PRELIMINARY CHARACTERISATION OF REGOLITH MATERIALS FROM TOP CREEK CATCHMENT, CENTRAL WEST NSW: CONTROLS ON FLUID FLOW AND COMPOSITION

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INTRODUCTION

The Top Creek Catchment, approximately 35 km south of Cowra in central west NSW (Figure 1), sits on regolith developed on Silurian (Douro) Hawkins felsic volcanic rocks and the Young Granodiorite. This study forms part of a broader project that describes Top Creek Catchment in its regional geological and regolith setting and uses regolith-landform mapping to facilitate interpretation of shallow fluid-flow patterns in the Top Creek area (Hadrill & Moore 2002). Indicators of dryland salinity have been recognised in this area for a number of years (Wooldridge 1999) and mitigation strategies applied in the adjacent Breakfast Creek Catchment to the north have been used as a case study for dryland salinity hazard management in the past (Hayman 1996). The Top Creek Landcare Groups are keen to evaluate the extent of the land salinisation problem in the Top Creek Catchment.

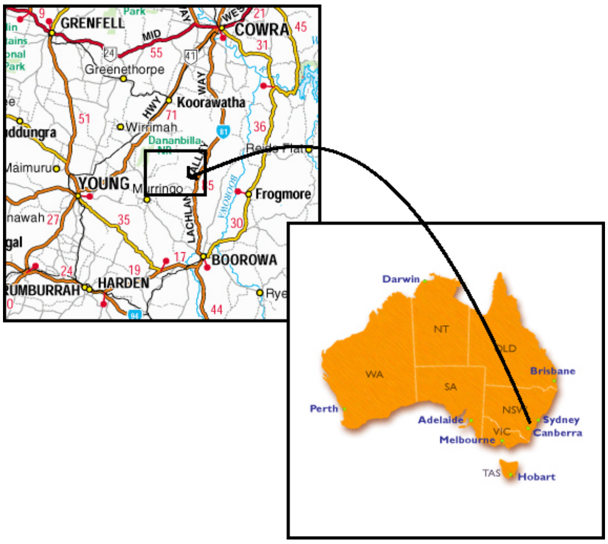

Figure 1: Location of Top Creek (NRMA 2002).

This study aims to provide a preliminary description of the physical characteristics of the regolith materials developed on the two principal lithologies in the Top Creek Catchment. This work will enable a comparison with previous work on the Young Granodiorite and felsic volcanic rocks of the Illunie suite, from the Upper Tyagong area (Southwell 2001). This comparison is important because the Illunie Volcanics have been segregated into a different part of the groundwater-flow-system (GFS) classification (Coram *et al.* 2000) than the Hawkins Volcanics. This study provides a framework to establish whether there is a scientific basis for the difference in classification or whether the classification should be modified. This work complements detailed regolith-landform mapping in the area that will assist with the evaluation of salt stores in the landscape surrounding Top Creek and help show how this salt can be mobilised into the hydrologic system.

Identifying the causal factors that lead to symptoms of dryland salinity is highly important when sustainable management of land is to be achieved. A multidisciplinary approach is required in an attempt to manage the problem, and therefore assist in salinity hazard mitigation. Characterisation of GFS using regolith-landform mapping techniques can help define the range of mitigation strategies that will be most appropriate for a given area. With the availability of remotely sensed imagery one can further interpret the current extent of land affected by dryland salinity and delineate areas exposed to potential problems.

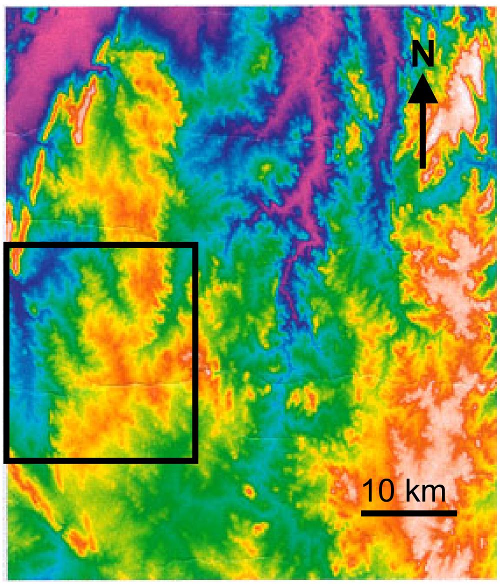

Figure 2. Top Creek Catchment study area (box). Boorowa 1:100,000 sheet Digital Elevation Model (NSW DMR 2000).

PHYSIOGRAPHY

The study area lies in an upland catchment where streamflow is regionally controlled by landscape features (Figure 2). From the eastern mapping boundary, the landscape displays a stepped sequence where the landforms grade from alluvial plains upward into rises and low hills and eventually broaden into a north-south trending plateau. In the north of the area, this landform trends to the northwest, bounding the northern part of Top Creek Catchment. The western flank of the plateau is defined by Stony Creek, a northerly flowing tributary that flows along a north-south lineament into the westerly flowing Top Creek. A smaller plateau in the south is confined by Stony Creek to the east, and a series of smaller tributaries such as Spring Creek that flow along sub-parallel paths, in a north by northwest direction into Top Creek. Washpan Creek flows from the north into Top Creek, and is bounded by a north-south trending plateau to the east and to the north. Distinctive sandstone ridges trend north-south, physically bounding the mapping area to the west. They have been classified as erosional hills, with relief up to 300 m above local drainage.

REGIONAL GEOLOGY

The Silurian felsic volcaniclastic Douro Group occurs within the Cowra-Yass Synclinorial zone, which extends 520 km from an area south of Dubbo towards Yass, in the Palaeozoic Lachlan Fold Belt. The Douro Group includes the Hawkins Volcanics, the Yass Sub-Group and the Willow Bridge Tuff. It is one of the most widely outcropping of all Silurian rock units, extending north from Canberra to just south of Cowra in an elongated belt, widening to 40 km in some areas (Offenburg 1974, Pickett & Bradley 1982).

The Douro Group is dominantly composed of extensive, uniform, coarse, dark-grey to grey-green crystal tuffs of dacitic to rhyodacitic composition. These contain coarse phenocrysts of quartz and plagioclase with accessory alkali feldspar, biotite, and hornblende arranged in a fine-grained matrix. The crystal tuffs are rarely flow-banded and resemble ignimbrites. Most of these volcanics were deposited in partly subaerial, and partly shallow-marine environments (Pickett & Bradley 1982).

THE INFLUENCE OF BEDROCK ON FLUID FLOW

Apart from finer grain size, volcanic rocks possess broader scale structural characteristics that greatly differ from plutonic rocks. Rapidly cooled volcanic rocks have a much more complex fracture pattern that affects not only the way they are weathered but also how fluid flows through them. Greater joint frequency gives preferred access to groundwater, however, larger faults can become barriers if they are filled with impermeable material, e.g. quartz veins. Pyroclastic rocks are typically porous although not very permeable due to poor sorting and an abundance of fine material (Erdelyi 1988). Differential sorting in volcanic ash beds may form semi-horizontal barriers to groundwater flow. If interbedded with sedimentary material, the overall porosity is increased and therefore water storage ability too. If these rocks are interconnected with fractured, more permeable sediments or lava, then a water conduit is created between storage rocks and recharge areas (Erdelyi 1988).

In the Boorowa-Yass area, one of the main influences on groundwater flow is the physical character of the bedrock (Nicoll & Scown 1993). Bedrock of low hydraulic conductivity, for example Silurian volcanics, permits less recharge to the groundwater system compared with Ordovician sediments, where the hydraulic conductivity can be a higher by a factor of ten. Tree cover significantly modifies the amount of water flowing through different rock types, i.e. landscapes with a higher tree coverage tend to recharge less than those with lower tree cover (Nicoll & Scown 1993).

METHODS

A regolith-landform map is currently being compiled for Top Creek at 1:15,000 scale using stereo-pair aerial photographs, and available topographic and geological map resources (e.g. Johnston *et al.* 2001). Map units are ground truthed through visual interpretation of regolith-landforms in the Top Creek Catchment. Geophysical data sets (e.g. gamma spectroscopy, aeromagnetics) and other remotely sensed imagery (e.g. ASTER, SPOT, Landsat TM) are being used to aid mapping and detailed landform analysis. Manipulation of ASTER data has enabled a more detailed interpretation of remnant vegetation coverage compared with more conventional datasets (e.g. Landsat and SPOT satellite imagery). Regolith samples have been collected from regolith profiles over Hawkins Volcanics and Young Granodiorite substrates for analysis in the laboratory. Soil colour, texture, pore water (1:5), pH, EC and soil moisture tests were conducted. These data provide a preliminary framework for an ongoing study of mineralogical, chemical and physical features of the regolith in the study area. Regolith material collected on the Young Granodiorite acts as a control for comparison between this study of the Hawkins Volcanics and previous work on the Illunie Volcanics.

RESULTS

Regolith-Landforms

Mapped regolith-landform units (RLUs) have allowed for preliminary interpretation of the dominant features exhibited in the study area. Landforms underlain by the Young Granodiorite tend to have more subdued relief compared with landforms developed on the Hawkins Volcanics. The landforms on the granitic rock are characterised by a thicker regolith veneer. Exposed rock is mostly confined to hilltops where tors are up to 5m in height. Meandering channels ranging from 5 m to 20 m wide dominate the drainage pattern in this landscape. Depositional landforms are more common in the lower parts of the Top Creek Catchment, where channel sediments are composed of quartzose and lithic gravels and sands. In the eastern part of the study area, developed on Hawkins Volcanic rocks, landscapes are notably different. Outcrops are more abundant but are generally smaller in size (up to 2 m relief) and have a more scattered distribution. The regolith veneer is thinner and drainage patterns and channel morphology are more directly influenced by the underlying bedrock. Channels located in the headwaters of Top Creek are incised and partially confined by subcropping bedrock.

Interpretation of ASTER Imagery

ASTER imagery can be used to interpret the extent of remnant vegetation in the study area (Figure 3). The degree and type of vegetation cover has been delineated at a useable resolution through manipulation of appropriate band combinations. These include ASTER bands 3N (red), 2 (green) and 1 (blue), and consequently areas in red (grey) indicate modified pasture and areas under crop. Dark and pale green (black & dark grey) regions are representative of extant or native vegetation, and the white shades reveal soils with little covering such as ploughed fields.

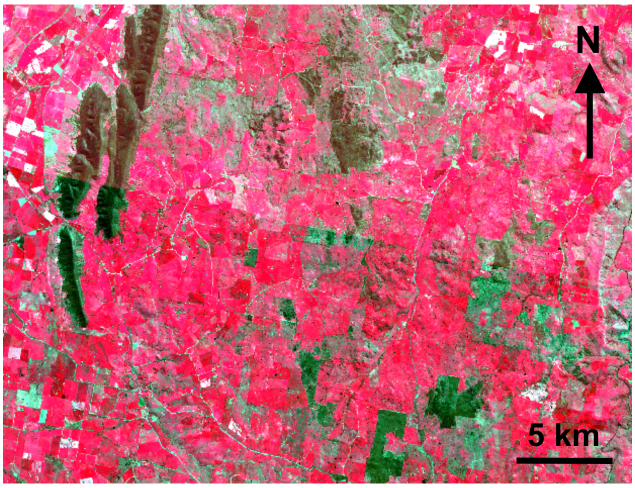

Figure 3: ASTER image of the study area. Vegetation type and cover is delineated through manipulation of reflectance bands 3 (red), 2 (green) and 1 (blue).

Analysis of Regolith Materials

Analysis of regolith profiles has revealed notably different patterns in moisture content at depth. Profiles on the Young Granodiorite show increased moisture content in the slightly weathered bedrock and alluvial profiles in the upper horizons (Figure 4). In comparison, the alluvial and colluvial materials in the Hawkins Volcanic profiles, show an increase in moisture content with depth. Subcropping bedrock and colluvial profiles on Young Granodiorite show a slight increase in moisture with depth. Profiles for subcropping bedrock and slightly weathered bedrock on the Hawkins Volcanics remained relatively constant in moisture content (Figure 4).

Regolith Moisture Content - Young Granodiorite & Hawkins Volcanics

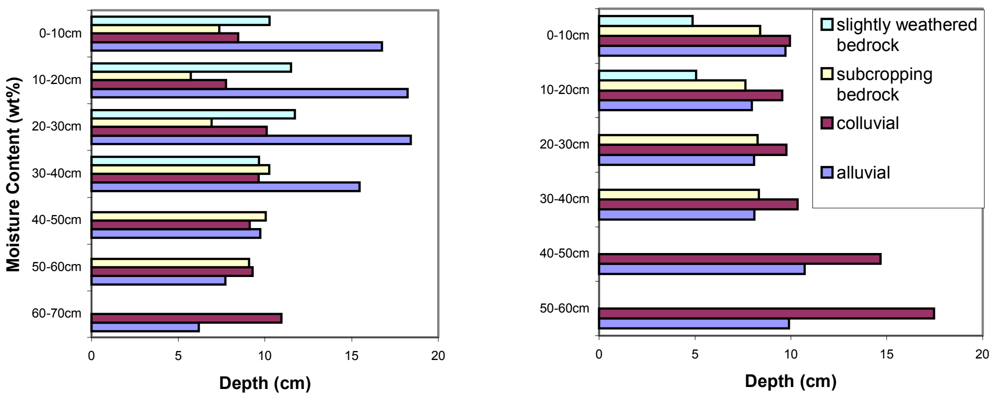

Figure 4: Regolith moisture content (wt. %) for Young Granodiorite (left) and Hawkins Volcanics (right) samples.

In general, the pH readings for both colluvial and alluvial profiles increase steadily with depth for granodioritic regolith material (Figure 5). Readings taken from slightly weathered bedrock and subcropping bedrock profiles show no notable trends. The electrical conductivity (EC) readings taken from the alluvial profile on granodiorite steadily decreases with depth. The 0-10 cm horizon has notably higher EC readings overall when compared with remaining horizons for that rock type.

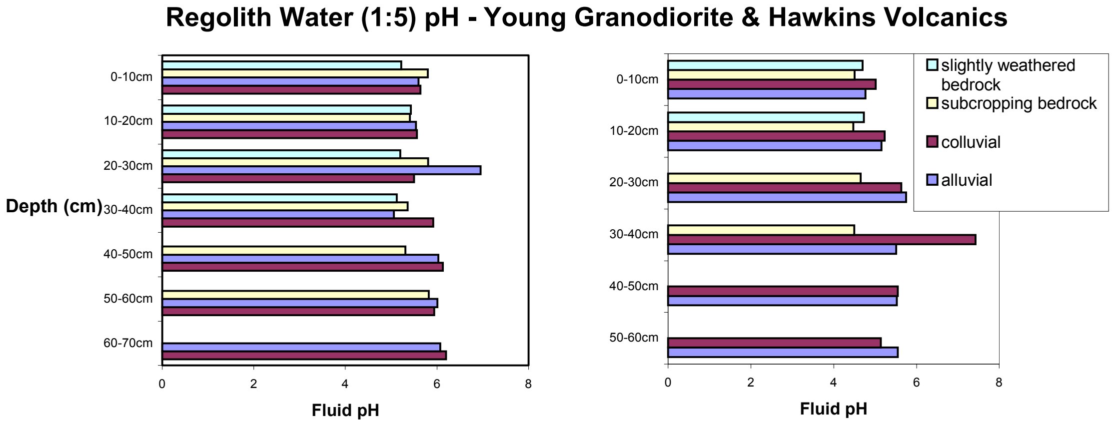

Figure 5: Regolith water pH for Young Granodiorite (left) and Hawkins Volcanics (right) samples.

Readings for pH taken from colluvial and alluvial profiles on Hawkins Volcanics exhibit an increase in pH to a depth of approximately 20-40cm and then decrease at a steady rate. Slightly weathered bedrock and subcropping bedrock profiles show relatively consistent pH for the measured horizons (Figure 5). Electrical conductivity (EC) measurements on Hawkins Volcanics profiles reveal a less distinct trend, however readings are considerably higher in horizons at depth in the alluvial and colluvial profiles (Figure 6).

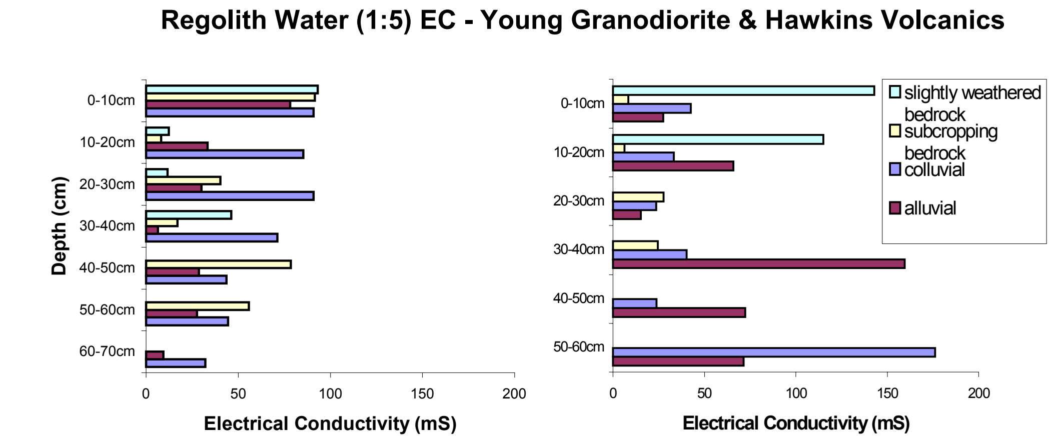

Figure 6: Regolith water electrical conductivity (mS) for Young Granodiorite (left) and Hawkins Volcanics (right) samples

DISCUSSION AND PRELIMINARY CONCLUSIONS

From observation of regolith-landform units in the study area and review of previous literature, one of the most influential factors controlling regolith and landform distribution is the underlying rock type. The fractured rock typical of upland catchments are the source of weathered materials forming the regolith veneer and provide the framework on which the landforms are structured. Evolution of the landscape features is then controlled by a series of environmental factors including: climate; time; biological activity; and land use. Regolith-landform features differ on the Young Granodiorite and Hawkins Volcanic units. For example, the coarser-grained plutonic material of the granodiorite has physically weathered in a more systematic manner compared with the felsic volcanic rocks. Because the crystal grains in the granodiorite have cooled at a slower rate, there is a greater capacity for crystals to have an intergrown texture, and the rock a more isotropic character. As a result, joints are distributed more regularly in the granodiorite and therefore tor distribution is more regular in the granodioritic landscape. The joint distribution is highly irregular in the Hawkins Volcanic unit and this leads to formation of more rubbly outcrops compared with the Young Granodiorite.

Young Granodiorite and Hawkins Volcanics also have different regolith moisture distribution, and regolith water pH and EC characteristics. Most moisture is held in the near surface for alluvial sediments on the granodiorite reflecting a well-developed soil interval on these materials. In contrast most moisture is held in the shallow subsurface of colluvial sediments for the Hawkins Volcanics indicating that water flows through the rocky upper part of the regolith profiles relatively readily. Although pH values remain relatively constant for profiles on both rock types, the average pH is relatively acid (pH 6) reflecting the chemistry of the felsic igneous substrates. The EC values show a decrease with depth on the Young Granodiorite suggesting that salt accumulation may be associated with the well-developed soil on this unit. In contrast the EC values for the Hawkins Volcanics show much greater fluctuations and reach elevated levels for different regolith materials at different depths. Skeletal soils developed over slightly weathered bedrock show elevated EC readings, perhaps as a result of evaporative concentration of salts in this zone. Elevated EC readings also correspond with the upper parts of the moist colluvial intervals, implying that salts are mobilised in laterally flowing shallow groundwater. On alluvial sediments the highest EC values are at slightly greater depths, also associated with shallow groundwater in this setting.

The observed veneer of regolith cover broadly thickens to the south on the Hawkins Volcanic unit. This is possibly a consequence of weathering processes preferentially occurring at different locations in different catchment settings. The Hawkins Volcanic unit extends across several catchment boundaries where a variety of localised processes could differentiate between weathering rates for the unit. However, there is also evidence for a Silurian marine transgression to the south of the study area (Johnston *pers. comm.* 2002) and this may contribute to a thicker regolith veneer to the south.

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