TRINGADEE AREA, QUEENSLAND

C. Phang, T.J. Munday and J.E. Wildman
CRC LEME, CSIRO Exploration and Mining, PO Box 1130, Bentley, WA 6102
Cajetan.Phang@csiro.au

INTRODUCTION

The Tringadee area lies within the Eastern Succession, 120 km south of Cloncurry (Figure 1) in the southeastern corner of the SELWYN 1:100 000 (7054) map sheet. An area of approximately 20 x 25 km was mapped, which includes the Pegmont Pb–Zn–Ag, Brumby Cu–Au, Tringadee Zn and Cowie prospects, and the Cannington Pb–Zn–Ag mine (Figure 2).

PHYSICAL SETTING

Geology

Variably eroded Mesozoic sediments lying on the margin of the Eromanga Basin characterise the Tringadee area. The Mesozoic sediments comprise siltstones with a basal sandstone and conglomerate. These thin to the north of the study area where Proterozoic bedrock crops out. The Proterozoic bedrock is mostly composed of granitic rocks, with lesser calc-silicates, amphibolites and metasediments (Figure 2).

Geomorphology

The Tringadee area is typically of low relief, largely comprising extensive depositional plains covered by well-developed black clay soils over recent alluvium. The black soils are common in the south and southeast of the area and are generally 1–2 m thick. The plains are interspersed with isolated low hills and mesas that generally rise <30 m above a mean altitude of 300 m AHD. Low hills and mesas of Mesozoic sediments dominate the central portion of the area (Figure 2). Similar landforms developed on the Proterozoic basement characterise the north and westerly portions of the mapped area. All drainages through the Tringadee area run southwards, the main drainage being Bustard Creek which drains into the Hamilton River.

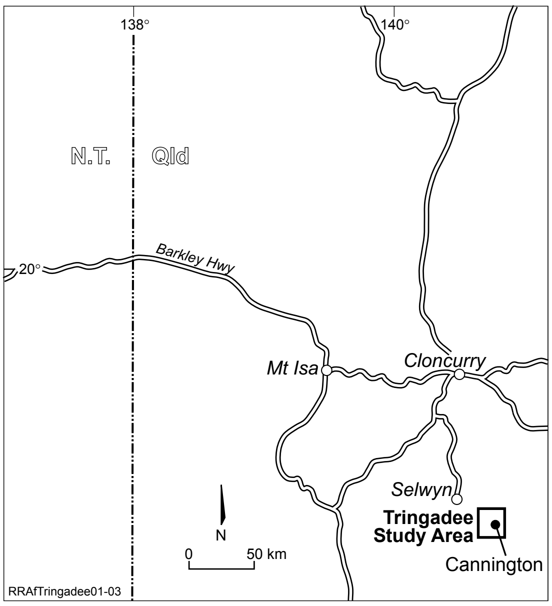

Figure 1. Location map of study area.

Climate and vegetation

The Tringadee area lies within the southeastern portion of the Selwyn Region which has a semi-desert tropical climate, with annual rainfall averaging 375 mm. The vegetation consists mainly of spinifex and sparse low trees and shrubs. Pockets of dense to open scrub of 'turpentine' bush (*Acacia lysiphloia*) are common, with eucalypts growing along main watercourses.

REGOLITH–LANDFORM RELATIONSHIPS

A 1:50 000 scale regolith–landform map covering an area of about 550 km^2 was produced from the combined interpretation of colour aerial photographs (1:25 000 scale), enhanced Landsat TM imagery, published geological maps, field traverses and drill hole intersections.

Important factors contributing to the variation in regolith materials and landforms in this area are the contrasting lithologies combined with processes of erosion, deposition, ferruginisation and silicification. Three major geomorphic environments are recognised:

1. *Low hills and mesas developed on Mesozoic sediments.* A schematic cross-section showing the regolith–landforms developed in Mesozoic sediments in the centre of the study area is shown in Figure 3. The remnant Mesozoic sediments occur as low relief (<30 m) mesas with patchy cappings of ferruginous duricrust. Some mesas have been eroded to form isolated low, conical hills or buttes. Much of the upper part of the Mesozoic sediments has been silicified to porcellanite and is commonly brecciated and cut by conchoidal fractures that have formed the loci for Fe accumulation.

Escarpments are typical in areas where brecciated, Fe-stained and mottled silicified saprolite has been eroded forming a siliceous breccia in a yellowish brown clay matrix. Locally, the brecciated Fe-stained saprolite stands out as steep faceted turrets. Blocky megamottles occur in this brecciated zone.

The pediments flanking the mesas and low hills contain deeply incised gullies with highly erodible pale to greyish brown saprolitic clays. The pediments expose goethite-rich subhorizontal bands in step-like microrelief. The ferruginous bands also form low knolls in which the saprolite has been stained an ochre colour by the high concentrations of goethite and Mn oxides. A polymictic lag of Fe-rich and quartz gravels and brecciated siltstone fragments, deposited by colluvial outwash, covers a major portion of the pediments.

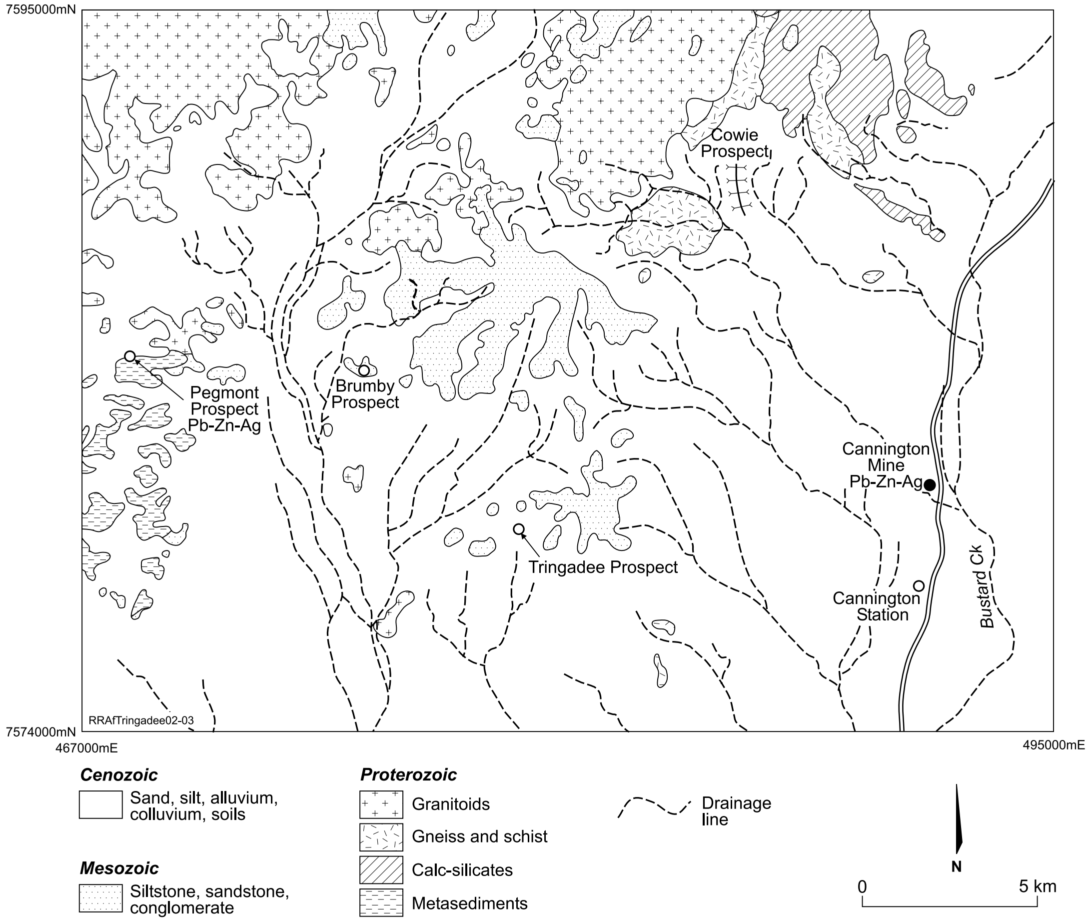

Figure 2. Simplified geological map of the Tringadee area.

2. *Low hills and mesas developed on the Proterozoic basement.* A schematic cross-section showing the regolith–landforms developed in Proterozoic basement in the north and west of the study area is shown in Figure 4. The landforms in this area are similar to the Mesozoic environment, except that low hills are more characteristic of the Proterozoic. The alluvium–colluvium is red due to the dominance of red Fe-stained quartzose sands derived from the granitoids.

In the northern part of the central area, a ferruginous vein related to late-stage hydrothermal activity associated with granite emplacement cuts across the granitic bedrock. In areas of low hills and erosional rises, the regolith consists of mottled saprolite with minor outcropping granitic saprock. Sheetflow deposits, consisting of red colluvial–alluvial sands and occasional subangular quartz pebbles, derived from the breakdown of quartz veins, occur around the apron of the low hills. The sheet flow deposits merge with the adjacent depositional plains where subcrops of a ferruginised sediment occur (Figure 4).

3. *Depositional plains*. Broad colluvial–alluvial depositional plains dominate the southern and southeastern parts of the area (Figure 2). They are generally inclined towards the south. Most of the drainage channels are well defined, although there are also some ill-defined channels and depressions which are probably only active during floods. The regolith material in the channels comprises alluvial sand and gravel.

The depositional plains are characterised by extensive areas of black soil punctuated by patches of red–brown alluvium composed of polymictic ferruginous gravel, granules and quartz clasts. The black soil plains also contain scattered subcrops of Proterozoic bedrock, such as metabasalt.

REGOLITH CHARACTERISATION

Regolith over Mesozoic siltstone

A schematic weathering profile over Mesozoic sediments is shown in Figure 5. Pockets of ferruginous duricrust with a lag of ferruginous nodules and a patchy mottled duricrust are confined to the top of mesas and buttes. The lateritic nodules are generated by the physical breakdown of mottled duricrust or, in places, mega mottles. The mottled duricrust mainly contains goethite, with some hematite, and is concentrated as coatings in voids and as infillings of fractures in the siltstone, forming a network pattern. Silica occurs mainly as quartz, with some opal-CT. The mottled duricrust and the nodules are rich in V (2500–9000 ppm) and are enriched in Si, Al, Pb, Ba and Cr compared to other regolith units on the mesa. The saprolite matrix is a highly siliceous porcellanite of quartz and opal-CT.

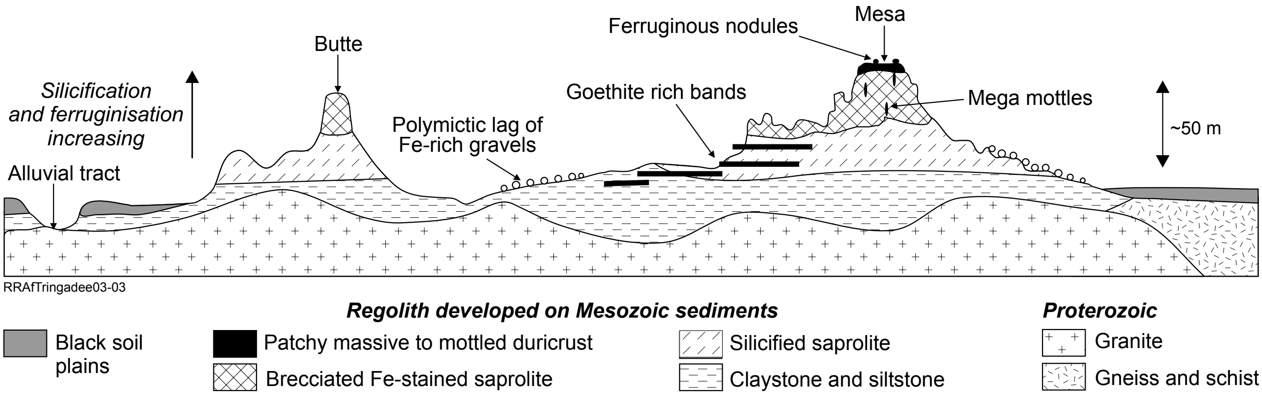

Figure 3. Schematic cross-section of regolith–landforms developed over Mesozoic sediments.

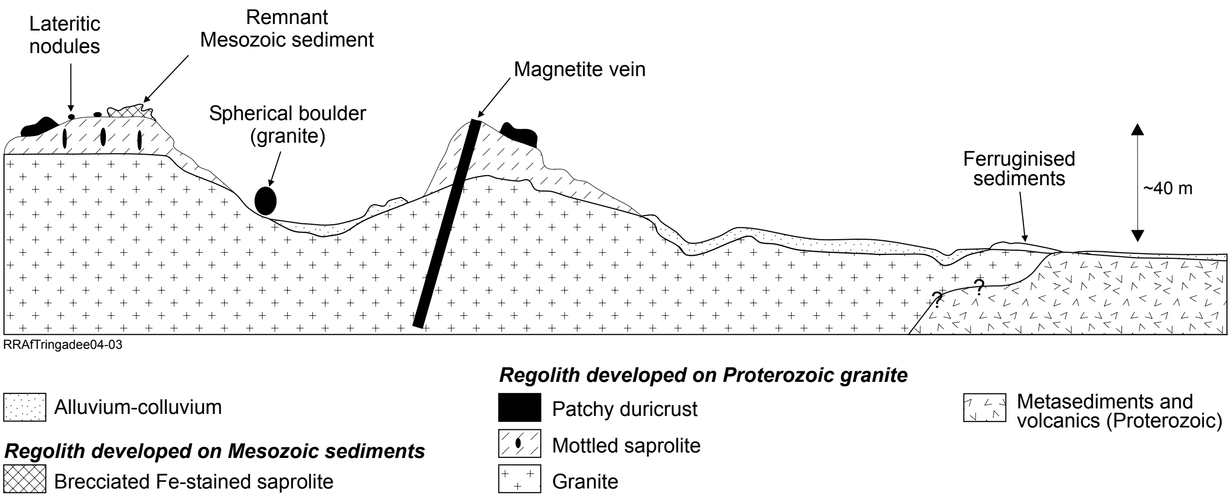

Figure 4. Schematic cross-section of regolith–landforms developed over Proterozoic basement.

Collapse of the saprolite through removal of the clay matrix by leaching induces brecciation and fragmentation. This destabilises the weathering profile and causes slumping and mass wasting of the overlying regolith. Elliptical weathering hollows, with annular ridges of about 1 m diameter, occur near the tops of the mesas and are filled with ferruginous nodules. Within the siltstone, fine sandy layers occur. Percolation of Fe-rich fluids through these porous sandy layers has formed goethite-rich ferruginous bands, which are more common in the lower part of the profile. The lower part of the profile also contains smectitic claystone and siltstone, and gullying is common.

Regolith over granite, magnetite veins and amphibolite

A schematic weathering profile over the Proterozoic granite bedrock is given in Figure 6. Pockets of ferruginous nodules with patchy ferruginous duricrust are limited to the tops of mesas. The ferruginous duricrust consists of pisoliths cemented with ferruginous saprolite fragments of the Proterozoic granite. There is evidence of silicification in the upper part of the weathering profile. In places, the mesas also support a lateritic weathering profile of the Mesozoic sediments above. The unconformity between the Mesozoic and Proterozoic rocks is commonly marked by a coarse sand and conglomerate which is generally ferruginised.

Towards the northern part of the central area, a ferruginous vein cuts across the granitic bedrock. This vein now consists dominantly of hematite, minor goethite, kaolinite and mica, and has a microscopic trellis fabric (martite) that indicates derivation from magnetite. The hematite is rich in Mn and Co compared to other regolith materials. The trellis microfabric is also common in lateritic nodules over granite, indicating that the weathering of these magnetite veins has contributed to the lag of lateritic nodules. The saprock contains white patches of kaolinite from the weathering of feldspars and reddish hematitic mottles from weathered biotite.

The regolith developed over amphibolite outcrop is mainly ferruginised bedrock with red lithosols.

Ferruginised sediment

Subcrops of ferruginised sediment occur beneath the depositional plains. The ferruginised sediment has two facies. The upper facies is a massive, goethite-rich layer that patchily overlies the lower facies. The lower facies contains fine and coarse detrital grains of quartz and plagioclase, cemented by Fe oxides. The ferruginised sediment formed by cementation of colluvial sand

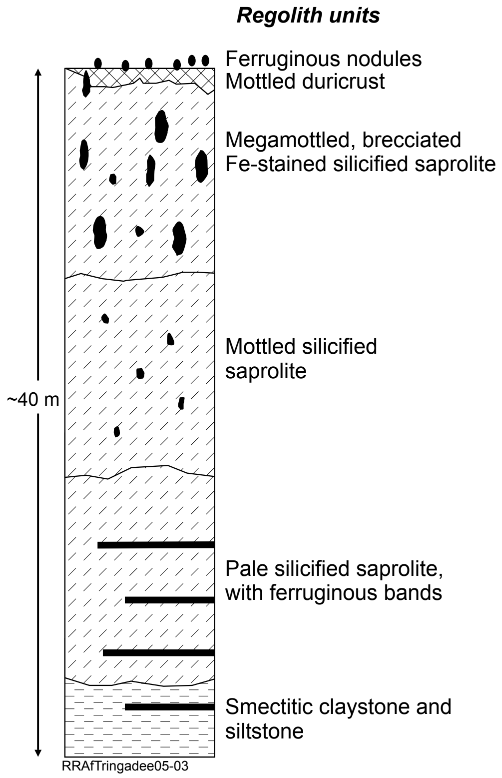

Figure 5. Schematic weathering profile over Mesozoic sediments.

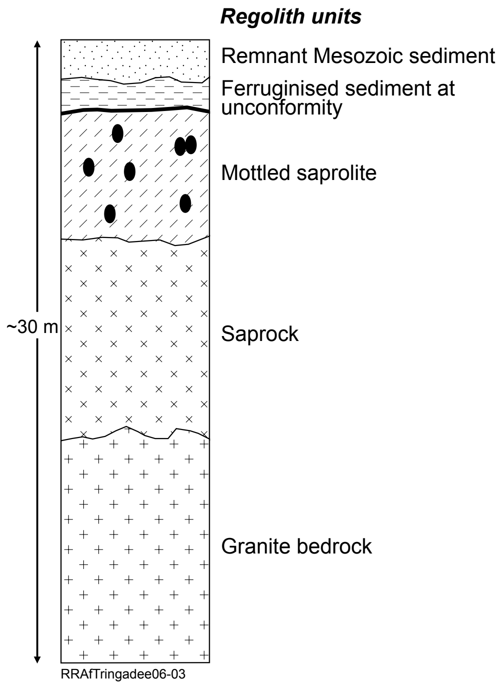

Figure 6. Schematic weathering profile over granitoid rocks.

and quartz pebbles probably eroded from granite. The Fe oxides were probably sourced laterally from nearby ferruginous bedrock units, such as amphibolites and metabasalts.

Black soils

The black soil plains are characterised by a gilgai micro-relief formed by shrinking and swelling of smectitic clays. The black colour is due to organic matter derived from the grassy vegetation. The soils are commonly 1–2 m thick and are developed on recent colluvium–alluvium overlying Mesozoic saprolite, although Proterozoic basement rocks, such as metabasalt, may also have contributed to their development. The soils are generally dark brown to black, depending on their physiographic position, with darker coloured soils occupying lower lying areas where smectite has formed as a result of high concentrations of Ca, Mg and Si in the groundwater. The black soils have about 70% in the <75 µm fraction, the remainder being largely quartz grains and pebbles. The <75 µm fraction consist mainly of quartz and smectite, with lesser kaolinite and feldspar. Compared to regolith materials of the Mesozoic and Proterozoic mesas, the black soils are enriched in Mn, Mg, Ca and Zr.

REGOLITH EVOLUTION

The Mesozoic sediments are flat-lying and unmetamorphosed, the region being part of a relatively stable tectonic block (Blake *et al*., 1983). The most widespread Mesozoic sedimentary unit is the Gilbert River Formation, which consists of poorly sorted cross-bedded sandstone and conglomerate in its lower part, and siltstone in its upper part. Blake *et al.* (1983) stated that in the late Cretaceous or early Tertiary, the region was gently uplifted, initiating the most recent geologic cycle of weathering, erosion and deposition. The dating of Mn oxides on samples from the Pegmont, Cowie and Tringadee prospects using $^{40}Ar/^{39}Ar$ analysis (Vasconcelos, 1998), shows a remarkable concordance in the weathering ages of Middle Miocene (13–12 Ma) for the Cannington region.

Lateritic weathering of the Mesozoic sediments formed mottles and lateritic duricrust. Iron may have been derived laterally or from ferruginous veins emplaced in the granite during late-stage hydrothermal activity. Silicification has impregnated more permeable parts of the lateritic weathering profile. At times of intense leaching, movement of clay out of less silicified parts of the weathering profile resulted in the development of a brecciated Fe-stained silicified saprolite. Development of collapsed saprolite and differential erosion of the Mesozoic sediments related to differences in the degree of silicification or ferruginisation, are probably responsible for the varying elevations of the sediment capped mesas. Some Mesozoic mesas on granite in the north are about 100 m higher than those in the south. This variation is reflected by the present main drainage (Bustard Creek), which flows south. It is unclear if deep weathering of the granite occurred prior to Mesozoic sedimentation, although this seems unlikely (Li Shu and Robertson, 1997). The sediments were deposited over an undulating topography, which controlled the dispersion of elements.

The goethite and Mn oxide-rich bands at the base of the mesas reflect past redox zones or permeability contrasts within the sediments associated with cyclical sedimentation. Goethite and Mn oxides in these bands have scavenged Zn and other trace elements. Gentle uplifting also resulted in fractures in the Mesozoic forming conduits for fluids rich in Fe. These are common at the Brumby Prospect where ferruginous veins cut across one another.

REFERENCES

Blake, D.H., Jaques, A.L. and Donchak, P.J.T., 1983. Selwyn region, Queensland, 1:100,000 geological map commentary. Bureau of Mineral Resources, Geology and Geophysics (Geoscience Australia), Canberra, Australia. 29pp.

L. Shu and Robertson, I.D.M. 1997. Surficial geology around the Eloise Cu-Au mine and dispersion into Mesozoic cover from the Eloise Mineralisation, N.E. Queensland. CRC LEME, Perth. Open File Report 135. 72 pp.

Vasconcelos, P., 1998. Geochronology of weathering in the Mount Isa and Charters Towers regions, Northern Queensland. CRC LEME, Perth. Open File Report 139. 185 pp.