Cooperative Research Centre for Landscape Environments and Mineral Exploration

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RTMAP REGOLITH DATABASE FIELD BOOK AND USERS GUIDE

(Second Edition)

Colin Pain, Roslyn Chan, Michael Craig, David Gibson
Penny Kilgour, and John Wilford

CRC LEME OPEN FILE REPORT 231

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PREFACE

This handbook was first released as BMR Record 1991/29 (Pain et al. 1991). One of the objectives of CRC LEME has been to produce a glossary and classification of regolith terminology, and a second edition of this handbook. The glossary of regolith terminology has already been released (Eggleton 2001), and this is the second edition of the mapping handbook.

We have updated the attribute lists and other details to take account of changes to the RTMAP database structure. We have also changed some definitions to be consistent with the glossary. Otherwise, very little change has been made to the text. Readers should note that this is a handbook for RTMAP. However, the general discussions, and the list of attributes, will be of use to workers who will not be using that database. Within the next 12 months a new field handbook for regolith mapping will be released by CRC LEME. That handbook will supersede this one.

The archival RTMAP database resides in the Geoscience Australia Corporate Database, in the Oracle Database Management System (see the GA website http://www.ga.gov.au). Some details, including authority tables, can also be found on the Geoscience Australia Web Page. Go to Online Databases, then to Lookup Tables near the bottom of the page. There is a plan to enable users to enter data from remote locations via the World Wide Web. This facility will be advertised on both the CRC LEME (http://crcleme.org.au) and Geoscience Australia web pages when available.

We thank Tony Eggleton and Patrice de Caritat for their very helpful reviews of this report.

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July 2007

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This chapter introduces regolith concepts and mapping techniques, and forms a theoretical basis for later chapters that introduce the database, list the terms used, and provide definitions.

1.1 What is Regolith?

There are a number of definitions of regolith to be found in various journals and books. The word itself was introduced by Merrill in 1897 and has been in use since then. The term comes from the Greek *rhego*s = blanket and *lithos* = stone, in other words, the blanket over the rock.

Four similar definitions are presented here, which give the general idea of what we mean by the term *regolith*.

- The entire unconsolidated or secondarily re-cemented cover that overlies more coherent bedrock, that has been formed by weathering, erosion, transport and/or deposition of the older material. The regolith thus includes fractured and weathered basement rocks, saprolites, soils, organic accumulations, glacial deposits, colluvium, alluvium, evaporitic sediments, aeolian deposits and ground water (Eggleton 2001).

- A general term for the layer or mantle of fragmented and unconsolidated rock material, whether residual or transported, that nearly everywhere forms the surface of the land and overlies or covers bedrock (Chan *et al*. 1986).

- The mantle of materials, including weathered rocks and sediments, altered or formed by land surface processes (Speight & Isbell 1990).

- The weathered and/or transported material, the upper part of which is called soil, overlying or covering bedrock.

Regolith includes rock debris of all kinds, including weathered rock in place, alluvium, colluvium, aeolian deposits, volcanic ash, and glacial till. It is commonly called “soil” by engineers, but for our purposes, soil is the organically influenced regolith that is at the surface. These points have been emphasised in earlier work by Geoscience Australia (then BMR) (Ollier & Joyce 1986, Chan 1988, Chan *et al*. 1988).

The underlying zone of rocks formed or altered by deep-seated crustal processes is the bedrock. Regolith and bedrock are thus characterised by different processes, rather than by necessarily different materials. Regolith is bedrock that has been altered by processes at or near the surface including weathering, erosion, transportation, and terrestrial sedimentation. This includes induration of regolith by cementation to form, for example, duricrusts. Thus some regolith is not unconsolidated, but is very hard.

1.2 Regolith Research

The regolith problem can be approached in a number of ways. These include mineralogical and geochemical studies, mapping of small areas, and regional mapping. The mineral exploration industry needs answers to such questions as, is the regolith at a site transported or *in situ* and, what is the nature of weathering? Information about the regolith can also assist with the interpretation of (see Chan 1989):

- geological maps
- soil geochemical surveys
- stream sediment geochemical surveys
- airborne geophysical surveys
- drilling

How do we get the information? There seem to be two general approaches. One is to map the regolith, and try to work out the three-dimensional distribution of regolith materials. The second is to study the mineralogy and geochemistry of the regolith in an attempt to explain its origins and associations.

Mapping the regolith requires considerable fieldwork. Moreover, much of this mapping must rely on observations of mine pits, road cuttings, stream banks and other exposures. These exposures give us information that drill cores can never give us. It is often impossible to identify regolith types from drill holes. A core or hand specimen of sand or clay gives few clues about its origin. We need to know about the three dimensional characteristics of the regolith to make a positive identification. This is not so true of hard rocks, where identifications can often be made on the basis of drill cores or even chips of rock.

We are thus seeking information not only about the regolith, but also about the landscape relationships of the regolith. We are not simply revising the stratigraphy of the upper part of the stratigraphic column. We are documenting the regolith and its landscape relationships in a way that will allow extrapolation of results from one area to another. This will also allow interpretation of regolith and landscape history, and extrapolation of landscape properties and character.

A considerable amount of research has been carried out on the mineralogy and particularly the geochemistry of regolith in Australia (eg Butt 1987, Bird and Chivas 1989). This research is concerned with weathering changes in the regolith, and the pathways of elements through the regolith. Much of it has concentrated on the regolith of small areas, and there is little published on the relationships between geochemistry and landscape position (see, however, Butt & Zeegers 1989).

1.3 Regolith Mapping

1.3.1 General Approach

In designing an approach to mapping the regolith we must keep in mind the purpose of the mapping program, and the users of our map products. Regolith mapping at Geoscience Australia was initiated to answer questions raised by the mineral exploration industry, but recent trends suggest that we shall be answering landuse questions as well.

These two purposes are rather different. At the regional level of our activities, the mining industry would like to know about the genesis and history of various regolith types, and correlations between various regolith units across the landscape. They would also like to know the relationships between regolith type and mineral deposits, and the distribution of various regolith types with economic potential (Chan 1989).

People with interests in landuse, on the other hand, will be concerned not only with those things that interest the mining industry, but also with those aspects of the regolith that have a bearing on land suitability for various uses, as well as degradation and environmental fragility.

1.3.2 Regolith Landform Units[1]

Regolith is not easily mapped. Even soils, the upper "skin" of the regolith, generate much argument about their mapping, and soil maps do not indicate the characteristics of the regolith at depth. It is possible to look at the regolith at any point in the landscape, but there is a practical limit to doing this. The only land features that can be mapped with speed and accuracy are surface features, or landforms. We must therefore establish the relationships between regolith and landforms. Moreover, this must be done for each locality, because the systematic study of the regolith is in its infancy, and there are as yet no universal laws that relate regolith to landforms.

[1] "Regolith landform units" were called "regolith terrain units" until 1993, when a joint working group changed the name to better reflect the nature of the mapping unit (Craig et al. 1993).

Regolith contrasts with hard rock bodies in several important ways that influence how we can study it (see Pain and Ollier, 1995, for a more detailed discussion of regolith and stratigraphy).

- Regolith is generally much thinner than hard rock units. It occurs as a thin, sometimes discontinuous, layer over the hard rock.

- Individual units of sedimentary regolith are usually discontinuous. They may occur as accumulations of sediment in the lower parts of the landscape (eg fluvial sediments in valley floors). Because of this discontinuity it is generally inappropriate to give formal rock unit names to bodies of terrestrial sediments. With few exceptions there is no reason to suppose that these bodies can be correlated from one drainage basin to the next, let alone across much wider regions.

- Weathered regolith occurs as "skins" of various kinds, differing with age of landsurface, and underlying rock. Despite attempts to show that particular weathering patterns, such as duricrusts, can be used to correlate different land surfaces, it is becoming clear that this cannot be done with any degree of confidence (eg Ollier & Galloway 1990, Pain & Ollier 1992). Duricrusts are an obvious part of the regolith, and of the landscape, but they have been over-interpreted in much of the work carried out on landscapes in Australia. This has been especially so when geologists, trained to think in terms of initially continuous layers of strata, interpreted discontinuous duricrusts as remnants of a former continuous sheet.

- Similarly, it seems unrealistic to speak of "periods of weathering" in anything but a very broad sense. Weathering continues from the moment a land surface is exposed until it is destroyed either by erosion or burial. Deep weathering is primarily a product of a long period of stability in a landscape.

- At a local scale, in a particular landform type for example, there is commonly a strong relationship between the present landform and regolith cover. This expresses itself in the phenomenon known to soil scientists as a toposequence. Toposequences are systematic variations in soil morphology with position in a landscape. This concept fits regolith very well, and can be used in a predictive sense once the toposequence relationships are worked out.

What surface feature or features do we use to map regolith? Regolith is an integrated expression of geology, present and past climates, landforms, geomorphic processes, and landscape evolution. It will be clear from the very close relationship between regolith and landforms that landforms are the most important of these factors. This is because they are expressed on the surface, and they reflect many of the other attributes listed above. Moreover, regolith type is closely associated with landforms and with geomorphic processes. This means that, as a first approximation, we may use landforms as a surrogate for regolith (Chan 1988). In this respect, our mapping methodology has its origins in techniques developed for mapping landforms and soil (Stewart & Perry 1953, Ollier 1977). However, we are concerned with the characteristics and distribution of the regolith rather than landforms *per se*.

Geoscience Australia and CRC LEME thus map Regolith Landform Units. Chan (1988) notes that a Regolith Landform Unit:

> consists of one or, more usually, several recurring landscape elements and their associated underlying regolith packages which together form a distinct regolith landform entity.

A more general definition is:

> A land area characterised by similar landform and regolith attributes; it refers to an area of land of any size that can be isolated at the scale of mapping.

Note that the second definition makes the Regolith Landform Units independent of scale.

A survey of Regolith Landform Units delineates the Regolith Landform Unit pattern of an area and characterises each kind of Regolith Landform Unit in a way that can be used as a basis for prediction.

This prediction can take the form of identifying similar regolith and landform types elsewhere in the study area, or more specifically the prediction of mineral prospectivity (Chan 1989). The survey is carried out in a scientific way that provides base information of general application. This eliminates the need for a new survey whenever a new problem arises. The survey supplies information that can be combined, analysed, or amplified for many practical purposes, but the purpose should not be allowed to modify the method of the regional regolith survey in any fundamental way.

In the context of mapping within Geoscience Australia, the techniques of Regolith Landform Unit mapping are different from those employed for mapping of rock stratigraphic units. Regolith Landform Units are units of land, using the term in its broadest sense. The methods used to map them have more similarities to mapping of soils and land systems than to mapping rocks. At a more detailed level, it may be possible to map units that are composed of similar regolith materials, and the methods used for this more detailed mapping would be similar to those used for mapping rock units. However, at the level of Regolith Landform Units, we are for all practical purposes mapping land units rather than units of material. In what follows, we consider the problems associated with mapping Regolith Landform Units.

The fundamental basis for mapping Regolith Landform Units is landforms. Reconnaissance surveys of soils, land systems, and Regolith Landform Units will in all likelihood produce very similar boundaries. This is because landforms are used as a surrogate for the attributes we are really attempting to map. Landforms are usually related genetically to soils and to regolith in a way that is not true for hard rock stratigraphic units. Landforms and regolith are formed at the same time, and once we understand the interrelationships between regolith and landforms, we can use landforms to predict regolith patterns.

Initial boundaries are drawn on the basis of landforms, and the resulting map polygons are described in terms of regolith types and landforms. In many cases these will be the final boundaries. However, if it is warranted, subdivision of these landform-based units into Regolith Landform Units can be carried out on the basis of regolith type. For each Regolith Landform Unit we record a wide range of attributes. These attributes are listed below in the chapter on the database tables.

Regolith Landform Unit grouping is loosely hierarchical, and open, and identification of units proceeds from the highest levels of landform and regolith type through a number of choices to the lowest level. If any of the choices for subdivision cannot be made with the available information, the unit is not subdivided further. In practice the level reached in the hierarchy of landform and regolith classifications depends on the scale of mapping.

In producing regolith landform maps, a major distinction is made between areas dominated by *in situ* regolith, and sediment-dominated areas. These basic subdivisions are largely a result of landform evolution, and reflect the relationships between weathering and erosion.

1.3.3 Classification versus Mapping Units

The arrangement of regolith materials in a classification is based on logical and hierarchical relationships between the different kinds of regolith. However, such an arrangement has little in common with the spatial arrangement of these materials in a landscape. Similarly, the arrangement of landforms in a landform classification has little in common with the association of various landforms in a landscape. The arrangement of regolith and landform in a landscape depends on the geomorphic evolution and character of the area. There is thus a fundamental difference between regolith and landform classifications and regolith landform mapping units.

Classification units consist of regolith or landform units that are defined in terms of various regolith or landform characteristics. They are ideal or conceptual units that can be precisely defined. They are used as a medium for the transfer of knowledge, and can be grouped in various ways for particular purposes. In traditional geology an equivalent is lithologic units, for example, granite and sandstone.

Mapping units are real regolith landform units that reflect associations between regolith and landforms in a landscape. They can be conveniently mapped, and their definition will depend to some extent on the scale of the map. The more detailed the map scale, the less heterogeneous the regolith landform mapping units will be. A mapping unit will almost always include regolith materials and landform types that do not belong to the appropriate classification unit. These different regolith or landform types occur in areas that are too small to appear on the map; for example, narrow sedimentary areas in floodplains in dominantly erosional landforms with deeply weathered saprolite. There is no equivalent in traditional geology to a regolith landform unit. The nearest would be lithostratigraphic units mapped on the basis of their attributes.

Pain et al.; (2001) provide more details about regolith mapping in Australia.

2. MAPPING PROCEDURES

In this chapter we set out some of the details of producing regolith landform maps. Other aspects of survey procedure are included to make the details of our methodology as complete as possible. More information can be found in Gunn et al. (1988), a new edition of which is in press at the time of writing.

An understanding of landform mapping is very important for regolith landform mapping. This is true for the following reasons:

1. Regolith landform units are based on landforms, so it is important to be able to recognise different landform types.

2. Landforms tell us something about the underlying rock types. At its simplest, for example, low gently sloping landforms are often found on softer rocks, while steep mountains are often found on harder rocks.

An important aspect of mapping landforms and regolith landform units is that the study of small sample areas that are representative of larger areas allows us to transfer our knowledge from the sample areas to the larger areas. This is extrapolation and is an important part of regolith landform unit surveying. It is also important to understand that extrapolation from landforms to regolith landform units requires valid conceptual models of landform and regolith evolution. The equivalent in bedrock geology is subsurface extrapolation from outcrops.

There are several ways we can get information about landforms. Landform types can be recognised on maps, especially topographic maps. Contour lines and spot heights give us landform information, such as elevation, relief and dissection, and drainage patterns. Geology maps help explain landform distributions by giving the distribution of different kinds of rocks with different resistance to erosion. Soil maps may also be useful, particularly where the soil type descriptions include information about their parent materials.

Landforms are easily recognised from remotely sensed images such as aerial photographs, Landsat and SPOT images and airborne and space-borne radar images.

Field interpretation of landscapes is also important. Fieldwork is carried out to confirm and characterise the relationships between regolith and landforms.

2.1 Before Fieldwork

Collect as much information as possible about the survey area before fieldwork. This should include a literature survey to find out what has been done in the area before the current survey, and a study of the available maps and images of the area. Here we consider only maps and images, although any drill hole, geochemical and geophysical data available should also be examined.

2.1.1 Information from Maps

Two major kinds of information can be obtained from maps. Geological and soil maps provide information about materials, while topographic maps give information about landform shape, elevation, relief and drainage patterns.

Geology Maps

Most commonly the legend of a bedrock geology map is presented on the basis of the age of the rocks. The rocks in the map area are classified according to the geological period in which they were formed. Unfortunately, this is often not much use to someone interested in landform, or regolith landform mapping. It is therefore necessary to interpret the legend in a way that is meaningful for regolith landform units. There are two aspects to this, the recognition of lithologic types, and the grouping of geology map units to give a map of lithologic types.

Soil Maps

Soil maps vary a great deal in the amount of useful information they contain about the regolith. Most soil maps, irrespective of the classification system used, contain information about the parent materials of the various soil units mapped. On more detailed maps, the soil mapping units may be grouped to reflect the parent materials. However, at a reconnaissance scale, soil maps are usually prepared using landforms as a surrogate for soils, so the information they contain about the regolith is less useful. Nevertheless, the boundaries on such maps will often be very similar to those of Regolith Landform units. The major difference between a soil map and a regolith landform map is that the latter describes the regolith, of which the soil is only the uppermost layer.

Topographic Maps

Topographic maps contain a great deal of information about the nature and distribution of landforms. Spot heights give simple elevation for a point. Contours, on the other hand, give more information than just to elevation. They give information about land slope, and it is therefore possible to prepare a map of landforms from a suitable topographic map. The accuracy of the map will depend on the contour interval. Contours also give information about the degree and depth of dissection. Moreover, it is possible to obtain numerical values for these features. The contour values give the depth of dissection, while measurements or estimates of relative areas of interfluves and incised valleys give the degree of dissection. The following definitions will help with this:

Depth of dissection is a measure of the depth to which rivers have cut. It is often assumed that the rivers began cutting down from the same general level.

Degree of dissection is an indication of the amount of an original surface that is left. A slightly dissected surface has only a few valleys cut into it, while a highly dissected surface may have only a small part of the original surface left. In areas where there is nothing left of the original surface, it is unrealistic to use the term *degree of dissection*. These areas are completely dissected, and should be described in terms of their relative relief and drainage density.

Relative relief is another important feature that can be obtained from contours, and is a measure of the average difference in elevation between the highest and lowest parts of the area under study. It can best be envisaged as the difference in elevation between two planes, one that passes through the highest points and another that passes through the lowest points in a landscape. Relief is a relative measure, and is not related to absolute altitude, which is height above sea level.

Most topographic maps show the rivers and streams of the area covered by the map. On a spare copy of the map, or on an overlay, it is useful to go over all the rivers and streams with a dark pencil so that the drainage lines and patterns stand out against the rest of the map. In this way, particular drainage patterns and densities will be clearly visible.

The following definitions should be remembered when using drainage lines on maps to obtain information about landforms:

Drainage density is a measure of the amount of drainage lines in an area, and is usually calculated as length of drainage channel per unit area (e.g. km/km^2). It is an indication of the amount of surface water flowing in channels in the study area. All channels that carry water, whether permanent or intermittent, are counted.

Channel spacing is another way of measuring the amount of drainage. This is obtained by drawing a straight line of a given length across a mapping unit, and counting the number of channels the line crosses. Speight (1990) discusses this measure, and gives a formula for converting channel spacing to drainage density. Channel spacing is used in RTMAP.

Drainage patterns are the plan shapes made by the drainage lines, or valley floors. Examples of drainage patterns are “dendritic” and “rectangular”.

Channel patterns are the plan shapes of individual channels. Examples of channel patterns are "meandering" and "braided".

Many of the attributes discussed in this section can be derived from digital topographic data.

2.1.2 Information from Images

Traditionally aerial photographs have played an essential role in landform mapping. Photo scales of 1:10,000 to more than 1:100,000 have been used successfully for many years in landform mapping. The advent of images acquired from satellite platforms since the early 1970s has provided us with a new data source, with images covering much wider areas than aerial photographs. In the next few sections we first look at different image types, and then at the information that can be obtained from them.

Image Types Used for Landform Mapping

In this section we consider very briefly the different types of images used for landform mapping, particularly from the point of view of the different information they contain. This is not the place to give a review of the use of images for regolith landform mapping.

Aerial photographs are the traditional tools for landform mapping. Boundaries between landform types are easily drawn on the photographs under a stereoscope, and then transferred to a map.

Satellite scanners such as Landsat Thematic Mapper (TM), ASTER and SPOT are well known sources of images for landform mapping. An important difference lies in the range of radiation that is captured by the scanner sensors. With photographs, the images usually cover only the range of visible light, although infrared photographs also cover the near infrared. Scanners, on the other hand, receive radiation over a wide range of wavelengths, but in a number of bands with a restricted range. In particular, some information is received in narrow wavelength bands in the near infrared. These bands are less affected by atmospheric interference, and so tend to contain more landform information than the visible wavelengths.

Initially these images were not stereoscopic. However, we now have stereoscopic imagery from SPOT covering large areas at a suitable scale and resolution to be useful for mapping landforms at scales more detailed than 1:50,000.

Other image types that are of value are digital elevation models (DEMs), and radiometric images. DEM images are derived from elevation data and so give direct information about landforms, including shaded images that are a picture of the landforms. Radiometric images, on the other hand, give surface chemical data that can be used directly for mapping surface regolith.

Many of the characteristics and applications of a wide variety of images are described in Papp (2002).

Image Features that Contain Landform Information

When mapping landforms from imagery of any kind, it is important to know which characteristics of the images being used to obtain information about landforms. The standard image characteristics for interpretation are tone (colour on colour images), lines, texture, and shape. Of these, colour or grey tone result from ground cover reflectance rather than landforms and are therefore of less interest to us than the other three characteristics.

For landform mapping we can therefore choose wavelength bands which are least affected by atmospheric interference, because we are not looking for specific colours or grey tones. In practice this means use of near infrared bands such as Landsat TM bands 5 and 7, and SPOT band 3. Normally one band is enough, because we are not usually interested in colour composite images, which tell us more about ground cover than landforms. However, we may make use of multi-band data, and process it to highlight landform features. For example, the first principal component of a number of bands often contains a great deal of landform information.

Whatever the type of image we have to work with, there are routine procedures to be followed for landform mapping, in particular the use of the image features discussed in the next three sub-sections (Pain 1985).

Lines

Three kinds of line observable on images are used in landform mapping. These are structural lineaments, ridges and rivers. Structural lineaments are easily seen on most images, especially Landsat and SPOT, and are a useful way of telling the difference between landforms with strong structural control and those that have no structural control. It is necessary to take care, however, because not all lineaments on images result from rock structure.

Because structural lineaments are almost always revealed in the landscape by erosional processes, it is reasonable to place areas with obvious lineaments in the major category of erosional landforms.

Ridges and rivers, or valley floors, can be considered together, because together they make up most of the landscape. We can recognise four major categories on images:

Distinct ridges and rivers
Rivers without ridges
Ridges without rivers
Neither ridges nor rivers.

These major categories can be illustrated as profile forms (Figure 1). Where stereoscopic imagery is available, there is no problem distinguishing many more different profile types. Where there is no stereoscopic imagery, recognition of the four types noted above can be very useful. However, it can often be difficult telling the difference between flat and gently rounded landforms on such imagery, and also seeing small drainage channels that are less than the ground resolution of the available imagery. Under these circumstances discriminating ridges and valley bottoms on images may be very difficult. Moreover, because of the lack of elevation data, it may not be possible to distinguish between low plains and high plateaus. For this reason it is important to use images in conjunction with maps.

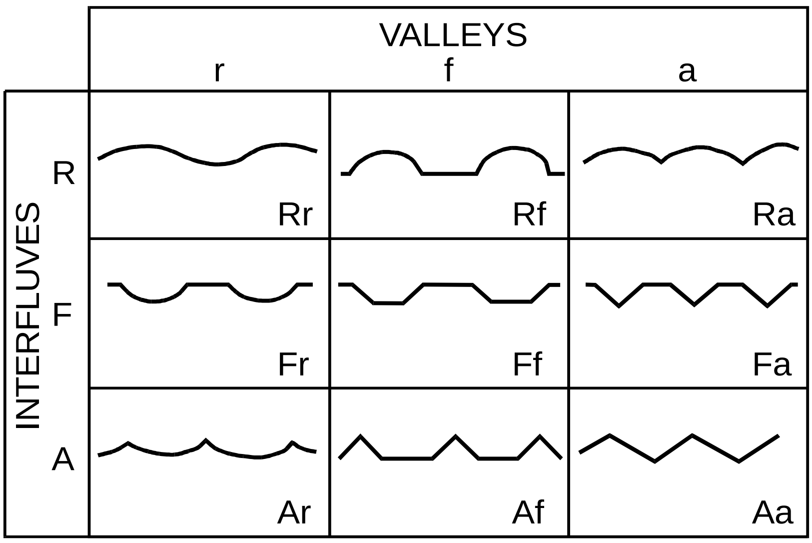

Figure 1. Possible combinations of valley and interfluve profile shapes – R = rounded, F = flat and A = angular (Ollier 1967). These shapes can be recognised in large part on images.

Texture

Texture can be used to distinguish between areas that have different densities of dissection (drainage densities), or repetitive landform features. A simple classification might be smooth, fine and coarse texture, but often imagery will allow more classes. Areas with smooth texture usually have low relief and very little variation. Coarse textures indicate low drainage densities, and fine textures may indicate high drainage density.

Shape

Shape is important mainly because of the direct evidence it gives for particular landform types. Shape provides information that can be used with other features in classifying land units. For example, volcanos usually have a distinct shape, as do beach ridges.

Recognition of Land Units on Images

The only way to learn how to recognise landform units, or any other sort of units, on images, is by practice. However, there are a few simple rules that can be followed.

1. Keep in mind the features listed above (lines, texture and shape) when viewing the images.

2. Remember that you are looking for landform features. Vegetation or land cover dominates features on many images. Do not let these features confuse you in your interpretation of landform units, but where appropriate, use their variation as a clue to landform..

3. As you draw boundaries, make notes about the characteristics of the areas inside the boundaries. In this way you can see why you are drawing boundaries. Always complete your boundaries. Do not leave map polygons unclosed.

2.1.3 Regolith Information

There are abundant data available from drill holes and geochemical and seismic surveys for many parts of Australia. Find out what is available for your project area, and see how it fits in with the preliminary boundaries you have drawn.

2.1.4 Preparation of the Pre-field Map

The landform unit boundaries derived from the images should be compiled onto a map. For a 1:250,000 scale final map, the pre-field maps should be at 1:100,000. This is a convenient scale for mapping in the field, and topographic maps are readily available at this scale for much of Australia.

At least 2 copies of each 1:100,000 map sheet should be available. One should be kept flat and clean in the home office, for digitising any base data required, and for reference. The second can be taken in the field, and used as necessary. Regolith landform unit boundaries can be transferred onto this field map before going into the field. A copy of the regolith landform unit boundaries should also be made on stable film. This copy can be amended as necessary in the light of field results.

Preliminary regolith landform unit data sheets should also be completed for each mapped regolith landform unit on the pre-field map.

2.2 Fieldwork

Fieldwork is an essential step in mapping regolith landform units. This is when you confirm or change the impressions gained from the images and maps, and see for yourself what the landscape and regolith really looks like. It is also important to check the relationships between the landform characteristics of the different regolith landform units, and the geology, regolith and soils that cannot be directly observed on the images.

In addition to completing field site forms, always make notes about everything of relevance to the mapping exercise. This is important. When you are in the field you will already have done your image and map interpretation, and you will also be able to see the landscape in front of you. You have all the information you are ever going to have about the area with you! Make full and complete notes, on the assumption that you will never return to the area for further checking.

2.2.1 Reconnaissance Checking

The first step in fieldwork should be a reconnaissance of the area of study. This can be made by driving through a representative part of the study area, or that part of the study area near your base. It is good practice to get to the higher points in the landscape so you can see more than one regolith landform unit. If possible, a survey flight over the project area is also valuable. This overview gives a good idea of the general features of the landscape, and also allows you to place the different regolith landform units in context. The reconnaissance should also be used to check the general relationships between regolith landform units and geology.

2.2.2 Selection of Sites

Wherever possible, sites should be selected on or near roads and paths. This will make fieldwork efficient, and less time consuming, while still allowing good field observations. Before going into the field, note the location of the different land units in relation to transport routes, and make your field plans accordingly. Remember that one of the essential reasons for mapping land units in the first place is to allow extrapolation from known areas to unknown areas. In most cases it is possible to extrapolate your observations from accessible areas into areas that are far from roads or paths.

Wherever possible, use road cuttings, riverbanks, or other exposures for your observations of rock types and regolith. However, you should be aware that such exposures are an interruption of the continuity of the landscape, and that regolith processes and therefore character at a cutting may differ from those in the regolith near by. At the very least, cuttings should be shaved back somewhat to reveal “fresh” regolith.

2.2.3 Landscape Observations

Observations of the landscape (in its broadest sense) can give a lot of detail that is not available from maps and images. For regolith landform mapping, remember that the map has at least two uses, mineral exploration and land assessment. For the first use you should be looking for any relationships between landforms, regolith, and mineral deposits. For the second, a thorough inventory of land resources is needed. In both cases it is essential to look for explanations of the landscape - its origins, active and relict geomorphic and weathering processes, and any information that will allow extrapolation to areas you will not be able to visit.

Landform Characteristics

The images give a general idea of landform characteristics, but field observations give the opportunity to get information about the details of landforms. Note whether the slopes are smooth, undulating or irregular, and whether there is any obvious control by underlying rocks.

Geomorphic Processes

Make a note of the types of geomorphic processes within regolith landform unit boundaries. Landslides can easily be recognised. Surface wash and other types of geomorphic processes can also be recognised with practice. Note both active processes, and evidence for prior processes that led to the formation of the regolith landform units as they are at present (see section 3.7.18).

Dissection

As we have seen, dissection can easily be observed on images of suitable scales. However, it is important to supplement the information obtained from images with field observations. Depending on the scale of the images, you may have missed the detail of dissection of individual slopes. This can include gullies that are cut into slope materials. The nature of the dissection can also be noted in the field in a way that is not possible with images.

Rock Types

During the reconnaissance trip you will have noted something of the lithologies, and how they relate to regolith landform units, and to the mapping units on the geology map. At the detailed site observations, note the lithologies not only at the site itself, but also in the surrounding area. It is often useful to find contacts between different rock types. This will allow you to compare rocks on both sides of the contact, and also to note any changes in regolith and landforms that may occur from one side of the contact to the other.

Surficial Regolith and Soils

In common with other observations you make about the regolith landform units, do not confine yourself to the specific sites chosen for detailed description and sample collection. Look at the general features of the regolith in road cuttings and other exposures. Make notes about any variations you see along the roads you travel on. Note the relationships between regolith and other physical features such as rock type, slope angles, landform types, erosion types, and vegetation or landuse.

2.2.4 Regolith Profile Observations

Methods of Profile Observation

Obtaining information about the regolith at depth can be a problem. Deep exposures, especially those more than 2 m deep, should be studied wherever possible. Examples of such exposures are road cuttings, stream banks, gullies, and mine pits. Alternatively, drilling may be used, and some information can be obtained from shallow seismic data. Ground penetrating radar offers a new and as yet largely untried source of data about the regolith.

In recent years Airborne Electromagnetic (AEM) surveys are providing data that show great promise for assessing regolith distribution and characteristics down to depths in excess of 100 metres. Worrall et al. (1999) give good recent examples.

Deep exposures are by far the best source of information about the third dimension of regolith. Core or loose samples from drill holes can only be identified with difficulty as a particular regolith type. However, much of the Australian continent has a very low relief, and drill holes are often the only way of assessing geophysical techniques such as AEM. It is therefore important to be familiar with material from drill holes.

Site Data Entry

The RTMAP database has a series of entry screens for site data, and we have produced a summary data form for field use (Figure 2, Figure 3). Site data forms can be printed and bound into a convenient field notebook.

The first page of the site data form is for information about the site as a whole. The second page is for individual layers, or zones, at the site. In the regolith context, a zone is a part of the regolith having a distinctive character, differing from adjacent parts. Where there are several zones at a single site, a new page is used for each zone. However, site data need be entered only once.

We are currently working on developing the tools for digital field data entry.

Details about completing the site data are given in Chapters 3 and 4.

2.3 Data Entry and Map Production

2.3.1 Entering Regolith Landform Unit Data

If possible the regolith landform unit data should be completed before you leave the field, either on cards or entered into the computer. The reason for this is very simple. When you are in the field, you have all the available information, and especially the landscape, with you in a way you can never have when you return to the office. Any decisions about location of boundaries, and inclusion or exclusion of areas in various units, must be made in the field camps and preferably as soon as possible following the observations. It is no good thinking that extra time will allow better decisions on these things. It won't! The only thing that will happen is you will forget essential details. Do it immediately, while you still have all the information on hand.

2.3.2 Preparation of Map

The same rules apply here. You should do as much as possible to finalise the draft map before leaving the field camps. It is much more difficult to check problem areas once you have returned to the central office.

Once back at the office, all data should be entered into RTMAP, and checked for accuracy. Data entry is explained in Chapter 3. The draft map should be finished, and entered into the GIS. Details of final map preparation on the GIS will be dealt with in another report.

2.3.3 Map Legends

The current list of Geoscience Australia regolith landform map symbols is given in Tables 2.1 and 2.2.

ORIG[_____] **SITE ID**[______________] DATE [__-___-___] **STATE**[____]

REGION [___________________] LOC DESCR [________________________]

[____]

1:100K[______] **AMGEAST**[_____________] **AMGNORTH** [___ ____ ________]

LOC METHOD [____] **ABS ACC** [_____] AIRPHOTO[_____________________]

EXPOSURE[________] SLOPE[______] ASPECT [____________]

LANDFORM[_________________________] GEOMORPH1 [_________________]

GEOMORPH2[_______________________] STRATUNIT[___________________]

ROCKTYPE[___] QUAL_1[__________________] LITHNAME[______________]

SOIL[____]

[____]

VEG[____]

HAZARDS[____]

PHOTO[____]

ABSTRACT[____]

[____]

ZONE [___] **THICKNESS** [_____] DEPTH TO LOWER BOUNDARY [__________]

FRESH BEDROCK BELOW [__] **REGOLITH** [____________________________]

DEGREE OF WEATHERING [__] DESCR[________________________________]

[____]

SKETCH

Figure 2. Page 1 from RTMAP field notebook.

DATA

TYPE SUB-TYPE DESCRIPTION

[_______][_______][____]
[_______][_______][____]
[_______][_______][____]
[_______][_______][____]
[_______][_______][____]
[_______][_______][____]
[_______][_______][____]
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[_______][_______][____]
[_______][_______][____]
[_______][_______][____]
[_______][_______][____]
[_______][_______][____]

SAMPLE ID DESCRIPTION

[____________][____]
[____________][____]
[____________][____]
[____________][____]
[____________][____]
[____________][____]

CARRY OVER [_] SHEET [_] OF [_]

Figure 3. Page 2 from RTMAP field notebook.

Table 2.1. RTMAP codes and map symbols for regolith

RTMAP Code	Regolith Description	Map Code
BU00	unweathered bedrock	BU
EVA00	evaporite	E
EVA01	halite	EH
EVA02	gypsum	EG
EVA03	calcrete	EC
SDA00	alluvial sediments	A
SDA10	channel deposits	AC
SDA20	overbank deposits	AO
SDC00	colluvial sediments	C
SDC01	scree	CS
SDC02	landslide deposit	CL
SDC03	mudflow deposit	CM
SDC04	creep deposit	CC
SDC05	sheet flow deposit	CH
SDC06	fanglomerate	CF
SDE00	aeolian sediments	I
SDE01	aeolian sand	IS
SDE02	loess	IL
SDE03	parna	IP
SDF00	fill	F
SDG00	glacial sediments	G
SDL00	lacustrine sediments	L
SDM00	marine sediments	OM
SDP00	swamp (paludal) sediments	P
SDP01	peat	PP
SDS00	coastal sediments	O
SDS01	beach sediments	OB
SDS02	estuarine sediments	OE
SDS03	coral	OC
SDT00	terrestrial sediments	T
UOC00	clay (unknown origin)	UC
UOM00	weathered material (unknown origin)	UW
UOS00	sand (unknown origin)	US
VOL00	volcanic sediments	V
VOL01	lava flow	VF
VOL02	tephra	VT
WIR10	saprolith	S
WIR11	saprock	SS
WIR12	moderately weathered bedrock	SM
WIR13	highly weathered bedrock	SH
WIR14	very highly weathered bedrock	SV
WIR15	completely weathered bedrock	SC
WIR15.1	mottled zone	SV
WIR15.2	pallid zone	SV
WIR16	saprolite	SP
WIR20	residual material	R
WIR21	lag	RL
WIR22	residual sand	RS
WIR23	residual clay	RC
WIR24	soil on bedrock	RB

Table 2.2. RTMAP codes and map symbols for landforms

RTMAP Code	Landform Description	Map Code
AL00	alluvial landforms	a
AL10	alluvial plain	ap
AL11	flood plain	af
AL12	anastomatic plain	aa
AL13	bar plain	ab
AL14	covered plain	ac
AL15	meander plain	am
AL16	floodout	ao
AL17	stream channel	ar
AL20	alluvial terrace	at
AL30	stagnant alluvial plain	as
AL40	terraced land	al
AL50	alluvial swamp	aw
CO00	coastal lands	c
CO01	beach ridge	cb
CO02	chenier plain	cc
CO03	coral reef	cr
CO04	marine plain	cm
CO05	tidal flat	ct
CO06	coastal dunes	cd
CO07	coastal plain	cp
CO08	beach	cc
DE00	delta	d
DU00	aeolian landforms	u
DU10	aeolian dunes	ud
DU11	longitudinal dunefield	ul
DU12	transverse dunefield	ut
DU13	irregular dunefield	ui
DU14	source bordering dune	ub
DU15	lunette	uu
DU20	aeolian sheet	us
DU21	climbing sheet	uc
ER00	erosional landforms	e
ER10	erosional plain	ep
ER11	pediment	ei
ER12	pediplain	ea
ER13	peneplain	en
ER14	etchplain	ee
ER20	rises	er
ER21	residual rise	eu
ER30	low hills	el
ER31	residual low hill	es
ER40	hills	eh
ER50	mountains	em
ER60	escarpment	ec
ER70	badlands	eb
ER80	drainage depression	ed
FA00	fan	f
FA01	alluvial fan	fa
FA02	colluvial fan	fc
FA03	sheet-flood fan	fs
GL00	glacial features	g
GL10	depositional glacial features	gd

GL20	erosional glacial features	ge
KA00	karst	k
MA00	made land	m
ME00	meteor crater	t
PL00	plain	p
PL01	depositional plain	pd
PL02	lacustrine plain	pl
PL03	playa plain	pp
PL04	sand plain	ps
PT00	plateau	l
PT01	plateau edge	le
PT02	plateau surface	ls
VO00	volcano	v
VO01	caldera	vc
VO02	cone (volcanic)	vv
VO03	lava plain	vl
VO04	ash plain	va
VO05	lava flow	vf
VO06	lava plateau	vp

3. REGOLITH AND LANDFORM ATTRIBUTES

In this chapter we provide comments on attributes which can be used as a reference when entering data into RTMAP, either directly, or via hard copy forms. We also provide lists of allowable entries for a number of attributes. These lists are the "authority tables" used in RTMAP. In these cases, RTMAP will accept only entries from the authority tables. Where users find situations where the authority tables are incomplete, they should contact the RTMAP custodian at Geoscience Australia with a view to adding an entry to the appropriate authority table.

Some authority tables have been updated since the first printing of this handbook.

A discussion and definitions of the attributes are found in Chapter 4.

In RTMAP, as in any database, data are entered into locations called fields. These fields are fixed in length. A few of the fields must be filled in, but most are optional. Details of field names and lengths, and whether they are optional or not, are found in Lenz (1991) and Hazell et al. (1995). Figure 4 and Figure 5 show the simplified logical relationships of mapping unit data and field site data in RTMAP.

Where appropriate we have used the classifications found in the *Australian Soil and Land Survey Field Handbook* (McDonald et al. 1990). We have done this because that handbook is now well established as an authority for land and soil surveys. However, in most cases we have changed the codes to allow easier searches and reporting using ORACLE. In McDonald et al. (1990), the codes are derived from the first letters of the class. In RTMAP we have arranged attributes into hierarchical order, to allow grouping of attributes. For example, to retrieve regolith landform units containing low hills the code ER30 would be used. However, to retrieve regolith landform units with all kinds of erosional landforms, the code ER% would be used (% is a wildcard character in ORACLE).

The two most important entities within RTMAP are the regolith landform mapping unit (UNIT) and the site (SITE). The regolith landform mapping unit can combine more than one landform type and several regolith types. The site occurs in one landform type, but can be made up of several regolith types. Each regolith type may have several zones. These many-to-one relationships are noted below where appropriate. Information from SITE data can help with compilation of UNIT data.

The attributes are dealt with in the order in which they appear on the data entry screens. Compulsory fields are coloured blue-green, while optional fields are white. Where there is a lookup table, the following symbol appears on the screen: 

Lookup tables are given here where appropriate. Many of them can also be obtained from the Geoscience Australia web site, www.ga.gov.au. Go to Online Databases, then to Lookup Tables near the bottom of the page. The lists on the web are kept up to date, so they may vary from the ones presented here.

As noted earlier, this hand book has been written primarily for those who have direct access to the RTMAP database. However, most of the fields and values will be of use to others.

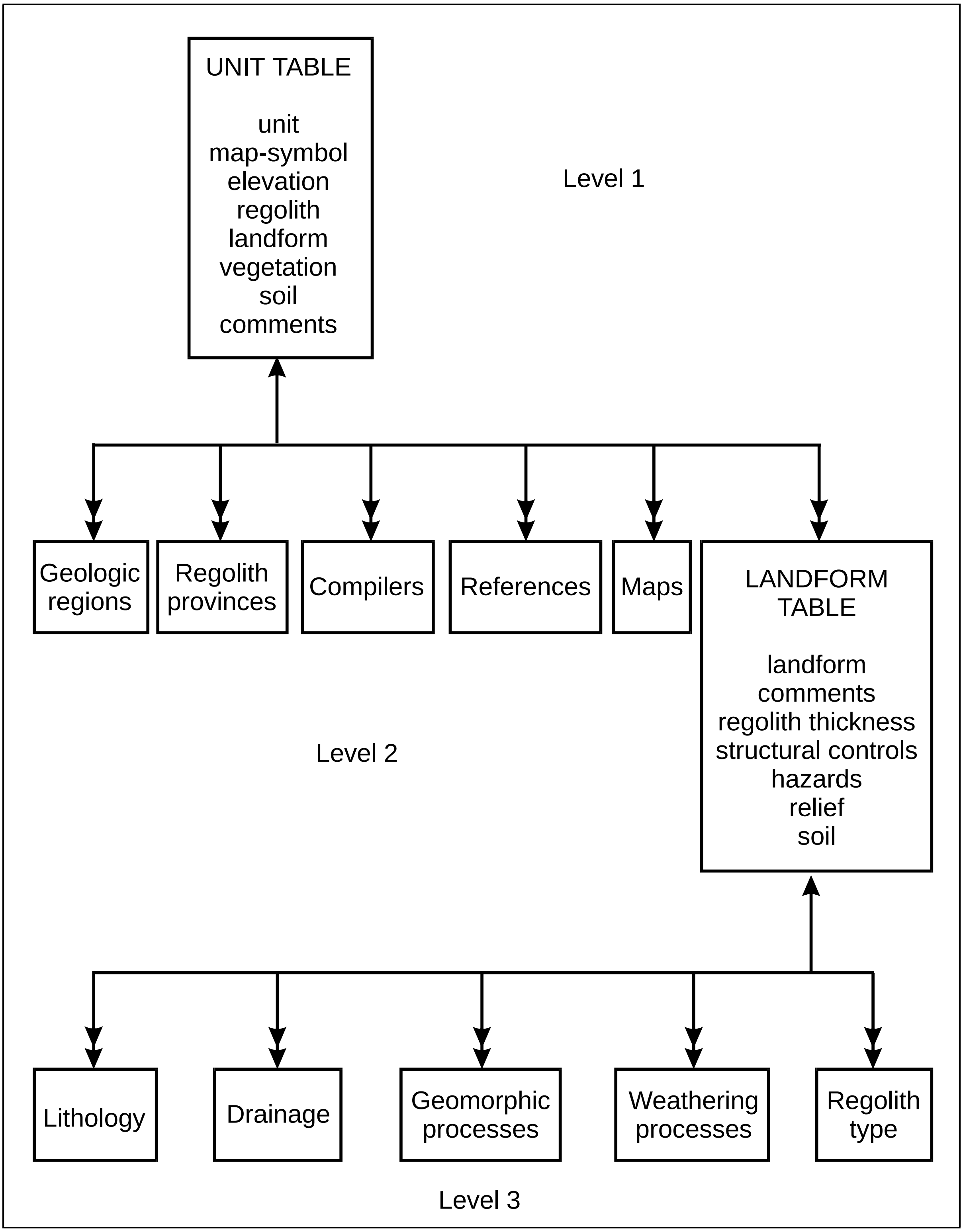


Figure 4. Simplified logical relationships of mapping unit data in RTMAP. Level 2 data have a many to one relationship to level 1 data, and level 3 data have a many to one relationship to level 2 data.

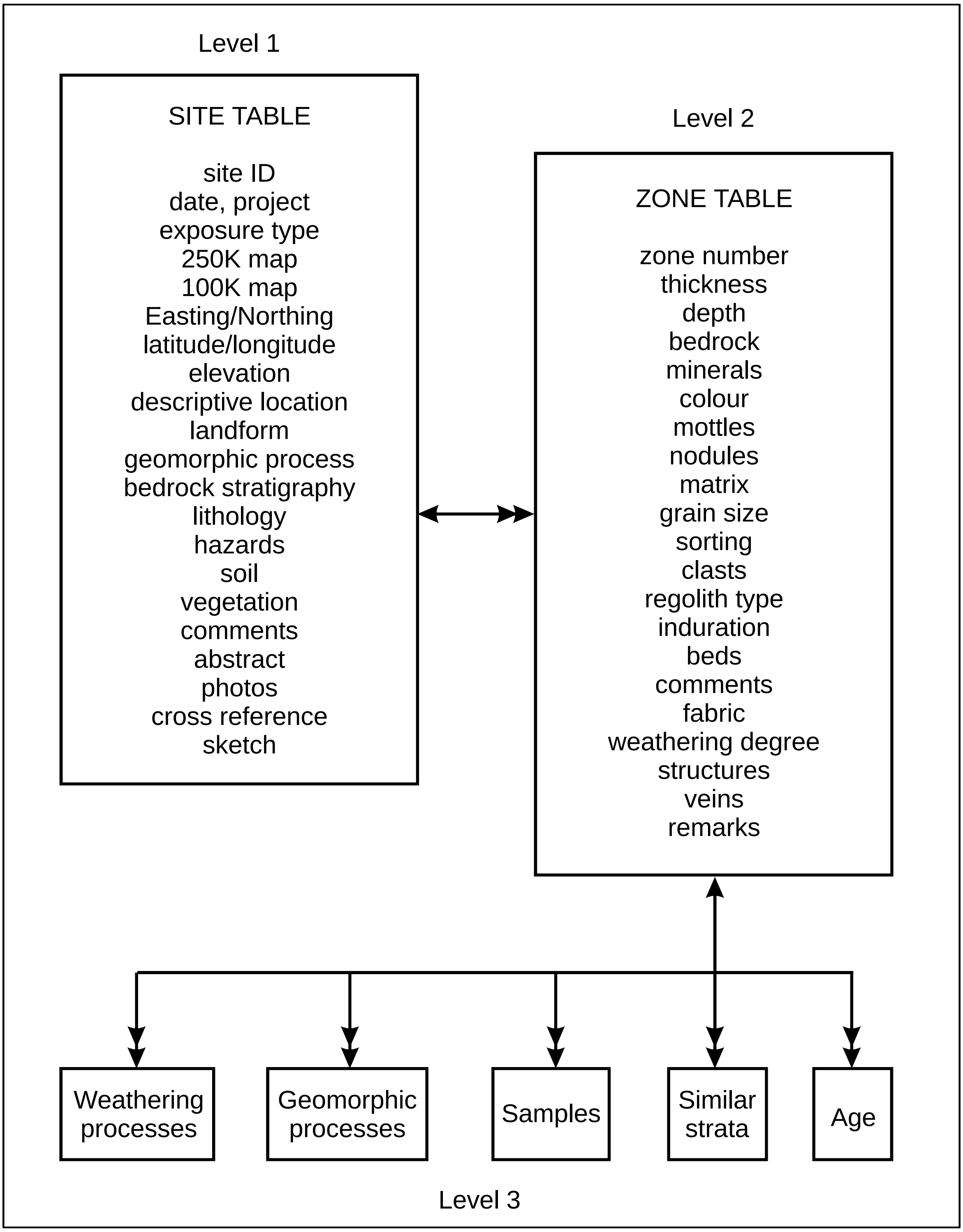


Figure 5. Simplified logical relationships of field site data in RTMAP. Level 2 data have a many to one relationship to level 1 data, and level 3 data have a many to one relationship to level 2 data.

3.1 Regolith Landform Unit Fields

These fields (Figure 6) contain elevation and relief information on the regolith landform unit and descriptive information on regolith, landforms, vegetation and soils. They refer to the whole unit, and not just part of it.

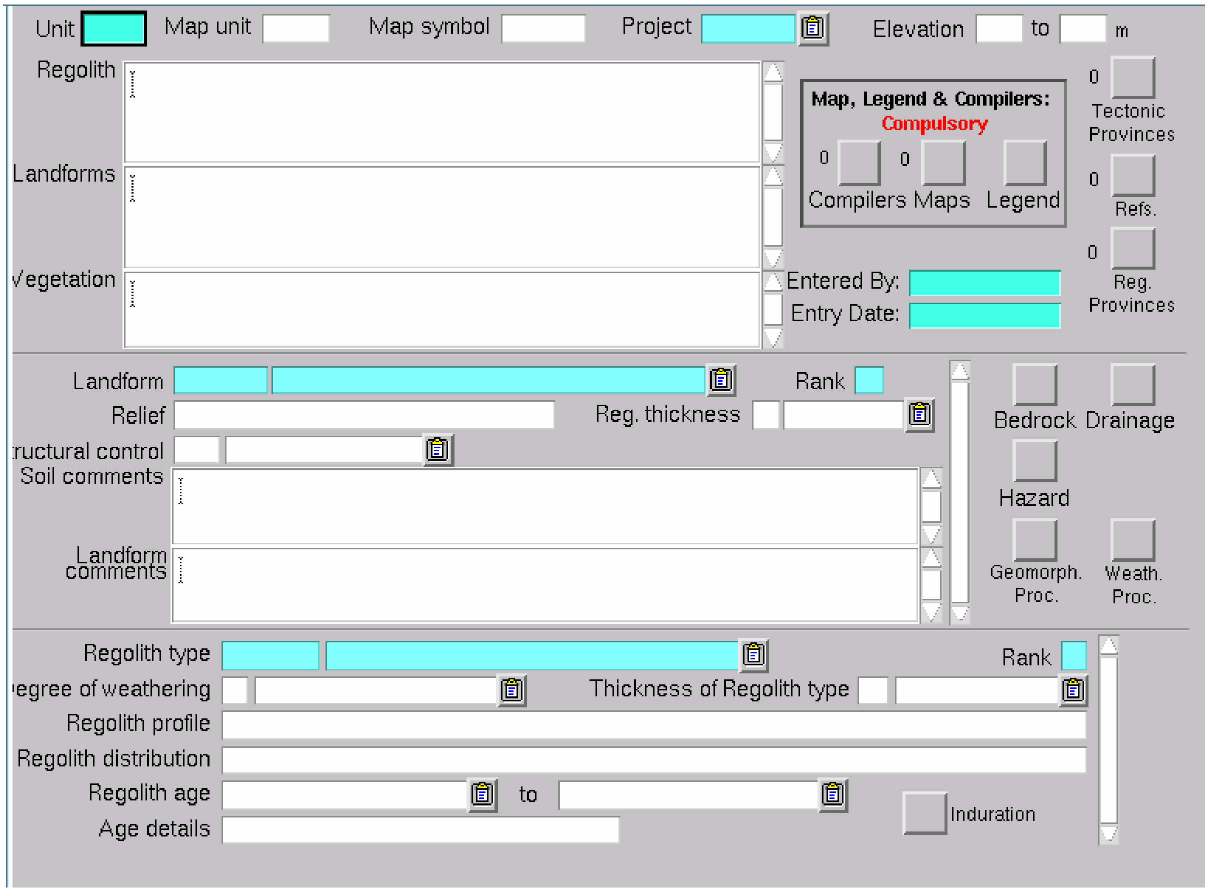


Figure 6. The Unit screen in RTMAP.

3.1.1 Unit ID (U_ID)

This is a unique automatically created sequential number cued by data entry. It is the number that identifies the regolith landform unit in RTMAP, and it links all the tables together. This number should also be used as the polygon label in a GIS.

3.1.2 Map Unit

This is a unique alphanumeric symbol entered by the compiler at the time of map compilation. It corresponds to a polygon or number of polygons on the map face, and is necessary to link the map in the GIS to the data entry in RTMAP.

3.1.3 Map Symbol

An appropriate map symbol from Tables 2.1 and 2.2 may be used here.

3.1.4 Project

Enter a project code from the project authority table. If the project is not on the list, contact the RTMAP custodian at Geoscience Australia.

3.1.5 Elevation

Enter the lower and upper values of the elevation range for the whole unit.

3.1.6 Regolith, Landforms and Vegetation

These are free text fields for descriptions of regolith, landforms and vegetation within the unit as a whole.

3.1.7 Compilers

Enter the compiler(s) name(s) from the lookup table (listed under "Originators" on the Geoscience Australia web site). If a compiler is not on the list, contact the RTMAP custodian at Geoscience Australia.

3.1.8 Maps

Enter the 1:100,000 map sheet name(s) from the lookup table.

3.1.9 Legend

This field is to choose the style of legend description required for the map. There are currently two choices, a geochemical description, and the standard regolith description.

3.1.10 Tectonic Provinces

Enter one or more elements from the Tectonic Elements Table. This table lists the 93 tectonic structural elements of Australia, from Palfreyman (1984) (Figure 7).

01	Adavale Basin
02	Adelaide Fold Belt
03	Albany-Fraser Province
04	Amadeus Basin
05	Arafura Basin
06	Arckaringa Basin
07	Arnhem Block
08	Arrowie Basin
09	Arunta Block
10	Bancannia Trough
11	Bangemall Basin
12	Birrindudu Basin
13	Bonaparte Basin
14	Bowen Basin
15	Bremer Basin
16	Broken Hill Block
17	Canning Basin
18	Cape York-Oriomo Inlier
19	Carnarvon Basin
20	Carpentaria Basin
21	Clarence-Moreton Basin
22	Coen Block
23	Cooper Basin
24	Daly River Basin
25	Darling Basin
26	Davenport Geosyncline
27	Denison Block
28	Drummond Basin
29	Duaringa Basin
30	Dundas Trough
31	Eromanga Basin
32	Esk Trough
48	Laura Basin
49	Leeuwin Block
50	Litchfield Block
51	Maryborough Basin
52	McArthur Basin
53	Money Shoal Basin
54	Mount Isa Block
55	Mount Painter Block
56	Murphy Inlier
57	Murray Basin
58	Musgrave Block
59	Nabberu Basin
60	New England Fold Belt
61	Ngalia Basin
62	Northampton Block
63	Oaklands Basin
64	Officer Basin
65	Ord Basin
66	Otway Basin
67	Paterson Province
68	Pedirka Basin
69	Perth Basin
70	Pilbara Block
71	Pine Creek Geosyncline
72	Polda Basin
73	Rocky Cape Block
74	Rum Jungle Block
75	South Nicholson Basin
76	Stansbury Basin
77	Stuart Shield
78	St Vincent Basin
79	Styx Basin

33 Eucla Basin
34 Galilee Basin
35 Gascoyne Block
36 Gawler Block
37 Georgetown Block
38 Georgina Basin
39 Gippsland Basin
40 Halls Creek Province
41 Hamersley Basin
42 Hillsborough Basin
43 Hodgkinson Fold Belt
44 Kanmantoo Fold Belt
45 Karumba Basin
46 Kimberley Basin
47 Lachlan Fold Belt
80 Surat Basin
81 Sydney Basin
82 Sylvania Dome
83 Tasmania Basin
84 Tennant Creek Block
85 The Granites-Tanami Block
86 Torrens Basin
87 Tyenna Block
88 Victoria River Basin
89 Warburton Basin
90 Wiso Basin
91 Wonominta Block
92 Yambo Block
93 Yilgarn Block

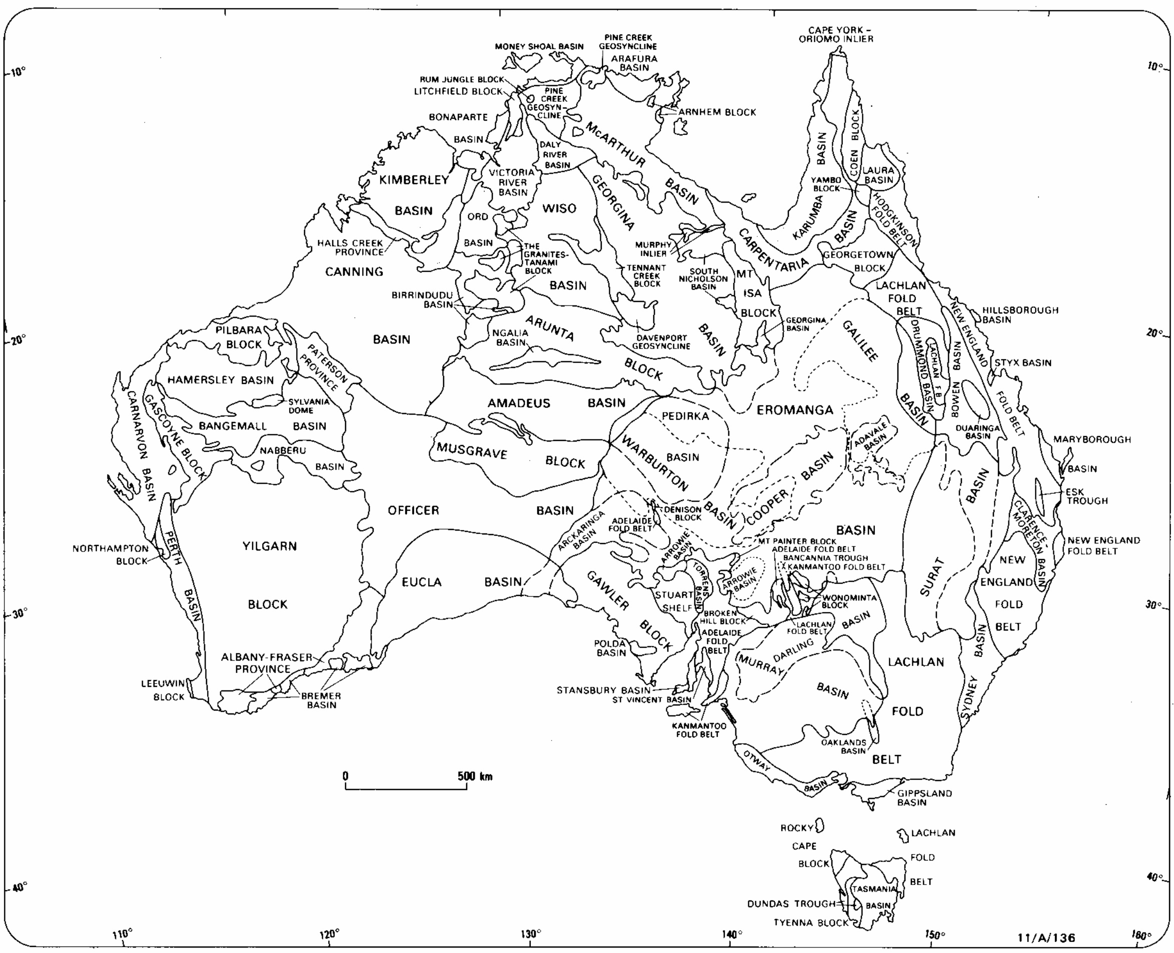


Figure 7. Tectonic Structural Elements of Australia (Palfreyman 1984).

3.1.11 Refs

This field is for information about bibliographic references. A ref(erence) number code is entered and the author(s) and date of publication will be displayed on the screen in response. Full information is contained in the table REFS. The number code is a sequential system-generated number. The entry screens are shown in Figure 8.and Figure 9

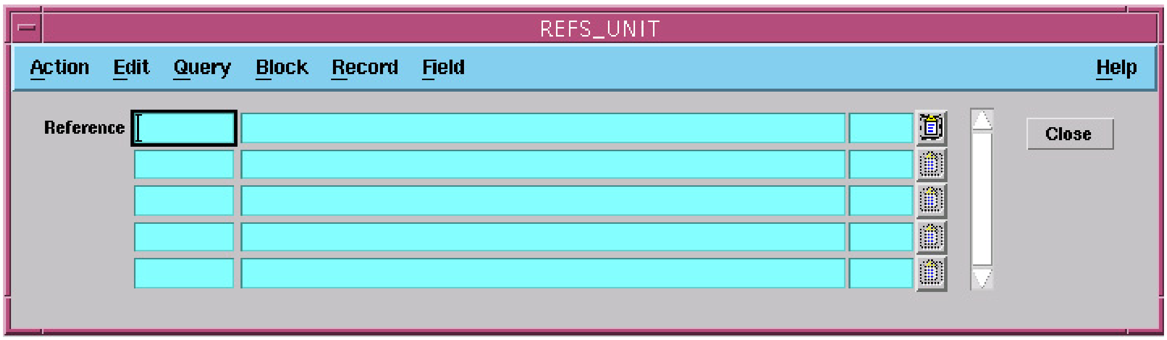


Figure 8. Bibliographic reference lookup screen. Clicking on the lookup button brings up the reference entry screen (Figure 9).

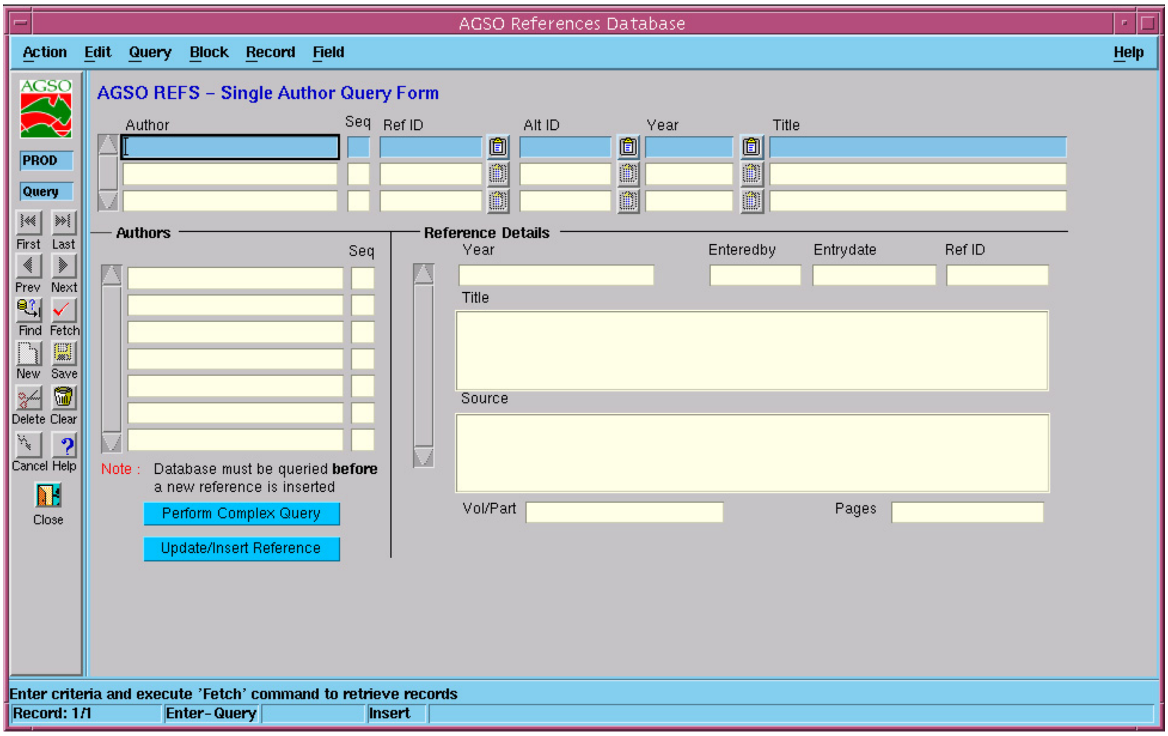


Figure 9. Bibliographic reference entry screen.

3.1.12 Regolith Landform Provinces

This field is for Regolith Landform Province names, from the Table PROV. The Province details are followed by the major/subordinate (M/S) code to indicate if the regolith landform unit is a major or subordinate component within the Regolith Landform Province. Current provinces are:

1	Walling Rock
2	Boorabbin
3	Cave Hill
4	Kurrajong Range
5	Niagara Creek
6	Leonora
7	Edjudina Range
8	Donkey Rocks
9	Kalgoorlie
10	Moon Rock
11	Emu Rocks
12	Binneringie
13	Mulgabiddy Creek
14	Minnie Hill
15	Ethel Hill
17	Pitcher Range
18	Neale Plateau
19	Streich Mound
20	Moonyoora
21	Carlisle Plain
22	Nyanga Plain
23	Nullarbor Plain
24	Bremer Range
25	Cowarna Rocks
26	Hampton Tableland
27	Kambalda
28	Murdonna Hill
29	Fraser Range
30	Lake Lefroy

3.2 Landform Unit Fields

There may be many landform units within one regolith landform unit. The following fields are completed for each landform unit.

3.2.1 Landform Pattern and Element

Enter the landform pattern or element code from the Landform Authority Table. This is followed by the rank to indicate if the landform unit is a major or subordinate component of the regolith landform unit. See Appendix 1 for the distinction between landform patterns and elements.

Landform Patterns

AL00	alluvial landforms		
AL10		alluvial plain	
AL11			flood plain
AL12			anastomotic plain
AL13			bar plain
AL14			covered plain
AL15			meander plain
AL16			floodout
AL17			stream channel
AL20		alluvial terrace	
AL30		stagnant alluvial plain	
AL40		terraced land	
AL50		alluvial swamp	
CO00	coastal lands		
CO01		beach ridge plain	
CO02		chenier plain	
CO03		reef	
CO04		marine plain	
CO05		tidal flat	
CO06		coastal dunes	
CO07		coastal plain	
CO08		beach	
DE00	delta		
DU00	aeolian landforms		
DU10		aeolian dunes	
DU11		longitudinal dunefield	
DU12		transverse dunefield	
DU13		irregular dunefield	
DU14		source bordering dune	
DU15		lunette	
DU20		aeolian sheet	
ER00	erosional landforms		
ER10		erosional plain (<9m relief)	
ER11			pediment
ER12			pediplain
ER13			peneplain
ER14			etchplain
ER20		rises (9 - 30m relief)	
ER21			residual rise
ER30		low hills (30 - 90m relief)	
ER31			residual low hill
ER40		hills (90 - 300m relief)	
ER50		mountains (>300m relief)	
ER60		escarpment	
ER70		badlands	
ER80		drainage depression	
FA00	fan		
FA01		alluvial fan	
FA02		colluvial fan	
FA03		sheet-flood fan	
GL00		glacial landforms	
GL10		depositional glacial landforms	
GL20		erosional glacial landforms	
KA00	karst		
MA00	made land		
ME00	meteor crater		
PL00	plain		
PL01		depositional plain	
PL02		lacustrine plain	
PL03		playa plain	
PL04		sand plain	
PT00	plateau		
PT01		plateau edge	
PT02		plateau surface	
VO00	volcano		
VO01		caldera	
VO02		cone (volcanic)	
VO03		lava plain	
VO04		ash plain	
VO05		lava flow	
VO06		lava plateau	

Landform Elements

C	crest	F	flat
CHCR	hillcrest	FPLA	plain
CSUS	summit surface (broad crest)	FRFL	rock flat
CREC	rise crest	FRPL	rock platform
CDUC	dune crest	FCOS	cut-over surface
		FSCD	scald
H	hillock	FPED	pediment
HTOR	tor	FFAN	fan
HRER	residual rise	FVLF	valley flat
HTUM	tumulus	FTEF	terrace flat
HDUN	dune	FCBE	channel bench
HDUH	hummocky (weakly oriented) dune	FBKP	back plain
HDUB	barchan	FSRP	scroll plain
HDUP	parabolic dune	FFLD	flood-out
HDUT	transverse dune	FTEP	terrace plain
HDUF	linear or longitudinal (seif) dune	FTDF	tidal flat
HCON	cone (volcanic)	FITF	intertidal flat
HMOS	mound spring	FSTF	supratidal flat
HMOU	mound	FFIL	fill-top
		FBER	berm (coastal)
R	ridge	FREF	reef flat
RLEV	levee		
RBAR	bar (stream)	V	open depression
RSCR	scroll	VALC	alcove
RPST	prior stream	VGUL	gully
RDUN	dune	VCIR	cirque
RFOR	fore dune	VDDE	drainage depression
RLUN	lunette	VSTC	stream channel
RBRI	beach ridge	VSTB	stream bed
REMB	embankment	VTDC	tidal creek
RDAM	dam	VEST	estuary
		VSWP	swamp
U	unspecified slope	VSWH	channel swale
UCLI	cliff	VSWD	dune swale
USCA	scarp	VSWC	coastal swale
UHSL	hill slope	VTRE	trench
UCUT	cut face		
ULDS	landslide	D	closed depression
UEMB	embankment	DLAK	lake
		DPLY	playa
S	simple slope	DDBA	deflation basin
SBAN	bank (stream)	DDOL	solution doline
SBEA	beach	DDOC	collapse doline
SDUS	dune slope	DOXB	ox-bow
SRES	rise slope	DLAG	lagoon
		DSWP	swamp
M	mid-slope	DBOU	blow-out
MBRK	breakaway	DCIR	cirque
MCFS	cliff-foot slope	DMAA	maar
MSFS	scarp-foot slope	DCRA	crater
MBEN	bench	DPIT	pit
MBER	berm (artificial)		
L	lower slope		
LCFS	cliff-foot slope		
LSFS	scarp-foot slope		
LPED	pediment		
LFOO	foot slope		
LTAL	talus		
LCFS	cliff-foot slope		

3.2.2 Relief

Enter here the average local relief, the difference in elevation between the highest and lowest parts of the landform unit. Speight (1990) notes that the estimation of relief is made easier by visualising two surfaces that are planar or gently curved, one touching the major crests of the landform unit, and the other passing through the major depressions The average vertical separation of the two surfaces is a measure of the relief. (This should not be confused with elevation, which is absolute height above sea level.)

3.2.3 Structural Controls

The type of structural control on landforms in the landform unit is given from the following list.

NS	no structural control
AN	anticline
AD	anti dip slope
BF	block faulting
CU	cuesta forms
DB	dipping beds
DI	dip slope
DS	dyke/sill
FT	faulted
HG	horst/graben
HO	horizontal bedding
JN	jointing
MN	monocline
SA	strike aligned
SN	syncline

3.2.4 Regolith Thickness

Regolith thickness over an entire regolith landform unit is obviously impossible to determine. This field is for a general indication of the maximum thickness of regolith in the unit. Enter a thickness code from the following list:

0	unknown
1	< 0.5 m
2	< 2 m
3	> 2 m
4	> 5 m
5	> 15 m
6	> 50 m

3.2.5 Soils Comments

The amount of soils information that can be entered will depend to a large extent on the observer. Those with knowledge of soil classification (e.g. Northcote Key, Great Soil Groups, or the new Australian Soil Taxonomy) should use these. Others should note only the main morphological features of the soil. There are lists of some soil classifications, and some definitions, in Chapter 4.

3.2.6 Landform Comments

This is a comment field for free-text description of the landform within the unit. This could include depth and degree of dissection, if appropriate.

3.2.7 Bedrock Details

The bedrock details are for the lithology of the bedrock below this particular landform unit. There may be more than one bedrock type under a single landform unit. The “Bedrock” button on the Units screen gives the following entry block (Figure 10).

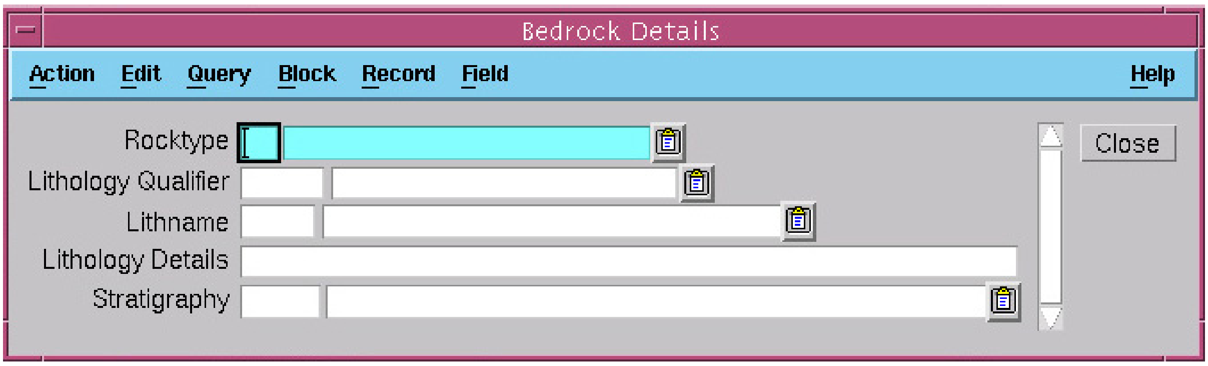


Figure 10. The Bedrock Details entry block in RTMAP.

Rock Type

Rock type is entered from the following table.

1	unknown	12	metabasite
2	felsic intrusive	13	felsic gneiss
3	intermediate intrusive	15	metasomatite
4	mafic intrusive	16	mineralisation
5	felsic extrusive	17	regolith
6	intermediate extrusive	19	vein
7	mafic extrusive	20	volcaniclastic
8	ultramafic	21	tectonite
9	alkaline igneous	22	organic
10	clastic sediment		
11	chemical sediment		

Lithology Qualifier

If working in GA, choose terms from the lookup table in the GA databases. Otherwise use your own terms.

Lithology Name

If working in GA, choose terms from the lookup table in the GA databases. Otherwise use your own terms.

Stratigraphy

If the named stratigraphic units are known, enter the details from the authority table.

3.2.8 Drainage

There are 4 data types relating to drainage (Figure 11). These are the drainage pattern, drainage character, drainage type, and stream channel spacing.

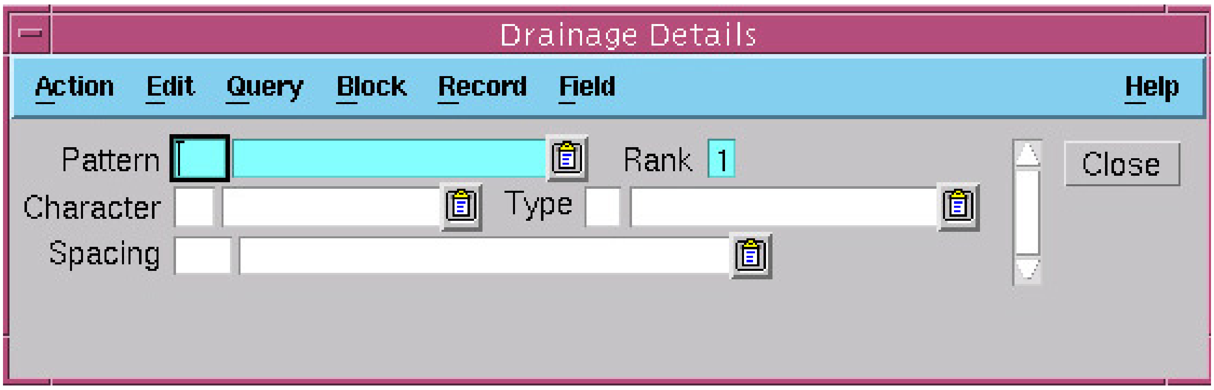


Figure 11. The drainage entry screen.

Codes are obtained from the following lists:

Data type	Data subtype	
P drainage pattern	AB	anabranching
P	AG	angulate
P	AN	annular
P	AS	anastomosing
P	BA	barbed
P	CP	centripetal
P	CR	circumvolcanic
P	CV	convergent
P	DN	dendritic
P	DS	distributary
P	DV	divergent
P	GU	gutter
P	IN	interrupted
P	NA	none
P	PA	parallel
P	RA	radial
P	RC	rectangular
P	RT	reticulate
P	TR	trellis
C drainage character	D	dry
C	I	intermittent
C	T	tidal
T drainage type	A	antecedent
T	C	captured
T	D	diverted
T	N	normal
T	R	reversed
T	S	superimposed
S drainage spacing	AB	absent or very rare >2500 m
S	CS	closely spaced 250 - 400 m
S	MS	moderately spaced 400 - 625 m
S	NU	numerous <150 m
S	SP	sparse 1500 - 2500 m
S	VC	very closely spaced 150 - 250m
S	VW	very widely spaced 1000 - 1500
S	WS	widely spaced 625 - 1000 m

3.2.9 Environmental Hazards

If the landform unit is susceptible to any environmental hazards, enter a code from the following list:

NH	no recognised hazards	SC	solution cavities
AV	snow avalanche	SD	sand drift
CP	coastal progradation	SO	soil erosion
CO	coastal erosion	ST	storm surge
FF	flash flood	SU	subsidence
FL	flood	TS	tsunami
LA	landslide	VE	volcanic eruption
RO	rockfall	GU	gully erosion
SA	salinity	GI	gilgai

3.2.10 Geomorphic Processes

Enter the geomorphic process, the rank, and the active or relict (A/R) code. The active code allows present day processes to be recorded, while the relict code allows recognition of processes active in the past that were responsible for the origin of the landform unit. The geomorphic process code comes from the following table:

GR00	gravity
GR01	vertical collapse
GR02	particle fall
GR03	creep
GR04	landslide
GR05	mudflow
WT00	water
WT01	channelled stream flow
WT02	over-bank stream flow
WT03	sheet flow, sheet wash or surface wash
WT04	waves
WT05	tides
WT06	detrital deposition in still water
WT07	rilling/gullying
WT08	subsurface solution/piping
IC00	ice
IC01	frost
IC02	glacial erosion
IC03	glacial deposition
IC04	periglacial
WI00	wind
WI01	wind erosion (deflation)
WI02	sand deposition
WI03	dust deposition
VO00	volcanism
VO01	lava flow
VO02	ash flow
VO03	ash fall
BI00	biological agents; coral
HU00	human agents
MT00	impact by meteors

3.2.11 Weathering Processes

Enter the weathering processes, the rank, and the active or relict (A/R) code. The active code allows present day weathering processes to be recorded, while the relict code allows recognition of weathering processes active in the past. The weathering process code comes from the following table:

WE00	weathering
PH00	physical weathering
PH01	abrasion
PH02	frost weathering
PH03	induced fracture
PH04	insolation weathering
PH05	moisture swelling
PH06	sheeting
PH07	salt weathering
PH08	volume increase
PH09	wetting and drying
CH00	chemical weathering
CH01	solution
CH06	hydrolysis
CH07	ferrolysis
CH08	precipitation/evaporation
IN00	induration
IN01	bauxitic induration
IN02	calcareous induration
IN03	clay induration
IN04	ferruginous induration
IN05	gypsiferous induration
IN06	siliceous induration
BI00	biotic weathering

CH02	oxidation and reduction
CH03	carbonation
CH04	hydration
CH05	chelation

3.3 Regolith Type Fields

There may be many regolith types within one landform unit.

3.3.1 Regolith Type

Enter the code for regolith type in this field, and the rank. The regolith type comes from the following table:

BU00	unweathered bedrock
EVA01	halite
EVA02	gypsum
EVA03	calcrete
SDA00	alluvial sediments
SDA10	channel deposits
SDA20	overbank deposits
SDC00	colluvial sediments
SDC01	scree
SDC02	landslide deposit
SDC03	mudflow deposit
SDC04	creep deposit
SDC05	sheet flow deposit
SDC06	fanglomerate
SDE00	aeolian sediments
SDE01	aeolian sand
SDE02	loess
SDE03	parna
SDF00	fill
SDG00	glacial sediments
SDL00	lacustrine sediments
SDM00	marine sediment
SDP00	swamp (paludal) sediments
SDP01	peat
SDS00	coastal sediments
SDS02	estuarine sediments
SDS03	coral
SDT00	terrestrial sediments
UOC00	clay (unknown origin)
UOM00	weathered material (unknown origin)
UOS00	sand (unknown origin)
VOL00	volcanic sediments
VOL01	lava flow
VOL02	tephra
WIR10	saprolith
WIR11	saprock
WIR12	moderately weathered bedrock
WIR13	highly weathered bedrock
WIR14	very highly weathered bedrock
WIR15	completely weathered bedrock
WIR15.1	mottled zone
WIR15.2	pallid zone
WIR16	saprolite
WIR20	residual material
WIR21	lag
WIR22	residual sand
WIR23	residual clay

3.3.2 Degree of Weathering

The degree of weathering code from the following list can be used to modify regolith types.

0	unknown
1	fresh
2	slightly weathered
3	moderately weathered
4	highly weathered
5	very highly weathered
6	completely weathered
7	varied weathering

3.3.3 Thickness

This thickness entry is for specific regolith types. The thickness entry in section 3.2.4 refers to general regolith thickness in the landform unit as a whole.

0	unknown	4	> 5 m
1	< 0.5 m	5	> 15 m
2	< 2 m	6	> 50 m
3	> 2 m		

3.3.4 Regolith Profile

This is a descriptive field for recording the total known gross profile characteristics of the regolith, including any truncation or covering that may have occurred.

3.3.5 Regolith Distribution

This is a descriptive field for comments on the 3 dimensional landscape position of the regolith type. It can be used to describe any toposequence relationships observed in the regolith type.

3.3.6 Regolith Age

The age fields are completed if the regolith type has been dated or an age can be inferred, and if it does not belong to a stratigraphic unit. The age range can be entered from the lookup tables, or age details can be entered in the appropriate field.

3.3.7 Induration

In the case of indurated regolith, select an induration type from the following list. The rank should also be entered for each induration type.

IN00	indurated material
IB00	bauxitic induration
IC00	clay induration
IF00	ferruginous induration
IG00	gypseous induration
IH00	humic induration
IK00	calcareous induration
IS00	siliceous induration
DC00	completely cemented duricrust
DC10	alcrete (bauxite)
DC20	calcrete
DC40	ferricrete
DC41	massive ferricrete
DC42	nodular ferricrete
DC50	gypcrete
DC60	silcrete
DC61	silcrete sheet
DC62	silcrete pods
DM00	moderately cemented duricrust
DM20	calcareous, moderately cemented
DM40	ferruginous, moderately cemented
DM60	siliceous, moderately cemented
DP00	partially cemented duricrust
DP10	bauxitic hardpan
DP30	clay hardpan
DP40	ferruginous hardpan
DP60	siliceous hardpan
DP70	humic hardpan
NO00	nodules
NO10	bauxitic nodules
NO20	calcareous nodules
NO30	clay nodules
NO40	ferruginous nodules
NO60	siliceous nodules

3.4 Field Observations (Sites)

This screen is common to all Geoscience Australia National Geoscience Databases, and contains information about individual sites that are studied in detail (Figure 12). This group of database fields describes a field site and contains identifying information and location data. The Outcrops, Ozchem and Ozchron buttons lead to other Geoscience Australia databases.

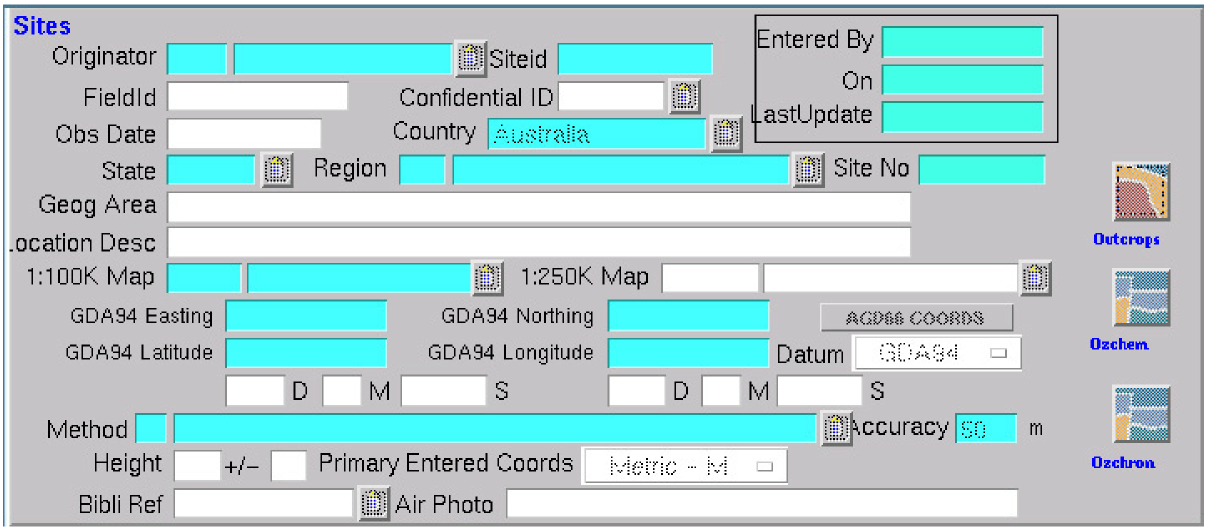


Figure 12. Sites data entry block.

3.4.1 Originator

This number is obtained from the table of originators, held in the Geoscience Australia corporate database. The Geoscience Australia database administrator must issue anyone who wishes to enter data into RTMAP with an originator number.

3.4.2 Site ID

Site ID is a compulsory field in RTMAP, and is a number that uniquely identifies each site. Use a code with a minimum of 10 digits, as follows: YYYYPPSSSS

Where YYYY is the 4 digits of the year in which the site was recorded in the field, PP is the project code (obtainable from CRC LEME or Geoscience Australia), and SSSS is the number you assign from the block of numbers allocated to you by your project leader.

3.4.3 Field ID

Field ID is an optional field for use during fieldwork.

3.4.4 Confidential ID

This field is a flag to indicate that the data is confidential to the originator and/or the project.

3.4.5 Date

This is the date of data collection in the field, and is in the form 00-MON-1999.

3.4.6 Country

Select the country from the lookup table. The default is Australia

3.4.7 State

Select the state from the lookup table (Section 3.2.1).

3.4.8 Geological Region

Select the geological region (Figure 13) from the lookup table.

2	Adelaide	30	Dundas	105	Northeast Tasmania
3	Albany	31	Eromanga	64	Officer
4	Amadeus	33	Eucla	65	Ord
6	Anakie	282	Fly-Highlands	66	Otway
5	Arafura	100	Fraser	67	Paterson
7	Arnhem	34	Galilee	68	Pedirka
8	Arrowie	35	Gascoyne	69	Perth
9	Arunta	36	Gawler	70	Pilbara
112	Ashburton	37	Georgetown	71	Pine Creek
10	Bancannia	38	Georgina	72	Polda
11	Bangemall	39	Gippsland	106	Proserpine
12	Birrindudu	40	Halls Creek	48	Quinkan
13	Bonaparte	41	Hamersley	73	Rocky Cape
14	Bowen	44	Kanmantoo	107	Savory
15	Bremer	46	Kimberley	75	South Nicholson
94	Bresnahan	101	King Island	78	St Vincent
16	Broken Hill	102	King Leopold	77	Stuart
95	Burke River	47	Lachlan	79	Styx
43	Cairns	49	Leeuwin	80	Surat
97	Caloola	50	Litchfield	81	Sydney
17	Canning	51	Maryborough	82	Sylvania
19	Carnarvon	103	Marymia	85	Tanami
20	Carpentaria Lowlands	52	McArthur	84	Tennant Creek
83	Central Tasmania	53	Money Shoal	108	Tibooburra
98	Charters Towers	54	Mount Isa	86	Torrens
21	Clarence-Moreton	55	Mount Painter	18	Torres Strait
99	Clarke River	56	Murphy	87	Tyennan
22	Coen	57	Murray	88	Victoria River
24	Daly River	58	Musgrave	96	Wilsons Promontory
25	Darling	59	Nabberu	109	Winnecke
26	Davenport	60	New England	90	Wiso
27	Denison	61	Ngalia	91	Wonominta
28	Drummond	104	Nongra	93	Yilgarn
29	Duaringa	62	Northampton	0	unknown

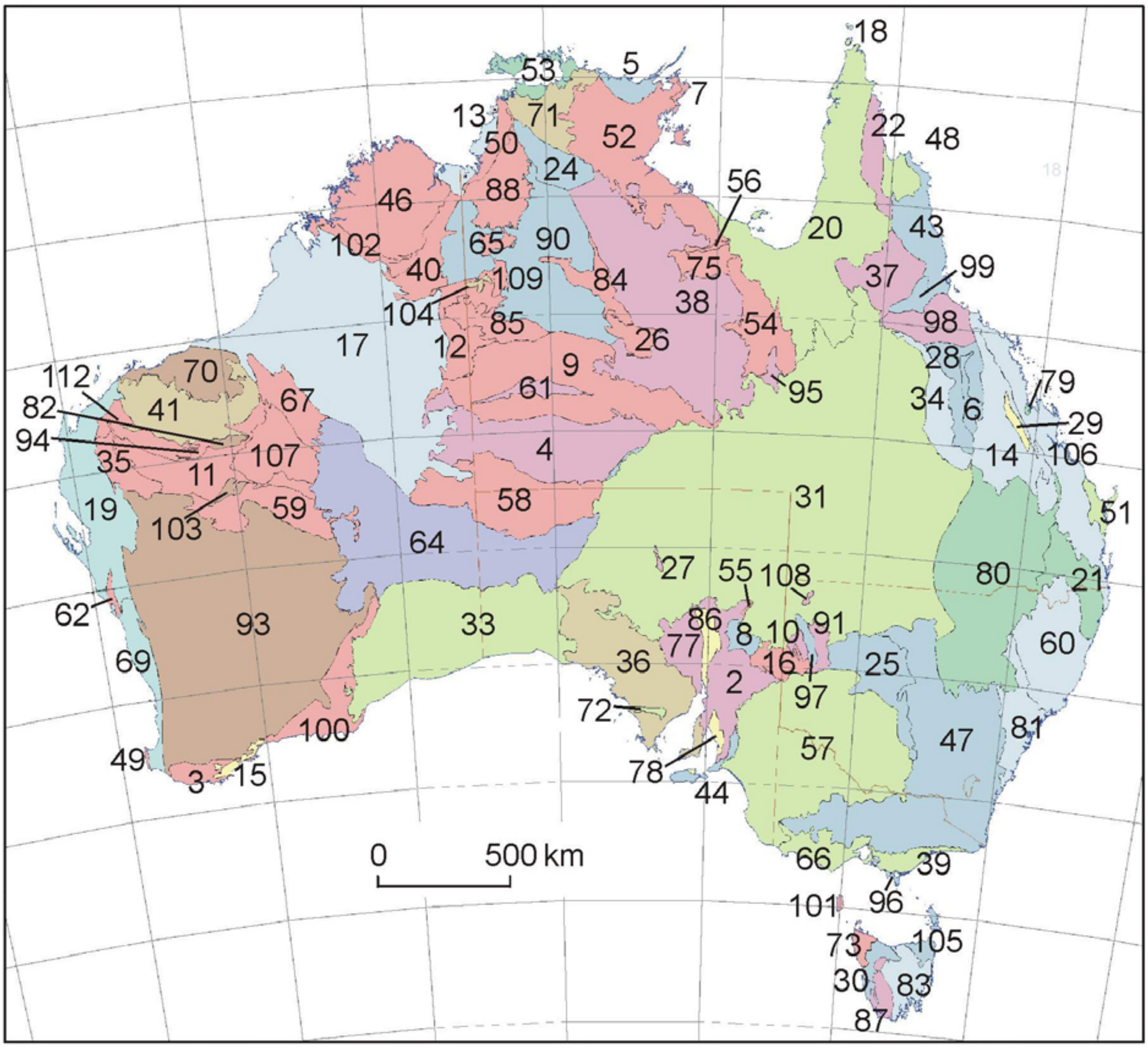


Figure 13. Geological regions.

3.4.9 Geographic area

This field is for the general geographic location of the site.

3.4.10 Location Description

This field is used for any details of the site location.

3.4.11 1:100K Map

Enter the 1:100,000 map number and name from the lookup table.

3.4.12 1:250k Map

Enter the 1:250,000 map number and name from the lookup table.

3.4.13 GDA94 Easting and Northing

These two fields are for AMG map coordinates. An internal check ensures that the coordinates fall in the named 1:100,000 map sheet.

3.4.14 Datum

The datum for Australian sites must be GDA94. AGD66 coordinates can be entered or viewed using the AGD66 to GDA94 conversion form, opened by pressing the AGD66 COORDS button.

3.4.15 Method and Accuracy

Enter the method and accuracy of site location from the lookup tables.

3.4.16 Height

Enter the elevation of the site, together with an error margin.

3.4.17 Bibliographic Reference

See section 3.1.11 (Figure 8 and Figure 9).

3.4.18 Air Photo

Enter information about the air photo on which the site occurs (Run and photo number, scale).

3.5 Field Observations (Rtsite)

These fields record site data that are entered into RTMAP. The entry block is shown in Figure 14.

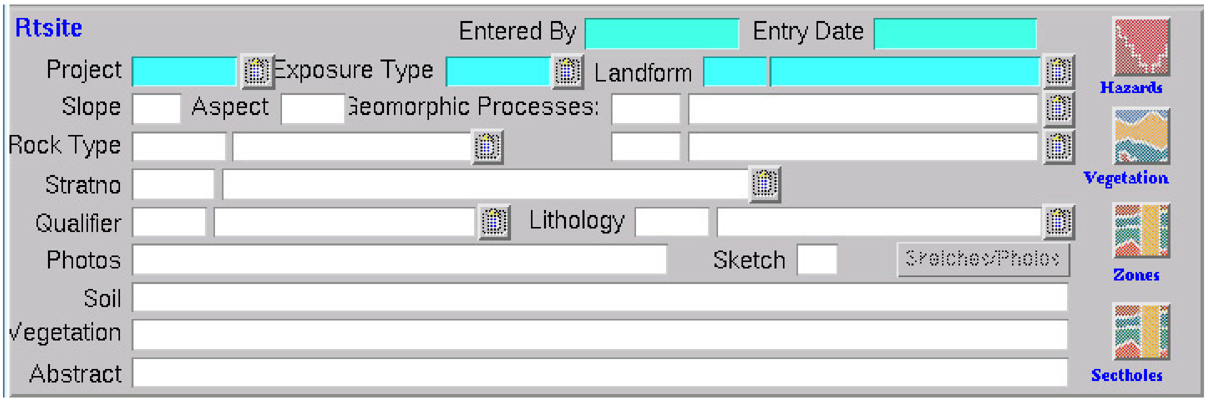


Figure 14. Rtsite data entry block.

3.5.1 Project

Choose the project from the lookup table.

3.5.2 Exposure type

The type of site is selected from the following list:

AUGER	Auger hole (soil/otherwise)	OUTCR	Outcrop
CANAL	Canal	PROSP	Prospect
CLIFF	Cliff	QUARR	Quarry
CORE	Core	RAILW	Railway
COST	Costean	ROAD	Road/highway cutting
CUTTI	Cuttings	RUBBL	Rubble
DAM	Dam	SOIL	Soil
FLOAT	Float	STREA	Stream (for creeks/rivers)
GRAVE	Gravel scrape	SURF	Surface
GULLY	Gully (for gullies/washouts)	TRENC	Trench
MINE	Mine	OTHR	Other

3.5.3 Landform

Enter a code for landform type from the landform table.

3.5.4 Slope and Aspect

These fields are for slope angle in degrees (0 - 90) and aspect in degrees (0 - 360).

3.5.5 Geomorphic Process

There is space for 2 codes for the geomorphic processes responsible for the formation of the site. The geomorphic process codes come from the geomorphic process lookup table (see section 3.2.10).

3.5.6 Bedrock type

Enter the code, from the rock type lookup table, for the bedrock type underlying the regolith at this site, if known.

1	unknown	12	metabasite
2	felsic intrusive	13	felsic gneiss
3	intermediate intrusive	14	metasediment
4	mafic intrusive	15	metasomatite
5	felsic extrusive	16	mineralisation
6	intermediate extrusive	17	regolith
7	mafic extrusive	19	vein
8	ultramafite	20	volcaniclastic
9	alkaline igneous	21	tectonite
10	clastic sediment	22	organic
11	chemical sediment		

3.5.7 Bedrock Stratigraphic Name

This is for the bedrock stratigraphic unit that underlies the regolith at this site, if known. Stratigraphic unit codes are from the STRAT lookup table.

3.5.8 Bedrock Qualifier

Enter the code, from the lithology qualifier lookup table (section 3.2.7.2), for the bedrock lithology underlying the regolith at this site, if known.

3.5.9 Bedrock Lithology

Enter the code, from the lithology lookup table (section 3.2.7.3), for the bedrock lithology underlying the regolith at this site, if known.

3.5.10 Sketches/Photos

Press the Sketches/Photos button, and enter details in the relevant fields (Figure 15).

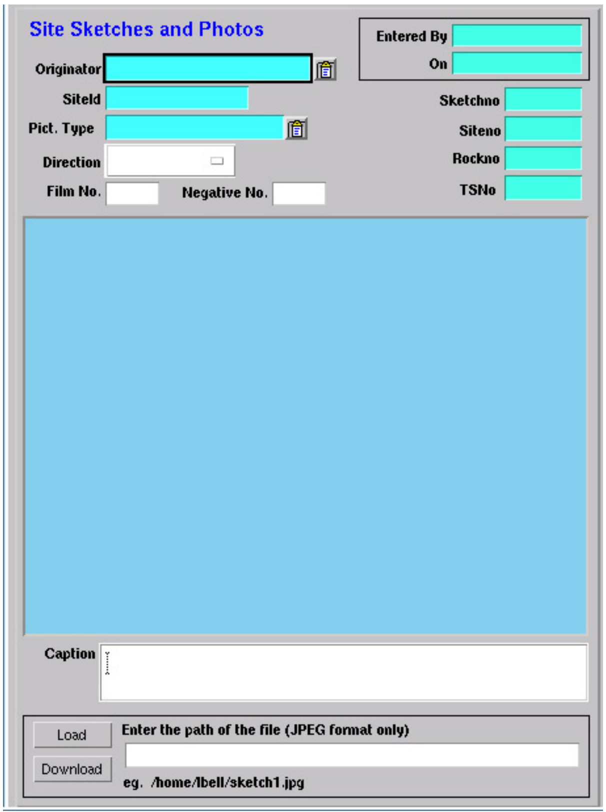


Figure 15. Site sketches and photos entry screen.

3.5.11 Sketch

Enter Y here if a sketch was made of this site during field data collection.

3.5.12 Soil

This field is for a description of the soil at the site.

3.5.13 Vegetation

This field can contain a description of the vegetation at the site. If more details are needed, use the Vegetation button.

3.5.14 Abstract

The abstract field is for a summary description of the site, including brief comments about the zones.

3.5.15 Hazard

This button opens a data entry block that is used for environmental hazards.

3.6 Field Observations (Zone Details)

The following fields contain information pertaining to a single zone within a field site. Usually there will be several zones at each field site. The entry screen is shown in Figure 16.

Figure 16. Zones entry screen.

3.6.1 Zone Number

The zone number is a 2-digit number in the format 01, 02, 03 etc., increasing with relative age. Usually this means increasing depth from surface, but it may mean elevation or other indicator of relative age. If the latter, a sketch should be provided in the notebook.

3.6.2 Obs. Thickness

This is a number field for the average thickness of the zone, in the format: 3 digits, decimal point, 2 digits, given in metres.

3.6.3 Depth to Lower Boundary

Enter the depth of the lower boundary of the zone in metres (2 decimals allowed).

3.6.4 Regolith Type

This field is for the regolith type, and comes from the regolith type lookup table (section 3.3.1).

3.6.5 Bedrock

Enter Y if there is bedrock immediately below this zone.

3.6.6 Degree of Weathering

Enter the degree of weathering from the lookup table (section 3.3.2.)

3.6.7 Zone description

An optional 240-character field for comments on the zone that cannot be placed elsewhere.

3.6.8 Other data

This field is for any other observations about the zone.

3.7 Field Observations (Zone Data)

The Zone data block in RTMAP allows a range of additional attributes to be recorded as needed. The attributes currently available in Geoscience Australa's database structure are listed in Table 3.2. Not all of them are directly relevant to the study of regolith.

Table 3.2. Data types available in the Geoscience Australa corporate database.

ALT	Alteration Style	PHO	Photodata
ALTI	Alteration Intensity	POR	Porosity
BED	Bedding Thickness	QZGS	Quartz grain size
BNDS	Lower boundary-shape	QZSP	Quartz grain sphericity
BNDT	Lower boundary-type	RAD	Gamma Ray Spectrometry (cps)
BST	Bedrock structures	RCC	Regolith clast composition
CFD	Coarse fragment orientation	REF	Reference
CM	Common mineral	REM	Remarks
COL	Colour	RSTR	Rock Strength
CON	Consistence	SEGA	Segregations-abundance
COP	Colour pattern	SEGC	Segregations-composition
FOS	Fossil	SEGS	Segregations-size
DRMA	Nature of drilled material	SEGT	Segregations-type
FAB	Fabric	SEQ	Sequence Types
GP	Geomorphic processes	SF	Sampled For
GS	Grain Size	SOM	Sedimentary Occurrence Mode
IN	Induration	SOR	Sorting
IOM	Igneous Occurrence Mode	SP	Sample Provenance
IS	Internal Stratification	SPH	Sphericity
ITX	Igneous Texture	SS	Sedimentary Structures
MAG	Magnetic. sus. (SI Units x 10-5)	SSTR	Soil strength
MAGS	Sample container size	ST	Sample type
MC	Munsell colour	STK	Stickiness

MET	Metamorphic Grade	STX	Sedimentary Texture
MI	Mineral	TEC	Tectonic Features
MOTA	Mottles-abundance	TH	Regolith thickness
MOTS	Mottles-size	VEIN	Vein, dyke or sill
MTX	Metamorphic Texture	WEA	Degree of Weathering
PH	PH level	WP	Weathering processes

Each attribute, or data type, has a number of sub types, which are listed below.

The sub type field is followed by a description field, which is an optional free text field of 64 characters for descriptor values (e.g. pH, or Magnetic susceptibility), or any additional information relating to the data type or sub type. Though this field is free text, values for instrument readings should be recorded as numbers only. This allows them to be easily retrieved for use in GIS. For example, values for magnetic susceptibility or gamma-ray counts should be entered without any units or comments. Additional comments relating to the readings, including units, should be recorded as a separate record using the remarks data type (REM).

Many definitions of data types and sub types are contained in the handbook by McDonald et al. (1990), and it is strongly recommended that users of RTMAP also obtain a copy of that handbook.

Rank is an optional single integer field for a number from 1 to 9. When a particular data type is used more than once, the corresponding sub types can be ranked in order of importance or dominance at the site. This is useful when interrogating the data with a GIS because it provides users with a method of identifying and displaying only the dominant sub type in a group of identical data types.

3.7.1 Age Determination

At present comments about zone age should be entered using the remarks data type (REM). However, the OZCHRON database will be expanded and linked to this table in the future.

3.7.2 Bedding Thickness

Data type		Sub type	
BED	Bedding Thickness	LA	laminated (<10 mm)
BED		VTN	very thin (10-30 mm)
BED		TN	thin (30-100 mm)
BED		ME	medium (100-300 mm)
BED		TK	thick (300-1000 mm)
BED		VTK	very thick (>1000 mm)

3.7.3 Internal Stratification

Data type		Sub type	
IS	Internal Stratification	CLA	corrugated lamination
		CLR	climbing ripples
IS		CMI	cryptomicrobial (algal laminae)
IS		CTS	contorted stratification
IS		CV	convolute
IS		HO	horizontal
IS		HPL	horizontal parallel laminae
IS		HX	hummocky cross bedding
IS		HXS	herringbone cross-stratification
IS		LAM	lamination (within a bed)
IS		LPX	low-angle planar cross bedding
IS		LTX	low-angle trough cross bedding
IS		MAS	massive
IS		OXB	overturned cross bedding
IS		PID	pillowed

IS		RG	reverse grading
IS		RXL	ripple cross laminae
IS		STRL	stromatolitic lamination
IS		WB	wavy bedding
IS		XB	cross-bedded

3.7.4 Sequence Types

Data type		Sub type	
SEQ	Sequence Types	CU	coarsening upward sequence
SEQ		FU	fining upward sequence
SEQ		TKU	thickening upward
SEQ		TNU	thinning upward

3.7.5 Sedimentary Occurrence Mode

Data type		Sub type	
SOM	Sedimentary Occurrence Mode	CLAS	clast
SOM		CMT	cement
SOM		CNC	concretion
SOM		MT	matrix
SOM		SDY	dyke

3.7.6 Sedimentary Structures

Data type		Sub type	
SS	Sedimentary Structures	ADR	adhesion ripples
SS		AMB	armoured mud balls
SS		ASYM	asymmetrical ripple mark
SS		BIO	bioturbated
SS		BP	ball-and-pillow
SS		BU	burrows
SS		BUB	bubble prints
SS		CC	current crescents
SS		CHB	churned bedding
SS		CIC	cone-in-cone
SS		CNC	concretions
SS		COP	coprolite
SS		CRY	crystal casts
SS		CSP	cusp structures
SS		DC	desiccation cracks
SS		DS	dish structure
SS		DWS	de-watering structures
SS		ES	erosive structures
SS		FGNS	faceted grains
SS		FLM	flame structures
SS		GEO	geopetal
SS		GSP	gas pits
SS		HMK	harrow marks
SS		ICL	intraclast (eg. mudflake)
SS		IM	imbricated
SS		INV	involution
SS		IR	interference ripples
SS		LC	load casts
SS		MC	mud cracks
SS		MSV	mud and sand volcanoes
SS		MT	matrix
SS		PTG	parting
SS		PM	percussion marks

SS		PN	pseudonodules
SS		POP	polished pebbles
SS		RHP	rain and hail prints
SS		RIP	ripple marks
SS		RS	reactivation surface
SS		SC	striated clasts
SS		SD	sandstone dykes
SS		SHC	shale clasts
SS		SHR	shrinkage cracks
SS		SLN	streaming lineation
SS		SMR	symmetrical ripple mark
SS		SLS	slump structures
SS		SSD	soft sediment deformation
SS		STY	stylolites
SS		SYN	synaeresis cracks
SS		TM	tool marks
SS		TO	toroids
SS		TR	trails
SS		VCLA	vertical clasts
SS		WBL	whirl-balls
SS		WM	wrinkle marks (runzelmarken)

3.7.7 Sedimentary Texture

Data type		Sub type	
STX	Sedimentary Texture	BX	breccia
STX		CEM	cemented
STX		GP	geopetal
STX		MCC	micritic
STX		ON	oncolitic
STX		OO	oolitic
STX		PE	peloidal

3.7.8 Bedrock structures

Within RTMAP, this data type is for bedrock structures which remain within the regolith, so will refer only to saprolite.

Data type		Sub type	
BST	Bedrock structures	BE	bedding
BST		CL	cleavage
BST		CO	corestones
BST		DY	dykes
BST		JT	joints
BST		VN	veins

3.7.9 Boundary

Two data types describe the lower boundary of each zone (see Chapter 4 for definitions).

Data type		Sub type	
BNDS	Lower boundary-shape	SM	smooth
BNDS		D	discontinuous
BNDS		I	irregular
BNDS		T	tongued
BNDS		W	wavy
BNDT	Lower boundary-type	SH	sharp
BNDT		A	abrupt

BNDT		C	clear
BNDT		D	diffuse
BNDT		G	gradual

3.7.10 Nature of drilled material

Data type		Sub type	
DRMA	Nature of drilled material	AGG	aggregate
DRMA		CHPS	chip strong
DRMA		CHPW	chip weak
DRMA		DISAGG	disaggregate

3.7.11 Regolith clast composition

This data type is for the composition of the > 2 mm fraction.

Data type		Sub type	
RCC	Regolith clast composition	AFG	alkali feldspar granite
RCC		AFS	alkali feldspar syenite
RCC		AGL	agglomerate
RCC		AGLT	argillite
RCC		AMP	amphibolite
RCC		ANS	anorthosite
RCC		ANT	andesite
RCC		APL	aplite
RCC		ARKS	arkose
RCC		ARNT	arenite
RCC		BIOC	biocarbonate
RCC		BLT	basalt
RCC		BSN	basanite
RCC		BTH	bomb, block tephra
RCC		BX	breccia
RCC		CBT	carbonatite
RCC		CHAR	charnockite
RCC		CHLK	chalk
RCC		CHRT	chert
RCC		CHT	chromitite
RCC		CLCR	calcrete
RCC		CLST	claystone
RCC		CNGL	conglomerate
RCC		DAC	dacite
RCC		DLST	dolostone
RCC		DLT	dolerite
RCC		DMCT	diamictite
RCC		DRT	diorite
RCC		DTMT	diatomite
RCC		DUN	dunite
RCC		EGL	eclogite
RCC		EVPT	evaporite
RCC		FGLT	fanglomerate
RCC		FLNT	flint
RCC		FRCT	ferricrete
RCC		GAB	gabbro
RCC		GBN	gabbronorite
RCC		GFL	granofels
RCC		GNS	gneiss
RCC		GNST	grainstone
RCC		GPST	grapestone
RCC		GRD	granodiorite
RCC		GRN	granulite

RCC	GRSN	greisen
RCC	GRT	granite
RCC	GRU	grus
RCC	GSN	gossan
RCC	GST	greenstone
RCC	GYWK	greywacke
RCC	HBT	hornblendite
RCC	HDG	hornblende gabbro
RCC	HFL	hornfels
RCC	HZB	harzburgite
RCC	IGM	ignimbrite
RCC	IRFM	iron formation
RCC	IRST	ironstone
RCC	KBL	kimberlite
RCC	KTT	komatiite
RCC	LHZ	lherzolite
RCC	LMST	limestone
RCC	LPR	lamproite
RCC	LPY	lamprophyre
RCC	LTT	latite
RCC	MARL	marl
RCC	MBL	marble
RCC	MDST	mudstone
RCC	MIG	migmatite
RCC	MTS	metasomatite
RCC	MYL	mylonite
RCC	MZB	monzogabbro
RCC	MZD	monzodiorite
RCC	MZG	monzogranite
RCC	MZT	monzonite
RCC	NRT	norite
RCC	OBS	obsidian
RCC	OFS	opx alkali feldspar syenite
RCC	OHT	olivine hornblendite
RCC	OPHL	ophiolite
RCC	OST	opx syenite
RCC	PCLN	porcellanite
RCC	PEG	pegmatite
RCC	PELT	pelite
RCC	PER	peridotite
RCC	PHD	plagioclase-bearing hornblendite
RCC	PHP	pyroxene hornblende peridotite
RCC	PHSP	phosphorite
RCC	PHT	pyroxene hornblendite
RCC	PHY	porphyry
RCC	PHYL	phyllite
RCC	PKR	peralkaline rhyolite
RCC	PPD	pyroxene peridotite
RCC	PRX	pyroxenite
RCC	PSMT	psammite
RCC	QAS	quartz alkali feldspar syenite
RCC	QGB	quartz gabbro
RCC	QTE	quartzolite
RCC	QTY	quartz trachyte
RCC	QTZ	quartz
RCC	QZA	quartz anorthosite
RCC	QZD	quartz diorite
RCC	QZG	quartz-rich granitoid
RCC	QZL	quartz latite
RCC	QZM	quartz monzonite
RCC	QZS	quartz syenite
RCC	QZT	quartzite
RCC	RHD	rhyodacite

RCC		RHY	rhyolite
RCC		SCHT	schist
RCC		SDST	sandstone
RCC		SHLE	shale
RCC		SHT	shoshonite
RCC		SKN	skarn
RCC		SLA	slate
RCC		SLST	siltstone
RCC		SPGT	sparagmite
RCC		SPIL	spilite
RCC		SRLT	saprolite
RCC		SRP	serpentinite
RCC		SYN	syenite
RCC		TBDT	turbidite
RCC		TFT	tuffite
RCC		TLLD	tilloid
RCC		TLLT	tillite
RCC		TNL	tonalite
RCC		TRC	trachyte
RCC		TRVN	travertine
RCC		TUF	tuff
RCC		TYA	trachyandesite
RCC		TYB	trachybasalt
RCC		TYD	trachydacite
RCC		WHL	wehrlite

3.7.12 Coarse fragment orientation

Data type		Sub type	
CFD	Coarse fragment orientation	U	undisturbed
CFD		D	dispersed randomly
CFD		R	reoriented
CFD		S	stratified (e.g. stone lines)

3.7.13 Colour

These data types can be used for descriptions of colour, colour changes or combinations The use of MC (Munsell colour) is preferred if meaningful comparisons are to be made.

Data type		Sub type	
COL	Colour	BK	black
COL		BL	blue
COL		BR	brown
COL		BU	buff
COL		CH	chocolate
COL		CR	cream
COL		FA	fawn
COL		GR	green
COL		GY	grey
COL		IR	iridescent
COL		KH	khaki
COL		MA	maroon
COL		OL	olive
COL		OR	orange
COL		PI	pink
COL		PU	purple
COL		RE	red
COL		VC	varicoloured
COL		VI	violet

COL		WH	white
COL		YE	yellow
COP	Colour pattern	MO	mottled
MC	Munsell colour	Enter code from Munsell colour book	

3.7.14 Consistence

Consistence refers to the strength of cohesion and adhesion in soil and regolith materials. Strength will vary according to water status. Strength is the resistance to breaking or deformation. Stickiness is a characteristic determined on wet material. McDonald and Isbell (1990) discuss these properties further, and provide definitions and means of determination.

Data type		Sub type	
SSTR	Soil Strength	S0	loose
SSTR		S1	very weak (<25 kPa)
SSTR		S2	weak (25-50 kPa)
SSTR		S3	firm (50-100 kPa)
SSTR		S4	very firm (100-200 kPa)
SSTR		S5	strong (200-400 kPa)
SSTR		S6	very strong (>400 kPa)
STK	Stickiness	NS	non-sticky
STK		SS	slightly sticky
STK		MS	moderately sticky
STK		VS	very sticky

3.7.15 Porosity

Data type		Sub type	
POR	Porosity	0	non porous, dense
POR		1	Slightly porous
POR		2	Porous

3.7.16 Rock Strength

Data type		Sub type	
RSTR	Rock Strength	R1	very low rock strength (1.5-3 Mpa)
RSTR		R2	low rock strength (3-10 Mpa)
RSTR		R3	medium rock strength (10-25 Mpa)
RSTR		R4	high rock strength (25-80 Mpa)
RSTR		R5	very high rock strength (>800 Mpa)

3.7.17 Fabric

In pedology fabric describes the appearance of the soil material (McDonald and Isbell 1990), and the term can be extended to regolith materials. Differences in fabric are associated with the presence or absence of aggregations, and the presence, size and arrangement of voids in the regolith mass. More sub types will be added to this data type.

Data type		Sub type	
FAB	Fabric	RP	relict primary

3.7.18 Fossil

Data type		Sub type	
FOS	Fossil	FOSI	fossil invertebrates
FOS		FOSP	fossil plants
FOS		FOST	trace fossils
FOS		FOSV	fossil vertebrates
FOS		STRO	stromatolite

3.7.19 Geomorphic Processes

This data type is used for geomorphic processes responsible for the formation of the zone. The sub types are from the geomorphic processes lookup table (section 3.2.10).

Data type		Sub type	
GP	Geomorphic processes	BI00	biological agents; coral
GP		DI00	diastrophism; earth movements
GP		GR00	gravity
GP		GR01	vertical collapse
GP		GR02	particle fall
GP		GR03	creep
GP		GR04	landslide
GP		GR05	mudflow
GP		HU00	human agents
GP		IC00	ice
GP		IC01	frost
GP		IC02	glacial erosion
GP		IC03	glacial deposition
GP		MT00	impact by meteors
GP		VO00	volcanism
GP		VO01	lava flow
GP		VO02	ash flow
GP		VO03	ash fall
GP		WI00	wind
GP		WI01	wind erosion (deflation)
GP		WI02	sand deposition (wind)
GP		WI03	dust deposition (wind)
GP		WT00	water
GP		WT01	channelled stream flow
GP		WT02	over-bank stream flow
GP		WT03	sheet flow, sheet or surface wash
GP		WT04	waves
GP		WT05	tides
GP		WT06	detrital deposition still water
GP		WT07	rilling/gullying
GP		WT08	subsurface solution/piping

3.7.20 Grain size

Enter the size of particles in the zone, from the following list. This list is derived from several sources. Choose the size ranges best suited to the materials in the zone.

Data type		Sub type	
GS	Grain Size	MUD	clay (<0.002 mm)
GS		SLT	silt (0.002-0.062 mm)
GS		SA	sand (0.062-2 mm)
GS		VFS	very fine sand (0.062-0.125 mm)
GS		FS	fine sand (0.125-0.5 mm)

GS	MS	medium sand (0.25-0.5 mm)
GS	CS	coarse sand (0.5-1 mm)
GS	VCS	very coarse sand (1-2 mm)
GS	GV	gravel (2-60 mm)
GS	FG	fine gravel (2-6 mm)
GS	MG	medium gravel (6-20 mm)
GS	CG	coarse gravel (20-60 mm)
GS	CB	cobble (64-256 mm)
GS	ST	stone (256-600 mm)
GS	BO	boulder (>256 mm)
GS	LPL	lapilli (4-64 mm)
GS	BM	bomb (>64 mm)
GS	GL	granule (2-4 mm)
GS	PB	pebble (4-64 mm)
GS	F	fine (<1 mm)
GS	M	medium (1-5 mm)
GS	C	coarse (>5 mm)
GS	MX	microcrystalline
GS	PEG	pegmatitic
GS	VC	very coarse
GS	VF	very fine
GS	CLAY	clay (<0.002 mm)
GS	CSLT	coarse silt (0.031-0.0625 mm)
GS	FSLT	fine silt (0.0078-0.0156 mm)
GS	MSLT	medium silt (0.0156-0.031 mm)
GS	RMUD	clay/silt (<0.0625 mm)
GS	VFSLT	very fine silt (0.0039-0.0078 mm)

3.7.21 Quartz grains

Quartz clasts have been separated out because of their importance in sedimentary regolith materials. There are two data types, quartz grain size and quartz sphericity.

Data type		Sub type	
QZGS	Quartz Grain Size	BO	boulder (>256 mm)
QZGS		CB	cobble (64-256 mm)
QZGS		CLAY	clay (<0.002 mm)
QZGS		CSA	coarse sand (0.5-1 mm)
QZGS		CSLT	coarse silt (0.031-0.0625 mm)
QZGS		FSA	fine sand (0.125-0.25 mm)
QZGS		FSLT	fine silt (0.0078-0.0156 mm)
QZGS		GL	granule (2-4 mm)
QZGS		GV	gravel (>2 mm)
QZGS		MSA	medium sand (0.25-0.5 mm)
QZGS		MSLT	medium silt (0.0156-0.031 mm)
QZGS		PB	pebble (4-64 mm)
QZGS		RMUD	clay/silt (<0.0625 mm)
QZGS		SA	sand (0.0625-2 mm)
QZGS		SLT	silt (0.002-0.0625 mm)
QZGS		VCS	very coarse sand (1-2 mm)
QZGS		VFSA	very fine sand (0.0625-0.125 mm)
QZGS		VFSLT	very fine silt (0.0039-0.0078 mm)
QZSP	Quartz Sphericity	ANG	angular
QZSP		RO	rounded
QZSP		SANG	sub-angular
QZSP		SRO	sub-rounded
QZSP		VANG	very angular
QZSP		WRO	well-rounded

3.7.22 Induration

This datatype covers the degree and type of induration.

Data type		Sub type	
IN	Induration	IN00	indurated material
IN		DC00	completely cemented duricrust
IN		DC10	alcrete (bauxite)
IN		DC20	calcrete
IN		DC40	ferricrete
IN		DC41	massive ferricrete
IN		DC42	nodular ferricrete
IN		DC50	gypcrete
IN		DC60	silcrete
IN		DC61	silcrete sheet
IN		DC62	silcrete pods
IN		DM00	moderately cemented duricrust
IN		DM20	calcareous, moderately cemented
IN		DM40	ferruginous, moderately cemented
IN		DM60	siliceous, moderately cemented
IN		DP00	partially cemented duricrust
IN		DP10	bauxitic, partially cemented
IN		DP30	clay hardpan
IN		DP40	ferruginous hardpan
IN		DP60	siliceous hardpan
IN		DP70	humic hardpan
IN		DU00	duricrust
IN		IB00	bauxitic induration
IN		IC00	clay induration
IN		IF00	ferruginous induration
IN		IG00	gypseous induration
IN		IH00	humic induration
IN		IK00	calcareous induration
IN		IS00	siliceous induration
IN		NO00	nodules
IN		NO10	bauxitic nodules
IN		NO20	calcareous nodules
IN		NO30	clay nodules
IN		NO40	ferruginous nodules
IN		NO60	siliceous nodules

3.7.23 Mottling

These data types are used for comments about the size and abundance of any mottling present. Contrast with surrounding material, and strength or induration, are currently dealt with in the remarks data type (REM).

Data type		Sub type	
MOTA	Mottles-abundance	0	no mottles
MOTA		1	very few (< 2%)
MOTA		2	few (2 - 10%)
MOTA		3	common (10 -20%)
MOTA		4	many (20 -50%)
MOTS	Mottles-size	FIN	fine (< 5 mm)
MOTS		MED	medium (5 – 15 mm)
MOTS		CSE	coarse (15 – 30 mm)
MOTS		VCS	very coarse (30 – 100 mm)
MOTS		MEG	megamottles (> 100 mm)

3.7.24 Nodules

Comments about any nodules present, including size, abundance, contrast with surrounding material, and strength or induration, are currently dealt with in the remarks data type (REM). The data type Segregations can also be used for nodules (see 3.7.26).

3.7.25 Matrix

Comments on, and a description of the matrix of the zone, are currently dealt with in the remarks data type (REM).

3.7.26 Common minerals

This is for common minerals that can be identified in the zone. The minerals data type (MI) contains a comprehensive list of minerals.

Data type		Sub type	
CM	Common minerals	AB	albite
CM		ACT	actinolite
CM		ADS	andesine
CM		ALM	almandine
CM		ALN	allanite
CM		ALSI	aluminosilicate (unspecified)
CM		AMPH	amphibole
CM		AN	anorthite
CM		AND	andalusite
CM		ANL	analcime
CM		ANR	anorthoclase
CM		AP	apatite
CM		APY	arsenopyrite
CM		ASOX	oxidised arsenopyrite
CM		ATH	anthophyllite
CM		AUG	augite
CM		AZ	azurite
CM		BN	bornite
CM		BRL	beryl
CM		BRT	barite
CM		BT	biotite
CM		BTW	bytownite
CM		CAL	calcite
CM		CAMP	clino-amphibole
CM		CARB	carbonate
CM		CC	chalcocite
CM		CCP	chalcopyrite
CM		CHR	chromite
CM		CIN	cinnabar
CM		CL	chlorite
CM		CLAY	clay mineral
CM		CLD	chloritoid
CM		COR	corundum
CM		CPX	clinopyroxene
CM		CRD	cordierite
CM		CRS	cristobalite
CM		CST	cassiterite
CM		CUM	cummingtonite
CM		CUOX	oxidised copper minerals
CM		CUP	cuprite
CM		CV	covellite
CM		CZO	clinozoisite
CM		DI	diopside

CM	DMD	diamond
CM	DOL	dolomite
CM	EN	enstatite
CM	EP	epidote
CM	FELD	feldspar
CM	FL	fluorite
CM	FSPD	feldspathoid
CM	FY	fayalite
CM	GLN	glaucophane
CM	GLT	glauconite
CM	GN	galena
CM	GNT	garnet
CM	GP	gypsum
CM	GR	graphite
CM	GRS	grossular
CM	GT	goethite
CM	HBL	hornblende
CM	HEM	hematite
CM	HL	halite
CM	ILL	illite
CM	ILM	ilmenite
CM	JD	jadeite
CM	KFS	K-feldspar
CM	KLN	kaolinite
CM	KY	kyanite
CM	LAB	labradorite
CM	LCT	leucite
CM	LMT	laumontite
CM	LWS	lawsonite
CM	MAL	malachite
CM	MC	microcline
CM	MCS	marcasite
CM	MGS	magnesite
CM	MGT	magnetite
CM	MICA	mica
CM	MNT	montmorillonite
CM	MNZ	monazite
CM	MOL	molybdenite
CM	MS	muscovite
CM	NE	nepheline
CM	OAMP	orthoamphibole
CM	OGC	oligoclase
CM	OL	olivine
CM	OPL	opal
CM	OPQ	opaque mineral
CM	OPX	orthopyroxene
CM	OR	orthoclase
CM	PBOX	oxidised lead minerals
CM	PGT	pigeonite
CM	PHL	phlogopite
CM	PHOS	phosphate
CM	PL	plagioclase
CM	PMP	pumpellyite
CM	PO	pyrrhotite
CM	PRH	prehnite
CM	PRL	pyrophyllite
CM	PRP	pyrope
CM	PY	pyrite
CM	PYOX	oxidised pyrite
CM	PYRX	pyroxene
CM	QZ	quartz
CM	RDN	rhodonite
CM	RT	rutile

CM		SANI	sanidine
CM		SCH	scheelite
CM		SCP	scapolite
CM		SD	siderite
CM		SERI	sericite
CM		SERP	serpentine
CM		SIL	sillimanite
CM		SP	sphalerite
CM		SPL	spinel
CM		SPS	spessartine
CM		SRL	schorl
CM		ST	staurolite
CM		STB	stibnite
CM		STP	stilpnomelane
CM		SULP	sulphide
CM		TLC	talc
CM		TOUR	tourmaline
CM		TOZ	topaz
CM		TR	tremolite
CM		TRD	tridymite
CM		TTN	titanite
CM		U	uranium
CM		UROX	uranium oxide mineral
CM		USP	ulvospinel
CM		VES	vesuvianite
CM		VRM	vermiculite
CM		ZEOL	zeolite
CM		ZNOX	oxidised zinc minerals
CM		ZRN	zircon

3.7.27 Segregations

These data types are for the abundance, composition, size and type of segregations in the zone.

Data type		Sub type	
SEGA	Segregations-abundance	0	no segregations
SEGA		1	very few (< 2%)
SEGA		2	few (2 - 10%)
SEGA		3	common (10 - 20%)
SEGA		4	many (20 - 50%)
SEGA		5	very many (> 50%)
SEGC	Segregations-composition	U	unidentified
SEGC		A	aluminous
SEGC		E	earthy
SEGC		F	ferruginous
SEGC		H	organic
SEGC		K	calcareous
SEGC		L	argillaceous
SEGC		M	manganiferous
SEGC		O	other
SEGC		Y	gypseous
SEGC		Z	saline
SEGS	Segregations-size	FIN	fine (< 2 mm)
SEGS		MED	medium (2 – 6 mm)
SEGS		CSE	coarse (6 – 20 mm)
SEGS		VCS	very coarse (20 – 60 mm)
SEGS		ECS	extremely coarse (> 60 mm)
SEGT	Segregations-type	C	concretions

SEGT		F	fragments
SEGT		N	nodules
SEGT		P	pisoliths
SEGT		T	tubules

3.7.28 Similar Strata

The REM data type can be used to make a note of zones at other sites that have similar characteristics. Both Site ID and Zone Number for the other sites must be entered. This field can also be used for informal identifying names that might be applied to the zone.

3.7.29 Sorting

This data type describes the particle sorting:

Data type		Sub type	
SOR	Sorting	W	well sorted
SOR		MSO	moderately sorted
SOR		P	poorly sorted
SOR		VP	very poorly sorted
SOR		UNS	unsorted

3.7.30 Sphericity

Data type		Sub type	
SPH	Sphericity	ANG	angular
SPH		RO	rounded
SPH		SAN	sub-angular
SPH		VA	very angular
SPH		WR	well-rounded

3.7.31 Veins

This field is for comments about any veins present.

Data type		Sub type	
VEIN	Vein	QZ	quartz
VEIN		APL	aplite
VEIN		CARB	carbonate
VEIN		DAC	dacite
VEIN		DLT	dolerite
VEIN		GRD	granodiorite
VEIN		GRSN	greisen
VEIN		GRT	granite
VEIN		LPY	lamprophyre
VEIN		PEG	pegmatite
VEIN		PHY	porphyry
VEIN		QMG	multi-generation quartz veins

3.7.32 Weathering Degree

This is for the degree of weathering:

Data type		Sub type	
WEA	Weathering degree	0	unknown
WEA		1	fresh
WEA		2	slightly weathered

WEA		3	moderately weathered
WEA		4	highly weathered
WEA		5	very highly weathered
WEA		6	completely weathered
WEA		7	varied weathering

3.7.33 Weathering Processes

This data type is used for weathering processes responsible for the formation of the zone.

Data type		Sub type	
WP	Weathering processes	PH00	physical weathering
WP		BI00	biotic weathering
WP		CH00	chemical weathering
WP		CH01	solution
WP		CH02	oxidation and reduction
WP		CH03	carbonation
WP		CH04	hydration
WP		CH05	chelation
WP		CH06	hydrolysis
WP		CH07	ferrolysis
WP		CH08	precipitation/evaporation
WP		HA00	hydrothermal alteration
WP		IN00	induration
WP		IN01	bauxitic induration
WP		IN02	calcareous induration
WP		IN03	clay induration
WP		IN04	ferruginous induration
WP		IN05	gypsiferous induration
WP		IN06	siliceous induration
WP		PH01	abrasion
WP		PH02	frost weathering
WP		PH03	induced fracture
WP		PH04	insolation weathering
WP		PH05	moisture swelling
WP		PH06	sheeting
WP		PH07	salt weathering
WP		PH08	volume increase
WP		PH09	wetting and drying
WP		WE00	weathering

3.7.34 Weathering Structures

The REM data type can be used for any comments about weathering characteristics of the zone.

3.7.35 Magnetic Susceptibility

Data type		Sub type	
MAG	Mag. sus. (SI Units x 10^{-5})	MAX	maximum
MAG		MN	mean
MAG		MIN	minimum

Because magnetic susceptibility measured in the laboratory varies with the container size, there is an additional data type, sample container size.

Data type		Sub type	
MAGS	sample container size	PETRIE1	petrie dish (85x10 mm)
MAGS		PETRIE1	petrie dish (52x10 mm)

MAGS	TRAY1	tray 5 compartments (190x35x10 mm)
MAGS	TRAY2	tray 5 compartments (190x35x20 mm)
MAGS	TRAY3	tray 20 compartments (24x48x28 mm)

3.7.36 Gamma Ray Spectrometry

Readings for K, Th, U and total count should be entered separately, and the values placed in the description field, as numbers only without any units or comments. Additional comments relating to the readings should be recorded as a separate record using the remarks data type (REM).

Data type		Sub type	
RAD	Gamma Ray Spectrometry (cps)	K	potassium
RAD		TH	thorium
RAD		U	uranium
RAD		TC	total count

3.7.37 PH

Enter the general pH level

Data type		Sub type	
PH	pH level	ACID	acidic (0-6.9)
PH		BASIC	basic (8-14)
PH		NEUT	neutral (7-7.9)

3.7.38 Photo data

Enter data on photographs taken at the site.

Data type		Sub type	
PHO	Photodata	BW	black and white
PHO		CP	colour print
PHO		S	slide
PHO		D	digital

3.7.39 Remarks

The REM data type can be used for any free-text additional comments about the zone. The sub data type is GE.

3.7.40 Samples

The following 3 data types may be entered in the Zones Data block.

Data type		Sub type	
SF	Sampled For	UNK	unknown
SF		GC	geochronology
SF		HS	hand specimen
SF		MIPA	micropaleontology
SF		MAPA	macropaleontology
SF		PI	PIMA
SF		SO	soil chemistry
SF		SS	stream sediment chemistry
SF		TS	thin section
SF		XRD	X-Ray Diffraction

SP	Sample Provenance	UNK	unknown
SP		ADTS	aeolian detritus
SP		COLV	colluvium
SP		DSPB	displaced block (near situ)
SP		GLE	glacial erratic
SP		RB	alluvial detritus
SP		VD	volcanic ejectamenta
ST	Sample type	OC	outcrop sample
ST		AUG	auger
ST		CORE	core sample
ST		CUTT	cuttings sample
ST		FLT	float sample
ST		PERC	open hole percussion
ST		RAB	rotary airblast
ST		REVC	reverse circulation percussion
ST		SIDE	sidewall sample
ST		SOIL	soil

The following fields in the Samples block also relate to samples taken in the field:

Site ID is the site identifier, and is carried over from the zone description. *Zone Number* is also carried over.

Sample Number is a code that uses the site number plus an optional extra 2 characters:

YYYYPPSSSS + aa or nn or an

Where site number is as before,

aa = maximum two letter code where you have more than one sample at the same site.

nn = maximum of 99 number codes for multiple samples.

an = maximum number letter code for multiple samples.

Sample Description contains any comments or description of the sample. Field sample identification can also be entered here.

4. ATTRIBUTE DEFINITIONS

In this chapter we have followed standard definitions where possible, especially those in McDonald et al. (1990). Where appropriate, sources have been given. In doing this, we point out that this handbook is not a textbook. We assume that users are either familiar with most of the terms we use here, or that they have access to appropriate textbooks. We also refer readers to the CRC LEME *Glossary of Regolith Terms* (Eggleton 2001).

Attribute definitions are presented in the same order that they appear on the entry screens in RTMAP. However, unlike Chapter 3, not all attributes are considered here. We consider only those that we feel need definitions as we use them in RTMAP.

4.1 Soils Definitions

In RTMAP, soil refers to the organically affected upper part of the regolith. Soils are formed by interactions between the mineral material of the regolith and organic matter derived largely from vegetation growing in the regolith. Here we refer to 3 classifications that are used in Australia.

4.1.1 Principal Profile Form

The principal profile form comes from Northcote (1979). The simple definitions given here will allow people without any knowledge of soil science to place soils in one of the groups listed in the soils table. The definitions are taken largely from Northcote (1979), and readers should refer to that publication for more details. Northcote's classification refers to the arrangement of horizons in the soil.

O Organic

Organic soils are dominated by plant remains in at least the top 30 cm, and they can be much deeper. Any soil containing more than 30% organic matter may be considered to be organic.

Uc Uniform, coarse textured

Uniform soils are dominated by mineral material, and have small, if any, differences in grain size (texture) throughout the profile. The range of texture falls within the span of one texture group (see texture classes in Northcote, 1979). Uc soils have textures in the sand and sandy loam or coarser classes.

Um Uniform, medium textured

Uniform soils with textures in the loams and clay loams classes.

Uf Uniform, fine textured, not cracking

Uniform soils with textures in the clay classes, and seasonal cracking of the soil material does not occur.

Ug Uniform, fine textured, cracking

Uniform soils with textures in the clay classes, and the soil material is characterised by seasonal cracking.

Gc Gradational, calcareous throughout

Gradational soils are dominated by the mineral fraction and show increasingly finer (more clayey) texture grades on passing to greater depths. The changes in texture are gradual, and over the whole profile span more than one texture group. Gc soils are calcareous throughout.

Gn Gradational, not calcareous throughout

Gn soils are gradational, but are not calcareous throughout. However, calcium carbonate may be present in the lower parts of the soil, either as nodules or dispersed through the soil material.

Dr Duplex, red clay B horizons

Duplex soils are dominated by the mineral fraction and have a texture contrast of more than 1.5 texture groups between the A (surface) and B (subsurface) horizons. Further, the boundary between the two horizons is less than 10 cm thick. Dr soils have red B horizons, which in the Munsell Notation means a hue as red, or redder than, 5YR.

Db Duplex, brown clay B horizons

Db soils are duplex, with brown B horizons, which in the Munsell Notation means a hue yellower than 5YR.

Dy Duplex, yellow-grey clay B horizons

Dy soils are duplex, with yellow-grey B horizons.

Dd Duplex, dark clay B horizons

Dd soils are duplex, with dark B horizons, which in the Munsell Notation means a value/chroma less than 3/2 or 2/2.

Dg Duplex, gley clay B horizons

Dg soils are duplex, with gley B horizons, which in the Munsell Notation means any value on the Munsell `gley' chart.

4.1.2 Great Soil Group

Stace et al. (1968) provide a description and classification of Australian soils into great soil groups. The great soil groups are based on both soil morphology and soil genesis. Interested readers are referred to that publication. The following are the great soil groups. Codes are taken from Isbell and McDonald (1990).

SK	Solonchak	SS	Siliceous sand
A	Alluvial soil	ES	Earthy sand
L	Lithosol	GBK	Grey brown calcareous soil
KS	Calcareous sand	RK	Red calcareous soil
DL	Desert loam	GE	Grey earth
RBH	Red and brown hardpan soil	YE	Yellow earth
GC	Grey clay	TR	Terra rossa soil
BC	Brown clay	E	Euchrozem
RC	Red clay	X	Xanthozem
BE	Black earth	K	Krasnozem
R	Rendzina	GBP	Grey brown podzolic soil
CM	Chernozem	RP	Red podzolic soil
PS	Prairie soil	YP	Yellow podzolic soil
W	Wiesenboden	BP	Brown podzolic soil
SZ	Solonetz	LP	Lateritic podzolic soil
SDS	Solodized solonetz	GP	Gleyed podzolic soil
SC	Solodic soil	P	Podzol
SH	Soloth	HP	Humus podzol
SB	Solonized brown soil	PP	Peaty podzol
RBE	Red brown earth	AH	Alpine humus soil
NKB	Non calcic brown soil	HG	Humic gley
C	Chocolate soil	NP	Neutral peat

BRE	Brown earth	ALP	Alkaline peat
KRE	Calcareous red earth	ACP	Acid peat
RE	Red earth	NSG	No suitable group

4.1.3 New Australian Classification

Isbell (1996) has published a new scheme for the classification of Australian soils, based on morphological, chemical and physical properties. The following classes are used:

AN	Anthroposols	KU	Kurosols
CA	Calcarosols	OR	Organosols
CH	Chromosols	PO	Podosols
DE	Dermosols	RU	Rudosols
FE	Ferrosols	SO	Sodosols
HY	Hydrosols	TE	Tenosols
KA	Kandosols	VE	Vertosols

4.2 Landform Definitions

Landforms are an expression of the evolution of the landscape in which they occur. They are a culmination of processes, both past and present, acting on that landscape. Landforms are also highly visible in the landscape, and can be recognised from topographic maps and from various kinds of imagery, both airborne and spaceborne.

The landform units listed here are equivalent to the landform patterns of Speight (1990). According to Speight landform patterns are areas more than 600 m across, and are made up of landform elements. In RTMAP we use the concept of landform units and landform elements in much the same way. At a scale of 1:250 000 we are mapping landform units, and the landform elements are too small to map. However, some landform elements are listed here, and more will be added, as our mapping includes more detail of smaller areas.

The listing is grouped together into related landform types under general headings, to give a hierarchical classification (see Chapter 3). Speight (1990) defines most of the landform units listed in this table. Other definitions, and more details, can be found in Fairbridge (1968) and Eggleton (2001).

4.2.1 Landform Units

AL00 Alluvial Landforms

A complex landform pattern on valley floors with active, inactive or relict erosion and aggradation by channelled and over-bank stream flow.

AL10 Alluvial plain

A level, or gently sloping, or slightly undulating land surface produced by extensive deposition of alluvium, generally adjacent to a river that periodically overflows its banks; it may be situated on a flood plain, a delta, or an alluvial fan.

AL11 Flood plain

Alluvial plain characterised by frequently active aggradation by over-bank stream flow (i.e. by flooding more often than every 50 years) and erosion by channelled stream flow.

AL12 Anastomotic plain

Flood plain on which the stream channels join and divide, as do the veins on a leaf. Flood plain with slowly migrating, deep alluvial channels, usually moderately spaced, forming a divergent to unidirectional integrated reticulated network. There is frequently active aggradation by over-bank and channelled stream flow.

AL13 Bar plain

Flood plain having sub-parallel stream channels which both aggrade and erode so as to develop a generally corrugated surface with numerous bars. Flood plain with numerous rapidly migrating shallow alluvial channels forming a unidirectional integrated reticulated network. There is frequently active aggradation and erosion by channelled stream flow.

AL14 Covered plain

Flood plain with a number of alluvial channels which are widely-spaced (i.e., a little under a km), migrating, more or less parallel, and deep (i.e., width-depth ratio <20:1). Aggradation by over-bank stream flow occurs at least once every 50 years, providing further alluvial cover.

AL15 Meander plain

Flood plain aggraded and eroded by meandering streams. Flood plain with widely spaced, rapidly migrating, moderately deep alluvial stream channels that form a unidirectional integrated non-tributary network. There is frequently active aggradation and erosion by channelled stream flow with subordinate aggradation by over-bank stream flow.

AL16 Floodout

Flat inclined radially away from a point on the margin or at the end of a stream channel, aggraded by over-bank stream flow, or by channelled stream flow associated with channels developed within the over-bank part.

AL20 Alluvial terrace

Former flood plain on which erosion and aggradation by channelled and over-bank stream flow is slightly active or inactive because of deepening or enlargement of the stream channel has lowered the level of flooding. A pattern that includes a significant active flood plain, or former flood plains at more than one level, becomes terraced land.

AL30 Stagnant alluvial plain

Alluvial plain on which erosion and aggradation by channelled and over-bank stream flow is slightly active or inactive because of reduced water supply, without apparent incision or channel enlargement that would lower the level of stream action.

AL40 Terraced land

Landform pattern including one or more terraces and often a flood plain. Relief is low or very low (9 – 90 m). Terrace plains or terrace flats occur at stated heights above the top of the stream bank.

AL50 Alluvial swamp

Almost level, closed or almost closed depression with a seasonal or permanent water table at or above the surface, commonly aggraded by overbank stream flow and sometimes biological (peat) accumulation.

CO00 Coastal lands

Level to gently undulating landform pattern of extremely low relief eroded or aggraded by waves, tides, overbank or channel flow, or wind. The landform pattern may be either active or relict.

CO01 Beach ridge plain

Level to gently undulating landform pattern of extremely low relief on which stream channels are absent or very rare; it consists of relict parallel linear ridges built up by waves and modified by wind.

CO02 Chenier plain

Level to gently undulating landform pattern of extremely low relief on which stream channels are very rare. The pattern consists of relict, parallel linear ridges built by waves, separated by and built over flats aggraded by tides or over bank stream flow.

CO03 Coral reef

Continuously active or relict landform pattern built up to the sea level of the present day or of a former time by corals and other organisms. It is mainly level, with moderately inclined to precipitous slopes below sea level. Stream channels are generally absent, but there may occasionally be fixed deep erosional tidal stream channels forming a disintegrated non-tributary pattern.

CO04 Marine plain

Plain eroded or aggraded by waves, tides, or submarine currents, and aggraded by deposition of material from suspension and solution in sea water, elevated above sea level by earth movements or eustacy, and little modified by subaerial agents such as stream flow or wind.

CO05 Tidal flat

Level landform pattern with extremely low relief and slowly migrating deep alluvial stream channels which form dendritic tributary patterns; it is aggraded by frequently active tides.

CO06 Coastal dunes

Level to rolling landform pattern of very low to extremely low relief without stream channels, built up or locally excavated, eroded or aggraded by wind. This landform pattern occurs in usually restricted coastal locations.

CO07 Coastal plain

Level landform pattern with extremely low relief either with or without stream channels, built up by coastal, usually tidal, processes.

CO08 Beach

Short, low, very wide slope, gently or moderately inclined, built up or eroded by waves, forming the shore of a lake or sea.

DE00 Delta

Flood plain projecting into a sea or lake, with slowly migrating deep alluvial channels, usually moderately spaced, typically forming a divergent distributary network. This landform is aggraded by frequently active over-bank and channelled stream flow that is modified by tides.

DU00 aeolian landforms

Landform pattern built up or locally excavated, eroded or aggraded by wind. Mabbutt (1977) provides a useful summary of the variety of aeolian landforms found in arid climates.

DU10 aeolian dunes

Low mounds, ridges, banks, or hills of loose, windblown granular material (generally sand, in some places volcanic ash), either bare or covered with vegetation, capable of being moved from place to place by wind but always retaining their own characteristic shape.

DU11 longitudinal dune field

Dune field characterised by long narrow sand dunes and wide flat swales. The dunes are oriented parallel with the direction of the prevailing wind, and in cross section one slope is typically steeper than the other is.

DU12 transverse dune field

Dune field characterised by long narrow sand dunes and wide flat swales. The dunes are oriented normal to the direction of the prevailing wind, and in cross section the windward slope is typically steeper than the lee slope.

DU13 irregular dune field

Dune field with a mixture of longitudinal and transverse dunes, as well as other more complicated forms.

DU14 source bordering dune

A dune formed adjacent to the source of the wind blown material. Most commonly the source is a river or floodplain which supplies aeolian sediment during periods of low or no flow.

DU15 lunette

Elongated, gently curved, low ridge built up by wind on the margin of a playa, typically with a moderate, wave-modified slope towards the playa and a gentle outer slope.

DU20 aeolian sheet

A sheet of aeolian material, generally sand, formed when wind moulding of the surface is prevented either by vegetation, or more usually because the sand grains are too coarse. They are commonly associated with sources that give coarse sand grains, such as alluvial plains, or weathering of coarse-grained granite, as in the Yilgarn of Western Australia.

ER00 Erosional landforms

Landform pattern of very low to high relief and very gentle to steep slopes. The pattern is eroded by continuously active to slightly active or inactive geomorphic processes.

ER10 Erosional plain

Level to undulating or, rarely, rolling landform pattern of extremely low relief (< 9 m) eroded by continuously active to slightly active or inactive geomorphic processes.

ER11 Pediment

Gently inclined to level (< 1% slope) landform pattern of extremely low relief, typically with numerous rapidly migrating, very shallow incipient stream channels that form a centrifugal to diverging integrated reticulated pattern. It is eroded, and locally aggraded, by frequently active channelled stream flow or sheet flow, with subordinate wind erosion. Pediments characteristically lie down-slope from adjacent hills with markedly steeper slopes.

ER12 Pediplain

Level to very gently inclined landform pattern with extremely low relief and no stream channels, eroded by slightly active sheet flow and wind. Largely relict from more effective erosion by stream flow in incipient channels as on a pediment.

ER13 Peneplain

Level to gently undulating landform pattern with extremely low relief and sparse slowly migrating alluvial stream channels that form a non-directional integrated tributary pattern. It is eroded by slightly active sheet flow, creep, and channelled and over bank stream flow.

ER14 Etchplain

Level to undulating or, rarely, rolling landform pattern of extremely low relief, formed by deep weathering and then erosion of the resulting weathered regolith. Removal of the weathered material may be either partial or complete (see also Ollier 1984).

ER20 Rises

Landform pattern of very low relief (9 - 30 m) and very gentle to steep slopes. The fixed erosional stream channels are closely to very widely spaced and form a dendritic to convergent, integrated or interrupted tributary pattern. The pattern is eroded by continuously active to slightly active creep and sheet flow.

ER21 Residual rise

Landform facet of very low relief (9 - 30 m) and very gentle to steep slopes. This term is used to refer to an isolated rise surrounded by other landforms.

ER30 Low hills

Landform pattern of low relief (30 - 90 m) and gentle to very steep slopes, typically with fixed erosional stream channels, closely to very widely spaced, which form a dendritic or convergent integrated tributary pattern. There is continuously active sheet flow, creep, and channelled stream flow.

ER31 Residual low hill

Landform facet of low relief (30 - 90 m) and gentle to very steep slopes. This term is used to refer to an isolated low hill surrounded by other landforms.

ER40 Hills

Landform pattern of high relief (90 - 300 m) with gently sloping to precipitous slopes. Fixed, shallow erosional stream channels, closely to very widely spaced, form a dendritic or convergent integrated tributary network. There is continuously active erosion by wash and creep and, in some cases, rarely active erosion by landslides.

ER50 Mountains

Landform pattern of very high relief (> 300 m) with moderate to precipitous slopes and fixed erosional stream channels which are closely to very widely spaced and form a dendritic of diverging integrated tributary network. There is continuously active erosion by collapse, landslide, sheet flow, creep, and channelled stream flow.

ER60 Escarpment

Steep to precipitous landform pattern forming a linearly extensive, straight or sinuous inclined surface which separates terrains at different altitudes, that above the escarpment commonly being a plateau.

Relief within the landform pattern may be high (hilly) or low (planar). An included cliff or scarp often marks the upper margin.

ER70 Badlands

Landform pattern of low to extremely low relief (< 90 m) and steep to precipitous slopes, typically with numerous fixed erosional stream channels which form a dendritic to parallel integrated tributary network. There is continuously active erosion by collapse, landslide, sheetflow, creep and channelled stream flow.

ER80 Drainage depression

Depression cut into a surface by erosional processes. This term should be used only in cases where a single depression or valley is incised into a plateau or other surface, and where the scale of mapping does not allow the depression to be subdivided into its component parts (e.g. rises, floodplain).

FA00 Fan

Level (< 1% slope) to moderately inclined complex landform pattern of extremely low relief with a generally fan-shaped plan form. The channels form a centrifugal to divergent, integrated, reticulated to distributary pattern.

FA01 Alluvial fan

Level (< 1% slope) to very gently inclined complex landform pattern of extremely low relief with a generally fan-shaped plan form. The rapidly migrating alluvial stream channels are shallow to moderately deep, locally numerous, but elsewhere widely spaced. The channels form a centrifugal to divergent, integrated, reticulated to distributary pattern. The landform pattern includes areas that are bar plains, being aggraded or eroded by frequently active channelled stream flow, and other areas comprising terraces or stagnant alluvial plains with slopes that are greater than usual, formed by channelled stream flow but now relict. Incision in the up-slope area may give rise to an erosional stream bed between scarps.

FA02 Colluvial fan

Very gently to moderately inclined complex landform pattern of extremely low relief with a generally fan-shaped plan form. Divergent stream channels are commonly present, but the dominant process is colluvial deposition of materials. The pattern is usually steeper than an alluvial fan.

FA03 Sheet-flood fan

Level (< 1% slope) to very gently inclined landform pattern of extremely low relief with numerous rapidly migrating very shallow incipient stream channels forming a divergent to unidirectional, integrated or interrupted reticulated pattern. Frequently active sheet flow and channelled stream flow, with subordinate wind erosion aggrade the landform pattern.

GL00 Glacial landforms

This term covers a wide range of landforms that are produced by glacial processes. In Australia most landforms of this type are all relict, with the exception of Heard Island. For more details, see Fairbridge (1968) or Davies (1969).

GL10 Depositional glacial landforms

This collective term includes features such as moraines of various kinds, as well as irregular landforms made up of glacial deposits. For more details, see Fairbridge (1968) or Davies (1969).

GL20 Erosional glacial landforms

Glacial erosion produces a variety of streamlined forms such as cirques and U-shaped valleys. For more details, see Fairbridge (1968) or Davies (1969).

KA00 Karst

Landform pattern of unspecified relief and slope (for specification use terms such as “Karst rolling hills”) typically with fixed deep erosional stream channels forming a non-directional disintegrated tributary pattern and many closed depressions without stream channels. It is eroded by continuously active solution and rarely active collapse, the products being removed through underground channels.

MA00 Made land

Landform pattern typically of very low or extremely low relief and with slopes in the classes level and very steep. Sparse, fixed deep artificial steam channels form a non-directional interrupted tributary pattern. The landform pattern is eroded and aggraded, and locally built up or excavated, by rarely active human agency.

ME00 Meteor crater

Rare landform pattern comprising a circular closed depression with a raised margin, it is typically of low to high relief and has a large range of slope values, without stream channels, or with a peripheral integrated pattern of centrifugal tributary streams. The pattern is excavated, heaved up and built up by a meteor impact and now relict.

PL00 Plain

Level to undulating or, rarely, rolling landform pattern of extremely low relief (< 9 m). Some types of plains are described under alluvial landforms, and some are also described under erosional landforms.

PL01 Depositional plain

Level landform pattern with extremely low relief formed by unspecified depositional processes.

PL02 Lacustrine plain

Level landform pattern with extremely low relief formerly occupied by a lake but now partly or completely dry. It is relict after aggradation by waves and by deposition of material from suspension and solution in standing water. The landform pattern is usually bounded by wave-formed cliffs, rock platforms, beaches, berms and lunettes that may be included or excluded.

PL03 Playa plain

Level landform pattern with extremely low relief, typically without stream channels, aggraded by rarely active sheet flow and modified by wind, waves, and soil phenomena. Playa plains are sediment sinks and are the lowest parts of the landscape.

PL04 Sand plain

Level landform pattern with extremely low relief, typically without stream channels, aggraded by active wind deposition and rarely active sheet flow.

PT00 Plateau

Level to rolling landform pattern of plains, rises or low hills standing above a cliff, scarp or escarpment that extends around a large part of its perimeter. A bounding scarp or cliff may be included or excluded; a bounding escarpment would be an adjacent landform pattern.

PT01 Plateau edge

The cliff, scarp or escarpment that extends around a large part of the perimeter of a plateau.

PT02 Plateau surface

The low relief surface of a plateau.

VO00 Volcano

Typically very high and very steep landform pattern without stream channels, or with erosional stream channels forming a centrifugal or radial tributary pattern. The landform is built up by volcanism, and modified by erosional agents.

VO01 Caldera

Rare landform pattern typically of very high relief and steep to precipitous slopes. It is without stream channels or has fixed erosional channels forming a centripetal integrated tributary pattern. The landform has subsided or was excavated as a result of volcanism.

VO02 Cone (volcanic)

Typically low to high relief and very steep landform pattern without stream channels, or with erosional rills forming a radial tributary pattern. The landform is built up by volcanism, and slightly modified by erosional agents.

VO03 Lava plain

Level to undulating landform pattern of very low to extremely low relief typically with widely spaced fixed stream channels which form a non-directional integrated or interrupted tributary pattern. The landform pattern is aggraded by volcanism (lava flow) that is generally relict; it is subject to erosion by continuously active sheet flow, creep, and channelled stream flow.

VO04 Ash plain

Level to undulating landform pattern of very low to extremely low relief typically with widely spaced fixed stream channels that form an integrated or interrupted tributary pattern. The landform pattern is aggraded by volcanism (ash fall) that is generally relict; it is subject to erosion by continuously active sheet flow, creep, and channelled stream flow.

VO05 Lava flow

A landform produced on the land surface by flowing magma. It is generally relict, and subject to erosion by continuously active sheet flow, creep, and channelled stream flow.

VO06 Lava plateau

A plateau aggraded by volcanism (lava flow) that is generally relict, and subject to erosion by continuously active sheet flow, creep, and channelled stream flow.

4.2.2 Structural Control

The type of structural control on landforms in the landform unit can often be determined from aerial photographs or satellite imagery. There is commonly a strong relationship between drainage patterns and structure. Hillslope form also reflects rock structure in many cases.

NS No structural control

Dendritic drainage patterns with no preferred orientation, and generally smooth slope forms often indicate homogeneous rocks which exercise no control on landforms.

AD Anti dip slope

Anti dip slopes, also known as scarp slopes or scarps, are formed across the dip of bedded rocks. They are frequently irregular because of differential erosion of more and less resistant rocks that are interbedded.

AN Anticline

Anticlines are characterised by outward facing dip slopes and inward facing anti-dip slopes. They also may have divergent drainage patterns. In the extreme form, domes, drainage may be radial.

BF Block faulting

Individual blocks may be either up- or down-thrown to give distinctive features in the landscape.

CU Cuesta forms

Cuestas have a steep anti dip slope and a more gentle dip slope. Both strike and dip of the underlying rock are reflected in the landforms.

DB Dipping beds

In areas where bedded rocks dip at significant angles, differential erosion of more and less resistant rocks can lead to linear valleys and ridges.

DI Dip slope

In some cases a long very gentle dip slope gives rise to a gently slope ramp. Parallel drainage is often found on such structural ramps.

DS Dyke/sill

Dykes and sills are frequently exposed by differential removal, by erosion, of the softer rocks around them. The volcanic rock then stands out in the landscape.

FT Faulted

Faults may show up as lineaments in the landscape, and in some cases may show up as a scarp. A fault scarp is a scarp formed by faulting, whereas a fault line scarp is one formed by erosion and backward retreat of a fault scarp.

HG Horst/graben

Horsts and grabens are formed by widespread block faulting giving rise to a mountain and valley topography that owes its origin in part at least to regional block faulting.

JN Jointing

Jointing patterns are usually expressed in the landscape as a result of weathering and geomorphic processes taking advantage of the weak points provided by the joints. Commonly the drainage pattern reflects such joint control.

MN Monocline

Monoclines may show a fall from a high to a low level in the landscape.

SA Strike aligned

In many areas both ridges and rivers are aligned along the strike of the bedrock. This may lead to the exposure of a series of cuestas, or in some cases anticlines and synclines.

SN Syncline

Synclines are characterised by inward facing dip slopes and outward facing anti dip slopes. Drainage may be convergent.

4.3 Environmental Hazard Definitions

Evidence of environmental hazards can be observed in the field, and assessments of hazard liability can be made. The hazards listed here are those that are either directly related to the regolith and landforms (e.g. landslides), or their impacts are restricted to particular landscape types that are identified as part of a regolith landform map (e.g. floods). Readers who want more information about environmental hazards should, as a beginning point, refer to Heathcote and Thom (1979) or Blong and Johnson (1986).

AV Snow avalanche

Rapid movement of snow down mountain slopes.

CO Coastal erosion

Erosion of coastal land by waves and wind. This may be brought about by several factors including human disturbance of the foredune, and various effects of climatic change such as rising sea level, and increased storminess.

FF Flash flood

Rapid rise of water level in rivers, sometimes with overbank flow, resulting from high intensity rain storms. These events are common in lower rainfall areas, and may occur downstream of the location of rainfall.

FL Flood

Rise of water in rivers followed by overbank flow, resulting from prolonged heavy rainfall. Flood waters may affect areas outside the area of rainfall.

LA Landslide

Rapid mass movement of regolith material down hillslopes.

RO Rockfall

Fall of rock from vertical or near vertical cliffs.

SA Salinity

Accumulation of salts at the surface or within the near-surface soil. This can arise from a number of causes ranging from a rise in water table levels in irrigated areas to emergence of subsurface water in lower footslope areas.

SC Solution cavities

In some circumstances, particularly on calcareous rock types, solution processes within the underlying rock can lead to the development of hollows and possibly collapse.

SD Sand drift

Movement of sand by wind erosion, transport and deposition.

SO Soil erosion

Loss of soil by erosion processes, including surface wash and rill erosion, as well as wind erosion.

ST Storm surge

Unusually high temporary sea levels resulting from storms that force sea water on to the land through a combination of strong onshore winds, high tides, and lowered barometric pressure.

SU Subsidence

Sinking of the ground surface, either slowly or by more rapid collapse, due, for example, underground caves in limestone, mines, and removal of water from aquifers.

TS Tsunami

Ocean waves generated by either volcanic or seismic activity, usually on the sea floor. Tsunami are sometimes erroneously called tidal waves.

VE Volcanic activity

Effects resulting from volcanic eruption.

4.4 Drainage Definitions

4.4.1 Drainage Pattern

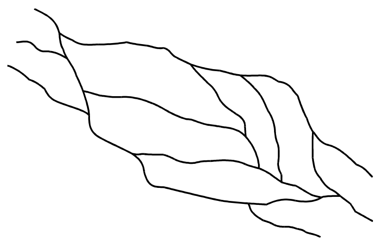
Drainage pattern refers to the plan shapes made by drainage channels on the land surface. It should not be confused with *channel pattern*, which refers to the plan shape of river reaches. Drainage patterns reflect a number of elements in the landscape. They may reflect underlying rock structures, or the nature of the original surface on which they were developed. Some of these interpretations are discussed briefly in the relevant definitions below.

Simple rivers have a dendritic drainage pattern. Complications to a dendritic pattern mean that rock structure or events in its geomorphic history or both have affected the drainage. Proper interpretation of drainage patterns contributes to an understanding of the geomorphic history of an area, and so to an understanding of regolith development. Drainage patterns are often one of the oldest features in a landscape, because they are developed very soon after an area is exposed to surface activity, and they can persist through several tectonic and erosional episodes.

The drainage patterns listed here are derived from a number of sources, including Ollier (1981) and Speight (1990).

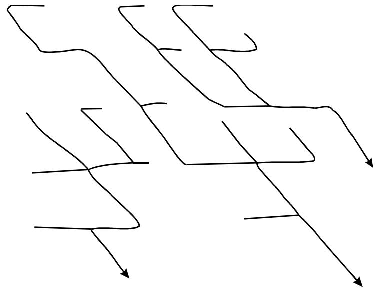
AB Anabranching

Drainage pattern where the channels divide and then join further down stream. This pattern is sometimes referred to as anastomosing, or reticulated. It is similar in form to the arrangement of channels in a braided river channel, but is at a much larger scale.



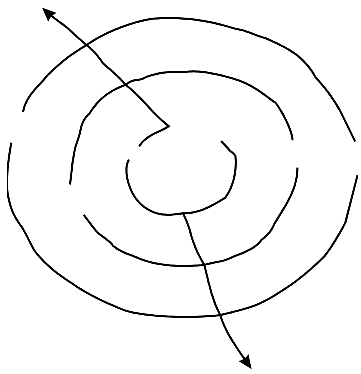
AG Angulate

Channels follow a roughly rhomboid plan. This type of pattern occurs mainly where intersecting joints weakens the underlying rock. These joints control the location of drainage lines.



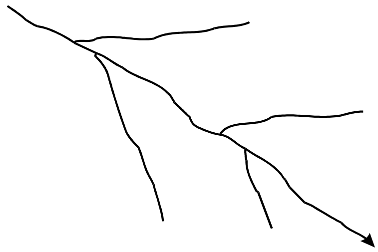
AN Annular

Drainage pattern where channels form parts of circles. Annular patterns are usually controlled by domal or anticlinal rock structures that are picked out by channels. They may be either circular or elliptical.



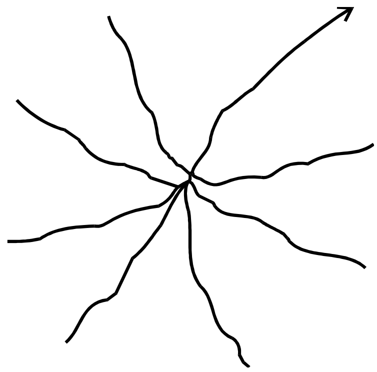
BA Barbed

Barbed drainage patterns are those where tributaries join the main channel at angles of greater than 90°. In this situation the tributaries tend to flow in a direction opposite that of the main channel. This can mean that the flow direction of the main channel has been reversed.



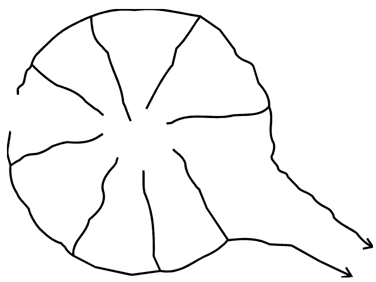
CP Centripetal

Drainage pattern where channels flow in towards a central point or area from a surrounding area encompassing at least 180°. In many cases this central area is a closed depression, such as a caldera, in which case the incoming channels drain a surrounding area encompassing 360°.



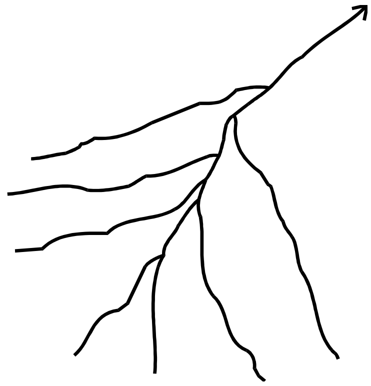
CR Circumvolcanic

In many areas with volcanic landforms, drainage lines flow in semicircular courses around volcanoes. These drainage lines are called circumvolcanic. Generally they indicate that former drainage lines have been diverted into a circular course by the eruption and growth of the volcano.



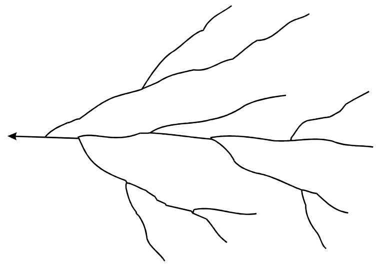
CV Convergent

Drainage pattern where channels converge towards a point or area from a surrounding area encompassing less than 180°. Such patterns can be found, for example, on synclines.



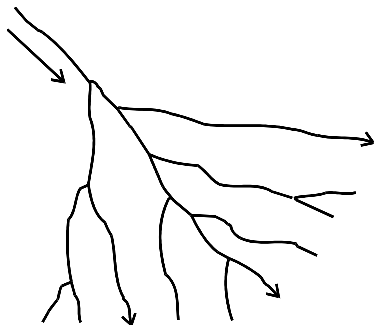
DN Dendritic

Integrated drainage patterns where small branch channels join, usually at acute angles, to feed a trunk channel. They show no preferred orientation, and are typical of areas where the underlying rock is more or less homogeneous.



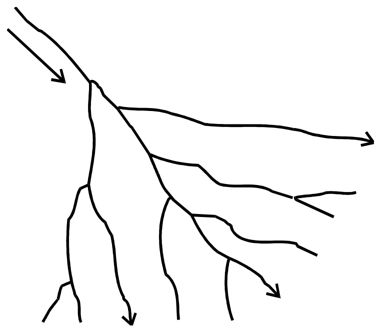
DS Distributary

Drainage pattern where a single channel breaks or diverges into a number of smaller channels. This pattern is typical of deltas, but can occur in any area where a single channel flows out of a confining valley. In some parts of Australia these areas are called "floodouts".



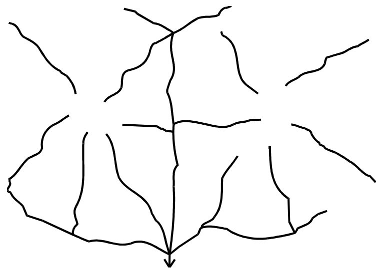
DV Divergent

Drainage pattern where multiple channels diverge from a small area to a surrounding area. Such patterns can be found, for example, on the ends of anticlines, and are typical of fans.

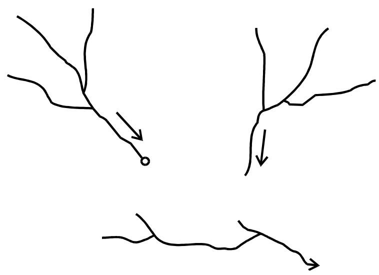


GU Gutter

Gutter drainage, like circumvolcanic drainage, is associated with volcanoes. It occurs where two volcanoes overlap, and the drainage lines flow along the low line of intersection.

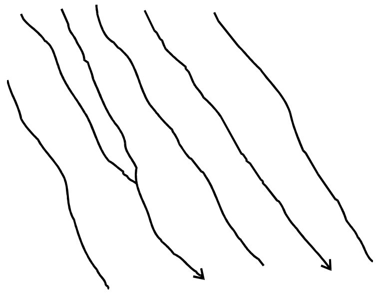


IN Interrupted



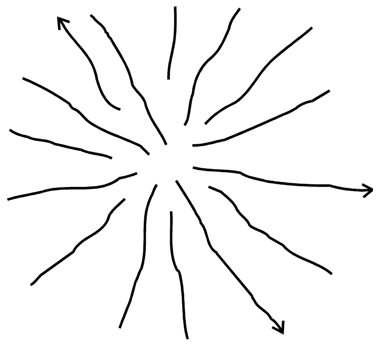
Drainage where the channel segments are short and unconnected. Typically this occurs in karst landforms, and in areas where the drainage pattern has not been fully integrated. Some parts of the arid centre of Australia show this pattern, because of the lack of sufficient precipitation, and disruption of drainage lines by wind blown materials.

PA Parallel



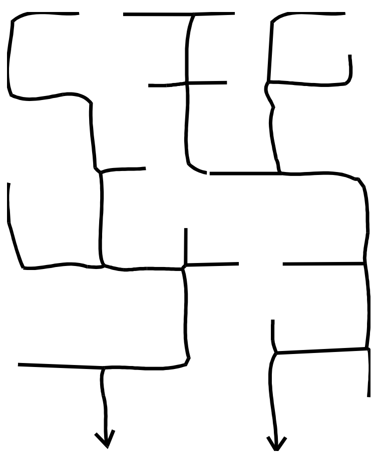
Drainage pattern where the channels are parallel to each other. This type of drainage is commonly initiated on sloping surfaces, and the presence of a parallel drainage pattern or its remnants may suggest the former presence of such a surface.

RA Radial



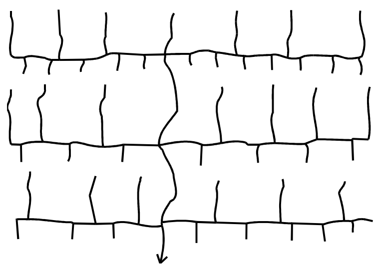
Drainage pattern where the channels radiate from a point or small area. Commonly this occurs on volcanoes or domal structures. A radial drainage pattern infers the former presence of such features, even if they are no longer present in the landscape.

RC Rectangular



A drainage pattern in which the channels follow a roughly rectangular plan with channels joining at about 90°. This type of pattern occurs where the underlying rock is broken by rectangular jointing or, less frequently, bedding which controls stream direction one way and joints the other.

TR Trellis



Drainage pattern where secondary channels flow at right angles to the main channel. The secondary channels are in turn joined at right angles by small tributaries flowing parallel to the main channel. This pattern is common in well-bedded rocks, commonly with scarp and dip slopes. Small tributaries on the scarp slopes are short and steep, while those on the dip slopes are longer and more gently sloping.

4.4.2 *Drainage Character*

Drainage character refers to the frequency of flow in river channels in the landform unit, and for RTMAP is restricted to the following:

D Dry

Channels which flow on very rare occasions. This drainage character is confined largely to the arid areas of central Australia.

I Intermittent

Channels that flow on a seasonal or irregular basis, containing water during wet parts of the year, and drying up during periods with no rain. Much of northern Australia has this drainage character.

P Perennial

Channels that flow all year round. This drainage character is confined to wetter areas on the margins of the Australian continent.

4.4.3 *Drainage Type*

Drainage type refers to the relationship between drainage lines and landscape evolution. Currently the following types are recognised.

A Antecedent

Antecedent drainage is developed when uplift or warping raises an area of highlands across the path of a river, but the uplift is sufficiently slow to allow river downcutting to keep pace, and therefore maintain its course.

C Captured

Drainage capture occurs when drainage from one catchment is diverted into another catchment. Sharp bends in river direction and barbed drainage patterns can indicate river capture.

D Diverted

Drainage may be diverted when uplift or warping raises an area of highlands across the path of a river. If the river cannot cut down its bed as fast as the rate of uplift, the river will be defeated, and then diverted to flow in another direction. In extreme cases, a closed depression with a lake may develop (e.g. Lake George).

N Normal

Normal drainage develops where there are no apparent tectonic, structural or lithologic controls on the major river/landscape relationships.

R Reversed

Reversed drainage is the reversal of flow in a river channel, and can occur as a result of tectonic tilting, causing lowering of the headwaters of a river system. Sometimes river capture can lead to drainage reversal.

S Superimposed

Superimposed drainage occurs when a river cuts down through rocks of varying hardness from above. Softer rocks are readily removed, but harder rocks remain as higher parts of the landscape. This commonly leads to rivers flowing in gorges right through high areas.

U Underground

Drainage occurring underground is found most commonly in karst areas. Surface drainage may disappear underground when it enters a limestone area, to emerge often many kilometres away.

4.4.4 Stream Channel Spacing

Stream channel spacing is a measure of drainage density, the total length of channel per unit area (Speight 1990). At a very broad level it is affected by precipitation, higher rainfall areas generally having closer stream channel spacing. At more local levels where climate is more uniform, stream channel spacing can reflect underlying lithology, with softer rocks often having a closer stream channel spacing than harder rocks.

Values for stream channel spacing can be obtained by laying a ruler on a map, and counting the number of channels that cross a line equivalent to 2 or 3 km. Several such measurements will give a representative value for each landform unit. Values for stream channel spacing are restricted to:

AB	Absent or very rare	> 2500 m
SP	Sparse	1500 - 2500 m
VW	Very widely spaced	1000 - 1500 m
WS	Widely spaced	625 - 1000 m
MS	Moderately spaced	400 - 625 m
CS	Closely spaced	250 - 400 m
VC	Very closely spaced	150 - 250 m
NU	Numerous	< 150 m

4.5 Geomorphic Process Definitions

In the database, geomorphic processes are those that form or modify landform units. They can refer to either present or past activity. This means that processes occurring now as well as those responsible for the evolution of a regolith terrain unit can be entered into the database. An active/relict (A/R) code is used to distinguish the two.

Brief definitions are included here. For more detailed descriptions of these processes the user is referred to a textbook on geomorphology, such as Chorley et al. (1984). Other suitable references are given at various points.

GR00 Gravity

Any geomorphic process that acts mainly as a result of gravity. For more details see Selby (1982).

GR01 Vertical collapse

Collapse of large fragments of rock and/or soil, commonly from cliff faces. The collapsed materials accumulate where they fall, and may be acted on by other processes.

GR02 Particle fall

More-or-less free fall of small particles of rock and/or soil from or near vertical faces.

GR03 Creep

Slow movement of rock and/or soil particles down slope under the influence of gravity. Creep operates at rates of a few millimetres per year, with wetting and drying, shrinking and swelling, and freezing and thawing all contributing to the down slope movement of material.

GR04 Landslide

Translational movement of material along a shearplane under the influence of gravity. The moving material may be either a single coherent mass, or it may consist of a number of sliding fragments. In this type of movement, the material generally maintains its orientation relative to the land surface. The resulting deposit contains unbroken blocks or rafts of material.

GR05 Mudflow

Turbulent movement of material down slope under the influence of gravity. In this type of movement the moving mass tumbles, rolls and flows down slope. The resulting deposit is a mixture of material of all sizes, with no obvious orientation or indication of original structure.

WT00 Water

The movement and deposition of material through the agency of water. For more details see Morisawa (1985).

WT01 Channelled stream flow

Erosion, transport and deposition of material in stream channels. These commonly give well-sorted deposits that are confined to river channels, either modern or relict (channel deposits).

WT02 Over-bank stream flow

Erosion, transport and deposition of material on flood plains and other areas adjacent to rivers by water which has flowed out of a confined channel (over-bank deposits).

WT03 Sheet flow, sheet wash, surface wash

Erosion, transport and deposition of material by sheets of water flowing over the ground surface. This unconfined flow occurs on hill slopes and on low angle landform units. It commonly removes fine material, leaving coarser material behind as a lag deposit.

WT04 Waves

Erosion, transport and deposition of material by wave action either on the seacoast or along lake edges. For more details on coastal processes see Davies (1980).

WT05 Tides

Erosion, transport and deposition of material by movement of tidal currents.

WT06 Detrital deposition in still water

Deposition of detrital material from a body of standing water onto the floor of the basin. In terrestrial landscapes this occurs in lakes. Sources of detrital material include channel flow into the lake, and wave action along lake edges.

WT07 Rill/gully erosion

Linear erosion by water, producing steep sided channels. Rills are less than 0.3 m deep and gullies are more than 0.3 m deep.

IC00 Ice

Erosion, transport and deposition of material by moving ice. For more details see Davies (1969).

IC01 Frost

Freezing and thawing of water, which leads to shattering and movement of rock fragments, and disturbance of soil material. Processes include solifluction, and the development of patterned ground.

IC02 Glacial erosion

Erosion and transport of material by glacial ice, giving rise to distinctive landforms such as U-shaped valleys and cirques.

IC03 Glacial deposition

Deposition of material from melting ice. The general term moraine refers to the deposits.

WI00 Wind

Erosion, transport and deposition of material by wind. For more details see Mabbutt (1977).

WI01 Wind erosion (deflation)

Erosion of material by the action of wind. This may involve entrainment of sand and dust particles, and their movement to other locations. It also includes the action of sand corrasion to produce ventifacts.

WI02 Sand deposition (wind)

Deposition of sand by wind to form various landform types including dunes and sand sheets.

WI03 Dust deposition (wind)

Deposition of dust being transported by wind in the atmosphere as suspended load. This process is responsible for deposition of loess. Where the dust is composed of clay pellets, it forms a special kind of loess, sometimes called parna in Australia.

DI00 Diastrophism; earth movements

Diastrophic movements are those that result directly or indirectly in relative or absolute changes of position, level or attitude of rocks forming the earth's crust. This includes uplift and faulting.

VO00 Volcanism

Volcanism refers to the group of processes generated by volcanic activity on the land surface (see Ollier 1988).

VO01 Lava flow

The flow of molten rock across the land surface.

VO02 Ash flow

The flow of volcanic ash material across the land surface. This includes nuée ardentes. The resulting deposits are sometimes called ignimbrites.

VO03 Ash fall

The fall of volcanic ash on to the land surface, typically leading to mantles of volcanic ash (tephra) over all parts of the landscape.

BI00 Biological agents

Formation or changes in the shape of landforms by animals or plants, for example, the development of coral reefs.

HU00 Human agents

Formation or changes in the shape of landforms by human activity.

MT00 Impact by meteors

Formation or changes in the shape of landforms by meteorite impact, typically to produce craters.

4.6 Weathering Process Definitions

Weathering is an essential first step in landscape development. Without weathering there can be no soil formation, nor can there be any erosion and transportation of rock materials. Weathering processes range from simple physical breaking of rocks into smaller pieces to complex chemical alteration of rock materials. Ollier (1984) provides a detailed discussion of weathering and landforms.

WE00 Weathering

Weathering refers to any process that modifies rocks, either physically by reducing the size of fragments, or chemically by altering the composition of constituent rock materials.

PH00 Physical weathering

Physical weathering is any process that leads to a reduction in the size of rock fragments.

PH01 Abrasion

Abrasion is the mechanical breaking of rocks or minerals by either friction or impact. Friction is common at the base of glaciers, for example, whereas impact abrasion is more common in streams and in areas of wind transport.

PH02 Frost weathering

Breaking and separation of rock fragments by the force exerted when water freezes to ice. Freeze-thaw cycles are very important in the breakdown and mixing of rock and soil material.

PH03 Induced fracture

Induced fracture occurs when a large rock rests on an underlying rock. This sets up stresses that can act on both the underlying and overlying rock.

PH04 Insolation weathering

Insolation weathering occurs when temperature changes cause expansion and/or shrinkage of rocks. Repeated temperature changes may cause rocks to fracture, and for insolation weathering the heating agent is the sun.

PH05 Moisture swelling

Considerable changes in rock volume can be caused by a reversible absorption of moisture, and the volume changes may be enough to cause physical weathering.

PH06 Sheeting

Sheeting is the division of rock into sheets by joint-like fractures that are generally parallel to the ground surface. It is caused by pressure release and expansion of rock masses following erosion. Topographic jointing is another name for this process.

PH07 Salt weathering

The growth of salt crystals from solution can sometimes cause breakdown of rock materials in a manner similar to that caused by freezing of water.

PH08 Volume increase

Chemical alteration of rocks and minerals may cause an increase in volume. This volume increase usually leads to exfoliation, the peeling of thin shells of material from the parent rock.

PH09 Wetting and drying

Repeated wetting and drying of rock materials can lead to physical beak down of the materials into smaller fragments.

CH00 Chemical weathering

Chemical weathering occurs with any chemical alteration of rocks or minerals. It results from chemical reactions of minerals with air and water.

CH01 Solution

Solution is usually the first stage of chemical weathering, and may take place in running water or in a thin film of water round a solid particle. Dissolved chemicals are removed from the weathering rock.

CH02 Oxidation and reduction

Oxidation is a reaction between minerals and oxygen to produce oxides or, with water, hydroxides. Reduction is the opposite of oxidation and usually takes place in waterlogged and other anaerobic sites. Alternating oxidation and reduction in, for example, a zone of fluctuating water level, often leads to mottling of weathered materials.

CH03 Carbonation

Carbonation is the reaction of carbonate or bicarbonate ions with minerals. Carbon dioxide is common in soil air, and carbonation can be quite rapid where carbonic acid is readily available.

CH04 Hydration

Hydration is the addition of water to a mineral to form hydrated mineral forms, or hydroxides. Hydration is an important process in clay mineral formation.

CH05 Chelation

Chelation, or complexing, is the holding of an ion, usually a metal, within a ring structure of organic origin. It is an important process involving both mineral and organic materials.

CH06 Hydrolysis

Hydrolysis, a very important chemical weathering process, is a chemical reaction between minerals and the H^+ and OH^- ions of water.

CH07 Ferrolysis

Originally used by Brinkman (1970) to refer to the gradual destruction of clays in a soil through repeated cycles of replacement of exchange ions by Fe^{2+} during reducing conditions, followed by oxidation of the iron, consequent drop in pH, partial dissolution of the clays and the introduction of alumina in the exchange sites. More recently it has been used to refer only to the decrease in pH caused by hydromorphic oxidation of iron, according to the equation: $Fe^{2+} + 3H_2O = Fe(OH)_3 + 3H^+ + e^-$.

CH08 Chemical precipitation/evaporation

In suitable chemical environments various chemicals precipitate from solution and are deposited in various parts of the landscape. This may be an important source of materials in some parts of the landscape, especially in situations where water comes to the surface and is then evaporated.

IN00 Induration

Induration processes lead to either absolute or relative accumulation of a cementing agent, to form a duricrust. Sometimes the cementing agent replaces regolith materials. A duricrust is a hard crust formed by weathering processes.

IN01 Bauxitic induration

Cementation largely by aluminous materials.

IN02 Calcareous induration

The *in situ* cementation and/or replacement of regolith by carbonate.

IN03 Clay induration

Induration of regolith by clay.

IN04 Ferruginous Induration

Cementation by ferruginous materials.

IN05 Gypsiferous induration

The *in situ* cementation and/or replacement of regolith by gypsum.

IN06 Siliceous induration

The *in situ* cementation and/or replacement of regolith by silica.

HA00 Hydrothermal alteration

Hydrothermal alteration is produced by chemical changes in rock materials caused by hot water and steam rising through country rock. This is not weathering, but produces very similar effects. The best field distinction between clay bodies formed by weathering and hydrothermal alteration is that weathering decreases with depth, and hydrothermal alteration increases with depth.

BI00 Biotic weathering

Biotic weathering is a combination of chemical and physical weathering brought about by biological agents. It has a wide variety of effects, but is not usually more than locally important. See Ollier (1984) for more details.

4.7 Regolith Definitions

Landform classification has reached the stage where, although there may be minor disagreements, most people generally agree on the major groupings. However, regolith classification is an entirely different matter. There is still disagreement about what regolith is, and this disagreement extends to the use of different terms to describe regolith types. A good example is the use of the words *laterite* and *ferricrete*.

In developing a classification of regolith we must keep in mind its purpose. We are mapping regolith landform units at a publication scale of 1:250 000, although field mapping will be at 1:100 000. This rules out, in most cases, mapping specific regolith materials such as the mottled zone of a laterite profile. Regolith landform units will contain groupings of specific regolith materials. Often these groupings will be related both spatially and genetically, in the same way as the soils in a toposequence are related. The difference between a regolith "toposequence" and a soil toposequence is that the former is likely to be deeper and more complex. A group of regolith types will be a three dimensional entity which frequently contains a wide variety of specific materials.

The list presented here contains the basic regolith types, derived in part from Speight and Isbell (1990). It will expand, particularly with the addition of categories of regolith profiles, as data come both from our field mapping program and from workers outside the BMR.

4.7.1 Regolith Type

BU00 Unweathered bedrock

In some areas, particularly on steep slopes, or on young surfaces, the regolith consists of soil material formed directly on the underlying bedrock. Commonly the soil has a skeletal profile, and is less than 1 m thick. These areas are mapped as bedrock.

EVA00 Evaporite

Sediment formed by the precipitation of solutes from water bodies on the land surface, typically as lacustrine sediments.

EVA01 Halite

Evaporite consisting of sodium chloride.

EVA02 Gypsum

Evaporite consisting of hydrated calcium sulphate.

EVA03 Calcrete

Used broadly to refer to regolith carbonate accumulations, forming more-or-less-well cemented aggregates composed largely of calcium carbonate, but not excluding dolomitic or magnesitic material. Although some regolith carbonates clearly cement fragmental regolith to form duricrusts, others may be pisolitic, nodular, pebbly, slabby or powdery. Calcrete is a convenient field term for all such carbonate accumulations.

SDT00 Sediments (terrestrial)

Materials deposited on the land surface by terrestrial geomorphic processes.

SDA00 Alluvial sediments

Materials deposited on the land surface from transport by flowing water confined to a channel or valley floor.

SDA10 Channel deposits

Alluvium which is deposited in an alluvial channel. It is commonly coarser than surrounding deposits, and is found in both active and relict channels. It includes deposits in cut-off meanders, and point bar deposits.

SDA20 Overbank deposits

Alluvium that is deposited outside an alluvial channel from flowing water which has overflowed from the channel. It includes levees and back swamp deposits.

SDC00 Colluvial sediments

Sediment mass deposited from transport down a slope by gravity. Compared with alluvium, colluvium lacks bedding structure, is more variable in grain size, and contains mainly material derived locally.

SDC01 Scree

Scree, sometimes called talus, is colluvium deposited after falling or rolling from cliffed or precipitous slopes, consisting of loose rock fragments of gravel size or larger.

SDC02 Landslide deposit

Colluvium rapidly displaced down slope by failure of a mass of earth or rock. If the mass was not already part of the regolith the landslide incorporates it into the regolith. Original rock structures are fragmented and tilted by the action of the landslide.

SDC03 Mudflow deposit

Colluvium rapidly displaced down slope mixed with water to form a dense fluid. The material is more thoroughly disaggregated than that of a landslide deposit, but lacks the bedding and sorting of grain sizes seen in alluvium.

SDC04 Creep deposit

Normally a thin layer of rocky or earthy colluvium which moves very slowly down slope. In some circumstances it may be recognised by, for example, bending of rock bands down slope, but in other cases can only be inferred.

SDC05 Sheet flow deposit

Colluvium deposited from transport by a very shallow flow of water as a sheet, or network of rills on the land surface. Sheet flow deposits are very thin except at the foot of a slope and beneath sheet flood fans.

SDC06 Fanglomerate

Sedimentary regolith consisting of slightly water-worn, heterogeneous fragments of all sizes, deposited in an alluvial fan.

SDE00 Aeolian sediment

Sediment deposited from transport by wind.

SDE01 Aeolian sand

Wind blown sediment of sand size, often taking the form of dunes, with characteristic bedding structures.

SDE02 Loess

Aeolian sediment of silt size, often deposited over the landscape as a blanket.

SDE03 Parna

Aeolian sediment of clay size, commonly transported as flakes of larger size, up to sand size.

SDF00 Fill

Artificial sediment mass formed by earth moving works. Fill is sometimes compacted to the status of a very weak rock, but typically remains an earth mass.

SDG00 Glacial sediments

Sediment deposited from transport by moving ice. It is neither bedded nor sorted. It has a matrix of clay or silt enclosing larger particles of unweathered rock ranging up to large boulders.

SDL00 Lacustrine sediments

Sediments deposited from transport by waves and from solution and suspension in still water in a closed depression on land.

SDM00 Marine sediment

Sediments deposited from transport by waves and from solution and suspension in seawater. Marine sediments may occur in the regolith where the sea has withdrawn from an area during the Quaternary Period.

SDP00 Swamp (paludal) sediments

Fine grained regolith material accumulated in a closed or almost closed depression with a seasonal or permanent water table at or above the surface, commonly consisting of over-bank stream deposits and sometimes by biological (peat) accumulation.

SDP01 Peat

Black or brown, partly decomposed, fibrous vegetative matter that has accumulated in a waterlogged environment such as a bog.

SDS00 Coastal sediments

Sediments deposited in the coastal zone by coastal processes.

SDS01 Beach sediments

Sediment mass deposited from transport by waves or tides at the shore of a sea or lake.

SDS02 Estuarine sediments

Sediments deposited in an estuary or lagoon, from transport by tidal currents.

SDS03 Coral

Material accumulated by the growth of coral in place.

UOC00 Clay (unknown origin)

Some clay deposits cannot be attributed to any particular origin. Such deposits should be placed in this category.

WMU00 Weathered material (origin unknown)

This category covers those materials that are weathered, and so are regolith, but contain no features that allow them to be characterised as being either in situ or transported.

UOS00 Sand (unknown origin)

Some sand deposits, particularly in inland locations, cannot be attributed to any particular origin. Such deposits should be placed in this category.

VOL00 Volcanic material

Material derived from igneous activity at the surface.

VOL01 Lava

Igneous rocks solidified after eruption on to the land surface.

VOL02 Volcanic ash (tephra)

Material deposited on the land surface after ejection from a volcano. It often contains a proportion of highly weatherable glass, and mantles the landscape.

WIR00 In situ weathered rocks

Rock masses that have suffered chemical, mineral and physical changes on exposure to land surface processes, resulting in a loss of up to 85% of the rock strength (Speight and Isbell 1990). Weathered rocks have thus been altered by weathering processes such that they are broken into smaller fragments and/or changed in composition. The degree of weathering can vary from slight to complete (see under Degree of Weathering).

WIR10 Saprolith

In situ regolith produced by weathering of rock masses due to exposure to land surface processes. A number of terms are in general use for naming all or parts of a weathering profile. Some definitions are given here, with preferred terms for use in RTMAP indicated. An undisturbed deep weathering profile consists of an upper soil layer and a lower *in situ* weathered layer. The former is developed from the material below, but may have been disturbed. It is best classed as residual material. The latter is quite undisturbed.

The various layers or zones in deep weathered regolith are often assumed to be genetically related. In some cases this may be true, but there are so many exceptions reported in the literature that we have chosen to leave out all genetic connotations in our definitions. Moreover, the various layers do not always occur in the same sequence, making genetic implications suspect in many cases.

The term *lateritic profile* is sometimes used to refer to a particular type of deep weathered regolith that has ferruginous upper layers, and kaolinised lower layers.

WIR11 Saprock

Saprolite that still contains rock structure, and in which only a relatively small proportion of the weatherable minerals in the original rock have been altered.

WIR12 Moderately weathered bedrock

Moderately weathered bedrock has strong iron staining, and up to 50 % earth material. Corestones, if present, are rectangular and interlocked. Most feldspars have decayed, and there are microfractures throughout. Moderately weathered rock can be broken by a kick (with boots on), but not by hand.

WIR13 Highly weathered bedrock

Highly weathered bedrock has strong iron staining, and more than 50% earth material. Core stones, if present, are free and rounded. Nearly all feldspars are decayed, and there are numerous microfractures. The material can be broken apart in the hands with difficulty.

WIR14 Very highly weathered bedrock

Very highly weathered bedrock is produced by the thorough decomposition of rock masses due to exposure to land surface processes. The material retains structures from the original rock. It may be pallid in colour, and is composed completely of earth material. Corestones, if present, are rare and rounded. All feldspars have decayed. It can easily be broken by hand.

WIR15 Completely weathered bedrock

Completely weathered bedrock retains no structures from the original rock. There are no corestones, but there may be mottling. It is composed completely of earth material.

WIR15.1 Mottled zone

Material, usually strongly weathered, where iron segregation results in the development of ferruginous mottles, commonly reddish in colour. Size of mottles can range from millimetres to tens of centimetres. The latter are sometimes called megamottles. The mottled zone is frequently near the top of a deeply weathered regolith profile, lying above the pallid zone.

WIR15.2 Pallid zone

Kaolinised zone usually found in the lower part of a weathering profile. This zone is generally light grey to white in colour, and may or may not retain original rock structure.

WIR16 Saprolite

The term *saprolite* (Becker 1895) is used in RTMAP to refer to all those parts of a weathering profile which have been formed strictly *in situ*, with interstitial grain relationships being undisturbed. This contrasts with residual material, which has been disturbed (see below, WIR20). Saprolite is altered from the original rock by mainly chemical alteration and loss without any change in volume. This is sometimes referred to as constant volume alteration. Saprolite is often equivalent to the C horizon in pedology. Some workers confine the use of the term to weathered material below the zone of pedological alteration (or pedoplasmation - Flach *et al.* 1968).

WIR20 Residual material

Material derived from weathering of rock and remaining in place after part of the weathered material has been removed. It results from loss of volume from the weathered mass.

WIR21 Lag

A deposit, commonly thin, of fragments larger than sand size, spread over the land surface. Its most common origin is as the coarse material left behind after fine material has been transported away by wind or, less commonly, sheet flow.

WIR22 Residual sand

A deposit of sand sized material, commonly composed largely of quartz, covering the land surface, and derived from the removal of finer material either in solution or suspension in subsurface water. It includes the sandy top of some soil types.

WIR23 Residual clay

Clay material that remains behind after weathering has removed part of the original rock. A common example is the clay soil material found on limestone after solution has removed the calcareous part of the rock.

WIS00 Shallow soil on fresh bedrock

In some areas, particularly on steep slopes, or on young surfaces, the regolith consists of soil material up to 2 m thick formed directly on the underlying bedrock. Commonly the soil has a skeletal profile, and is less than 1 m thick.

4.7.2 Induration

IN00 Indurated material

Regolith material that has been hardened and/or cemented to some degree. This category can be further subdivided according to the dominant indurating material, as follows:

IB00	Bauxitic induration
IK00	Calcareous induration
IC00	Clay induration
IF00	Ferruginous induration
IG00	Gypsiferous induration
IS00	Siliceous induration

DU00 Duricrust

Mass of hard material formed within the regolith by either relative or absolute accumulations of natural cements in sediment (which may be variably weathered), saprolite or partially weathered rock.

DC00 Completely cemented duricrust

Smooth textured duricrust where >90% of the material has been cemented. The suffix "crete" is used for these materials.

DC10 Alcrete (bauxite)

Completely cemented duricrust cemented mainly by aluminium compounds.

DC20 Calcrete

Completely cemented duricrust cemented mainly by calcium carbonate.

DC40 Ferricrete

Completely cemented duricrust cemented mainly by iron.

DC41 Massive ferricrete

Ferricrete which has little or no internal differentiation.

DC42 Nodular ferricrete

Ferricrete that is differentiated internally and gives the appearance of cemented nodules.

DC50 Gypcrete

Completely cemented duricrust cemented mainly by gypsum.

DC60 Silcrete

Completely cemented duricrust cemented mainly by silica. These materials can be further subdivided as follows:

DC61 Silcrete sheet
DC62 Silcrete pods

DM00 Moderately cemented duricrust

Duricrust where the material is 70 - 90% cemented. It often has a grainy texture and may be mottled. These materials can be further subdivided as follows:

DM20 Calcareous
DM40 Ferruginous
DM60 Siliceous

DP00 Partially cemented duricrust

Duricrust with less than 70% cemented material, often with an open texture, for which the term hardpan is used. This category can be further subdivided:

DP10 Bauxitic
DP30 Clay
DP40 Ferruginous
DP60 Siliceous
DP70 Humic

NO00 Nodules

Nodules are irregular to spherical units of regolith material that occur enclosed within the regolith, as lag, or in duricrusts. They generally have rounded edges. They are distinct because of a greater concentration of some constituent, a difference in internal fabric or a distinct boundary with the surrounding material. We use the term as more or less equivalent to the *glaebule* of Brewer (1964). It does not include fragments of weathered rock, or coarse sedimentary particles unless they have been modified. For example, a fragment of rock weathered and coated with a cutan would fit our definition.

There are many possible subdivisions of this category, such as pisoliths and concretions. These may be included in revisions. The following subdivisions of this category are included at this time:

NO10 bauxitic nodules
NO20 calcareous nodules
NO30 clay nodules
NO40 ferruginous nodules
NO60 siliceous nodules

4.7.3 Degree of Weathering

For each regolith type listed above it is necessary to assess the degree of weathering. Speight and Isbell (1990) have developed a schema for *in situ* rocks. We have modified this slightly, and have included practical tests from Ollier (1965). We have extended Speight and Isbell's schema to cover transported materials. It should be noted that this assessment is for chemical weathering only. Physical weathering can be assessed on the degree to which rocks have been broken into smaller particles.

0 Unknown

This category is used during reconnaissance mapping when an RTU has been recognised on imagery or maps, but has not been visited in the field.

1 Unweathered

Regolith with no visible signs of weathering. Normally this class will be confined to sedimentary regolith types because, by definition, fresh bedrock is not regolith.

2 Slightly weathered

Slightly weathered rock has traces of alteration, including weak iron staining, and some earth material. Corestones, if present, are interlocked; there is slight decay of feldspars, and a few microfractures. Slightly weathered rock is easily broken with a hammer.

Slightly weathered sediments have traces of alteration on the surfaces of sedimentary particles, including weak iron staining. Some earth material may be present, filling voids between coarse particles.

3 Moderately weathered

Moderately weathered rock has strong iron staining, and up to 50% earth material. Corestones, if present, are rectangular and interlocked. Most feldspars have decayed, and there are microfractures throughout. Moderately weathered rock can be broken by a kick (with boots on), but not by hand.

Moderately weathered sediments have strong iron staining, and up to 50% earth material. Labile particles up to gravel size are completely weathered. Larger particles have thick weathering skins. Most feldspars in larger particles have decayed.

4 Highly weathered

Highly weathered rock has strong iron staining, and more than 50% earth material. Core stones, if present, are free and rounded. Nearly all feldspars are decayed, and there are numerous microfractures. The material can be broken apart in the hands with difficulty.

Highly weathered sediment has strong iron staining, and more than 50% earth material. All except the largest particles are weathered right through. Boulders have thick weathering skins.

5 Very highly weathered

Very highly weathered rock is produced by the thorough decomposition of rock masses due to exposure to land surface processes. The material retains structures from the original rock. It may be pallid in colour, and is composed completely of earth material. Corestones, if present, are rare and rounded. All feldspars have decayed. It can easily be broken by hand.

Very highly weathered sediment is thoroughly decomposed, but still retains the shapes of the original sediment particles, as well as laminations and bedding. It is composed completely of earth material.

6 Completely weathered

Completely weathered rock retains no structures from the original rock. There are no corestones, but there may be mottling. It is composed completely of earth material.

Completely weathered sediment retains no structures from the original sediment. It is composed completely of earth material. There may be mottling.

4.7.4 Zone Data

This section defines some of the attributes recorded for zones.

Boundary

The following definitions are from McDonald and Isbell (1990).

Lower boundary-shape

SM	smooth	almost a plain surface
W	wavy	undulations with depressions wider than they are deep
I	irregular	undulations with depressions deeper than they are wide
T	tongued	depressions considerably deeper than they are wide
D	discontinuous	the zone is itself discontinuous

Lower boundary-type

SH	sharp (<5 mm wide)	D	diffuse (50-100 mm wide)
A	abrupt (5-20 mm wide)	G	gradual (>100 mm wide)
C	clear (20-50 mm wide)		

Consistence

Consistence refers to the strength of cohesion and adhesion in soil and regolith materials. Strength will vary according to water status. Strength is the resistance to breaking or deformation. Stickiness is a characteristic determined on wet material. McDonald and Isbell (1990) discuss these properties further, and provide definitions and means of determination.

Soil strength is determined subjectively by the force just sufficient to break or deform a 20 mm piece of material when a compressive force is applied between thumb and forefinger.

S0	loose	No force required. Separate particles such as loose sand
S1	very weak (<25 kPa)	Very small force, almost nil
S2	weak (25-50 kPa)	Small but significant force
S3	firm (50-100 kPa)	Moderate or firm force
S4	very firm (100-200 kPa)	Strong force but within power of thumb and forefinger
S5	strong (200-400 kPa)	Beyond power of thumb and forefinger. Crushes underfoot
S6	very strong (>400 kPa)	Either crushes under foot with difficulty, or not at all

Stickiness is determined on wet material by pressing the wet sample between thumb and forefinger and then observing the adherence of material to the fingers.

NS	non-sticky	Little or no material adheres
SS	slightly sticky	Soil adheres to thumb and forefinger but is not stretched notably and comes off rather cleanly
MS	moderately sticky	Soil adheres to thumb and forefinger and tends to stretch rather than pull free of fingers
VS	very sticky	Soil adheres strongly to thumb and forefinger and stretches notably

Rock strength

Rock strength is the strength of the intact material rather than that of the mass, the strength of which has generally been reduced by jointing, fracturing etc.

	Strength	knife	pick	hammer
R1	very low, (1.5-3 Mpa)	deep cut	crumbles	flattened or powdered
R2	low, (3-10 Mpa)	Shallow cut or scratch	Deep indent	Shattered into many small fragments
R3	medium, (10-25 Mpa)	Nil or slight mark	Shallow indent	Breaks readily into a few large and some small fragments
R4	high, (25-80 Mpa)	Nil	Nil	Breaks into one or two large fragments
R5	very high (>800 Mpa)	Nil	Nil	Nil

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