THE UNIVERSITY OF ADELAIDE AUSTRALIA

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Cooperative Research Centre for Landscape Environments and Mineral Exploration

# Phyto-exploration in arid subtropical, arid mediterranean and tropical savanna environments: Biogeochemical mechanisms and implications for mineral exploration


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# 4 Tanami Region – Background

## 4.1 Introduction

The Tanami Desert of northern Australia is highly prospective for mineral exploration, due to the number of known mineral deposits in the area and the large areas that have been under-explored. The first crossing of the Tanami Desert was by Nat Buchanan in 1896 (Gibson 1986). When gold was discovered in 1904 mineral exploration soon boomed in the region (Gibson 1986; Tunks & Crooke 2007). Several large deposits have been developed since Au was discovered in the 1900s (Wilford 2000). It hosts the world-class Callie Au-deposit (Cross *et al.* 2005) and other smaller deposits and prospects. However, most of these deposits were found in outcrop, or immediately around outcrop as undercover extensions (Perry 1962). Outcrop across the region is sparse, which means large areas of the Tanami are under-explored (Wygralak *et al.* 2001; Crispe *et al.* 2007). The transported cover materials are mostly between 10-20 m thick with some palaeo-drainage systems reaching a thickness of over 100 m (Wilford 2003). Pattern drilling of surface geochemical or geophysical targets has been widely used in this area but is extremely expensive, time consuming, and has been of limited success (Gibbons & Webb 1997; Wilford 2000; Wilford 2003; Petts & Hill 2005; Worrall *et al.* 2007; Reid *et al.* 2008). The high prospectivity but lack of exploration success associated with the covered areas demands that other mineral exploration techniques be developed, with the objective of providing a surficial chemical expression of mineralisation buried by transported regolith that contains either geochemically barren or complexly dispersed geochemical expressions of underlying mineralisation.

## 4.2 Location and Geology

The Tanami Desert occupies roughly 160,000 km$^2$ covering the central west of the Northern Territory and into Western Australia (Gibson 1986). The northern, eastern and south-eastern parts are comprised of pastoral leases for cattle grazing and the rest is mostly Aboriginal Reserve (Gibson 1986). Due to the large amount of Aboriginal Reserve access to the Tanami region is restricted to the Tanami Highway (Gibson 1986).

The region hosts a number of significant Au deposits in addition to the deposits examined in this study (Figure 4.1) (Huston *et al.* 2007; Mernagh & Wygralak 2007; Tunks & Crooke 2007). The largest deposit is Callie, which is characterised by sheeted vein sets in the hinges of folded carbonaceous rocks within the Dead Bullock Formation, which is overlain by the Killi Killi Formation turbidites (Cross *et al.* 2005; Adams *et al.* 2007; Bagas *et al.* 2007; Crispe *et al.* 2007; Williams 2007). The Killi Killi Formation (1840 – 1830 Ma) is comprised of siltstones and sandstones and is the youngest member of the Tanami Group (Crispe *et al.* 2007). The basal unit of this group is the Dead Bullock Formation, a fining-upward deep water succession dominated by siltstone, carbonaceous siltstone, iron formation and mafic sills. The Tanami Group is underlain by Archaean (2550-2500 Ma) rocks and is overlain by rhyolite, ignimbrite, siliciclastic sediment and felsic ignimbrite of the Ware Group (1825-1810 Ma). Rocks of the Tanami and Ware Groups were intruded by granites (1825 -1790 Ma) which have been subdivided on geochemical criteria into the Birthday, Frederick and Grimwade Suites. In the Tanami Mine corridor the Ware Group is overlain by basalt and immature sediment of the Mount Charles Formation, which are interpreted to reflect a continental rift succession (Huston *et al.* 2007). The age of this succession is poorly constrained, but it is likely to have been deposited at about 1800Ma, with an early Archaean sedimentary provenance distinct from that of the Tanami and Ware Groups.

Deposition of Au at Callie is interpreted to have occurred at a redox front where oxidised auriferous fluids encountered reduced graphitic sediments (Williams 2007). At The Granites Mine, gold is hosted within quartz-carbonate veins in an amphibolite facies iron formation, coinciding with a rheological contrast near the top of the Dead Bullock Formation. The Groundrush deposit is hosted in a metamorphosed dolerite sill within lower Tanami Group metasediments. Numerous other gold deposits are hosted in brittle faults and fractures within basalt and sediment of the Mount Charles Formation, and reflect shallower-level mineralisation processes than the Callie and The Granites deposits (Adams *et al.* 2007; Tunks & Crooke 2007). Palaeoproterozoic basement in the Tanami Region (2500 Ma) is unconformably overlain by the openly folded, late Palaeoproterozoic platform cover succession of the Birrindudu Group, and by Neoproterozoic to Palaeozoic sediments and volcanics of the Centralian Superbasin, Antrim Plateau Volcanics and Canning Basin (Wygralak *et al.* 2001; Wilford 2003). High grade metamorphism occurred at 1865 Ma associated with the Hooper Orogeny, and called the Tanami Event (Wygralak *et al.* 2001; Cross *et al.* 2005; Bagas *et al.* 2007; Crispe *et al.* 2007; Mernagh & Wygralak 2007).

Gold mineralisation is generally in folded and faulted corridors of early Proterozoic rocks (Wilford 2000), with the main occurrences of Au structurally controlled by strike-slip faults generally oriented around 350$^{o}$00’00”, 020$^{o}$04’00”, and 060$^{o}$07’00”. The major geology of the region is made up of two Proterozoic tectonic units: the Granites-Tanami Block; and, the Birrindudu Basin (Wilford 2003). These units are overlain by the Cambrian Antrim Plateau Volcanics and Upper Cambrian shallow marine and terrestrial sediments (Wilford 2000). The study areas of Titania and Coyote are underlain by Killi Killi Formation bedrock within the Granites-Tanami Block. The Killi Killi Formation predominantly includes thick sequences of Palaeoproterozoic (1848±22 Ma) turbidites and greywackes and is part of a widespread northern Australian turbidite package (Vandenberg *et al.* 2001; Cross *et al.* 2005; Petts & Hill 2005). Most of the known Au mineralisation in the area is hosted in this unit and the older Proterozoic unit, the Dead Bullock Formation (Mernagh & Wygralak 2007). As a result, these units have been the focus of the majority of the minerals exploration programs.

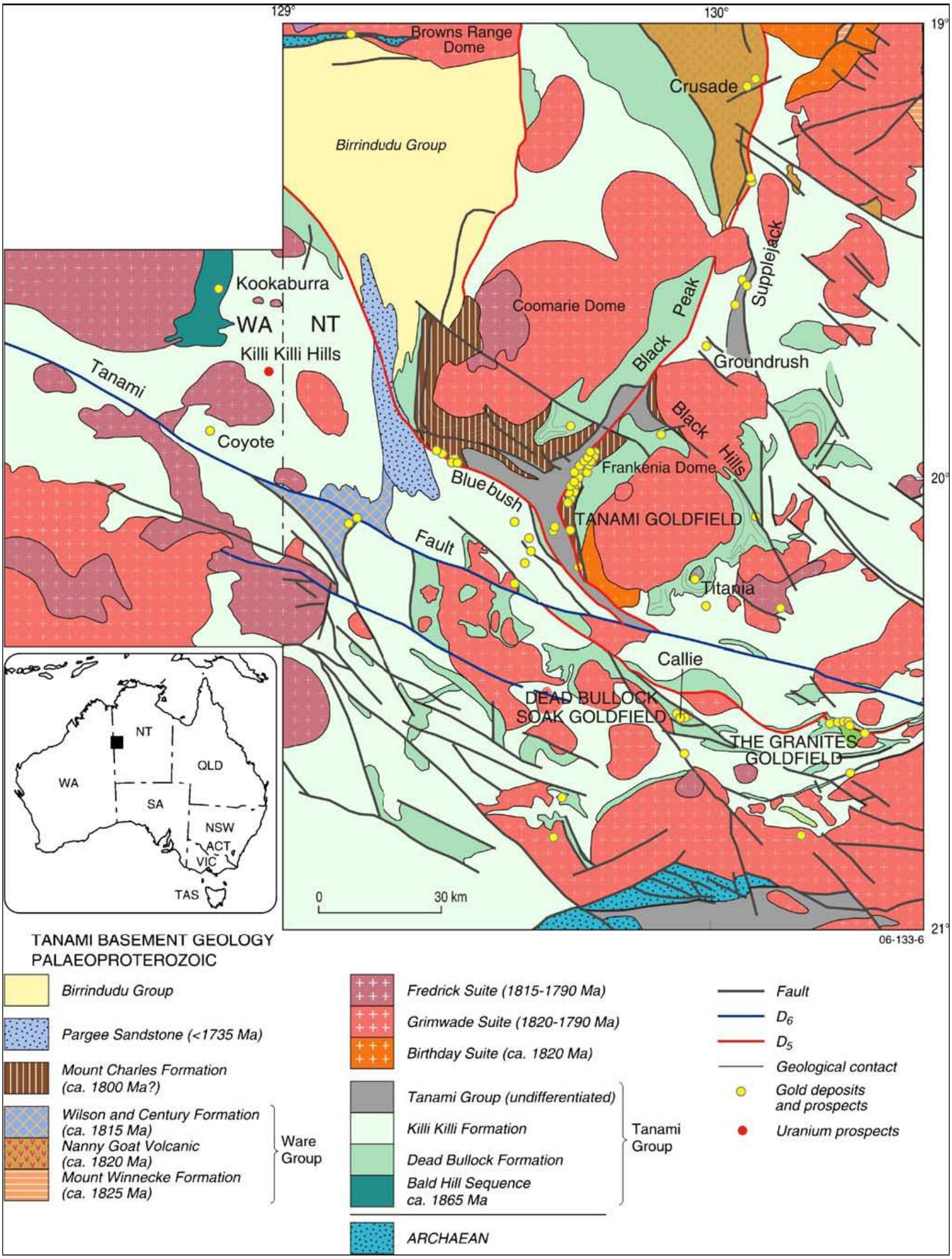

**Figure 4.1: Location of all known Au deposits within the Tanami Region, taken from Huston *et al.* 2007.**

## 4.3 Landscape

The Tanami has low topographic relief, with most slopes less than 0.5 degrees, with large areas having no recognisable drainage channels (Wilford 2000). The main landscape process responsible for transporting the surface materials here are shallow overland water flow dominated by sheetwash (Horton 1945; Wilford 2000) mostly derived from low hills and rises to the west, and aeolian saltation, particularly associated with the prevailing easterly winds.

The main landforms are sand plains, playa plains, linear dunes, colluvial fans, colluvial depositional plains, salt and freshwater lakes, and erosional plains, rises and low hills (Gibson 1986; Wilford 2003). The surficial regolith materials mostly consist of reworked, ferruginous, quartz sands; these are incorporated into alluvial sediments, aeolian sediments, colluvial sediments, lacustrine sediments, saprolite covered by thin colluvium and saprolite (Wilford 2000). There has been intense chemical weathering of bedrock in the region with *in-situ* weathering profiles up to 90 m thick dating back to the Cambrian Antrim Plateau Basalts (Wilford 2000; Worrall & Pillans 2006). The thickness of the weathering is dependant upon the position in the landscape, the denudation history, the composition, permeability and porosity (Wilford 2000). For deep weathering the rates of erosion must be less than the rate of weathering (Wilford 2000). The large amounts of ferruginous materials could be related to fluctuating groundwater levels which are still seen today (Wilford 2000; Wilford 2003)

There has been a long weathering history with variable amounts of erosion and deposition. The regolith materials over this area have previously been considered a barrier to geochemical exploration programs, but understanding the processes that form the regolith materials can be a useful tool in aiding mineral exploration (Wilford 2000). *In-situ* regolith materials, including weathered bedrock, tend to be restricted to areas of higher relief, whereas transported regolith materials occur throughout the landscape (Wilford 2000; Worrall & Pillans 2006). The erosion and re-deposition of materials across the Tanami can lead to geochemical anomalies occurring at the surface which may not reflect buried mineralisation (Wilford 2000).

Areas of thinner cover are much more extensive than previously thought, this is of particular importance as even shallow transported sediments can geochemically mask buried mineralisation (Wilford 2000). The transported materials vary in thickness from 1 m in the west to over 100 m in the east, associated with buried 'palaeodrainage' systems, assumed to be from the Tertiary (Gibbons & Webb 1997; Wilford 2000; Wilford 2003), but in many cases also poorly constrain contemporary, ephemeral floodwaters. These palaeodrainage systems have been considered to be a barrier to mineral exploration in underlying bedrock but are potential sites for placer Au deposits (Gibbons & Webb 1997; Wilford 2000). The palaeodrainage regolith materials are mostly composed of dark grey silts and clays with minor fine sands, with abundant gypsum and regolith carbonate, particularly within the upper 1-2 m of most profiles. These systems have been well preserved due to the low relief over the area leading to low erosion rates, some systems have also been preserved by the Antrim Basalts (Wilford 2003). The low relief also leads to the regolith-landform associations in the Tanami being some of the oldest in the world (Wilford 2000).

The contact between the transported materials and the *in-situ* materials is often an important zone for hydrogeochemical precipitation and dispersion (Wilford 2000). The dispersion in the groundwaters is due to fluctuations in the Tertiary and possibly back into the Carboniferous (Wilford 2000). Elevated Au concentrations are often associated with the ferruginous zone due to the scavenging potential of Fe-oxides (Wilford 2000). The Au at the surface is diluted due to the aeolian sand component of the soil which is barren of Au (Wilford 2000).

## 4.4 Climate

The Tanami Desert is semi-arid with irregular, summer-dominated, monsoonal rainfall patterns (Gibson 1986; Gibbons & Webb 1997; Wilford 2000; Wilford 2003). The mean annual rainfall is 357 mm measured from the Rabbit Flat roadhouse (Figure 4.15), although long term climatic data is not available (Gibson 1986; Wilford 2000; Wilford 2003; Petts &

Hill 2005). The average maximum temperature rises to 39$^{o}$C in January and the average minimum is 6$^{o}$C in July (Gibson 1986). The evaporation potential is 3750 mm taken from Rabbit Flat which roughly 10 times the average rainfall (Wilford 2000).

## 4.5 Vegetation

The vegetation communities of this region contain dry savannah woodland typical of most of semi-arid northern Australia (Gibson 1986). Hummock-grasslands dominated by spinifex (*Triodia spp*) are widespread and abundant across much of semi-arid and arid Australia, and in northern Australia they are typically associated with open dry savannah woodland, where *Eucalyptus/Corymbia* trees are widespread and locally abundant, along with small trees and shrubs of *Acacia* and *Melaleuca* (Gibson 1986; Wilford 2000). Some of the species looked at that colonise vast parts of the region such as spinifex (*Triodia pungens*), turpentine (*Acacia lysiphloia*), snappy gum (*Eucalyptus brevifolia*), bloodwood (*Corymbia opaca*), and dogwood (*Acacia coriacea subsp. sericophylla*) (Gibson 1986). Some of these species have distinct landform associations such as: drainage depressions being characterised by *Triodia pungens* and *Melaleuca glomerata* on sodic soils, with *Cyperus bulbosus* which is a preferred food for bilbies (Gibson 1986). Rock outcrops are dominated by *Grevillea wickhamii* and *Acacia lysiphloia* (Gibson 1986).

***Acacia bivenosa* (two-nerved wattle)**

*Acacia bivenosa* (two-nerved wattle) has a widespread distribution across much or northern Australia (Figure 4.2). The species is a dense, glabrous shrub, 1-2 m high, 1-2 m diameter. It has deep golden, spherical flowers that cover the shrub following the wet season in summer. *Acacia bivenosa* grows on a variety of soils but mostly sandy and in areas of seasonal surface water accumulation (Moore 2005). This species has a series of shallow lateral roots and a single thicker sinker root to depth. This species was sampled at the Titania Prospect and seen at the Coyote Prospect in small numbers.

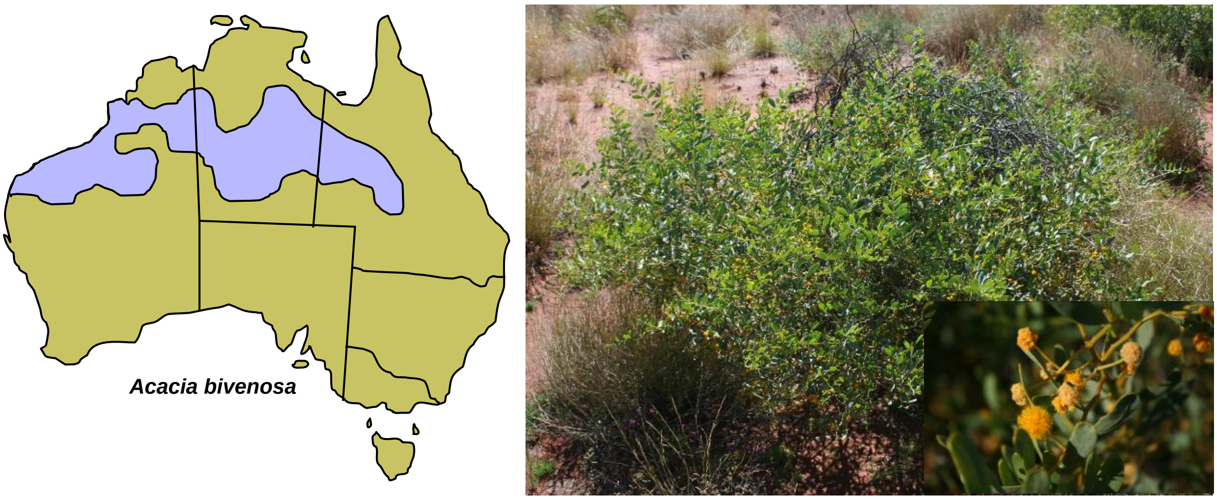


**Figure 4.2: *Acacia bivenosa* form, flowers and distribution, adapted from Moore 2005**

### *Acacia coriacea ssp. sericophylla* (dogwood)

The dogwood has an irregular distribution across northern Western Australia and the Northern Territory (Figure 4.3) (Mitchell & Wilcox 1994; Latz 1996; Moore 2005). It is a small tree, 3-7 m high with grey, corky or flaky bark. The species has pale yellow, globular flowers and grey-green phyllodes, 15-30 cm long and up to 1 cm wide. *Acacia coriacea* grows on dry spinifex sandplains and recovers slowly from fire. This makes its distribution irregular within the Tanami region. This species was sampled at the Coyote, Titania and Hyperion Prospects and seen at the Larranganni Prospects.

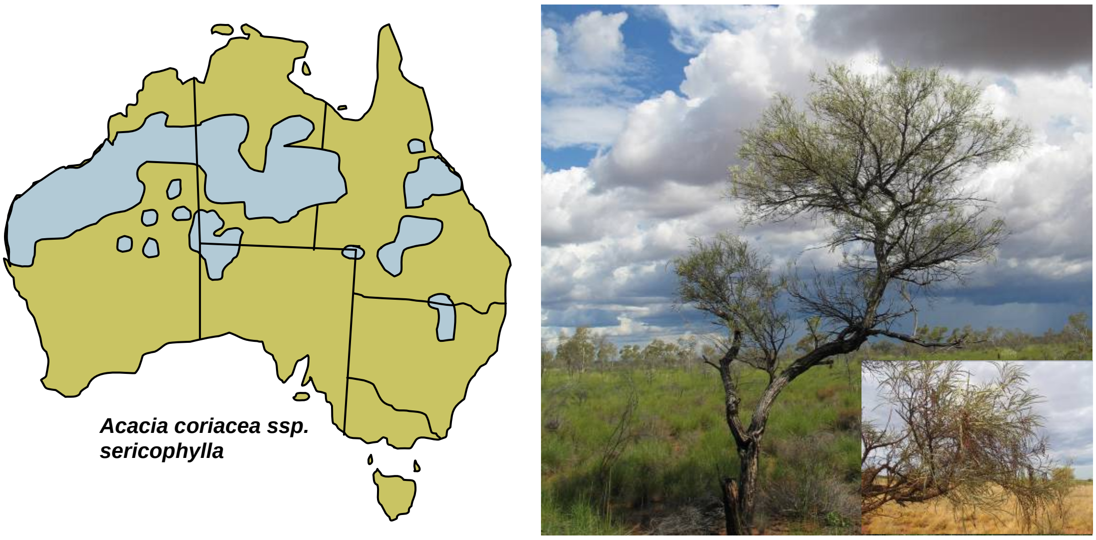


**Figure 4.3:** ***Acacia coriacea ssp. sericophylla*** **form, fruit and distribution, adapted from Moore 2005**

### *Acacia lysiphloia* (turpentine)

Turpentine is a low shrub 2-4 m high and 2-4 m wide with red-brown scaly bark (Latz 1996). It is common within its range across Northern Territory and into Western Australia and Queensland (Figure 4.4). The species has sticky stems and oblong, sticky phyllodes 2-5 cm long. *Acacia lysiphloia* grows in a variety of soils in both woodland and hummock grassland communities. This species was seen at Coyote, Titania, and Larranganni Prospects and sampled at the Hyperion Prospect.

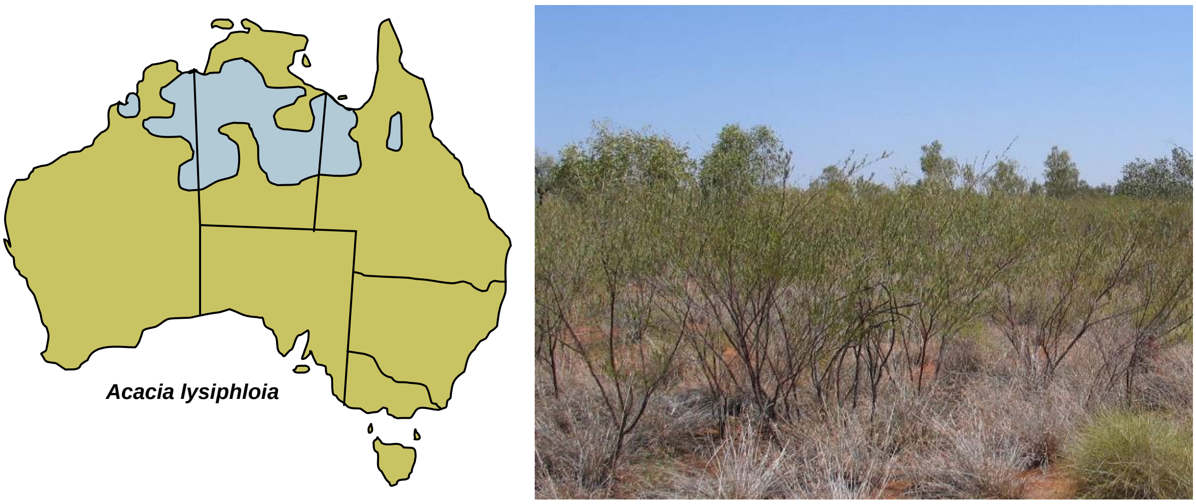


**Figure 4.4:** ***Acacia lysiphloia*** **form and distribution, adapted from Moore 2005**

***Corymbia opaca* (desert bloodwood)**
The desert bloodwood is a tall, shady tree to 15 m high with brown, flaking to orange-brown bark. The distribution of this species is across the western Northern Territory and into Western Australia (Figure 4.5) (Latz 1996; Moore 2005). This species has long, dull leaves, 9-17 cm long and 1-3.5 cm wide; it also has white flowers in clusters of 7. This species was sampled at the Coyote, Hyperion and Titania Prospects.

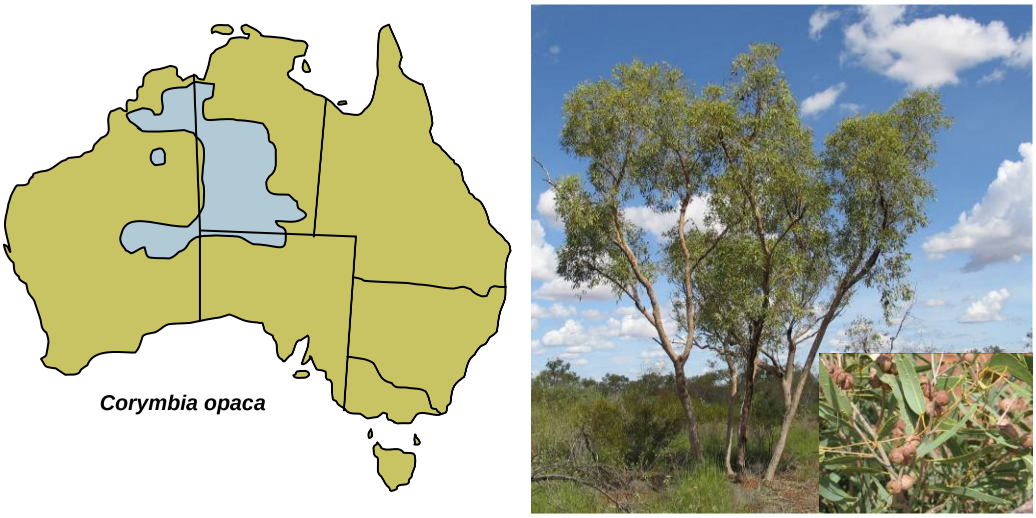


**Figure 4.5: *Corymbia opaca* form, galls and distribution, adapted from Moore 2005**

***Eucalyptus brevifolia* (snappy gum)**
*Eucalyptus brevifolia* and the closely related *E. leucophloia* used to be named *Eucalyptus pallidifolia* (Blake 1953). They are both trees to 10 m high with white powdery bark that forms sparse woodlands (Perry 1962). Both species combined cover a large area of northern Australia with *brevifolia* dominant to the west and *leucophloia* dominant to the east (Figure 4.6). They have blue-grey to yellow-green leaves, 5-10 cm long and 1-2 cm wide, with 7-11 cream flowers in clusters.

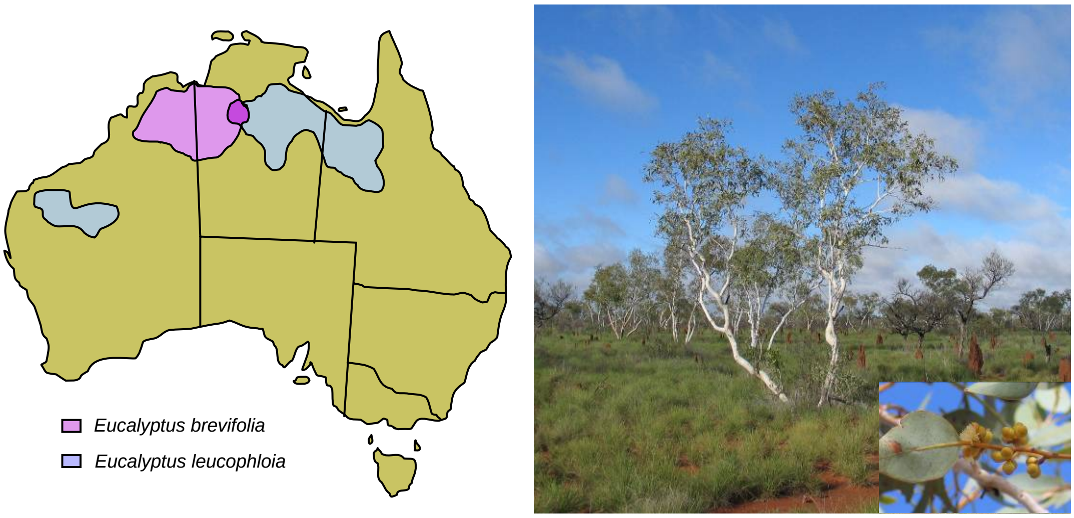


**Figure 4.6: *Eucalyptus brevifolia* and the related *Eucalyptus leucophloia* distribution, form and flowers, adapted from Moore 2005**

It mainly occurs on stony hill slopes on quartzite and sandstone where it is associated with *Plectrachne schinzii* and /or *Triodia pungens* (Blake 1953; Perry 1962; Nicolls *et al.* 1965). It is especially characteristic of the rugged hills of the steeply dipping earlier Pre-Cambrian schists but is also found on the later Pre-Cambrian sandstones and quartzites and rarely on other rocks (Blake 1953). *Eucalyptus brevifolia* was sampled at the Coyote, Hyperion and Larranganni Prospects, and was seen in the hills to the west of the Titania Prospect. Previous studies with this species (Nicolls *et al.* 1965) have indicated that snappy gum can be used as a geobotanical indicator for Pb/Zn as it will not grow in sites with high metal concentrations. It was also unsuccessfully used to regenerate tailings at the Mount Isa mine (Johnson & Putwain 1981).

### *Eucalyptus pachyphylla* (red-budded mallee)

*Eucalyptus pachyphylla* is a multi-trunked tree to 4 m high with smooth, white or brown bark. Its distributions is across central Northern Territory and into Western Australia (Figure 4.7). This species has thick leaves, 9-16 cm long and 2-4 cm wide; it also has large yellow flowers that develop from large red buds. The red-budded mallee grows on red sandplains, dunes or loamy flats associated with spinifex (Latz 1996). This species was collected at the Coyote, Hyperion and Titania Prospects.

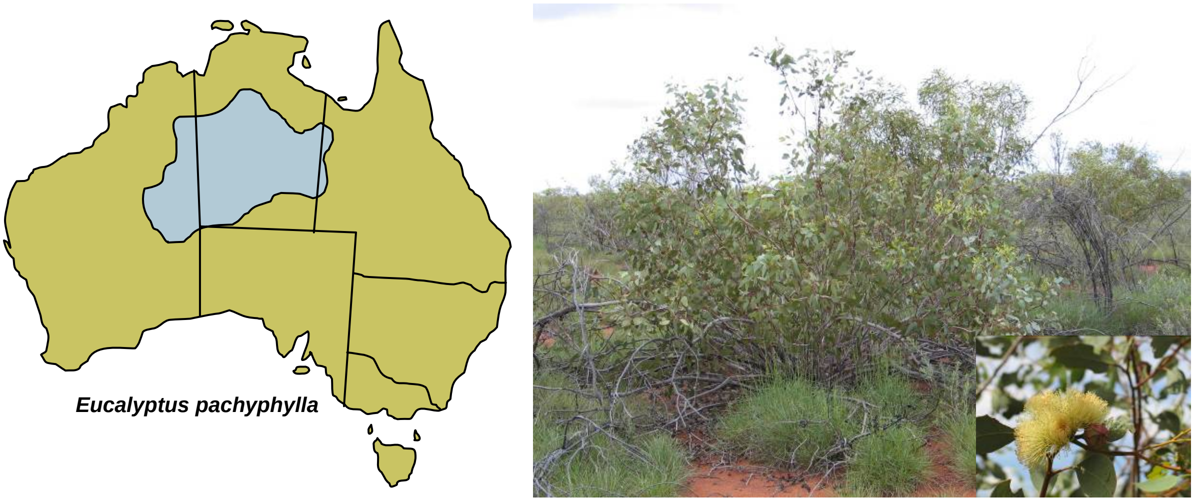


**Figure 4.7: *Eucalyptus pachyphylla* form, flowers and distribution, adapted from Moore 2005**

### *Eucalyptus pruinosa* (silver box)

The silver box is either in mallee form or as a small tree 3-8 m high with rough and flaky light-brown bark. The distribution of this species is variable as it is predominant in northern Australia but it is also advancing south through the Tanami region (Figure 4.8) (Gibson 1986; Moore 2005). The species has large, opposite, heart shaped leaves, 15 cm long by 9 cm wide, and the leaves are often a dull grey colour. It has small cream flowers which occur in clusters of 3-7. *Eucalyptus pruinosa* was collected from the Coyote, Larranganni and Hyperion Prospects.

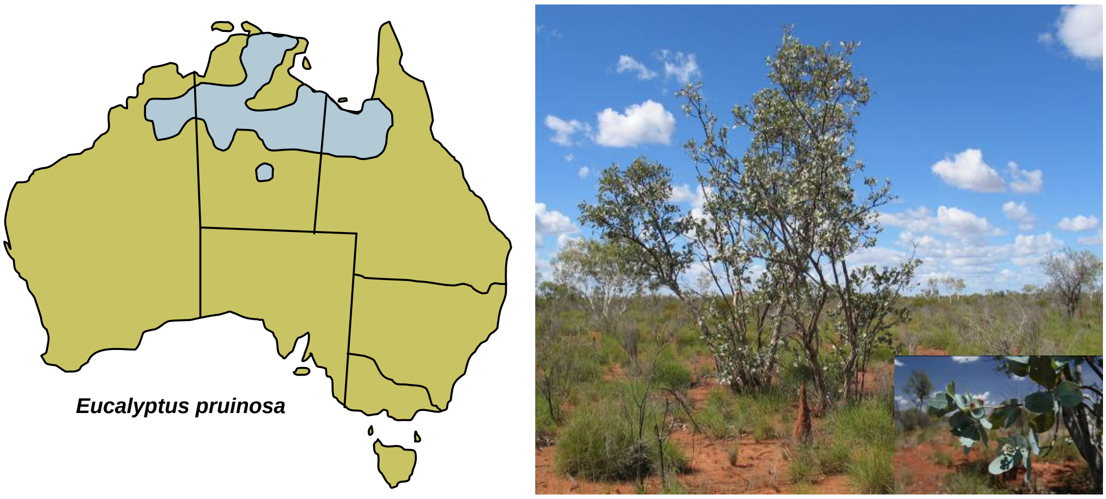


**Figure 4.8: *Eucalyptus pruinosa* form, fruit and distribution, adapted from Moore 2005**

***Grevillea striata* (beefwood)**

*Grevillea striata* is a tall tree 3-15 m in height with dark furrowed bark. It has a vast distribution across semi-arid and arid Australia (Figure 4.9) (Mitchell & Wilcox 1994; Moore 2005). This species has long and thin drooping leaves, 10-35 cm long and 0.5-1 cm wide, with 10 prominent veins on the underside. The flowers are white to cream starting from green buds. The beefwood grows in many varied sandy and gravely soils, usually on plains, and they prefer areas of greater water runoff (Latz 1996; Pronk 1997). This species was sampled at the Coyote and Titania Prospects.

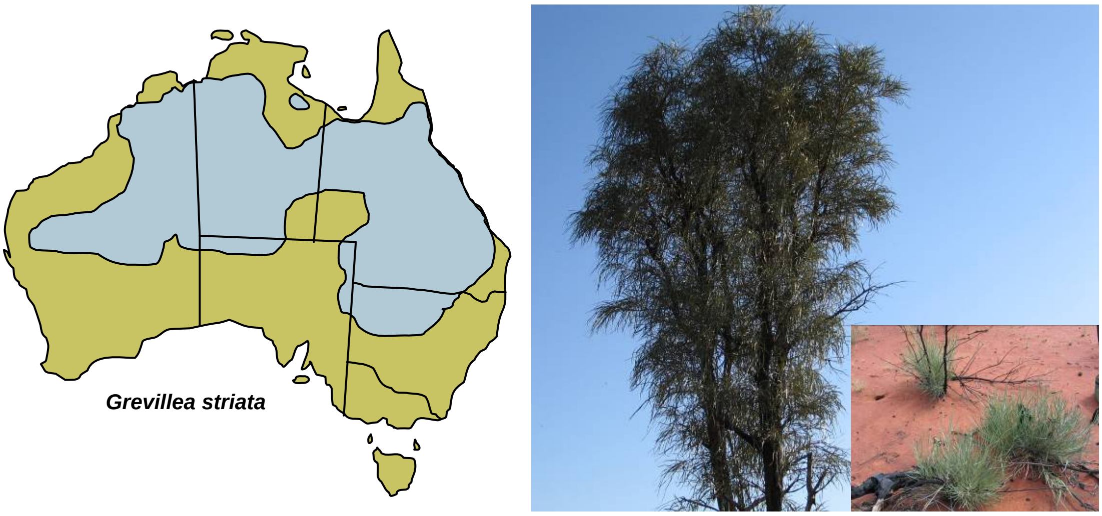


**Figure 4.9: *Grevillea striata* form, leaves and distribution, adapted from Moore 2005**

***Hakea macrocarpa* (corkwood)**

This species of corkwood is a tree to 5 m in height with thick corky, deeply fissured bark. The two corkwood distributions overlap in the Tanami region, but this species extends over much of the Northern Territory and into north-western Western Australia (Figure 4.10). *Hakea macrocarpa* has long, flat leaves 10-30 cm long and 0.5-1.5 cm wide with a prominent mid-vein. It has cream to greenish flowers on 5-15 cm long racemes; it also has black nectar within the flowers. This species prefers dry habitats, often on sandplains associated with spinifex species (Latz 1996). This species was sampled at the Titania Prospect and was seen at the Coyote and Hyperion Prospects.

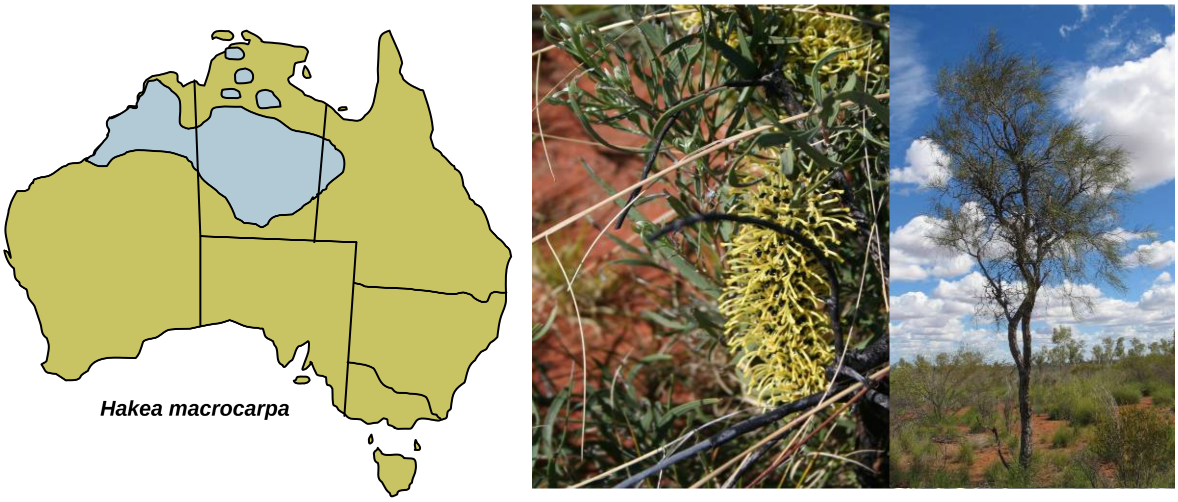


**Figure 4.10: *Hakea macrocarpa* form, flowers and distribution, adapted from Moore 2005**

### *Melaleuca glomerata* (inland paperbark)

*Melaleuca glomerata* is a bushy shrub to 2 m in height with white papery bark. Its distribution is across southern Northern Territory and northern Western Australia (Figure 4.11). This species has thin, grey leaves, 1.5-3 cm long and 1-5-2.5 mm wide, it has cream to light yellow flowers in globular heads. The inland paperbark grows on red, clayey sands and red earths associated with settings receiving extra water, such as near creeks, salt lakes, and clay pans (Beard 1969; Latz 1996; Holliday 2004; Moore 2005). This species was sampled at the Titania Prospect.

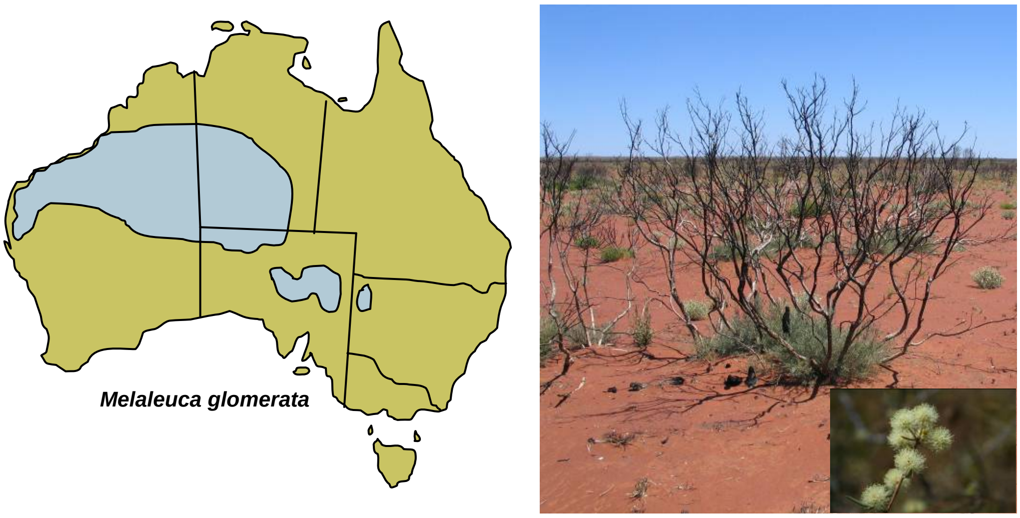


**Figure 4.11:** ***Melaleuca glomerata*** **form, flowers and distribution, adapted from Moore 2005**

### *Melaleuca lasiandra* (sandhill tea-tree)

*Melaleuca lasiandra* (sandhill tea-tree) has a wide distribution across tropical northern Australia (Figure 4.12) (Latz 1996; Holliday 2004; Moore 2005). It is a paper-barked shrub, 2-4 m high, and 2-3 m diameter. The species has small cream flowers and hairy or silky branchlets. *Melaleuca lasiandra* grows on red, clayey sands and red earths associated with settings receiving extra water, such as near creeks, salt lakes, and clay pans (Moore 2005). Its presence is often used to recognise areas of intermittent flooding (Beard 1969; Wooller *et al.* 2005). The rooting habit of this species has a series of lateral roots up to 5 m from the plant base, and from there plunging to depth. This species tends to produce strong and vigorous re-growth after fire, even if there have not been rains or influx of surface water, suggesting that their roots extract significant amounts of water from groundwater aquifer systems. This species was sampled at the Titania Prospect and seen at the Coyote Prospect.

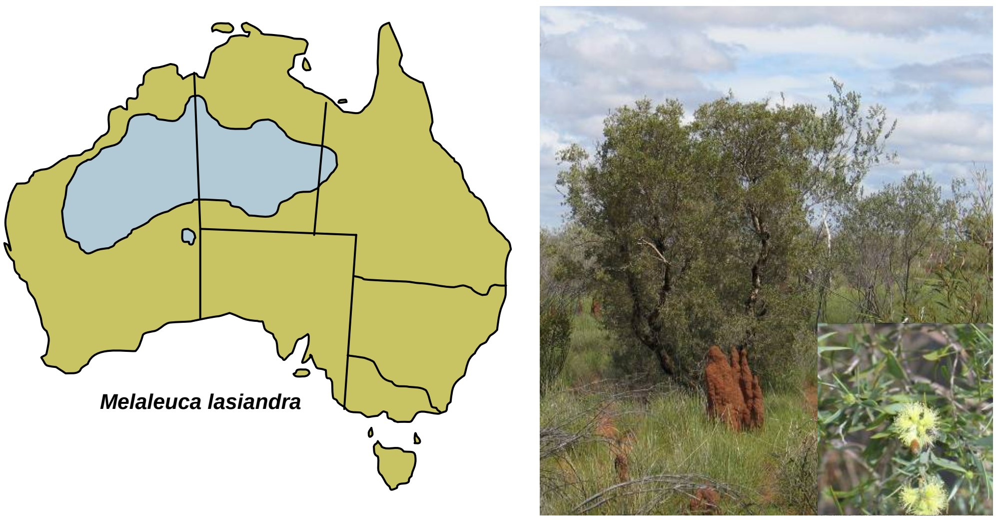


**Figure 4.12:** ***Melaleuca lasiandra*** **form, flowers and distribution, adapted from Moore 2005**

***Triodia pungens* (soft spinifex)**

*Triodia pungens* (soft spinifex) has a very widespread distribution, it occurs throughout the spinifex range above 22$^{o}$ latitude which is the region with the highest rainfall and highest nutrient levels of all the spinifex range (Figure 4.13) (Burbidge 1945; Burbidge 1953; Perry 1962; Griffin 1990; Mitchell & Wilcox 1994; Latz 1996). It is also one of Brown's original 6 recorded species and the type species for the genera (Burbidge 1946a; Burbidge 1953). It is significantly different from other *Triodia* species as it produces resin from a secreting epidermis and a large number of siliceous cells on the abaxial epidermis (underside of the leaf) (Burbidge 1944b; Burbidge 1945; Burbidge 1945a; Burbidge 1946; Burbidge 1946a; Burbidge 1953; Burbidge 1960; Lazarides 1997). The resin was actually used as currency by indigenous people of the area, as it was strong for binding axe heads and spear points (Burbidge 1946a). The general form of *Triodia pungens* is 0.3 – 1 m high, 0.3 – 1.6 m diameter, dense, irregularly shaped tussocks (Burbidge 1944b; Burbidge 1946a; Perry 1962; Lazarides 1997).

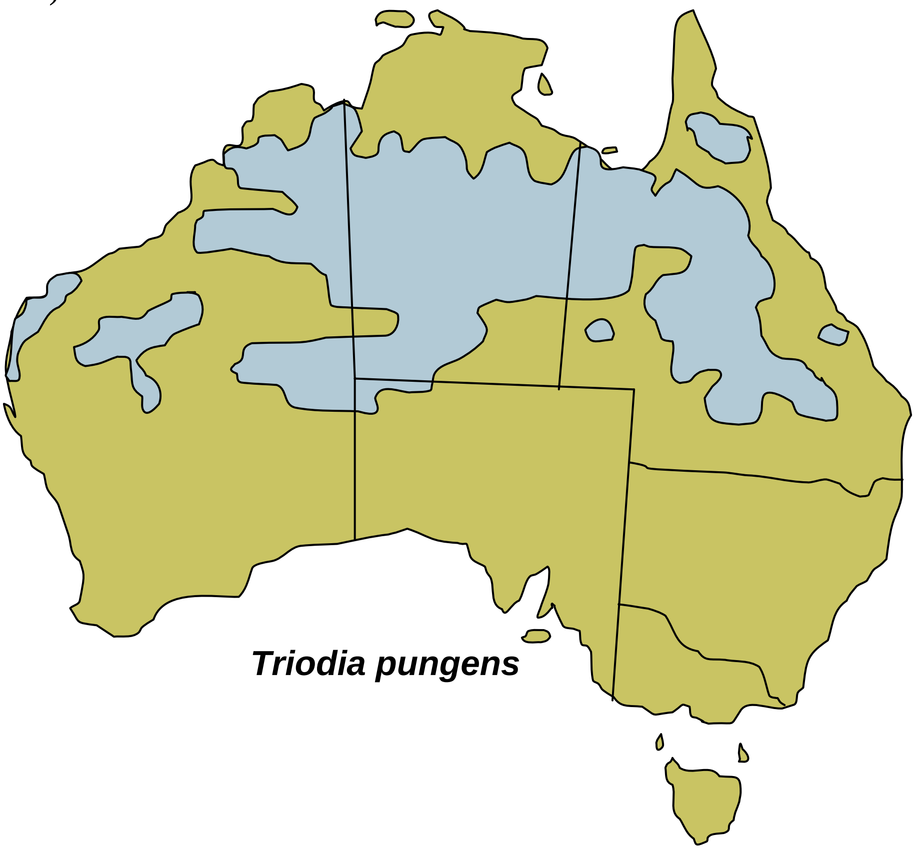


**Figure 4.13: Distribution of *Triodia pungens* adapted from Sharp & Simon 2002.**

It typically grows on red, clayey sands and red earths on both plains and rocky hills with intermediate to acid pH (Perry 1962; Cole 1965; McWilliam & Mison 1974; Griffin 1990). It is known to be deep rooting with a fibrous root system extending beyond 30 m, as seen in pits near the Tanami Mine. This species was sampled at the Coyote, Hyperion and Titania Prospects and seen at the Larranganni Prospects. Previous studies with spinifex have indicated that they cannot tolerate high Pb values (Nicolls *et al.* 1965), and could tolerate very high levels of W and Cu over mine tailings (Pyatt & Pyatt 2004). Copper was found to be directly related to soil concentrations which indicated that Cu is essential to spinifex growth (Timperley *et al.* 1970), however, it is indicated that non-nutrient elements that are uptaken passively can also show correlation with soil concentrations (Kovalevsky 1987). Work over a gold deposit only focussed on gold and the results were thought to be noisy (Marshall & Lintern 1995).

The species is very important in the regions that it grows, as it tends to be the dominant plant, which means that it provides homes for many animals, like dunnarts (Churchill 2001). The hummocks generate a microclimate where the temperature within the hummock is several degrees cooler (up to 12.5$^{o}$C) in hot weather and warmer (up to 6.5$^{o}$C) in cool weather (Churchill 2001). This species is also the only spinifex palatable by cattle and sheep (Burbidge 1944a) (Burbidge 1946a) (Holm & Allen 1988).

The individual tussocks are formed from the development of long stolons (runners, Figure 4.14), which can become rooted and eventually become completely independent of the original plant (Burbidge 1945). The development of roots on the original plant and the stolons is dependent on the amount of moisture in the surface soil (Burbidge 1945). Roots which do not reach the ground are dormant until another rainfall event in which they grow rapidly and deep (Burbidge 1945). Field observations have shown that the soft spinifex plants are very deep rooted. They have a number of thin (approximately 1 mm thick) roots that have been observed (S. Hill, pers. comm 2005) in mine pits at depths down to 30 m and still continuing downward. In dry, well-drained sites, lateral roots and root hairs are typically absent up to these depths.

**Figure 4.14: Tussock form and 'runner' form of *Triodia pungens*.**

## 4.6 Study sites

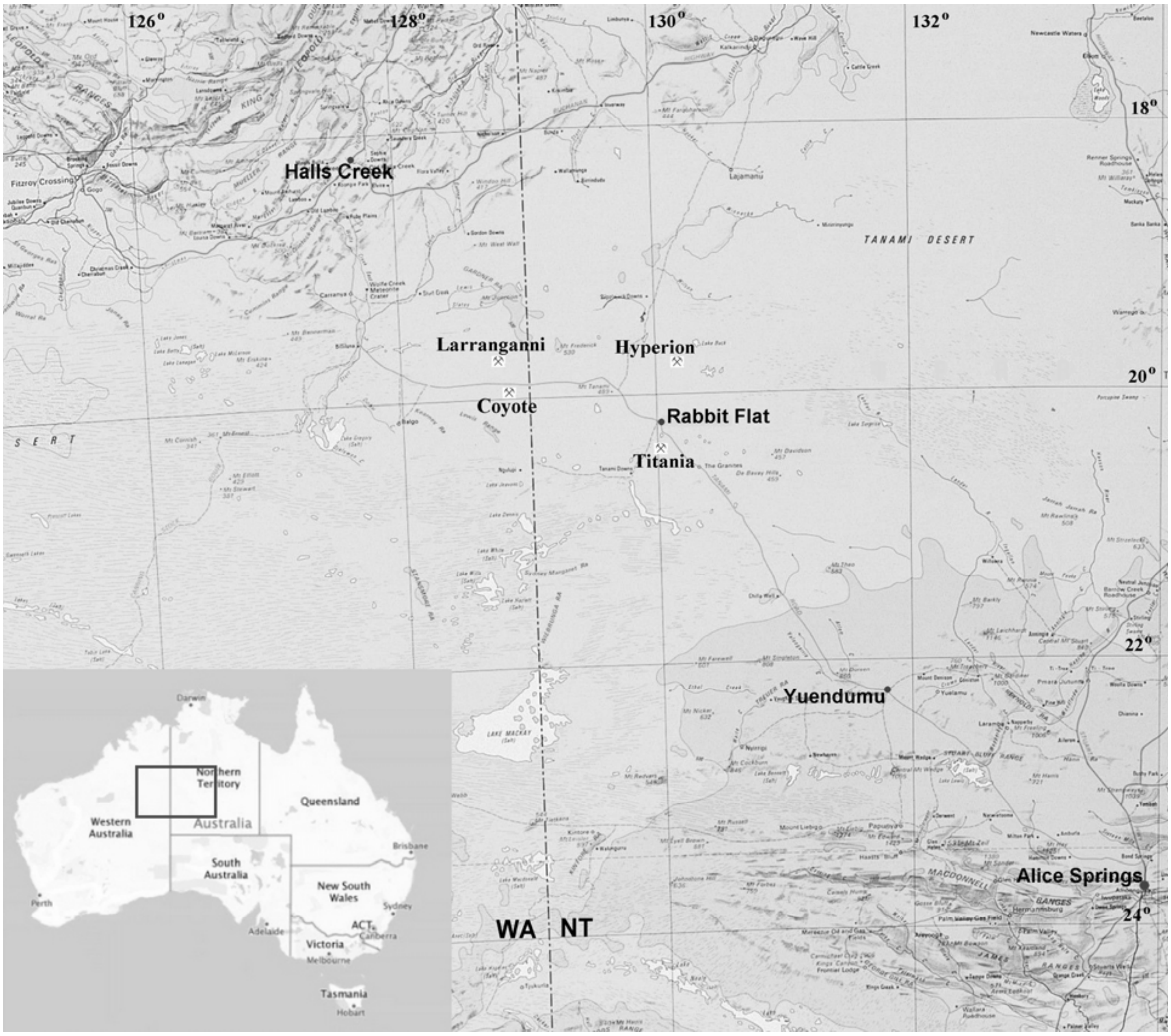


**Figure 4.15: Location of the 4 Tanami Prospects with respect to the nearest towns (http://www.ga.gov.au/ 2006).**

### 4.6.1 Coyote

The Coyote Au Deposit is located in Western Australia approximately 300 km west of Halls Creek and approximately 750 km northwest of Alice Springs and 4 km north-east of the Trans-Tanami Fault (Figure 4.15) (Petts & Hill 2005; Bagas *et al.* 2007). The mineralisation at Coyote is hosted by quartz veins in the turbiditic sediments of the Killi Killi Formation (Bagas *et al.* 2007). The transported cover over this site varies between 5-15 m in thickness and is comprised of mixed aeolian and sheetflow deposits (Figures 4.19 and 4.20). The cover thickness increases towards the south of the sampled area as this is heading towards a thicker palaeodrainage system in the south. The mineralisation is focussed around a tightly folded anticline (Figures 4.16 and 4.17) (Bagas *et al.* 2007). The Coyote Anticline is defined by a thick silty layer known as the 'marker silt' with the southern limb of the anticline dipping steeply to the south and the northern limb dips at around 40$^{o}$ to the north (Bagas *et al.* 2007). There are a series of north-west to south-east trending reverse faults roughly 300 m apart which post date the folding of the anticline (Bagas *et al.* 2007). Weathering occurs to a depth of 170 m over the mineralisation which complicates the alteration signature of the ore (Figure 4.18) (Bagas *et al.* 2007).

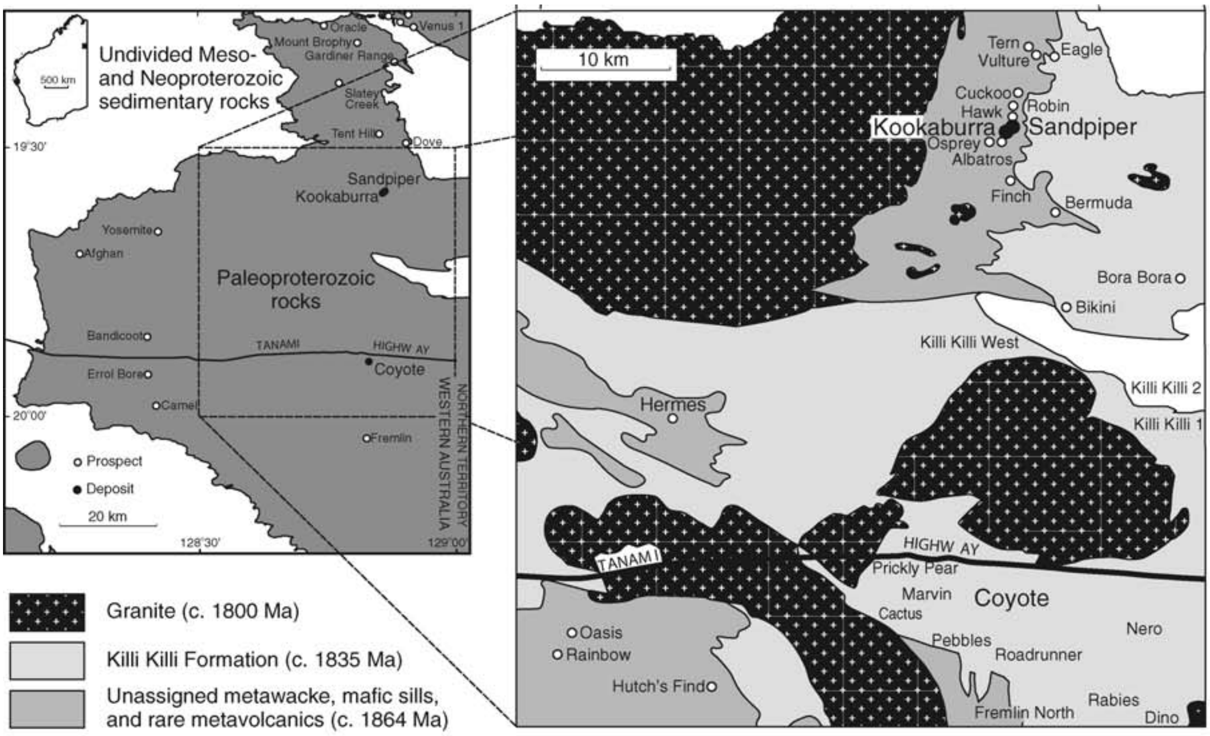


**Figure 4.16: Interpreted geology across the Coyote and Larranganni prospects (Bagas *et al.* 2008)**

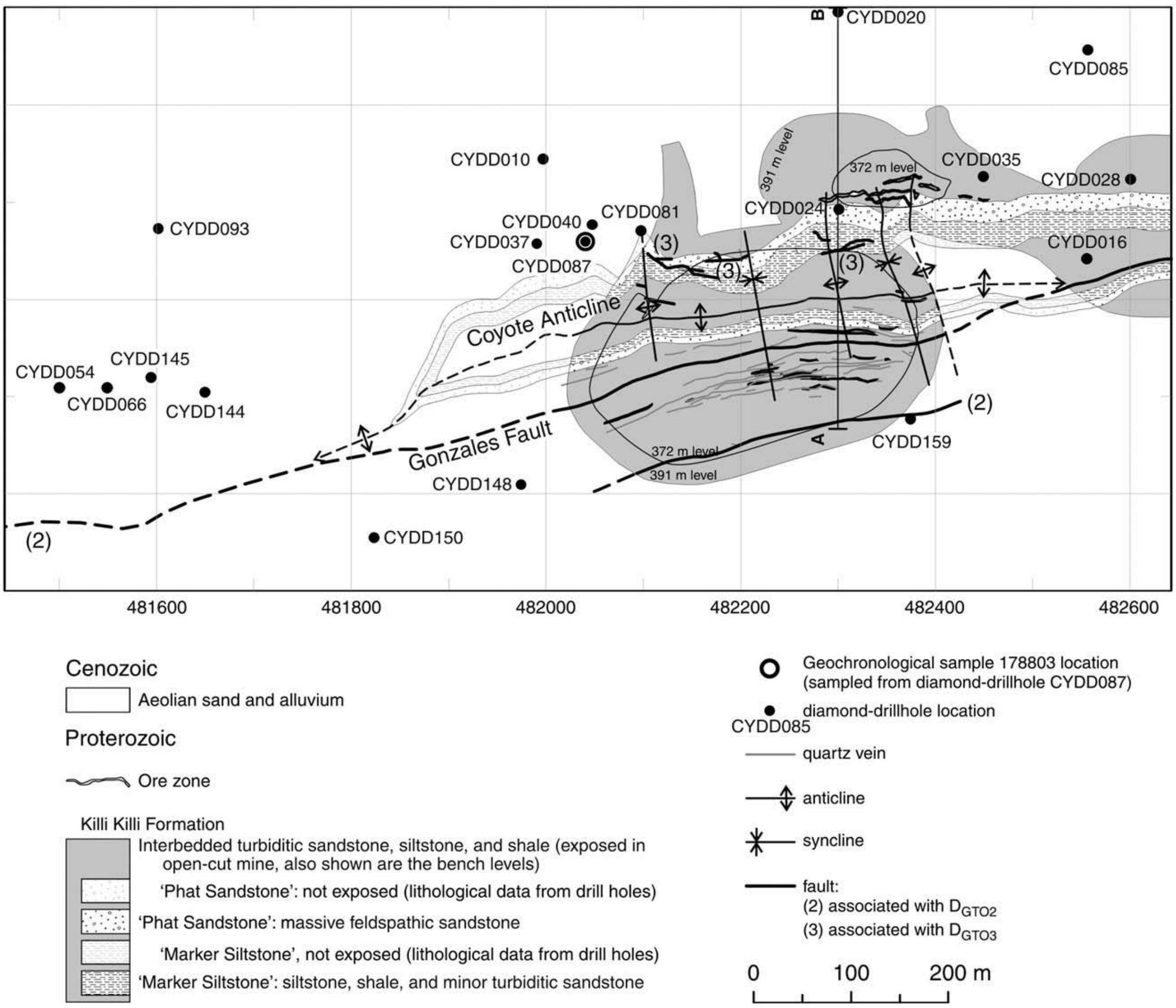


**Figure 4.17: Interpreted geology of the Coyote prospect (Bagas *et al.* 2008)**

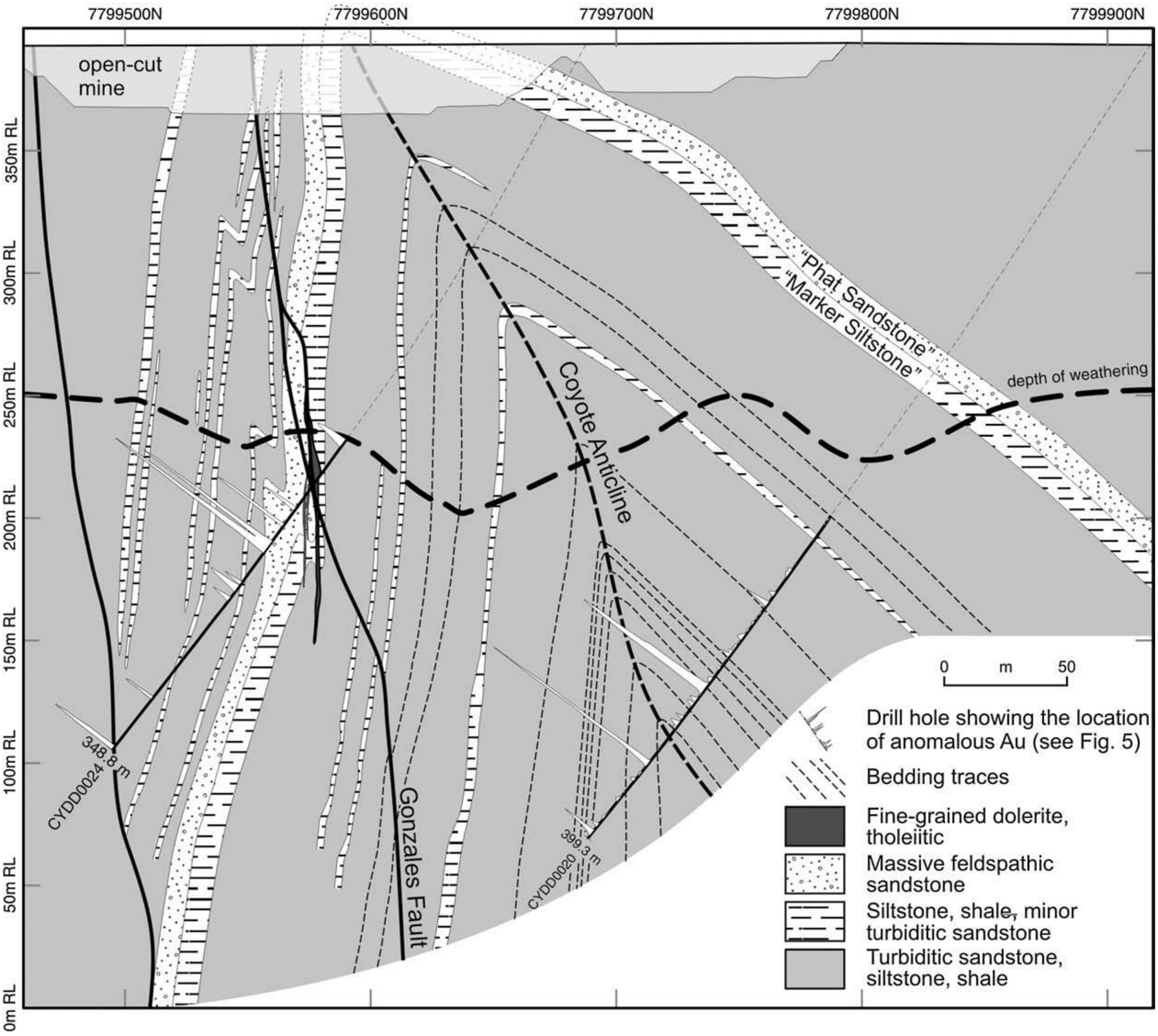


**Figure 4.18: Geological section along 482300mE corresponding with the biogeochemical transect (Bagas *et al.* 2008)**

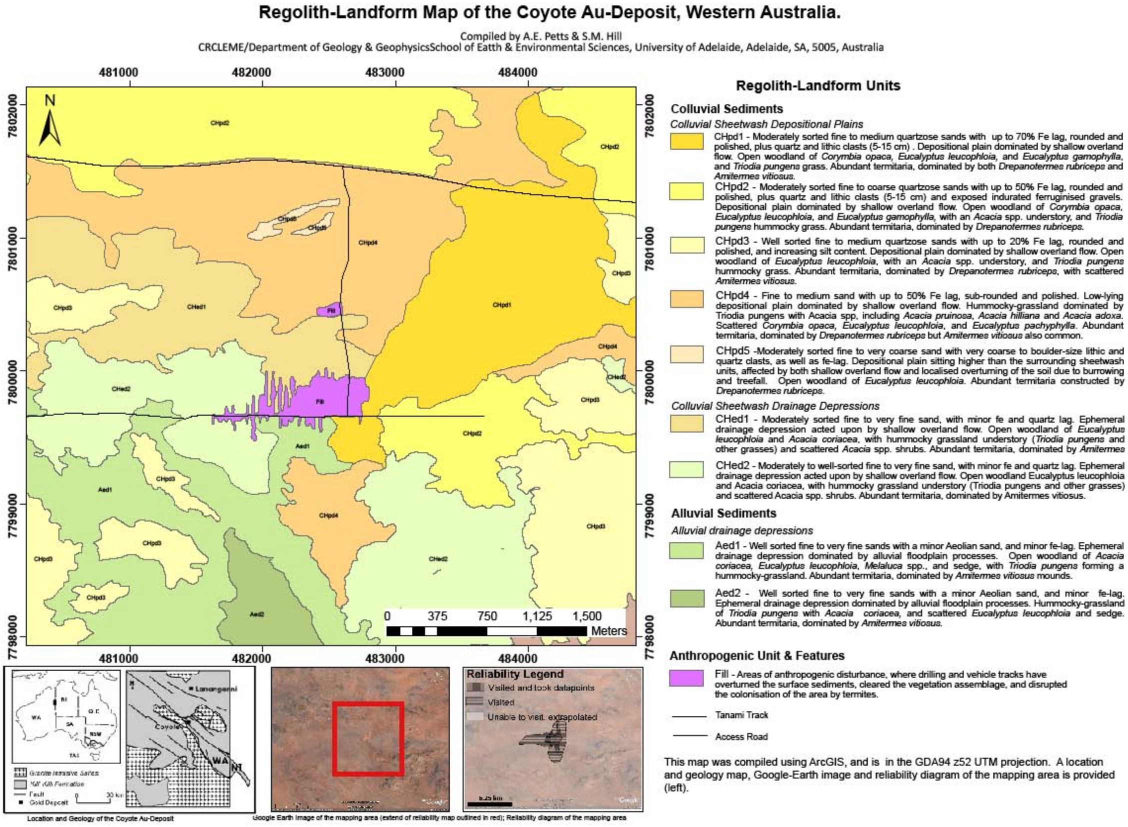


**Figure 4.19: Regolith-landform map across the Coyote prospect (Petts 2007a)**

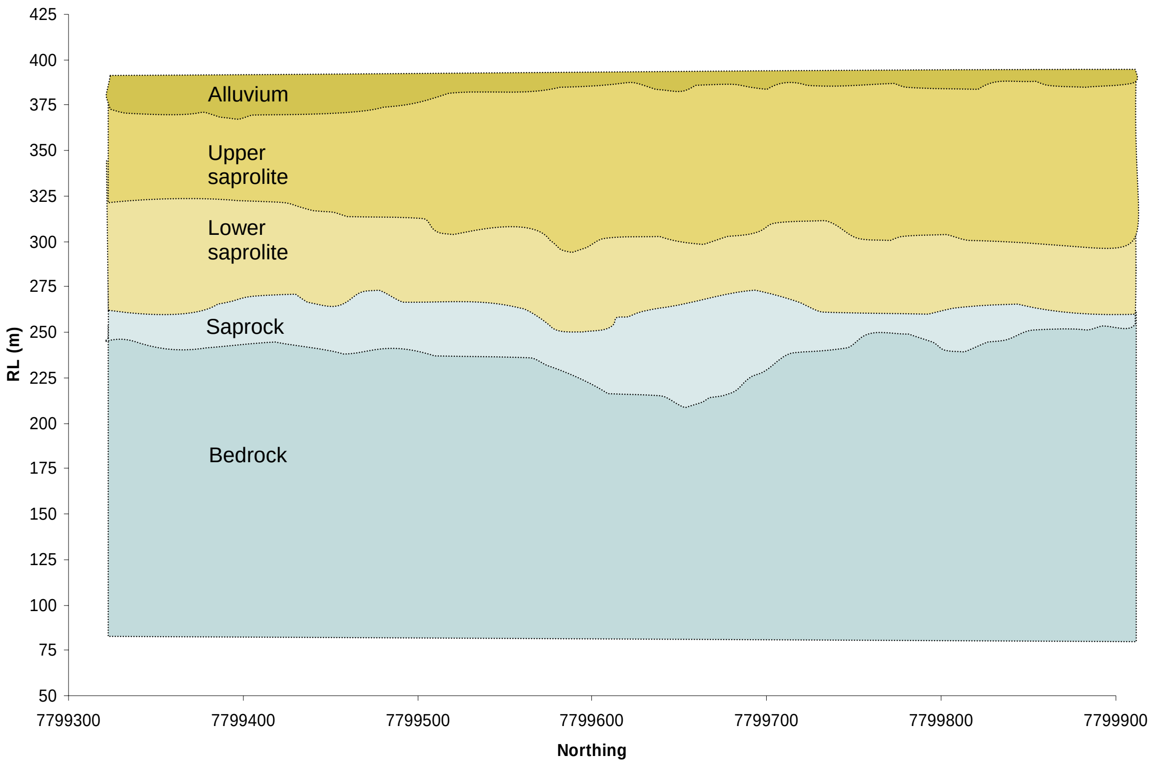


**Figure 4.20: Regolith cross section across the Coyote prospect, 42325mE, adapted from Tanami Gold drill logs.**

### 4.6.2 Larranganni

The Larranganni Prospects (Cuckoo, Hawk, Kookaburra, Osprey, Pelican, and Sandpiper) are roughly 40 km north of the Coyote Prospect (Figure 4.15). Gold was first recognised in this area by Talbot in 1910 (Bagas *et al.* 2007). The Kookaburra and Sandpiper deposits were discovered by Glengarry Resources in 1996 during regional geochemical sampling after a series of near misses by previous companies (Doust 1997; Bagas *et al.* 2007). They all have strong Au anomalism associated with structurally complex zones in areas of shallow (<1 m) cover (Glengarry 2000). The Au is hosted within thin quartz veins within the underlying bedrock of the Stubbins Formation (1864 Ma metawacke, pelite and dolerite sequences, Figures 4.16 and 4.21) (T. Beardsmore, 2005, written comm.). This is often called the Bald Hill sequence (the oldest rocks in the Tanami), which is in contact with the Killi Killi Formation (Bagas *et al.* 2007; Huston *et al.* 2007). This site has the highest elevation of all the sampled Tanami sites as it is situated atop a bedrock plateau, however, the topography across the site itself is low (<5 m across the Kookaburra-Sandpiper transect).

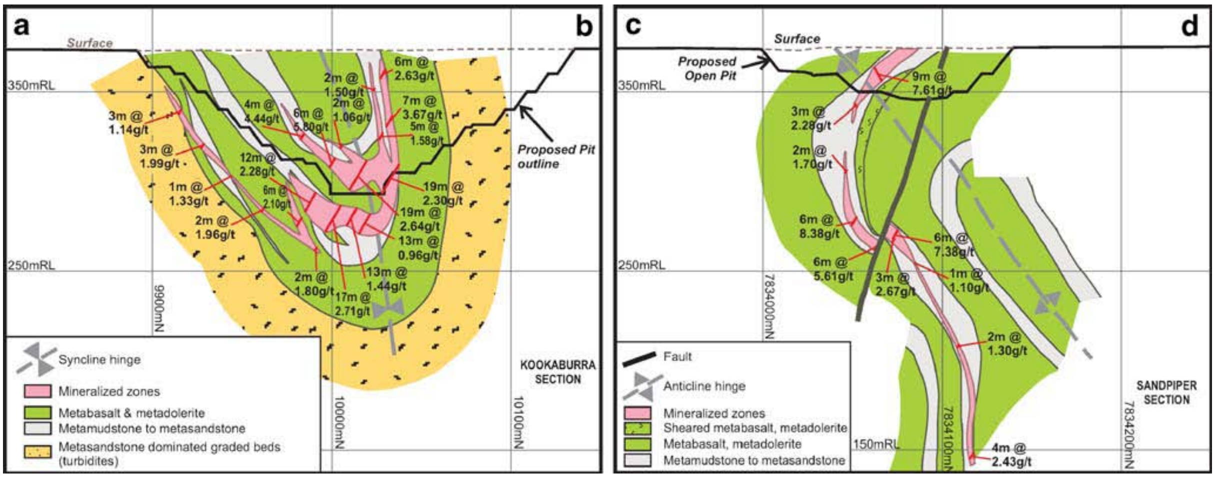


**Figure 4.21: Geological cross sections of the Kookaburra and Sandpiper prospects (Bagas *et al.* 2007)**

### 4.6.3 Hyperion

The Hyperion Prospect held by Newmont Asia pacific is approximately 70 km north of Rabbit Flat (Figure 4.15). Mineralisation at this prospect is approximately 100,000 ounces Au hosted as native gold and accessory in sulphides (arsenopyrite and chalcopyrite) present in quartz veins along the contact between the Groundrush dolerite/basalt and an unnamed monzogranite dyke (Figures 4.22 and 4.23) (Power 2004). It was noted as being ‘blind’ to traditional exploration methods. The transported cover (mostly sheetwash deposits) is 7 m thick on average (Worrall *et al.* 2005b).

NOTE:
This figure is included on page 36 of the print copy of the thesis held in the University of Adelaide Library.

**Figure 4.22: Geological cross section north-south across the Hyperion prospect (Power 2004)**

NOTE:
This figure is included on page 36 of the print copy of the thesis held in the University of Adelaide Library.

**Figure 4.23: Geological cross section west-east across the Hyperion prospect corresponding with the biogeochemical transect (Power 2004).**

### 4.6.4 Titania

The Titania Prospect held by Newmont Asia Pacific includes an estimated 600,000 ounces of Au mineralisation, hosted within the extensively folded, lower greenschist facies sediments of the Palaeoproterozoic (1848±22 Ma) Killi Killi Formation intruded by dolerite sills (Figure 4.24) (Gibbons & Webb 1997; Wygralak & Mernagh 2001; Huston *et al.* 2007). The Killi

Killi Formation predominantly includes thick sequences of turbidites and greywackes (Wilford 2003; Cross *et al.* 2005; Petts & Hill 2005). The prospect contains the Oberon deposit and anomalous zones of the Lamaque and Oberon East deposits (Gibbons & Webb 1997). Ore minerals include arsenopyrite along with traces of chalcopyrite, sphalerite and pyrrhotite. There is a close association between Au and arsenopyrite. The eastern part of the prospect includes a palaeodrainage system and mineralisation is covered by approximately 15-30 m of transported cover, generally thickening to the east (Gibbons & Webb 1997).

NOTE:
This figure is included on page 37 of the print copy of the thesis held in the University of Adelaide Library.

**Figure 4.24: North-south geological cross section across the Titania prospect (Readford 1999)**

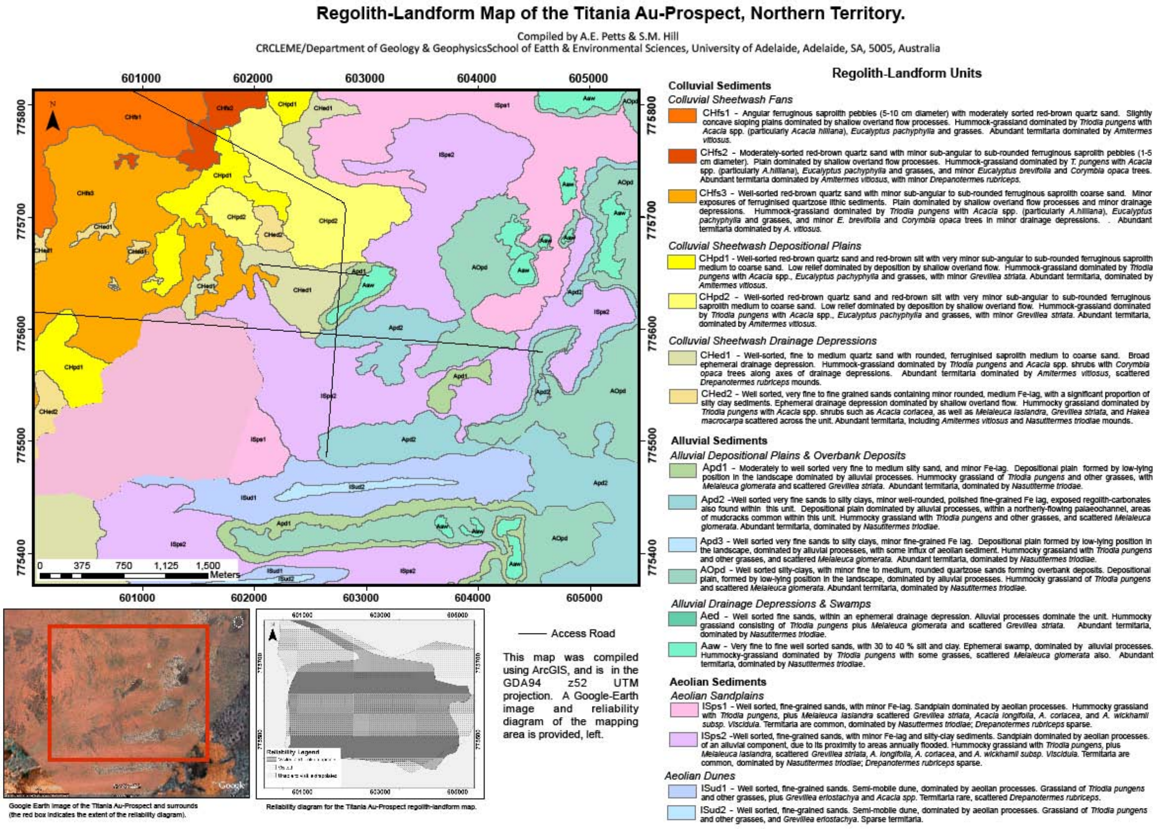


**Figure 4.25: Regolith-landform map across the Titania prospect (Petts 2007b)**

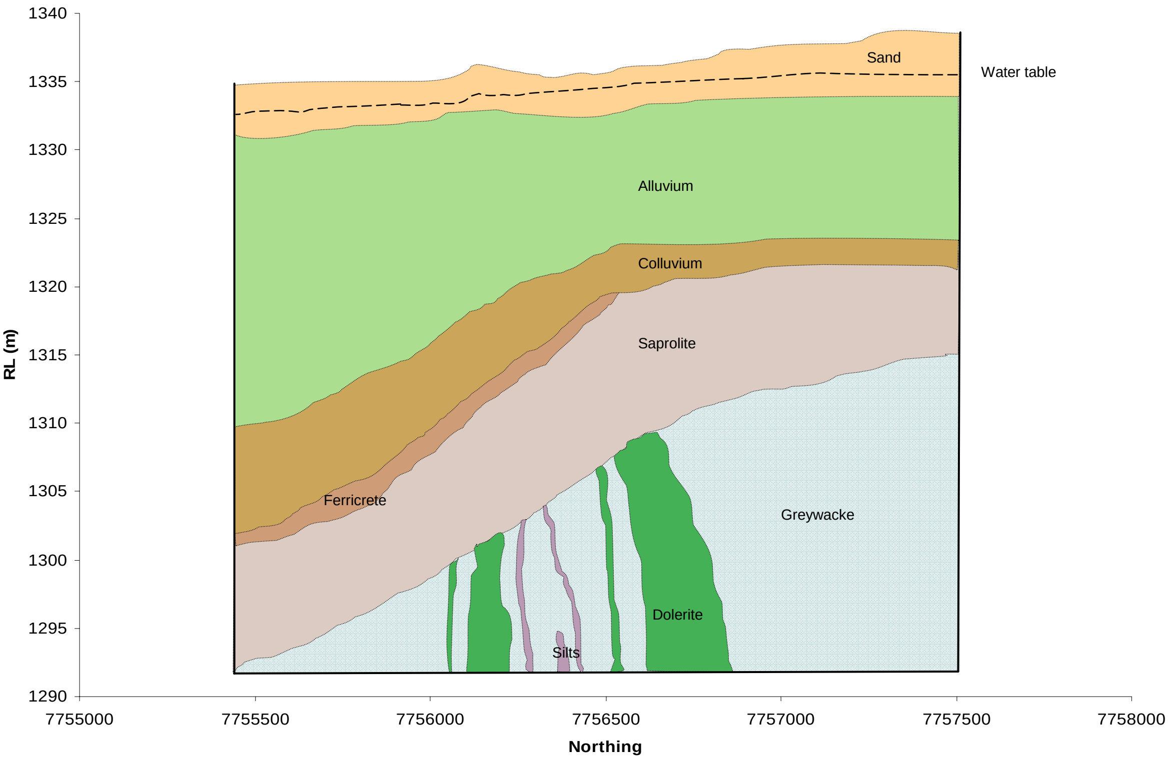


**Figure 4.26: Regolith cross section across 603000mN, interpreted from Newmont drill logs**

It is just south of the Rabbit Flat roadhouse (Figure 4.15). Gold mineralisation at the Titania Prospect is buried by transported regolith including mixed aeolian, sheetflow deposits over palaeodrainage sediments (Figures 4.25 and 4.26). This mineralisation is one of the only regional examples of discovery through significant transported regolith and therefore provides an important site for developing an understanding of buried mineralisation. The discovery was due to surveying areas that were poorly understood, following up a single point anomaly, and personnel persistence (Gibbons & Webb 1997). No earlier prospectors worked in the area before the discovery by North Flinders Mines in 1996, due to the thickness of transported cover (Gibbons & Webb 1997).

The landscape is colonised by hummock grasses (*Triodia pungens*) and shrubland including *Acacia bivenosa*, *Acacia coriacea*, *Eucalyptus pachyphylla* and *Eucalyptus odontocarpa* (Gibbons & Webb 1997). *Grevillea eriostachya* mostly grows over the dunes, while *Melaleuca glomerata* and *Melaleuca lasiandra* typically colonise low-lying areas. *Grevillea wickhamii and Acacia hilliana* tend to grow over areas of shallow cover. In this type of environment most plants are known to be deep rooting in order to access the groundwater during seasonally dry periods (Cole *et al.* 1968). There has been a large amount of drilling performed over this prospect and care had to be taken to avoid sampling vegetation in proximity to drill spoil.