REGOLITH ASSESSMENT AND NATURAL RESOURCE MANAGEMENT

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Abstract
The biophysical aspect of natural resource assessment draws on information from a range of disciplines. Regolith geology is a specialty that links many facets of the natural environment, and so can contribute valuable information to management decision-making. Examples from north Queensland are used to show that deeper regolith materials influence soil properties, interact with deep-rooted trees and perennial pasture species and control water movement into and out of groundwater systems. The methodology for assessing regolith on a broad scale involves the iterative development of conceptual models, based on a range of datasets, which are tested and refined through targeted field work.

Additional Keywords: weathering, groundwater, soil forming factors, Burdekin catchment

Introduction

Australia's natural resources are valued for their productive capacity, as well as aesthetic and intrinsic value, biodiversity, ecosystem function, cultural heritage, tourism, recreation and community health (NLWRA 2002). Thus, sustainable management of our resources must combine considerations of a range of biophysical, social and economic elements.

Addressing the biophysical aspect of natural resource management requires information on the processes operating within our landscapes and ecosystems, and on their present condition and changes over time. This requirement draws on numerous studies of our natural environment such as biology, ecology, meteorology, pedology, hydrology and geology. These components of the environment are interrelated, and investigation of each cannot be conducted without consideration of the others. A holistic method, which incorporates a number of the aforementioned approaches, could provide greater understanding of our biophysical environment for natural resource management.

The study of regolith geology is a relatively new specialty that links many of these disciplines. The regolith is defined as the mantle of unconsolidated or secondarily cemented material, that is altered or formed by processes at or near the land surface (see Taylor and Eggleton 2001; Pain *et al*. 2000). This includes all weathered rock, sediments, secondary mineral accumulations, soils and organic accumulations, biota and groundwater. Knowledge of the distribution of regolith materials (*regolith architecture*) informs on active landscape processes, as well as past processes that have contributed to the evolution of a landscape. This information is vital for understanding issues such as the movement of water through the landscape, and the current distribution and properties of soils.

This paper will consider applications of regolith assessment for natural resource management, with particular reference to catchments in the northern Burdekin region of Queensland. Managing the landscapes in this region involves challenges such as preventing soil erosion, maintaining the quality of both ground and surface water, and preventing groundwater rise and secondary salinity. These pressures can impact on a range of assets, including agricultural land, streams, physical infrastructure and ecosystem health. In this case, valuable global assets, such as the Great Barrier Reef, are also being affected. Regolith research is fundamental in understanding these forms of degradation, as many of the processes are driven by regolith characteristics.

The paper will also outline methods used in regolith assessment in Queensland, which include mapping methodologies, desktop research and the development of conceptual models, and field investigations involving drilling, morphological descriptions, laboratory analyses and geophysical techniques. The thickness and variability of the regolith, and its typical lack of exposure, will always challenge resources for observation and measurement. More readily available data, such as geological and soil mapping, is useful but describes only part of the system. Remote sensing approaches are limited in providing sub-surface data, but the role of geophysical methods has been recognised in many recent studies. However, rigorous application of conceptual modelling approaches, based on evidence of regolith processes, offers potential for broad scale mapping and identification of areas for more detailed study.

Applications for natural resource management

Regolith information can aid in understanding many landscape processes that are relevant to natural resource management. Regolith architecture has a major influence on the movement of water and solutes that enter the unsaturated zone from our land management practices, and on groundwater recharge and discharge. The regolith provides vital information for predicting the distribution of soil properties. It retains a record of past processes that have shaped the landscape, which may have contributed to a more complex distribution of materials than modern landforms indicate. The chemistry of the regolith, and therefore of the soil, can differ significantly from that of the parent rock due to chemical weathering processes.

The northern Burdekin region in north Queensland includes the catchments of the Burdekin and Cape Rivers (Figure 1), part of one of the largest eastern catchments in Australia. Land use is predominantly beef cattle grazing on native pastures, along with mining. Land- and water-related pressures on natural assets in this region include surface runoff and erosion, land clearing, weed infestation, deep drainage and salinity, water allocation and declining water quality (Burdekin Rangelands Implementation Group 2004). The Great Barrier Reef is a significant asset impacted by management practices in this region. It is recognised that increased sediment and nutrient loads from these and other catchments are disturbing the inshore reef zone, as a result of development such as urban infrastructure, agricultural production, tourism and mining (The State of Queensland and Commonwealth of Australia 2003).

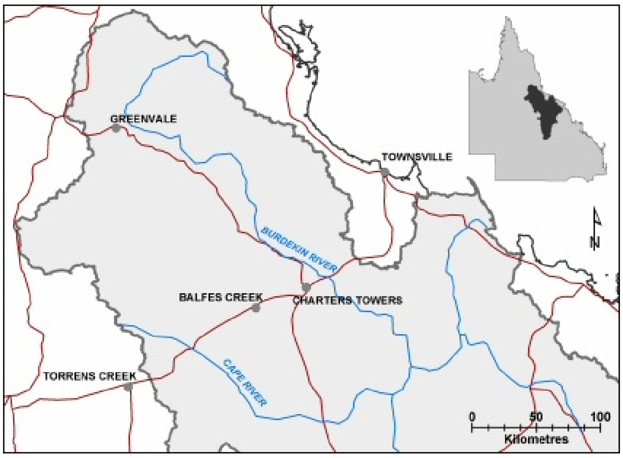

Figure 1. Burdekin and Cape River catchments in the north Burdekin region, Queensland.

Regolith as soil parent material

Where weathered material underlies soil, it is this regolith that is the parent material of the soil, rather than bedrock (Ollier and Pain 1996). The regolith may have significantly different, or more variable, physical and chemical properties than the original bedrock, such as in the intensely weathered landscapes common in Australia that consist largely of leached and ferruginised, kaolinite-dominated materials. Thus, properties of the regolith can strongly control soil properties, of which the most important for natural resource management in north Queensland are soil fertility for pasture growth, and erodability and salinity for ecosystem health and water quality.

Coventry (1982) recognised that geomorphic history and regolith variability are major controls on soil type in the subdued landscape of the Torrens Creek area, which includes the headwaters of the Cape River catchment. In this region, typical topography-controlled sequences are not apparent, with yellow and grey soils in upper slope positions, and red soils in lower areas. Coventry concluded that soil distribution in this area was controlled more by variation in transported and *in situ* weathered materials, hydrology of the soils and regolith and, particularly, the depth to weathered rock. The distribution of these soil types is significant, as they differ markedly in their hydrology and potential for deep drainage and groundwater recharge (Williams and Coventry 1980).

Interaction with deep-rooted vegetation

Native and forest trees, and perennial pasture species, have roots extending several, to tens of, metres below the surface (see review by Knight 1999). The deeper regolith is therefore highly significant in influencing root growth, and providing a store of moisture and nutrients to these species. Knight (1999) notes a study by Kimber in south-western Australia, where roots of Jarrah trees were strongly affected by indurated zones in the intensely weathered regolith. Similar weathering and induration patterns are present in many north Queensland landscapes, such as the Cape River plains, and the Alice Tableland on the western margin of the Burdekin catchment.

Roots play a major role in stabilising the shallow regolith, so understanding root distribution is relevant for preventing erosion, which degrades pasture lands and increases sediment load in streams in north Queensland which, in turn, impacts the aquatic ecosystems. Knowledge of the interaction between deep roots and regolith also contributes to the understanding of water balance and groundwater recharge. Secondary salinisation is a hazard in several parts in the north Burdekin region, so clearing of native vegetation in these areas must be carefully managed, as it will impact on groundwater recharge and salt mobilisation.

Regolith architecture influencing water movement

Physical variations in the regolith often relate to varying in hydrologic properties. Water entering the unsaturated zone and moving through groundwater systems is influenced by these variations, in that different regolith zones may provide barriers or preferential paths for water movement. This information is applicable to a range of issues, such as salinity, groundwater pollution and irrigation.

In the Balfes Creek area, south-west of Charters Towers, several different regolith/landform regions are characterised by particular hydrogeological regimes (Street *et al*. 1998). Regolith architecture, and hence water movement, is complex in the low-lying plains in this region. Airborne electromagnetic data acquired in this study area highlighted possible palaeochannels transmitting water, which could not have been predicted from surficial materials and landforms. This type of information is useful for identifying salt stores and potential for salt mobilisation and discharge.

Methods of regolith assessment

Mapping methodology

The general philosophy to regolith mapping involves the use of a range of more readily available surrogates, such as geology, landforms, soils and vegetation, to infer likely regolith properties and architecture. The use of landform as a surrogate is common in regolith mapping in Australia, as described by Pain *et al*. (2000).

In Queensland, the regolith of the Burdekin, Fitzroy, Condamine-Balonne and south-east catchments is currently being mapped at a broad scale for salinity risk assessment. This covers vast areas of land (approximately 30% of the state), which necessitates extensive background research and planning prior to any field work being carried out. Conceptual models of the regolith are developed using numerous spatially continuous and point datasets, including geology, soil, vegetation and land system mapping, digital elevation models and their derivatives, drill hole logs, gamma radiometrics, magnetics and climate layers (see example in Figure 2). These models are essentially hypotheses that will then be tested through targeted field observations.

Landforms	Level to gently undulating plains
Geology	Tertiary – Quaternary basalt
Soils	Red and brown ferrosols (Rogers *et al*., 1995).
Regolith zone properties	**1.** Residual red/brown clay w corestones, <1m - few metres thick (3.05m thick in RN39668). Common lag of basalt cobbles on surface; patches of cobble-free clay (colluvial accumulation in local depocentres). Penetrates more deeply down fractures.
	2. Relatively thin zone of moderately weathered basalt bedrock; corestones with thin weathering skins surrounded by earth material, bounded by fractures. Zone penetrates more deeply down fractures.
	3. Fresh basalt bedrock with numerous fractures; minor sand lenses between flows, some lava tubes.
Hydrologic properties	**1.** High permeability – very little water remains on surface
	2. High permeability – mix of intergranular porosity & fracture porosity
	3. High permeability due to presence of many fractures and vesicular zones
Reg salt store	All low salt store
Groundwater	Rapid infiltration through upper clay zone, moderate recharge to fractured rock (particularly vesicular zones) & porous sand aquifers; transport through all zones down to adjacent low lying discharge areas. Both artesian and sub-artesian waters are present, with moderate flow rates. Good water quality (Grundy & Bryde, 1989).
Salinity hazard / risk	Low hazard within this unit; is associated with groundwater discharge in adjacent black clay and swamp/lake units on margins of plateau.

Regolith zones

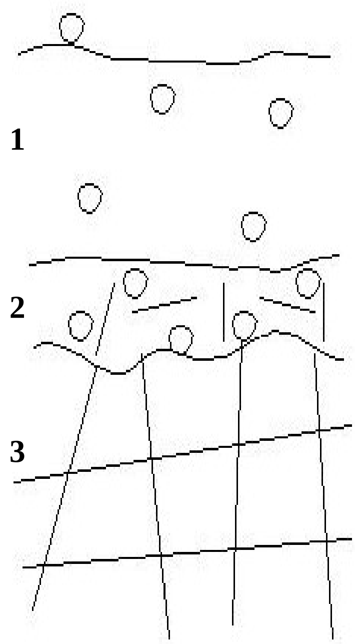

Figure 2. Preliminary conceptual regolith model for part of the McBride volcanic province, north of Greenvale.

Field investigations

The nature of this approach to regolith assessment is the iterative development of regolith models, so field work is conducted to test and refine the conceptual models developed in the earlier stages of research. The program will be targeted to areas of high salinity hazard, as well complex landscapes that are poorly understood, regions lacking in existing data, and landscapes considered to be representative of broader areas.

Observation and sampling of existing exposures, such as road cuttings, is a cost effective method of investigation, but these exposures are limited in their vertical extent and are uncommon in many of the subdued landscapes in north Queensland. Shallow drilling in areas of particular interest, combined with interpretation of the spatially continuous datasets such as radiometrics and magnetics, will overcome these limitations, to provide data on deeper materials.

The refined regolith models will be used to generate layers of regolith attributes relevant to salinity processes. These datasets can then be used directly for natural resource management decision making, but are particularly designed for use in an integrated salinity modelling framework, which assists in risk assessment, target setting and exploring different management options.

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