THE REGOLITH-LANDFORMS OF THE HAZELDEAN PLUG AREA, MONARO VOLCANIC PROVINCE, SOUTHEAST NSW

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INTRODUCTION

This paper describes regolith-landforms and the local landscape evolution in the immediate vicinity of the Hazeldean Plug (Lambert & White 1965), which is an ankaramite volcanic plug assumed to have erupted at ca. 50 ± 2-3 Ma (Roach 1996), within the Monaro Volcanic Province (MVP), 20 km southwest of Cooma. The local basement consists of Ordovician metasediments (Lewis *et al.* 1994) and granitoids of the Berridale Batholith (White *et al.* 1977). These have been weathered and stripped and are overlain by quartzose Late Cretaceous to Early Tertiary palaeochannels and lacustrine deposits which have been preserved by the lava pile. The contemporary landscape includes volcanic plains and rises above relatively low relief, undulating granitic-derived landforms with torfields and a hornfelsed Ordovician sediment metamorphic aureole around the Berridale Batholith immediately to the east.

The Monaro Volcanic Province (MVP) lies between Cooma, Bombala, Berridale, Dalgety and Adaminaby in the NSW Southern Highlands. It is an intraplate lava field similar to the many located along Australia's southeastern and eastern continental margin (Johnson 1989 and references within). Basaltic lavas and intrusives of the area have been dated as Palaeocene-Oligocene (58-34 Ma; Taylor *et al.* 1990) using K/Ar age determinations on whole rocks and single amphibole crystals. There are over 65 volcanic eruption centres recorded within the MVP (Brown *et al.* 1993, Roach *et al.* 1994), many of which are prominent landscape features including plugs, dykes, maars and lava lakes (Roach 1999). Landscapes of the MVP are an amalgam of ancient, buried facets now being exhumed, and post-eruptive ones now being eroded. The MVP contains features that can be related to the rifting of Australia and New Zealand, the formation of the Great Divide and Great Escarpment (Ollier 1982) and the immediately post-Gondwanan and neotectonic landscape evolution of southeastern Australia. The MVP has been used as a research and teaching location for volcanic landscape evolutionary studies since the 1980s by staff and students of the Canberra College of Advanced Education (now University of Canberra) and the Australian National University, and CRC LEME as part of a Masters course for the Minerals Council of Australia's Masters of Economic Geology coursework program.

Previous geological mapping has been at 1:500,000 scale (Monaro sheet; NSW Department of Mines 1971); 1:250,000 (Bega-Mallacoota sheet; Lewis *et al.* 1994); and, 1:100,000 (Berridale sheet; White *et al.* 1977, M.C. Brown *pers. comm.*). No regolith-landform or soil-landscape maps have been produced for the Berridale 1:100,000 sheet, however, Tulau (1994a, b) produced a soil-landscape map of the adjoining Cooma 1:100,000 sheet.

SETTING

The oldest bedrock in the local area includes Ordovician metasediments of the Adaminaby Group (Lewis *et al.* 1994), which outcrop to the east of the mapping area. These are tightly to isoclinally folded and display a prominent axial plane cleavage that is typically parallel to bedding. These are intruded by granitoids of the Berridale Batholith, principally the Silurian Arable Tonalite (Chappel *et al.* 1991) in the local area. The Berridale Batholith is partially surrounded and bisected by contact metamorphic aureoles as side screens and roof pendants where it contacts the Adaminaby Group sediments. These aureoles now protrude as linear or arcuate ridges of typically < 100 m relief. Pre-basaltic quartzose sediments and palaeosols, which may be from the Late Cretaceous or Early Tertiary, immediately overlie saprolith of the Arable Tonalite. In the local area, the quartzose sediments are rounded to well rounded, fine- to medium-grained, relatively well-sorted and display cross-bedding in one exposure near the Hazeldean Plug. In the mapping area these have been indurated by microcrystalline quartz and hematite to form sub-basaltic silcrete. These are interpreted as channel deposits in a palaeodrainage system. In other parts of the MVP these may also be intercalated with the lower lava pile, indicating reworking by syn-volcanic drainage. In the same stratigraphic horizon as the quartzose sediments dense, black-coloured, fine-grained magnetic rocks also occur. These are interpreted to be "bole", clay- and hematite-rich overbank deposits that have been contact metamorphosed to a hornfels by the nearby Hazeldean Plug (about 50 m to the east), an overtopping lava flow, or both. The bole contains microscopic magnetite and corundum (Taylor & Roach 2005). In other parts of the MVP the pre-basaltic material contains lacustrine sediments and lignites implying that there were numerous lakes within and around the edges of the lava pile associated with early volcanism (Taylor *et al.* 1990, 1995, Brown 1994).

The climate is classified as cool temperate with mild to warm summers and cold winters, frequently experiencing snowfalls. Mean temperatures range from a minimum of –2.8°C in winter to a maximum of 26.9°C in summer, although the lowest and highest recorded temperatures at the Cooma Visitors Centre (-11.5°C and 37.9°C) indicate that winters can be well below freezing and summers warm to hot. Rainfall averages about 550 mm per annum, which tends to be concentrated in summer, however, the estimated annual evaporation rate is > 1,000 mm. The area is in a rain shadow formed by the Snowy Mountains to the west and the Coastal Range (Great Escarpment) and Gourock Range to the east, both of which receive well over 1,000 mm per annum (BOM 2005).

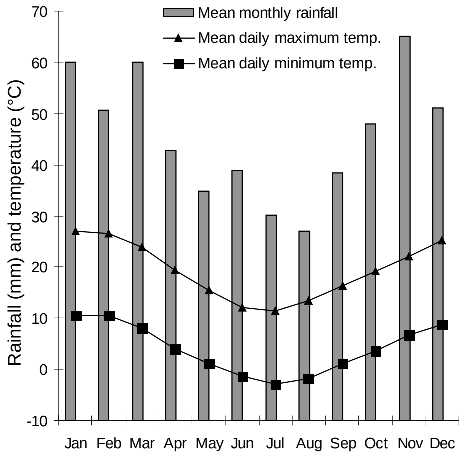

Figure 1: Climate averages for the Cooma Visitors Centre (BOM 2005).

The vegetation of the local area largely consists of *Stipa sp.* grassland of Costin's (1954) "Dry Tussock Grassland" vegetation alliance. In areas of pasture improvement, this may also be planted with lucerne, clover, rye grass and phalaris. Thistles are an abundant weed where the soil is disturbed. The natural grassland dominates on the basalt areas, and continues over the sandier soils of the Berridale Batholith rocks, which have largely been cleared post-settlement. The other main vegetation alliance in the area is "Savannah Woodland" (Costin 1954), consisting principally of snow gum (*Eucalyptus pauciflora*) over *Stipa sp*. grasses. Other species include wattles (*Acacia spp.*) and introduced species such as *Pinus radiata*.

Landuse in the area is principally sheep and cattle grazing. Some warm-weather grain and feed cropping occurs in areas of lower relief.

REGOLITH-LANDFORM UNITS

Regolith-landform units (RLUs) for mapping (Figure 2) are assigned codes according to the scheme of Pain *et al.* (in prep.). The main attributes recorded at individual field sites and within RLU descriptions include: regolith lithology; landform expression; surface material; minor attributes; vegetation community and dominant species; and, land management hazards.

IN SITU REGOLITH

Slightly Weathered Bedrock (SS)

Slightly weathered bedrock is on the undulating tor-fields of the Berridale Batholith. The bedrock is still relatively hard and forms prominent ‘stacks’ of tors up to 3 m high, particularly on the rises to the east of the mapping area. In the central part of the area, relief is more subdued and smaller tors stand singly or in multiples upon the plains and rises associated with basaltic colluvium. The tors are slightly iron oxide-stained and feature prominent lichen colonies. Road cuts reveal saprolite (‘grus’) with prominent quartz and aplite veins and some < 1 m diameter incipient tors. The main landforms associated with slightly weathered bedrock are:

- SSep: Erosional plains with less than 9 m of relief, flanking higher-relief landforms in the south of the area. Torfields < 3 m tall are colonised principally by native *Stipa* grasses in open grassland with weeds (mostly thistles) and lucerne, clover, phalaris and ryegrass where pastures have been improved but may have occasional snow gum (*Eucalyptus pauciflora*) trees; and,
- SSer: Erosional rises with 9-30 m relief, principally in the east of the area, with abundant large tors to > 3 m tall typically occupying > 60% of the polygon area. These are colonised by *Stipa* grasses, weeds (principally thistles), snow gums (*E. pauciflora*), wattles (*Acacia sp.*) and some introduced tree species (principally *Pinus radiata*) in an open to thick sclerophyll woodland.

Minor regolith materials associated with these RLUs include grey angular to subangular quartz sandy loams mixed with heavy black or brown basalt-derived clays near the edges of basaltic landforms or in small depressions near the lava pile, and occasional basaltic and silica- or hematite-indurated quartzose sediment float also near the lava pile.

Moderately Weathered Bedrock (SM)

Moderately weathered bedrock occupies a slightly lower landscape position than the slightly weathered bedrock. This generally has a more subdued relief and fewer tors than the SSep and SSer RLUs. Outcrop, where visible, is more ferruginised than SS RLUs and there is a greater dominance of quartzose sandy soils. The main landforms associated with moderately weathered bedrock are:

- SMep: Erosional plains with less than 9 m relief occupying nearly 50% of the mapping area. These have few low tors standing (< 2 m tall) with grey sandy loams composed of sub-angular to subrounded quartz and lithics to granule size. Lower areas near the lava pile may have heavy black clays mixed with the sandy material and minor basaltic and ferruginised silcrete float. Undulations and minor drainage depressions contain heavier clay-rich black soils in swampy deposits. This RLU is colonised principally by native *Stipa* grasses in open grassland with weeds (mostly thistles) and lucerne, clover, phalaris and ryegrass where pastures have been improved; and,
- SMer: Erosional rises with between 9 and 30 m relief in two small areas. These have abundant tors up to 3 m tall with quartzose sandy loam in the north of the area. The unit in the south of the area has a small number of tors and soils are more clay rich, due to clays being washed off the surrounding basaltic rises and plains. This RLU is colonised principally by native *Stipa* grasses in open grassland with weeds (mostly thistles) and lucerne, clover, phalaris and ryegrass where pastures have been improved.

Basaltic regolith

Basaltic regolith is regarded separately to granite-derived regolith. Basaltic regolith is developed in plains and rises of moderate relief in the local landscape. Each contains subangular to subrounded blocky basaltic rubble (except the unit "V") surrounded by heavy, black to dark brown, self-mulching clay soils. The regolith-landforms associated with basaltic regolith are:

- V: Slightly weathered intrusive ankaramite basalt outcrop of the Hazeldean Plug. Angular to subangular basalt boulders and cobbles with fresh surfaces display dark, glassy feldspars, olivine and pyroxene. Weathered surfaces display hematite pseudomorphs after olivine, feldspars as opaque white laths and slightly weathered pyroxenes, giving the rocks a spotted appearance. Basalt blocks sit in a heavy, black-brown, self-mulching clay lithosol. The landsurface is a rise to low hill with approximately 20-30 m relief and is approximately 50 m diameter. This RLU is colonised principally by native *Stipa* grasses

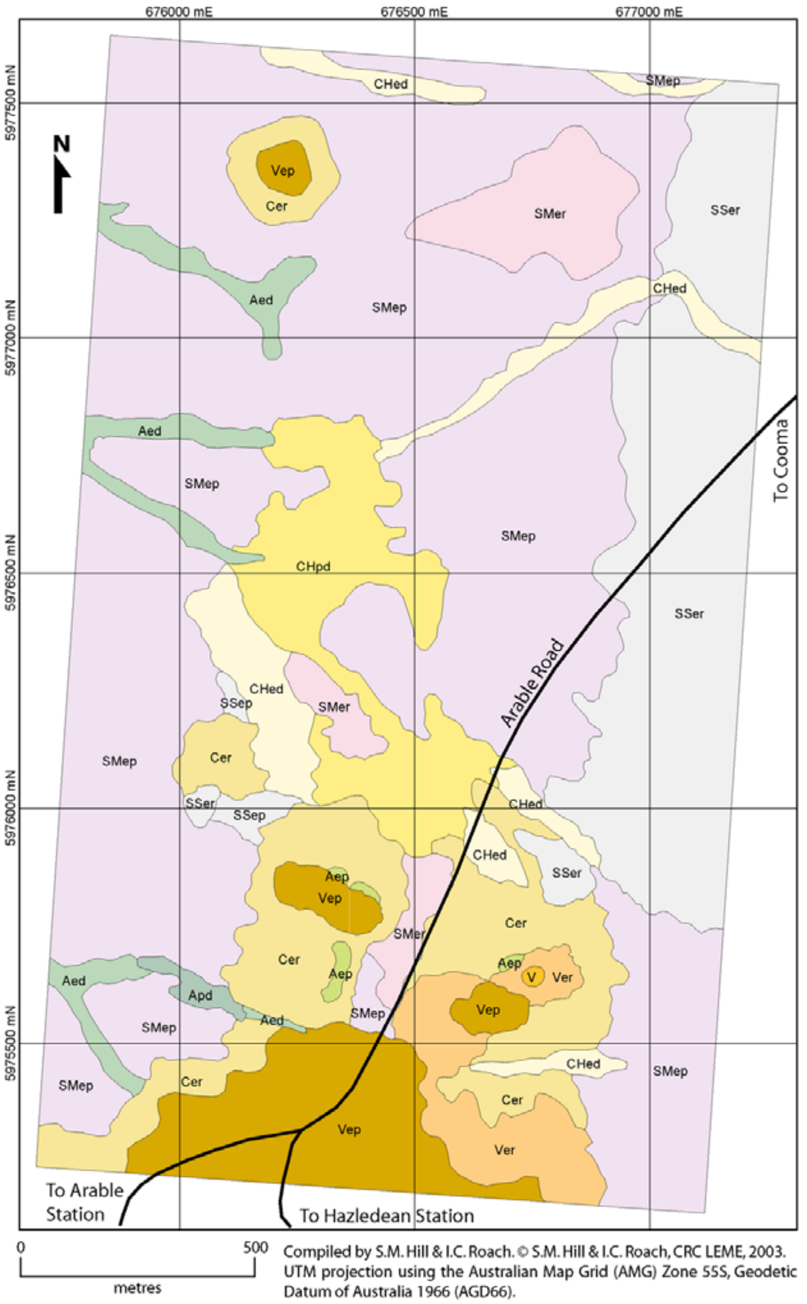

Figure 2: Regolith-landform map of the Hazeldean Plug area.

in open grassland, with mixed weeds and pasture grasses and has an exotic African boxthorn (*Lycium ferocissimum*) growing at the crown of the hill;

- Ver: Erosional rises with between 9 and 30 m relief at the edges of basaltic erosional plains. Slightly to moderately weathered subangular to subrounded basalt blocks to cobble size sit in a heavy, self-mulching, black-brown clay lithosol. This RLU is colonised principally by native *Stipa* grasses in open grassland, with mixed weeds and pasture grasses where improved; and,
- Vep: Erosional plains with less than 9 m relief at the top of the local landscape. Slightly to moderately weathered subangular to subrounded basalt pebbles and cobbles sit in a heavy, self-mulching, black-brown clay lithosol. This RLU is colonised principally by native *Stipa* grasses in open grassland, with mixed weeds and pasture grasses where improved.

TRANSPORTED REGOLITH

Alluvial Sediments (A)

Alluvial sediments are associated with the pre-basaltic landsurface and the present landsurface. They occupy the low points of the present landscape but are inverted in the palaeolandscape now being exhumed, which in this area may be as old as 50 My. The main regolith-landform units associated with alluvial sediments include:

- Aed: Mixed basalt- and granitoid-derived sediments including heavy black-brown clays and subangular to subrounded quartzose and lithic sands and granules and lithic lag associated with a low relief alluvial depression, occasionally with a small < 0.5 m deep, < 2.0 m wide alluvial channel in the base. In the north these have sandy quartzose sediment only. This RLU is colonised principally by native *Stipa* grasses in open grassland, with mixed weeds and lucerne and pasture grasses where improved. This RLU has greater relief than CHed;
- Aep: Subrounded to rounded quartzose sediments of fine sand to granule size, occasionally displaying cross-bedding, indurated by microcrystalline quartz with minor microcrystalline anatase and hematite. Exposures occur at the interface between the underlying Palaeozoic basement and the overlying Tertiary basalts, at mid-level in the local landscape, and are of low to moderate relative relief, most likely being channels < 2 m deep and < 10 m wide. Rare contact metamorphosed soils (bole) occur near the Hazeldean plug, consisting of subrounded nodules to cobble size dense, magnetic, black rock containing considerable magnetite. This RLU is colonised principally by native *Stipa* grasses in open grassland, with mixed weeds and pasture grasses where improved; and,
- Apd: Mixed basalt- and granitoid-derived sediments including heavy black-brown clays and subangular to subrounded quartzose and lithic sands and granules associated with a swampy depression. This RLU is colonised principally by native marsh grasses, *Stipa* grasses and weeds (predominantly thistles).

Colluvial Sediments (C and CH)

Colluvial sediments are a component of most of the higher-relief RLUs in the area, however, in parts of the area they are significant enough to form RLUs in their own right. Colluvial sediments, where the dominant sediment transport mechanism is by way of slope creep and rock fall, flank most of the higher-relief volcanic landforms, and include:

- Cer: Subangular to subrounded basaltic lithic lag to cobble size in heavy, self-mulching, black-brown clay lithosol with rare quartzose, granitic and silcrete lithic clasts, on a moderate-relief landform associated with the edges of basaltic plains and rises. This RLU is colonised principally by native *Stipa* grasses in open grassland, with mixed weeds and pasture grasses where improved;

Shallow overland flow, dominated by sheetflow, is only a minor transport component across the area, with much of the surface water soaking into the porous regolith rather than running off. However, shallow overland flow is responsible for the erosion and transport of sediment from the upper parts of the landscapes, such as erosional rises and plains, and their deposition in local depositional ‘sinks’ associated with depositional plains during peak rainfall events. The main erosional settings for these materials include:

- CHed: Quartzose sand-rich soils where associated with SSer and SMep and clay-rich soils where associated with Cer and Ver in a very low relief depression. Quartzose, granitic lithic and basaltic lag is rare. Colonised by *Stipa* grasses and weeds in the west and a snow gum (*Eucalyptus pauciflora*) woodland in the east.

The main depositional settings include:

- CHpd: Quartzose silts and black-brown clays, depending on the proximity to Cer, Ver and Vep with rare quartzose, granitic lithic and basaltic lag in a planar depression. Colonised by native *Stipa* grasses in open grassland, with mixed weeds and pasture grasses where improved

INDURATED REGOLITH

Silicified Regolith

Massive, tabular pods of quartzose sediment mostly indurated by microcrystalline quartz. Aep is indurated by micro-crystalline quartz with variable ferruginisation and microcrystalline anatase induration. The main morphological facies of silicified regolith include massive, tabular pods, preserving sedimentary structures in the host material, such as graded bedding and trough cross bedding.

Metamorphosed regolith

Massive, dense, magnetic black nodules to cobble size associated with silcretes in the Aep RLU. These contain microcrystalline magnetite and corundum (Taylor & Smith 1975, Taylor & Roach 2005) that are the metamorphic products of hematite and kaolinite, indicating that the original materials were fine-grained, clay-rich ferruginised regolith materials.

DISCUSSION: REGOLITH AND LANDSCAPE EVOLUTION MODEL

The Hazeldean area sits in a region that has been part of landscape evolution studies for over 180 years. The Monaro Range, part of the Great Divide, is located several km to the north of the mapping area, and the timing of it's inception is controversial. The pre-basaltic landscape evolution history below is summarised primarily from Lewis *et al.* (1994) and references within.

Pre-basaltic landscape evolution

The Hazeldean mapping area lies in the southern Lachlan Fold Belt, a Palaeozoic arc system that occupies much of the southeastern part of Australia. The local geological history began during the Late Cambrian to Early Ordovician when the region lay under a considerable depth of ocean, during which the stratigraphically lowest known rocks, the Adaminaby Group, were deposited as a "monotonous" series of turbidites (Lewis *et al.* 1994) presumably over oceanic crust. Sediment sources are believed to be from highlands to the west and south of the region (Crook *et al.* 1973). This was probably deformed and faulted several times, forming local unconformities, before the onset of igneous activity (Lewis *et al.* 1994). During the Late Silurian and Early Devonian an island arc, and later, a volcanic arc system (latest references in Gray & Foster 2004), moved from west to east through the area, resulting in uplift, folding, granitoid intrusion, coeval volcanism (Lewis *et al.* 1994) and greenschist facies regional metamorphism and contact metamorphism of the Adaminaby Group rocks. The Berridale Batholith, of which the Hazeldean area is a part, intruded at around 420-410 Ma (Chappell *et al.* 1991). The landscape at this time would have been emergent, with coral reefs forming around volcanic islands from about the Middle Silurian and eventually dry land in the Devonian. A major crustal shortening event occurred some time in the Middle Devonian, resulting in the unearthing of the nearby Cooma, Jerangle and Cambalong metamorphic complexes by thrust faulting, and further folding of the local rocks. By the Middle to Late Devonian, the whole landmass would have been subaerial, possibly with large lakes and shallow seas to the east, would have been colonised by early land plants and would have been undergoing weathering and erosional stripping. Extensive terrestrial alluvial systems (the Merimbula Group) are known in the region closer to the present coastline and towards Bombala from the Late Devonian (Lewis *et al.* 1994). Dyke intrusion and occasional volcanism occurred in the Jurassic (Lewis *et al.* 1994), associated with the commencement of pre-rift crustal thinning of the Southern Ocean and Tasman Sea. Sporadic volcanism and mafic-intermediate instrusions occurred into the Cretaceous, and at about 100 Ma, a series of large mafic-ultramafic volcanoes and intrusive complexes, like Mount Dromedary (Gulaga), formed along the incipient continental rift in eastern Gondwanaland between Australia and New Zealand (Bryan *et al.* 1997). At this stage the land surface was well forested (Taylor *et al.* 1990). It would have been one of gently rolling country, with wide sandy rivers cutting across a palaeosurface probably draining north-northwest into the major Mesozoic basins in central Australia (Ollier & Pain 1997). At about 100-90 Ma tectonism occurred with the culmination of continental rifting between the proto-Australian and New Zealand land masses and the opening of the Tasman Sea. The eastern Australian seaboard, a passive margin, rose in response to this, and various theories exist as to why this occurred, e.g., magmatic underplating (Wellman 1979, 1980) and thermal expansion (Lister *et al.* 1986, Lister & Etheridge 1989). It was at this stage that the Great Divide was initiated and the coastline of southeastern Australia began to take its contemporary form. This period is marked by major erosion (Kohn *et al.* 1999), with detritus deposited in the Mesozoic sedimentary basins flanking southeastern Australia (Otway, Bass Basins), drainage alteration and/or reversal, and the inception of the Great Escarpment along the eastern coastline (Ollier 1982).

Basaltic landscape evolution

Basalts of the MVP first erupted at around 60-58 Ma (Taylor *et al.* 1990) onto a land surface that had at least 400 m vertical relief (Taylor *et al.* 1985) under a cool to cold, temperate climate dominated by rainforest (Taylor *et al.* 1990). Basaltic magmatism is believed to have followed the earlier Jurassic and Cretaceous mafic/ultramafic volcanism associated with the incipient rift, caused by the subsequent thermal perturbations in the local mantle either by the withdrawal of a lower lithospheric slab along the passive margin (Lister *et al*. 1986, Lister & Etheridge 1989), by mantle diapirs (O'Reilly & Zhang 1995) or by hotspots (Wellman 1979, 1980, Sutherland 1983), or combinations of the above. Early lavas blocked the local drainage, at this stage believed to be mainly southeast (Brown 1984), which reversed after the rise of the Great Divide began at about 100 Ma (Wellman 1979, Kohn *et al.* 1999), forming lakes surrounding the outskirts of the lava pile. These filled with a variety of lacustrine sediments and peat (Taylor *et al.* 1990) and pillow basalts and hyaloclastite with intermingled sediments and plant remains where lava flows entered the standing water (McQueen *et al.* 1993). Early volcanism was predominantly sub-alkaline, consisting of Hawaiian-style effusive tholeiitic and transitional eruptions building inter-connected lava shields and filling the valleys with long lava flows (Roach 1996). At about 51-49 Ma (Taylor *et al.* 1990, Roach 1996) a series of ankaramite lava eruptions occurred, including the Hazeldean Plug, signifying the end of the shield-building stage of volcanism. These lavas erupted as thick, viscous, crystal-rich A'a-style flows perhaps during Strombolian- or Vulcanian-style eruptions, in close proximity to the vents (Roach *et al.* 1994, Roach 1996). Stratigraphically above the ankaramite units, alkaline lavas, scorias and hydrovolcanic tuffs indicate a very different style of volcanism. The final stage was dominated by Strombolian to Vulcanian and Surtseyan-style volcanic activity (all weakly to moderately explosive styles), with minor Hawaiian-style activity. The sub-alkaline lava shields with their ankaramite mantles would have been topped by alkaline lavas and scoria cones (Strombolian/Vulcanian-style activity), and hydrovolcanic (phreatomagmatic) eruptions occurred where later basaltic eruptions occurred through groundwater or lakes, forming maars with tuff rings/cones (Surtseyan-style activity). At about 34 ma (Taylor *et al.* 1990), possibly later (ca. 30 Ma), volcanic activity ceased in the MVP, but continued elsewhere in the NSW Southern Highlands. During the life of the MVP, local cessations in eruption occurred, for perhaps as long as 3 My, allowing rainforest to re-establish over some lava surfaces and deep weathering to occur, resulting in the formation of bauxite horizons (Taylor *et al.* 1992). These were later over-topped by successive lavas, preserving them in the volcanic stratigraphy of the MVP.

Post-basaltic landscape evolution

Since volcanism ceased, in the Hazeldean area, weathering and erosion have been the dominant landscape evolutionary processes. The lava pile is weathering down and back, principally by chemical weathering, exposing the pre-basaltic quartzose landsurface. Many of the displaced streams are exhuming their pre-basaltic courses, although some, for instance the Murrumbidgee and Snowy Rivers, have been significantly re-routed by the lava pile and/or neotectonics (e.g., Sharp 2004). Extensive alluvial terraces and plains now occur along the major drainages, with sediments composed principally of heavy black-brown clays derived from the lava pile.

Significance of indurated materials at Hazeldean

Sub-basaltic indurated sediments at Hazeldean mark part of the extensive pre-basaltic drainage network. Exactly which direction the alluvial systems that deposited these sediment drained is uncertain, because it is difficult to measure palaeocurrent indicators at the site. There does seem to be general agreement on south-southeast (Brown 1994, Sharp 2004) based on sub-basaltic structure contour and palaeocurrent indicator mapping in other parts of the MVP. These materials are important to recognise and carefully map because they are useful for mineral exploration (they may contain gold, gemstone and even diamond placer deposits), landscape evolution (they can help indicate when the Great Divide formed) and groundwater flow (they are important aquifers) studies in the local region.

Tectonic control of volcanism and neotectonics

A series of basement fractures have controlled the location of eruptive centres in the MVP (Roach *et al.* 1994). These consist largely of oblique conjugate fracture sets (NE and NW orientation), that are possibly crustal-scale, with a trans-tensional stress regime (Roach *et al.* 1994, Roach 1999). The intersections of these conjugate fracture sets provide ideal pathways for magmas to reach the upper crust; the majority of eruption sites are located over these intersections. A small number of eruptions sites are located over the intersections of NE- or NW-striking fractures and major meridional (N-S striking) fractures that dominate the landscape of the region, creating the horst and graben landscape that exists today. Basement fractures are visible through the lava pile as linear drainage lines and aligned springs, implying significant post-basaltic tectonism and even neotectonism. Neotectonics may also have played a role in local drainage reversal in the northern MVP, causing the upper Murrumbidgee River to reverse between Cooma and Adaminaby (Sharp 2004).

Significance of volcanism for drainage rearrangement

Part of the debate about southeastern Australian landscape evolution focuses on the timing of uplift along the Great Divide and the inception of the Great Escarpment. Another major force controlling drainage rearrangement in the local area is the MVP itself. Basalts of the MVP filled the landscape, blocking and re-routing the local drainage that, in the early history of the MVP, appeared to be mostly southeast, towards the proto-Tasman Sea. Brown (1994) modelled the drainage re-arrangement that occurred during the life of the MVP using the best available evidence. The large lava pile blocked off the southeast drainage and re-routed the local rivers including the Snowy, Murrumbidgee, Eucumbene, Numeralla, Tuross, MacLaughlin, Towamba and Bombala. The Great Divide was also shifted eastwards at Hazeldean along the Monaro Range, which is in part composed of basalts of the MVP, or has been armoured against erosion by the basalts which have since been weathered away. The Monaro Range, which runs NW-SE slightly to the north of the Hazeldean Plug, divides water from the Snowy River catchment (which runs out to the Tasman Sea) and the Murrumbidgee River catchment (which runs through Murray River to the Southern Ocean). Modern drainage is now a hybrid of pre- and post-basaltic drainage, with some rivers slowly eroding and re-occupying their former courses (Towamba), and others completely re-routed and/or reversed (Snowy, Murrumbidgee).

CONCLUSIONS

The Hazeldean area of the northern MVP is an ideal location for teaching and learning. It is a microcosm of many of the research problems which present themselves when working on the Cainozoic lava fields of eastern Australia, and is central to the over 180 year old debate regarding the rise of the Southern Highlands and the inception of the Great Divide, the establishment of the Great Escarpment, Tertiary climate change, bauxite weathering and more.

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