# GEOMORPHOLOGY MAPPING FOR NRM ISSUES, SOUTHERN QUEENSLAND

Amy L. Kernich[1] & Colin Pain[2]

[1]Geoscience Australia, GPO Box 378, Canberra, ACT, 2601
[2] CRC LEME, Geoscience Australia, GPO Box 378, Canberra, ACT, 2601

## INTRODUCTION

This work is part of an ongoing collaborative project the Lower Balonne Airborne Geophysics Project (LBAGP) between the CRC for Landscape Environments and Mineral Exploration (CRC LEME), Bureau of Resource Sciences (BRS) and the Queensland Department of Natural Resources and Mines (QDNRM). The study area is located in the upper reaches of the Murray Darling Basin and has significant agricultural value as cotton irrigation and cattle grazing land. The area faces water allocation issues and there have been reports of salinity hazards occurring in this heavily irrigated area.

The Lower Balonne study area contains parts of the modern Balonne and Moonie Rivers and their associated floodplains. Alluvial deposits from the current and prior river systems dominate the central study area with older Maranoa alluvial fan deposits to the West and residual Cretaceous Griman Creek material mainly to the North.

Previous regional NRM work over the Lower Balonne area includes the Land System mapping and associated report produced by Galloway *et al.* (1974) and the recent Queensland Department for Natural Resources and Mines salinity hazard map (QDNRM 2002). Detailed soil surveys were undertaken by QDNRM in 4 key areas within the study area in 1998 with the aim to eventually extrapolate the data over the region although this never eventuated. A recent study on sediment provenance and dispersion in the Condamine-Balonne catchment was undertaken by Brennan (2001).

Groundwater flow systems and the presence of salinity hazards in the area will be determined by regolith materials and their architecture at the surface and at depth. The major aim of recent work was to describe and interpret the surface geomorphology in terms of Regolith Landform Units (Kernich *et al.* 2003). This output is useful in its own right for surface materials, morphology and landscape evolution information as well as being integrated with sub-surface information such as AEM and drill hole data to better define and assess ground water flow systems and the possible salinity hazard.

## METHOD

Objectives of this work were three fold: to interpret the different data layers and compile a map of surface morphology and materials, to assess the different data sources, and to gain insights into landscape processes to help interpret sub-surface materials and distribution.

Data sources available and collected for this project include remotely sensed data, ground samples and drill hole information, and airborne and ground geophysical data. Data utilized for the surface geomorphology mapping comprised Landsat TM data, ASTER data, airborne gamma-ray radiometric data, a Digital Elevation Model (DEM), aerial photographs, and ground regolith sampling.

Remotely sensed data were most heavily relied upon for identifying mapping units as the project time scale was short. Geomorphic units were delineated primarily from Landsat TM and gamma-ray radiometrics. These large units were recognised mainly on form and materials that were easily recognised in the radiometric RGB image. Smaller regolith landform units on the Regolith Landform Map were then identified by a mixture of radiometric interpretation, especially for the sand-rich channel units and Maranoa Fan subdivisions, as well as detailed air photo interpretation. Landsat and ASTER data were used to verify and further delineate the boundaries of the units within the study area as well as enhance the interpretation of surface processes. Process information on unit boundaries was much enhanced from Landsat TM interpretation. Aerial photographs were also used to provide detail of some units.

## RESULTS

Mapping units were compiled at two levels, a detailed one that maps regolith landform units (Figure 1) and a less detailed one that presents the major geomorphic units in the area (Figure 2). The regolith landform map was compiled at a scale of about 1:100,000 and thus has a minimum mapping unit of around 150-300 m

(McDonald *et al.* 1990). The map depicting major geomorphology units was derived from the regolith landform map. Both maps were produced as GIS outputs for the LBAGP and in a GIS environment, data is easily rescaled. This means that an appropriate mapping scale was determined not by the scale of the output but rather the scale of the landscape features present.

The Regolith Landform Map has 22 detailed units based on regolith materials and form, while the Geomorphic map is divided into the 8 major units based on landform and the geomorphic processes responsible for their formation.

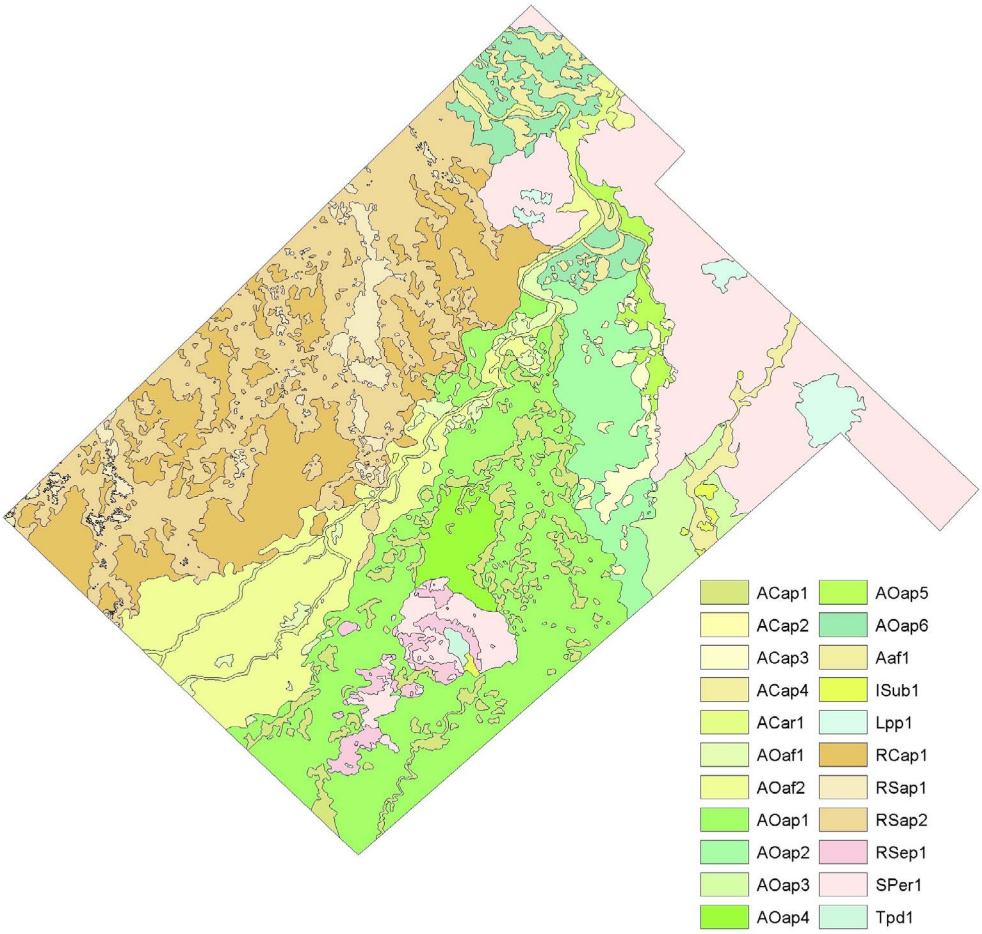


**Figure 1:** Regolith Landform Map – Lower Balonne (unit descriptions in Table 2).

The Regolith Landform Map is useful for surface detail, especially in terms of surface salinity hazard identification and for assessing which data sources were most appropriate in its construction. For information on landscape evolution and for sub-surface interpretation, the more regional Geomorphic Units were considered.

**Table 1:** Geomorphic units numbered in order of decreasing relative age

| | |
|---|---|
| 1 | Saprolite and residual material on Cretaceous Griman Creek Formation |
| 2 | Maranoa Fan – Early Quaternary fan |
| 3a | Oldest Balonne River Channels and deposits |
| 3b | Oldest Moonie River channels and deposits |
| 4 | Older Balonne River Channels and deposits |
| 5 | Former Maranoa and Balonne River Floodplains and deposits |
| 6 | Younger Balonne River Floodplain and deposits |
| 7 | Modern Balonne River Channels and deposits |
| 8 | Modern Moonie River channels and deposits |

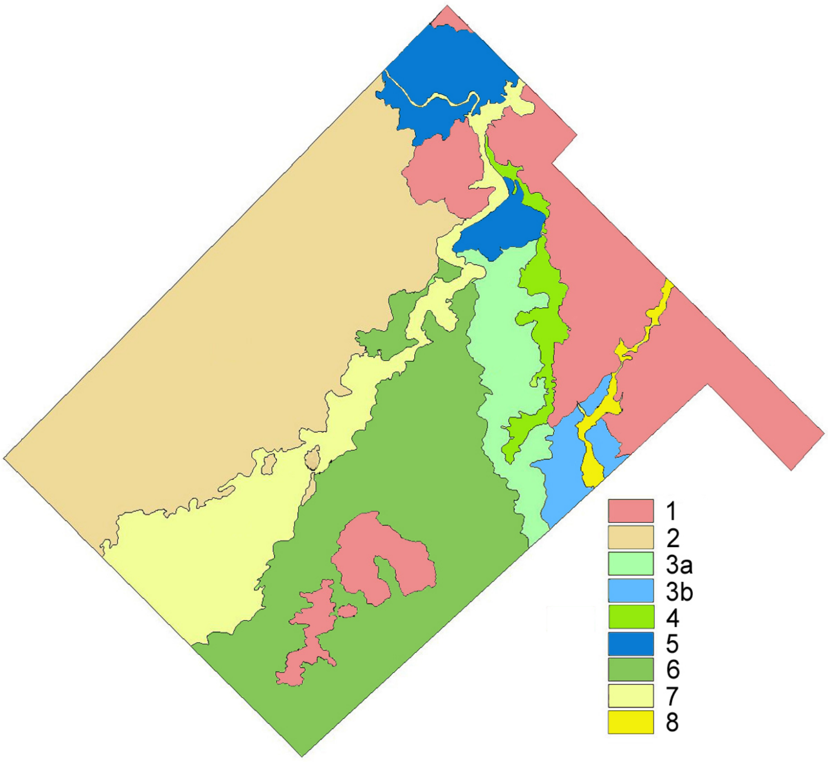


**Figure 2:** Major geomorphic units in the Lower Balonne area.

**Landform evolution**

The origin of the materials within the Griman Creek Formation (Unit 1) is well understood and is documented by Senior (1978, 1979). Originally marine sediments of Cretaceous age, this unit has been slightly deformed and extensively weathered to form silcrete and ferricrete in various amounts (Senior 1978). Weathering and erosion of the Griman Creek Formation since its exposure at the surface in the late Cretaceous has resulted in the present form of Unit 1. The weathering profile is believed to strongly influence the groundwater characteristics in the area by forming an aquiclude for the alluvial sediments above.

The Maranoa fan (Unit 2) formed after faulting in the Griman Creek Formation formed a depression in which the palaeo-Balonne River flowed. Alluvium from the Maranoa and Condamine Rivers filled this depression, and spilled over to the east of the fault, to be deposited onto the weathered and eroded Griman Creek Formation. At present there is little active channel flow on the fan (Galloway *et al.* 1974) and it now has a slightly weathered and eroded form. The Maranoa fan is Pliocene – Early Pleistocene in age (MacPhail 2003).

During this same period the Moonie River may have been bringing alluvium from further east, and transporting it into the depression through a buried channel that shows up on the AEM images. AEM and 3D regolith architecture is covered in the report by Fitzpatrick *et al.* (in prep).

At some point following the deposition of Maranoa Fan, the Balonne River was diverted to its present course between two low rises in Unit 1 upstream from St George. After it changed course, the Balonne River flowed to the east of its present course. At the same time the Moonie River was bringing material from further east and presumably because it was blocked by sediments from the Balonne River, turned to the south to take up its present course.

Following the deposition of Unit 3 the Balonne River flowed for a time further east to form the small area of Unit 4. Wider channels and meanders and sand dominated deposits suggest a higher flow regime during the deposition of this unit compared with present-day deposition. The Balonne River then began its move to the west and formed unit 5 after cutting the northern part of unit 4. Unit 6 appears to be have been formed by transgressive movement from east to west. It is marked by a great complexity and number of anastomosing channel packages, some distributary.. The Modern Balonne River system, Unit 7, is a western continuation of Unit 6. In the north, the modern Balonne River channel is deep and well established and has been confined to the same area since the beginning of formation of Unit 6. To the south the modern channel opens out onto an anastomosing plain with branching and reconnecting small scale channels. The floodplain and low terraces of the modern Moonie River are contained in unit 8.

Source bordering dunes have also formed along the western and eastern sides of the modern Balonne River and are prominent in large dunes in the south along the present Moonie River.

**CONCLUSIONS**

The regolith landform map produced here was compiled mainly from Landsat and radiometric imagery. The latter in particular allowed more accurate location of regolith materials than the former. However, the regolith-landform map could have been compiled from existing information, without the airborne geophysical data. Thus, where this kind of data exists, it is not necessary to acquire new geophysical data until existing data have been assessed.

The surface distribution of regolith materials on most geomorphic units is a fair indication of the complexity of regolith materials at depth. Regolith distribution patterns of prior channels in the major alluvial geomorphic units can be described, even if their actual location can not be predicted. Unit 2 is an exception, where weathering and erosion has caused the surface distribution of materials on the Maranoa Fan to be quite different from materials distribution at depth. Surface mapping also does little to characterise the sub-surface character of the Griman Creek formation which is present at depth throughout the study area and is a crucial factor in the ground water flow systems. Overall, however, knowledge of the surface distribution of regolith materials, their boundary character, and the processes that are responsible for that distribution, can be used as part of the input into models of the 3D regolith architecture, and of the evolution of the Lower Balonne landscape.

Areas that may be a salinity hazard have also been identified through this study of the regolith and landforms of the Lower Balonne area. These areas are mainly along the eastern boundary of the Maranoa fan which is a major area of concern because of its sodic soils, the active seepage that appears to be going on in the area, and its proximity to the current Balonne River.

The regolith landform map is certainly of adequate scale to allow planning at a sub-catchment and perhaps farm scale. Importantly, when used in conjunction with the radiometric images, it shows situations where multiple land holders must be involved in any planning exercise, because it shows the surface connectivity of the different regolith materials.

**REFERENCES**

BRENNAN S. 2001. *Contemporary sediment sources and spatial dispersal patterns in a large, lowland river system, the Condamine-Balonne*. B. App. Sc. Honours Thesis, University of Canberra, unpublished.

GALLOWAY R.W., GUNN R.H., PEDLEY L., COCKS K.D. & KALMA J.D. 1974. Lands of the Balonne-Maranoa Area, Queensland. *Land Research Series* **34**. CSIRO, Australia 242 pp., 2 maps.

KERNICH A., PAIN C.F., KILGOUR P. & MALY B. 2003. *Regolith Landform Mapping for NRM issues: Lower Balonne, Southern Queensland.* CRC LEME **Restricted Report 193R**.

MACPHAIL M.K. 2003. *Palynostratigraphic analysis of core samples from the St. George district in southeast Queensland*. Palaeontological report prepared for Dr. K. Lawrie, CRCLEME/Geoscience Australia.

MCDONALD R.C., ISBELL R.F., SPEIGHT J.G., WALKER J. & HOPKINS M.S. 1990. *Australian Soil and Land Survey Field Handbook, 2nd Edition*. Inkata Press, Melbourne, 198 pp.

QDNRM 2002, *Murray Darling Basin Salinity Hazard Map*. National Action Plan on Salinity and Water Quality, Queensland Department of Natural Resources and Mines.

SENIOR B.R. 1978. Silcrete and chemically weathered sediments in Southwest Queensland. *In:* LANGFORD-SMITH T. ed. *Silcrete in Australia*. Department of Geography, University of New England, pp. 41-50.

SENIOR B.R. 1979. Mineralogy and chemistry of weathered and parent sedimentary rocks in Southwest Queensland. *BMR Journal of Australian Geology and Geophysics* **4**, 111-124.

**Table 2:** Regolith Landform Map Units and Descriptions.

| GROUP | | MAP SYMBOL | DESCRIPTION |
|---|---|---|---|
| Modern Floodplain | Alluvial sediments | Aaf1 | Stream channels, levees and back plain deposits of the modern Moonie floodplain. |
| | Alluvial sediments | ACar1 | Channel silts and sands and minor levee and channel splay deposits of the modern Balonne and Maranoa River channels. |
| | Alluvial sediments | AOaf1 | Sand dominated levees and channel splay deposits of the modern Balonne floodplain with minor source bordering dunes. |
| | Alluvial sediments | AOaf2 | Grey clays of the modern Balonne back plain commonly with well developed gilgai structures. Local occurrences of vertisols and nodular carbonate accumulations. Minor sandy levee and channel bank deposits. |
| Younger alluvial plain | Alluvial sediments | ACap1 | Sandy alluvium in levees and scroll bars associated with former channels of the Balonne River. |
| | Alluvial sediments | AOap4 | Clay dominant sediments associated with a back plain of the former Balonne River with minor sandy channel deposits. |
| | Alluvial sediments | AOap1 | Clay and sandy clay alluvium on a back plain associated with the former Balonne River. Vertisols and gilgai structures present as well as some duplex soils. |
| | Terrestrial sediments | Tpd1 | Fine silt and clay on a depositional plain surrounded by residual Cretaceous material. |
| Older alluvial plain | Alluvial sediments | AOap2 | Clay and sandy clay alluvium with some gilgai structures on a back plain associated with the former Balonne River. |
| | Alluvial sediments | ACap2 | Sandy alluvium in levees and scroll bars associated with former channels of the Balonne River. |
| | Alluvial sediments | AOap5 | Clay and sandy clay alluvium with some gilgai on a back plain associated with the former Balonne River. Minor occurrences of residual cretaceous sands and clays. |
| | Alluvial sediments | ACap3 | Sandy alluvium in levee and scroll bar deposits associated with the former channels of the Balonne River. |
| | Alluvial sediments | AOap6 | Clay and sandy clay alluvium on a back plain associated with the former Balonne River. |
| | Alluvial sediments | ACap4 | Sandy alluvium in levees and circular scroll bars associated with former channels of the Balonne River. |
| | Alluvial sediments | AOap3 | Clay and sandy clay alluvium on a back plain associated with the former Balonne and Moonie Rivers. Occasional levees, scroll bars and channel bank deposits. |
| Other sediments | Lacustrine sediments | Lpp1 | Clay pans with saline clay and silty clay sediments. |
| | Aeolian sediments | ISub1 | Well sorted aeolian sand in source bordering dunes adjacent to channels deposits. |
| Maranoa Fan | Residual material | RSap1 | Residual sand on low interfluves between drainage lines on the Maranoa Fan. |
| | Residual material | RSap2 | Residual clayey sand on slopes below interfluves between drainage lines on the Maranoa Fan. |
| | Residual material | RCap1 | Residual predominantly sodic clay on shallow valley floors between drainage lines on the Maranoa Fan. Vertisols, gilgai structures and local occurrences of gypsum present. |
| In-situ regolith | Residual material | RSep1 | Moderately weathered residual red/brown to yellow sands with minor clays on erosional plains, derived from the underlying Griman Creek Formation. |
| | Saprolith | Sper1 | Residual sands and clays over saprolite formed from the variable weathering of the Cretaceous Griman Creek Formation. In places strongly mottled with silcrete and ferricrete. |