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Regolith-Landform mapping of the Gnaweeda Greenstone Belt, Western Australia

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Abstract

Regolith-landform mapping of the Gnaweeda Greenstone Belt located at Meekatharra, Western Australia. It was conducted at a scale of 1: 100,000, covering the Turnberry Au prospect and the Mistletoe Au deposit, in order to assist mineral exploration in this area. Understanding the regolith is a fundamental tool in developing and establishing effective mineral exploration techniques in regolith-dominated terrain. Apart from mineral exploration, knowledge of regolith also applies to natural resource management as it links many facets of the natural environment. The process of map production begins with creating a preliminary regolith-landform map using aerial photographs and ASTER data. Unit identification and digitization on screen were performed. Field verification was conducted along the tracks where access was possible. A preliminary map, field observation and all available data were brought together in order to compile a final map. The regolith-landform in this area consists of fourteen units. Five types of landforms are recognized: depositional plain, erosional plain, alluvial plain, sandplain and erosional rise. The landform is dominated by depositional plains.

Keywords: Geochemical exploration, Mineral exploration, Regolith, Regolith-landform, Regolith-landfrom map,

INTRODUCTION

The definition of regolith is the entire altered, unconsolidated or secondarily re-cemented cover that overlies more coherent bedrock which has been formed by the weathering, erosion, transport and/or deposition of older materials. It, thus, includes fractured and weathered basement rocks, saprolites, soils, organic accumulations, glacial deposits, colluvium, alluvium, evaporitic sediments, loess and aeolian deposits and groundwater (Butt and Zeegers, 1992; Robertson and Butt, 1997; Eggleton, 2001). In other words, regolith is 'everything from fresh rock to fresh air' (Eggleton, 2001).

Regolith-landform mapping is defined as an area delineated on a map as a specific association of regolith materials, landform and may correlate bedrock geology (Butt et al., 1997). Regolith-landform units allow a quick visual assessment of landscapes. For example, in these study areas, the landscape is dominantly flat (depositional and alluvial plains) with some slightly angled slopes (erosional plains) and low rises (erosional rises).

Regolith-landform mapping is a useful complement to geochemical exploration in the Yilgarn Block of Western Australia (Craig, 2001). As rock outcrop in Australia is less than 15% of the land area, this makes regolith mapping important. The regolith is a barrier to mineral exploration and understanding its distribution and origin is important for exploration planning. The methods used for the regolith-landform mapping of the study areas for this project are based on the techniques of Pain (2008) and Craig (2001). The purpose of the map is to give an overview of the distribution of regolith materials and their landform expressions on a regional scale and to produce a tool for mineral exploration. Apart from this, regolith-landform mapping could be applied to landscape research and land management (Hill, 2002).

The study areas are approximately 35 km northeast of Meekatharra (Figure 1), the historical Au mining town and the largest centre in the Murchison Province, Western Australia. Meekatharra is approximately 765 km north east of Perth. The Gnaweeda Greenstone Belt lies at the east of Meekatharra-Wydgee Greenstone Belt which is highly-auriferous.

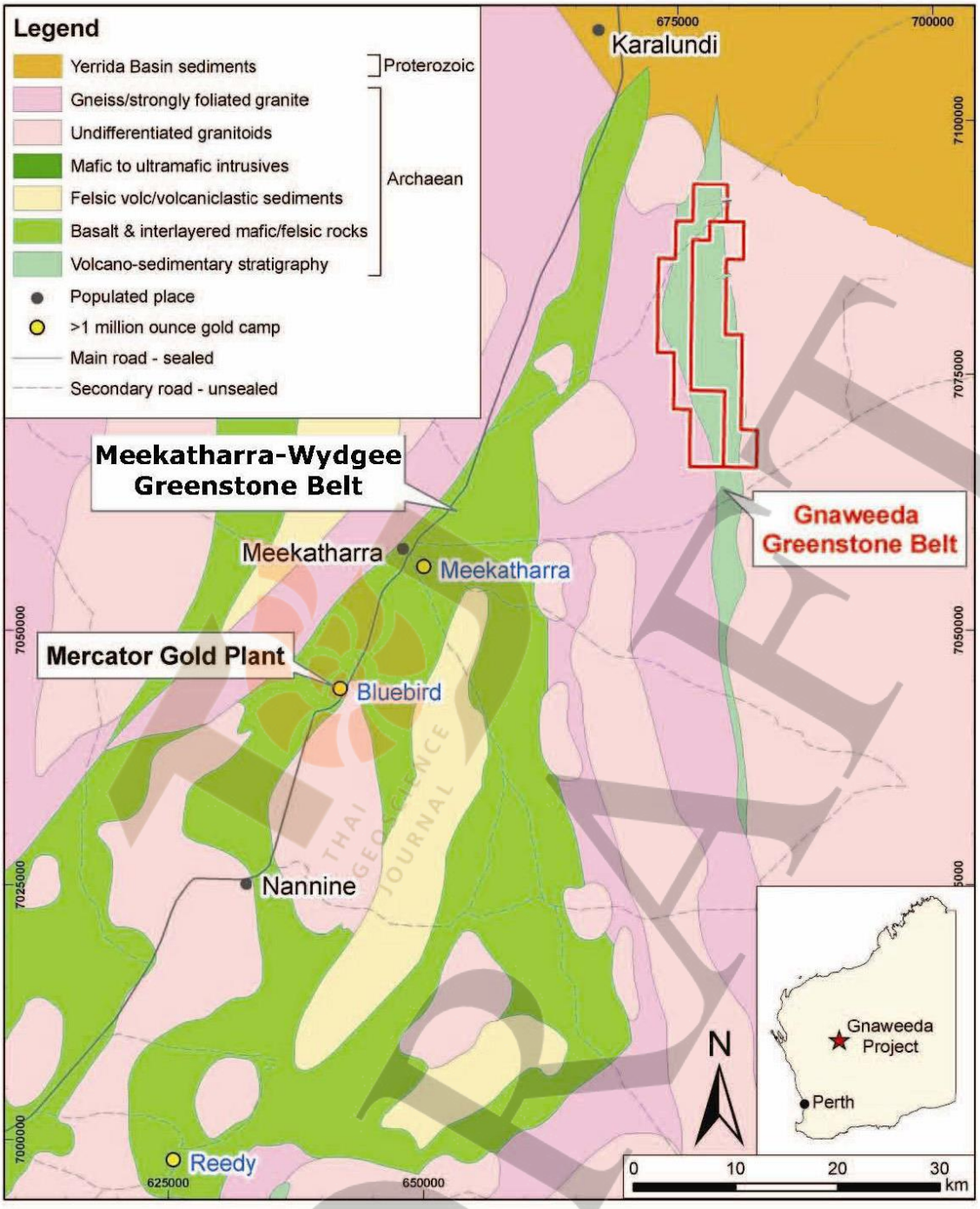

Figure 1: Location of the study areas, the Turnberry Au prospect and the Mistletoe Au deposit within the Gnaweeda Greenstone Belt, Western Australia (modified from Ray and Reardon, 2010) (Map projection is GDA94, MGA Zone 50UTM).

GEOLOGY OF THE GNAWEEDA GREENSTONE BELT

The Gnaweeda Greenstone Belt consists of three litho-tectonic subdomains (Western, Central and Eastern Sub-domains) (Figure 2) based on aeromagnetic interpretation, drill hole data and geological information (Bunting and McIntyre, 2003).

The Western Sub-domain includes a broadly conformable package of non-magnetic mafic volcanics and intrusive rocks, with extensive, continuous interlayered strongly magnetic units of mafic to ultramafic rocks. These magnetic units identify large-scale isoclinal folding (Bunting and McIntyre, 2003).

The Central Sub-domain consists of a package of gabbro or dolerite, with weakly

magnetic ultramafic units and discrete lenses of felsic volcanics, sediments and felsic intrusives. The strikes of these rock units are broadly parallel to the overall strike of the Gnaweeda Greenstone Belt. The foliated magnetic package (Am2 – Figure 1) is patchy. It appears to represent a high strain and shear within the greenstone and it associated with Turnberry mineralisation (Bunting and McIntyre, 2003).

The Eastern Sub-domain comprises a sequence of complexly folded, mainly mafic and ultramafic volcanic rocks with variably magnetic properties. These include strongly magnetic fragments of olivine orthocumulate that probably represent fragmented remnants of a larger layered mafic-ultramafic intrusion. Cumulate layering in the ultramafic rock is often at a high angle to the overall strike of the greenstone belt and it appears to have been intruded or truncated by the eastern granitoid rocks (Bunting and McIntyre, 2003).

The boundary between the Central and Eastern Sub-domains appears to be a major structure that is associated with Au mineralisation in the foliated magnetic package (Bunting and McIntyre, 2003).

There are many mafic dykes throughout the area and the dominant swarms are oriented northeast and east-west (J. Bunting, pers. comm. to David Tellick, Teck Cominco Australia).

In the Gnaweeda Greenstone Belt, mineralisation is developed both in mafic and felsic rocks. In mafic rocks, Au is extensive but low grade. In felsic rocks with quartz veining, Au is higher grade. Anomalous Au and As were identified in the foliated magnetic package. Host rocks for Au in this magnetic package include mainly mafic volcanics, mafic intrusive (i.e. gabbro or dolerite) and felsic porphyries (McIntyre, 2005).

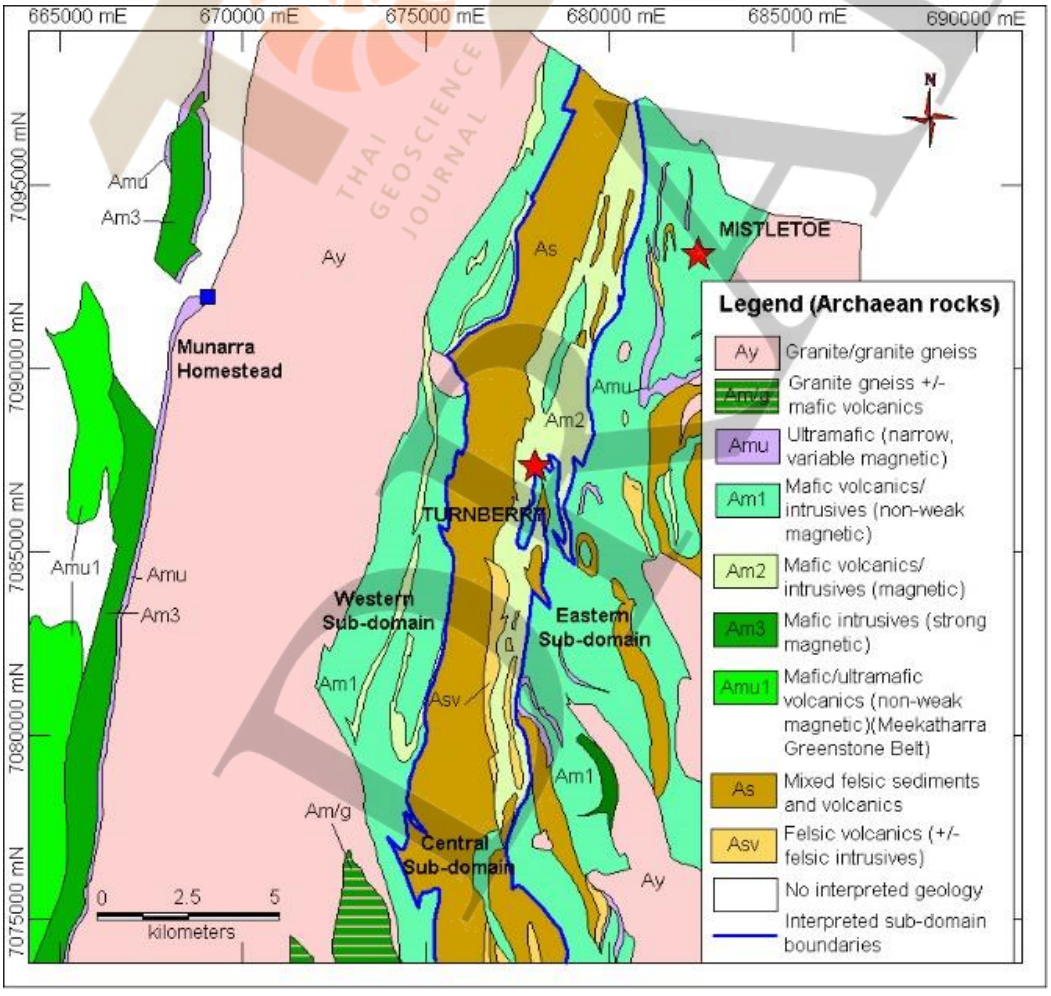

Figure 2: Geology of the Gnaweeda Greenstone Belt and location of the Turnberry prospect and the Mistletoe Au deposit (star symbols), Western Australia (modified from interpreted geology from Teck Cominco

MAP PRODUCTION

A preliminary map was produced using aerial photographs and ASTER data (Figure 3 and 4). ASTER provides satellite images. It can be used for land surface studies. ASTER is also expected to apply in many areas of global change-related such as vegetation and ecosystem dynamics, hazard monitoring, geology and soils, and the generation of digital elevation models (DEMs). The ASTER data bands were combined using the ER Mapper program. For this work, the ASTER data band 321 through RGB creating a natural color composite image was used. After unit identification, digitization on screen was done using the MapInfo program. The completed preliminary regolith-landform units digitized over aerial photography and ASTER data are shown in Figure 5. Field verification point was conducted along the tracks where access was possible. Field notes, regolith materials and photographs were taken from each regolith-landform unit. The location of each regolith-landform unit was recorded by GPS. The field verification points are displayed in Figure 6.

After field verification, all available data were brought together to enable extrapolation and interpolation to the areas that were not accessible. Apart from aerial photographs, ASTER data and field observations, other data that were used to produce this map as reliably as possible are geological maps (Pirajno et al., 1998), interpreted geology (Teck Cominco Australia Pty Ltd), and the geochemical and regolith map 1:250,000 of Glengary sheet (Crawford et al., 1996). Some boundaries of the preliminary regolith-landform units were modified or changed in the light of information from field observations. The compiled regolith-landform map and units are presented in Figures 7. The final regolith-landform map with a full detailed legend is included as an Appendix.

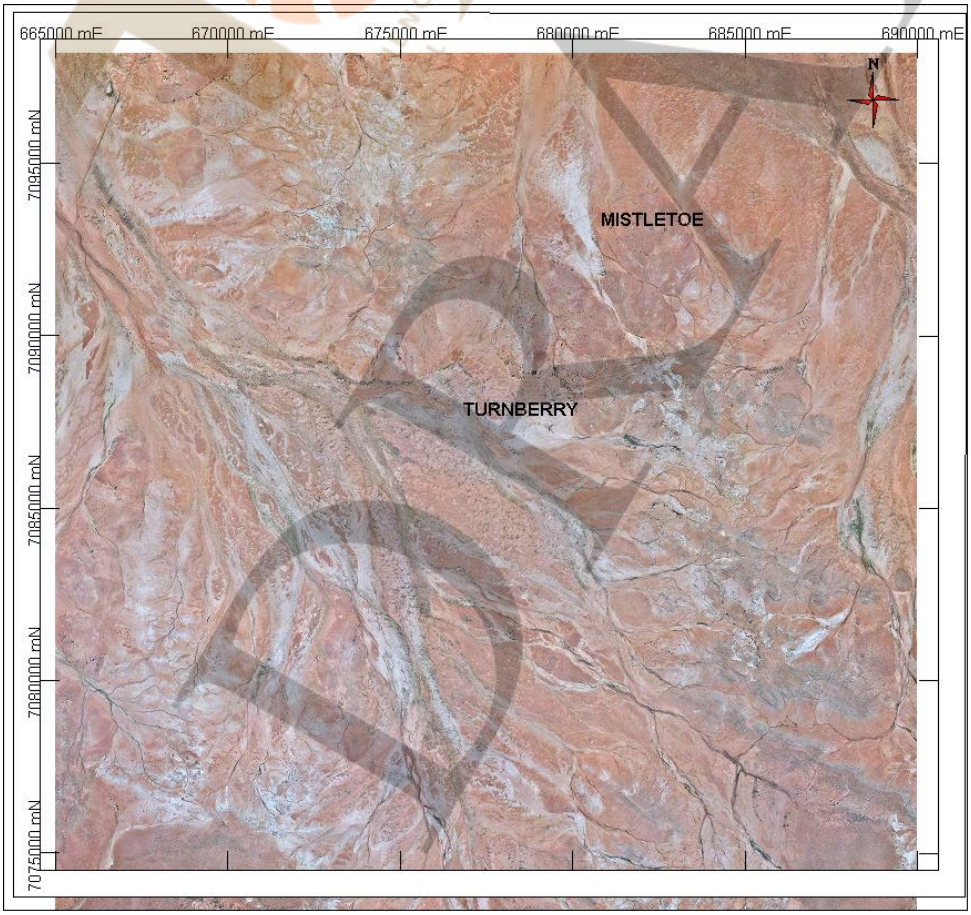

Figure 3: Aerial photography at the study area used for making a preliminary regolith-landform map, the Gnaweeda Greenstone Belt, Meekatharra, Western Australia.

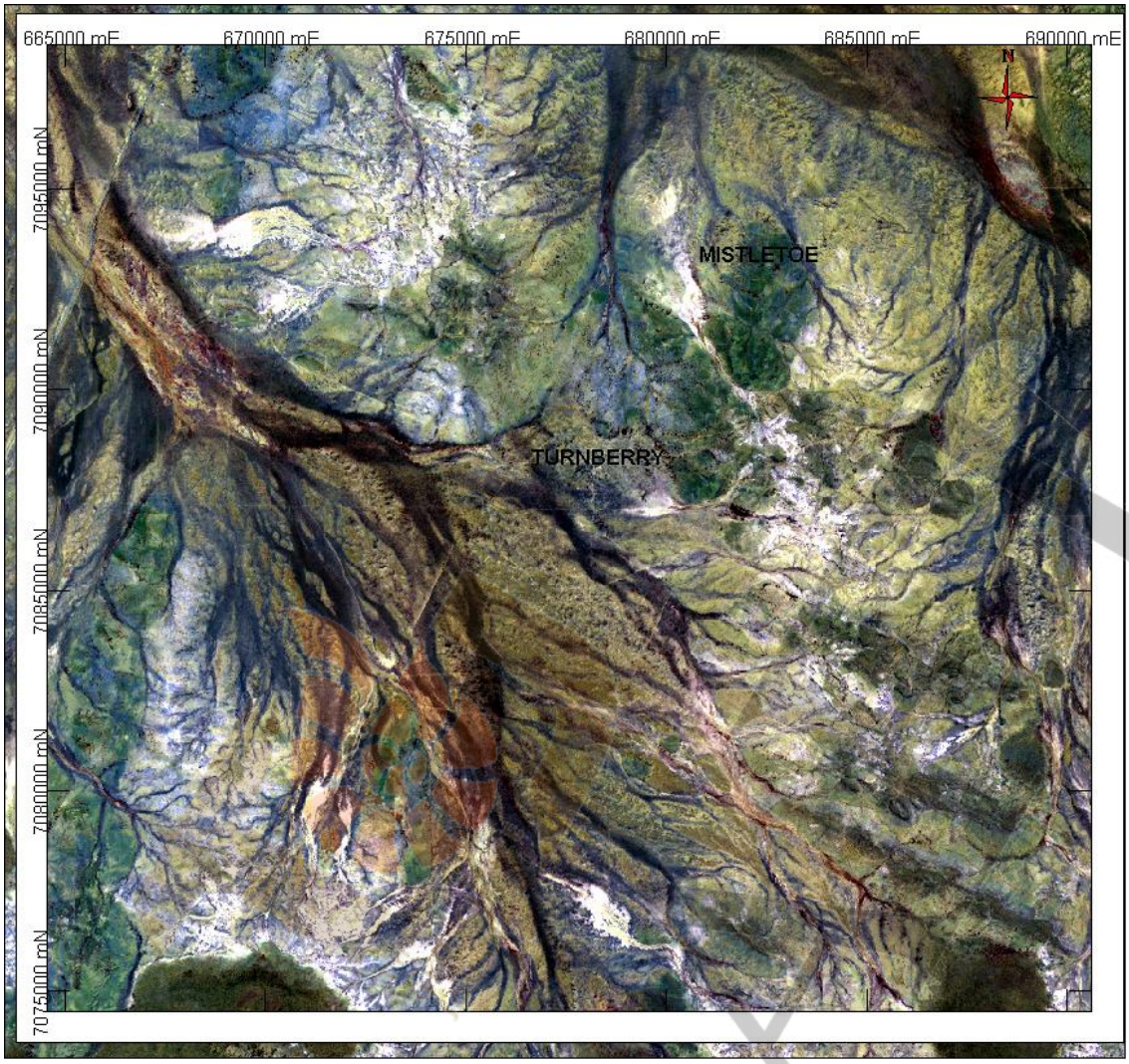

Figure 4: ASTER data band 321 used for making a preliminary regolith-landform map, the Gnaweeda Greenstone Belt, Meekatharra, Western Australia.

REGOLITH-LANDFORM MAP

The regolith-landform in this area consists of fourteen units (Figure 7). Five types of landforms are recognized: depositional plain, erosional plain, alluvial plain, sandplain and erosional rise. The landform is dominated by depositional plains.

The Gnaweeda Greenstone Belt comprises transported and *insitu* regolith. Transported regolith contains colluvial sediment, alluvial sediments and evaporite. *Insitu* regolith consists of residual material and saprolite. Regolith materials comprise mainly colluvial sediments, with alluvial sediments developed along the channel, some residual material, and saprolite found beside the channel systems. Transported regolith of the Gnaweeda Greenstone Belt occupies the largest surface area of the map. Colluvial sediments in this area are sheetwash. Colluvial sheetwash is found both on the erosional and depositional plain.

Transported regolith on the depositional landform has been divided into four regolith-landform units, and all the materials fall into the broad category of colluvial sheetwash. Each type of sheetwash is associated with a characteristic vegetation type. On unit CHpd1, the regolith is dominated by orange sand with some angular quartz gravel and angular-subrounded ferruginous lag. *Acacia aneura*, *Eremophila fraseri* and *Eremophila forresti i*are dominant (Figure 8). On unit CHpd2, which comprises pebble to cobble size siliceous fragments, sparse and smaller vegetation, *Acacia aneura* and *Eremophila fraseri* are found. At the northeast of the map, colluvial sheetwash consists of ferruginous

loose sand (CHpd3). This regolith material is associated with a medium density of *Acacia aneura* (2-5 m high), *Eremophila fraseri* and *Eremophila forrestii* (Figure 9). The merging of the depositional landform with alluvial plain is the main characteristic of CHpd4. This unit contains ferruginous loose sand, mud and quartz gravel with a common distribution of *Acacia aneura* and *Eremophila fraseri*, *Eremophila forrestii* and *Triodia* (spinifex) (Figure 10).

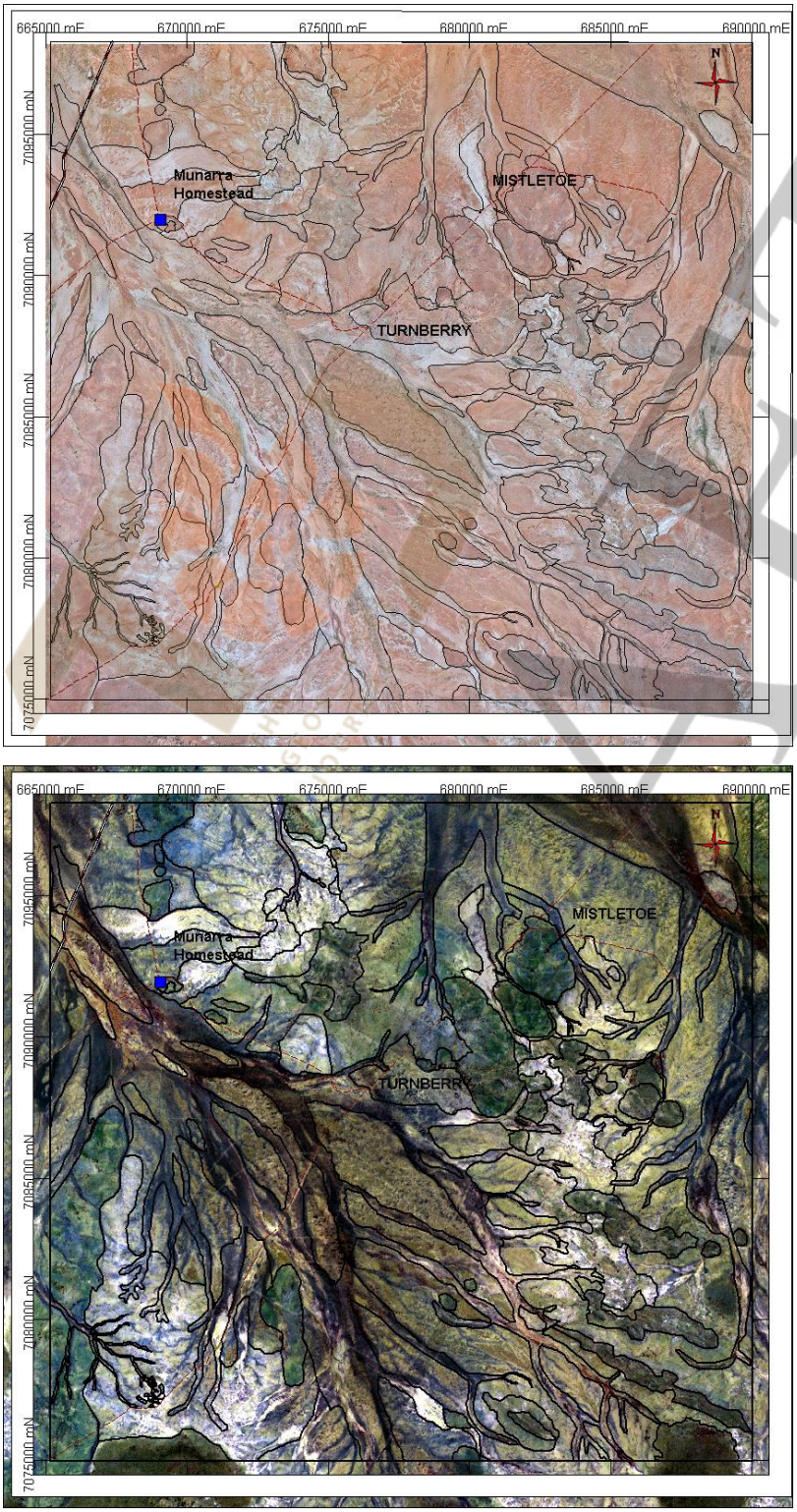

Figure 5: A completed digitization on the screen of the preliminarymap overlying (a) aerial photography and (b) ASTER regolith-landform map of the Gnaweeda Greenstone Belt, Western Australia.

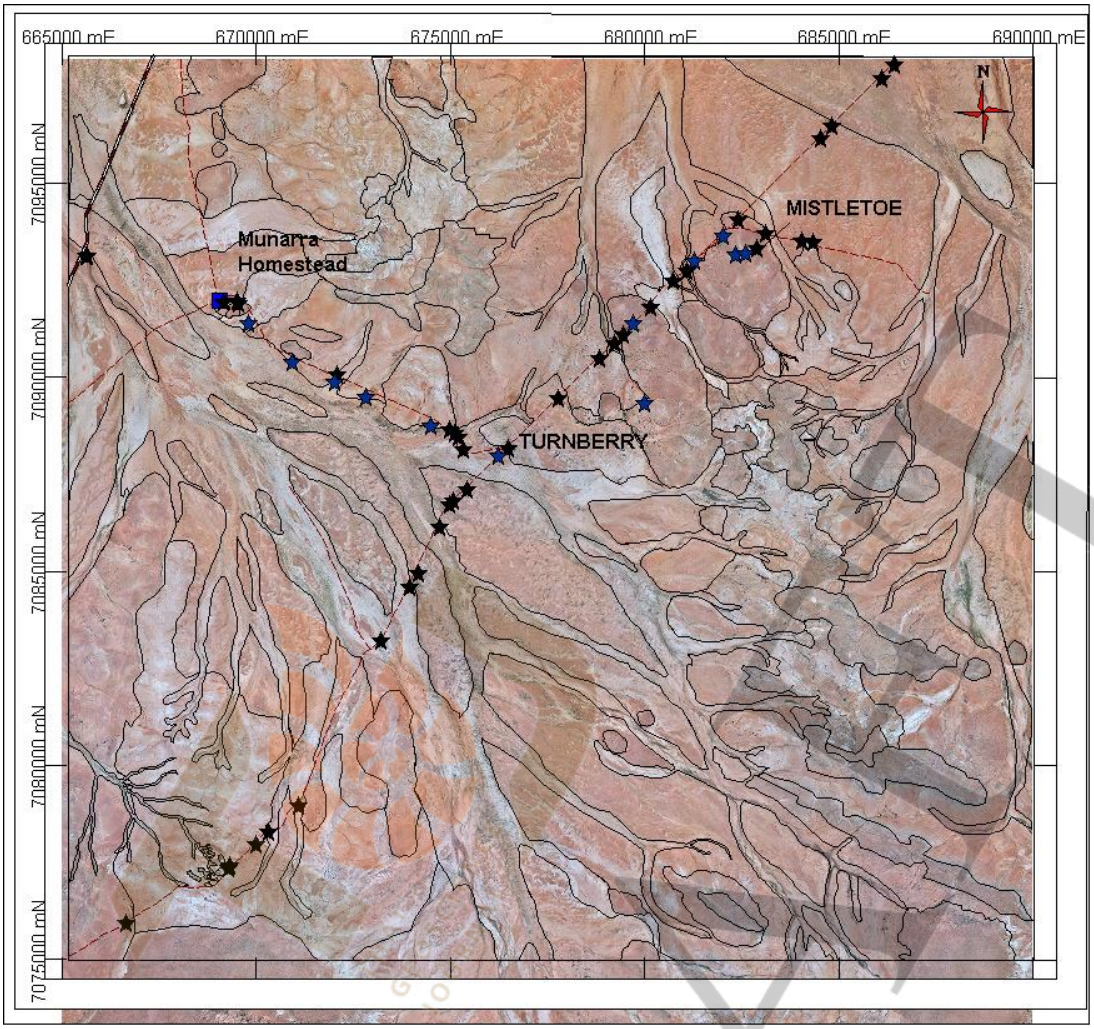

Figure 6: Regolith-landform units field verification points of the Gnaweeda Greenstone Belt, Meekatharra, Western Australia. Star symbols represent field verification point.

Colluvial sheetwash erosional plains (CHep) mainly occupy the Mistletoe study area and at the south east corner of the map. The main components of this unit are ferruginous, quartz and saprolitic lag of various sizes, with some exposure of ferruginous saprolite. *Acacia aneura* is dominant; *Eremophila fraseri* and *Eremophila forrestii*are also common (Figure 11).

Alluvial sediments fill the channel landscape sequences from northwest to southeast both in the northern and the central part of the map. The materials consist of sand to silt with quartz gravel (Figure 12a) in drainage channels (Figure 12b). In the over bank flood plain, the main components are reddish-brown mud to sand. The vegetation is denser, larger, and taller in the channels. The height of *Acacia aneura* (dominant species) in this area can be high up to 10 m or more.*Eremophila fraseri* is common in this regolith-landform unit. *Eremophila forrestii* generally occurs as an understorey to the high *Acacia aneura* tree (Figure 12c). Calcrete on alluvial plain (ECap) occurs at the northeastern part of the map.

Insitu regolith mostly occupies the high relief of the landscape. It is characterized by bedrock exposure and residual landforms. Residual erosional plains (Rep) occupy northwestern and eastern part of the map and are characterized by angular quartz lag (1-20 cm) in reddish brown silt sand. It may be derived from granite bedrock (from interpreted geology). Vegetation is sparse and dominated by *Acacia aneura* with a few *Acacia pruinocarpa* (gidgee). Residual sandplain (Rps) includes ferruginous quartz-rich sands and silt. It may be derived from sedimentary rock.

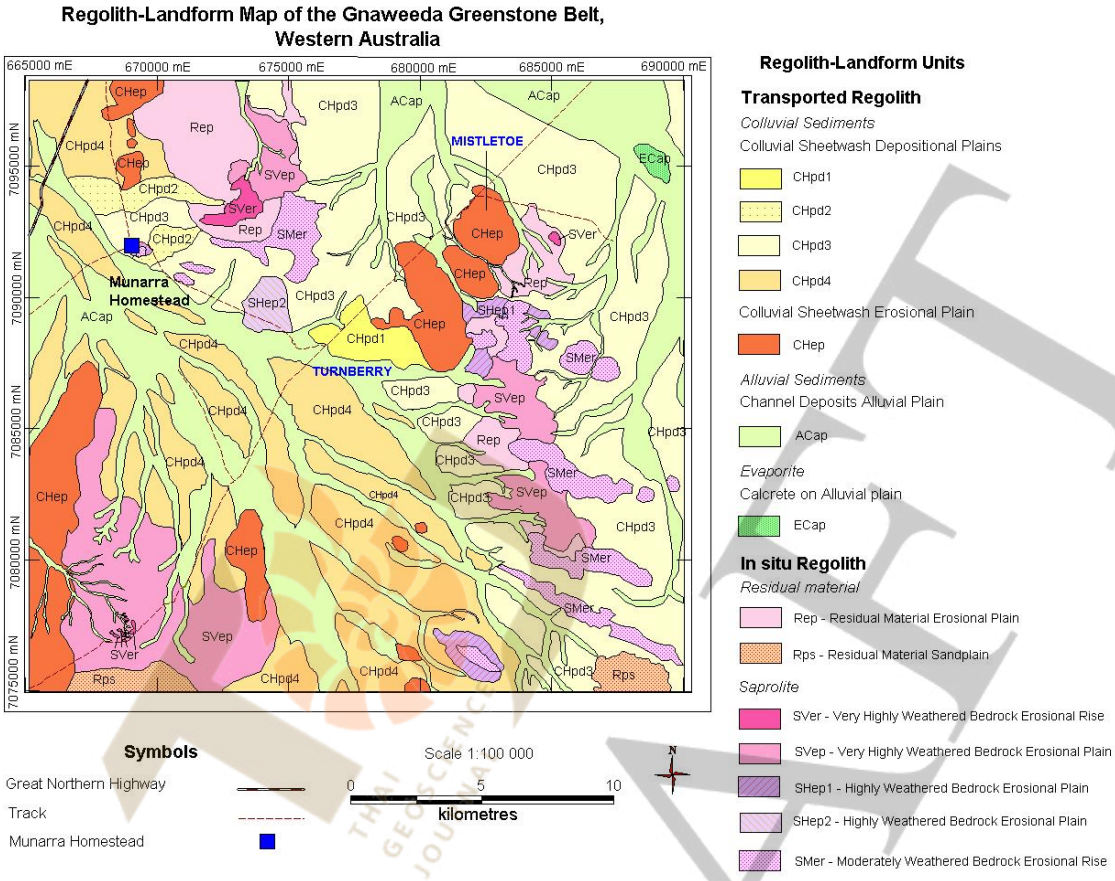

Figure 7: Regolith-landform map of the Gnaweeda Greenstone Belt, Western Australia (UTM GDA94, MGA Zone 50).

(a) (b)

Figure 8: Regolith materials and landform for the CHpd1 regolith-landform unit; (a) sand, angular quartz gravel and angular-subangular ferruginous lag (b) a depositional plain (CHpd1) dominated by *Acacia aneura, Eremophila fraseri* and *Eremophila forrestii*, Meekatharra, Western Australia.

Figure 9:View of landscape for the CHpd3 regolith-landform unit. Vegetation is dominated by small size of *Acacia aneura* (2-5 m high), *Eremophila fraseri* and *Eremophila forrestii*, Meekatharra, Western Australia.

(a) (b)

Figure 10: Surface materials (a) for the CHpd4 regolith-landform unit; ferruginous sand, mud and quartz gravel. (b) Landform setting of the unit, Meekatharra, Western Australia.

(a) (b)

Figure 11: Surface material for the CHep regolith-landform unit; (a) angular to subrounded ferruginous lag with angular to subangular quartz lag. (b) Landscape view of the unit, Meekatharra, Western Australia.

(a)

(b) (c)

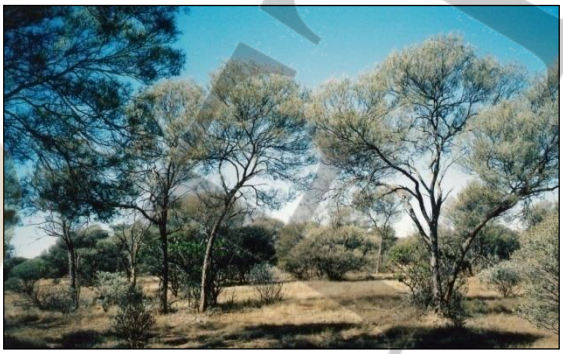

Figure 12: Regolith materials and landscape view for the ACap regolith-landform unit; (a) sand, silt and quartz gravel; (b) channel deposit and (c) high *Acacia aneura* tree with a common of understorey bush, *Eremophila forrestii*, and *Eremophila fraseri*, Meekatharra, Western Australia.

Very highly weathered bedrock erosional rises (SVer) occurred a few spots in the area especially at the southwestern part of the map. This regolith-landform unit is derived from granite rockswith sparse to medium vegetation of *Acacia aneura* and *Eremophila fraseri* (Figure 13).

(a) (b)

Figure 13: Landscape view of a SVer regolith-landform unit; (a) very highly weathered bedrock erosional rises and (b) view on the top of the rises, Meekatharra, Western Australia.

Very highly weathered bedrock erosional plain (SVep) is next to SVer unit and it is also derived from granite rocks. This unit consists of mix of angular quartz (0.5-12 cm) and fragments of granite saprolite (1-20 cm) in brown silt sand soil. Vegetation is sparse and is dominated by *Acacia aneura* (Figure 14).

(a) (b)

Figure 14: Surface material for the SVep unit; (a) mix of angular quartz and fragments of granite saprolite. The landform setting is erosional plain (b) with sparse vegetation dominated by *Acacia aneura*, Meekatharra, Western Australia.

Highly weathered bedrocks on erosional plains have been subdivided into two units. Unit SHep1 contains lithic fragments of silicified bedrock with sparse vegetation of *Acacia aneura* and *Eremophila fraseri* (Figure 15) and another is characterized by subangular quartz gravel (1-7cm) and saprolite on ferruginous sand (SHep2).

Figure 15: View of the landscape for the SHep1 regolith-landform unit. Surface materials include lithic fragments of silicified rock in ferruginous soil. Vegetation is sparse with *Acacia aneura* and *Eremophila fraseri*, Meekatharra, Western Australia.

Moderately weathered silicified bedrock erosional rises (SMer) are distributed at the northwestern and eastern part of the portion of the map. Sparse vegetation is dominated by *Acacia aneura* and spinifex (Figure 16).

(a) (b)

Figure 16: Weathered silicified bedrock (a) with the (b) landform setting (erosional rises) of the unit SMer. *Acacia aneura* and spinifex is common in this unit, Meekatharra, Western Australia.

CONCLUSIONS

A regolith-land form map was compiled using ASTER image and aerial photographs with limited field verification points and existing geological information. The regolith-landform map of the Gnaweeda Greenstone Belt provides an overview of regolith-landform features and regolith materials in this area. The similar features in ASTER data and aerial photography of checked units can help to interpolate to regolith-landform units in inaccessible areas. The regolith-landform map shows a relationship with the interpreted geology (Figure 2). It delineates the weathering products of the two granitoid belts that bound the Gnaweeda Greenstone Belt.

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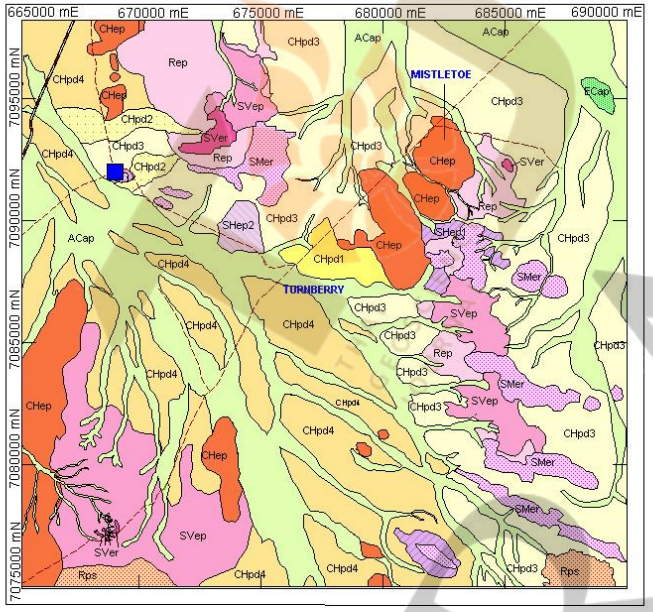
APPENDIX – REGOLITH-LANDFORM MAP

Regolith-Landform Map of the Gnaweeda Greenstone Belt, Meekatharra, Western Australia

Compiled by S. Soongpankhao and M. Aspandiar

Department of Applied Geology, Western Australian School of Mines, Curtin University, Perth, Western Australia, Australia



Symbols

Great Northern Highway

Track

Munarra Homestead

Scale 1:100 000

0 5 10

kilometres

N

Regolith-Landform Units

Transported Regolith

Colluvial Sediments

Colluvial Sheetwash Depositional Plains

CHpd1 - Dominantly orange sand made of angular quartz gravel and angular to subrounded ferruginous lag. Medium density vegetation dominated by Acacia aneura, Eremophila fraseri and Eremophila forrestii.

CHpd2 - Pebble and cobble size of quartz and ferruginous lag (2-10 cm) on ferruginous loose sand. Sparsely vegetated, dominated by Acacia aneura with some presence of Eremophila fraseri.

CHpd3 - Ferruginous loose sand. A lot of small bushes, not many high trees. Acacia aneura is dominant and its average height is 2-5 m. Other species are Eremophila fraseri and Eremophila forrestii.

CHpd4 - Sheetwash deposit depositional plain merging with alluvial plain. Ferruginous loose sand, mud and quartz gravel. Strong micro-relief around vegetation. Medium to dense vegetation dominated by A. aneura, E. fraseri, E.forrestii

Colluvial Sheetwash Erosional Plains

CHep - Angular to subrounded ferruginous lag (1-6 cm) is dominant with minor angular quartz (1-15 cm) about 20-40%. Some exposures of saprolite. Medium vegetation dominated by Acacia aneura. Eremophila fraseri and Eremophila forrestii are common

Alluvial Sediments

Channel Deposits Alluvial Plain

ACap - Dominantly sand to silt with quartz gravel within drainage channels and densely vegetated with A. aneura in a larger size. Dominantly reddish-brown mud to sand in overbank flood plains and sparsely vegetated with A. aneura and E. fraseri

Evaporite

Calcret on Alluvial plain

ECap - Calcret

In situ Regolith

Residual material

Residual Material Erosional Plain

Rep - Angular quartz lag (1-20 cm) on reddish brown silt sand. Sparse vegetation dominated by Acacia aneura with a few of Acacia Pruinocarpa.

Residual Material Sandplain

Rps - Residual sandplain. Ferruginous quartz-rich sands and silt.

Saprolite

Very Highly Weathered Bedrock Erosional Rise

SVer - Very highly weathered bedrock on erosional rise; derived from granite rocks. Vegetations are sparse with Acacia aneura and Eremophila fraseri.

Very Highly Weathered Bedrock Erosional Plain

SVep - Mix angular quartz (0.5-12 cm) and fragments of granite saprolite (1-20 cm) on sandy soil. Sparse vegetation dominated by Acacia aneura.

Highly Weathered Bedrock Erosional Plain

SHep1- Lithic fragments of silicified rock in ferruginous soil. Sparse vegetation dominated by Acacia aneura and Eremophila fraseri.

SHep2 - Subangular quartz gravel (1-7cm) and saprolite on ferruginous sand.

Moderately Weathered Bedrock Erosional Rise

SMer - Silicified bedrock on erosional rise. Angular quartz in fine matrix, striking gently toward south. Vegetations are dominated by Acacia aneura.