GRANITES–TANAMI REGION, NORTHERN TERRITORY

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INTRODUCTION

The Granites–Tanami region is located approximately 600 km northwest of Alice Springs and about 400 km southwest of Halls Creek in the Northern Territory. The region includes THE GRANITES (SF52-3) and TANAMI (SE52-15) 1:250 000 map sheets (Figure 1). Descriptions of regolith materials are largely based on work by Ireland and Mayer (1984), Henderson *et al*. (1995), Scott (1994), and Wilford (2000).

PHYSICAL SETTING

Bedrock Geology

The regional geology, mineralisation and tectonic setting of the Granites–Tanami region have been described by Hodgson, (1975, 1976), Blake (1978), Blake *et al*. (1979), Ireland and Mayer (1984), Plumb (1990), Mayer (1990), Lovett *et al*. (1993), Henderson *et al*. (1995), and Tunks and Marsh (1996). The region consists of two major Precambrian tectonic units — the Granites–Tanami Block and the Birrindudu Basin. The oldest rocks in the region are associated with the Granites–Tanami Block and include lower Proterozoic variably metamorphosed sedimentary and volcanic rocks (siltstone, arenite, greywacke, conglomerate, phyllite, schist, banded chert, amphibolite, basalt, ironstone, and acid porphyry). Also included are lower to mid Proterozoic granites and acid volcanics (biotite granophyre, biotite adamellite, biotite-hornblend granodiorite and acid porphyry rocks). The Birrindudu Basin sediments consist of arenites, siltstone, limestone, shale, sandstone, stromatolitic chert and conglomerate. These Proterozoic rocks are overlain by the Cambrian Antrim Plateau Volcanics (tholeiitic basalt, minor tuffaceous sandstone, arenite and stromatolitic chert) and Upper Cambrian shallow marine and terrestrial sediments (limestone, sandstone and mudstone).

A major unconformity separates the Cambrian and Proterozoic rocks from flat lying Cretaceous pebble conglomerates, sandstone, and minor siltstone. These Cretaceous sediments are not common in the study area, occurring mainly as isolated ferruginous and silicified plateaux and rises.

Geomorphology

Mapping in the area (Wilford, 2000) has identified ten major landform types, including: alluvial plains, playa plains, dune fields, colluvial fans, colluvial depositional plains, pediments and erosional plains, rises (9–30 metres relief) and low hills (30–90 metres relief). Plateaux are also present, but are not very common. Overall, the Granites–Tanami region has very low relief, most of the slopes having gradients of less than 0.5 degrees (Figure 2). Colluvial sheet flood sediments on depositional plains constitute the most extensive regolith–landform association.

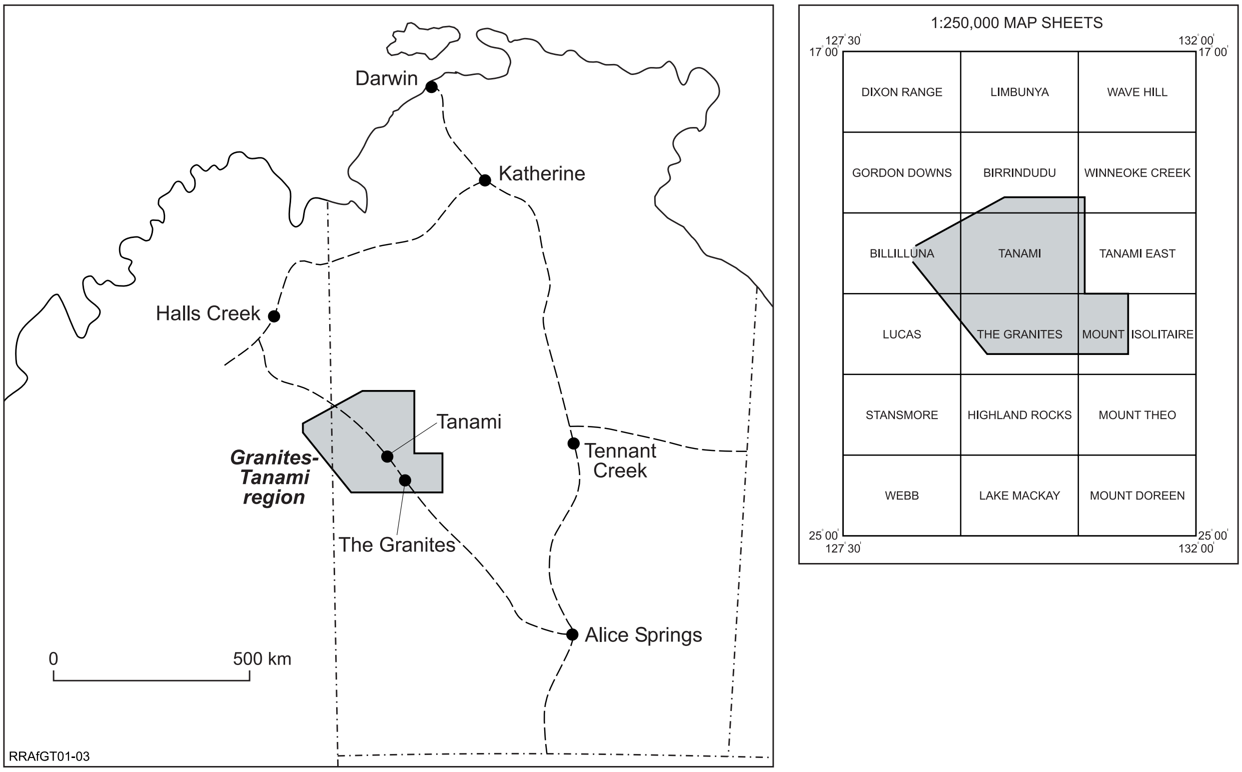

Figure 1. Location map of the Granites–Tanami region.

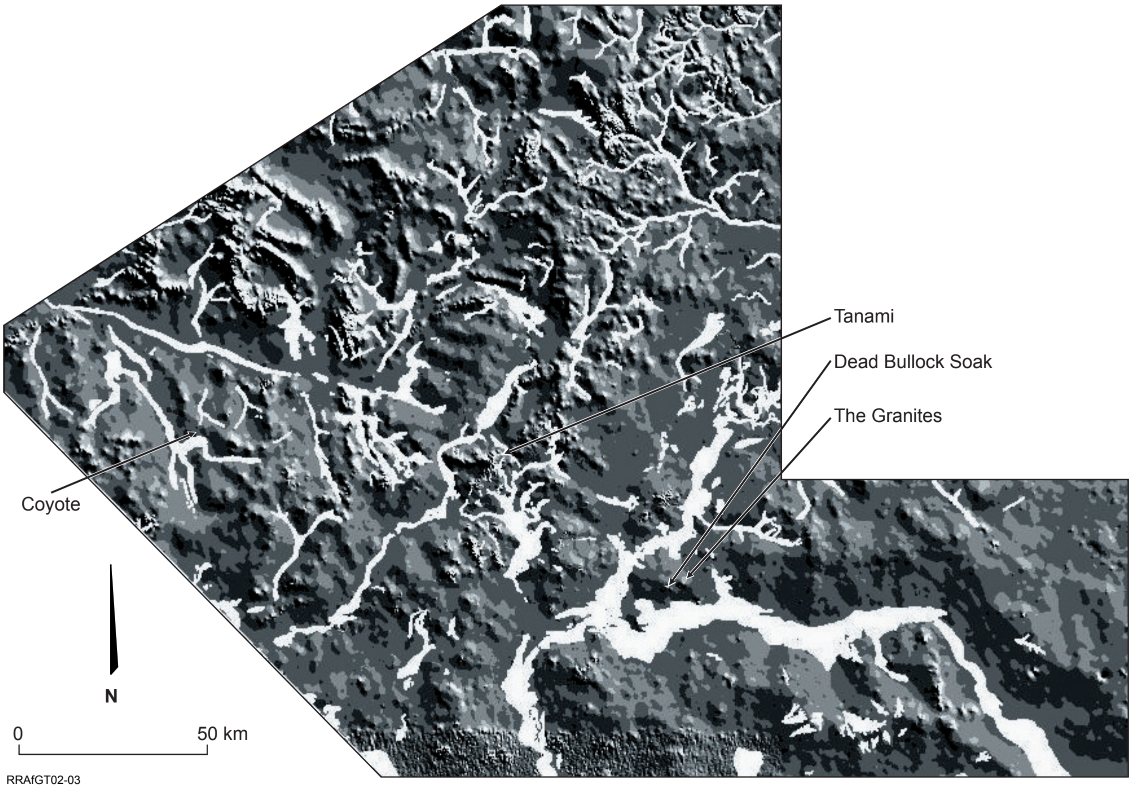

Figure 2. Hillshaded digital elevation model. Major palaeochannel shown in white.

Climate and Vegetation

The area has an arid subtropical climate with distinct wet and dry seasons (Bureau of Meteorology, 1984). Most rain occurs in the summer months between November and March. Rabbit Flat, east of the Tanami Mine, has a mean annual rainfall of 357 mm. Temperatures vary from a December mean maximum of 39ºC, to 10–15ºC cooler during the winter months.

Vegetation of the area consists largely of spinifex (*Triodia pungens* and *Plectrachne schinzii*), *Acacia* spp., *Grevillea* spp., and *Eucalyptus* spp. Gibson (1986) provides a comprehensive assessment of vegetation species and flora assemblages in the region.

REGOLITH–LANDFORM RELATIONSHIPS

Most of the rocks in the area are deeply weathered (ferruginous and highly weathered saprolite) and poorly exposed. Drilling and open pit mining in the area have revealed weathering to depths of up to 100 metres. Most Proterozoic and Palaeozoic rocks in the region are covered by alluvial–colluvial sediments and aeolian sands. These sediments vary in thickness from less than 1 metre on erosional landforms to 100 metres where they are associated with Tertiary palaeochannels (Figure 3).

A variety of indurated regolith materials formed by cementation with iron, silica and carbonate occur in the region. These materials are associated with ferricrete, ferruginous duricrust, silcrete (microcrystalline and cryptocrystalline chalcedony), silicified saprolite, silicified calcrete, and pedogenic and groundwater calcretes.

Erosional scarps

Erosional scarps are important landform features in the Granites–Tanami area because they form breaks between different types of regolith. Older and typically indurated (e.g. iron oxide and carbonate impregnated) regolith materials occur along and above the scarp edge and less weathered regolith is exposed below the scarp. Erosional scarps highlight areas of active erosion.

Erosional scarps are well developed on highly ferruginous indurated bedrock (e.g. Antrim Plateau Volcanics). They are also developed on calcrete exposed along the edge of major palaeochannels. In places, scarps form the boundaries to flat or gently undulating surfaces on dissected hills. These landforms might be relicts of a former Cretaceous land surface of subdued relief, caused by earlier terrestrial erosion and shallow marine deposition.

REGOLITH CHARACTERISATION

Deeply weathered regolith profiles vary in both their composition and fabric, but generally consist of a transported or *in situ* Fe gravel layer (Fe nodules, granules, ferruginous lithic fragments and minor quartz) over mottled saprolite and saprock. The ferruginous gravel layer may either be unconsolidated or indurated by iron oxides to form a ferruginous duricrust. The latter probably reflects mobilisation and precipitation of iron oxides within a fluctuating groundwater regime. Fine to medium aeolian sands (typically <50cm thick) and colluvial sheet flood fan sediments usually cap the ferruginous gravel layer. In places, several cut and fill alluvial cycles and buried palaeosols occur in the alluvial

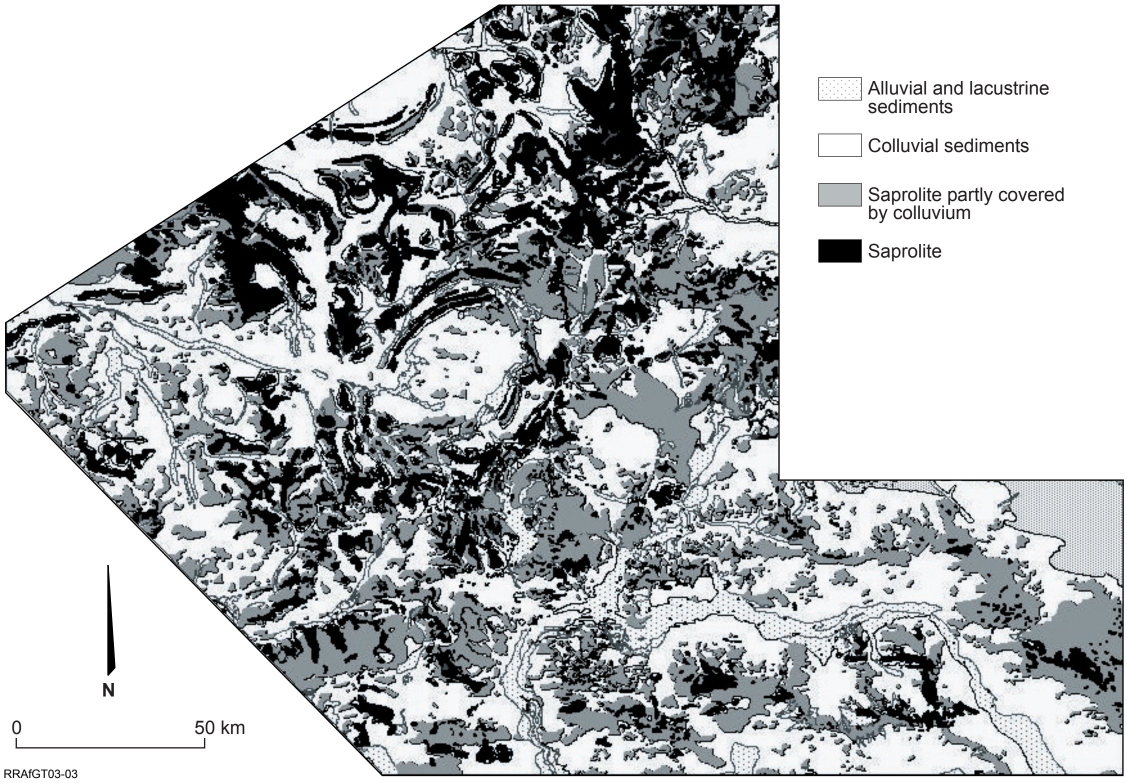

Figure 3. Major regolith types. (Modified from Wilford, 2000)

sediments that unconformably overly highly weathered bedrock.

Paleaochannels

A complex palaeodrainage system has been preserved in the Granites–Tanami region due to its low relief. Palaeovalley floors and associated sediments are, in places, preserved by the Cambrian Antrim Plateau Basalts. These basalts flowed down and buried alluvial sediments and highly weathered basement rocks along valley floors.

Alluvial and colluvial sediments associated with Tertiary palaeodrainages are more extensive than the Cambrian palaeovalleys. The palaeodrainage system comprises large, broad trunk drainages fed by narrower tributaries (Figure 2). The trunk palaeodrainages have complex depositional facies consisting of alluvial, colluvial and lacustrine sediments, and various chemical precipitates such as calcrete and silcrete. Palaeo-tributaries consist mostly of alluvial and colluvial sediments that have been largely covered by more recent sheet-flood fan colluvium and aeolian sand.

DATING

Palaeomagnetic dating (Wilford, 2000) of ferruginous and mottled saprolite from deeply weathered profiles exposed in mine pits at Tanami and Dead Bullock Soak suggest bedrock weathering is at least mid Palaeozoic in age, with further weathering preserved in the mid Tertiary.

REGOLITH EVOLUTION

A landscape evolution model from the Early Cambrian to the present day is summarised below. The evolutionary sequence is based on regolith–landform mapping (Wilford, 2000), drilling by AGSO (Blake, 1974), company datasets, palaeomagnetic dating (Wilford, 2000) and palaeogeographic reconstructions of nearby central Australian basins (Senior *et al*., 1994).

1. *Cambrian to Silurian.* The Tanami region was a subaerial landmass with a highly weathered regolith and well developed drainage system prior to the eruption of the Antrim Plateau Volcanics (Figure 4a, b). During the mid to late Cambrian, flood basalts (Antrium Plateau Volcanics) flowed along these valleys burying alluvium and highly weathered Proterozoic basement rocks (Figure 4b). During the Ordovician and Silurian the Granites–Tanami region was subaerially exposed and deeply weathered.

2. *Devonian.* The Alice Springs Orogeny (400–300 Ma) resulted in local reactivation of major faults and minor uplift. The Granites–Tanami region continued to be exposed and weathered.

3. *Carboniferous.* Weathering of the Granites–Tanami region continued from the Devonian (Figure 4c). The presence of ferruginous saprolite, dated as Carboniferous by palaeomagnetics, implies that the climate during the mid to late Carboniferous was conducive to deep chemical weathering. Highly ferruginous and mottled weathering profiles developed in a landscape with moderate to low relief (Figure 4c).

4. *Permian to Jurassic.* The next significant event is likely to have been the Permian glaciation. This was presumably a period of

accelerated denudation of which there appears to be no remaining sedimentary record in the region. Shallow marine sediments were deposited in the Canning Basin to the west of the Tanami region. Exposure and weathering of the Tanami region occurred during the Jurassic (Figure 4c).

5. *Cretaceous.* Siltstone, sandstone and conglomerates were deposited during the Cretaceous, but their extent in the Granites–Tanami region is unclear. The sediments were probably fluvial and lacustrine deposits in rivers flowing to a sea to the north. Cretaceous sediments were likely to have been relatively thin and restricted to valleys and depressions, such as lakes (Figure 4d).

6. *Early to mid Tertiary.* The early Tertiary was a period of intense weathering. After retreat of the Cretaceous sea the climate was probably characterised by high rainfall, favouring deep, chemical weathering (Figure 4e). Many of the deep weathering profiles in the area probably developed at this time and also in the Eocene when similar conditions prevailed. Well-differentiated regolith profiles developed particularly on mafic and argillaceous rocks. Some of these materials were eroded and deposited as colluvial fans down slope from low hills. These sediments were interbedded with lacustrine clays and fine sands in the lower parts of the landscape. Silcrete and silicified saprolite also formed in these deeply weathered profiles. Silica-rich groundwater associated with river channels precipitated silica at the unconformity between the sediments and underlying kaolinised and mottled zones of the saprolite. Local uplift over the northeastern corner of the Tanami area triggered erosion and

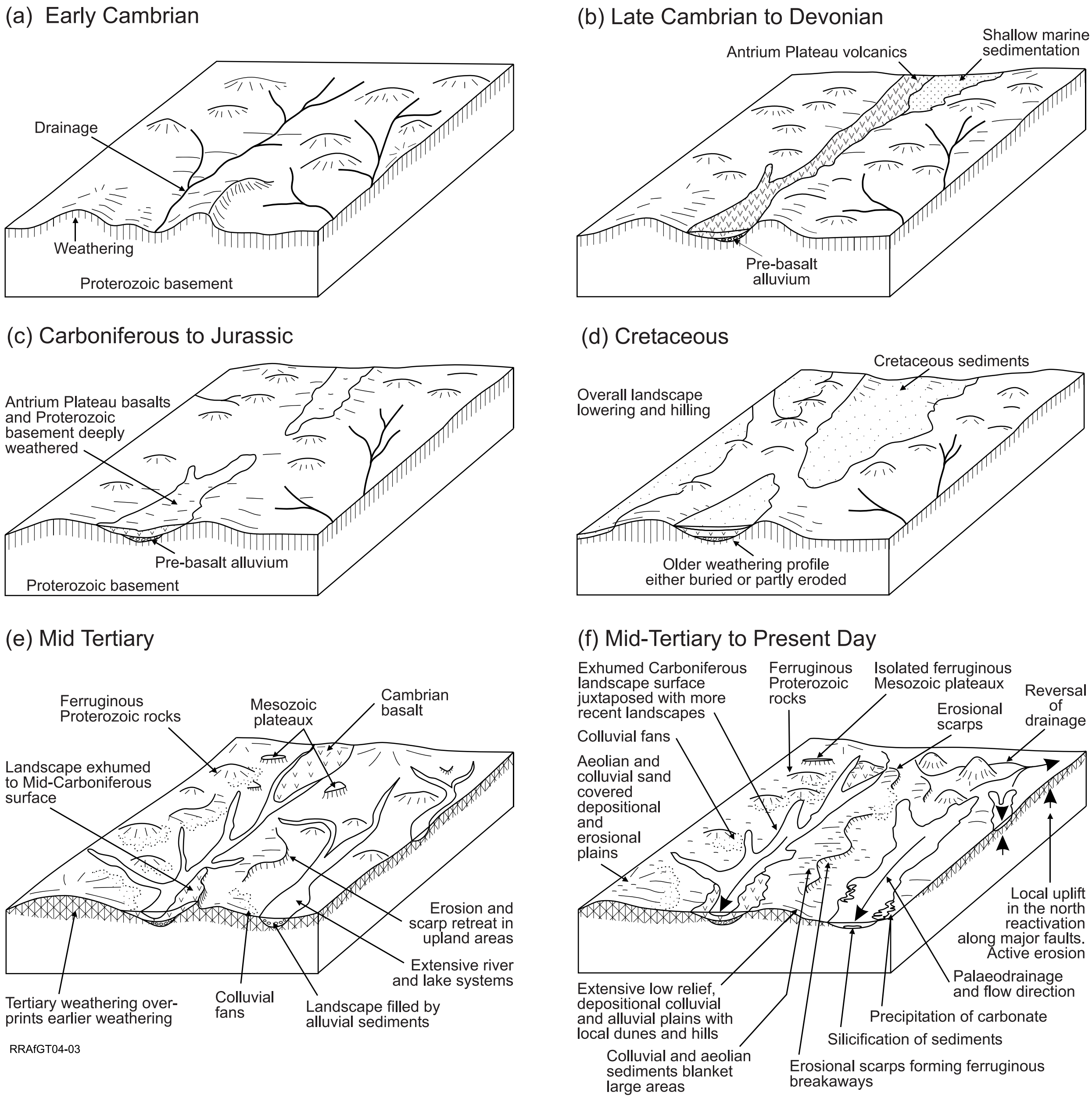

Figure 4. Regolith–landscape evolution of the Granites–Tanami region.

scarp retreat (Figure 4f). Rivers that once flowed to the south and west were captured and diverted to the east.

7. *Mid Tertiary to Present.* From the mid Miocene onwards, the climate was semi-arid to arid. River channels progressively filled with sediment (alluvium and colluvium), flattening an already smooth landscape (Figure 4f). Colluvial fans and footslope deposits inter-fingered with alluvial sediments down slope from rises and low hills. Playas developed in the larger palaeochannels as a result of ponding. Valley calcrete developed and in places silcrete formed from silica rich groundwater. Gypsum precipitated on playa floors. Dunes were formed by the deflation and remobilisation of alluvial and colluvial sand on depositional plains. There is some evidence that local warping has caused reversal of stream flow in some places.

Differential erosion and exhumation of the landscape during the Tertiary has left a complex mosaic of regolith materials with different weathering styles and ages. The present day weathering and geomorphic process rates are low due to the semi arid climate. However, mobilisation and precipitation of calcium and silica is currently active in the groundwater systems beneath palaeochannels. Sheet flow processes are currently active in transporting colluvial sands into valley floors and palaeochannels.

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