

## THE REGOLITH-LANDFORMS OF THE LOWER ONKAPARINGA RIVER, SA

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### INTRODUCTION

Urban development and landuse practices can be closely linked to landforms and the associated regolith materials. Therefore the knowledge of an area's regolith and landscape features can be used to help plan urban areas and landuse development. Some of this knowledge can be presented on maps that show regolith materials and associated landscape features. Regolith-landform maps have not been widely produced in S.A., and even fewer, in the context of urban planning and landuse management, although many similar maps exist (e.g., soil-landscape maps). This research demonstrates the validity of regolith-landform mapping to an area in S.A. with a diverse range of regolith and landforms, and its application to urban planning and land management. The lower Onkaparinga River catchment encompasses a diverse set of landforms and landuse practices, including: coastal beach; dune and estuarine systems; alluvial plains; exposed bedrock and colluvial deposits. This research is the first detailed 1:10,000 regolith-landform map of an urban area to be produced in Australia, and it is of further interest because it includes many different regolith-landform settings and landuse practices. The following is a summary of the mapping research as well as an outline of some of its applications.

### SETTING

The Lower Onkaparinga River is 40 km south of Adelaide, extending inland from the mouth of the Onkaparinga River at Port Noarlunga to the east through the Onkaparinga Gorge and into the southern Mount Lofty Ranges (Dept Environment & Planning 1991). This study area is centred on the lower part of the Onkaparinga River catchment (Figure 1). The major feature of the western part of the study area is the Onkaparinga Gorge, created by the steep incision of the Onkaparinga River. The Onkaparinga Gorge is surrounded by undulating hills and rises largely controlled by the relative uplift of the area along the Clarendon Fault. As the river leaves the gorge and flows west towards the coast, the landscape gradually changes to low-lying alluvial terraces, plains, swamps and channels. At the river mouth the landscape is influenced by tidal and aeolian processes, and includes dunes, estuarine channels, tidal flats and beach. Along the coast, immediately to the south and further to the north of the river mouth, cliffs border the coastal landscape.

The geology of the study area consists of three broad units. In chronological order, from oldest to youngest:

- Proterozoic siltstones, sandstones and limestones of the Marinoan series (Preiss 1987). These form prominent exposures within the Onkaparinga Gorge and underlie thin cover in areas of medium to high relief east of the Clarendon Fault;
- Tertiary sediments including marine and alluvial sands, limestones, silts, and gravels of the Noarlunga Embayment within the St Vincent Basin (Preiss 2003). They are exposed on erosional rises and plains east of the Clarendon Fault, and on rises and within cliffs in the west of the area, such as along the coast; and,
- Quaternary and Pleistocene deposits, consisting of unconsolidated clays, silts, sands, and gravels, some of which are indurated by regolith carbonates (Preiss 2003). Includes the Bridgewater Formation - a calcarenite and marl exposed as a reef 350 m offshore from Pt. Noarlunga (Drexel & Preiss 1995).

The Noarlunga region has similar climatic conditions to Adelaide, although in higher elevated areas to the east conditions are generally slightly cooler and wetter (Department of Environment & Planning 1991). General climate features include cool, wet winters and warm, dry summers (Department of Environment & Planning, 1991). Average daily temperatures range from around 15°C to 28°C in the summer months and 7°C to 13°C in the winter months (Bureau of Meteorology 2003). Average monthly rainfall ranges from 24 mm in February to 100 mm in July, with an average annual rainfall of 723 mm (Bureau of Meteorology 2003). Wind direction and velocity over the area is variable with summer winds mostly derived from the southwest, and winter winds predominantly from the northwest to the southwest (Department of Environment & Planning 1991). Vegetation throughout the Noarlunga region has been extensively modified through grazing and clearing for agriculture, plus the influence of fires and the invasion of weed species (Department of Environment & Planning 1991). This has resulted in a sparse mosaic of remnant native vegetation

communities amongst introduced species (Department Environment & Planning 1991). Some of the natural tree species in the area include grey box (*Eucalyptus woollbiana*), pink gum (*Eucalyptus fasciculosa*), she oak (*Casuarina cristata*), dryland tea tree (*Mellaluca lanceolata*), blue gum (*Eucalyptus leucoxylon*) and river red gum (*Eucalyptus camaldulensis*) (Department Environment & Planning 1991). Introduced olive trees (*Olea europaea*) are also widespread across these areas. Open grassland communities occupy large portions of the area and are dominated by introduced species such as salvation jane (*Echium lycpisis*), medics (*Medicago sp.*) and clovers (*Trifolium sp.*) (Department Environment & Planning 1991). Alluvial and estuarine regions are mostly colonised by saltmarshes dominated by samphire (*Arthrocnemum sp.*), and other chenopods, including saltbush. Coastal dune vegetation consists of heath and low open shrubland (Department Environment & Planning 1991).

The land adjacent to and including the Onkaparinga River is part of a National Park and Recreation Park, mainly used for recreational activities such as bush walking, bird watching, fishing and canoeing. Areas outside of the parks, particularly in the east amongst the undulating hills, are widely used for agricultural, viticultural and quarrying purposes. The remaining areas are dominated by urban landscapes within the suburbs of Pt Noarlunga, Noarlunga, Christies Beach, Seaford, Hackam and Morphett Vale.

### PREVIOUS RESEARCH

Currently there are few regolith maps produced for urban areas, although there have been landform, soil and geomorphological maps produced for urban area and for urban planning or landuse. W.M. McArthur & G.A. Bartle (1980) produced an early example of mapping that is closely related to regolith and landuse mapping for urban areas. This incorporated a series of maps and an accompanying report on Urban Planning in the Perth Metropolitan Northwest Corridor, Western Australia. A recent study, which involved regolith in the urban area of Adelaide was compiled by Sheard & Bowman (1996). The urban expansion of Adelaide during the 1950s and 1960s led to the use of previously undesirable soil types for suburban development and a subsequent increase in the failure of masonry buildings due to soil subsidence and heave (Sheard & Bowman 1996). Some of the aims of that project included the re-examination of soils and their implications for landuse in the metropolitan area. This mapping did not extend as far south as the Onkaparinga River catchment. The Onkaparinga region has been studied in various forms. Ward (1966) looked at the geology, geomorphology and soils of the region, and considered the impacts of marine transgressions on soil and landform development. Bourman (1972) studied the geomorphic aspects of the Onkaparinga drainage system, in particular the physical geography of the river and its depositional terraces. The Department of Housing Trust and Urban Development (1984) produced a summary position paper on the conservation and development works of the Onkaparinga estuary. More recently, the Department of Environment and Planning (1991) produced a management plan of the area and Dyson (2002), compiled a report on the distribution of contaminants in the Onkaparinga Estuary.

### REGOLITH-LANDFORM UNITS

Regolith-landform mapping units here 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). This RLU approach presents units based on the regolith description using upper-case letter codes and landforms using lower-case letter codes. Modifier numbers further subdivide different RLUs based on other attributes. RLU information is represented in several ways, including; as a polygon on a map; by letter codes; as a non-interpretive description in a map legend; and, in an accompanying GIS or report (Hill 2002). The map of the Lower Onkaparinga area has a total of 43 RLUs, which broadly include the following regolith materials:

- Slightly weathered bedrock and saprolith;
- Moderately and highly weathered bedrock;
- Alluvial sediments;
- Colluvial sediments;
- Coastal sediments;
- Ferruginous regolith;
- Regolith carbonate accumulations and;
- Quarries and anthropogenic derived fill.

### IN SITU REGOLITH

#### **Slightly Weathered Bedrock and Saprolith (SS, S)**

These units include hills and cliffs of exposed bedrock, with moderate to high relief and a slope gradient of

over 30%. They mostly occur in the gorge section of the river catchment. These units are made up of a red - brown, purple and blue/grey coloured, fine grained, well-sorted, laminated siltstone. Included in these units is a Tertiary calcarenite and marl, (Department of Environment & Planning 1991) forming a natural reef or coastal barrier.

#### **Moderately and Highly Weathered Bedrock (SM, SH)**

A large portion of the study area consists of moderately weathered bedrock. Three main types of moderately weathered bedrock are present throughout different geomorphological settings. Fine grained, highly-sorted, red-brown to blue-grey laminated, siltstones and limestones of the Umberatna Group. Unconsolidated Tertiary sediments, mainly consisting of sandstone, limestones, siltstones and clays. Unconsolidated Quaternary deposits, generally, sandstones, clays, marls and calcretes. Landscape settings include, gentle rises, undulating low hills, coastal escarpments and riverbank escarpments.

### **TRANSPORTED REGOLITH**

#### **Alluvial Sediments (A)**

These materials consist of sands, silts, clays and muds of varying composition, including: transported silts with varying quartz content; black organic-rich mud; quartz-rich sands; and, locally derived lithic fragments. Landform expressions include: channels; alluvial plains (both ancient and recent); alluvial swamps (both stagnant and active (Aaw<sub>1+2</sub>)); and alluvial drainage depressions. These RLUs are mostly associated with the main channel and catchment area of the Onkaparinga River both in the gorge and on the plains near the coast.

#### **Colluvial Sediments (C)**

The most common colluvial type of sediment in the study area, are mixed soil creep and sheet-flow deposits. These vary in composition but mostly include silts, sands, clays and locally derived lithic fragments of siltstone and limestone. They are typically expressed within: erosional rises; erosional depressions; and, depositional plains. Siltstone, limestone silty, soil, quartz sands, concretes and road aggregate are present in landslide deposits (Cler<sub>1</sub>, Clel<sub>1</sub>) at two sites on the northern side of the Onkaparinga Gorge.

#### **Coastal sediments (O)**

These units are dominated by white to yellow, fine to medium grained moderately to well-sorted quartz sands, with minor heavy mineral components. They mostly forming beach, dune and plain landforms along or adjacent to the coast or coastal regions of Port Noarlunga and Christies Beach. Sands associated with the river mouth and dune/beach system show evidence of aeolian transport, and coastal processes through pitting, frosting and extensive rounding on individual grains.

### **INDURATED REGOLITH**

#### **Ferruginous Regolith**

Ferruginisation is a minor attribute on some RLUs. Tertiary siltstones, limestone, sandstones and clays, located throughout the study area, are most extensively ferruginised. Mottling and iron oxide staining and minor veining are the main forms of ferruginisation.

#### **Regolith Carbonate Accumulations (RCA).**

RCAs are widespread throughout the study area. RCAs are present on a majority of lithologies although they are less developed on exposed Umberatna Group lithologies. RCAs are best described as an overprint feature of the area that form towards the uppermost parts of the regolith. RCA morphologies include: carbonate silts or powders; pisoliths; nodules; rhizomorphs; hardpans; and, veins. RCA profiles typically have a combination of these forms in the area.

### **QUARRY AND ANTHROPOGENIC FILL (Q,M).**

These units exist where the original regolith-landform features have been obscured or changed by anthropogenic modification, usually for damming and reservoirs. A large limestone quarry (Q) exists in the southeast of the area as well as other minor quarries throughout the area.

### **DISCUSSION: APPLICATIONS OF THE REGOLITH-LANDFORM MAP FOR LAND MANAGEMENT AND URBAN PLANNING**

Using a regolith-landform map as a tool or aid in defining an area for land management and or urban planning, has not been widely applied in Australia. Some examples include:

- Areas prone to flooding are associated with contemporary alluvial material, such as within channels, tidal flats and alluvial plains;
- Areas with less stable slopes tend to associated with colluvial RLUs and in some cases steep sloped

exposures of bedrock materials;

- Erosion style and risk can be described, judged or interpreted through the use of regolith-landform mapping. For example an erosional low hill (el) will typically have a greater risk of erosion than a depositional plain (pd). The style of erosion is associated with the regolith material, for example, a slightly weathered exposed bedrock (SS) is going to erode differently to a sheetflow deposit (CH) because the regolith is made up of different material and the process of erosion is most different;
- Pollutant and contaminant dispersion in the Onkaparinga estuary can be associated and based on the estuary's evolution and sedimentology (Dyson, 2002). For example, the temporal and spatial distribution of toxicants in surficial sediments and the leaching of toxicants from effluent ponds into the estuary through highly permeable and porous point bar sands by tidal pumping (Dyson, 2002). Involving, sediments, which were deposited from both landward fluvial and seaward, tidal-inlet fill, flood-tidal delta, source;

\* The Onkaparinga estuary is host to many different and diverse ecological habitats. Some of these habitats include: river mouth and beach; tidal influenced eustarine channel; stagnant and cyclic swamps and backwaters as well as areas within the gorge. Regolith-landform mapping can be used as a tool in identifying areas of ecological importance. The flexibility of regolith-landform mapping can account for other features that define a habitat, such as flora and fauna.

- Regolith-landform maps can assist coastal management practices, as they show areas that host different regolith-landform process. Depositional areas and features such as dunes and beaches are broadly distinguished from active erosional areas such as cliffs and bluffs. The ability of the regolith-landform map to distinguish the differing regolith-landform processes, enabling the identification of coastal management issues and how they can be addressed. For example: dune erosion, dune stability, beach erosion, cliff erosion and cliff stability;
- Urban development requires resources, namely solid materials for building and construction (e.g. fresh rock quarries, sand, gravel aggregates and clays). These materials need to be easily and readily accessible and therefore preferably locally derived. Regolith-landform mapping can provide a basis of understanding and knowledge of the regolith and therefore used for the identification and sourcing of these resources and materials.

## CONCLUSIONS

Urban regolith-landform mapping is a unique method being developed within the Onkaparinga Catchment of South Australia. The Onkaparinga Catchment has a diverse range of landforms and landuse practices. The methods applied in creating a regolith-landform map allow for the construction of an integrated database of the landscape and the processes, which affect it. Results acquired through mapping such areas can then be used throughout many different applications, such as the issues, implications and processes, which affect land management and urban planning.

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Acknowledgments: Funding from the Cooperative Research Centre-Landscape Evolution and Mineral Exploration (CRC-LEME) for scholarship and operating budget is gratefully acknowledged. I would like to personally acknowledge Steven Hill for helping establish the project and his continual supervision, inspiration and field assistance throughout its duration.