BROKEN HILL 1:100,000 REGOLITH-LANDFORM MAP: DEVELOPMENT, FEATURES AND APPLICATIONS

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INTRODUCTION

The Broken Hill region is a regolith-dominated terrain—over 90% of the landscape in far western NSW is dominated by regolith. Interestingly, the mineral exploration that has primarily focussed on the less than 10% bedrock exposure yielded the discovery of the famous Broken Hill Ag-Pb-Zn orebody. Even this was initially overlooked in the early years of mineral exploration because of its weathered nature (and so-called resemblance to a 'hill of mullock'). The search for further ore deposits has offered little reward, however, exploration in the regolith-dominated terrains has been limited and constrained by knowledge and framework.

This account highlights many of the features of the Broken Hill Domain 1:100,000 regolith-landform map (Hill 2001), outlining the development of the map, some of the methods used in its production, and the potential for the map to be utilised for a range of purposes.

MAPPING BACKGROUND

Prior to the late 1990's very little regional information and accounts of the region's regolith and landforms existed. Limited accounts could be found in geological reports, soil and geomorphological research manuscripts and as a part of the broad units in the 1:250,000 Land System maps (Walker 1991). This discrepancy has been addressed by some of the recent regolith-landform research in the region. The Broken Hill 1:100,000 regolith-landform map was the first regolith-landform mapping project to be undertaken in this region.

In 1993, CRA Exploration (now Rio Tinto Exploration) suggested and supported a PhD study of the regolith and landscape in the Broken Hill region, culminating in the thesis of Hill (2000). One of the major requirements of this research was to produce a regional regolith map. This was largely in response to the success of the CSIRO-AMIRA regolith projects that this company had helped sponsor in places like the Yilgarn. This was also because of the difficulties that mineral explorers had had with exploring and obtaining meaningful sampling materials in the regolith-dominated parts of the Broken Hill landscape. Although parts of this landscape were red, its offered very different exploration challenges to the 'lateritic' terrains of parts of Western Australia. This became particularly apparent when, despite of encouragement to map the regolith of the area using the RED (Residual-Erosional-Depositional) scheme, much of this landscape could not be placed within this conceptual mapping framework. For example, most of the indurated regolith materials such as ferricretes and silcretes are developed in depositional materials (mostly palaeovalleys) and could not be interpreted as relicts of a single, formerly extensive, indurated palaeoplain.

More recently the NSW DMR have become major sponsors in the project through programs such as the BHEI (Broken Hill Exploration Initiative) and Discovery 2000. The research undertaken through these programs has encouraged the development of regional mapping to stimulate mineral exploration in regolith-dominated terrains around Broken Hill.

MAPPING STUDY AREA

The area of the Broken Hill Domain 1:100,000 regolith-landform map corresponds with the Broken Hill Stratigraphic Map (Willis 1989), an interpretive bedrock geological map that was intended to provide a regional overview and synthesis. It was decided to produce the Broken Hill Domain 1:100,000 regolith-landform map of the same area as Willis (1989), although also including the regolith-dominated areas otherwise obscured by the legend in bedrock geology map. It was, however, deemed too provocative to place the regolith map legend over areas of bedrock exposure! This area includes the area of the Broken Hill Domain in NSW, the Euriowie Domain and the adjacent areas of Adelaidean rocks and the margins of the Murray and Lake Eyre Basins (Figure 1).

MAPPING METHODS

The main objective of this regolith-landform was to produce a regional overview of the distribution of the major regolith types and their landform expressions. This has resulted in a multi-purpose presentation style,

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that could be equally applicable to regional regolith and landscape research, mineral exploration programs and land management. The map was initially produced as a part of a PhD study of the regolith and landforms of the same area (Hill 2000), although has since been published through CRC LEME.

The mapping scheme adopted for this map was the RLU (Regolith Landform Unit) approach developed through Geoscience Australia (Pain *et al*. in press). Although this approach utilises some form of genetic interpretation in its presentation, the mapping unit descriptions both in the field and in the map legend were designed to be mostly descriptive rather than interpretative. This means that the mapping legend descriptions should stand for each of the RLUs independent of the more interpretative mapping code and polygon colours shown on the map face (see Hill 2002).

Mapping was based interpretation of RC9 black and white air photographs at approximately 1:82,000 scale, plus data sets from the Broken Hill Exploration Initiative (BHEI) releases including radiometric, digital elevation and total magnetic data. Field mapping included the establishment and checking of polygon boundaries and also the description of field site attributes such as: regolith materials; landforms; surface materials; and vegetation communities and dominant species. During field mapping indurated regolith materials including regolith carbonate accumulations (RCAs), silicified, ferruginised, and gypseous regolith were sampled for geochemical, mineralogical and thin section analysis (Hill 2000).

REGOLITH-LANDFORMS

The landscape of the area is dominated by the bedrock-dominated mountains, hills and rises of the Barrier Ranges through the central portion of the map area, with regolith-dominated, low-lying rises and plains within the margins of the Lake Eyre Basin to the west and north-west, the Murray Basin to the south and south-east, and the Lake Bancannia Basin to the north-east. Details of the regolith and landscape evolution of the area may be found in Hill (2000).

The map shows a total of 39 RLUs, that have been presented within a framework of the following regolith types:

- alluvial sediments;
- aeolian sediments;
- colluvial sediments;
- lacustrine sediments;
- fill; and,
- saprolith.

Alluvial Sediments

These materials can be categorised into two main types: 1. alluvial sediments associated with the contemporary drainage systems (contemporary alluvial sediments); and, 2. alluvial sediments isolated from the contemporary drainage systems either through topographic elevation or deep burial (ancient alluvial sediments). The contemporary alluvial sediments mostly consist of a mixture of lithic and quartzose sands and gravels with minor silts and clays. Their landform expressions are within: alluvial plains (Aap_{1-4}); alluvial swamps ($Aaw_{1\&2}$); drainage depressions (Aed_1); alluvial fans ($Afa_{1\&2}$); depositional plains (Apd_{1-5}); and alluvial channels (ACa_{1-3}). These RLUs mostly occur in low-lying areas flanking the Barrier Ranges and within major valley systems that extend through the ranges. The ancient alluvial sediments mostly consist of quartzose sands and gravels with minor kaolinitic silts and clays. They are mostly exposed on erosional rises and may be indurated dominantly by micro-crystalline silica (Aer_1) or ferruginous cement (Aer_2). The mapped ancient alluvial sediments mostly represent topographically inverted, indurated palaeovalley systems and are mostly exposed on the margins of the Barrier Ranges and the flanking basins.

Aeolian Sediments

These mostly consist of well-sorted, deep red-brown and light red-brown sands with minor silt and clay. Aeolian materials are a widespread component of RLUs in the area, however, they are only dominant and mappable features in association with aeolian landforms such as sand plains that include hummocky, degraded longitudinal dunes ($ISps_1$). They have only been extensive enough to map at this scale in the far north-west of the area on the margins of the Strzelecki Desert and as patches within the fans of the Mundi Mundi Plain.

Colluvial Sediments

The most extensive colluvial sediments that are able to shown a map of this scale are sheet-flow deposits. These mostly include mixtures of quartzose and lithic gravels, sands, silts and clays, expressed within:

drainage depressions ($CHed_1$); erosional rises ($CHer_{1-2}$); sheetflow fans ($CHfs_{1-3}$); and depositional plains ($CHpd_{1-6}$). Many of these RLUs have distinctive surficial patterns of alternating bands of surface lag gravels and shrub covered red-brown fine sands that broadly conform to elevation contours. These sediments mostly occur flanking hills and rises, particularly as large, lobed sheetflow fans along the southern and eastern margins of the Barrier Ranges, and as depositional lobes within the fans of the Mundi Mundi Plain in the west of the area.

Lacustrine Sediments
The areas of lacustrine sediments mappable at this scale are found within the Stephens Creek and Umberumberka Reservoirs. They mostly consist of red-brown silts and clays, although they are often covered by standing water. Other lacustrine sediments are buried beneath some of the colluvial and alluvial sediments, particularly near the southern margins of the Barrier Ranges (Hill 2000).

Fill
This unit includes the urban area of the city of Broken Hill, and the Broken Hill airport, where the original regolith-landform features have been obscured by anthropogenic modification such as construction and landscaping.

Saprolith
These RLUs include areas dominated by exposures of weathered bedrock that range from slightly to highly weathered. Highly weathered bedrock consists mostly of friable kaolinitic saprolite, typically with ferruginous mottles, exposed within erosional rises ($SHer_1$), mostly along the margins of the Barrier Ranges and flanking sedimentary lowlands (e.g. in the northwest of the mapping area along the Kantappa Escarpment). Much of the primary mineralogy in moderately weathered bedrock is replaced, or is beginning to be replaced, by secondary minerals. It is typically ferruginised, and exposed within erosional rises ($SMer_1$) mostly in the south of the area along the margins of the Barrier Ranges and Murray Basin. Slightly weathered bedrock corresponds mostly with areas of bedrock exposure that are shown on most geological maps. The slight weathering grade is typically expressed by a surficial ferruginous staining and the opening of joint sets. It may be exposed within erosional mountains ($SSem_1$), hills ($SSeh_1$), and rises ($SSer_1$), mostly within the Barrier Ranges, and progressively less so towards the flanking lowlands.

SOME IMPLICATIONS OF THE MAPPING
This mapping has been produced to give a general representation of regolith materials and associated landforms, and as such has the potential for multi-purpose applications. More specifically however, it can be used as a tool and to provide a framework for landscape research, mineral exploration and land management.

The original construction of the map provided a regional framework for a PhD study of the regolith and landscape evolution of the area (Hill 2000). This was particularly valuable for providing coverage of the entire study area, rather than only subjectively emphasising key sections or parts of the area. By showing the distribution of major regolith-landform features, the map can be used to provide a framework and support regional landscape evolution accounts. For instance, the landscape expression of many tectonic features such as the Mundi Mundi, Kantappa, Mulculca and Redan Faults can be seen. By highlighting certain units derivative maps can be produced, for example of palaeovalley systems represented by Aer_1 and Aer_2 RLUs.

For mineral exploration programs the map is most useful for providing a regional regolith-landform framework for planning regional exploration approaches. Terrains dominated by transported regolith and bedrock-dominated terrains can be easy recognised. Regional dispersion pathways and sedimentary depocentres, that may help link regional regolith samples to regional geochemical targets, can also be seen. This map is limited in showing the local distribution of regolith sampling media and local dispersion pathways for individual exploration tenements, which are best done on more detailed maps such as the 1:25,000 series.

So far the map has not been widely used for land management purposes, however, potential exists for these applications. The RLUs on the map can be broadly related to the regional suitability of some areas to different grazing pressures. Many of the RLUs can be related to the regional pattern of water movement through the landscape, along with associated sediment, trace nutrients and seed dispersal. Erosional and depositional units can also be linked to differences in soil erosion and sediment burial. The map also provides information on the main vegetation communities and dominant vegetation species for each RLU.

DERIVED MAPPING EXTENTIONS

This mapping has been used as a basis for other regolith-landform maps in the region since it was completed. From this map, areas for more detailed (1:25,000) mapping have been identified, resulting in the program for producing the current Broken Hill 1:25,000 Regolith-Landform mapping series (Hill 2001). So far the 1:25,000 mapping has been undertaken in 1:25,000 sheet areas in the south of the Broken Hill Domain, although it is hoped to extend this mapping across much of the Broken Hill region. These more detailed maps show more homogeneous RLUs and represent the distribution of more specific regolith materials. More detailed landform information can be related to local landscape processes such as regolith dispersion pathways. Further 1:100,000 mapping is also planned for adjoining areas in far western NSW. To the north of this sheet, mapping of the Teilta sheet is underway and due for completion in 2003.

CONCLUSIONS

The Broken Hill Domain 1:100,000 regolith-landform map (Hill 2001), provides the a regional overview of the main regolith-landform features of the Broken Hill region. This compliments existing regional bedrock geology coverages (e.g. Willis 1989), and has a wide range of applications for landscape researchers, mineral explorers and land managers.

REFERENCES

HILL S.M. 2000. *The regolith and landscape evolution of the Broken Hill Block.* PhD thesis, ANU Department of Geology, unpublished.

HILL S.M. 2001. *Broken Hill Domain Regolith-Landforms (1:100,000 map).* CRC LEME, Canberra/Perth

HILL S.M. 2001. New maps for old exploration challenges in the regolith at Broken Hill. *Minfo, New South Wales Mining and Exploration Quarterly* **72**, 23-24.

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.* CRC LEME 63-67.

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

WALKER P.J. 1991. Land Systems of western New South Wales. *Soil Conservation Service of New South Wales Technical Report* **25**.

WILLIS I.L. 1989. *Broken Hill Stratigraphic Map.* New South Wales Geological Survey, Sydney.

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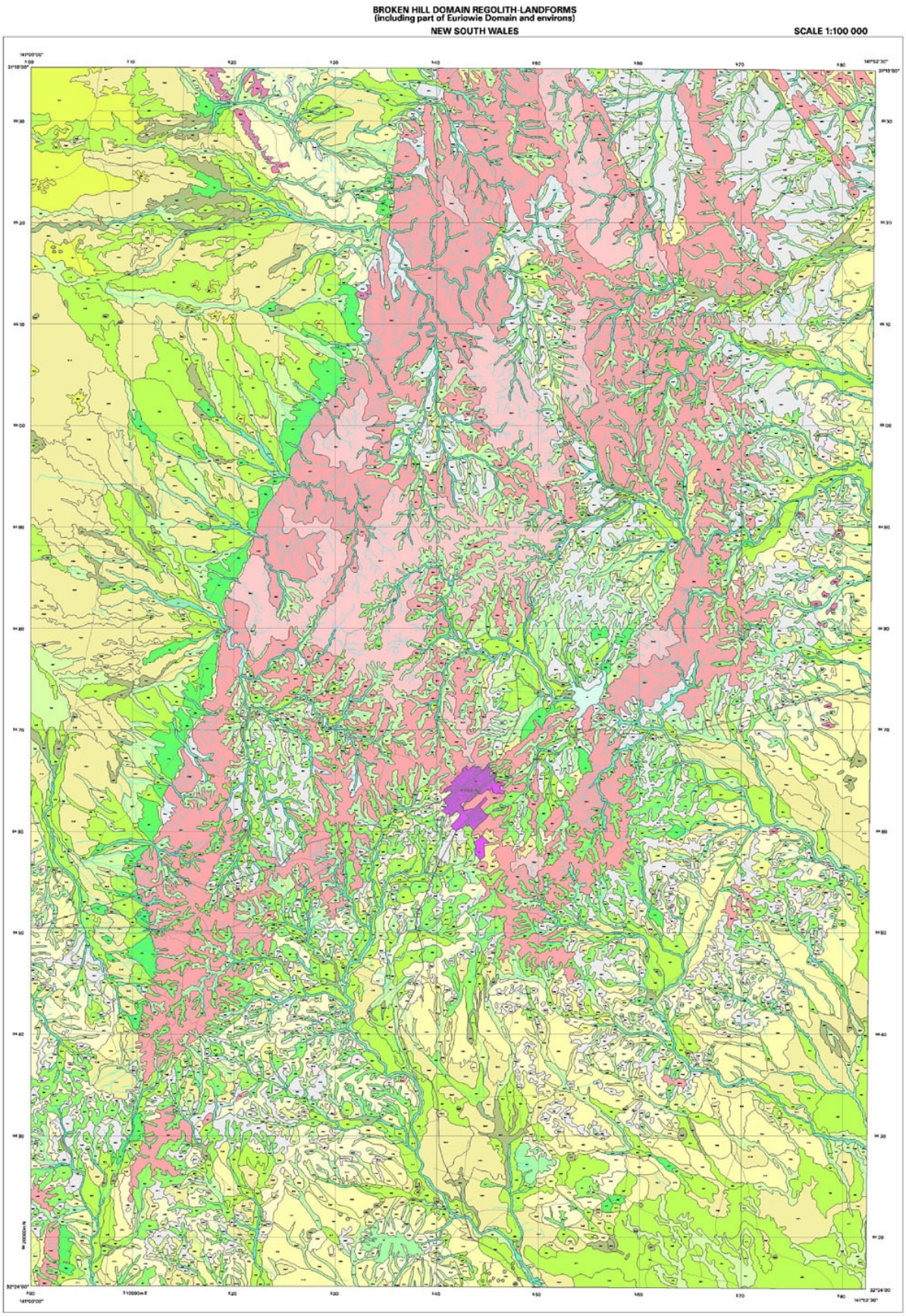

Figure 1: RLU polygons of the Broken Hill 1:100,000 regolith-landform map (Hill 2001).