Regolith landforms of Bimbowrie Station

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Introduction

Bimbowrie Station is in the NE of South Australia, ~100 km west of Broken Hill, and was purchased by the Department for Environment and Heritage in May 2004 to provide a significant contribution to the protection of the natural and cultural heritage of the region (Fig. 1).

As part of PIRSA's recent prospectivity analysis of Bimbowrie Station, a three-month project was undertaken to characterise the regolith materials and landforms and to produce a regolith landform map of the station. The results of this preliminary evaluation of the regolith and landforms at Bimbowrie have implications for mineral exploration, landscape evolution studies, and environmental rangeland management.

Physical setting

Climate

Bimbowrie has a semi-arid to arid climate with hot to extremely hot dry summers and mild to cool, dry winters, with a mean daily maximum temperature of 33 °C in January, and a mean daily minimum of 4 °C in July. The area

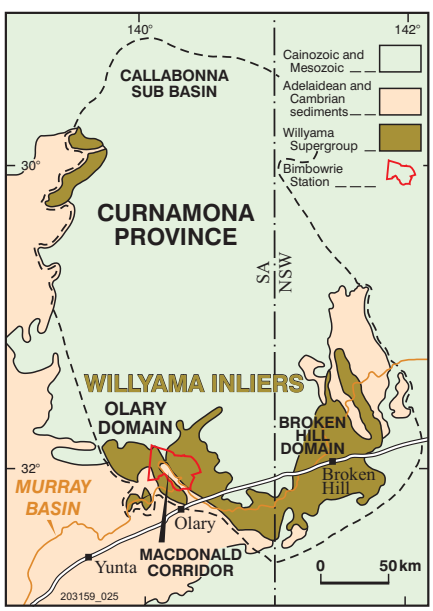

***Figure 1** Location of Bimbowrie Station and key geological features.*

experiences irregular low rainfall, which is characterised by low frequency, high intensity rainfall events. Evaporation far exceeds precipitation with mean annual rainfall of 236 mm at nearby Yunta and 254 mm at Broken Hill, whilst average annual evaporation in the region is 2500 mm.

Due to the sparse vegetation cover, rainfall events can result in widespread physical dispersion of erosional products along drainage lines and across sheetflow plains. The catastrophic 1997 floods in the Olary area provide an extreme example of effects of water in an arid landscape. The flooding was caused by thunderstorm activity which included 200–300 mm of rainfall in the area between Manna Hill and Cockburn, whilst neighbouring Outalpa Station received 274 mm of rain in just four hours. This intense downpour resulted in sheetflow and gullying on rises and plains, with significant erosion and sediment transport along alluvial channels. As floodwaters escaped alluvial channels, sediments were deposited onto flanking alluvial and depositional plains.

Geology

The geology of Bimbowrie records globally significant events and hosts widespread mineralisation. The potential for Zn, Pb, Au, Cu and U mineralisation, and the thin nature of the regolith in the north and west, continues to attract exploration.

Rocks include the Palaeoproterozoic Willyama Supergroup and Mesoproterozoic granites of the Willyama Inliers, and the rift-fill Neoproterozoic Adelaidean strata of the MacDonald Corridor. Lithologies vary considerably: the Kalabity and Outalpa Inliers are composed of Palaeoproterozoic metasediments and igneous rocks that include psammitic, psammopelitic and pelitic schists, quartzites, albites, calcalbites and marbles, and also felsic volcanics, subvolcanic granites and amphibolite sills. Mesoproterozoic granites are voluminous and there are later mafic dykes. The Neoproterozoic rocks comprise metasiltstones, quartzites, glacially derived diamictites and conglomerates, and sedimentary ironstones.

Globally significant events include Palaeoproterozoic sedimentation approximately coeval with the formation of the syngenetic Pb–Zn–Ag mineralisation at Broken Hill, early Mesoproterozoic FeO–Cu–Au mineralisation of similar timing to that at Olympic Dam deposit in the adjoining Gawler Craton, and Neoproterozoic glaciation (Conor 2004; Conor et al., 2005). The Willyama sediments were deformed and metamorphosed during the Olarian Orogeny (1600 Ma), and both the Willyama and Adelaidean rocks were affected by the Delamerian Orogeny (~500 Ma).

Regolith landforms

Weathered bedrock

Despite the range of lithologies present within Bimbowrie, the bedrock exposures (SS units, Fig. 2; Fig. 3) are only slightly weathered, with little variation in weathering grade at the mapped scale.

Thin surficial weathering, minor iron oxide staining, and open fractures are the most widespread weathering features. At a local scale lithological variations result in variable weathering and landform expression with more easily weathered lithologies such as amphibolitic, micaceous, and pelitic units grading towards a moderate weathering grade.

Weathered bedrock units are expressed in the landscape as rises, low hills and hills. The presence of widespread mineralisation raises the possibility of significant physical and chemical dispersion of mineralised geochemical signatures into the lower lying landscape units.

Colluvial sediments

Colluvial sediments are present over a range of landforms including erosional and depositional plains, erosional rises

and sandplains. They can be broadly defined within two main groups consisting of sheetflow sediments (CH units, Fig. 2), which occur over all the landforms mentioned, and colluvial sediments (C units, Fig. 2), which are found on erosional rises flanking some bedrock highs.

The sheetflow sediments are characterised by red-brown silts with angular to sub-angular quartzose and lithic sands and gravels. Some of the sheetflow landforms are typified by a distinctive 'contour-band' surface pattern consisting of irregular sandy bands vegetated by bladder saltbush (*Atriplex vesicaria*) and/or black bluebush (*Maireana pyramidata*) between bands of sparse vegetation cover and pebbly surface lags. Sheetflow deposits on sandplains (CHps unit, Fig. 2; Fig. 4) within Bimbowrie are common flanking the major drainage lines in the NW. These landforms are typified by angular to sub-angular quartzose sands with lesser silts and lithic fragments, and represent sheetflow reworking of aeolian materials derived from local alluvial channels.

The colluvial sediments (C units, Fig 2; Fig. 5) are characterised by boulders to cobbles of locally derived lithic fragments, with silts and sub-angular quartzose sands.

Alluvial sediments

Alluvial landforms include small drainage depressions and alluvial channels incising bedrock highs, and wide channels with alluvial plains draining the bedrock highs. The alluvial sediments within

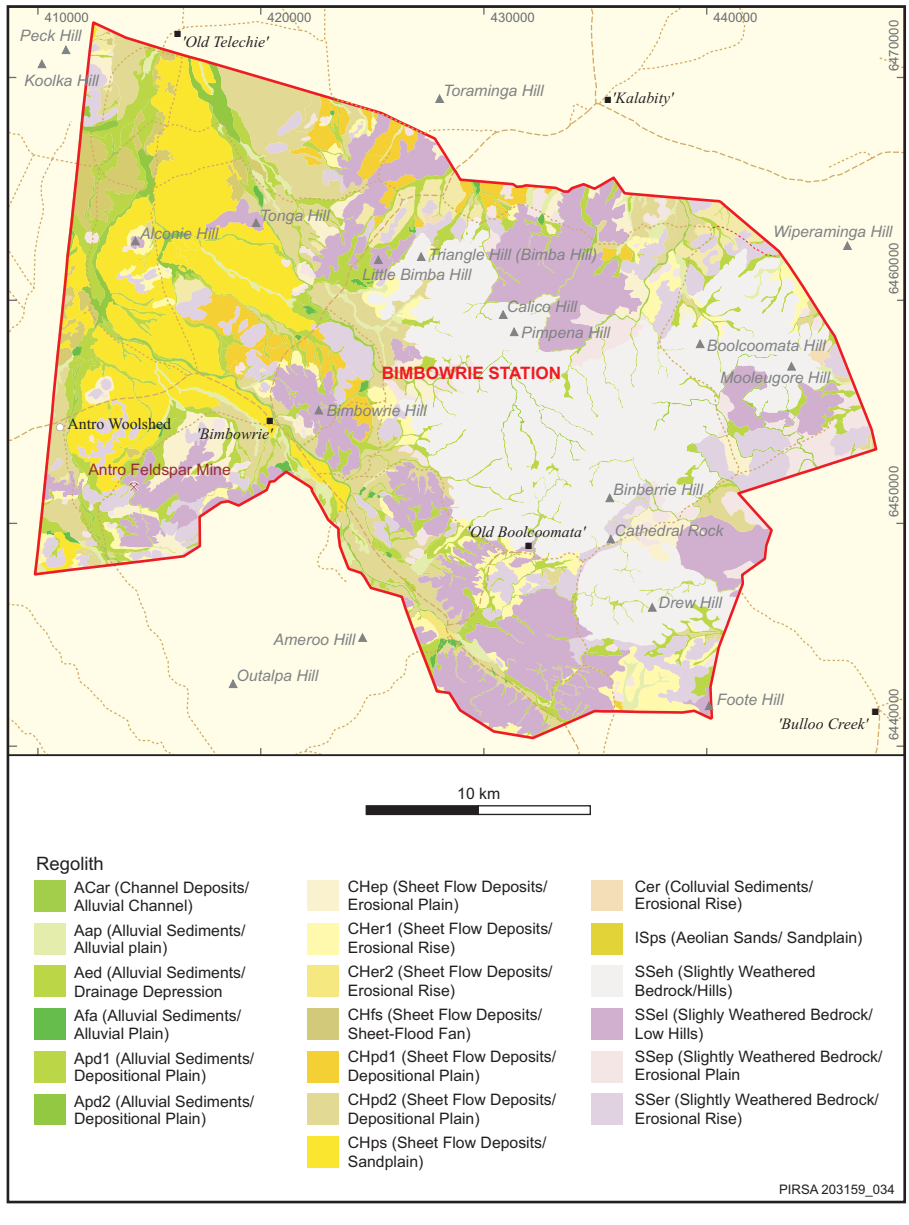

Figure 2 *Regolith landforms of Bimbowrie Station (after Burtt et al., 2005).*

Figure 3 *Slightly weathered quartz ironstone with thin skeletal soils, Peryhumuck Mine.* *(Photo 404913)*

Figure 4 *Well vegetated sheetflow dominated sand plain, Bimbowrie Station.* *(Photo 404915)*

Figure 5 *Drainage depression containing coarse sands and locally derived boulders, Bimbowrie Station. (Photo 404914)*

the bedrock-dominated areas (SS units, Fig. 2) generally consist of coarse quartz, feldspar and lithic fragments derived from the local geology. The major alluvial channels (ACar, Fig. 2) associated with the northerly flowing Bimbowrie Creek in the NW of the station, contain dominantly quartzose sediments; however, most still contain medium sand to boulder-sized lithic fragments derived from distal bedrock sources indicative of major physical dispersion along drainage lines during large rainfall events. Alluvial plain and fan sediments are generally clay rich with quartzose sands and sand-sized lithic fragments.

Aeolian sediments

Aeolian sediments are commonly encountered at Bimbowrie as a thin cover of silts and quartzose sands that are present throughout the landscape and as thicker sand sheets commonly flanking major alluvial channels. In the north and west of the station there are a number of aeolian sandplains (ISps units, Fig. 2) that consist of silts, clays and very fine to coarse-grained, sub-rounded to rounded quartzose sands mainly derived from local alluvial channels.

Geobotany

Each of the regolith landforms described supports a distinctive vegetation community. Some of the more common species within each regolith landform are described here.

Within the bedrock-dominated areas, vegetation communities typically consist of an open woodland of mulga (*Acacia aneura)* and dead finish (*Acacia tetragonophylla*) over small-leaved hop bush (*Dodonaea lobulata*) and rock sida (*Sida petrophila*), with black bluebush (*Maireana pyramidata*) in some areas.

The vegetation within colluvial landforms consists of widespread black bluebush and limestone copperburr (*Scleroleana obliquicuspis*), with rosewood (*Alectryon oliefolius*) and bladder saltbush (*Atriplex vesicaria*) in some areas. However, within the sheetflow sandplains (CHps) the vegetation community closely resembles that of the aeolian sandplains with an open shrubland of hopbush (*Dodonaea viscosa*), turpentine bush (*Eremophila sturtii*), black bluebush and spiny saltbush (*Rhagodia spinescens*), with occasional bladder saltbush, and prickly wattle (*Acacia victoriae*).

Vegetation communities within the alluvial landforms include an open woodland of river red gums (*Eucalyptus camaldulensis*) along drainage depressions (Aed units, Fig. 2) within bedrock highs (SS units, Fig. 2) and most alluvial channels (ACar units, Fig. 2). Within alluvial plains and fans, and some channels, an open shrubland of prickly wattle, black bluebush, small-leaved bluebush (*Maireana brevifolia*) and bladder saltbush, typifies the vegetation.

Within the aeolian sandplains, vegetation communities consist of an open shrubland of hopbush, turpentine bush, black bluebush and spiny saltbush, with occasional bladder saltbush and prickly wattle.

Table 1 highlights the plants that have been used in biogeochemical studies.

Biogeochemical sampling media

Biogeochemical exploration has been used successfully in the Northern Hemisphere since the early 1900s: especially in Russia, Canada and the United States of America. Plants have a number of potential advantages when compared to soil sampling (Hill and Hill, 2003), including:

- widespread cover across the landscape
- ease of sampling
- ability to penetrate regolith or to provide an amalgamated chemical signature for an enlarged sampling area
- ability to selectively extract and concentrate some elements
- minimal site disturbance and remediation associated with sampling
- a proven selection of species for targeting a wide range of elements, mineralisation styles and regolith landform settings at regional and local scales.

Many plants identified within the broad regolith landform settings described above have been shown to be effective biogeochemical sampling media. Table 1 summarises the proven biogeochemical sampling media, and their regolith–landscape associations at Bimbowrie, and provides references for further information. Biochemical sampling is illustrated in Figure 6.

Table 1 *Proven biogeochemical sampling media and their regolith–landscape associations at Bimbowrie*

Plant	Regolith–landform association	Sampling scale	Reference
Mulga (*Acacia aneura)*	Weathered bedrock	Regional/local	Thomas et al. (2002), Hill et al. (2003); Hill and Hill (2003)
Black bluebush (*Maireana pyramidata*)	Weathered bedrock; alluvial sediments; colluvial sediments; aeolian sediments	Local	Hill and Hill (2003)
River red gums (*Eucalyptus camaldulensis*)	Alluvial sediments	Regional	Hill and Hill (2003), Hulme and Hill (2005)
Prickly wattle (*Acacia victoriae*)	Alluvial sediments; colluvial sediments; aeolian sediments	Local	Thomas et al. (2002), Hill et al. (2003)
Bladder saltbush (*Atriplex vesicaria*)	Alluvial sediments; colluvial sediments; aeolian sediments	Local	Brown and Hill (2003, 2005), Hill and Hill (2003)

Figure 6 *Biogeochemical sampling of black bluebush, Bimbowrie Station. (Photo 404916)*

There is also evidence that *Eremophila* may be a useful sampling media with potential for targeting Au, Cu, V, and Ni (Lintern et al., 1997). Further detailed sampling is needed to determine the biogeochemical variation within *Eremophila* species.

Landscape evolution

Some of the key components of the weathering and landscape evolution of the area include:

- a Late Cretaceous landscape with relatively high relief
- extensive weathering and erosion during the latest Cretaceous to early Tertiary, with weathering products deposited in the Murray Basin to the south and the Callabonna Sub-basin to the north
- continuing uplift and erosion during the Tertiary and Quaternary
- post-settlement increase in erosion rates, with incision and gullying of alluvial and colluvial sediments due to reduced vegetation cover (Fanning, 1999).

The presence of stepped erosional surfaces cutting across slightly weathered bedrock exposures at a number of locations throughout Bimbowrie indicate at least two stages of mid Tertiary/Quaternary uplift. A rough correlation of erosional surfaces across the MacDonald Corridor indicates the MacDonald Fault has not been reactivated during this uplift.

Mineral exploration significance

The results of the regolith landform mapping and characterisation project within Bimbowrie are relevant to mineral exploration in the following ways:

- The regolith–landform map provides an understanding of the potential for widespread dispersion and residence of lithic fragments with mineralised signatures from bedrock highs.
- The map provides a regional overview of the regolith materials and landforms of the station, and can be used in the planning and interpretation of regional geochemical and biogeochemical exploration programs.
- The information collected during mapping can be used to produce derivative maps highlighting the distribution of potential geochemical and biogeochemical sampling media to assist exploration.

The information provides a framework for future landscape evolution studies, such as the investigating the ages and elevations of erosional surfaces observed throughout Bimbowrie. Further landscape evolution studies would improve the understanding of the timing and nature of neo-tectonism within the Olary Spur, and its relationship to uplift in the Flinders Ranges to the west and Barrier Ranges to the east. This information would assist in improving the understanding of palaeogeochemical dispersion vectors and palaeochannel formation and activity, and thus be relevant to uranium, diamond, gold and mineral sands exploration in the Curnamona Province and Murray Basin.

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