sedimentary features in the Gum Vale Beds have not been preserved as a result of the excess weathering. These rocks are highly ferruginised with large open joints and fractures, with orange and green lichen colonization.

Both units have similar minor regolith attributes, including rounded to subrounded orange-brown, quartzose sands, hardpan regolith carbonate accumulations, and angular to sub-angular locally derived colluvium. They are typically colonized by emu bush (*Eremophila* spp.) mulga (*Acacia aneura*) and chenopod shrublands, including black bluebush *(Maireana pyramidata)* and pearl bluebush (*Maireana sedifolia)*. Variations in the weathering grades of the bedrock are attributed to lithological variations, landscape position and length of exposure.

Transported regolith

Colluvial & Sheet-wash Sediments

Colluvium and sheet-wash sediments cover most of the Basins and the lower flanks of the inliers. These sediments have been derived from the local bedrocks, with variations in units being a direct result of topographical and lithological variations. Colluvial sediments are abundant where the primary transport mechanism is slope movement. This typically occurs within and directly surrounding the inliers. Sheet-wash sediments are the most abundant regolith materials across the area. These sediments are eroded from high regions of the landscape and are then transported into the lower depositional areas. As a result, much of the higher areas are flanked by sheet-wash contour banded surface micro-topography. Colonization of these units is controlled by regolith type, typically dominated by chenopod shrublands and open woodlands.

Aeolian Sediments

Aeolian sediments are a component of many of the regolith units in the area. The aeolian regolith primarily consists of rounded to sub-rounded, orange-brown-red, quartzose sands and silts with minor sheet wash sediments including sub-rounded to sub-angular lithic pebbles. Some exposures of partially silicified sediments are exposed within incised channels and hardpan regolith carbonate accumulations are a minor feature. ‘Pods’ of rounded colluvium are associated with very shallow drainage pathways. The landforms associated with the aeolian units are typically of low relief, including sand plains and erosional plains. Aeolian regolith-landform units (RLUs) are colonized by open woodlands, including mulga (*Acacia aneura*) and bastard mulga (*Acacia clivicola*) with minor bluebushes (*Maireana* spp.).

Alluvial Sediments

Alluvial systems within the area are dominated by channels, plains and swamps, with a diversity of sediments associated with these systems. Locally-derived gravels combined with more extensively transported sediments comprise most alluvial units, with bedrock exposure abundant within channels and tributaries. Development of many channels and minor drainage is shaped by local bedrock and structural features, inhibiting the development of streams in some regions.

Vegetation within the alluvial systems is highly variable, generally reflected as strong geobotanical associations. Colonization of larger streams and channels typically includes riparian woodland species, such as river red gums (*Eucalyptus camaldulensis*) and western rosewoods (*Alectryon oleifolium*), with the smaller drainage depressions colonized by chenopod shrublands, including thorny saltbush (*Rhagodia spinescens*) and Mexican poppy (*Argemone mexicana)*.

Indurated regolith

Indurated regolith features are widespread in the region, forming in a variety of landscape settings. The style and type of induration is dependant upon environmental conditions at the time of formation and the mineralogy of the cement indurating the sediments. The four primary types of indurations within the study area include: ferruginous regolith; silicified regolith; regolith carbonate accumulations; and, gypseous regolith.

Silicified Regolith

Silicified regolith is the most abundant induration type within the basin areas. *In situ* silicified accretions form the mesas to the west of Mt Browne and the Mt Poole summit. These are topped with indurated Eyre Formation, helping to preserve these sediments. Several silicification morphologies occurr within these mesas including massive-columnar elongated structures and glaebular, rounded clast morphologies. Weathering and erosion of these silicified sediments has resulted in the widespread distribution of the more rounded glaebular clasts throughout the basin areas. Slight ferruginous staining and a strong association with gypseous regolith suggest that these silicifications are a by-product of pyrite weathering and ferrolysis. Some of the upper units within the Mesozoic stratigraphy have also been partially indurated by quartzose cement. These sediments are primarily exposed within the sand sheets to the east of Mt Browne and west of Mt Poole. Silicification of the Mesozoic sediments helped to preserve many primary structures such as cross-bedding and bedding laminations.

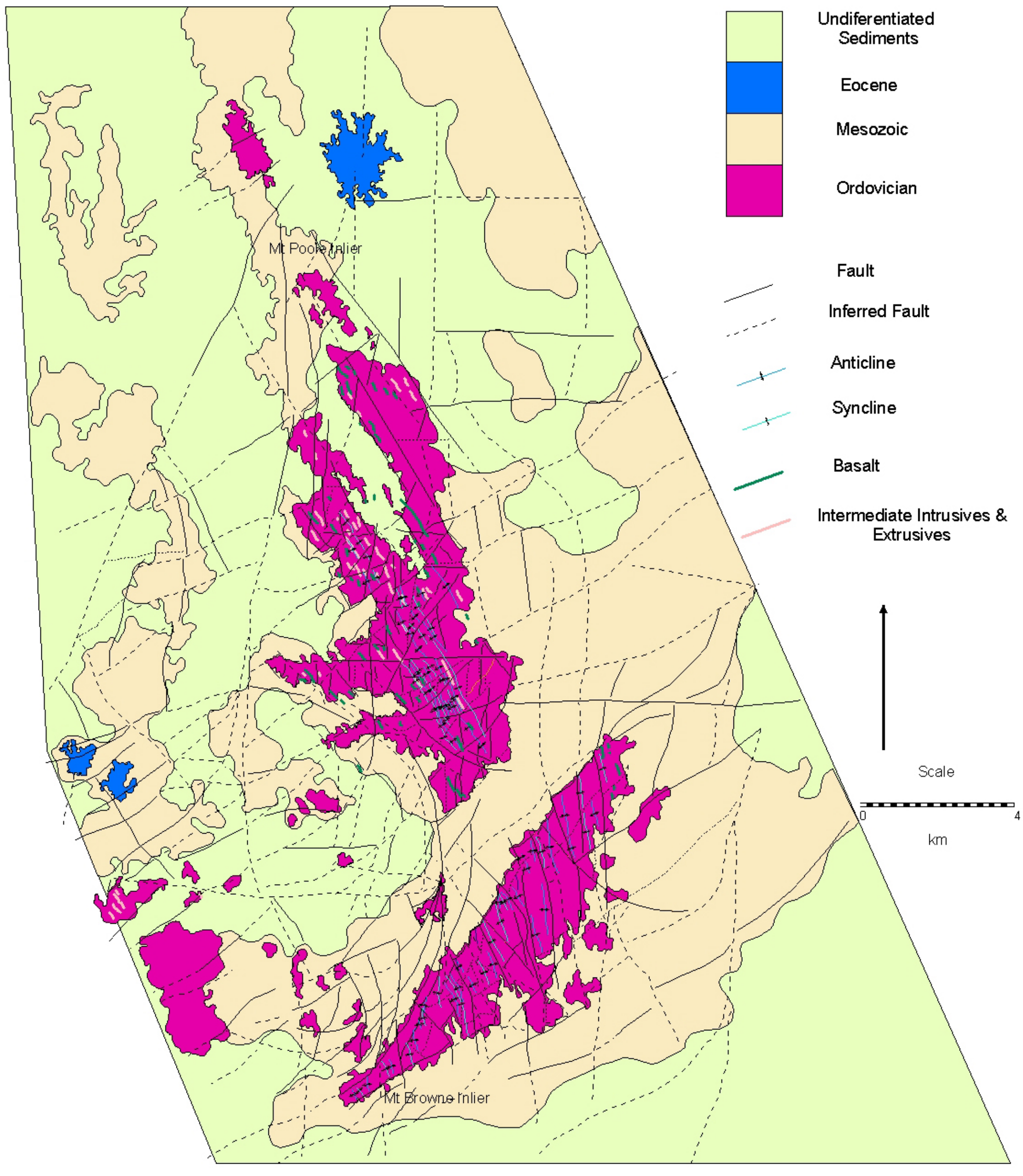

Figure 2: Simplified geological map of the Mt Brown and Mt Poole Inliers and surrounding area.

Gypseous Regolith

Gypseous regolith is abundant in areas that have well developed siliceous indurations. Polycrystalline aggregates of gypcrete and powdered gypsum are dispersed around silcrete ‘pods’, typically associated with the weathered Wittabrenna Shale and indurated Eyre Formation. Soils associated with these indurations have large components of disseminated gypsum crystals, which has influenced the poor structure of these profiles.

The gypseous regolith within the area is a product of the weathering of pyrite from within the Wittabrenna Shale and Eyre Formation.

Regolith Carbonate Accumulations

Hardpan regolith carbonate accumulations, including calcrete and dolocrete, are locally associated with the Ordovician saprolite and the less ferruginised Mesozoic saprolite exposures with in the area. Powdery carbonate accumulations are associated with more highly weathered exposures of Cretaceous sediments. The dominant landscape positions for regolith carbonate accumulations include slope breaks, swales, exposed fault plains, incised channels and sand plains.

Ferruginised Regolith

Ferruginous regolith, including ferricretes, is widely distributed throughout the area. The dominant morphologies include ferruginised saprock surface lags and nodular ferruginous clasts. Ferruginised sediments are uncommonly associated with local lithological variations that control hydromorphic and palaeo-redox characteristics. Primary components of the ferruginised sediments are goethite and hematite, with some lithic inclusions. Weathering of the ferruginised regolith has resulted in surface staining on some rocks and the formation of liesegang rings on some of the ferruginised Mesozoic saprolite. Ferruginised clasts are common with in the Ordovician metasediments, where ilmenite and hematite have replaced pyrite.

REGOLITH AND LANDSCAPE EVOLUTION

The Mt Browne and Mt Poole Inliers have a very complex landscape history in which many morphological processes have helped to shape the contemporary landforms and regolith development. Some important features include:

- The morphology of the inliers has largely been controlled by a series of high angle, north-east to south-west trending reverse faults (Figure 2). These faults form a system of horst and graben structures that have resulted in the uplift and subsequent exhumation of much of the Mt Browne Inlier and some of the Mt Poole Inlier. The exhumation of stepped palaeosurfaces along many of these fault plains, particularly within the inliers, indicates that there have been several reactivations of these faults. Displacement of silicified Eocene sediments indicates that the most recent activation occurred post-Eocene. These structures may have contributed to the silicification of the Eyre Formation, with the faulting producing a change in the water-table, resulting in a change of redox conditions. This created an oxidizing environment facilitating pyrite weathering and ferrolysis, causing an increase in the acidity of the groundwater leading to silicification. This also accounts for the abundance of gypsum in the surrounding regolith profiles, as the gypsum is a by-product of sulphide weathering.
- Uplift and tilting resulting from the faulting has resulted in the large-scale exposure of the highly cleaved metasediments and the formation of the inliers. As a result of this the very slabby metasediments have shed large amounts of colluvium into the surrounding regolith-dominated areas.
- A later north-northwest faulting episode has displaced several structures from the horst and graben set (Figure 2). These faults are interpreted as sinistral, oblique, reverse faults that have formed as a result of a change in primary stress orientation. Large alluvial channels have formed in faulted ‘canyon-like’ structures and exposures of metasediments have been exhumed outside of the upland part of the inlier. These structures are closely associated with hardpan regolith carbonate accumulations.
- As a result of these faulting events, several palaeosurfaces within the inliers have been exhumed. The most prominent palaeosurface is the sub-Mesozoic terrace that intersects most the auriferous quartz veins within the Depot Glen Beds. The exposure of these veins has resulted in the shedding of colluvium, which is a large component of several regolith profiles, and the distribution of most of the alluvial Au in the area.
- The Basin area west of Mt Browne has been shaped by two separate sets of faults that have resulted in uplift and increased erosion of the regolith profiles in the Basin (Figure 2). The southern part of the Basin consists of undulating rises and intense channel incision associated with a set of fault splays. Furthermore, a younger north-south orientated strike-slip fault set has caused dextral displacement of the fault splays. As a result of the uplift, there has been displacement of regolith profiles, increased erosion and exposures of Ordovician metasediments. Powdery regolith carbonate accumulations and nodular ferricretes cap many exposures of bedrock resulting from these splays.
- As a result of the neotectonics within the region, many alluvial systems have been reworked and rejuvenated. Areas that have experienced significant uplift have very different stream morphology to lower areas. This is seen in many large-scale channels bounding the two inliers, where horst block expressions of the channel are relatively linear, whereas within the graben blocks the streams

meander. This is attributed to post-uplift incision attempting to readjust to the local base level change.

- Drainage incision within the area is also largely affected by the bedrock lithologies. Parts of the Mesozoic sediments that have been partially indurated inhibit the vertical incision of the drainage such that the incision energy is distributed in a horizontal direction, resulting in the formation of shallow but wide depression.

CONCLUSION

By combining the regolith and bedrock geology for the Mt Browne and Mt Poole Inliers a landscape evolution model was created and a better understanding of the area's geology was developed. As a result of this, it was established that the depth of cover of the surrounding Basins is much less that initially speculated, increasing the mineral exploration prospectivity of the area. Structural trends within the inliers indicate that the geomorphology of the area is complex.

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