THE REGOLITH-LANDFORMS OF SANDSTONE PADDOCK, FOWLERS GAP, WESTERN NSW

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INTRODUCTION

The Fowlers Gap Arid Zone Research Station is host to a wide range of regolith materials and associated landforms that have been developing since at least the Mesozoic (Gibson 1996, 2000, Jansen 2001). Many of these features are clearly expressed in the contemporary arid landscape and therefore provide an excellent venue for teaching the fundamentals of regolith-landform mapping and for developing models for regolith and landscape evolution.

Previous regolith-landform mapping of the area has only been conducted at 1:500,000 scale (Gibson & Wilford 1996). This provides a general representation of the area but does not intend to show the local-scale heterogeneity and complexity of many of its regolith and landforms. Beginning with Sandstone Paddock, the regolith-landforms of this area are being mapped at 1:25,000 scale. This mapping will provide more detail than the previous Land Systems maps over the station (Mabbutt 1972, 1973, Walker 1991) and the 1:500,000 regolith-landform map (Gibson & Wilford 1996, 1998). This will provide a useful landscape context for the many multi-disciplinary environmental and land management studies undertaken in the area, as well as providing a fundamental framework for developing regional regolith and landscape evolution models, both for academic objectives and for the development of regional mineral exploration models. The first results from this more detailed regolith-landform mapping program, presented here at 1:10,000 scale (Figure 1), have been completed during the course of Honours- and Masters-level regolith-landform mapping courses conducted during April and August 2003 by CRC LEME for the Minerals Council of Australia's Minerals Tertiary Education Council (MTEC). This is part of an ongoing and integrated regolith mapping teaching (Hill & Roach 2003, Roach 2003) and research program (when time permits).

SETTING

The Fowlers Gap Arid Zone Research Station is located in southeastern central Australia, 100 km NNE of Broken Hill. It extends across the northern Barrier Ranges and the margins of the Bancannia Basin to the east and the Lake Eyre Basin to the northwest. Sandstone Paddock is located in the northwest of the station, and extends across the uplands of the Barrier Ranges, mostly including the headwaters and gorge of Sandy Creek.

The oldest bedrock in the study area consists of Neoproterozoic Adelaidean metasediments of the Farnell Group (Cooper *et al*. 1978) that are mostly exposed in a N-S trending zone extending across the central parts of the paddock. These include moderately deformed, low-grade metamorphosed marine sediments including quartzite, phyllite, limestone and dolomite. Late Devonian Nundooka Sandstone of the Mulga Downs Group occurs in the east of the paddock and consists mostly of quartzose arenite with some kaolinitic finer-grained units (Beavis & Beavis 1984, Neef *et al*. 1995). Unconsolidated to weakly lithified Early Cretaceous fine sandstones and siltstones (Ward & Sullivan 1973) of the Telephone Creek Formation (Fisher 1997) have been identified in the west of the paddock (Gibson 1996, 1997, 2000) and to the east of the study area (Beavis & Beavis 1984, Fisher 1997) and are extrapolated to have extended across the entire area (Gibson 1997). Although there has been some confusion regarding either the Mesozoic or Tertiary stratigraphic context of many of the sediments in the area, a small area of silicified Tertiary fine sands are exposed south of Sandstone Tank (Ward *et al.* 1969, Greenwood *et al*. 1997). A mixture of Quaternary alluvial, colluvial and aeolian sediments have also accumulated within the area, particularly associated with broad valley systems (Mabbutt 1972, Chartres 1982a, b, 1985, Akpokodje 1987, Jansen 2001). The Adelaidean and Late Devonian bedrock are juxtaposed by the Nundooka Creek Fault, which forms a major SSE-NNW trending zone through the area. Another major N-S trending structure extends across the western parts of the paddock, and appears on the 1VD aeromagnetics.

The climate is predominantly dry with hot summers and mild winters (Bell 1972). A mean annual rainfall of 231 mm was recorded between 1966-1996, however, longer-term determinations including unofficial station records suggest that the mean annual rainfall since the 1880s is closer to 200 mm (Jansen 2001). Rainfall patterns are extremely variable and the station lies in the transitional zone between summer and winter rainfall dominance.

The vegetation of the area mostly consistes of chenopod shrublands dominated by bladder salt-bush (*Atriplex vesicaria*) and copper-burrs (*Sclerolaena* spp.) across plains and rises, particularly in the west of the area, and mulga (*Acacia aneura*) and belah (*Casuarina pauper*) open woodland with a chenopod understorey across rises and hills in the east of the area. Riparian woodlands of river red gum (*Eucalyptus camaldulensis*) occur along the lower stretches of Sandy Creek Gorge. Tree cover has markedly declined over the post-settlement period for use in fences, firewood and drought-fodder (Jansen 2001).

The area has hosted pastoral grazing since the 1860s. Until 1949 it was part of the Corona Run, and since 1966 the University of NSW has run the area as an Arid Zone Research Station that includes some sheep, goat, and cattle grazing. Rabbits arrived in the region in 1885 and have been a very significant herbivore grazer since that time.

REGOLITH-LANDFORM UNITS

Regolith-landform units (RLUs) for mapping are assigned codes according to Pain *et al.* (in prep.). The main attributes recorded at individual field sites and within RLU descriptions include: regolith lithology; landform expression; surface material; minor attributes; vegetation community and dominant species; and, land management hazards (Hill 2002).

IN SITU REGOLITH

Slightly Weathered Bedrock (SS)

The slightly weathered bedrock of the area has developed from two main rock types: 1. Adelaidean metasediments; and, 2. Devonian sedimentary rocks. The slightly weathered bedrock is still relatively hard, and shows slight surficial ferruginous staining, cryptogam colonisation, and opening of fracture sets. The main landform assemblages, and resulting RLUs, are:

- erosional plains with less than 9 m topographic relief developed on both the weathered Adelaidean ($SSep_1$) and weathered Devonian ($SSep_2$) bedrock;
- erosional rises with 9 – 30 m topographic relief developed on the weathered Adelaidean ($SSer_1$) and weathered Devonian ($SSer_2$) bedrock;
- erosional low hills with 30-70 m topographic relief, developed on both the weathered Adelaidean ($SSel_1$) and weathered Devonian ($SSel_2$) bedrock.

Minor regolith materials associated with these RLUs include red-brown fine sand and silt, typically derived from aeolian additions or their local reworking by shallow overland flow. Minor hardpan and powdery regolith carbonate accumulations (RCAs) are locally developed, particularly associated with Devonian sandstones with minor calcareous components. These RLUs mostly support open woodlands dominated by mulga (*Acacia aneura*) and belah (*Casuarina pauper*) with a mixed understorey locally dominated by chenopods including bladder salt-bush (*Atriplex vesicaria*) and blue-bushes (*Maireana* spp.). Gully erosion is locally developed within these RLUs.

Moderately Weathered Bedrock (SM)

Moderately weathered bedrock has a limited landscape expression in the area, and is mostly confined to areas of relatively recent erosion in gullies or sheet eroded areas. Within Sandstone Paddock, areas of moderately weathered bedrock large enough to be mapped as RLUs at 1:25,000 scale are limited to materials derived from the weathering of Adelaidean bedrock in the far south and northwest of the area, and weathered Cretaceous sediments in the west of the paddock. The moderately weathered material is highly friable, and easily falls apart when kicked. Most of the weathered bedrock types were slates, where the slatey cleavage has now opened up, accounting for the weakness of this material. Many of the primary aluminosilicate minerals have been replaced by kaolin clays and may have a weak ferruginous staining and in many cases there is a well-developed cryptogam cover. More calcareous and dolomitic bedrock types show well-developed rillen-karren and surface dissolution features and powdery and minor hardpan regolith carbonate accumulations (Hill *et al.* 1999).

The landscape expression is typically quite subdued, and mostly forms erosional rises with 9–30 m topographic relief ($SMer_1$). Minor regolith materials associated with this RLU include red-brown fine sand and silt, typically derived from aeolian additions or their local reworking by shallow overland flow. This is colonised by open woodland dominated by mulga (*Acacia aneura*) and belah (*Casuarina pauper*) with a mixed understorey locally dominated by chenopods including bladder salt-bush (*Atriplex vesicaria*) and blue-bushes (*Maireana* spp.). Gully erosion is typically widely developed with this RLU.

TRANSPORTED REGOLITH

Alluvial Sediments (A)

Alluvial sediments are mostly associated with the channel and tributaries of Sandy Creek. The main landform assemblages and their associated materials include:

- Aap_1: red-brown, subrounded to subangular quartzose and lithic sands, gravels and silts, associated with a low relief landsurface containing a mixture of incised channels and smooth depositional surfaces. Vegetation cover is an open chenopod shrubland dominated by bladder salt-bush (*Atriplex vesicaria*) and blue-bushes (*Maireana* spp.), with minor prickly wattle (*Acacia victoriae*) and needlewood (*Hakea leucoptera*) trees.
- Apd_1: red-brown, subrounded to subangular quartzose and lithic sands, gravels and silts, associated with a smooth, low relief landsurface, typically associated with the depositional floodout of channels and drainage depressions. Vegetation cover is a chenopod shrubland dominated by blue-bushes (*Maireana* spp.).
- Aed_1: red-brown, subrounded to subangular quartzose and lithic sands, gravels and silts, with locally exposed slightly weathered bedrock, associated with incised channels and the immediately flanking gully slopes. Vegetation is typically a chenopod shrubland dominated by blue-bushes (*Maireana* spp.) and bladder saltbush (*Atriplex vesicaria*).
- Aep_1: rounded and minor angular quartzose sands and pebbles, with local concentrations of leaf, fruit and wood impressions, indurated by microcrystalline quartz and minor microcrystalline anatase and hematite, associated with exposures with low topographic relief locally shedding material into flanking sediments. Vegetation is a very sparse chenopod shrubland mostly dominated by bladder saltbush (*Atriplex vesicaria*).
- Aer_1: rounded and minor angular quartzose sands and pebbles, with local concentrations of leaf, fruit and wood impressions, indurated by microcrystalline quartz and minor microcrystalline anatase and hematite, associated with exposures with slight topographic relief, locally shedding material into flanking sediments. Vegetation is a very sparse chenopod shrubland mostly dominated by bladder saltbush (*Atriplex vesicaria*).

Aeolian Sediments

Aeolian sediments are a component of RLUs across the study area, however, in some cases the aeolian accumulations are extensive enough to be mappable in their own right at 1:25,000 scale. In these cases they typically consist of well-rounded and well-sorted, red-brown quartzose fine sand. The largest accumulations of these materials occur within sand plains ($ISps_1$) along the west-facing footslopes of erosional rises and low hills. These areas are typically colonised by an open woodland dominated by mulga (*Acacia aneura*) with a mixed understorey typically with an abundance of blue-bushes (*Maireana* spp.).

Colluvial Sediments (C and CH)

Colluvial sediments are a component of most RLUs in the area, however, for much of the area they are significant enough to form RLUs in their own right. Colluvial sediments, where the dominant sediment transport mechanism is by way of slope creep and rock fall, flank most prominent bedrock and indurated regolith exposures. They include:

- Cer_1: angular lithic (mostly quartzite) and quartzose gravels with minor red-brown quartzose sands, associated with areas of slight topographic relief. Vegetation is a chenopod shrubland dominated by bladder salt-bush (*Atriplex vesicaria*).
- Cer_2: angular gravels of silicified sediment clasts and angular to rounded quartzose gravels with minor red-brown quartzose sands, associated with areas of slight topographic relief. Vegetation is a chenopod shrubland dominated by bladder salt-bush (*Atriplex vesicaria*).

Shallow overland flow, dominated by sheetflow, is very prevalent across the area. This is responsible for the erosion and transport of sediment from the upper parts of the landscapes, such as erosional rises and plains, and their deposition in local depositional 'sinks' associated with depositional plains. The main erosional settings for these materials include:

- $CHer_1$: angular lithic (mostly quartzite) and quartzose gravels with minor red-brown quartzose sands, associated with areas of slight topographic relief, with prominent 'contour band' surface patterns, and locally shedding material into flanking sediments. Vegetation is a chenopod shrubland dominated by bladder salt-bush (*Atriplex vesicaria*).
- $CHer_2$: rounded quartzose gravels and angular silicified sediment gravels with minor red-brown quartzose sands, associated with areas of slight topographic relief, with prominent 'contour band'

surface patterns, and locally shedding material into flanking sediments. Vegetation is a chenopod shrubland dominated by bladder salt-bush (*Atriplex vesicaria*).

- $CHep_1$: rounded quartzose gravels and angular silicified sediment gravels with minor red-brown quartzose sands, associated with areas of low topographic relief, with prominent ‘contour band’ surface patterns, and locally shedding material into flanking sediments. Vegetation is a chenopod shrubland dominated by bladder salt-bush (*Atriplex vesicaria*).
- $CHep_2$: rounded quartzose gravels and angular silicified sediment gravels with minor red-brown quartzose sands, associated with areas of low topographic relief, with irregular ‘contour band’ and circular depressions typically about 10 m diameter, and locally shedding material into flanking sediments. Vegetation is a chenopod shrubland dominated by bladder salt-bush (*Atriplex vesicaria*).
- $CHed_1$: red-brown, subrounded to subangular, quartzose and lithic sands, gravels and silts, associated with elongate depressions, with irregular ‘contour banding’ surface patterns and numerous circular depressions typically of about 10 m diameter. Vegetation is typically a chenopod shrubland dominated by blue-bushes (*Maireana* spp.) and bladder saltbush (*Atriplex vesicaria*).

The main depositional settings include:

- $CHpd_1$: angular lithic (mostly quartzite) and quartzose gravels with minor red-brown quartzose sands, associated with areas of low topographic relief, with prominent ‘contour band’ surface patterns. Vegetation is a chenopod shrubland dominated by bladder salt-bush (*Atriplex vesicaria*) and minor blue-bushes (*Maireana* spp.).
- $CHpd_2$: rounded quartzose gravels and silicified sediment gravels with minor red-brown quartzose sands, associated with areas of low topographic relief, with prominent ‘contour band’ surface patterns. Vegetation is a chenopod shrubland dominated by bladder salt-bush (*Atriplex vesicaria*) and minor blue-bushes (*Maireana* spp.).
- $CHpd_3$: angular, mixed lithic, silicified sediments and quartzose gravels with minor red-brown quartzose sands, associated with areas of low topographic relief, with irregular ‘contour band’ surface patterns. Vegetation is a chenopod shrubland dominated by blue-bushes (*Maireana* spp.) and minor bladder salt-bush (*Atriplex vesicaria*).

INDURATED REGOLITH

Silicified Regolith

Massive, tabular pods of sediment mostly indurated by microcrystalline quartz. Aep_1 and Aer1 RLUs are indurated by microcrystalline quartz with minor ferruginisation and microcrystalline anatase induration. Minor silicification is also hosted by the moderately weathered Cretaceous sediments ($SMer_1$), with silicification being more complex and extensively exposed in the region outside of this mapping area (such as within the mesas immediately west of this area). The main morphological facies of silicified regolith include massive, tabular pods, preserving leaf, wood and seed impressions and sedimentary structures in the host material, such as graded and trough cross bedding. Minor columnar and nodular silicification morphologies also occur in the area.

Ferruginised Regolith

Ferruginisation is relatively restricted in this area. The main occurrences are associated with ferruginised saprolite, including a NNW-SSE trending zone of ferruginised weathered Adelaidean metasediments in the central west of the paddock, and ferruginised zones and beds within the weathered Cretaceous sediments. Variable hematite cement contents occur with the silicified sediments, particularly along the SW margins of the Aer1 RLU that hosts abundant plant fossils.

Regolith Carbonate Accumulations (RCAs)

Nodular, hardpan and powder RCA morphologies (Hill *et al.* 1999) are locally associated with Devonian sandstones ($SSel_1$, $SSer_1$, $SSep_1$), but are most extensive near areas of moderately weathered Adelaidean limestone and dolomite ($SMer_1$).

DISCUSSION: REGOLITH AND LANDSCAPE EVOLUTION MODEL

Previous studies have indicated several key components of the area’s long-term regolith and landscape evolution that this study further illuminates.

Extrapolation and significance of sedimentary and indurated palaeo-landsurfaces

Regionally extensive palaeo-surfaces, indurated regolith (‘duricrusts’) and sedimentary units have been a major feature of previous long-term landscape evolution studies in the region. This study finds little to support many of the previous extrapolations across this area by previous workers, more specifically:

- Silicified regolith (duricrusts and silcretes) has been widely extrapolated and interpreted to be part of former low relief landsurfaces, such as mid-Tertiary landsurfaces including the Cordillo Surface (e.g., Mabbutt 1972, 1973, Neef *et al.* 1995). In contrast, the silicified regolith mapped in this area is associated with localised silicification within palaeo-valley systems that flowed between ridges of relatively resistant bedrock (discussed below);
- Extrapolation of Cretaceous sediments overtopping the northern Barrier Ranges, and thereby formerly extending across this area (Gibson 1996, 1997, 2000), is not supported by positive evidence in the area. Remnants of Cretaceous sediments occur in the western half and further to the west and to the east of the area. Although it may be argued that they have since been eroded away from across the entire area, the coarse-grained basal Early Cretaceous sediments described by Gibson (2000) suggest that uplands existed in this area during the Early Cretaceous, and may not have allowed for Cretaceous deposition across the entire ranges. Based on drilling logs and sedimentary sections, Jansen (2001) suggests that the Early Cretaceous depositional sequence thins from 201 m thick within the Bancannia Basin depocentre to < 70 m thick towards the Barrier Ranges. This continues to thin farther west, leaving the higher parts of the ranges (including the higher parts of Sandstone Paddock) exposed. As such, the presently higher parts of the northern Barrier Ranges may have formed part of a subaerial land-mass, perhaps a peninsula or archipelago, flanked by two structurally controlled, submerged sedimentary depocentres to the west and east.
- Early Tertiary Eyre Formation correlations in the area (e.g., Neef *et al.* 1995) cannot be substantiated. This is not only due to the major shortfallings in areas of proven Mesozoic sediments (particularly outside of this mapping area, as shown by Gibson 1996, 1997, 2000) but also within the mapping area where there are major lithological differences between the Early Tertiary Eyre Formation. This includes an abundance of well-rounded, well-sorted and highly polished pebbles at its basal beds (Alley 1998), and the Early Tertiary alluvial sediments from Sandstone Paddock that include a mixture of angular and rounded, and in parts, poorly-sorted pebbles. Chronologically these sediments may be equivalent, with the palaeosediments here possibly representing more proximal feeder channels into the Eyre Formation alluvial sediments of Lake Eyre Basin, constrained to the east and west by resistant sandstone and quartzite ridges.

Palaeodrainage and sedimentary history

From the palaeobotanical (Greenwood *et al.* 1997) and sedimentological descriptions, and mapping results presented, it is suggested that the Aer_1 and Aep_1 RLUs are associated with an Early Tertiary palaeo-drainage system. Trough cross-bedding indicates that palaeo-flow was towards the NNW. The western margins of these palaeo-valley sediments have been topographically inverted by erosion along the southern tributaries of Sandy Creek, upstream of Sandstone Tank, however, some exposures of similar fossiliferous, silicified sediments occur lower in the landscape further east. Many of these less elevated exposures of silicified sediments are partially covered by sheetflow sediments dominated by rounded quartzose pebbles, which are most likely derived from equivalent palaeo-valley sediments. This suggests that a major NNW flowing palaeo-drainage system extended through this area, across the present course of the main Sandy Creek channel. In the south of the paddock this closely corresponds with the position of the Nundooka Creek Fault Zone, suggesting that the Early Tertiary palaeo-drainage was strongly controlled by bedrock structure and locally constrained by strike ridges composed of relatively resistant bedrock. This entire interpretation is significant because it suggests that the E-W trending, transverse drainage system of Sandy Creek was initiated after the Early Tertiary, rather than during the Early Tertiary as suggested by Jansen (2001). It also suggests that much of the topographic relief and the strong bedrock lithological and structural controls were in place at least by the Early Tertiary.

The chronological and palaeo-environmental context for induration

The silicified palaeovalley sediments contain relatively intact Early Tertiary plant remains. The silicification must therefore post-date the Early Tertiary deposition. The preservation of delicate leaf remains suggests that silicification may have closely followed deposition. This is consistent with silicification having taken place in the Early to Mid-Tertiary. Although this may be chronologically equivalent to the ‘Cordillo Silcretes’ of the Lake Eyre Basin, as discussed earlier the silicification here is more closely associated with a palaeo-valley system rather than a regional extensive low-relief landsurface (i.e., the ‘Cordillo Surface’). The Eocene plant assemblage reflected in the fossil remains suggests that the climate at the time of sedimentation was wetter than the contemporary climate. The abundance of water and organic remains in the sediments may have had a significant influence on silicification, such as providing acidic conditions suitable for the leaching and subsequent removal of Al, the local mobilisation of Ti to form the microcrystalline anatase, and the precipitation of Si-compounds.

Bedrock and structural controls on landscape development

The relief and drainage evolution of the area strongly reflects local bedrock lithologies and structural trends, such as that shown by the trellis drainage pattern in the Sandy Creek gorge area. The thickly bedded coarse-grained Devonian sandstones are very resistant to weathering and erosion in the area of the gorge, and further west the Adelaidean quartzites similarly form elongate ridges of low hills and rises. Jansen (2001) suggests that the nature of the cement is important in explaining the landscape expression of the Devonian sedimentary rocks, with rocks with siliceous cement being more resistant to weathering and erosion than those with kaolinitic cements. The Nundooka Creek Fault is also an important structural control, with differential weathering and erosion having outweighed any possible post-Early Cretaceous vertical tectonic displacement (Gibson 2000, Jansen 2001).

CONCLUSIONS

It is hoped that a continuation of this teaching and mapping program will allow some of these research findings to be further developed. This program has already promoted the skills and importance of regolith-landform mapping to course participants, and it is intended that it will also make important contributions to the knowledge of regolith and landscape evolution in this area and be of use to other researchers and land users in the area.

REFERENCES

ALLEY N.F. 1998. Cainozoic stratigraphy, palaeoenvironments and geological evolution of the Lake Eyre Basin. *Palaeogeography, Palaeoclimatology, Palaeoecology* **144**, 239-263.

AKPOKODJE E.G. 1987. The mineralogical relationship between some arid zone soils and their underlying bedrocks at Fowlers Gap Station, New South Wales, Australia. *Journal and Proceedings of the Royal Society of New South Wales* **120**, 90-99.

BEAVIS F.C. & BEAVIS J.C. 1984. *Geology, Engineering Geology and Hydrogeology of Fowlers Gap Station.* University of New South Wales Research Series **6**.

CHARTRES C.J. 1982a. The pedogenesis of desert loam soil in the Barrier Range, western New South Wales. I. Soil parent materials. *Australian Journal of Soil Research* **20**, 269-281.

CHARTRES C.J. 1982b. The pedogenesis of desert loam soils in the Barrier Range, western New South Wales. II. Weathering and soil formation. *Australian Journal of Soil Research* **26**, 17-31.

CHARTRES C.J. 1985. A preliminary investigation of hardpan horizons in north-west New South Wales. *Australian Journal of Soil Research* **23**, 325-337.

COOPER P.F., TUCKWELL K.D., GILLIGAN L.B. & MEARES R.M.D. 1978. *Geology of the Torrowangee and Fowlers Gap 1:100,000 sheets*. Geology Survey of New South Wales, Sydney. 164 pp.

FISHER A.G. 1997. *An investigation of silcrete, ferricrete and Telephone Creek Formation at Fowlers Gap Arid Zone Research Station, Western NSW*. BSc Honours thesis, University of New South Wales, unpublished.

GIBSON D.L. 1996. Cretaceous sediments, tectonics, and landscape development in the northern Barrier Ranges. *Regolith 96 Abstracts.* CRC LEME, Perth.

GIBSON D.L. 1997. Recent tectonics and landscape evolution in the Broken Hill region. *Australian Geological Survey Organisation Research Newsletter* **26**, 17-20.

GIBSON D.L. 2000. Post-Early Cretaceous landform evolution along the western margin of the Bancannia Trough, western NSW. *Australian Rangeland Journal* **22**, 32-43.

GIBSON D.L. & WILFORD J.R. 1996. *Broken Hill Regolith-Landforms (1:500,000 map scale).* CRC LEME, Perth/Canberra.

GIBSON D.L. & WILFORD J.R. 1998. *Broken Hill Regolith-Landforms, revised edition (1:500,000 map scale).* CRC LEME, Perth/Canberra.

GREENWOOD D.R., ROWLETT A.I., ALLEY N.F. & HILL S.M. 1997. Palaeobotanical evidence for the initiation of the drying of the Australian interior. *In:* PRICE D. & NANSON G. eds. *Quaternary Deserts and Climate Change Program and Abstracts ICGP 349.* University of Wollongong, School of Geosciences, unpaginated.

HILL S.M. 2002. Some issues and challenges for regolith-landform mapping with particular reference to the Broken Hill region. *In:* ROACH I.C. ed. *Regolith and Landscapes in Eastern Australia*, pp. 63-67. CRC LEME.

HILL S.M. & ROACH I.C. 2003. Regolith geoscience education and training within the western NSW teaching laboratory. *In:* PELJO M. (comp.) Broken Hill Exploration Initiative: Abstracts from the July 2003 conference. *Geoscience Australia* **Record 2003/13**, 79-80.

HILL S.M., MCQUEEN K.G. & FOSTER K.A. 1999. Regolith carbonate accumulations in western and central NSW: characteristics and potential as an exploration sampling medium. *In:* TAYLOR G. & PAIN C.F. eds. *New Approaches to an Old Continent: Proceedings of Regolith 98.* CRC LEME, 191-208.

JANSEN J.D. 2001. B*edrock channel morphodynamics and landscape evolution in an arid zone gorge: Sandy Creek, northern Barrier Range, south-eastern central Australia*. PhD thesis, Macquarie University, unpublished.

MABBUT J.A. 1972. Geomorphology of the Fowlers Gap-Calindary area. *In:* MABBUTT J.A. ed. *Lands of the Fowlers Gap – Calindary area, New South Wales.* University of New South Wales Research Series **4**, 81-99.

MABBUT J.A. 1973. Geomorphology of the Fowlers Gap Station. *In:* MABBUTT J.A. ed. *Lands of Fowlers Gap Station, New South Wales.* University of New South Wales Research Series **5**, 85-122.

NEEF G., BOTTRILL R.S. & RITCHIE A. 1995. Phanerozoic stratigraphy and structure of the northern Barrier Ranges, western New South Wales. *Australian Journal of Earth Sciences* **42**, 557-570.

PAIN C., CHAN R., CRAIG M., GIBSON D., URSEM P. & WILFORD J. in prep. *RTMAP regolith database field book and users guide*. CRC LEME **Report 138**.

ROACH I.C. 2003. Three years of MTEC. *In:* Roach I.C. ed. *Advances in Regolith*, pp. 345-351. CRC LEME.

WALKER P.J. (comp.) 1991. Land systems of western New South Wales. *Soil Conservation Service of New South Wales* **Technical Report 25**, 615 p.

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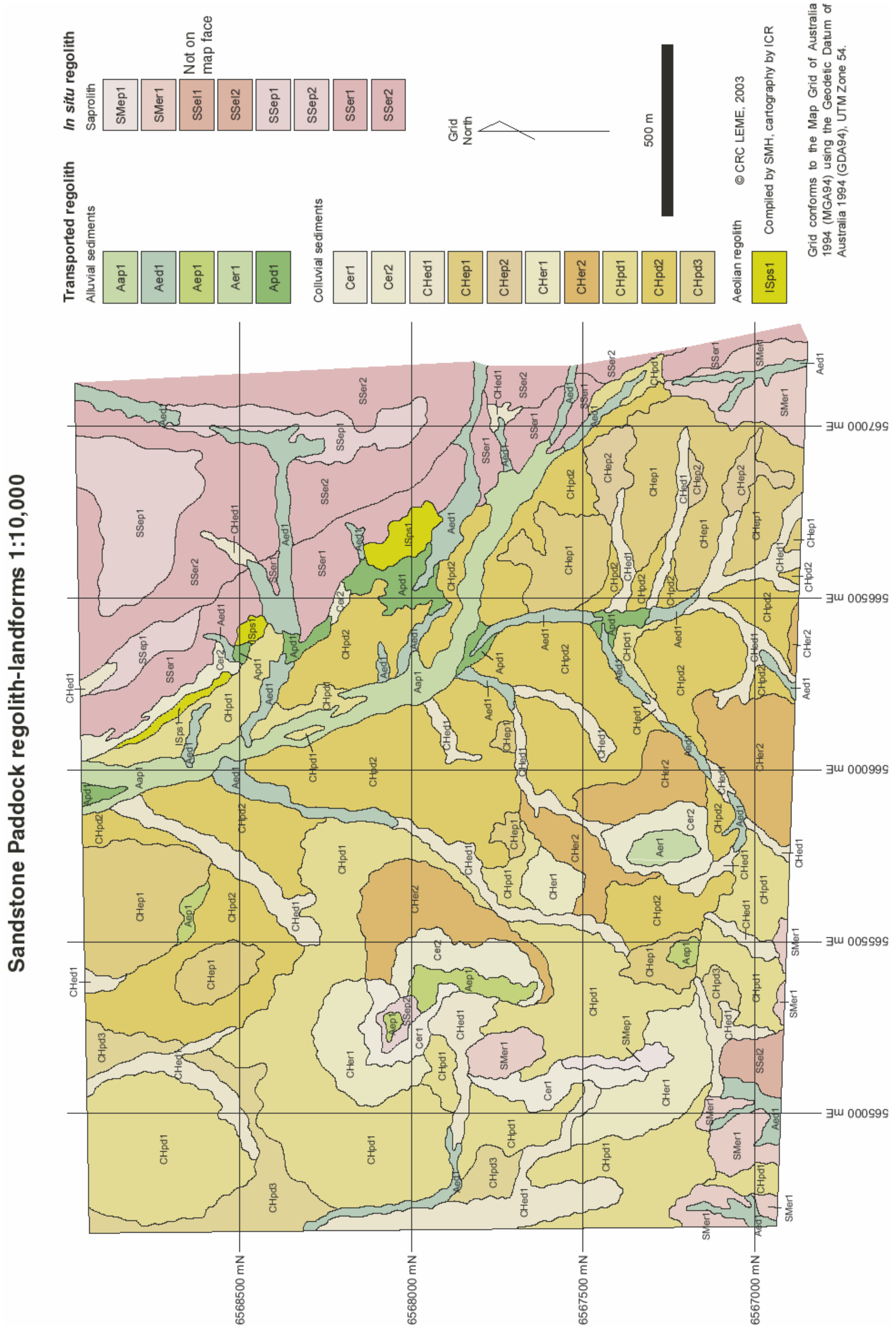

Figure 1: 1:10,000 Regolith-landform map of part of Sandstone Paddock, Fowlers Gap (not to scale).