KRAWAREE WEST, UPPER SHOALHAVEN RIVER CATCHMENT, NSW

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INTRODUCTION

The Shoalhaven River catchment has been a focus of Australian landscape evolution studies throughout much of the 20th Century (see references later), however the upper part of the catchment has received less attention. This study was initiated as a re-assessment of previous interpretations of tectonic offset of Cainozoic basalts along the Shoalhaven Fault in this area (Lewis, 2000; Lewis and Roach, 2000; Lewis *et al.*, 2002) but also included regolith-landform mapping. This case study outlines some of the regolith and landform features of this area.

PHYSICAL SETTING

Location

The Krawaree West area is defined by the western parts of the Krawaree 1:25,000 topographic sheet. The mapsheet area is named after Krawaree homestead which is approximately 50 km southeast of Canberra (Figure 1).

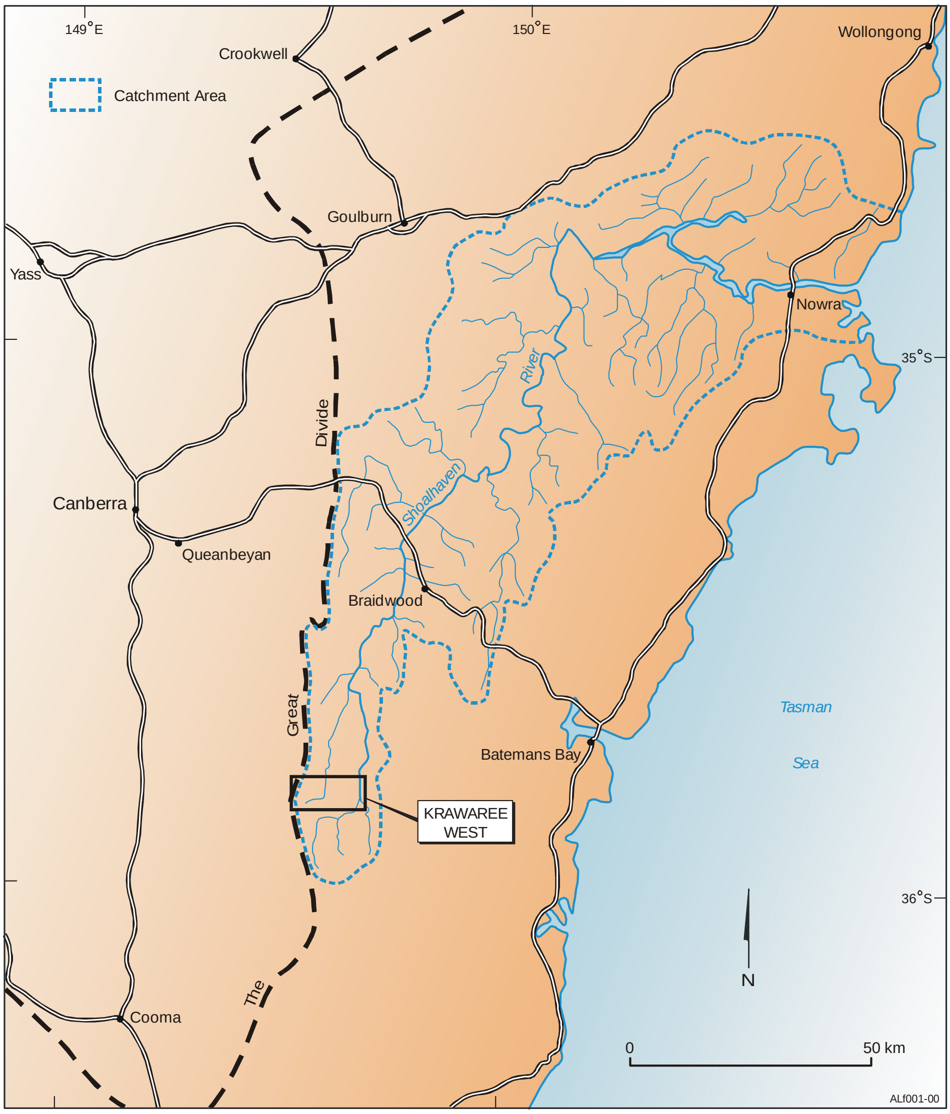

Figure 1. Location of Krawaree West study area (from Lewis, 2000).

Geology

The study area is within the Palaeozoic Lachlan Fold Belt and here includes: Ordovician metasediments (interbedded quartz sandstone, siltstone and shale); Silurian volcanics (Kadoona Dacite, Toggannoggra Rhyolite, Kain Porphyry); Devonian granites (Jinden Adamellite, Ballallabra Adamellite, Gourock Granodiorite); and, Upper Devonian sedimentary rocks, principally "red bed" coarse sandstones and conglomerates (Minuma Range Group) (Wyborn and Owen, 1982; 1986). The study area is cut by a series of meridional and NE-SW striking fractures which are conjugate with others outside the study area. The Shoalhaven Fault is a high angle reverse fault that trends N-S in the western part of the study area, and corresponds with a linear range-front. The Mulwaree Fault is another major structure that trends NW-SE across the Gourock Range in the study area, and in part corresponds with the headwaters of Jerrabattgulla Creek. The Gundillion Fault in the east of the study area does not have a prominent landscape expression in this area, although its N-S trend closely corresponds with the eastern margin of the Shoalhaven River valley.

Cainozoic sediments and basaltic lavas include many of the materials described below as regolith materials. This includes Miocene (19.1 ± 0.4 Ma) basalt that has been previously interpreted as being displaced by the Shoalhaven Fault (Wyborn & Owen, 1982; 1986), but are most likely an incised pile of flows that have been topographically inverted (Lewis 2000, Lewis *et al.*, 2002).

Geomorphology

The area is within the Eastern Highlands and is in the upper part of the Shoalhaven River catchment which here includes the generally northerly flowing Shoalhaven River and the major tributary Jerrabattgulla Creek. Topographic relief is up to 500 m, associated with narrow valleys that open towards the north into the middle Shoalhaven Plain (Craft,1931; Galloway, 1969). The western portion of the area includes the Gourock Range and a sub-linear easterly facing range-front which closely approximates the position of the Shoalhaven Fault (Figure 2). A bedrock-dominated ridge trends approximately N-S through the central part of the area and includes Mt Italy and Jinden Hill. The Gourock Range includes the continental Drainage Divide referred to as ‘The Great Divide’, which in this case is the interfluve between the Shoalhaven River catchment which ultimately flows into the Tasman Sea to the east, and the Queanbeyan River catchment which ultimately flows through the Murrumbidgee and Murray River systems into the Southern Ocean (Figures 1 and 2).

Climate

Rainfall in the area is evenly distributed throughout the year, with annual rainfall amounts typically between 600 and 900 mm (Bureau of Meteorology, 2004). The mean maximum annual temperature is 18-22°C (Bureau of Meteorology, 2004).

Vegetation

The dominant vegetation type in the area is wet and dry sclerophyll woodland dominated by eucalypts. Wet sclerophyll forests mostly occur on easterly- and southerly-facing slopes and gullies, and dry sclerophyll forest mostly occurs on northerly- and westerly-facing slopes. Much of the original vegetation on areas of lower relief has been cleared—alluvial plains and adjacent slopes host pasture for sheep and cattle grazing and limited grain production, and many rises and hills host pine (*Pinus radiata*) plantations.

REGOLITH-LANDFORM RELATIONSHIPS

Weathered Bedrock

Differential weathering of the variety of bedrock types and structures largely accounts for the different landform settings of weathered bedrock in the area. Slightly weathered bedrock may form a variety of landforms such as erosional rises, hills and mountains (in the west) with some exposures within alluvial channels. It mostly occurs within areas of Ordovician metasediments, Jinden Adamellite and a prominent ridge of Gundillion Conglomerate (Minuma Range Group) in the northeastern part of the area. Moderately weathered bedrock is restricted to erosional rises mostly within areas of granite bedrock, such as the Jinden Adamellite. Highly weathered bedrock mostly conforms to small zones within weathering profiles typically exposed in road cuttings, such as along the Braidwood – Cooma Road.

Alluvial Sediments

Sediments underlying rises and low hills capped with basalt are interpreted to represent topographically inverted sediments associated with the pre-basaltic (pre-Miocene) Jerrabattgulla Creek catchment. Exposures of these sediments that have been silicified are interpreted to have formed from palaeo-groundwater aquifers and associated springs. Contemporary alluvial sedimentation is mostly confined to the axes of valley systems, and includes channels, swamps, depositional plains, fans and drainage depressions.

Colluvial Sediments

Colluvial sediments are at least a minor component of all regolith-landform units in the area, particularly in the higher relief areas . A series of detailed slope studies in the area showed that slopewash was more significant than soil creep in accounting for downslope movement of regolith (Williams, 1972; Williams, 1973; Williams, 1978; Clarke *et al.* 1999). Prominent landslide and debris flow deposits occur along the Jerrabattgulla Creek valley in association with the basalt and sub-basaltic sediments. This association is interpreted to reflect saturation and discharge of intra-basaltic and sub-basaltic aquifers, and create a local geohazard risk near houses and infrastructure in this area.

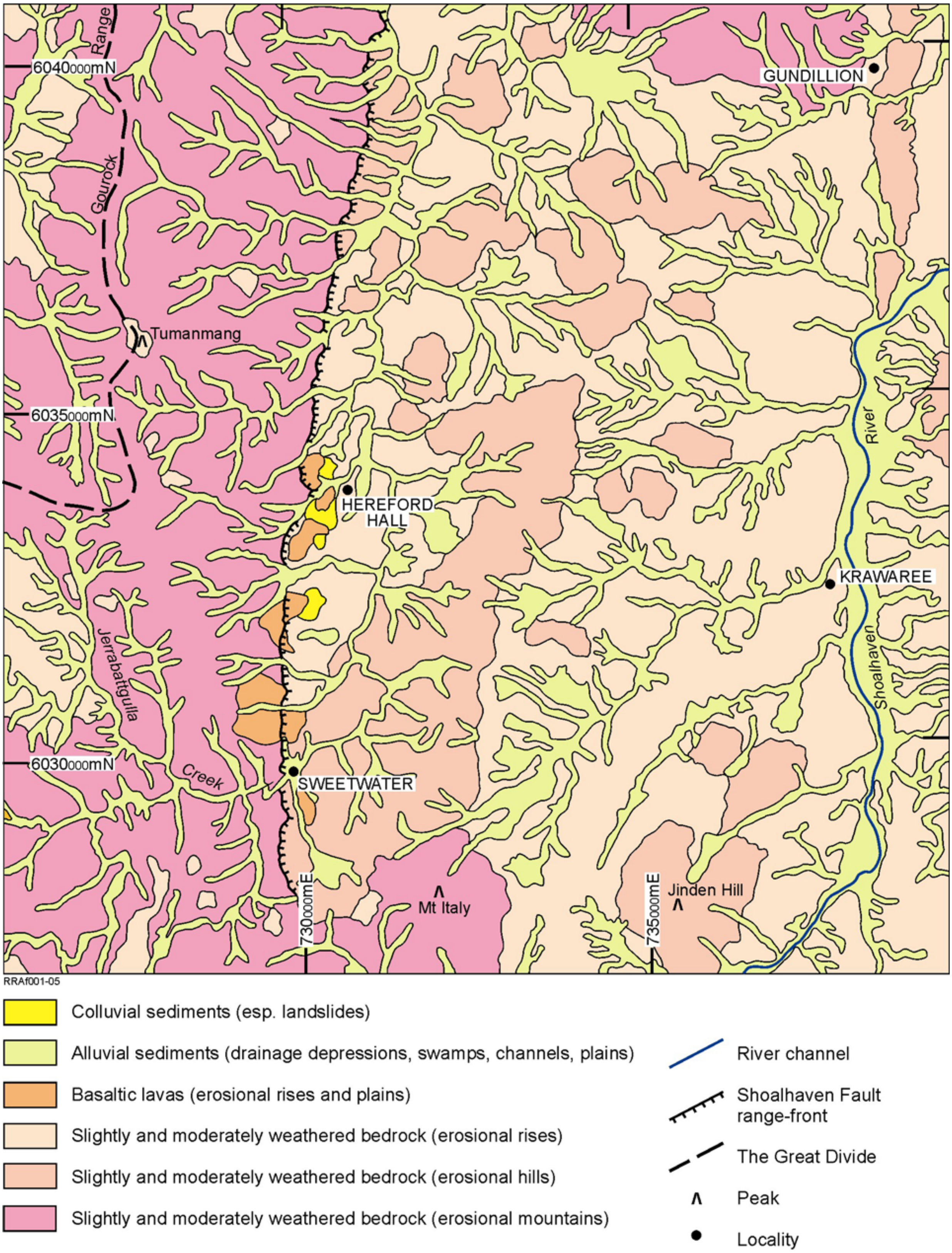

Figure 2. Simplified regolith-landform map (after Lewis, 2000).

Volcanic Regolith

Valley-filling flows of basalt extend along the Jerrabattgulla Creek valley from Sweetwater in the south to Hereford Hall in the north. Each of the 8 mapped basalt flows have distinctive flow terraces (here interpreted to be erosional rather than primary) and collectively they form erosional rises above the contemporary valley of Jerrabattgulla Creek (Figure 3). The low gradient of individual lava flows suggests that they were valley-filling from south to north, rather than having flowed eastwards across the existing rangefront associated with the Shoalhaven Fault.

REGOLITH CHARACTERISATION

Weathered Bedrock

Weathered bedrock occurs in the area with various degrees of weathering ranging from slightly and moderately weathered bedrock to localised patches of highly weathered bedrock. Exposures of weathering profiles occur most frequently on the Jinden Adamellite, although rare exposures of Ordovician and Devonian bedrock occur in the east of the study area. Slightly weathered bedrock exhibits minor alteration, such as minimal iron-oxide surface staining, and core stones are typically angular and tightly interlocking in the Jinden Adamellite (Figure 3). Moderately weathered bedrock typically has strong iron-oxide staining and mostly forms rounded tors and corestones with relatively open joint spaces in the Jinden Adamellite. Highly weathered bedrock is clay-rich and contains prominent iron-oxide staining. It still retains the primary bedrock fabrics (saprolite) and its upper transition to transported regolith is typically marked by a distinctive stoneline, particularly on the Jinden Adamellite. Weathering profiles are shown in many road cuttings to locally extend over 3 m deep, although Galloway (1969, p.83) reports of weathering depths of up to about 100 m. Ordovician rocks tend to be moderately to highly weathered in exposures, with crumbly textures and open joints in local shales. Ordovician sandstones and Devonian sedimentary rocks tend to be slightly to moderately weathered and prominently iron oxide-stained, particularly the Devonian sedimentary rocks.

Alluvial Sediments

Sub-basaltic sediments consist mostly of poorly-sorted quartz and kaolinite gravels, sands, silts and clays, which include zones cemented by micro-crystalline quartz (silcrete). Silicification occurs as grey, massive, tabular ‘pods’, with whole rock silica contents between 97.7 and 98.2 wt % and minor amounts of TiO_2 (0.42-0.71 wt %) mostly in the form of micro-crystalline anatase and Fe_2O_3 in the form of hematite.

Colluvial Sediments

Although minor colluvial deposits are widespread in the area and contain a wide range of local rock types, the most distinctive landslide and debris flow deposits occur in the Jerrabattgulla Creek valley, containing a mixture of weathered basalt and associated clays as well as clasts of quartzose sands and gravels derived from the sub-basaltic gravels. These have been observed moving after heavy rain by local landholders.

Volcanic Regolith

Basalts in the study area contain olivine nephelinite, nepheline basanite, nepheline tephrite, nepheline hawaiite, hypersthene hawaiite, hypersthene trachybasalt, hyperthene basalt and quartz tholeiite (Lewis, 2000). These basalts are mostly slightly to moderately weathered, and locally include columnar basalts and weathered, rounded basalt corestones exposed along the eroded margins of each flow.

DATING

Basalt from the upper flow terrace near Hereford Hall provided a K-Ar age of 19.1 ± 0.4 Ma (Wyborn & Owen, 1982; 1986). This dating has implications for providing some constraint by way of a chronological benchmark for pre- and post-basaltic regolith evolution. ^{14}C dating of charcoal samples from colluvial deposits yielded ages mostly between 3100 and 1640 BP, and have been interpreted to relate to widespread (possibly climatically driven), Holocene slope instability (Williams, 1978). The well-developed podsolic soil formed on these deposits must post-date these times.

REGOLITH EVOLUTION

The differential weathering and erosion of various Palaeozoic rock types and structures accounts in a major part for the regolith and landforms of this area. The palaeo- and contemporary drainage of the area largely follows lithological and structural features, as is demonstrated by the well-developed N-S trends of ridges and valleys following the main structural grain of the landscape.

There is evidence of a long history of weathering at Krawaree West. The quartzose and kaolinitic composition of the sub-basaltic sediments suggests a highly weathered provenance, and therefore extensive pre-Miocene weathering. The basaltic flows have also been extensively weathered indicating significant post-Miocene weathering. The timing of silicification of the sub-basaltic sediments is not known with certainty (it may be a pre- or post-basaltic over-print). Silcretes described from further north in the Shoalhaven catchment are developed within the pre-Eocene Badgerys Sub-Group sediments (Nott, 1992) and Taylor & Ruxton (1987) suggest an Early-Mid Tertiary to Late Tertiary timing of silicification in the Middle Shoalhaven Plain. No certain chronological correlations can be made between these silcretes and silicification at Krawaree West.

(a)

(b)

Figures 3a and 3b. Photographs of regolith-landform features at Krawaree West; a) erosional terraces composed of basalt lavas, south of Hereford Hall; b) slightly weathered granite tors that are part of an erosional rise near Hereford Hall.

The partially silicified, sub-basaltic sediments define a palaeovalley system that pre-dates the Miocene. It is not known how far back in time that this palaeo-drainage system may have extended but it is likely to be equivalent to much of the Tertiary palaeodrainage described in the middle Shoalhaven Plain (Craft, 1932; Taylor & Ruxton, 1987; Nott, 1992).

There has been considerable erosion of the landscape since the Miocene as the basalts in the upper Jerrabattgulla Creek valley have been topographically inverted. The sub-basaltic sediments are elevated above the present creek channel by up to 70 m indicating an average denudation rate along the creek of ca. 3.7 m/My. The Jerrabattgulla Creek valley system had also largely been formed prior to the Miocene, signifying that much of the landscape is likely to have approximated its present form at least by the Miocene.

Structural offset of granites in the area indicates significant post-Devonian tectonism, while the occurrence of Cainozoic tectonism is likely but less certain. Previous interpretations of post-basaltic (post-Miocene) tectonism (Wyborn & Owen, 1986) have not been supported in reassessments associated with this study (Lewis, 2000; Lewis *et al.*, 2002). Most important here has been the use of lava flow geochemistry and stratigraphy to show that lava flows are part of an incised pile, rather than a repeated pile caused by tectonic replication on either side of a fault (Lewis, 2000; Lewis & Roach, 2000; Lewis *et al.*, 2002). Further north of Krawaree West (on the Kain 1:25 k sheet) however, there are several raised river terraces along the Shoalhaven River and, facetted spurs and large alluvial fans along the range-front associated with the Shoalhaven Fault, consistent with some relatively young tectonism at least in that area. Galloway (1969) interprets significant late Tertiary reactivation of older structures, and subsequent drainage rearrangement.

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