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TOMINGLEY 1:25,000 REGOLITH-LANDFORMS MAP, CENTRAL WESTERN NEW SOUTH WALES

Ian C. Roach

CRC LEME OPEN FILE REPORT 233

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CRC LEME is an unincorporated joint venture between CSIRO-Exploration & Mining, and Land & Water, The Australian National University, Curtin University of Technology, University of Adelaide, Geoscience Australia, Primary Industries and Resources SA, NSW Department of Primary Industries and Minerals Council of Australia.

Headquarters: CRC LEME c/o CSIRO Exploration and Mining, PO Box 1130, Bentley WA 6102, Australia

The Tomingley 1:25,000 regolith-landforms map characterises regolith materials and landforms around the township of Tomingley in central western New South Wales. The Tomingley area is the focus of historic and recent alluvial and hard-rock gold mining activities. The Tomingley 1:25,000 regolith-landforms map is designed for minerals explorers to help recognise the sources of transported regolith materials and to adjust their exploration techniques to suit the conditions accordingly.

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Address and affiliation of Author:
Dr Ian C Roach
MTEC Lecturer in Regolith Geoscience
CRC LEME
Dept Earth and Marine Sciences, The Australian National Univeristy
Acton, Canberra, ACT 0200, Australia

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CRC LEME
c/o CSIRO Exploration and Mining
PO Box 1130
Bentley, Western Australia 6102

PREFACE AND EXECUTIVE SUMMARY

The Tomingley 1:25,000 regolith-landforms map is part of the larger CRC LEME Tomingley phytogeochemical exploration project initiated in 2005 (part of the Program 1 Lachlan Fold Belt Synthesis project). This volume describes the procedures and outcomes of 1:25,000 scale mapping adjacent to the township of Tomingley in central western New South Wales.

The Tomingley phytogeochemical exploration project has the following objectives:

- Detailed regolith-landform mapping to characterise regolith materials and landforms to interpret sources and sinks of transported regolith;
- Detailed soil geochemical and floral (plant organ) sampling to determine the nature and extent of any possible gold dispersion in transported regolith and vegetation above the Wyoming 1 gold deposit.
- Assess the viability of phytogeochemical exploration over traditional soil geochemistry for locating gold and other metal deposits under moderate cover in the Macquarie Arc region of central New South Wales.

This report and map represent the completion of the first of the project objectives.

The Tomingley 1:25,000 regolith-landforms map gives mineral explorers and land managers a new insight into the nature, sources and dispersion pathways of regolith materials in the Tomingley area. This knowledge will be valuable for modifying mineral exploration models and land management practices.

Ian C. Roach
Project Leader

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ABSTRACT

The Tomingley 1:25,000 regolith-landforms map contains nearly 1200 polygons, 56 individual regolith-landform units (RLUs) and covers an area of 214.2 km^2. The map face and legend describes the nature of regolith materials, landforms and major vegetation types and communities that exist in the area. The map covers the highly prospective Tomingley region, part of the Forbes-Parkes mineralised zone that includes major gold deposits at Northparkes and Peak Hill. New discoveries at Wyoming, just south of Tomingley, lie buried by up to 60 m of transported regolith cover. The Tomingley 1:25,000 regolith-landforms map is primarily designed to be used by minerals explorers to determine the sources and sinks of regolith materials for their exploration programs in this regolith-dominated terrain.

1. INTRODUCTION

This report summarises the processes and mapping philosophy used in the production of the Tomingley 1:25,000 regolith-landforms map and details the regolith-landform map legend and implications for landscape evolution in the mapping area. The map is produced as part of a larger project detailing the possible phytogeochemical (plant organ) expression of gold mineralisation above the Wyoming gold deposits near Tomingley, central western New South Wales, which will be published separately.

1.1 Background

The Tomingley area lies in the northern Macquarie Arc, part of the Lachlan Fold Belt, in central western NSW (Figure 1). Ordovician volcanic rocks of the Macquarie Arc host some of eastern Australia's largest gold deposits including the > 1 M oz Northparkes and Cowal deposits and the > 20 M oz Cadia-Ridgeway copper-gold deposits. Recent work by Alkane Exploration Ltd. (Alkane) has proven a resource of > 600,000 oz of gold in the Wyoming One and Wyoming Three deposits (Alkane 2005) south of Tomingley, along the line of lode from the company's Peak Hill gold mine.

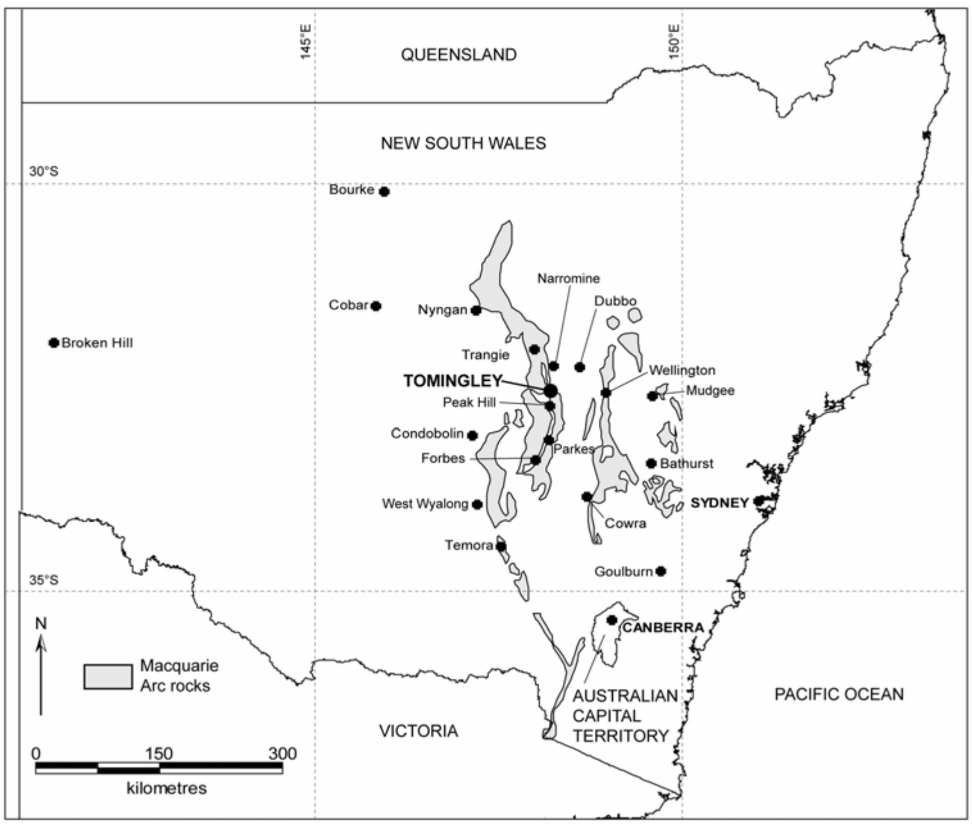

Figure 1: Location of Tomingley. The outline of Ordovician volcanic rocks of the Macquarie Arc (greyed polygons) is after Glen *et al.* (2002).

Oxide zone and hard rock sulphide zone workings in the region until 1981 yielded an estimated 2185.7 kg (ca. 70,270 oz) from the Tomingley area (Myalls United mine, about 500 m south of the Wyoming deposits, seems to have yielded the bulk of this) and an estimated 2703.4 kg (ca. 86,900 oz) from Peak Hill (Clarke 1983). Further heap leach extraction by Alkane on the oxide zone at Peak Hill, ceasing in 2005, yielded ca. 153,000 oz with an estimated 467,000 oz remaining below the weathering front as sulphide ore (Alkane 2005).

The Tomingley area is bordered to the north and west by the Mesozoic Surat Basin and has a variety of transported regolith materials of variable thickness (Chalmers *et al.* 2003; Bamford 2004; Bamford *et al.* 2004; Roach 2004; Roach & Walker 2005; Roach 2006a, b; Scott *et al.* 2005) ranging in age from Recent to possibly Mesozoic. *In situ* and transported regolith materials from a number of different sources are visible on aerial photography, airborne geophysics and satellite imagery. These form a complex surface of overlapping materials that may have different background geochemical values depending on their source and weathering grade. A number of the small saprolith outcrops along the line of lode north of Peak Hill contain small gold deposits, but transported regolith materials mask much of the underlying geology. An understanding of the distribution, nature and source of transported regolith is therefore essential for further mineral exploration work in the region.

1.2 Principal objective

The mapping project was designed to define regolith-landform units (RLUs) and interpret their bedrock source, based on field checking, previous geological mapping (Sherwin 1996) and geophysical data (Discovery 2000), in order to better understand sediment and metal dispersion pathways in the landscape. This is as an adjunct to phytogeochemical exploration and soil sampling over the Wyoming 1 gold deposit.

Work on the analysis and interpretation of soil, litter, bark and leaf/branchlet geochemical and phytogeochemical exploration data will be released in another report.

2. SITE DESCRIPTION

2.1 Location

The Tomingley 1:25,000 regolith-landforms map is centred on the township of Tomingley, between Peak Hill and Dubbo in central western NSW (Figures 1 and 2). The map covers 214.2 km^2 and contains nearly 1200 individual polygons and 56 different RLUs. Edge grid coordinates are 609000 mE (ca. 148°09' E) to 620000 mE (ca. 148°18'E) and 6404000 mN (ca. 32°29'S) to 6385000 mN (ca. 32°40'S), eastings and northings quoted using the Australian Map Grid, UTM zone 55 S, and the Australian Geodetic Datum of 1966. Major infrastructure in the area includes the Newell Highway and the Parkes to Narromine railway.

2.2 Access

The map area can be accessed relatively easily by public roads including the Newell Highway, the Parkes-Narromine road and paved and unpaved minor roads. These roads allow access into most RLUs except for those in the far north and far southwest of the mapping area. Fortunately, other examples of these RLUs were duplicated in more accessible areas.

2.3 Climate

The Tomingley area has a similar climate to Peak Hill (BOM 2005) (Figure 3), which lies ca. 18 km SSW, commencing records in 1890. Tomingley lies in Australia's temperate zone and experiences cool winters and warm summers with lowest and highest recorded temperatures ranging from -6°C in September to +45°C in February. Average yearly rainfall is 562 mm, which is distributed more-or-less evenly throughout the year, often as thunderstorms in the warmer months. However, the mean annual potential evaporation rate is between 1600 and 1800 mm. Northerly, southerly and southwesterly winds dominate, with the remainder being light to moderate from the rest of the wind rose.

2.4 Landuse

Most of the plains and rises of the Tomingley region are cleared and are used principally for cereal and canola cropping, except for the extensive areas characterised by gilgai microrelief. Where gilgais are poorly developed the land is under cultivation, however, the well developed gilgai plains are left largely uncleared and are used for sheep, cattle and horse grazing. Areas of bedrock exposure or colluvial footslopes may be cropped or grazed where relief is low, or left uncleared where slopes are too steep for the safe use of farm machinery. Remnant native vegetation tends to be confined to windrows along fences, tree lines along roads, scattered shade trees within paddocks or areas of higher relief that are too steep to be cultivated.

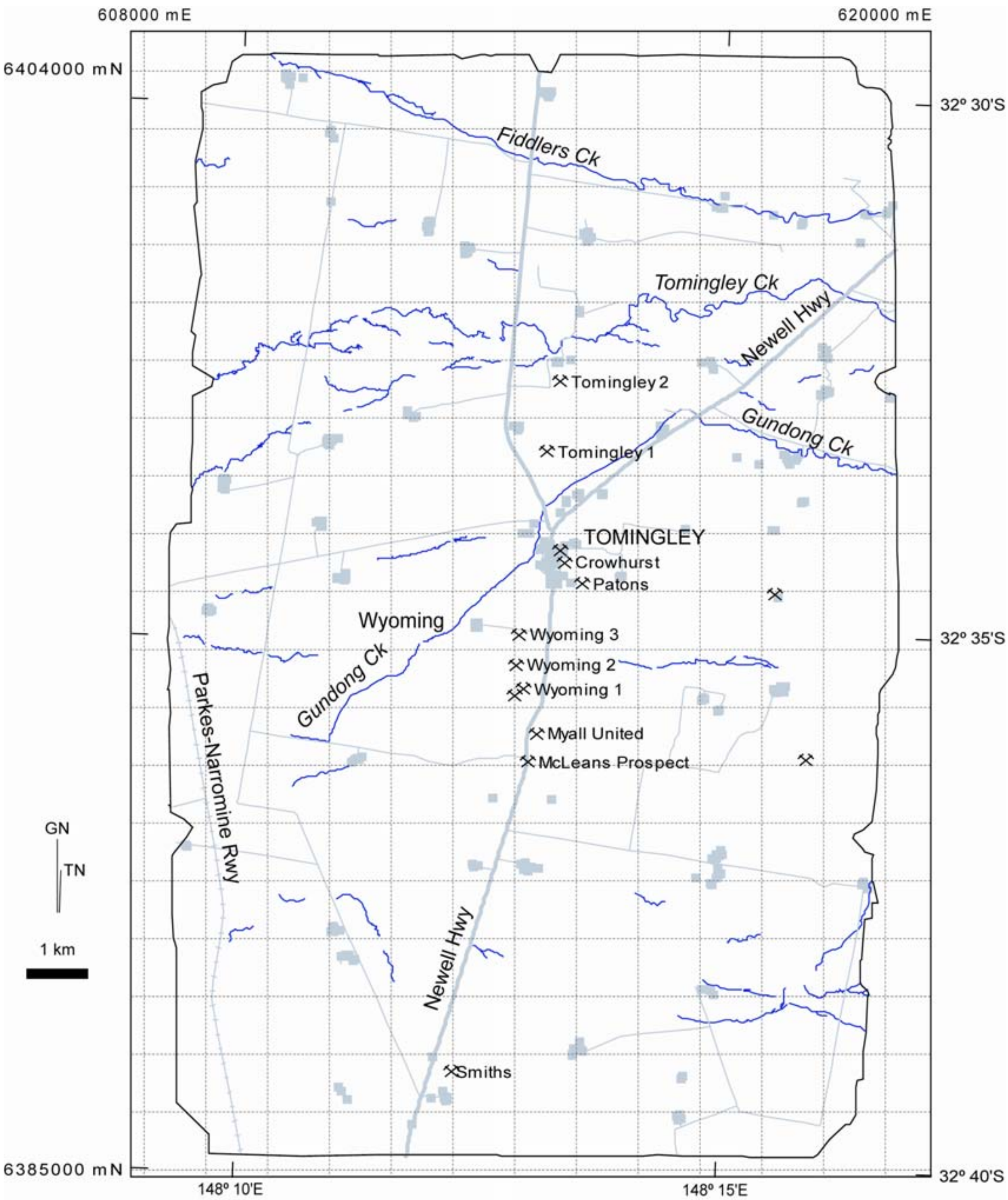

Figure 2: The Tomingley 1:25,000 regolith-landforms map outline and approximate bounds, showing cultural features (roads, railways and constructions), major drainage lines and positions of known gold deposits (crossed pick symbols) from MinView (2006). Grid coordinates are those of the Australian Map Grid using the Australian Geodetic Datum 1966, Universal Transverse Mercator projection Zone 55 S.

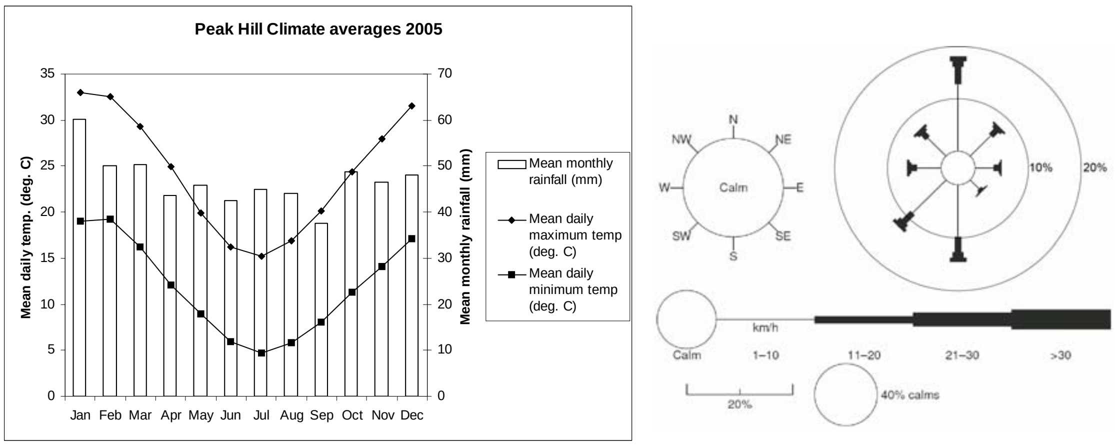

Figure 3: Climate averages and wind rose, Peak Hill Post Office. From BOM (2005).

2.5 Dominant vegetation

Vegetation is dominated by eucalypts including wide-spread grey box (*Eucalyptus microcarpa*), which occurs over most of the area and cohabitates with bimble box (*E. populnea*) in the sandy plains in the north, red ironbark (*E. sideroxylon*) in the saprolith ridges to the east, river red gum (*E. camaldulensis*) along major drainage lines, a mallee (most likely the green mallee *E. viridis*; Costermans 1981) occurring on saprolith rises in the southwest and yellow box (*E. melliodora*) with scattered occurrence. Other dominant tree species include the widespread white cypress pine (*Callitris glaucophylla*; Moore 2005) and buloke (*Allocasuarina luehmannii*; CHAH 2005). The drooping she-oak (*Allocasuarina verticillata*; CHAH 2005) is confined to gilgai plains. Other less common trees include the weeping pittosporum (*Pittosporum philliraeoides*; Moore 2005), which occurs principally on alluvial plains. Shrubs and bushes most commonly noted include rosewood (cattle bush, *Alectryon oleifolius*; Moore 2005), wilga (*Geijera parviflora*), budda (*Eremophilla mitchellii*), various wattles (*Acacia sp.*), wedge-leafed hopbush (*Dodonea cuneata*), punty bush (desert cassia, *Senna artemisioides ssp. Zygophylla*; Moore 2005) and rare warrior bush (*Apophyllum anomalum*). There are numerous grasses and forbs plus exotic weed species including the common saffron thistle (*Carthamus lantanus*; Brooke & McGarva 1998) on disturbed ground and the noogoora burr (*Xanthium occidentale*; Brooke & McGarva 1998) occurring in swampy areas near roads in the northwest. Undisturbed soils also host widespread cryptogam communities.

2.6 Regional geology

Seven main groups of basement rocks are mapped on the Narromine 1:250,000 geological sheet (Sherwin 1996) within the Tomingley 1:25,000 regolith-landforms map sheet boundary. These are also visible on aerial photography and radiometric imagery:

1. Ordovician-Silurian Cotton Formation (O-Sc), comprising coarse to fine sandstones and siltstones, with conspicuous quartz veining;
2. Mugincoble Chert (Om). The Mugincoble Chert is interpreted to be silicified Cotton Formation. These are both apparently contemporaneous with the Goonumbla Volcanics;
3. Ordovician Goonumbla Volcanics (Obv), comprising shoshonitic (K-rich mafic to andesitic) lavas and volcanoclastics with significant vein gold mineralisation;
4. Silurian Mumbidgle Formation (Sfm, Sfv), comprising mudstone, siltstone and minor sandstone;
5. Middle Devonian Dulladerry Volcanics (Dds, Ddr, Ddc), comprising rhyolite lava, ignimbrite, porphyry and minor volcanoclastic sediments;
6. Obley Granite (Dog) of the Middle Devonian Yeoval Granite Complex, which intrudes the Dulladerry Volcanics; and,

7. Late Devonian Hervey Group (Dh), comprising quartz sandstones and reddish mudstones of the Clagger Sandstone, Kadina Formation, Mandagery Sandstone, Pipe Formation and Caloma Sandstone.

Sherwin (1996) also mapped various alluvial-colluvial units as Cz, Cza, Qa, Qr and Qt. These consist of older, slightly more consolidated, more deeply red coloured sediments (Cz) and, younger more greyish-brown sediments with noticeable meanders (Cza). Qa comprises recent alluvium in drainage systems, Qr comprises "eluvium" (*in situ* regolith) and colluvium and Qt scree and talus. Geological units from the Narromine 1:250,000 sheet are included in Figure 4.

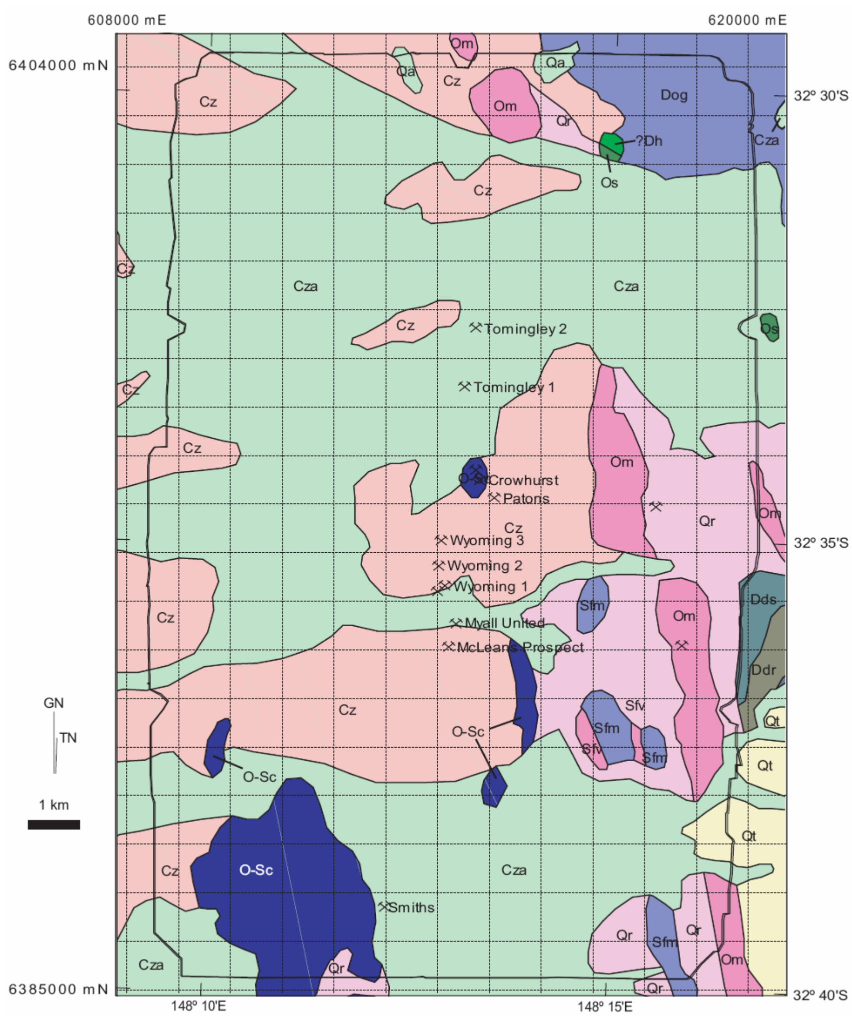

Figure 4: Geology of the Tomingley 1:25,000 regolith-landforms map area from the Narromine 1:250,000 geological sheet (Sherwin 1996). Refer to text for unit descriptions.

2.7 Landforms

Landforms described here are a précis of the more complete descriptions given in the legend entries of individual RLUs on the map and in the Map Units section (Section 4) below.

The landforms in the Tomingley 1:25,000 regolith-landforms map area (Figure 5) are dominated by broad, very slightly undulating, westward-sloping active and stagnant alluvial plains that are large alluvial fan systems formed by the larger drainage systems including Fiddlers Creek, Tomingley Creek and Gundong Creek, as well as numerous un-named smaller creeks flowing roughly east to west from the Hervey Range and its foothills. The alluvial fan systems are not marked on the Tomingley 1:25,000 regolith-landforms map because they are too large; they are instead shown as smaller landscape facets. The alluvial plains have a number of small rises in the western and central parts of the map related to outcropping units of resistant Cotton Formation rocks.

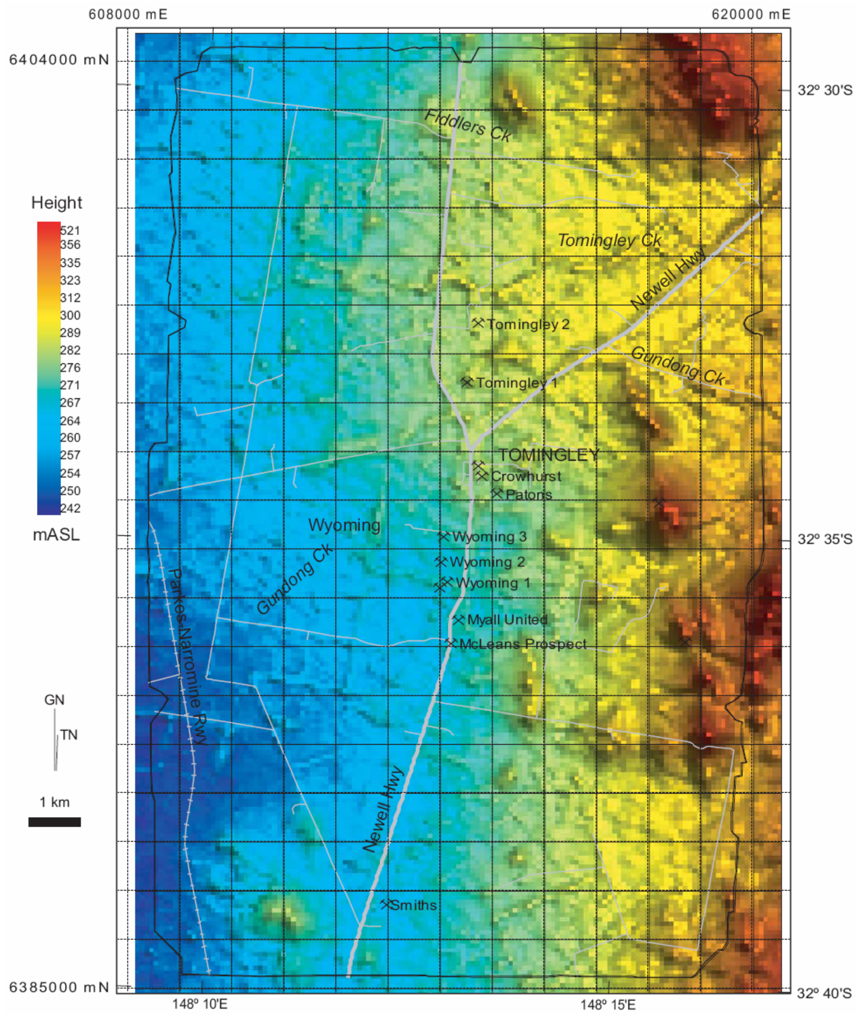

Figure 5: Shuttle Radar Topography Mission version 2 (SRTM2) digital elevation model (DEM) of the Tomingley 1:25,000 regolith-landforms map area.

The eastern half of the map area is dominated by rises and low hills that form the foothills of the Hervey Range, lying to the west outside the mapping area. These often have small concave colluvial pediments at their bases. The contact between the alluvial plains and pediments varies from a break in slope with a rapid soil colour change, often associated with an alluvial/colluvial drainage depression, to a gradation in slope and soil colour of tens of metres.

The SRTM2 DEM (Figure 5) shows some of the landforms discussed above but also shows many of the roads and major creeks in the mapping area. These are highlighted because they remain uncleared of native woodland vegetation whilst the surrounding farmland is largely cleared; there is a sharp elevation contrast of up to 20 m between the two.

3. REGOLITH-LANDFORM MAPPING METHODS

3.1 Work program

The Tomingley 1:25,000 regolith-landforms map was completed after fieldwork in 2004 and 2005. The work program consisted of a number of field trips including:

- May 2004 – reconnaissance sampling and site inspection, Wyoming 1 deposit;
- January 2005 – phytogeochemical sampling and limited regolith-landform mapping along sampling transects;
- April 2005 – limited regolith-landform mapping along sampling transects during phytogeochemical seasonality sampling program resample;
- August 2005 – wide area regolith-landform mapping during phytogeochemical seasonality sampling program resample;
- October 2005 – wide area regolith-landform mapping, collection of ground control points for orthophoto mosaic during phytogeochemical seasonality sampling program resample; and,
- November 2005 – wide area regolith-landform mapping, collection of ground control points for orthophoto mosaic during phytogeochemical seasonality sampling program resample.

In the second half of 2006 an orthophoto mosaic was constructed and regolith-landform units were compiled, culminating in the production of the Tomingley 1:25,000 regolith-landforms map in October 2006.

3.2 Mapping Technique

Site descriptions and ground control points were collected during fieldwork in 2005 and 2006 using a Garmin hand-held GPS receiver which typically displayed a quoted spherical error of 5 m, but could be as much as 50 m in error for repeat measurements between field trips, depending on satellite geometry.

Regolith-landform unit site descriptions included 5 principal attributes for each RLU (after Hill and Roach 2006):

1. Dominant regolith lithology (including induration);
2. Dominant landform;
3. Surficial features (including lag);
4. Minor features (possible geohazards and any other distinguishing attributes); and,
5. Dominant vegetation community structure type and species.

Aerial photography was used as the principal mapping base. Two 1:50,000 colour aerial photographs, Peak Hill 1:100,000 Run 1 #0159 and Run 2 # 0174, acquired by the NSW Department of Lands, 10th May 2004, were used to provide the basemap, together with the Peak Hill 1:100,000 topographic map for terrain height. Sites were mapped onto airphoto overlays in the field. Preliminary RLUs were then mapped onto stereo pair overlays using RLU site descriptions to extrapolate before further field checking.

3.3 Regolith-landform unit nomenclature

Regolith-landform unit descriptions follow the RTMAP scheme of Pain et al. (2000). The scheme labels RLUs using a flexible range of alphanumeric codes, for instance, "SSer1" representing slightly weathered saprolith (saprock) "SS" on an erosional rise "er" with a dominant regolith lithology of type "1", in this case Cotton Formation rocks. Regolith-landform units have been given a numerical modifier of 1 to 7 in keeping with the regional geological stratigraphy of the mapping area described in **Section 2.6**. The RTMAP scheme was also modified to include the prominent gilgai plains, which are included as "Aag" RLUs (alluvial sediments "A" on alluvial gilgai plains "ag") with appropriate numerical modifiers related to dominant source materials. All RLU codes are listed here (Table 1) and explained on the map face.

Table 1: RLU codes used on the Tomingley 1:25,000 regolith-landforms map and their explanations.

RLU codes for regolith materials depicted here are:		**RLU codes for landforms used here are:**		**RLU modifier codes used here reflect bedrock lithologies or regolith material sources are:**	
A	Alluvial sediments	ag	alluvial plain with gilgai depressions	1	Cotton Formation (O-Sc) sandstones and siltstones
AC	Alluvial channel sediments	ah	alluvial channel	2	Mugincoble Chert (Om)
AO	Alluvial overbank sediments	ap	alluvial plain (with numerous small drainage depressions)	3	Goonumbla Volcanics (Obv)
C	Colluvial sediments	aw	alluvial swamp	4	Mumbidgle Formation (Sfm, Sfv)
CH	Colluvial sheetflow sediments	ed	erosional drainage depression	5	Dulladerry Volcanics (Dds, Ddr, Ddc)
F	Fill	ep	erosional plain (0-9 m relief)	6	Obley Granite (Dog)
SM	Moderately weathered bedrock (saprolite)	er	erosional rise (9-30 m relief)	7	Hervey Group (Dh)
SS	Slightly weathered bedrock (saprock)	el	erosional low hill (30-90 m relief)		
		fa	alluvial fan		
		m	man-made		
		pd	depositional plain (with no significant drainage depressions)		

3.4 Technical aspects of map production

3.4.1 Datum and Projection
Map coordinates were collected and are quoted using the Australian Map Grid, Australian Geodetic Datum 1966, Universal Transverse Mercator Projection Zone 55S, in keeping with Alkane's GIS database of the area.

3.4.2 Aerial Orthophoto mosaic
Orthographically-corrected aerial photographs (orthophotos) were used as the final map base. Aerial photographs were scanned at 300 dots-per-inch (dpi), colour- and brightness-balanced in Adobe Photoshop and saved as uncompressed TIFF files. Orthophotos were processed using ER Mapper version 6.4 software with camera parameters supplied by the NSW Land Information Centre, the SRTM2 DEM from the National Aeronautics and Space Administration (NASA) and ground control points collected during fieldwork. Completed RLUs were transcribed from the stereopair overlays onto orthophoto overlays for final map production.

3.4.3 Map production and Geographical Information System
Completed orthophoto RLU overlays were scanned to greyscale 400 dpi TIFF files and were edited in Adobe Photoshop to remove overhangs, undershoots, scuffs and dust spots. The cleaned images were then raster-to-vector converted using Vextrasoft Vextractor™ version 2.95 software, imported as DXF files into MapInfo version 8 GIS software and converted to polygons.

3.4.4 RLU polygon production
Regolith-landform units mapped on the aerial photography were cross-checked against airborne gamma-ray spectrometric data from the Northern Parkes Discovery 2000 dataset (Discovery 2000) and the Narromine 1:250,000 geological sheet (Sherwin 1996) polygons. Regolith-landform unit polygons were modified where necessary to better reflect the interpreted dominant source materials.

3.5 Accessory images

A series of accessory images accompany the Tomingley 1:25,000 regolith-landforms map, including:

- SRTM2 DEM image. This model features 90 m ground resolution pixels and is sunshaded from the northeast to enhance topographic features;
- Derivative regolith materials source map. This depicts all regolith-landform units with *in situ* or transported materials interpreted to have the same bedrock parent. Polygons with the same modifier number (see map legend) have been selected and coloured to indicate those areas that should have similar background geochemical characteristics;
- Intensified RGB airborne gamma-ray spectrometrics image from the North Parkes Geoscience Dataset (Discovery 2000). Potassium (K), thorium (Th) and uranium (U) gamma-ray emissions are represented as the colours red, green and blue respectively. The image has been intensified by adding Total Counts as an intensity layer using ER Mapper version 6.4 software to highlight strong and weak gamma-ray emitters as bright or dark areas as well as *in situ* and transported regolith types with differing proportions of the three radioelements K, Th and U.;
- First vertical derivative (1VD) coloured and sunshaded aeromagnetic image from a high-resolution survey commissioned by Alkane. The image depicts broad roughly north-south striking structures related to bedrock geology and fractures that are overlain by short wavelength, high amplitude, curved and anastomosing near-surface features that have been interpreted as magnetic palaeochannels. This image is courtesy of Alkane;
- Aerial orthophoto mosaic basemap. Aerial photographs include Peak Hill 1:100,000 Run 1 #0159 and Run 2 #0174, acquired by the New South Wales Department of Lands, 10th May 2004;
- Location diagram; and,
- Observation diagram, depicting the location of all site descriptions used to compile the map.

These images and maps are included to highlight specific features on the map and to help the user interpret the nature of regolith materials on the map face, as well as informing about the surface relief, sources and sinks of regolith materials and subsurface regolith structure.

3.6 Final map compilation

MapInfo version 8 GIS was used to produce a series of data tables covering the Tomingley 1:25,000 regolith-landforms map, including:

- Regolith-landform unit polylines;
- Regolith-landform unit polygons with labels;
- Drainage digitised from the orthophoto basemap;
- Cultural features including roads, railways, buildings and other constructions; and,
- Mineral occurrences using sites downloaded from the NSW Department of Primary Industries' MinView website (MinView 2006).

For the final map these tables were exported from MapInfo as a single Windows metafile and were imported into Adobe Illustrator version 11. Here the individual tables were separated into layers, which allowed them to be switched on and off to avoid confusion or accidental changes or deletion during the compilation process. The colour legend was also exported as a Windows metafile and imported into Illustrator, where the final legend text was added. This allowed legend entries of any length to be made, with mixed fonts; MapInfo GIS will only allow legend entries of 255 characters with no mixed fonts. Polygon label positions, captions and other general information were also adjusted or added here. Accessory images were also saved as a series of Windows metafiles and were imported into Illustrator separately.

The final hardcopy map was saved in Adobe PDF format for printing and permanent archiving and is included in the Appendices on CD-ROM together with the MapInfo GIS tables of the map.

4. PHOTOGRAPHIC AND AIRBORNE GAMMA-RAY SPECTROMETRIC CHARACTERISTICS OF WEATHERED BEDROCKS

Colour aerial photography (Figure 6) is the primary basis for mapping individual RLUs. This is extremely useful because of the stereo effect, enabling mapping of subtle landforms. Unfortunately, the aerial photography is of limited use in distinguishing different regolith materials because different basement rock types may release similar-looking light- or dark-toned sediments when weathered. Land use practices also make it difficult to distinguish subtle regolith-landforms, especially in areas that have been extensively cropped. However, the stereo photography is very useful for locating drainage channels, identifying subtle landforms such as drainage depressions (which appear lighter- or darker-toned than the surrounding plains) and for separating alluvial plains from colluvial depositional plains within the mapping area. This knowledge is instrumental for determining sediment migration pathways across the otherwise apparently "featureless" plains.

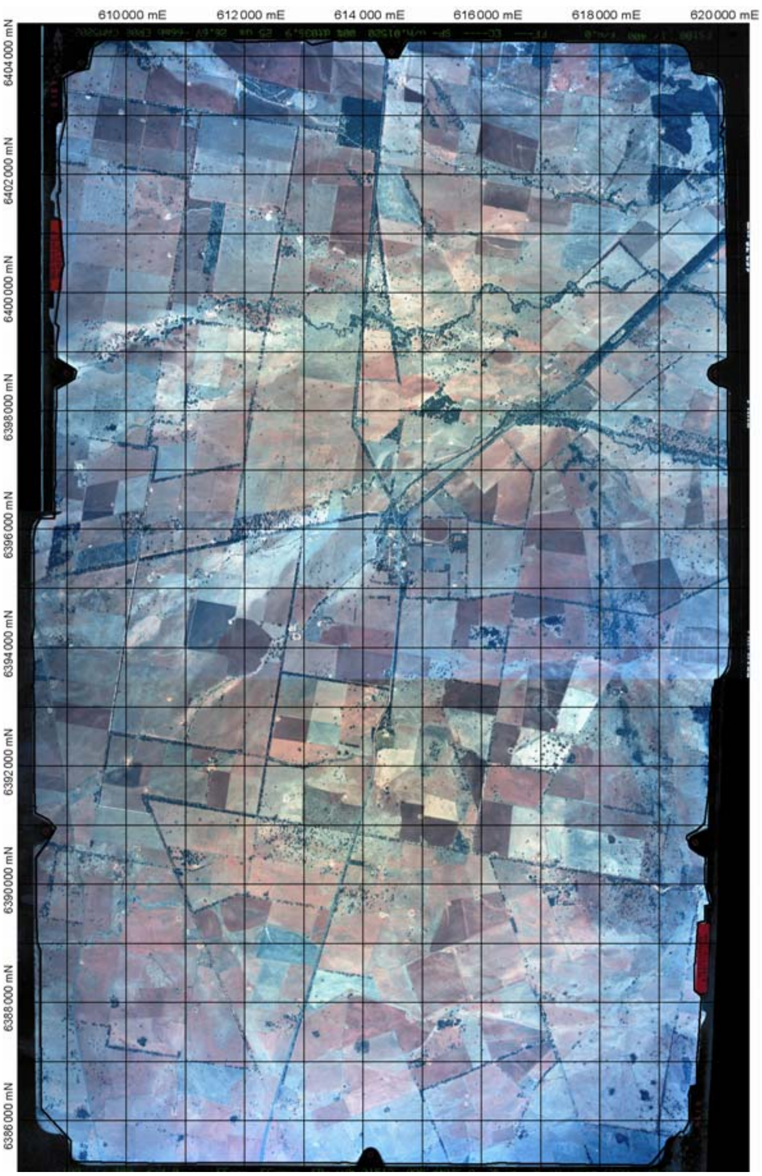

Figure 6: Aerial orthophoto mosaic of the Tomingley 1:25,000 regolith-landforms map area. The mosaic consists of two 1:50,000 colour aerial photographs, Peak Hill 1:100,000 Run 1 #0159 (top) and Run 2 # 0174 (bottom), acquired by the NSW Department of Lands, 10th May 2004. The mosaic was constructed according to the method detailed in Section 3.4.2.

Gamma-ray spectrometric imagery from the Northern Parkes Geoscience Dataset (Discovery 2000) has been used to interpret the distribution of *in situ* and transported regolith on a regional scale and to separate regolith materials that appear similar on the aerial photographs. The imagery has 135 m ground resolution pixels and is presented in a variety of formats, including a RBG image with potassium (K), thorium (eTh) and uranium (eU) represented as red, green and blue respectively, separate channels (K, eTh and Total Counts) and K/eTh ratio. None of the images on the dataset were calibrated to actual chemical abundance of the three radioelements but were manipulated in their original forms as digital numbers 0-255. The most useful image for this study was found to be a 99% histogram stretch of the RGB image of the mapping area (Figure 7b), used to both separate *in situ* regolith material from transported regolith and to estimate weathering grades. Another useful interpretation image was prepared by intensifying the RGB image with Total Counts added as an intensity layer using ER Mapper 6.4 software, both using a 99% histogram stretch. This intensified RGB image (Figure 7c) highlights the bedrock geology and weathering products and better separates strong and weak gamma-ray emitters, providing important clues to the sources and distribution of weathered materials.

A range of observations or empirical rules were developed from the RGB and intensified RGB gamma-ray spectrometric images (shown together with the bedrock geology in Figure 7), including:

1. Cotton Formation (O-Sc; Late Ordovician-Early Silurian) tends to be dull pink to white in the RGB images (moderate to high K, eTh and eU saturation). Colluvium tends to be darker pinks (low to moderate K, but lower eTh and eU saturation) through to green (low eTh saturation only). This latter colour may represent *in situ* leaching of K leaving eTh-rich residue, or, mixing of colluvium with alluvium derived from the Dulladerry Volcanics, which onlaps;
2. Mugincoble Chert (Om; Ordovician) tends to display dark brown colours signifying overall low K, eTh and eU saturation. This unit is black in the intensified RGB image, signifying low overall gamma-ray emission;
3. Goonumbla Volcanics (Obv; Late Ordovician-Early Silurian) is deep red in both images, indicating low to moderate K saturation;
4. Mumbidgle Formation (Sfm, Sfv; Late Silurian) is dull pink (moderate K and low eTh and eU saturation) in both images. Colluvium tends to be dark pink (low K, but lower eTh and eU saturation) through dark green (low eTh saturation only). This too may be a mixture of colluvium and alluvium derived from the Dulladerry Volcanics, which onlaps;
5. Dulladerry Volcanics (Dds, Ddr, Ddc; Middle Devonian) is bright pink-white in both images where fresh (high K, eTh and eU saturation), quickly fading to green (high eTh saturation), the green colour deepening along alluvial tracts leading to the west signifying additional leaching of Th. These sediments onlap Ordovician-Silurian saprolith outcrops, possibly mixing and resulting in blends from pink to green colours around outcrops of Cotton Fm and Mumbidgle Fm rocks;
6. Obley Granite (Dog; Yeoval Batholith, Middle Devonian) rocks tend to be bright pink to white where freshest (high K, eTh and eU saturation) in both images. Alluvium varies from white to dark pink in a large alluvial fan system leading westwards from the source. Colours signify K leaching in overlapping deposits of different ages: white youngest; pink oldest. This alluvial system appears to be sharply separated from green-coloured (eTh-bearing) sediments derived from weathering and leaching of Ordovician-Silurian-Late Devonian basement rocks.
7. Hervey Group (Dh; Late Devonian) rocks tend to have dark green-blue colours (low eTh and eU saturation only) in the RGB image, except for the dark red coloured Beargamil Subgroup (low K in excess of eTh and eU saturation) that is visible in both images as a moderately strong gamma-ray emitter. Alluvium derived from these tends to be black-dark blue speckled in the RGB image or black in the intensified RGB image and is visible as dark leads trailing away from the Hervey Group outcrops and possibly on the Bogan River floodplain in the far west of the mapping area.

These observations have been used to label polygons in the Tomingley 1:25,000 regolith-landforms map and to split polygons in a few situations where they have been shown to appear similar on aerial photography, but are interpreted in the gamma-ray spectrometric images to be composed of regolith materials from different sources.

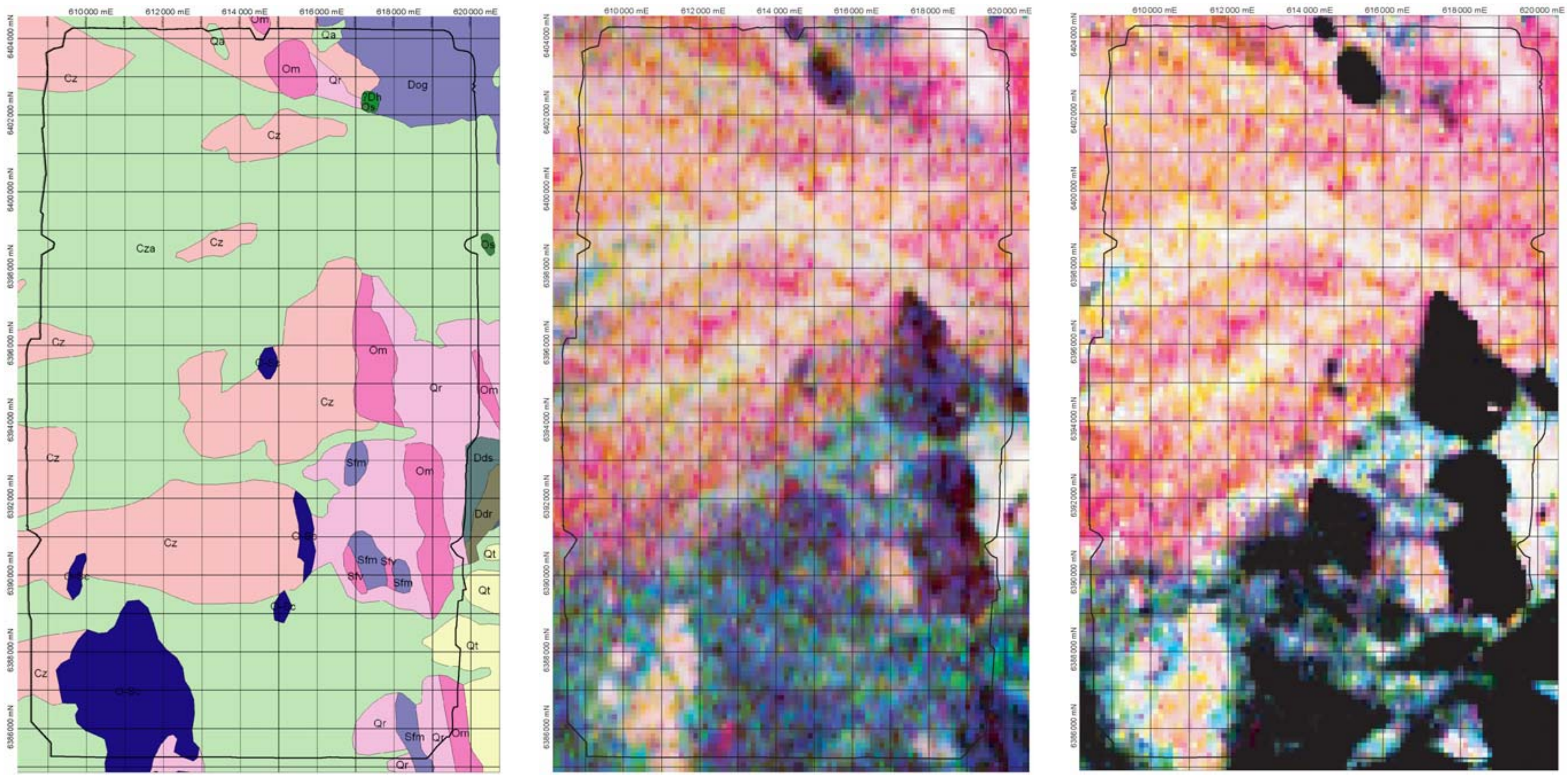

Figure 7a, b, c: Bedrock geology (Sherwin 1996) (left), RGB gamma-ray spectrometric image (centre) and 99% histogram stretched intensified gamma-ray spectrometric image (right) (Discovery 2000) of the Tomingley 1:25,000 regolith-landforms map area. Figure 7b is an unstretched subset of the larger Northern Parkes RGB gamma-ray spectrometric image (Discovery 2000) with K as red, Th as green and U as blue. Figure 7c is a subset of the same image but with Total Counts added as an intensity layer, brightening strong gamma-ray emitters and darkening weak gamma-ray emitters. Map grid interval is 1 km.

5. MAP UNITS

5.1 Introduction

Basement rocks are generally slightly to moderately weathered and weakly ferruginised, forming erosional plains and rises throughout the mapping area, rarely low hills. These have prominent colluvial mantles blending into the alluvial plains that dominate the landscape. It is only rarely that the boundaries between these regolith landforms are preserved undisturbed because of agriculture. Many of the alluvial RLUs have been modified by cultivation or drain digging. More detail regarding individual RLUs is available in the appendices of this report and on the Tomingley 1:25,000 regolith-landforms map.

5.2 Alluvial sediments

Alluvial sediments dominate RLUs in the Tomingley 1:25,000 regolith-landforms map, comprising 86.3% of the area. Alluvium is present in many RLUs that are superimposed over large prograding fans that have their apices in narrow, deeply-incised or wide flat valleys in the Hervey Range in the southeast and the Sappa Bulga Range in the northeast. Alluvial RLUs include alluvial channels, alluvial swamps, alluvial depressions, alluvial plains, alluvial depositional plains, gilgai plains and smaller alluvial fans at the bases of the two ranges. Smaller alluvial fans may also occur within the large fan systems in the extensive alluvial plains in the map area, but these are difficult to recognise because of extensive modification by agricultural practices. Instead, most of these are referred to as alluvial plains and alluvial depositional plains on the map sheet. Alluvium has been sourced from all 7 different bedrock types (described in Section 2.6) as subangular to subrounded, occasionally rounded to well rounded, quartzose and weathered lithic silts, sands and gravels up to cobble size (cobbles only occurring in alluvial channels). All of the alluvial units also contain small amounts of maghemite and large amounts of red-brown fine sand and silt, interpreted to represent an aeolian component (parna).

Aag1: Depressions containing dark organic-rich clays in small swamps and surrounding alluvial plains dominantly containing red-brown fine sand and silt with subangular to subrounded coarse sand to pebbles of quartz and weakly ferruginised mudstone, siltstone and sandstone lithic fragments and minor subrounded maghemite granules. Poorly to well developed gilgai with depressions up to 10 m in diameter and 1 m deep. Colonised by sedges and other water-tolerant grasses and forbs in the depressions and surrounded by an open woodland of *Eucalyptus microcarpa*, *Geijera parviflora*, rare *Alectryon oleifolius*, rare *Apophyllum anomalum*, grasses, forbs and exotic weeds.

Aag2: Depressions containing dark organic-rich clays in small swamps and surrounding alluvial plains dominantly containing red-brown fine sand and silt with subangular coarse sand to small pebbles of quartz and weakly ferruginised fine sandstone and shale lithic fragments and minor subrounded maghemite granules. Poorly to well developed gilgai with depressions up to 10 m diameter and 1 m deep. Colonised by sedges and other water-tolerant grasses and forbs in the depressions and surrounded by an open woodland of *Eucalyptus microcarpa*, *Allocasuarina verticillata*, *Alectryon oleifolius*, *Geijera parviflora*, *Eremophila sp.*, *Acacia sp.*, rare *Pittosporum philliraeoides*, rare *Apophyllum anomalum*, grasses, forbs and exotic weeds.

Aag4: Depressions containing dark organic-rich clays in small swamps and surrounding alluvial plains dominantly containing red-brown fine sand and silt with subangular to subrounded coarse sand to pebbles of quartz and weakly ferruginised chert lithic fragments and minor subrounded maghemite granules. Poorly to well developed gilgai with depressions up to 10 m diameter and 1 m deep. Colonised by sedges and other water-tolerant grasses and forbs in the depressions and surrounded by an open woodland of *Eucalyptus microcarpa*, *Alectryon oleifolius*, *Geijera parviflora*, *Eremophila sp.*, rare *Apophyllum anomalum*, grasses, forbs and exotic weeds.

Aag5: Depressions containing dark organic-rich clays in small swamps and surrounding alluvial plains dominantly containing red-brown fine sand and silt with subangular coarse sand to small pebbles of vein quartz, quartzose, chert and minor subrounded maghemite granules and possibly rhyolite porphyry lithic fragments. Poorly to well developed gilgai with depressions up to 10 m diameter and 1 m deep. Colonised by sedges and other water-tolerant grasses and forbs in the depressions and surrounded by an open woodland of *Eucalyptus microcarpa*, *Allocasuarina verticillata*, *Alectryon oleifolius*, *Geijera parviflora*, *Eremophila sp*., *Apophyllum anomalum*, *Acacia sp*., grasses, forbs and exotic weeds.

Aag6: Depressions containing dark organic-rich clays and quartz sands in small swamps and surrounding alluvial plains dominantly containing light to dark grey coloured subangular to subrounded quartzose coarse sands and granules and granules to small pebbles of weathered granite lithics with minor red-brown fine sand and silt and minor subrounded maghemite granules. Poorly to well developed gilgai with depressions up to 10 m diameter and 1 m deep. Colonised by sedges and other water-tolerant grasses and forbs in the depressions and surrounded by an open woodland of *Eucalyptus microcarpa*, *Eucalyptus populnea, Alectryon oleifolius*, *Geijera parviflora*, *Eremophila sp*., rare *Apophyllum anomalum*, grasses, forbs and exotic weeds.

Aag6a: Depressions containing dark organic-rich clays and quartz sands in small swamps and surrounding alluvial plains dominantly containing light grey coloured subangular to subrounded quartzose coarse sands and granules and granules to small pebbles of weathered granite lithics and minor subrounded maghemite granules. Poorly to well developed gilgai with depressions up to 10 m diameter and 1 m deep. Colonised by sedges and other water-tolerant grasses and forbs in the depressions and surrounded by an open woodland of *Eucalyptus microcarpa*, *Eucalyptus populnea, Alectryon oleifolius*, *Geijera parviflora*, *Eremophila sp*., rare *Apophyllum anomalum*, grasses, forbs and exotic weeds.

Aag7: Depressions containing dark organic-rich clays in small swamps and surrounding alluvial plains dominantly containing red-brown fine sands and silts and subangular to subrounded quartzose sands and minor subrounded maghemite granules. Poorly to well developed gilgai with depressions up to 10 m diameter and 1 m deep. Colonised by sedges and other water-tolerant grasses and forbs in the depressions and surrounded by an open woodland of *Eucalyptus microcarpa*, grasses, forbs and exotic weeds.

Aap1: Subangular to subrounded quartz, weakly ferruginised weathered siltstone and fine sandstone lithic sands and granules, red-brown fine sand and silt and minor subrounded maghemite granules. Low relief plain with anastomosing drainage depressions. Colonised principally by forbs and grasses and scattered *Eucalyptus microcarpa*, *Callitris glaucophylla*, *Allocasuarina luehmannii* and *Geijera parviflora*.

Aap6: Light grey coloured subangular to subrounded quartz and weathered granite lithic coarse sands and granules with rare lithic pebbles and grey clays, minor red-brown fine sand and silt and minor subrounded maghemite granules. Low relief plain with anastomosing drainage depressions. Colonised dominantly by *Eucalyptus populnea* with *Eucalyptus microcarpa*, forbs and grasses.

Aaw5: Dark grey to black organic-rich clays and silts with subangular to subrounded quartz and rhyolite porphyry lithic sands and granules. Water-saturated low-lying swampy tracts of alluvial systems. Colonised by sedges and other water-tolerant forbs and grasses.

Aaw6: Dark grey to black organic-rich clays and silts with subangular to subrounded quartz and weathered granite lithic sands and granules. Water-saturated low-lying swampy tracts of alluvial systems. Colonised by sedges and other water-tolerant forbs and grasses.

ACah5: Channel alluvium of subrounded to rounded silt to cobble sized clasts of quartz and weathered rhyolite porphyry, chert, mudstone, siltstone and sandstone lithics with minor red-brown fine sand and silt. Grey clays and lithic gravels exposed in stream banks. Stream channels < 10 m wide and < 3 m deep. Colonised principally by *Eucalyptus camaldulensis* with minor *Acacia sp*., *Eremophila sp*., forbs and grasses.

ACah6: Channel alluvium of subrounded to rounded quartz and weathered granite lithics of silt to cobble size with minor red-brown fine sand and silt. Grey clay, silt, sand and lithic gravels exposed in stream banks. Stream channels < 10 m wide and < 3 m deep. Colonised principally by *Eucalyptus camaldulensis* with minor *Eucalyptus populnea*, *Eucalyptus microcarpa*, *Acacia sp*., forbs and grasses.

ACah7: Channel alluvium of subrounded to rounded quartz and weakly ferruginised sandstone lithics of silt to cobble size. Grey clay, silt, sand and lithic gravels exposed in stream banks. In a stream channel < 10 m wide and < 3 m deep. Colonised principally by *Eucalyptus camaldulensis* with minor *Acacia sp*., *Eremophila sp*., forbs and grasses.

Aed1: Dark red to brown organic-rich sediments containing clays and quartzose silts with minor subangular to subrounded quartzose and weakly ferruginised siltstone and sandstone lithic sands and granules and minor subrounded maghemite granules. In broad shallow alluvial tracts. Colonised principally by forbs and grasses.

Aed2: Dark red to black organic-rich sediments containing clays and quartzose silts with minor subangular to subrounded quartzose and chert lithic sands and granules and minor subrounded maghemite granules. In broad shallow alluvial tracts. Colonised principally by forbs and grasses with minor *Eucalyptus microcarpa*, *Eucalyptus sideroxylon*, *Acacia sp*. and *Eremophila sp*.

Aed4: Dark red to brown organic-rich sediments containing clays and quartzose silts with minor subangular to subrounded quartzose and weakly ferruginised mudstone, siltstone and sandstone lithic sands and granules and minor subrounded maghemite granules. In broad shallow alluvial tracts. Colonised principally by forbs and grasses with minor *Eucalyptus microcarpa*, *Eucalyptus sideroxylon*, *Acacia sp*. and *Eremophila sp*.

Aed5: Dark red to brown organic-rich sediments containing clays and quartzose silts with minor subangular to subrounded quartzose and possibly weathered rhyolite porphyry lithic sands and granules and minor subrounded maghemite granules. In broad shallow alluvial tracts. Colonised principally by forbs and grasses with minor *Eucalyptus microcarpa*, *Eucalyptus sideroxylon*, *Acacia sp*. and *Eremophila* sp. in the east.

Aed6: Dark grey to brown organic-rich sediments containing clays and quartzose silts with minor subangular to subrounded quartzose and weathered granite lithic sands and granules and minor subrounded maghemite granules. In broad shallow alluvial tracts. Colonised principally by forbs and grasses with minor *Eucalyptus populnea, Eucalyptus microcarpa*, *Acacia sp*. and *Eremophila sp*.

Aed7: Dark red to black organic-rich sediments containing clays and quartzose silts with minor subangular to subrounded quartzose and sandstone lithic sands and granules and minor subrounded maghemite granules. In broad shallow alluvial tracts. Colonised by forbs and grasses.

Afa2: Red-brown fine sand and silt with minor angular to subangular coarse sand to pebbles of quartz and weakly ferruginised chert and minor subrounded maghemite granules. On a low relief alluvial fan. Colonised principally by forbs and grasses with rare *Eucalyptus microcarpa*, *Allocasuarina luehmannii* and *Callitris glaucophylla*.

Afa5: Red-brown fine sand and silt with minor angular to subangular coarse sand and granules of quartz and minor subrounded maghemite granules and possibly weathered rhyolite porphyry. On a low relief alluvial fan. Colonised principally by forbs and grasses with scattered *Eucalyptus microcarpa*, *Allocasuarina luehmannii*, *Callitris glaucophylla* and *Acacia sp*.

AOap5: Light red coloured subangular to subrounded quartz and possibly weathered rhyolite porphyry lithic coarse sands and granules with red-brown fine sand and silt and minor subrounded maghemite granules. In a plain with numerous anastomosing drainage depressions. Colonised by *Eucalyptus* *microcarpa*, *Callitris glaucophylla*, *Allocasuarina luehmannii*, *Geijera parviflora*, rare *Eucalyptus sideroxylon*, *Acacia sp*., *Eremophila sp*., forbs and grasses.

AOap6: Light grey coloured subangular to subrounded quartz and weathered granite lithic coarse sands and granules with rare pebbles and grey clays and minor red-brown fine sand and silt and minor subrounded maghemite granules. In a plain with numerous anastomosing drainage depressions. Colonised dominantly by *Eucalyptus populnea* with *Eucalyptus microcarpa*, rare *Eucalyptus melliodora*, *Callitris glaucophylla*, *Allocasuarina luehmannii*, *Geijera parviflora*, *Eremophila mitchellii*, *Senna artemisioides ssp. Zygophylla*, *Dodonea cuneata*, forbs and grasses.

Apd1: Red-brown fine sand and silt with minor angular to subangular coarse sand to pebbles of quartz and weakly ferruginised sandstone and siltstone and minor subrounded maghemite granules. On broad plains with extremely subdued relief. Colonised by *Eucalyptus microcarpa*, *Allocasuarina luehmannii*, *Callitris glaucophylla*, *Acacia sp*., *Pittosporum philliraeoides*, *Geijera parviflora*, forbs and grasses.

Apd2: Red-brown fine sand and silt with minor angular to subangular coarse sand to pebbles of quartz and weakly ferruginised chert and minor subrounded maghemite granules. On broad plains with extremely subdued relief. Colonised by *Eucalyptus microcarpa*, *Allocasuarina luehmannii*, *Callitris glaucophylla*, *Acacia sp*., *Geijera parviflora*, minor *Eucalyptus sideroxylon*, forbs and grasses.

Apd4: Red-brown fine sand and silt with minor angular to subangular coarse sand to pebbles of quartz and weakly ferruginised mudstone, siltstone and sandstone and minor subrounded maghemite granules. On broad plains with extremely subdued relief. Colonised by *Eucalyptus microcarpa*, *Allocasuarina luehmannii*, *Callitris glaucophylla*, *Acacia sp*., *Geijera parviflora*, minor *Eucalyptus sideroxylon*, forbs and grasses.

Apd5: Red-brown fine sand and silt with minor angular to subangular coarse sand and granules of quartz and minor subrounded maghemite granules and possibly weathered rhyolite porphyry. On broad plains with extremely subdued relief. Colonised by *Eucalyptus microcarpa*, *Allocasuarina luehmannii*, *Callitris glaucophylla*, *Acacia sp*., minor *Pittosporum philliraeoides*, forbs and grasses.

Apd6: Grey clays and silt with angular to subangular coarse sand and granules of quartz and weathered granite lithics and minor red-brown fine sand and silt and minor subrounded maghemite granules. On broad plains with extremely subdued relief. Colonised by *Eucalyptus microcarpa*, *Eucalyptus populnea, Allocasuarina luehmannii*, *Callitris glaucophylla*, *Acacia sp*., *Geijera parviflora*, minor *Pittosporum philliraeoides*, shrubs, forbs and grasses.

Apd7: Red-brown fine sand and silt with minor angular to subangular coarse sand and granules of quartz and minor subrounded maghemite granules. On broad plains with extremely subdued relief. Colonised by *Eucalyptus microcarpa*, *Eucalyptus populnea, Allocasuarina luehmannii*, *Callitris glaucophylla*, *Acacia sp*., *Geijera parviflora*, minor *Pittosporum philliraeoides*, shrubs, forbs and grasses.

5.3 Colluvial sediments

Colluvial sediments comprise 10.9% of the area of the Tomingley 1:25,000 regolith-landforms map. Colluvium is present on all saprolith plains, rises and low hills in the area. Colluvium is present as sheetwash on discrete low-relief landforms and in depositional plains at the base of higher-relief landforms, in colluvial slopes on the side of high relief landforms and in erosional plains at the tops of high-relief landforms where there is little discernable outcrop. Colluvium is derived from most bedrock lithologies present in the map sheet, except for Goonumbla Volcanics and Hervey Group rocks, as slightly to moderately weathered and slightly ferruginised angular to subangular sands and gravels to pebble size. Colluvium also contains minor subangular to subrounded maghemite granules and a proportion of red-brown fine sand and silt, interpreted to represent an aeolian component (parna).

Cer1: Colluvium of angular coarse sand to cobbles of quartz and weakly ferruginised siltstone and sandstone lithics over minor outcrop of the same with joints opening, red-brown fine sand and silt and minor subrounded maghemite granules. On an undulating rise. Colonised by *Eucalyptus microcarpa*, *Callitris glaucophylla*, *Acacia sp*., *Geijera parviflora*, forbs and grasses.

Cer2: Colluvium of angular coarse sands to pebbles of quartz and weakly ferruginised chert lithics with red-brown fine sand and silt and minor subrounded maghemite granules. On rises flanking saprolith ridges. Colonised by *Eucalyptus sideroxylon*, *Eucalyptus microcarpa*, *Callitris glaucophylla*, *Acacia sp*., *Geijera parviflora*, forbs and grasses.

CHel1: Colluvium of angular to subangular coarse sand to pebbles of quartz and weakly ferruginised sandstone and siltstone lithics mixed with grey coloured angular to subangular coarse sands to pebbles of quartz and weathered granite lithics and minor red-brown fine sand and silt and grey clays. On low hills flanking granite saprolith ridges. Colonised by principally by forbs and grasses and sparse *Eucalyptus microcarpa*.

CHel6: Colluvium of angular to subangular sands and gravels of quartz and weathered granite with grey clays and minor red-brown fine sand and silt. On low hills flanking granite saprolith ridges. Colonised by forbs and grasses with minor *Eucalyptus microcarpa*, *Eucalyptus populnea, Allocasuarina luehmannii*, *Callitris glaucophylla*, *Acacia sp*. and shrubs.

CHep1: Colluvium of angular to subangular coarse sands to pebbles of quartz and weakly ferruginised sandstone and siltstone with red-brown fine sand and silt and minor subrounded maghemite granules. On low relief, round-topped undulating plains slightly elevated above surrounding alluvial plains or flanking saprolith plains. Colonised by forbs and grasses with minor *Eucalyptus microcarpa*, *Eucalyptus viridis*, *Callitris glaucophylla*, *Allocasuarina luehmannii* and *Geijera parviflora*.

CHep2: Colluvium of angular to subangular coarse sand to pebbles of quartz and weakly ferruginised chert lithics with red-brown fine sand and silt and minor subrounded maghemite granules. On low relief undulating plains generally flanking saprolith plains and rises. Colonised by *Eucalyptus microcarpa*, *Eucalyptus sideroxylon*, *Callitris glaucophylla*, *Acacia sp*., *Geijera parviflora*, shrubs, minor *Eucalyptus populnea,* forbs and grasses.

CHep4: Colluvium of angular to subangular coarse sand to pebbles of quartz and weakly ferruginised mudstone, siltstone and sandstone lithics with red-brown fine sand and silt and minor subrounded maghemite granules. On low relief undulating plains flanking saprolith plains and rises. Colonised by *Eucalyptus microcarpa*, *Eucalyptus sideroxylon*, *Callitris glaucophylla*, *Acacia sp*., *Geijera parviflora*, shrubs, forbs and grasses.

CHep5: Colluvium of angular to subangular coarse sand to pebbles of quartz and weathered rhyolite porphyry lithics with red-brown fine sand and silt and minor subrounded maghemite granules. On low relief undulating plains flanking saprolith plains and rises. Colonised by forbs and grasses.

CHep6: Colluvium of angular to subangular coarse sand to pebbles of quartz and weathered granite lithics with grey clays and minor red-brown fine sand and silt. On low relief undulating plains flanking saprolith plains and rises. Colonised by forbs and grasses with minor *Eucalyptus microcarpa*.

CHer1: Colluvium of angular to subangular coarse sands to pebbles of quartz and weakly ferruginised sandstone and siltstone with red-brown fine sand and silt and minor subrounded maghemite granules. On round-topped rises elevated above surrounding alluvial plains or flanking saprolith plains. Colonised by forbs and grasses with minor *Eucalyptus microcarpa*, *Eucalyptus viridis*, *Callitris glaucophylla* and *Allocasuarina luehmannii*.

CHer2: Colluvium of angular to subangular coarse sand to pebbles of quartz and weakly ferruginised chert lithics with red-brown fine sand and silt and minor subrounded maghemite granules. On undulating rises flanking saprolith plains and rises. Colonised by forbs and grasses with minor *Eucalyptus microcarpa*, *Eucalyptus sideroxylon*, *Callitris glaucophylla*, *Geijera parviflora* and *Acacia sp*.

CHer4: Colluvium of angular to subangular coarse sand to pebbles of quartz and weakly ferruginised mudstone, siltstone and sandstone lithics with red-brown fine sand and silt and minor subrounded maghemite granules. On undulating rises flanking saprolith plains and rises. Colonised by forbs and grasses with minor *Eucalyptus microcarpa*, *Eucalyptus sideroxylon*, *Callitris glaucophylla*, and *Acacia sp*.

CHer5: Colluvium of angular to subangular coarse sand to pebbles of quartz and weathered rhyolite porphyry lithics with red-brown fine sand and silt and minor subrounded maghemite granules. On undulating rises flanking saprolith plains and rises. Colonised by forbs and grasses and minor *Eucalyptus microcarpa*, *Eucalyptus sideroxylon* and *Acacia sp*.

CHer6: Colluvium of angular to subangular sands and gravels of quartz and weathered granite with grey clays and minor red-brown fine sand and silt. On rises flanking granite saprolith low hills. Colonised by *Eucalyptus microcarpa*, *Eucalyptus populnea, Allocasuarina luehmannii*, *Callitris glaucophylla*, *Acacia sp*., *Geijera parviflora*, shrubs, forbs and grasses.

CHpd2: Colluvium of subangular to subrounded coarse sand to pebbles of quartz and weakly ferruginised chert lithics with red-brown fine sand and silt and minor subrounded maghemite granules. On low relief undulating plains flanking colluvial and saprolith plains and rises. Colonised by forbs and grasses with minor *Eucalyptus microcarpa*, *Eucalyptus sideroxylon*, *Callitris glaucophylla* and *Acacia sp*.

CHpd4: Colluvium of angular to subangular coarse sand to pebbles of quartz and weakly ferruginised mudstone, siltstone and sandstone lithics with red-brown fine sand and silt and minor subrounded maghemite granules. On low relief undulating plains flanking colluvial and saprolith plains and rises. Colonised principally by forbs and grasses with rare *Eucalyptus microcarpa* and *Eucalyptus sideroxylon*.

5.4 Fill

Fill comprises ca. 0.9% of the area of the Tomingley 1:25,000 regolith-landforms map. Fill is principally composed of bulldozed or graded regolith in and surrounding farm dams, which may be situated on saprolith plains, rises and low hills, or within drainage depressions in the extensive alluvial plains that dominate the map area. Fill also includes mullock dumps composed of unweathered bedrock and saprolith of Goonumbla Volcanics at the Myalls United mine site. This has been spread laterally from the mine site and alluvium from these dumps is also visible on gamma-ray spectrometric imagery as a dispersion plume extending up to 500 m to the southwest of the mine site. Farm dams are useful for determining subsurface regolith distribution in the otherwise relatively featureless alluvial plains. Dam excavations in the northwest of the map sheet reveal that quartz and weathered granite lithic alluvial cover derived from the large Yeoval Batholith alluvial fan can be relatively thin, perhaps < 1 m in some places. This overlies red fine-grained sediments possibly derived from weathered Hervey Group and Dulladerry Volcanics (described in Roach 2006b).

Fm : Principally bulldozed or graded regolith in and surrounding farm dams. Also includes mullock dumps composed of unweathered bedrock and saprolith of Goonumbla Volcanics at the Myalls United mine site.

5.5 Saprolite and saprock

Saprolite- and saprock-dominated map units comprise ca. 1.9% of the area of the Tomingley 1:25,000 regolith-landforms sheet. Saprolite (very highly to moderately weathered bedrock) and saprock (slightly weathered bedrock) consist of the weathered parts of most of the bedrock lithologies that outcrop within the mapping area, except for Dulladerry Volcanics and Hervey Group rocks (described in Roach 2006b) that outcrop to the east of the map sheet. Saprolite and saprock are present in plains and rises in the southwest of the map area and in plains, rises and low hills, forming prominent ridges or tor fields, in the east of the map area. Saprolite and saprock may be slightly ferruginised and have a thin cover of angular to subangular colluvium with minor subangular to subrounded maghemite granules and a proportion of red-brown fine sand and silt, interpreted as an aeolian component (parna).

5.5.1 Saprolite

SMep1: Moderately weathered and slightly to moderately ferruginised sandstone and siltstone of the Cotton Formation with discontinuous cover of angular to subangular coarse sands to pebbles of quartz and weakly ferruginised sandstone and siltstone with red-brown fine sand and silt and minor subrounded maghemite granules filling opening joints and bedding planes. In round-topped plains slightly elevated above surrounding alluvial plains. Colonised by forbs and grasses with *Eucalyptus viridis* in the west and *Eucalyptus microcarpa*, *Allocasuarina luehmannii*, *Callitris glaucophylla*, *Geijera parviflora* and *Acacia sp*. in the east.

SMep2: Moderately weathered and slightly to moderately ferruginised quartz and chert of the Mugincobble Chert with discontinuous cover of angular to subangular coarse sand to pebbles of quartz and weakly ferruginised chert with red-brown fine sand and silt and minor subrounded maghemite granules filling opening joints and bedding planes. On undulating plains flanked by colluvial plains and rises. Colonised by *Eucalyptus microcarpa*, *Eucalyptus sideroxylon*, *Callitris glaucophylla*, *Acacia sp*., *Geijera parviflora*, shrubs, forbs and grasses.

SMep3: Moderately weathered and slightly to moderately ferruginised greenish porphyritic mafic volcanic lavas with a discontinuous cover of angular to subangular pebbles to cobbles of greenish porphyritic mafic volcanic lavas with red-brown fine sand and silt and minor subrounded maghemite granules. On undulating plains slightly elevated above flanking alluvial plains. Colonised by *Eucalyptus microcarpa*, *Callitris glaucophylla*, *Allocasuarina luehmannii*, *Acacia sp*., *Geijera parviflora*, forbs and grasses.

SMep4: Moderately weathered and slightly to moderately ferruginised quartz, mudstone, siltstone and sandstone with a discontinuous cover of angular to subangular pebbles to cobbles of quartz and weakly ferruginised mudstone, siltstone and sandstone with opening bedding planes and joints filled with red-brown fine sand and silt and minor subrounded maghemite granules. On undulating plains. Colonised by *Eucalyptus microcarpa*, *Eucalyptus sideroxylon*, *Callitris glaucophylla*, *Geijera parviflora*, *Acacia sp*., forbs and grasses.

SMep6: Moderately weathered and weakly ferruginised granite with discontinuous cover of grey clays and angular quartzose and lithic coarse sands to pebbles with minor red-brown fine sand and silt. On an undulating plain Colonised by forbs and grasses with minor *Eucalyptus microcarpa* and *Callitris glaucophylla*.

SMer2: Moderately weathered and slightly to moderately ferruginised quartz and chert with discontinuous cover of angular to subangular coarse sand to pebbles of quartz and weakly ferruginised chert with red-brown fine sand and silt and minor subrounded maghemite granules filling opening joints and bedding planes. On rises flanked by colluvial plains and rises. Colonised by *Eucalyptus microcarpa*, *Eucalyptus sideroxylon*, *Callitris glaucophylla*, *Acacia sp*., *Geijera parviflora*, shrubs, forbs and grasses.

SMer4: Moderately weathered and slightly to moderately ferruginised quartz and weakly ferruginised mudstone, siltstone and sandstone and discontinuous cover of angular to subangular pebbles to cobbles of quartz and weakly ferruginised mudstone, siltstone and sandstone with opening bedding planes and joints filled with red-brown fine sand and silt and minor subrounded maghemite granules.

On undulating plains. Colonised by forbs and grasses.

5.5.2 Saprock

SSel6: Slightly weathered and slightly ferruginised granite consisting of tors and pavements with a discontinuous cover of minor grey clays, quartz and granite lithic coarse sands to boulders. On a low hill of rugged well-forested landscape. Colonised by *Eucalyptus microcarpa*, *Eucalyptus populnea, Callitris glaucophylla*, *Geijera parviflora*, *Acacia sp*., shrubs, forbs and grasses.

SSer6: Slightly weathered and slightly ferruginised granite consisting of granite tors and pavements with discontinuous cover of minor grey clays, quartz and granite lithic coarse sands to boulders. On a rise of rugged well-forested landscape. Colonised by *Eucalyptus microcarpa*, *Eucalyptus populnea, Callitris glaucophylla*, *Geijera parviflora*, *Acacia sp*., shrubs, forbs and grasses.

6. IMPLICATIONS FOR LANDSCAPE EVOLUTION

The Tomingley area is bordered to the north and west by the Mesozoic Surat Basin (or Great Australian Basin; Sherwin 1996) and has a variety of variable-thickness transported regolith materials already noted, e.g., Chalmers *et al.* (2003), Bamford (2004), Bamford *et al.* (2004), Roach (2004), Roach & Walker (2005), Scott *et al.* (2005) and Roach (2006a). These range in age from Recent to possibly Mesozoic. *In situ* and transported regolith materials from a number of different sources are visible on aerial photography, airborne geophysics and satellite imagery. These form a complex surface of overlapping and inter-mixed materials that may have different background geochemical signatures depending on their original rock type and weathering grade. Pattern drilling by Alkane gives an insight into the three dimensional structure of the regolith over the Wyoming deposit, described in Bamford (2004) and Bamford et al. (2004). A limited regional landscape evolution model has been developed using this 3D information, together with a new RLU map, presented here and in Roach (2006b). This review is limited to the post-Mesozoic development of the mapping area. A reasonable pre-Mesozoic geological history is presented in Sherwin (1996).

Drilling over the Wyoming deposits reveals relatively simple stratigraphy in the sedimentary cover in this area, consisting of loamy soil overlying sandy alluvium with gravel lenses, mottled clay-rich alluvium and finally saprolith. Transported regolith is of variable thickness and ranges from 0 to > 60 m over the Wyoming 1 deposit (Bamford 2004; Bamford *et al.* 2004). Further pattern drilling and high-resolution aeromagnetics by Alkane have revealed a complex palaeochannel system over the deposits with drainage predominantly to the north-northwest (Rimas Kairaitis, Alkane, *pers. comm.* 2005). Drilling to the north of Tomingley in the Fiddlers Creek-Tomingley Creek valley indicates a valley-fill sequence with as much as 100 m of sedimentary cover (Rimas Kairaitis, Alkane, *pers. comm.* 2006). The maximum age of these palaeochannels is not known, because there has been no dating. It is possible that these are feeder drainage systems into the Mesozoic Surat Basin (Great Australian Basin), which lies to the northwest of the Tomingley area, however it is more likely that they are much younger. An interpretation of palaeodrainage channels is presented in Figure 8.

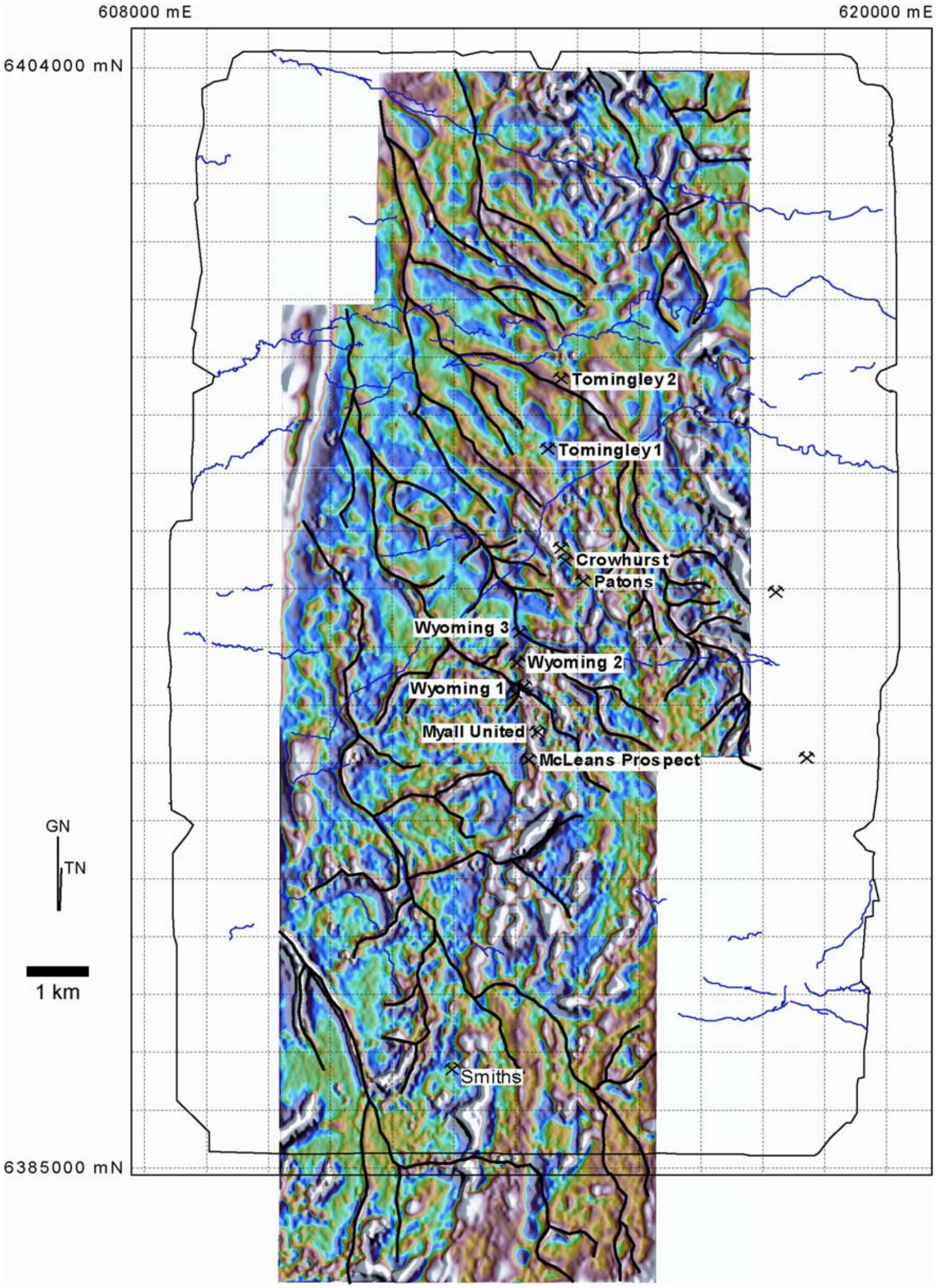

Figure 8: Interpreted N-NW-draining palaeochannels over the Tomingley 1:25,000 regolith-landforms map area. Outline of the Tomingley 1:25,000 regolith-landforms map is shown over a backdrop image of pseudocoloured, sun-shaded first vertical derivative (1VD) high-resolution aeromagnetics courtesy of Alkane. Known gold deposits are from Minview (2006).

Sediments were deposited in a landscape with at least 60 m, but possibly several hundreds of metres, of relief, in the Mesozoic or Tertiary. The landscape was already subaerially exposed and deeply weathered perhaps by the mid-Carboniferous (at least Late Palaeozoic), as shown by palaeomagnetic dating of mottles in weathered Goonumbla Volcanics at the Northparkes mine, south of Tomingley, by Pillans *et al.* (1999). There is evidence of widespread denudation in the Northparkes and Bathurst areas during the Middle Palaeozoic (Devonian-Carboniferous) during the time of rapid terrestrial sedimentation of the Hervey Range Group. There is also evidence of renewed denudation again, during the Late Cretaceous to Early Tertiary, possibly during a period of major mountain building in eastern Australia (Wellman 1979) and the filling of the Great Australian Basin. If apatite fission track thermochronology (AFTT) data from the Northparkes mine region (e.g., O'Sullivan *et al.* 1995; 2000) are valid, there was also a major denudation event during the Late Permian-Early Triassic interrupted by a period of major sedimentation between the Early Triassic and the Late Cretaceous. Thermochronology data indicating large several kilometre-scale denudation events followed by several kilometre-scale burial events are interpreted from the best evidence of the time, but often fail to correctly assess absolute denudation and burial amounts because of faults in the application of geothermal information (e.g., Roach 2000), which is sketchy. Therefore, thermochronology data are probably best restricted to use for broad times of major denudation rather than quantitative amounts.

The post-Carboniferous landscape contained the weathering products of subaerially exposed local rocks consisting of Goonumbla Volcanics but principally Hervey Range Group, Dulladerry Volcanics and Yeoval Batholith rocks, which would have been eroded in that order. Conjecturally, the lower, mottled clay-rich layer in the palaeochannel above the Wyoming deposits consists of a mixture of weathered Goonumbla Volcanics and possible Dulladerry Volcanics. Thin quartzose gravelly interbeds in the mottled clay-rich unit noted by Bamford (2004) could represent small amounts of quartzose material from the Goonumbla Volcanics, Dulladerry Volcanics and potentially Hervey Group sediments, carried along channel bottoms and point bars. Above this, the thick sandy unit with prominent gravely interbeds mostly likely indicates the lateral migration and vertical accession of the large quartzose and granite-lithic gravel-rich alluvial fan that crosses east to west across the north of the Tomingley regolith-landforms map. This fan originates from the Yeoval Batholith that lies to the east and spreads from a gap between the Hervey Range and the Sappa Bulga Range through which Tomingley and Gundong Creeks run. The sandy units represent alluvial plain deposits and the gravelly interbeds represent channel deposits. Finally, the loamy soil over the top of the Wyoming deposit represents the recent aeolian accession of red-brown fine sand and silt (parna) and its mixture, by bioturbation and alluvial-colluvial reworking, with the underlying sediments derived from all bedrock sources. Bamford (2004) and Bamford *et al.* (2004) noted increased calcium levels in the top 1 m of the soil profile, possibly signifying powdery regolith carbonate accumulations derived from calcium-rich parna.

Unfortunately, there has been no regolith dating of any kind performed successfully in the Tomingley area, the closest being the Northparkes mine, which yielded hematite fixation palaeomagnetic ages of Middle Carboniferous and Cainozoic (Pillans *et al.* 1999), and Peak Hill, which yielded hematite fixation ages of 12-15 Ma (Smith and Pillans 2005; Smith 2006). There were attempts to date the transported sediments above the Wyoming deposits using palynology, however, these samples were either contaminated with modern pollens or were barren (L. Stoian *pers. comm.* to K.G. McQueen 2004). Therefore, all we can say with certainty is that the transported sediments are younger than Middle Carboniferous and older than present day.

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