Regolith–landform mapping: a classical approach using new imagery

by

J. R. Gozzard

Introduction

Understanding the regolith is of great economic significance. Much of the focus for exploration is in areas dominated by a widespread cover of regolith. Extensive deep weathering and a variety of geomorphological processes have created associations of chemically and mineralogically complex materials that can be almost unrelated to the bedrock. Appreciation of the spatial variability of these materials is essential. Establishing the areal and three-dimensional relationships of the regolith reveals this spatial variability. Explorationists also need to understand how the landscape has evolved over time, in particular, the weathering and dispersion processes that have operated in the environment.

Classical mapping

The most common expression of a significant change in the nature of geological materials at the surface is a change in the landform. Observing variations in the landscape is at the core of classical geological mapping, which is based on morphological mapping that recognizes breaks and changes of slope, rates of change of slope, and slope-form lines. All such features are mapped, even though the significance of some of them may not be apparent at the time of survey. Breaks and changes of slope that are expressed in the topography have geological meaning.

Mapping techniques that use radially distorted stereoscopic aerial photography produce geological maps by correlating vegetation change, phototone and a visualization of topography in a spatially and spectrally uncontrolled environment.

The need for higher quality, larger scale maps has led to a demand for high-quality three-dimensional data to describe the landforms that underpin good geological interpretation. Mapping agencies are now able to move away from the use of uncontrolled sources. Effectively integrating spatially controlled information makes it possible to use the relationships between integrated datasets as a predictive tool to map regolith.

Land systems

Study of a complex and variable entity such as terrain requires some form of terrain classification rather than a separate description of each terrain component. This allows generalizations to be made about those terrain characteristics that are directly observable and measurable so that common attributes can be defined and described, and similarities can be grouped.

The land-systems approach is an integrated approach that looks at the areal identity of the terrain and recognizes distinctive components and patterns in the landscape. The basic land-system mapping unit is one where there is a recurring pattern of landform, geology, soil, and vegetation. This allows for extrapolative mapping and an understanding of why changes in the landscape occur.

The Geological Survey of Western Australia (GSWA) uses a modified land-systems method to map regolith. The mapping system reflects the key regolith and landscape processes and is significantly influenced by landform and the effect of bedrock lithology on the regolith.

A hierarchy of units maintains a consistent approach between mapping scales (scale independency) and the varying levels of complexity in both landscape and regolith patterns. The hierarchy has six levels — region, province, zone, system, subsystem, and phase. In GSWA's method a land system has a recurring pattern of landform, geology, regolith and vegetation. Each land system can be subdivided into subsystems. These are areas of common landform that have regolith that varies in a consistent manner across the unit. They are usually present on a single rock type within the land system.

This mapping method provides a high degree of correlation between various surveys so that the properties of the map units, regardless of level in the hierarchy, are survey independent and are thus the same in all survey areas in which the map unit is present.

Digital elevation data

Multispectral satellite imaging provides increasingly powerful tools for mapping regolith. However, these data lack good three-dimensional control and are often interpreted without the essential landform context. The availability of high-resolution digital elevation data with acceptable horizontal and vertical resolutions has opened the door for a return to classical morphological-mapping techniques.

Datasets derived from digital elevation models (DEM) are invaluable in the geomorphometric modelling and analysis of the landscape as part of mapping the regolith. Elevation, slope, aspect, profile convexity, and plan convexity provide a unifying framework for the description of a land surface because these morphometric parameters are process related.

Slope is the most important feature because all surfaces are composed completely of slopes. The classification of slope is important given the strong correlation between landform and regolith. Aspect is the next most important feature. Profile convexity indicates convex and concave profiles. Breaks and changes in slope can be readily identified on a map of profile convexity. Plan convexity gives a measure of the amount of dissection of a landscape.

Combining DEM data with multispectral data allows the creation of more-detailed maps, particularly when mapping the regolith. Spectral data can be draped over landscape models, or combined with geomorphometric parameters such as slope, aspect and plan convexity.

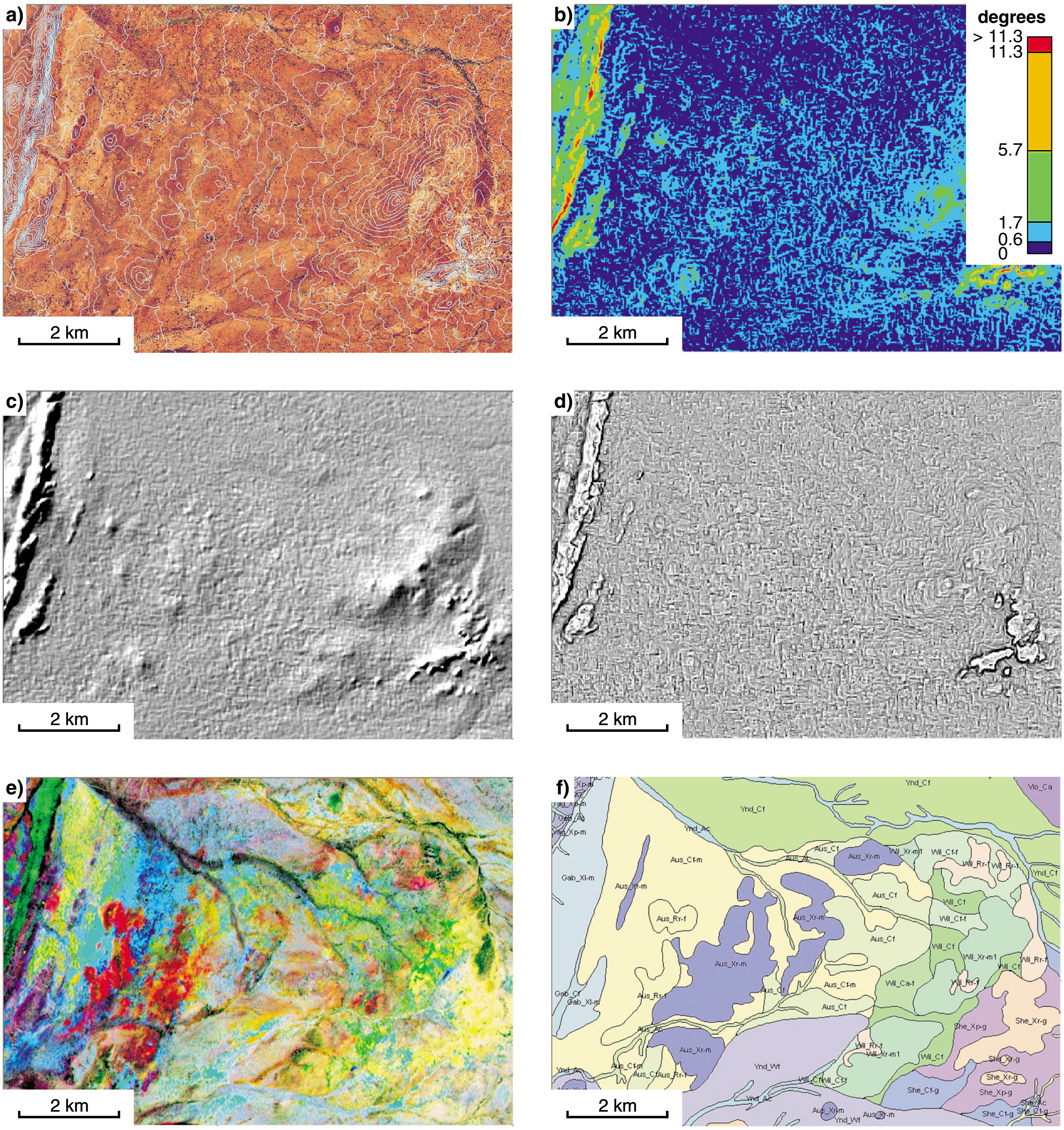
Bringing it all together

A land-systems approach was used to identify and characterize the regolith–landform relationships of the MEEKATHARRA* 1:100 000 sheet. A high-resolution DEM generated from scanned 1:25 000-scale colour stereo-aerial photography was used to significant advantage. The DEM was used to derive contours at 2, 5, and 10 m intervals and images of slope, aspect, profile convexity, plan convexity and a shaded-relief model, which were used extensively to characterize the landscape and establish the boundaries of the map units (Fig. 1).

Ratios of Landsat TM bands 5/7:4/7:4/2, a three-band subset of bands 7:5:4, and a decorrelation stretch of bands 7:5:4 were also used. These images are very useful for identifying map units at more regional scales. For work at larger scales, the 15 m-resolution panchromatic band of Landsat TM is merged with the colour images. This sharpens the images and provides the extra spatial dimension inherent in the panchromatic data, and highlights features that are invisible in the raw image.

This project shows how classical morphological mapping techniques can be adapted to integrate remotely sensed data and DEMs, resulting in a morphometric-based predictive approach to mapping regolith. Accurate delineation of spectrally and geomorphologically coherent units is achievable at a broad range of scales, allowing the rapid creation of regolith–landform maps and land-systems models.

* Capitalized names refer to standard 1:100 000 map sheets.



JRG78 31.01.06

Figure 1. A 10 × 7.5 km area of the Mount Opal area on the MEEKATHARRA 1:100 000 sheet showing: a) orthophotograph and 2 m contours; b) slope image highlighting slopes between 0 and 11.3°; c) shaded relief image with illumination from the northwest; d) profile convexity image (black indicates concave profiles, white indicates convex profiles); e) pan-sharpened Landsat TM interband ratios 5/7:4/7:4/2 (RGB); f) regolith–landform map