Cooperative Research Centre for Landscape Environments and Mineral Exploration

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EXPLANATORY NOTES FOR THE CANBELEGO 1:100,000 REGOLITH-LANDFORM MAP NEW SOUTH WALES

Ian C. Roach

CRC LEME OPEN FILE REPORT 238

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

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Addresses and affiliations of Authors:

I.C. Roach
Geoscience Australia
PO Box 378
CANBERRA
ACT 2601

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

PREFACE AND EXECUTIVE SUMMARY

The Canbelego 1:100,000 regolith-landform map adds to a 1:100,000 scale regolith-landform mapping program conducted in the Cobar region that also includes the Byrock, Sussex, Coolabah and Hermidale 1:100,000 regolith-landform maps. This volume describes the procedures and outcomes of 1:100,000 scale mapping in the Canbelego 1:100,000 map area.

This report provides details and/or discussion regarding:

- The location, geological, landscape and present climatic setting of the map area;
- Regolith-landform mapping methods and results in the map area;
- The geophysical signatures of different regolith-landform units in the map area;
- Possible landscape evolution scenarios for the area; and,
- Implications of the nature of the mapped regolith-landforms for future minerals exploration in the map area.

The Canbelego 1:100,000 regolith-landform map gives mineral explorers and land managers a new insight into the nature, sources and dispersion pathways of regolith materials in the Canbelego map area. This knowledge will be valuable for modifying mineral exploration models and land management practices.

Dr Ian C. Roach
CRC LEME, Australian National University

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Abstract

The Canbelego 1:100,000 regolith-landform map characterises regolith materials and landforms in the Canbelego sheet, number 8134, of the Australia. 1:100,000 map series. The map is approximately 2628 km^2 of which approximately 39.2% is colluvial regolith-landforms, 38.7% is alluvial regolith-landforms, 22% is saprolith regolith landforms and 0.02% man-made fill. The Canbelego 1:100,000 map area has approximately 227 m of relief with low-relief drainage emanating almost radially from its centre, all draining eventually into the Murray-Darling Basin. The map area is partially forested with remnant native vegetation in timber reserves and state forests. The Canbelego area is the focus of historic and active hard-rock gold and base metal mining activities and remains a focus for regional minerals exploration. The Canbelego 1:100,000 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, and for land managers to better understand surface materials and landscapes in which they occur.

1. INTRODUCTION

This report summarises the Canbelego 1:100,000 regolith-landform map (CANBELEGO), number 8134 of the Australian 1:100,000 map series. The report details the location, mapping methodology, regional geology and regolith-landforms mapped and also discusses some of the implications of the landscape evolution in the mapping area for land managers and minerals explorers. CANBELEGO was produced as a private consultancy for Cobar Management Pty. Ltd. Mapping commenced in September 2007 and was completed in January 2008.

2. SITE DESCRIPTION

2.1 Location and previous mapping

CANBELEGO lies to the southeast of Cobar in central-western New South Wales (Figure 1) within the Cobar (SH/54-14) 1:250,000 sheet area (Figure 2).

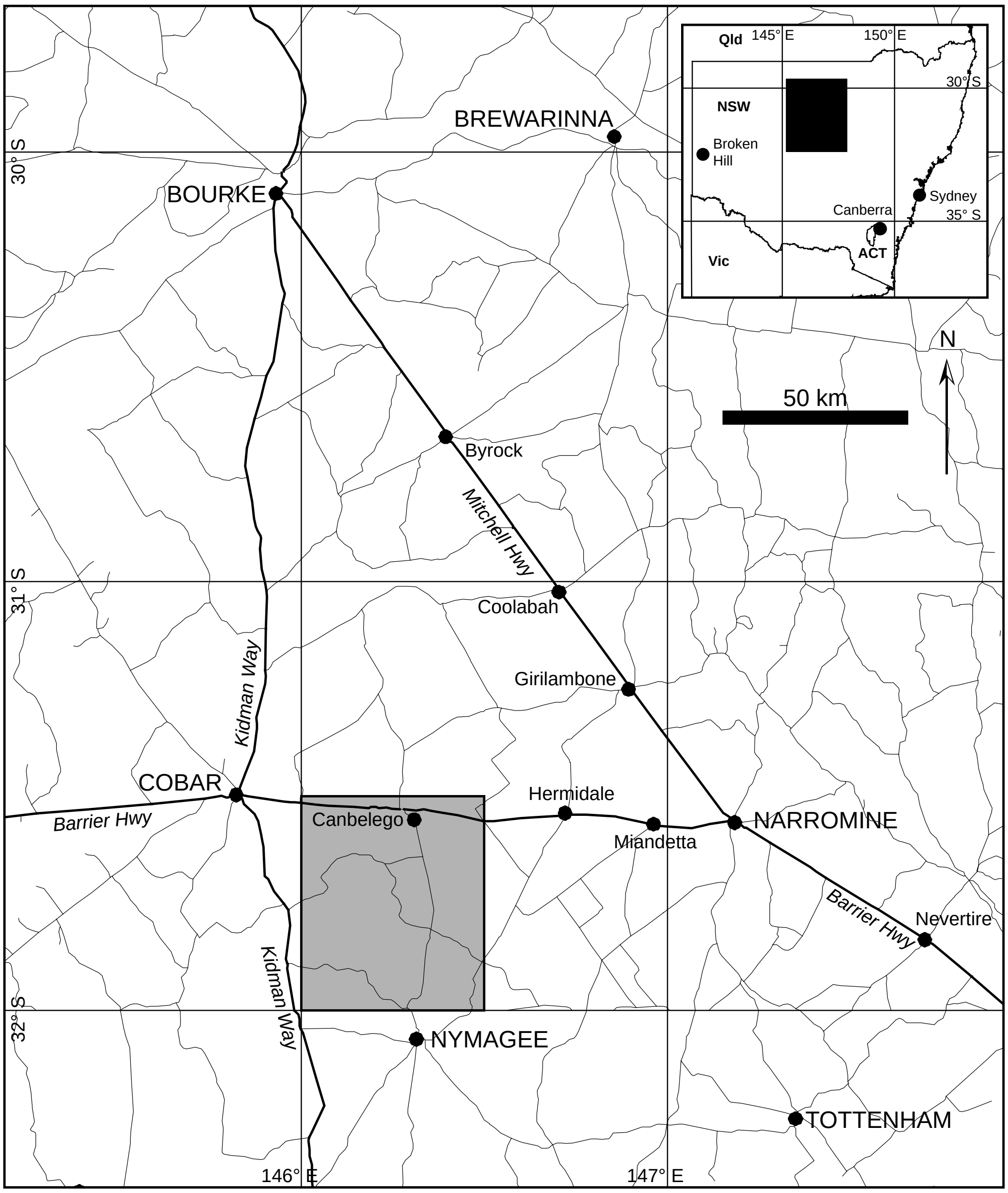


Figure 1: Location map of CANBELEGO (shaded) in relation to selected major and minor settlements in the region.

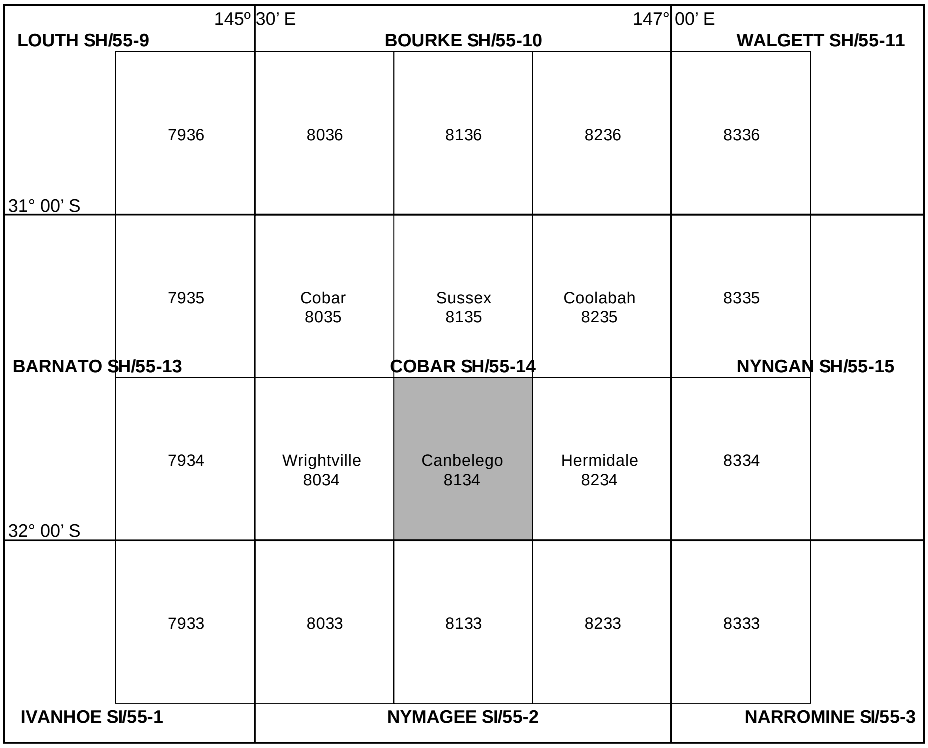


Figure 2: Location of CANBELEGO in relation to other 1:100,000 and 1:250,000 sheets in the region. 1:250,000 sheet names and numbers are in uppercase bold, 1:100,000 sheet names and numbers in normal font.

CANBELEGO is approximately 2,628 km^2 and contains the small settlement of Canbelego, situated near the Mt Boppy mine site in the northeast of the map area. CANBELEGO is located between 146° 00' and 146° 30' east longitude and 31° 30' and 32° 00' south latitude. These coordinates translate approximately to 405033 mE and 6514550 mN (top left) and 452772 mE and 6459455 mN (bottom right) corner coordinates of the Map Grid of Australia using the Geocentric Datum of Australia 1994.

CANBELEGO is bordered to the north and east by the Sussex, Coolabah and Hermidale 1:100,000 regolith-landforms map sheets (SUSSEX-COOLABAH, HERMIDALE). These maps were released as part of mapping work by staff and students of the Cooperative Research Centre for Landscape Environments and Mineral Exploration. They accompanied a series of publications, including Chan *et al.* (2003a, b) and Chan *et al.* (2004). Other regolith-landforms maps in the local area include that of Spry (2003) at 1:250,000 scale, which covers part of CANBELEGO. The geology of CANBELEGO was mapped by Felton (1981) following earlier mapping of the Cobar 1:250,000 geological sheet by Brunker (1967, 1969).

2.2 Access

CANBELEGO has good all-weather access across the north of the area on the sealed Barrier Highway and approaches from the southwest, south and southeast along the sealed Kidman Way and from a part-sealed road leading from the Kidman Way to Nymagee and Hermidale. The north-south gravel Canbelego-Nymagee road allows access to the entire eastern side of the area and is accessible in most weather except severe rain. The remainder of the roads consist of farm tracks and are dry weather-only; there are also many locked gates and "no trespassing" signs on these. The Cobar to Narromine rail line follows parallel to the Barrier Highway and has limited access, as does the main electrical power line to Cobar.

2.3 Climate

CANBELEGO lies between weather recording stations at Cobar and Nymagee. Climate data from these two stations are quite similar, therefore statistics from the Australian Bureau of Meteorology (BOM 2008) pertaining to Cobar are quoted here. Cobar is in the Köppen Grassland zone (semi-arid zone) of eastern Australia (Stern *et al.* n.d.), experiencing hot summers and cold winters. Temperatures fluctuate from a mean maximum of 33.9ºC in January (highest ever recorded 47ºC on 15 January 2001) to a mean minimum of 15.8ºC in June (lowest ever recorded -2.5ºC on 09 August 1994) (Figure 3). Mean rainfall is 393.8 mm, however, the average annual evaporation rate is between 2000 and 2400 mm. Rainfall is regarded as uniform and is distributed more-or-less evenly across the year but peaks slightly in January-February, most likely as the result of summer thunder storms from moist north-westerly tropical airflows. Winds are dominated by stronger westerly, south-westerly and southerly airflows; winds from other points of the compass are generally lighter (Figure 4).

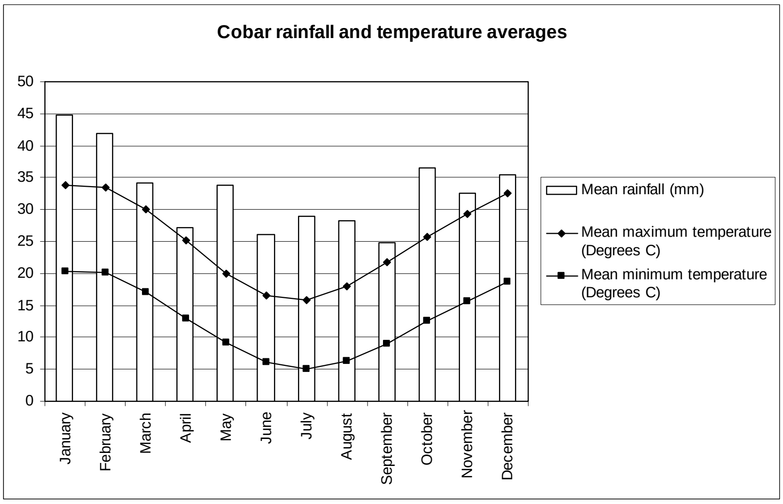


Figure 3: Cobar temperature and rainfall averages 1962-2007 from BOM (2008).

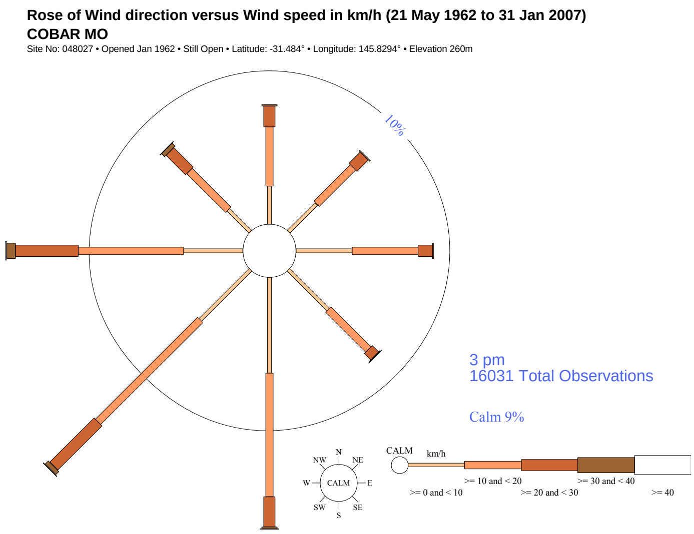


Figure 4: Cobar wind rose from BOM (2008).

2.4 Land use

CANBELEGO is predominantly used for cattle grazing however mixed feed cropping occurs in extensively cleared low-lying areas. Crops are often not successful because of frequent drought, therefore much of the land lies fallow during these times, turned over to feral animals including pigs and goats. Feral goats are often the only source of income for landholders during drought times. Mineral exploration activities occur over much of CANBELEGO. See Section 3.2 for further information.

2.5 Dominant vegetation-landscape associations

Vegetation on CANBELEGO conforms broadly to the bimble box-ironwood-mulga association of Beadle (1948). This association includes *Eucalyptus populnea* (bimble box or poplar box) in drainage depressions, *Acacia excelsa* (ironwood) on colluvial plains and *Acacia aneura* (mulga) on bedrock–dominated or sandy areas. CANBELEGO is now recognised as being part of the Cobar Peneplain Bioregion, containing parts of the Canbelego Downs and Nymagee Downs Subregions (Sahukar *et al.* 2003). Dominant and common species occurring on CANBELEGO are listed in Table 1. Plant names are taken from Costermans (1981), Cunningham *et al.* (1992) and Moore (2005).

Table 1: Dominant and some common plant species occurring on CANBELEGO.

Family/subfamily	Species	Common name
Asclepiadaceae	*Sarcostemma viminale*	caustic bush
Capparaceae	*Capparis mitchellii*	native orange
	Apophyllum anomalum	warrior bush
Casuarinaceae	*Casuarina pauper*	belah
Chenopodiaceae	*Sclerolaena sp.*	Copperburrs, galvanised burr, bathurst burr
Cupressaceae	*Callitris glaucophylla*	white cypress pine
Fabaceae	*Bossiaea walkerii*	shrub cactus
	Senna artemisioides	silver cassia
Malvaceae	*Brachychiton populneus*	kurrajong
Mimosoideae	*Acacia aneura*	mulga
	Acacia colletioides	spinebush, pin bush, wait-a-while
	Acacia rigens	needle wattle
	Acacia excelsa	ironwood
	Acacia decora	western golden wattle
	Acacia homalophylla	yarran
	Acacia pendula	weeping myall
Myoporaceae	*Eremophila mitchellii*	budda
	Eremophila sturtii	turpentine
	Eremophila maculata	spotted emu bush
Myrtaceaea	*Eucalyptus populnea*	bimble box, poplar box
	Eucalyptus intertexta	gum-barked coolabah, red box
	Eucalyptus socialis	red mallee
Pittosporaceae	*Pittosporum philliraeoides*	weeping pittosporum, butterbush
Proteaceae	*Hakea leucoptera*	needlewood
Rutaceae	*Geijera parviflora*	wilga
Sapindaceae	*Dodonea cuneata*	wedge-leafed hop bush
	Dodonea lobulata	lobe-leafed hop bush
	Alectryon oleifolius	rosewood, cattlebush

Some of the land in CANBELEGO is partially or fully cleared, however stony rises and hills contain much remnant vegetation, and several state forests occur within the area including the Canbelego State Forest (Surrounding Canbelego township) and the Barrow State Forest (between Canbelego and Nymagee), together with timber reserves. The area is also subject to much woody weed infestation of pre-European grasslands following heavy grazing, resulting in abundant regrowth of *Eremophila*, *Dodonea* and *Senna spp*. which are unpalatable to cattle (Sahukar *et al.* 2003).

Vegetation associations on CANBELEGO fall into several groups principally controlled by landscape position, availability of water and substrate type. These include:

1. Alluvial plains and drainage depressions;
2. Colluvial plains, rises and hills; and,
3. Bedrock-dominated rises and hills

1. Alluvial plains and drainage depressions:

These landscapes have silty to clayey soils with scattered gravel lags and, where uncleared, are dominated by woodlands, principally of monocultural stands of *Eucalyptus populnea* along drainage channels and in swamps where water supply is greater. Woodlands of *Eucalyptus intertexta* occur in the headwaters of drainage depressions where water supply is not sufficient to satisfy *Eucalyptus populneus*. Alluvial plains and drainage depressions also host scattered *Acacia excelsa*, *Acacia decora*, *Acacia homalophylla*, *Acacia colletioides* and *Acacia pendula*, together with scattered *Callitris glaucophylla*, *Capparis mitchellii*, *Apophyllum anomalum*, *Alectryon oleifolius* and rare *Pittosporum philliraeoides*, with an understory of *Geijera parviflora* (occasionally free-standing), *Eremophila mitchellii*, *Eremophila sturtii*, *Eremophila maculata*, grasses, forbs and widespread *Sclerolaena sp*.

2. Colluvial plains, rises and hills:

These landscapes have gravelly, normally well-drained soils (except for colluvial depositional plains, which are more clay-rich and are more related in materials to alluvial plains) and generally favour species adapted to needing less water. Where uncleared, these landscapes are dominated by woodlands consisting of mixed or occasionally monocultural stands of trees including *Callitris glaucophylla*, *Eucalyptus populnea*, *Eucalyptus intertexta*, *Eucalyptus socialis* (often as monocultures on more elevated sites), *Acacia aneura* (occasionally as monocultures on stonier sites), *Geijera parviflora*, *Acacia excelsa* and scattered *Casuarina pauper*, *Brachychiton populneus*, *Capparis mitchellii*, *Apophyllum anomalum* and *Alectryon oleifolius.* Woodlands have an understory commonly consisting of *Eremophilla sp.*, *Acacia homalophylla*, *Acacia decora*, *Dodonea sp.*, *Hakea leucoptera*, scattered *Sarcostemma viminale*, forbs, grasses and widespread *Sclerolaena sp*.

3. Bedrock-dominated rises and hills:

These landscapes commonly have a very thin lithosol mantle over bedrock. Where uncleared, dominant species found on these sites include monocultures or mixed woodlands of *Eucalyptus socialis*, *Casuarina pauper* on some ridgetops, *Callitris glaucophylla* and *Eucalyptus intertexta*. Less dominant tree species include *Eucalyptus populnea* in small drainage depressions and scattered *Acacia aneura* and *Brachychiton populneus*, with an understory of scattered *Acacia decora, Hakea leucoptera, Eremophila sp., Acacia sp., Dodonea cuneata* and *Dodonea lobulata*, *Senna artemisioides* and large numbers of *Bossiaea walkerii* in *Eucalyptus socialis* forest along the Canbelego-Nymagee Road near Koree Station.

The presence of regolith carbonate accumulations (RCA, including calcrete) commonly correlates with large stands of *Apophyllum anomalum*. In many cases these occur in powdery soils where rabbit burrows are common. These associations are also noted on SUSSEX and BYROCK.

3. GEOLOGY AND PHYSIOGRAPHY

3.1 Local geology

Summarised from Felton (1981), the geology of CANBELEGO (Figure 5) contains five broad geological age units:

1. Quaternary material consists mainly of alluvium containing red-brown fine sand and silt and common ferruginous gravel with minor maghemite. The red-brown fine sand and silt contains a large identifiable aeolian dust component (parna), consisting of sand- and silt-sized clay microaggregates and silt-sized quartz grains described by Greene *et al.* (2002), Tate *et al.* (2003) and Chan *et al.* (2003a, 2004).
2. Cenozoic unconsolidated gravel deposits consist of rounded to well-rounded quartz, quartzite and chert sand, pebbles, cobbles and boulders. These may be indurated by silica to form silcretes near The Rookery and Kopyje Stations and near the abandoned Florida rail siding.
3. Devonian material consists of rocks of the Cobar Supergroup including sandstone, siltstone, shale, limestone, conglomerate, rhyolite, dacite, diorite, airfall tuff, ignimbrite and agglomerate. These were deposited or intruded in a range of environments from sub-aerial to shallow- to deep-marine and also contain the mine sequence for the CSA Mine – the CSA Siltstone. Rocks are subject to generally low-grade regional metamorphism (formation of small white mica flakes) and feature open, upright, mostly symmetrical folds with prominent axial plane cleavages.
1. Silurian material consists of rocks of the Nymagee Igneous Complex consisting of gneissic granite, porphyritic granite, foliated granite, equigranular granite and minor migmatite, granodiorite, microgranite, pegmatite and aplite. Rocks are assumed to be of Silurian age because they intrude the Girilambone Beds below and are unconformably overlain by Early Devonian Cobar Supergroup rocks. Potassium-argon ages on muscovite gave ages of 409-411 ± 6 Ma.
4. Ordovician material consists of rocks of the Girilambone Beds are the most commonly outcropping bedrocks on CANBELEGO. These rocks comprise turbidite sequences including sandstone, greywacke, phyllite, chert and some altered basic volcanics. Rocks are low- to locally medium-grade metamorphosed from greenschist to amphibolite faces and are complexly folded.

3.2 Economic geology

A range of known hard rock, soft rock and residual mineral deposits and prospects occur on CANBELEGO (Figures 6a, 6b). Deposits occur principally around Canbelego-Mt Boppy within the Cobar Supergroup rocks, but minor vein-type deposits also occur within the Girilambone Beds, particularly along small shear zones where vein quartz is crystallised. A good overview of mineralisation is given in Felton (1981) and some details are also found in Markham and Basden (1975). Deposit types, deposit numbers from the Cobar 1:250,000 metallogenic sheet of Gilligan and Byrnes (1995) and deposit names are given in Table 2.

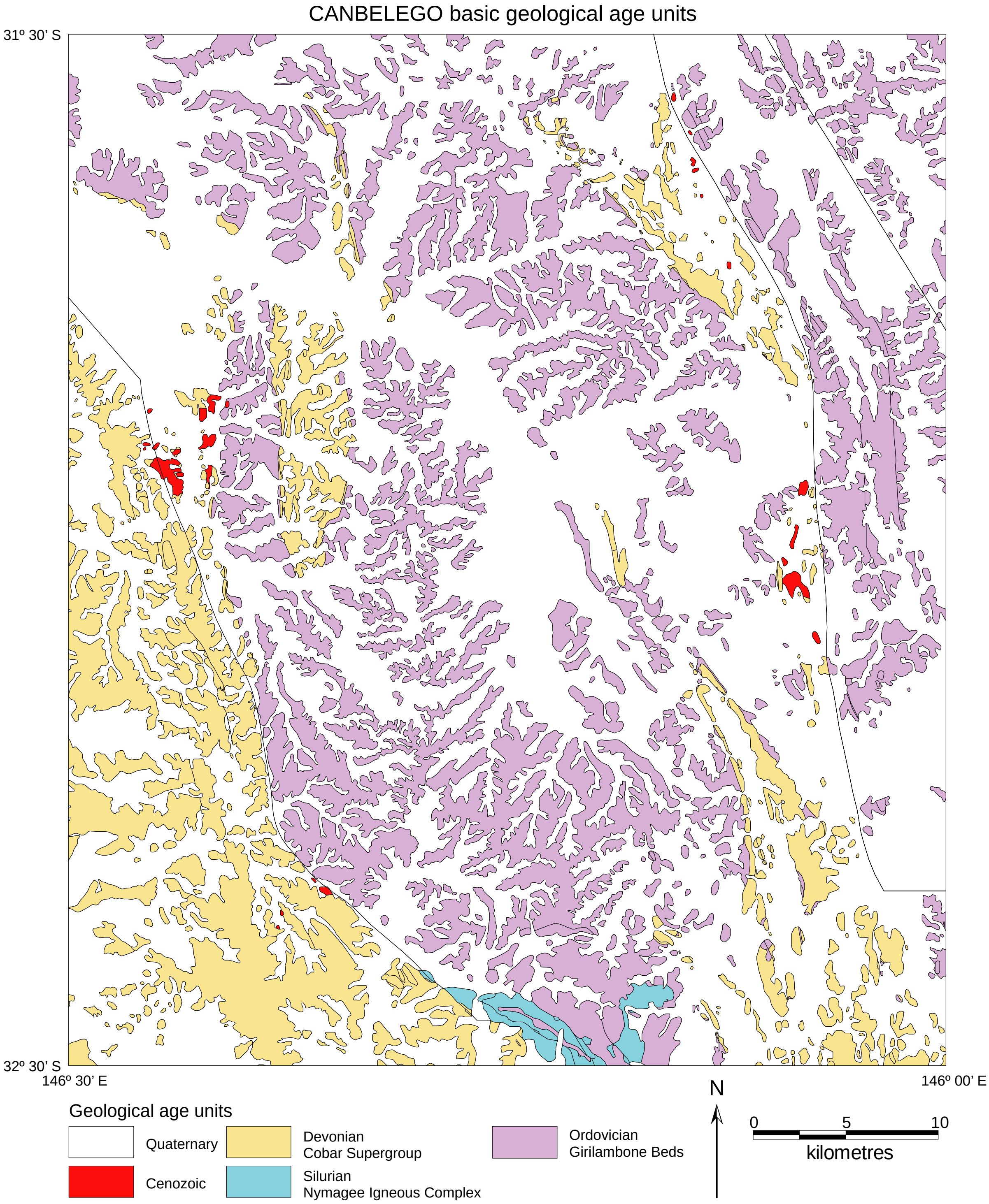
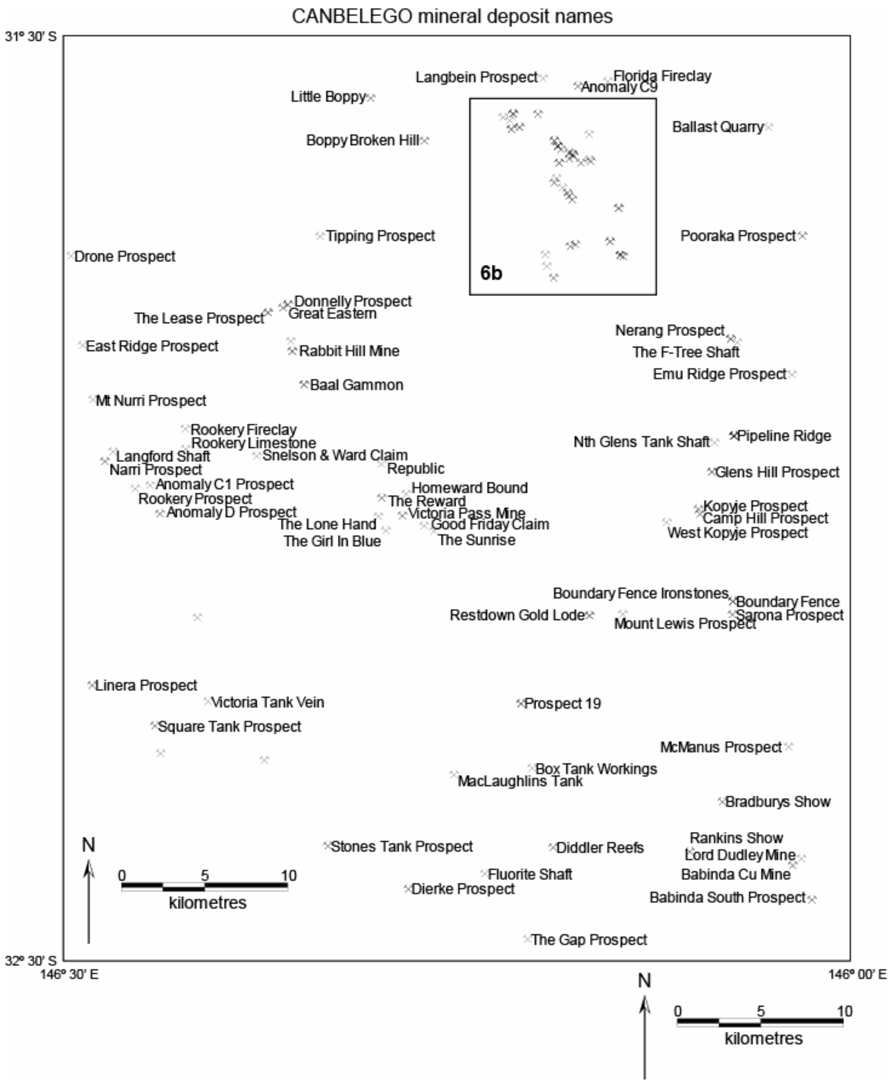


Figure 5: Simplified geological map of CANBELEGO after Felton (1981).



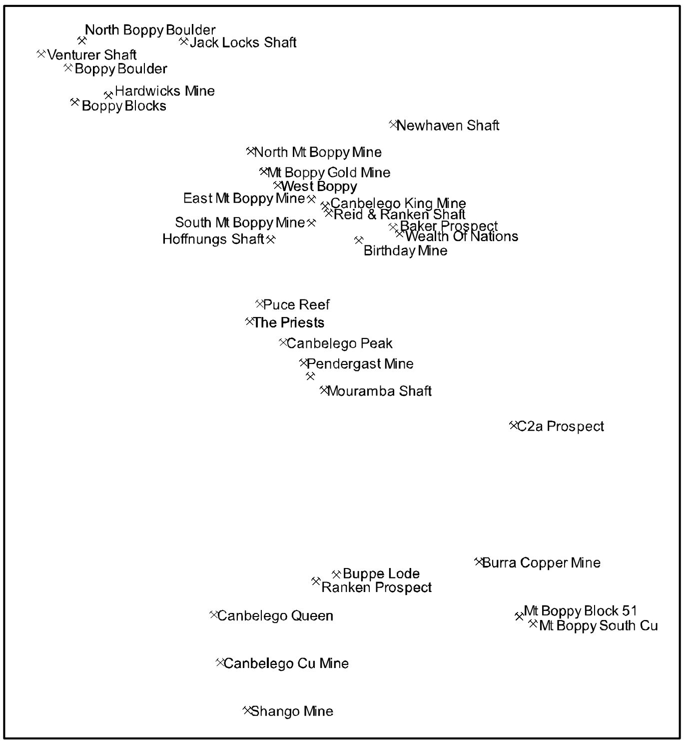


Figure 6a (above), 6b (left): Mineral deposit locations and deposit names on CANBELEGO. From Minview (2007) after Gilligan and Byrnes (1995).

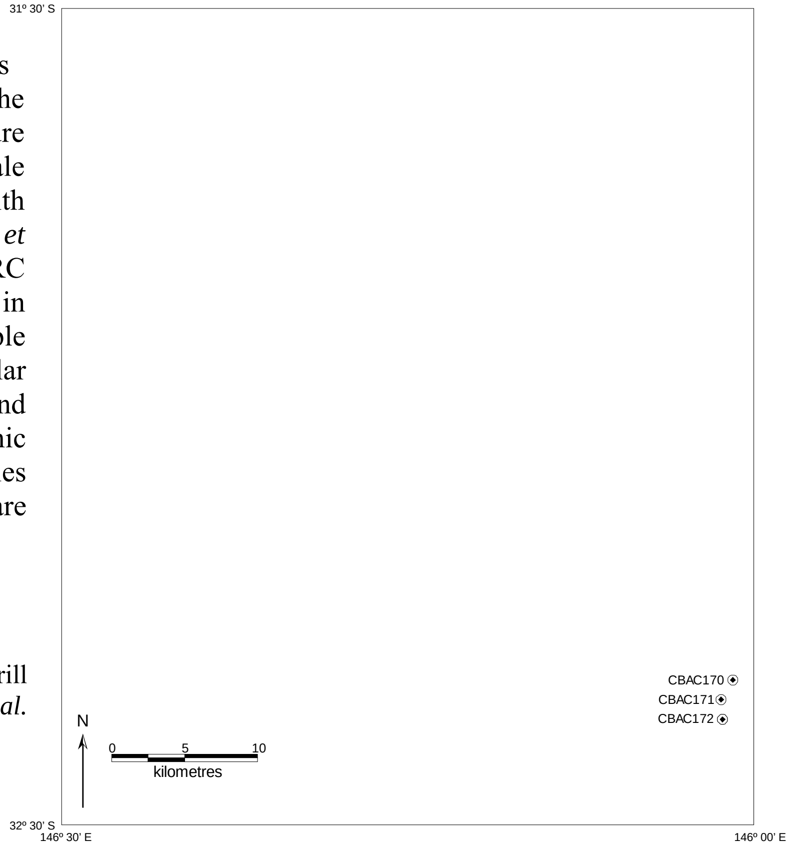
Table 2: Deposit types, deposit numbers and deposit names from the Cobar 1:250,000 metallogenic sheet after Gilligan and Byrnes (1995) from Minview (2007).

Cobar Type	Polymetallic vein	Vein Pb
CO0139 Narri Prospect	CO0130 Drone Prospect	CO0137 Mt Nurri Prospect
CO0140 Rookery Prospect	CO0144 The Lease Prospect	CO0215 Anomaly D Prospect
	CO0145 Great Eastern	
Construction/industrial	CO0148 Rabbit Hill Mine	Unclassified Pb
CO0204 Ballast Quarry	CO0149 Baal Gammon	CO0230 Dierke Prospect
CO0141 Rookery Fireclay	CO0178 C2a Prospect	
CO0187 Florida Fireclay	CO0196 Nerang Prospect	VHMS unassigned
CO0142 Rookery Limestone	CO0198 Camp Hill Prospect	CO0153 Venturer Shaft
CO0261 Fluorite Shaft	CO0199 Kopyje Prospect	CO0154 Boppy Boulder
	CO0200 Glens Hill Prospect	CO0157 Hardwicks Mine
Orogenic Au	CO0203 Emu Ridge Prospect	CO0158 Jack Locks Shaft
CO0235 Restdown Gold Lode	CO0228 Victoria Tank Vein	CO0159 Langbein Prospect
CO0235 Restdown Gold Lode	CO0231 MacLaughlins Tank	CO0160 North Mt Boppy Mine
CO0260 Stones Tank Prospect	CO0235 Anomaly C1 Prospect	CO0161 West Boppy
	CO0240 Boundary Fence Ironstones	CO0162 Mt Boppy Gold Mine
Vein Au	CO0242 Lord Dudley Mine	CO0163 Hoffnungs Shaft
CO0138 Langford Shaft	CO0262 Box Tank Workings	CO0164 East Mt Boppy Mine
CO0146 Donnelly Prospect		CO0165 South Mt Boppy Mine
CO0151 Little Boppy	Residual Fe-Mn	CO0166 Newhaven Shaft
CO0155 North Boppy Boulder		CO0167 Canbelego King Mine
CO0161 The F-Tree Shaft	CO0150 Tipping Prospect	CO0168 Reid & Ranken Shaft
CO0188 The Lone Hand	CO0156 Boppy Blocks	CO0169 Baker Prospect
CO0189 The Girl In Blue	CO0226 *no name given*	CO0170 Wealth Of Nations
CO0191 Victoria Pass Mine		CO0171 Birthday Mine
CO0192 Good Friday Claim	Unclassified base metal	CO0174 Canbelego Peak
CO0193 The Sunrise	CO0133 Anomaly C9	CO0175 Pendergast Mine
CO0194 The Reward	CO0136 East Ridge Prospect	CO0176
CO0195 Republic	CO0172 Puce Reef	CO0179 Buppe Lode
CO0197 West Kopyje Prospect	CO0173 The Priests	CO0180 Ranken Prospect
CO0201 Nth Glens Tank Shaft	CO0177 Mouramba Shaft	CO0182 Canbelego Cu Mine
CO0232 Prospect 19	CO0224 Linera Prospect	CO0183 Shango Mine
CO0234 Diddler Reefs	CO0227 *no name given*	CO0184 Burra Copper Mine
	CO0231 Sarona Prospect	CO0185 Mt Boppy Block 51
Vein Au-Cu	CO0236 Mount Lewis Prospect	CO0186 Mt Boppy South Cu
CO0243 Babinda South Prospect	CO0238 Bradburys Show	CO0202 Pipeline Ridge
	CO0239 Boundary Fence	
Unclassified Au		Unknown type
CO0190 Homeward Bound	Unclassified Cu	CO0233 The Gap Prospect
	CO0143 Snelson & Ward Claim	
Vein Ag	CO0230 Pooraka Prospect	
CO0225 Square Tank Prospect	CO0241 Babinda Cu Mine	
Vein Cu	Unclassified Fe-Mn	
CO0147 *no name given*	CO0233 McManus Prospect	
CO0152 Boppy Broken Hill		
CO0181 Canbelego Queen		
CO0229 *no name given*		
CO0237 Rankins Show		

3.3 Regolith stratigraphy

Three reverse-circulation (RC) holes were drilled through the regolith in the far southeast of CANBELEGO (Figure 7), along the Nymagee-Hermidale road, as part of mapping and regolith geochemical investigations by Chan *et al.* (2003b) on HERMIDALE. The RC holes, CBAC170-172, were logged in 1 m intervals and revealed a simple stratigraphy of up to 9 m of subangular to subrounded quartz sand and granules, clay, bedrock lithic fragments and ferruginous granules including maghemite. Logs are included in the appendix.

Figure 7 (right): Location of RC drill holes on CANBELEGO. After Chan *et al.* (2003b)



3.4 Physiography

The total elevation across CANBELEGO ranges from ca. 214 m above sea level (mASL) to ca. 507 mASL for a total relief of ca. 293 m, based on the Space Shuttle Radar Topography Mission 2nd edition Digital Elevation Model (SRTM2 DEM) (Figure 8).

CANBELEGO encompasses a variety of landforms including plains (0-9 m relief), rises (9-30 m relief), low hills (30-90 m relief) and hills (90-300 m relief). The landscape of CANBELEGO is dominated by low-relief alluvial-colluvial plains of Yanda Creek, which drains into the Darling River, and other smaller creeks. Erosion-resistant bedrocks of the Girilambone Beds, Nymagee Igneous Complex and the Cobar Supergroup (refer to Figure 5 for locations) form low ridges (here classified as rises, low hills and hills) and discrete, stand-alone rises, low hills and hills, principally along strike of the resistant units. Drainage is partly radial around elevated resistant bedrock in the south-central part of the area and is controlled in part by resistant bedrock units but also by basement faults including the Elliston, Rookery, Barrow and Coonara Faults, described by Felton (1981). Small colluvial pediments exist at the bases of some of the larger landforms and several small alluvial fans are mapped at the floodouts of streams leading into alluvial plains. Extensive low-relief pediments of colluvial sheetwash extend out into the drainage systems of the major creeks in the area.

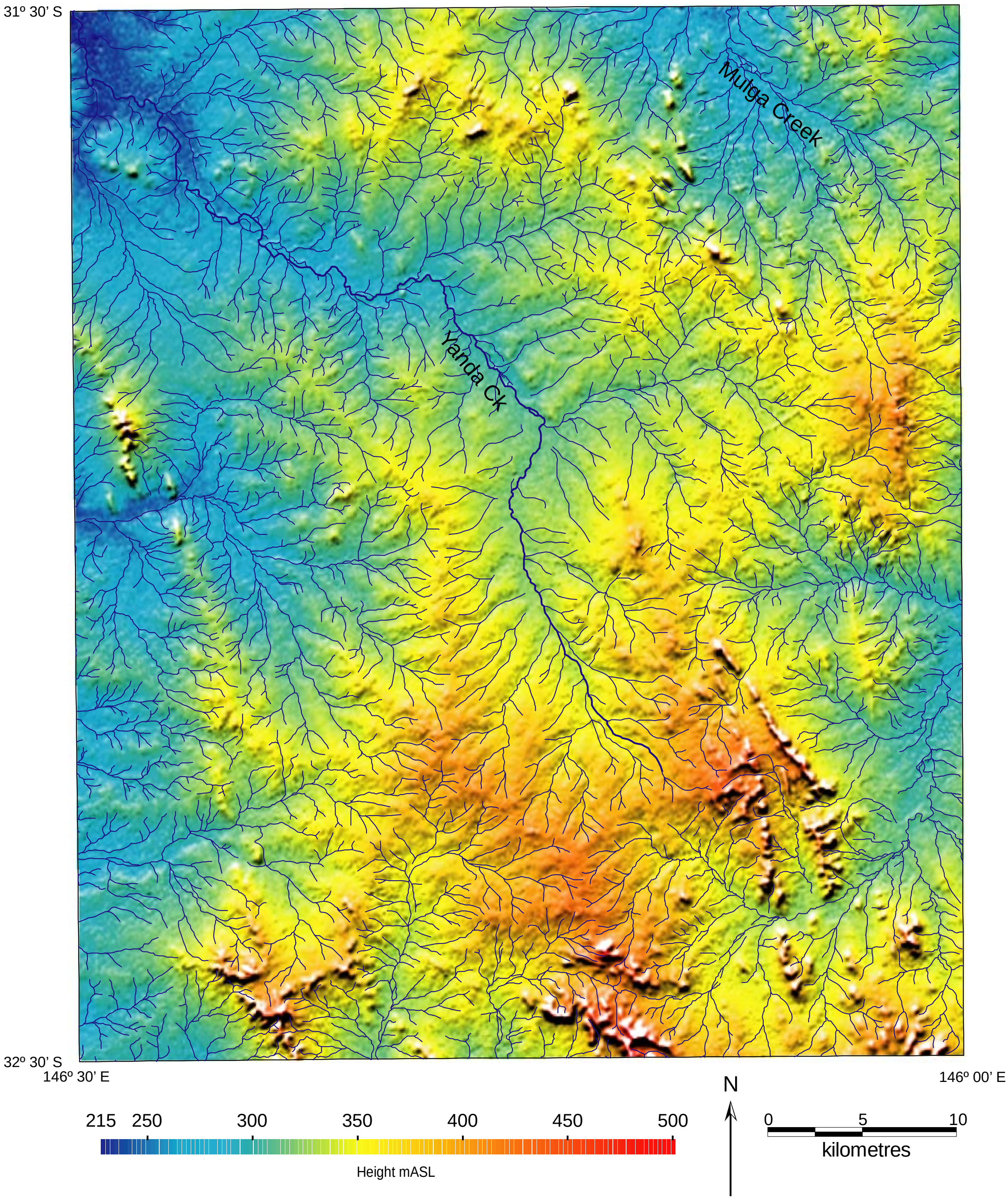


Figure 8: SRTM2 DEM of CANBELEGO highlighting the broad relief of the area and the drainage network. DEM is sunshaded from the NE and is courtesy of USGS.

4. REGOLITH-LANDFORM MAPPING METHODS

4.1 Work program

The compilation of CANBELEGO was completed in January 2008 after fieldwork in September 2007. Once individual field site descriptions were collected, site data were transferred to MapInfo GIS and linework was initially compiled over orthorectified 1:75,000 scale SPOT satellite images courtesy of the Geological Survey, New South Wales Department of Primary Industries (NSW DPI). Once completed, line overlays were scanned and raster-to-vector converted for entry into MapInfo GIS, where they were cleaned up and corrected. Final polygons were compiled from linework concluding in early January 2008.

4.2 Mapping Technique

Site descriptions and ground control points were collected during fieldwork using a Garmin hand-held GPS receiver which typically displayed a quoted spherical error of 5 m. Regolith-landform units (RLUs) are described using the RTMAP system developed by Geoscience Australia (Pain *et al.* 2007). The system uses an alphanumeric code to describe the dominant regolith materials and the dominant landform occurring in each polygon, together with a numerical identifier that can be used to separate polygons with similar materials and landforms but which have other important differences. The RLU codes use a capitalised regolith materials descriptor and lower case landform descriptor:

CHpd1

In this case, the RLU code describes colluvial sheetwash material (CH) on a depositional plain (pd) of type 1 (in this case the numerical descriptor separates CHpd units with and without a particular type of surface lag). Regolith-landform unit codes used in CANBELEGO are listed in Table 3.

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.

These data are included in this report (see Section 6 of this report) and as an abbreviated form in the digital map.

Table 3: RLU codes used on CANBELEGO and their explanations.

RLU codes for regolith materials depicted here are:		RLU codes for landforms used here are:		RLU modifier codes used here reflect different dominant lag types:	
A	alluvial sediments	ah	alluvial channel	1	Dominantly angular to subangular bedrock gravel lag with minor angular to rounded maghemite sand and gravel.
AC	alluvial channel sediments	ap	alluvial plain (with numerous small drainage depressions, low relief)	2	Dominantly rounded to well-rounded maghemite gravel lag with minor angular to rounded bedrock gravel and maghemite sand lag.
C	colluvial sediments	aw	alluvial swamp (low relief)		
CH	colluvial sheetflow sediments	ed	erosional drainage depression (variable relief)		
F	fill	ep	erosional plain (0-9 m relief)		
SS	slightly weathered bedrock (saprock)	er	erosional rise (9-30 m relief)		
SM	moderately weathered bedrock (saprolite)	el	erosional low hill (30-90 m relief)		
SH	highly weathered bedrock (saprolite)	eh	erosional hill (90-300 m relief)		
		fa	alluvial fan (low relief)		
		m	man-made		
		pd	depositional plain (with no significant drainage depressions, low relief)		

5. REMOTE SENSING AND AIRBORNE GEOPHYSICS

Regolith-landform unit polygon boundaries on CANBELEGO were interpreted from field site observations and from remotely-sensed satellite and airborne geophysical data sets including:

- A SPOT 2.5 m ground pixel resolution satellite image mosaic;
- An ASTER 15 m ground pixel resolution satellite mosaic; and,
- Airborne geophysics including aeromagnetics (Total Magnetic Intensity, First Vertical Derivative) and gamma-ray spectrometrics (K, eTh, eU as RGB and individual channels).

The SPOT image mosaic (Figure 9) was the primary base for mapping individual RLUs. This allowed the location of the bulk of the RLU boundaries, however, it proved to be of limited use in distinguishing some regolith materials, especially areas of maghemite lag under woodland. Land use practices on CANBELEGO also make it difficult to distinguish subtle regolith-landforms, especially in areas that have been extensively cleared.

Figure 9: SPOT 2.5 m ground pixel resolution mosaic, courtesy NSW DPI.

Airborne geophysics of CANBELEGO was flown as part of the larger Cobar-Bourke 1:250,000 sheets of the NSW DPI's Discovery 2000 program. Subsets of Total Magnetic Intensity (TMI; Figure 10), First Vertical Derivative aeromagnetics (1VD; Figure 11) and gamma-ray spectrometrics (Figure 12) were created from datasets available for free download from the Geophysical Data Archive Data Delivery System (GADDS 2007). These data were used to cross-check RLU boundaries in areas where the SPOT imagery was unclear, to assess the weathering grade of bedrocks and locate areas that contain large amounts of maghemite to develop a landscape evolution model. These data were also used to assess the difference between *in situ* and transported regolith and to draw boundaries between the two.

Aeromagnetic images highlight different features depending on their processing. The TMI image (Figure 10) dominantly shows magnetic basement features and most particularly highlights igneous rocks and folding and faulting in the Girilambone Beds and the Cobar Supergroup in the centre of the area. Some large features with dendritic drainage patterns are also visible in the image, particularly in the southwest and northwest. These are interpreted to be large maghemite lag-filled paleochannels and modern channels reworking older maghemite lag deposits, similar to those interpreted in BYROCK, HERMIDALE, SUSSEX and COOLABAH.

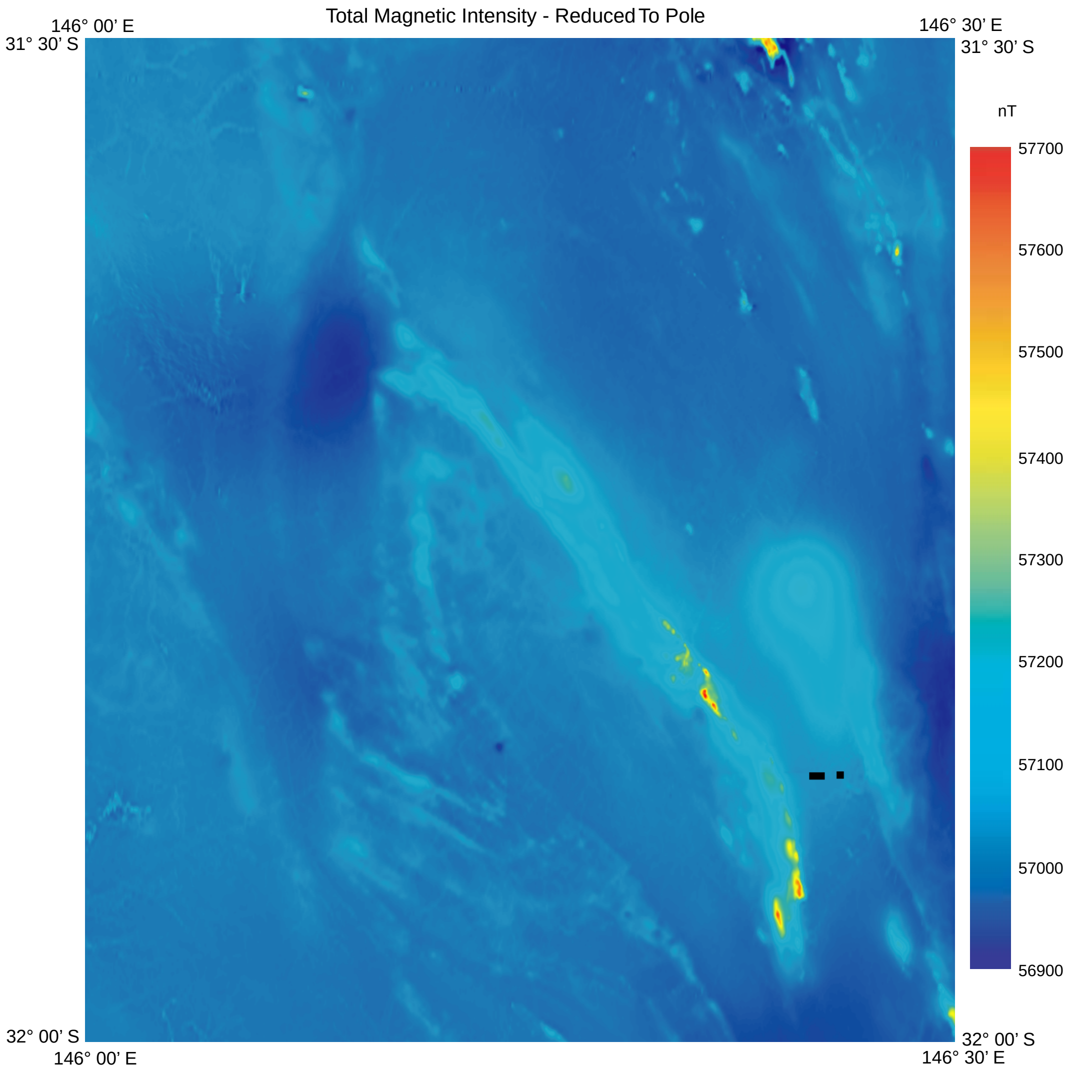


Figure 10: Total magnetic intensity (TMI) image of CANBELEGO as a pseudocolour image. Data from GADDS (2007).

The 1VD image (Figure 11) is much more useful for locating near-surface and surface features for regolith-landform mapping because it highlights high-amplitude, short wavelength features. The 1VD image again shows basement features including folding and faulting but also a widespread network of dendritic drainage patterns associated with maghemite-bearing gravel in modern drainage channels but also brighter, higher intensity dendritic patterns that appear "smeared" in places, particularly in the alluvial-colluvial plains surrounding Yanda Creek in the northwest of the area and in the colluvial plains in the southwest of the area. These patterns are interpreted to be paleochannels filled with maghemite-bearing gravel and the smearing as reworking of these older sediments into the modern drainage systems. Similar patterns are noted on BYROCK, but occur throughout the Cobar Peneplain.

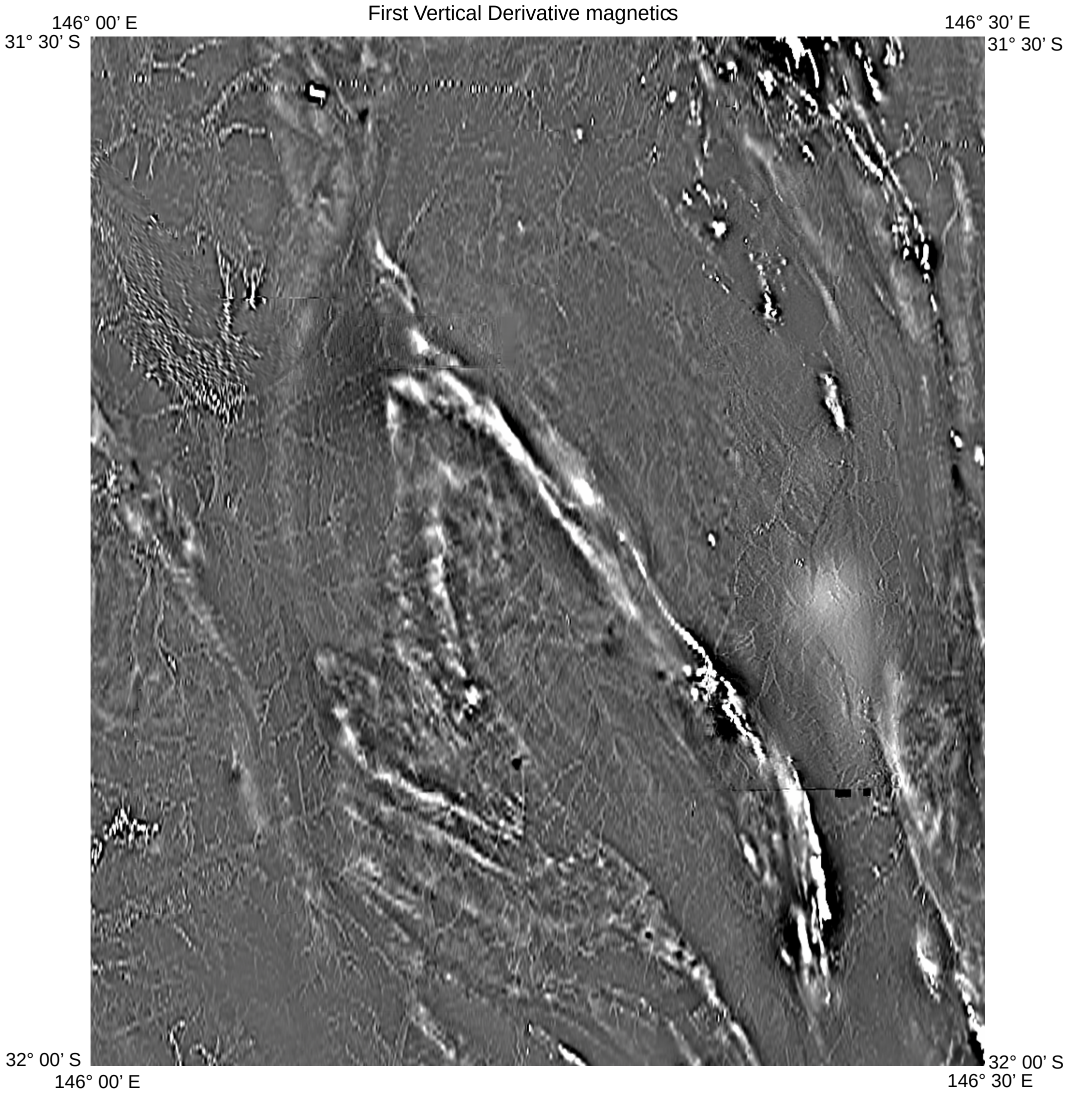


Figure 11: First Vertical Derivative (1VD) image of CANBELEGO as a greyscale 99.9% histogram stretch. Data from GADDS (2007).

The RGB gamma-ray spectrometric image (Figure 12) highlights both *in situ* and transported regolith materials. The most obvious features in this image are bedrock outcrops associated with intrusive and volcanic rocks of the Nymagee Igneous Complex (in the south of the area) and the Cobar Supergroup (in the northeast and southeast of the area), as bright red, yellow-green and white responses signifying saturation of the radioelements K, K+eTh, Th and K+eTh+eU. Large amounts of the three radioelements together signify the presence of fresh to slightly weathered bedrock exposed at the surface, with K hosted in fresh feldspar and Th and U hosted in resistate minerals such as zircon, monazite and titanite (Wilford *et al.* 1997). Other more subtle features exist:

- Dull white and pink (undersaturated K+eTh+eU and undersaturated K) responses indicating the presence of moderately weathered bedrock of the Girilambone Beds and Cobar Supergroup with thin colluvial soil cover;
- Arcuate and linear dark features indicating quartz-rich, radioelement-poor folded rocks in the Girilambone Beds and Cobar Supergroup;
- Dendritic-patterned dark features indicating quartz-rich sediments in the Yanda Creek drainage system;
- Bright green (saturated in eTh) patches in the southwest and west indicating large expanses of maghemite-rich gravel lag. Thorium is preferentially scavenged by maghemite over the other radioelements; and,
- Dull green responses over much of the area indicating localised patchy or linear concentrations of maghemite-rich gravel lag.

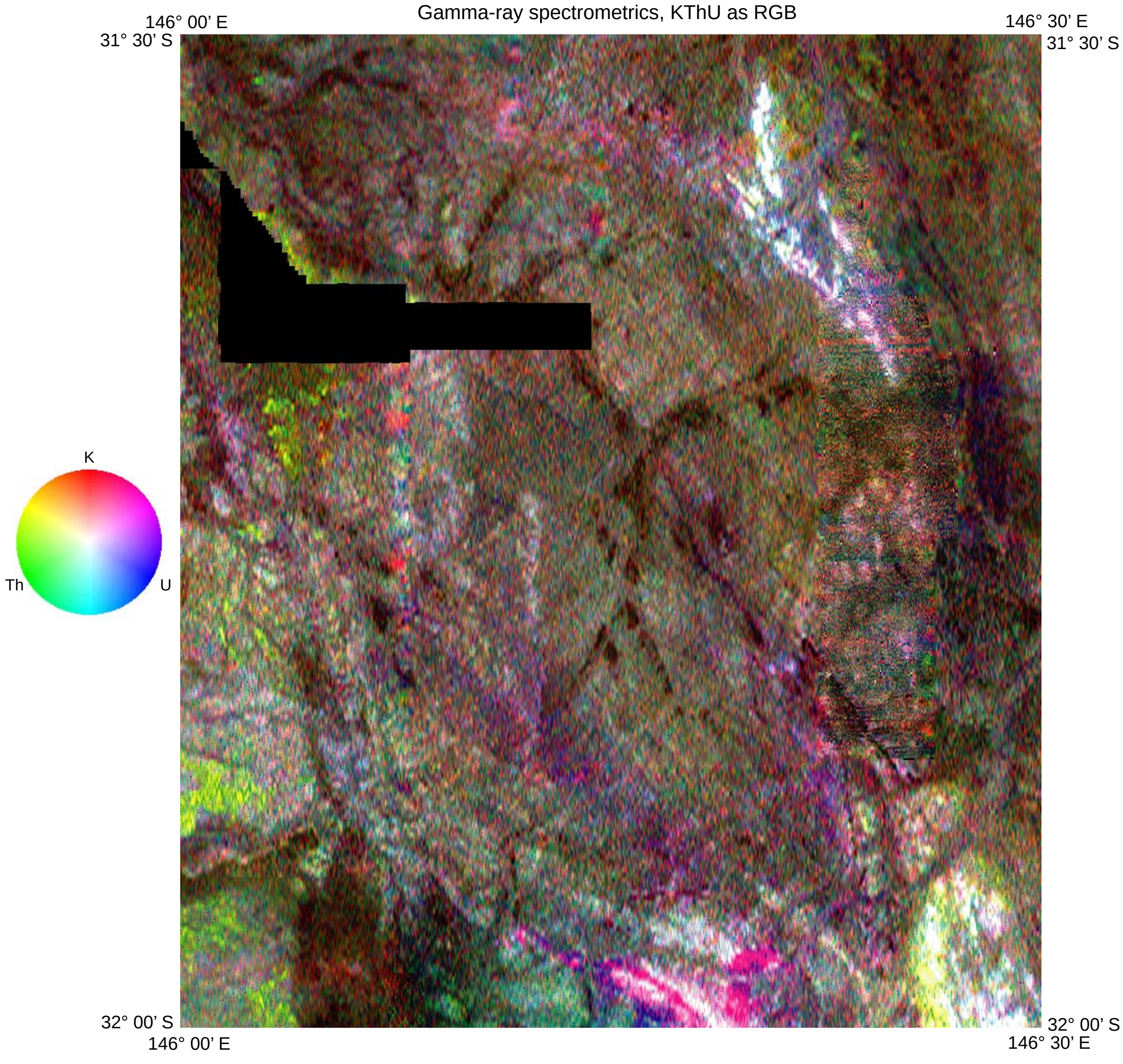


Figure 12: RGB gamma-ray spectrometric image of CANBELEGO with the radioelements K, Th and U as red, green and blue, respectively. Displayed as a 99.0% histogram stretch. Data from GADDS (2007).

6. MAP UNITS

6.1 Introduction

A range of regolith materials and landforms occur in CANBELEGO; these are summarised in Table 2. This section includes the detailed RLU descriptions that were used to develop the map legend in the digital version. Regolith-landform unit descriptions are necessarily brief and generic. The descriptions given in this section reflect the overall nature of each group of RLUs, however, there may be some variation from the given descriptions within individual polygons. Images of selected RLUs and regolith materials are included as plates in the appendix.

6.2 Alluvial sediments

Alluvial sediments make up a major proportion of RLUs in CANBELEGO, comprising approximately 38.7% of the total area. A large proportion of the sediment is composed of red-brown fine sand and silt, the bulk of which is assumed to be wind-blown parna. The remainder of the sediments have larger particles composed of vein quartz and lithic material, as well as varying amounts of maghemite, which ranges in size from powdery to small pebbles and in shape from angular to well-rounded. With the exception of the parna, sediments are sourced locally from colluvium and bedrock. Small amounts of sediment, listed as "Cenozoic" by Felton (1981) and mapped here as "Aep" and "Aer" RLUs, have been reworked from older deposits into the modern drainage system. These older deposits are possibly Miocene-Pliocene, or older.

Aap: Dominated by red-brown fine sand and silt with weakly to moderately ferruginised, subangular to rounded quartzose and lithic gravel and minor to major subangular to well-rounded maghemite gravel lags. Low relief horizontal to gently sloping undulating plain with minor drainage channels. Colonised dominantly by woodlands variously of *Eucalyptus intertexta*, *Eucalyptus populnea*, *Eremophila mitchellii*, *Geijera parviflora* and grasses, forbs and *Sclerolaena sp*.

Aaw: Dominated by red-brown fine sand and silt and clays with minor weakly ferruginised, subangular to rounded quartzose and lithic gravel and subangular to well-rounded maghemite gravel lags. Low relief, undulating, low-lying drainage depression. Colonised dominantly by open woodland of *Eucalyptus populnea*, grasses, forbs and *Sclerolaena sp*.

ACah: Dominated by red-brown fine silt and sand with scattered weakly to moderately ferruginised, angular to rounded quartzose and lithic gravel and cobbles with minor to major subangular to well-rounded maghemite gravel lags. Round- or flat-bottomed, broad, low gradient drainage depressions up to several hundred m width and < 10 m depth with discrete banks, seldom with a wide sandy channel or braided channels tens of m wide and < 2 m deep in the base. Colonised dominantly by woodland of *Eucalyptus populnea* and *Geijera parviflora* and grasses, forbs and *Sclerolaena sp*. in the channel base and as a riparian woodland.

Aed: Dominated by red-brown fine sand and silt with weakly to moderately ferruginised, subangular to subrounded quartzose and lithic gravel and minor to major subangular to well-rounded maghemite gravel lags. Broad drainage tracts up to 1000 m wide with very subdued relief, with flat or concave, low gradient bases. Colonised dominantly by woodland variously of *Callitris glaucophylla*, *Eucalyptus populnea*, *Eucalyptus intertexta*, *Eremophila mitchellii*, *Geijera parviflora*, *Acacia colletioides*, *Dodonea cuneata* and *Acacia excelsa* with rare *Sarcostemma viminale*, *Brachychiton populneus* and grasses, forbs and *Sclerolaena sp*.

Aep: Dominated by rounded to well-rounded, variably sorted, weakly to moderately ferruginised, quartzose and lithic gravel and cobbles with minor red-brown fine sand and silt and minor angular to well-rounded maghemite gravel. Variably indurated by silica. Low relief (< 9 m) landforms, locally shedding sediment into flanking channels and drainage depressions. Colonised dominantly by woodland of *Casuarina pauper*, *Eremophilla mitchellii* and *Geijera parviflora* and grasses, forbs and *Sclerolaena sp*.

Aer: Dominated by rounded to well-rounded, variably sorted, weakly to moderately ferruginised, quartzose and lithic gravel and cobbles with minor red-brown fine sand and silt and minor angular to well-rounded maghemite gravel lag. Variably indurated by silica. Slight relief (9-30 m) landforms locally shedding sediment into flanking channels and drainage depressions. Colonised dominantly by woodland variously of *Eucalyptus socialis*, *Eucalyptus intertexta*, *Acacia decora* and scattered *Callitris glaucophylla*, *Acacia colletioides*, grasses, forbs and *Sclerolaena sp*.

Afa: Dominated by red-brown fine sand and silt with minor to moderate, weakly to moderately ferruginised, subangular to rounded quartzose and lithic gravel and cobbles and minor subangular to well-rounded maghemite gravel lags. Low to slight topographic relief (< 9 m) fans including distributary channels and sheetflow outwash downstream of intersection points. Colonised dominantly by woodlands of *Eucalyptus populnea*, grasses, forbs and *Sclerolaena sp*.

Apd: Dominated by red-brown fine sand and silt with weakly to moderately ferruginised, subangular to rounded, quartzose and lithic gravel and minor to major subangular to well-rounded maghemite gravel lags. Smooth, low relief (< 9 m) landforms typically associated with intersection point floodouts of alluvial channels and drainage depressions. Colonised dominantly by woodland variously of *Eucalyptus populnea*, *Eucalyptus intertexta*, *Eremophila mitchellii*, *Acacia excelsa*, *Geijera parviflora* and scattered *Acacia homalophylla*, *Brachychiton populneus*, *Apophyllum anomalum*, *Pittosporum philliraeoides*, grasses, forbs and *Sclerolaena sp.*

6.3 Colluvial sediments

Colluvial sediments also make up a major proportion of RLUs in CANBELEGO, comprising approximately 39.2% of the total area. A large proportion of the sediment is composed of red-brown fine sand and silt, the bulk of which is assumed to be wind-blown parna. The remainder of the sediments are larger, more angular, particle sizes composed of vein quartz and lithic particles, as well as varying amounts of maghemite particles which range in size from powdery to small pebbles and in shape from angular to well-rounded. With the exception of the parna, sediments are sourced locally from colluvium and bedrock and reworked older sediments, particularly in the SW of the area where large colluvial erosional plains with abundant well-rounded maghemite-bearing gravel lags occur. These sediments, assumed to belong to paleochannel deposits, may have a minimum age of 16.8 ± 0.2 Ma (Sutherland 1985) estimated from a K-Ar age on leucitite basalt overlying magnetic paleochannel deposits on BYROCK (Chan *et al.* 2004).

Cer: Dominated by angular to subangular, weakly to moderately ferruginised, quartzose and lithic gravel, cobbles and boulders with minor red-brown fine sand and silt and minor angular to well-rounded maghemite-bearing gravel lags. Minor exposures of weakly to moderately ferruginised bedrock with ferruginous mottles occur in gullies. Slight topographic relief (9-30 m) slopes flanking higher relief landforms, shedding sediment into flanking channels, drainage depressions and plains. Colonised dominantly by woodland variously of *Eucalyptus intertexta*, *Eucalyptus populnea*, *Eucalyptus socialis*, *Callitris glaucophylla*, *Geijera parviflora*, *Acacia doratoxylon*, *Acacia decora*, *Dodonea cuneata* and scattered *Acacia rigens*, *Brachychiton populneus*, grasses, forbs and *Sclerolaena sp*.

CHed: Dominated by angular to subangular quartzose and lithic gravel, cobbles and boulders with minor red-brown fine sand and silt and minor angular to well-rounded maghemite-bearing gravel lags. Minor exposures of weakly to moderately ferruginised bedrock with ferruginous mottles in gullies. Elongate incised depressions and valleys between higher relief landforms. Colonised dominantly by woodland variously of *Eucalyptus populnea*, *Callitris glaucophylla*, *Geijera parviflora*, *Eremophila mitchellii*, *Dodonea cuneata*, grasses, forbs and *Sclerolaena sp*.

CHel1: Dominated by weakly to moderately ferruginised, angular to subangular quartzose and lithic gravel, cobbles and boulders with minor red-brown fine sand and silt and angular to subangular maghemite-bearing sand lags. Minor exposures of weakly to moderately ferruginised bedrock with ferruginous mottles. High topographic relief (30-90 m) landforms, shedding sediment. Colonised dominantly by woodland variously of *Eucalyptus populnea*, *Eucalyptus intertexta*, *Eucalyptus socialis*, *Casuarina pauper*, *Acacia excelsa*, *Acacia aneura*, *Acacia decora*, *Acacia homalophylla*, *Eremophila mitchellii*, *Geijera parviflora*, *Dodonea sp*. and rare to scattered *Callitris glaucophylla*, *Hakea leucoptera*, *Brachychiton populneus*, *Acacia pendula*, *Alectryon oleifolius*, *Apophyllum anomalum*, *Capparis mitchellii*, grasses, forbs and *Sclerolaena sp*.

CHep1: Dominated by red-brown fine sand and silt with weakly to moderately ferruginised, subangular to subrounded quartzose and lithic gravel and cobbles and minor subangular to well-rounded maghemite-bearing gravel lags. Minor exposures of weakly to moderately ferruginised bedrock with ferruginous mottles. Low-relief (< 9 m) landforms, low gradient, locally shedding sediment into flanking channels and drainage depressions. Colonised dominantly by woodland variously of *Eucalyptus populnea*, *Eucalyptus intertexta*, *Eucalyptus socialis*, *Casuarina pauper*, *Acacia excelsa*, *Acacia aneura*, *Acacia decora*, *Acacia excelsa*, *Acacia homalophylla*, *Eremophila mitchellii*, *Geijera parviflora*, *Dodonea sp.* and rare to scattered *Callitris glaucophylla*, *Hakea leucoptera*, *Brachychiton populneus*, *Acacia pendula*, *Alectryon oleifolius*, *Apophyllum anomalum*, *Capparis mitchellii*, grasses, forbs and *Sclerolaena sp*.

CHep2: Dominated by red-brown fine sand and silt and subangular to well-rounded maghemite-bearing gravel with minor weakly to moderately ferruginised, subangular to subrounded quartzose and lithic gravel and cobble lags. Minor exposures of weakly to moderately ferruginised bedrock with ferruginous mottles. Low-relief (< 9 m) landforms, low gradient, locally shedding sediment into flanking channels and drainage depressions. Colonised dominantly by woodland variously of *Eucalyptus populnea*, *Eucalyptus intertexta*, *Eucalyptus socialis*, *Casuarina pauper*, *Acacia excelsa*, *Acacia aneura*, *Acacia decora*, *Acacia excelsa*, *Acacia homalophylla*, *Eremophila mitchellii*, *Geijera parviflora*, *Dodonea sp.* and rare to scattered *Callitris glaucophylla*, *Hakea leucoptera*, *Brachychiton populneus*, *Acacia pendula*, *Alectryon oleifolius*, *Apophyllum anomalum*, *Capparis mitchellii*, grasses, forbs and *Sclerolaena sp*.

CHer1: Dominated by weakly to moderately ferruginised, angular to subangular, quartzose and lithic gravel, cobbles and boulders with minor red-brown fine sand and silt and minor angular to well-rounded maghemite-bearing gravel lags. Minor exposures of weakly to moderately ferruginised bedrock with ferruginous mottles. Slight relief (9-30 m) landforms, locally shedding sediment. Colonised dominantly by woodland variously of *Callitris glaucophylla*, *Eucalyptus populnea*, *Eucalyptus intertexta*, *Eucalyptus socialis*, *Casuarina pauper*, *Eremophila sp*., *Acacia colletioides*, *Acacia decora*, *Dodonea sp*., *Senna artemisioides* and rare *Apophyllum anomalum*, *Alectryon oleifolius*, *Pittosporum philliraeoides*, *Brachychiton populneus*, *Bossiaea walkerii*, grasses, forbs and *Sclerolaena sp.*

CHer2: Dominated by weakly to moderately ferruginised, angular to subangular, quartzose and lithic gravel, cobbles and boulders with angular to well-rounded maghemite-bearing gravel lags and minor red-brown fine sand and silt. Minor exposures of weakly to moderately ferruginised bedrock with ferruginous mottles. Slight relief (9-30 m) landforms, locally shedding sediment. Colonised dominantly by woodland variously of *Callitris glaucophylla*, *Eucalyptus populnea*, *Eucalyptus intertexta*, *Eucalyptus socialis*, *Casuarina pauper*, *Eremophila sp*., *Acacia colletioides*, *Acacia decora*, *Dodonea sp*., *Senna artemisioides* and rare *Apophyllum anomalum*, *Alectryon oleifolius*, *Pittosporum philliraeoides*, *Brachychiton populneus*, grasses, forbs and *Sclerolaena sp*.

CHpd1: Dominated by red-brown fine sand and silt with minor subangular to subrounded quartzose and lithic gravel and minor angular to well-rounded maghemite-bearing gravel lags. Minor exposures of weakly to moderately ferruginised bedrock with ferruginous mottles occur in gullies. Low-relief (< 9 m) landforms, with surficial contour band patterns and receiving sediment. Colonised dominantly by woodland variously of *Eucalyptus populnea*, *Eucalyptus intertexta*, *Eremophila mitchellii*, *Acacia excelsa*, *Geijera parviflora* and scattered *Acacia homalophylla*, *Brachychiton populneus*, *Apophyllum anomalum*, *Pittosporum philliraeoides*, grasses, forbs and *Sclerolaena sp*.

CHpd2: Dominated by red-brown fine sand and silt and subangular to well-rounded maghemite-bearing gravel with minor weakly to moderately ferruginised, subangular to subrounded quartzose and lithic gravel and cobble lags. Minor exposures of weakly to moderately ferruginised bedrock with ferruginous mottles occur in gullies. Low-relief (< 9 m) landforms, with surficial contour band patterns and receiving sediment. Colonised dominantly by woodland variously of *Eucalyptus populnea*, *Eucalyptus intertexta*, *Eremophila mitchellii*, *Acacia excelsa*, *Geijera parviflora* and scattered *Acacia homalophylla*, *Brachychiton populneus*, *Apophyllum anomalum*, *Pittosporum philliraeoides*, grasses, forbs and *Sclerolaena sp.*

6.4 Fill

Fill comprises ca. 0.02% of the area of CANBELEGO. Fill is principally composed of mullock and tailings surrounding the Canbelego Mine site.

Fm: Chaotic assemblage of regolith materials surrounding the Canbelego Mine site. Irregular landforms mostly consisting of mining waste dumps. Colonised dominantly by regrowth of native species and introduced woody weeds.

6.5 Saprolite and saprock

Saprolite- and saprock-dominated map units comprise ca. 22.0% of the area of CANBELEGO. Saprolite (very highly to moderately weathered bedrock) and saprock (slightly weathered bedrock) consist of the weathered parts of most of the bedrock types that outcrop within the mapping area. Saprolite and saprock may be slightly ferruginised and have a thin cover of angular to subangular colluvium with minor subangular to subrounded maghemite-bearing granules and a proportion of red-brown fine sand and silt, interpreted as an aeolian component (parna).

6.5.1 Saprolite

SHep: Soft, variably ferruginised kaolinitic bedrock and quartz veins with open joints filled by red-brown fine sand and silt and with minor angular to rounded maghemite-bearing gravel lag. Low-relief (< 9 m) landforms, low gradient, locally shedding sediment into flanking channels and drainage depressions. Colonised dominantly by woodland variously of *Eucalyptus intertexta*, *Eucalyptus populnea*, *Eremophilla mitchellii* with stands of *Casuarina pauper*.

SMel: Moderately hard kaolinitic and/or quartzose weathered bedrock with prominent cleavage planes and minor quartz veins or tors and pavements. Slight surficial ferruginisation and minor red-brown fine sand and silt with angular maghemite-bearing sand lag. Moderate topographic relief (30-90 m) landforms, locally shedding sediment into flanking channels, drainage depressions, rises and plains. Colonised dominantly by woodland variously of *Callitris glaucophylla* on hilltops with *Eucalyptus populnea*, *Eucalyptus intertexta*, *Acacia decora* and *Brachychiton populneus* on colluvial footslopes, grasses, forbs and *Sclerolaena sp.*

SMep: Moderately hard kaolinitic and/or quartzose weathered bedrock with prominent cleavage planes and minor quartz veins or tors and pavements. Slight surficial ferruginisation with minor red-brown fine sand and silt and minor angular to rounded maghemite-bearing gravel lag. Low-relief (< 9 m) landforms, low gradient, locally shedding sediment into flanking channels and drainage depressions. Colonised dominantly by woodland variously of *Callitris glaucophylla*, *Eucalyptus intertexta*, *Casuarina pauper*, *Geijera parviflora*, *Eucalyptus socialis*, *Acacia decora*, *Acacia homalophylla*, *Eremophila sp.*, *Dodonea sp.* and scattered *Acacia excelsa*, *Hakea leucoptera* and *Alectryon oleifolius* with grasses, forbs and *Sclerolaena sp.*

SMer: Kaolinitic and/or quartzose weathered bedrock with prominent cleavage planes and minor quartz veins or tors and pavements. Slight surficial ferruginisation with minor red-brown fine sand and silt and minor angular to rounded maghemite-bearing gravel lag. Slight relief (9-30 m) landforms, locally shedding sediment into flanking channels, drainage depressions and plains. Colonised dominantly by woodland variously of *Callitris glaucophylla*, *Eucalyptus intertexta*, *Casuarina* *pauper*, *Geijera parviflora*, *Eucalyptus socialis*, *Acacia decora*, *Acacia homalophylla*, *Eremophila sp*., *Dodonea sp*. and scattered *Acacia excelsa*, *Hakea leucoptera*, *Alectryon oleifolius*, grasses, forbs and *Sclerolaena sp*.

6.5.2 Saprock

SSeh: Hard bedrock and quartz veins comprising pavements, tors or blocky outcrop with minor ferruginised patches. Joints and fractures are filled with minor red-brown fine sand and silt and minor angular maghemite-bearing sand lag. High relief (90-300 m) landforms, locally shedding sediment into flanking channels, drainage depressions and plains. Colonised dominantly by woodland variously of *Eucalyptus populnea*, *Eucalyptus intertexta*, *Eremophila sp*., *Dodonea sp*., grasses, forbs and *Sclerolaena sp*.

SSel: Hard bedrock and quartz veins comprising pavements, tors or blocky outcrop with minor ferruginised patches. Joints and fractures are filled with minor red-brown fine sand and silt and minor angular maghemite-bearing sand lag. Moderate topographic relief (30-90 m) landforms, locally shedding sediment into flanking channels, drainage depressions, rises and plains. Colonised dominantly by woodland variously of *Callitris glaucophylla* on hilltops with *Eucalyptus populnea*, *Eucalyptus intertexta*, *Acacia decora* and *Brachychiton populneus* on colluvial footslopes, grasses, forbs and *Sclerolaena sp*.

SSep: Hard bedrock and quartz veins comprising pavements, tors or blocky outcrop with minor ferruginised patches. Joints and fractures are filled with minor red-brown fine sand and silt and minor angular to rounded maghemite-bearing gravel lag. Low-relief (< 9 m) landforms, low gradient, locally shedding sediment into flanking channels and drainage depressions. Colonised dominantly by woodland variously of *Eucalyptus intertexta*, *Eucalyptus populnea*, *Eucalyptus socialis*, *Casuarina pauper*, *Eremophila mitchellii*, *Callitris glaucophylla*, *Hakea leucoptera*, *Dodonea cuneata*, *Acacia decora*, *Acacia aneura*, grasses, forbs and *Sclerolaena sp*.

SSer: Hard bedrock and quartz veins comprising pavements, tors or blocky outcrop with minor ferruginised patches. Joints and fractures are filled with minor red-brown fine sand and silt and minor angular to subrounded maghemite-bearing gravel lag. Slight relief (9-30 m) landforms, locally shedding sediment into flanking channels and drainage depressions. Colonised dominantly by woodland variously of *Callitris glaucophylla*, *Eucalyptus populnea*, *Eucalyptus intertexta*, *Eremophila mitchellii*, *Capparis mitchellii*, *Geijera parviflora*, *Acacia decora*, *Dodonea sp*., grasses, forbs and *Sclerolaena sp*.

7. IMPLICATIONS FOR LANDSCAPE EVOLUTION AND MINERAL EXPLORATION

7.1 Present and paleo topography

CANBELEGO shares many of the same regolith-landforms as the nearby BYROCK, COOLABAH, HERMIDALE and SUSSEX and also has a similar landscape evolution history to these adjoining maps. The geological history of Palaeozoic bedrocks is given in Felton (1981) but the Mesozoic-Cenozoic evolution of the landscape is more difficult to determine because there is a paucity of dates or ages for the materials and the history must be constructed from fragments.

The Mesozoic landscape was likely to have had greater relief than the present landscape, which on CANBELEGO is about 293 m based on heights from the SRTM2 DEM (Figure 8). Reverse-circulation drilling along public roads on BYROCK, COOLABAH, HERMIDALE and SUSSEX shows that the transported regolith fill can be up to 100 m thick in places, especially in Mulga Creek on BYROCK (Chan *et al.* 2004), incised into saprolite. Mulga Creek has its headwaters in the northeastern part of CANBELEGO (shown in Figure 8). The section traversing Mulga Creek on BYROCK is interpreted to consist of two sequences of fill including: a lower humid-phase fill with no maghemite up to 60 m thick over saprolite in paleovalleys up to 8 km wide; and, an upper, arid-phase fill including maghemite granules up to 40 m thick in (paleo)valleys up to 18 km wide (Chan *et al.* 2004). On CANBELEGO the active valleys are no more than about 5 km wide.

The lower humid-phase sediments are more clay-rich and are interpreted by Chan *et al.* (2004) on BYROCK to be lacustrine sediments. Palynological samples from other bottom-of-hole sediments on BYROCK returned Aptian (Early Cretaceous or 115-108 Ma) ages, further indicating that these sediments are possibly related to the Surat Basin (Chan *et al.* 2004). There is no indication that sediments in the bases of paleovalleys on CANBELEGO are this old. Arid-phase sediments on BYROCK are assumed by Chan *et al.* (2004) to be no older than mid-Miocene, based on stratigraphic relationships with the humid-phase sediments and leucitite basalts at Wilga Tank, Ar-Ar dated at ca. 17.1 ± 0.2 Ma (McQueen *et al.* 2007).

On HERMIDALE, Chan *et al.* (2003b) correlate the arid-phase sediments to the Lachlan Formation of the Lachlan and Macquarie Rivers. Valley fill sequences on HERMIDALE are no more than about 40 m thick and contain minor to major amounts of maghemite-bearing ferruginous gravel. These sediments correspond to the upper, arid-phase infill on BYROCK and were probably deposited in channels and on alluvial-colluvial plains similar to those in the present landscape. The valley-fill sediments on CANBELEGO are more likely to be of similar age.

On SUSSEX, RC drilling along the Booroomugga Road over Mulga Creek (about 19 km north of the northern edge of CANBELEGO) returned up to 35 m of alluvial sediment (gravel, sand, sand and clay) over saprolite. As logged, the top ca. 15 m of sediment contains abundant maghemite-bearing ferruginous gravel, whereas the bottom 20 m does not contain ferruginous gravel (Chan *et al.* 2003a). This indicates that the Mulga Creek drainage system is shallowing southwards and potentially may contain several tens of metres of mixed alluvial sediment on CANBELEGO before thinning to nil in its upper reaches. Using the example from BYROCK, this further indicates that Mulga Creek potentially contains older humid-phase and younger arid-phase fills ca. 19 km north of the northern border of CANBELEGO. A similar prediction may be made regarding Yanda Creek, which is a slightly larger system than Mulga Creek on CANBELEGO. Unfortunately, no water bore logs are available for CANBELEGO to confirm these predictions (NSW Groundwater Works 2008) and the RC drilling program instigated by CRC LEME did not extend to northern CANBELEGO.

The contrast between the modern topography and the paleotopography of CANBELEGO was highlighted by trenches cut through the upper reaches of a Yanda Creek tributary at the Good Friday Prospect (GR 270850) in the central part of the area. Here the trenches were cut across the slope at intervals over a distance of about 100 m down a gently-sloping alluvial depression below a colluvial footslope and saprolite ridge. The trenches cut through thin colluvium and saprolite on the upper slope. On the mid-slope, the trenches cut through bedded alluvial sediment with poorly-sorted gravel bands into saprolite, and then > 2 m of poorly bedded sediment on the lower slope. Surface relief over the distance was no more than 2 m, however the trenches revealed > 2 m of sub-surface relief over the same distance.

The headwaters of Yanda and Mulga Creeks occur on CANBELEGO and, given the data gained about the age of these drainage systems on other map sheets, it can be surmised that the headwaters of these creeks have moved into their present positions by headward retreat since the Early Cretaceous. There is also potential for the presence of humid-phase fill older than mid-Miocene in the bases of Yanda and Mulga Creeks in the north of CANBELEGO. These, and other, creeks are now responsible for down-cutting of the elevated land in the centre of CANBELEGO and it is this sediment that is principally adding to the accession downstream along these active drainage channels, with a healthy contribution from the parna (red-brown fine sand and silt) that makes up the surface coating of the present landscape (Chan *et al.* 2003a, Tate *et al.* 2003).

On the eastern side of CANBELEGO large amounts of weakly consolidated rounded quartzose and lithic sediment occur, particularly in gullies on HERMIDALE and within the RC holes CBAC169-172 in the southeast of the area (shown in Figure 7). These sediments are interpreted to be reworked from rocks of the Cobar Supergroup, particularly conglomerates (K.G. McQueen *pers. comm.* 2008), and lie close to the surface with only a thin (< 1-2 m) alluvial-colluvial cover. These deposits likely mantle the steeper paleotopography of the area and are quarried along the Canbelego-Nymagee Road for use as road aggregate. These deposits where drilled also contain small amounts of maghemite-bearing gravel, so must be related to arid-phase deposits on HERMIDALE and SUSSEX.

7.2 Indurated regolith materials

CANBELEGO contains a range of partially to fully indurated regolith materials including ferruginised saprolite, silcrete, calcrete and red-brown hardpan. There is also a large amount of ferruginous gravel including maghemite scattered or concentrated in the surface deposits on CANBELEGO.

Ferruginised saprolite on CANBELEGO is characterised by red-brown Fe-oxyhydroxide-rich (mostly hematite) mottles seen occurring in road cuts, quarries and borrow pits. On SUSSEX, Fe-oxyhydroxide-rich mottles beneath leucitite lava at Wilga Tank, Ar-Ar dated at ca. 17.1 ± 0.2 Ma, returned a paleomagnetic age of ca. 15 ± 8 Ma (McQueen *et al.* 2007). Samples of ferruginous mottles from the Elura Mine (now the Endeavour Mine) and the McKinnons Mine elsewhere in the Cobar area returned two series of similar ages (McQueen *et al.* 2007): 10 ± 4 Ma (Elura) and 15 ± 4 Ma (McKinnons); and, ca. 60 Ma (Elura and McKinnons). Further research summarised by Pillans (2005) on broad-area regolith dating reveals that Fe-oxyhydroxide-rich mottles with similar paleomagnetic ages occur over much of NSW including Northparkes (Pillans *et al.* 1999) and Peak Hill (Smith and Pillans 2005). Paleomagnetic ages on Fe-oxyhydroxide-rich mottles are useful but must be treated with caution when discussing landscape evolution in the broader context. Paleomagnetic ages probably reflect a period where a large amount of Fe-oxyhydroxide (mostly hematite) was fixed within the regolith. However, the temptation is to suggest that there was a "weathering event" during the time of fixation and no Fe-oxyhydroxide fixation occurred before or after the "weathering event". It is likely that Fe-oxyhydroxide was also being fixed in the same area at different times, but at different rates and is too dispersed to give a good paleomagnetic age, or has simply not been preserved. Having introduced this note of caution when interpreting regolith paleomagnetic data, the weight of evidence discussed by Pillans (2005) now suggests that indeed there were large continent-wide processes occurring over the quoted paleomagnetic age periods, most likely the withdrawal of the Mesozoic inland sea from central Australia and the drying-out of Australia by northward continental drift, that caused large amounts of Fe-oxyhydroxide to become fixed in the regolith. This would have occurred by the gradual lowering of regional water tables as base levels lowered in response to eustatic change. Note that weathering and Fe-oxyhydroxide fixation in mottles may have occurred continually through

these processes to the present, but at different rates (Taylor and Shirtliff 2003).
Small outcrops of silcrete occur on CANBELEGO as individual plains and rises north of The Rookery homestead (GR 290910) and (described by Felton 1981) to the east of Kopyje and between Hermitage and the abandoned Florida railway station. The silcrete on The Rookery consists of poorly sorted angular to subrounded quartz sand and gravel with a weakly-developed candlewax texture. Felton (1981) described these as "remnants of extensive sheets". More recent research on silcrete formation indicates that silcretes form as long, thin pods or lenses within paleodrainage systems either:

- Slowly from intra-formational fluids charged with organic acids capable of slowly dissolving silica and precipitating it elsewhere (e.g., Taylor and Smith 1975), perhaps under basalt (Webb and Golding 1998); or,
- Quickly within river systems where there is a large supply of acid, for instance around inland or coastal acid sulfate soils commonly found within reducing soils (e.g., Fitzpatrick and Skwarnecki 2005), or in the presence of pyritic Mesozoic sediments (e.g., Hill 2005).

There is no evidence to suggest that more extensive sheets of silcrete once occurred on CANBELEGO as stated by Felton (1981). This interpretation is most likely a model-driven one after Browne (1972), who surmised that silcretes seen today are relics of a more extensive sheet that must have covered most of inland Australia

Regolith carbonate accumulations (RCAs; including calcrete) can be seen within gullies, quarries and borrow pits on CANBELEGO principally as laminated hardpan type within fractures and draped over the soil-saprolite interface or as powdery types within soil profiles. The presence of RCAs in other bedrock-dominated areas is also noted by the occurrence of the geobotanical indicator species *Apophyllum anomalum* (warrior bush) as large monocultural stands on areas with powdery white soils.

A red-brown hardpan occurs in some gullies and road cuttings. This consists of a hematite-rich consolidated clay soil B-horizon inset with gravel including quartz and ferruginous nodules below more friable red-brown fine sand and silt and gravel lag.

Maghemite occurs throughout CANBELEGO associated with hematite as surface ferruginous lag or within soil profiles and sediment deposits, visible in gullies, cuttings and RC holes. A range of morphologies are present including angular to well-rounded dusty, sandy, granular and pebbly types with hematite and maghemite either as a coating on lithic fragments or as solid concentric-layered ferruginous pisoliths. Ferruginous gravel occurs in greater or lesser amounts in all RLUs on CANBELEGO and has been comprehensively reworked into alluvial systems, seen as ferruginous lag on the surface and as dentritic-patterned magnetic highs on the 1VD aeromagnetics following modern drainage (Figure 11 and 13). Large amounts of ferruginous lag also occur in the southwest and west of CANBELEGO on colluvial sheetwash plains and rises, seen as bright green eTh-saturated areas on the RGB gamma-ray spectrometrics (Figure 12) and bright dendritic patterns in the 1VD magnetics (Figure 13). These areas do not conform to the modern drainage and are interpreted here to be erosional remnants of paleochannel deposits now being reworked by modern drainage. These deposits are now slightly elevated in the landscape (no more than about 10 m) because of relief inversion as the uplands of CANBELEGO have been modified by erosion.

7.3 Implications for minerals exploration

CANBELEGO is dominated by almost equal proportions of colluvial and alluvial sediments, followed by saprolith and only a small proportion of its area mapped as fill. As such, over 61% of the area contains regolith materials that are either *in situ* or have travelled only a limited distance from their source. The remainder of the area contains transported materials, but the whole is covered by a blanket of parna to various depths, except for exposed saprolith which may have fractures and joints filled with it. Parna contributes clays, carbonates and salts to the regolith and can mask geochemical signals from underlying mineral deposits, as well as complicate airborne geophysics by subduing underlying magnetic and gamma-ray spectrometric signals. Ferruginous gravel occurs to a greater or lesser extent throughout the area and is shown to be concentrated within the modern drainage channels and within paleochannel deposits with only limited extent in the southwest and west of the area. The presence of ferruginous lag can also complicate soil geochemistry (by scavenging some pathfinder elements preferentially over others) and airborne geophysics (by introducing surface anomalies that may mask other, more deeply-buried, ones). Remnant native vegetation also occurs over a large portion of the upland area and within state forests and timber reserves.

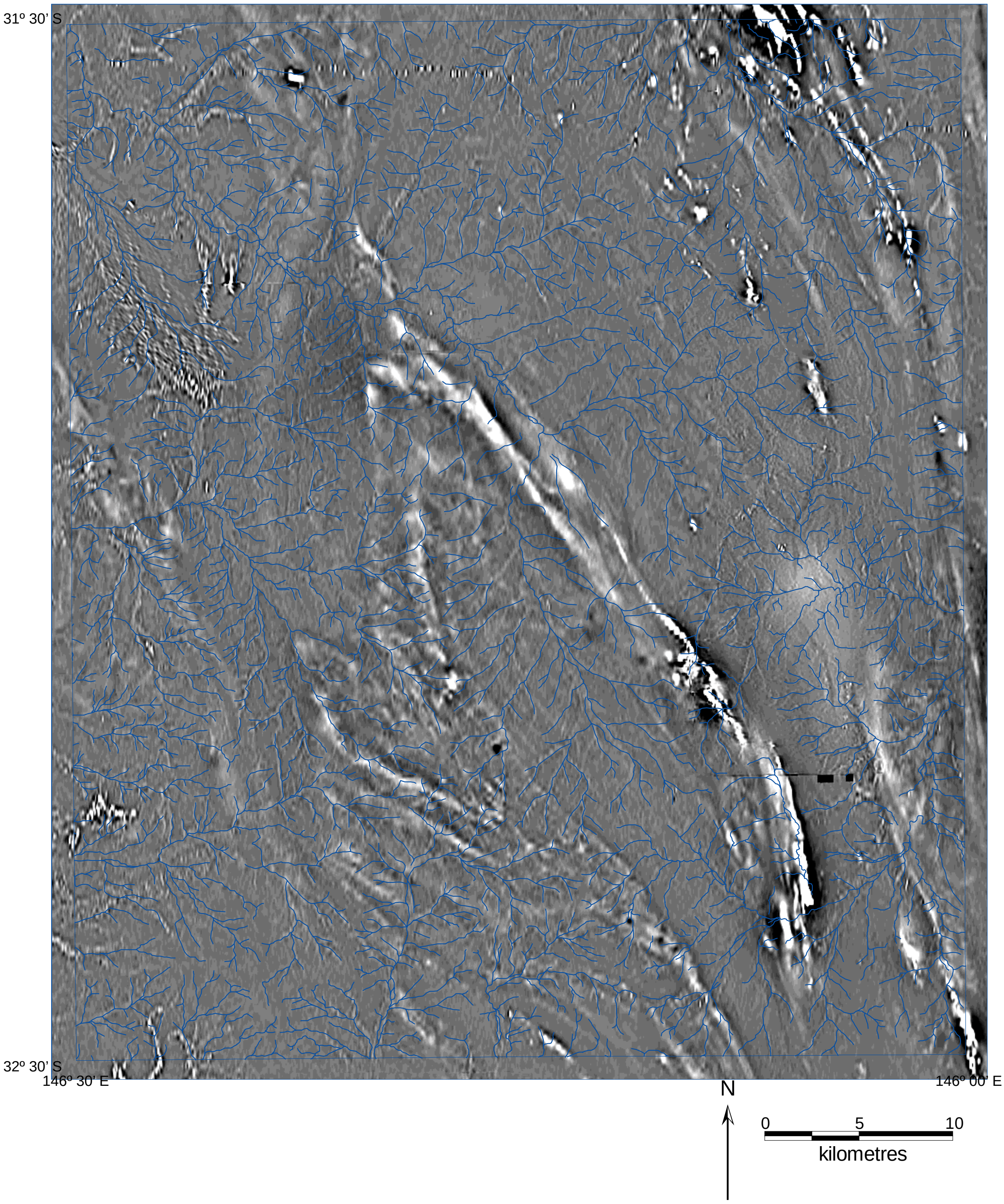


Figure 13: 1VD magnetics of CANBELEGO with modern drainage overlain. Data from GADDS (2007).

Many of these materials may be used as sampling media for mineral exploration over CANBELEGO, however, each has its own implications for detecting mineral deposits within the area.

7.3.1 Saprolith

Saprolith occurs over at least 22% of the area and may be sampled directly using hand tools. Saprolith includes slightly weathered rocks (saprock) and moderately to highly weathered rocks (saprolite). Saprolith is capable of carry geochemical signatures of mineralisation or direct ore indicators and can be analysed routinely. Care is needed when assessing the geochemistry of saprolite in order to take the weathering grade and Fe content into account, as pathfinder elements may be leached or concentrated in highly weathered or highly ferruginous samples, respectively. Most, if not all, of the deposits in the Cobar Basin were discovered by saprolite or gossan sampling (Hughes 1990 and references therein), except perhaps for Elura (Endeavour), which was discovered using airborne geophysics (Davis 1980, Dunlop *et al.* 1983).

7.3.2 Colluvium

Colluvium accounts for ca. 39.2% of the surface area of CANBELEGO. Colluvium includes a mixed lag of bedrock float, quartz vein material, parna and angular to well-rounded dust- to pebble-size ferruginous material. Colluvial cover depth varies over the area, from thin with patchy bedrock exposure to several tens of metres thick; it is best to look for gullies or road cuttings to gauge this. Colluvial materials may be used as sampling media as bedrock proxies, however, depending on the landform setting material may have been transported considerable distances and must be used with caution. On CANBELEGO, colluvium occurs on the footslopes of larger landforms, as erosional rises and as erosional plains. Angular lithic colluvium in footslopes may be collected with some degree of confidence that it is representative of the nearby parent material. However, subangular to subrounded lithic colluvium occurring in rises and plains may have been transported considerable distances, particularly when it contains a large proportion of rounded to well-rounded ferruginous material which may be an indicator of palaeochannel deposits up to mid-Miocene age. Detailed regolith-landform mapping needs to be conducted to investigate the local sources and sinks of colluvial sediments.

7.3.3 Alluvial (stream) sediments

Alluvial (stream) sediments account for 38.7% of the total area of CANBELEGO and have potential to be used for mineral exploration in the Cobar area. Sediments contain varying proportions of clay, parna (red-brown fine sand and silt), quartzose and lithic fragments and dusty to pebble-size ferruginous material. Traditional stream sediment surveys have focussed either on the "-80 mesh" clay-sized fraction or the "plus 80 mesh" silt-size and above fraction, however, each has its own problems on CANBELEGO. The clay-size fraction contains considerable transported material which has been added from parna, which itself is composed of silt and fine-sand sized clay aggregates (Greene *et al.* 2002). Parna carries metals including Na, Ca and Mg from its source areas, adding these to the local sediment, and may dilute the geochemical signature of nearby mineralisation. The silt-size and above fraction may contain quartz and lithic fragments from the local area, but also considerable amounts of ferruginous material which may have been transported large distances, and may have been recycled through the landscape more than once. Care needs to be taken when using stream sediments on CANBELEGO for these reasons; particle roundness is a good indicator of transport distance.

7.3.4 Ferruginous (maghemite) lag

Ferruginous lag, incorporating maghemite, occurs in nearly all RLUs on CANBELEGO and is present in trace amounts in saprolith RLUs as dusty and angular fragments. Ferruginous lag is concentrated in drainage channels and also on colluvial plains and slopes by sheetwash processes. Ferruginous lag has been shown to have application for regional minerals exploration in the Cobar basin and was used to successfully "locate" the Elura (Endeavour) deposit (Dunlop *et al.* 1983). Further work on ferruginous lag including the qualities of mature versus immature and magnetic versus non-magnetic (e.g., McQueen and Munro 2003, McQueen *et al.* 2004, McQueen and McRae 2004) shows the potential of ferruginous lag in exploring for mineral deposits in the area. Care needs to be taken when sampling ferruginous lag, together with accurate regolith-landform mapping, to attempt to determine the absolute source of the lag to interpret transported or blind anomalies.

7.3.5 Regolith carbonate accumulations (calcrete)

Regolith carbonate accumulations (RCAs, including calcrete) are common in the Cobar region

(McQueen 2006) and are found in gullies or excavations on CANBELEGO. RCA sampling for mineral exploration has been used successfully in South Australia and was directly responsible for the discovery of the Challenger Au deposit in the Gawler Craton (Lintern 2002). RCAs are found in the Cobar region in a range of morphologies including nodular, laminated hardpan, fracture-fill and powdery types and most commonly occur at the saprolite-soil interface. Different morphologies are interpreted to occur through different genetic processes, with the nodular and powdery types deemed to occur by pedogenic (soil-forming) processes, and the laminated hardpan and fracture-filling types by groundwater table (phreatic) fluctuations (Chen *et al.* 2002). McQueen (2006) collated geochemical data from RCAs across the Cobar area, including samples taken from CANBELEGO, and concluded that there is a Au-in-calcrete association with up to 4 ppb regionally and 12 ppb locally. Other pathfinder elements including Ag, Cu, Bi, Ni and Co are concentrated in RCAs, suggesting that where available RCA can be exploited for regional- and tenement-scale mineral exploration for Au and base metal deposits. Care must be taken when sampling and interpreting geochemistry that data from different morphological types are treated separately; different morphologies occur through different genetic process, and may have different threshold and anomalous elemental levels.

7.3.6 Native vegetation

Native vegetation offers an alternative to saprolite, soil and lag sampling for regional- and tenement-scale phytogeochemical minerals exploration programs, especially in the Cobar region. A range of native tree and shrub species occur on CANBELEGO that have potential for use as either geobotanical indicator species or phytogeochemical exploration sampling species because they are accumulators or hyperaccumulators. Geobotanical indicator species are those adapted to particular chemical niches (indicators), or those that avoid them (avoiders). Accumulators are those species that accumulate detectable levels of metals in their organs, and hyperaccumulators concentrate metals in their organs to orders of magnitude above background levels as part of their survival strategy (Brooks 1983). Depending on their survival strategies, different species may have lateral root systems for absorbing surface water, vertical root systems for absorbing ground water, or a combination of both that can be switched at will depending on rainfall. Thus, some species seek water from a wide shallow area whereas others will "drill" through tens of metres of cover into bedrock to locate water. As they do this they can accidentally or purposefully accumulate metals, or deliberately exclude them. CANBELEGO contains at least one geobotanical indictor species, *Apophyllum anomalum* (warrior bush), which prefers RCA-rich soil where possible, and will grow as monocultural stands where RCAs are prevalent. As a side note, the presence of large numbers of rabbit burrows also often reflects significant RCAs in the subsoil. A number of plants on CANBELEGO have also been shown to be metal accumulators in the Cobar region and elsewhere in New South Wales, for instance:

- *Callitris glaucophylla* (white cypress pine, previously named *Callitris columellaris*). Cohen *et al.* (1998) showed this species to be useful for locating base metal mineralisation around the McKinnons Mine and Mrangelli Prospect in the Cobar region and (Cohen *et al.* 1999) in the New England area. Hill (2004a) noted Cu concentrations above all other local species at Mundoe (east of Mt Hope, south of CANBELEGO) while Roach (2004) and Roach and Walker (2005) showed strong associations of Ag, Au, Ba, Co, Cr and Mn in trees above the Wyoming 1 Au deposit at Tomingley near Peak Hill;
- *Acacia aneura* (mulga). Shown to accumulate base metals but not Au at Tibooburra (Hill 2004) and to accumulate Ag, Cd, Pb, Sb and Zn at Broken Hill (Hill 2004b);
- *Eucalyptus populnea* (bimble box or poplar box). Shown by Hill (2004a) to contain elevated Pb and Zn in concentrations above other local species at Mundoe;
- *Eucalyptus oleosa* (red mallee). Shown by Hill (2004a) to contain elevated Cu and Zn above other local species at Mundoe; and,
- *Dodonea cuneata* (wedge-leaf hopbush). Shown by Hill (2004a) to contain elevated As and Zn at Mundoe.

Native vegetation can be useful sampling media provided the correct sampling and analytical procedures are taken, outlined by Hill (2002).

8. ACKNOWLEDGEMENTS

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10. APPENDIX

10.1 RC drill hole logs, CBAC170-172

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Drill Hole No:	CBAC 170			(Cover Sheet)
Drilling method:	Aircore	Logged by: B. Maly	Hole Completion Date:	31-Oct-01
Easting: 451170	Northing: 6469094		Datum: AMG66	
Method of locating collar:	GPS (handheld)	Azimuth:	-	
EOH:	6m	Inclination:	90	
Landform Position:	Lower slope of erosional plain/rise?, sub - crop on opposite side of the road			
Vegetation:	White Cyprus Pine, Wilga, Eucalypts			
Land use:	Farming			
Photos:				

depth interval (m) (from)	(to)	graphic c	s	g	colour	weathering	description (or lithology)	interp	sample number
-	0				R/B		Silty clay & magnetic granules to pebbles & sub angular to well rounded qtz granules to pebbles + lithic fragments	T	
0	1				R/B		Silt, sand, common mag granules, sub angular qtz pebbles, lithic fragments	T	CB 2215 (0-1)
1	2						fine sandstone, hard	SP	CB 2216 (1-2)
2	3						fine sandstone, hard	SP	CB 2217 (2-3)
3	4						fine sandstone, hard	SP	CB 2218 (3-4)
4	5						fine sandstone, hard	SP	CB 2219 (4-5)
5	6						fine sandstone, hard	SP	CB 2220 (5-6)
							Refusal at 6m due to very hard drilling. Very hard at 2-3		

drilllog2.xls

COBAR PROJECT 2000-2003 — NSWDMR and CRC LEME — Page __ of __

Drill Hole No:	CBAC 171			(Cover Sheet)
Drilling method:	Aircore	Logged by: S Debenham	Hole Completion Date:	01-Nov-01
Easting: 450385	Northing: 6467762		Datum: AMG66	
Method of locating collar:	GPS (handheld)	Azimuth:	-	
EOH:	57m	Inclination:	90	
Landform Position:	Erosional Plain, mid to upper slope (NNE aspect)			
Vegetation:	WCP, Eucalypt			
Land use:	Farming/Grazing			
Photos:				

depth interval (m) (from)	(to)	graphic c	s	g	colour	weathering	description (or lithology)	interp	sample number
-	0				R/B		Silt, clay & sand, qtz granules to small pebbles, magnetic coarse sand to pebbles, sub angular lithic granules	T	
0	1				R/B		silt, abundant sub angular to sub rounded mag granules, sandstone pebbles , brown clay.	T	CB 2221 (0-1)
1	2				Yellow		Sand, common mag, sandstone?, weakly cemented qtz sands to granules, chert?	T	CB 2222 (1-2)
2	3				Yellow		cemented qtz sand to granules, sandstone (ferruginous), chert?, carbonated coating, abundant mag granules.	T	CB 2223 (2-3)
3	4				Yellow		sub angular qtz coarse sand to granules, weakly cemented qtz sand , fine sandstone? Ferruginous, chert?,	T	CB 2224 (3-4)
4	5				Yellow		medium sand, sub angular qtz granules, chert? Highly weathered volcanoclastic? Common mag granules	T	CB 2225 (4-5)
5	6				Yellow		sub angular qtz granules to pebbles, common mag granules, fine sandstone? Ferruginous, chert?	T	CB 2226 (5-6)
6	7				Yellow/ R/B		Medium sand, sub angular qtz coarse sand to granules, sandstone? , chert?, common mag granules	T	CB 2227 (6-7)
7	8				Yellow/ grey		grey clay, carbonate , sub angular qtz coarse sand	T	CB 2228 (7-8)

drilllog2.xls

Comments:	Slightly harder drilling at 35m (qtz veining). Harder drilling at 45m depth. EOH at 57m.								
depth interval (m)		graphic			colour	weathering	description	interp	sample number
(from/to)		c	s	g			(or lithology)		
8	9				Buff		grey clay, sub angular qtz coarse sand, fine ferruginous sandstone (?)	T	CB 2229 (8-9)
9	11				Buff/White	HW	rock flour? Fine sandstone? Grey clay	T/SP	CB 2230 (11-15)
11	13				Yellow	HW	fine sandstone?	SP	CB 2231 (19-23)
13	15				Yellow	HW	fine sandstone?	SP	CB 2232 (33-37)
15	17				Pink	HW	finely laminated siltstone?, minimal chips, rock flour	SP	CB 2233 (47-51)
17	19				Yellow	HW	highly weathered volcanoclastic ?, minimal chips, fine sandstone?	SP	CB 2234 (55-57)
19	21				Yellow	HW	finely laminated siltstone?, minimal chips, rock flour	SP	
21	23				Yellow	HW	finely laminated siltstone?, minimal chips, rock flour, qtz veining	SP	
23	25				Yellow	HW	finely laminated siltstone?, minimal chips, rock flour	SP	
25	27				Yellow	HW	rock flour, no chips	SP	
27	29				Yellow	HW	rock flour, no chips	SP	
29	31				Yellow	HW	finely laminated siltstone,?, rock flour, minimal chips	SP	
31	33				Yellow	HW	rock flour, no chips, qyz veining	SP	
33	35				Yellow	HW	finely laminated siltstone? Rock flour, minimal chips, qtz veining.	SP	
35	37				Buff	HW	Rock flour, no chips, qtz veining	SP	
37	39				Buff	HW	rock flour, qtz veining, minimal to no chips, fine sandstone?	SP	
39	41				Buff	HW	Rock flour, no chips, qtz veining	SP	
41	43				Buff	HW	Rock flour, no chips, qtz veining	SP	
43	45				Buff	HW	Rock flour, no chips, qtz veining	SP	
45	47				Buff	HW	volcanoclastic?, minimal chips, qtz veining.	SP	

47	49				Buff/Yellow	HW	highly weathered, volcanoclastic?	SP	
49	51				Yellow	HW	volcanoclastic	SP	
51	53				Buff/Yellow	HW	volcanoclastic	SP	
53	55				Yellow/Gre	HW	volcanoclastic	SP	
55	57				White	MW	volcanoclastic	SP	

Drill Hole No:	CBAC 172			(Cover Sheet)
Drilling method:	Aircore	Logged by: S Debenham	Hole Completion Date:	01-Nov-01
Easting: 450480	Northing: 6466409		Datum: AMG66	
Method of locating collar:	GPS (handheld)		Azimuth:	-
EOH:	43m		Inclination:	90
Landform Position:	Erosional Plain, mid to upper slope, pit exposure - 30m to SW (carbonate coating)			
Vegetation:	White Cyprus Pine, Eucalypt, Wilga			
Land use:	Grazing			
Photos:				

Very hard drilling from 1m

depth interval (m) from	to	graphic c	s	g	colour	weathering	description (or lithology)	interp	sample number
-	0				R/B		Silty medium to heavy clay, angular to sub angular lithic (volcanic) granules to cobbles, abundant mag granules.	T	
0	1				R/B		silt, clay, sand, sub angular lithic (volcanoclastic) granules, fe stained chips, common mag granules.	T/SP	CB 2235 (0-1)
1	2				White	HW	Volcanoclastics, fe stained chips, sandy rock flour.	SP	CB 2236 (1-2)
2	3				White	HW	volcanoclastic, sandy rock flour	SP	CB 2237 (2-3)
3	4				White	HW	volcanoclastic, sandy rock flour	SP	CB 2238 (3-4)
4	5				White	HW	volcanoclastic, sandy rock flour	SP	CB 2239 (4-5)
5	6				White	HW	volcanoclastic	SP	CB 2240 (5-6)
6	7				White	HW	volcanoclastic	SP	CB 2241 (6-7)
7	8				White	HW	volcanoclastic	SP	CB 2242 (7-8)

Comments: EOH at 43m. Very hard ground at 39m.

depth interval (m) from	to	graphic c	s	g	colour	weathering	description (or lithology)	interp	sample number
8	9				White		volcanoclastic	SP	CB 2243 (8-9)
9	11				White		volcanoclastic	SP	CB 2244 (15-19)
11	13				White		volcanoclastic, carbonate	SP	CB 2245 (29-33)
13	15				White		volcanoclastic	SP	CB 2246 (39-42)
15	17				White/Yellow		volcanoclastic	SP	
17	19				Yellow		volcanoclastic, rock flour	SP	
19	21				Yellow		volcanoclastic, (siliceous chips?), qtz veining?, minimal chips, rock flour	SP	
21	23				Yellow		volcanoclastic, qtz veining?, chert?	SP	
23	25				Yellow		volcanoclastic, highly weathered), minimal chips, rock flour	SP	
25	27				Yellow		volcanoclastic	SP	
27	29				Yellow		volcanoclastic? Chert?, minimal chips	SP	
29	31				Yellow/Buff		volcanoclastic, minimal chips, rock flour.	SP	
31	33				Yellow		volcanoclastic, minimal chips, rock flour.	SP	
33	35				Yellow		rock flour, no chips, qtz veining?, chert?, siliceous chips?	SP	
35	37				Orange/white		volcanoclastic, minimal chips, rock flour.	SP	
37	39				Orange/white		volcanoclastic, (highly weathered)	SP	
39	41				buff		siltstone?, chert ?	SP	
41	43				buff		siltstone/shale? Silicified?	SP	

Plate 1: Indurated regolith materials.

Ferruginous lag containing angular to well-rounded maghematitic pisoliths and minor weakly- to moderately-ferruginised, angular to subangular lithic and quartz fragments with red-brown fine sand and silt (parna).

Lag containing weakly- to moderately-ferruginised angular lithic and quartz fragments, minor rounded to well-rounded ferruginous pisoliths and red-brown fine sand and silt (parna).

Weakly- to moderately-well formed ferruginous mottles weakly indurating highly weathered bedrock.

Scattered ferruginous pisoliths, quartz and lithic fragments in a semi-consolidated red-brown hardpan, consisting principally of weakly ferruginised clay.

Laminated, buff-coloured RCA coating joints and fractures in bedrock at the soil-saprolite interface.

Slightly to moderately silica- and clay-indurated sub- to well-rounded, poorly sorted Cenozoic sediments.

Silica-indurated subangular to subrounded, poorly sorted quartzose sediments (silcrete).

Silica-indurated subangular to subrounded, poorly sorted quartzose sediments (silcrete) displaying candlewax texture.

Plate 2: Saprock and saprolite.

Slightly weathered Devonian porphyry of the Cobar Supergroup forming a low hill, SE of Canbelego.

Slightly weathered Silurian granite of the Nymagee Igneous Complex forming a low hill, N of Nymagee.

Slightly weathered Devonian conglomerate of the Cobar Sypergroup forming a low hill, Boppy Mt.

Moderately weathered Ordovician sandstone and shale of the Girilambone Group.

Moderately weathered Ordovician sandstone and shale of the Girilambone Group with thick *Eucalyptus socialis* scrub.

Moderately weathered, moderately ferruginised Ordovician sandstone of the Girilambone Group.

Moderately weathered, mottled Ordovician sandstone of the Girilambone Group.

Highly weathered, bleached Ordovician sandstone of the Girilambone Group.

Plate 3: Alluvial and colluvial landforms.

Upper reaches of a low-relief alluvial drainage depression with mixed *Eucalyptus populnea* and *Eucalyptus socialis* woodland, The Rookery.

Cross-section of bedded, poorly-sorted alluvial sediments and stone line above saprolite at Good Friday Prospect GR 270850.

Broad, low-relief alluvial drainage depression with remnant *Eucalyptus populnea* and *Callitris glaucophylla* woodland, Koree.

Eucalyptus populnea riparian woodland marking the Yanda Creek channel, Meryula.

Colluvial sheetwash deposits with moderately well developed characteristic band-interband or "patterned ground" vegetation growth.

Sinuous litter dam composed of *Callitris glaucophylla* needles and twigs on ferruginous lag signifying colluvial sheetwash processes.

Low-relief colluvial plain forming footslope to bedrock rise, The Rookery.

Colluvial plains and rises below saprolite rises and low hills near Canbelego.