# INTEGRATING SOILS, REGOLITH AND SLOPE DYNAMICS IN THE STUDY OF THE *TERROIR* OF WINE REGIONS IN CENTRAL VICTORIA, AUSTRALIA.

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## INTRODUCTION

Soil mapping carried out in the 20th century in central Victoria is now being improved by 21st century regolith mapping, making use of airborne geophysical imagery and digital terrain models, in a program at the University of Melbourne sponsored by the Geological Survey of Victoria (Joyce 1998).

Regolith studies in central Victoria are leading to a better understanding of relationships between the modern surface soils, often thin and with transported components, and the ancient underlying regolith. An understanding of landscape evolution based on regolith studies can help explain slope dynamics in central and northern Victoria, and the origin of such aspects of *terroir* as soils, slope angle and aspect.

## THE REGION

The southeastern Australian landscape is characterised by ancient deep-weathering profiles and slow rates of uplift. The soils of the central uplands of Victoria have often developed on old regolith profiles *in situ*, or on the same material transported short distances downslope.

The long landscape history of southeastern Australia has allowed additional material to be added to soils during the Tertiary, particularly during the climatic fluctuations of the Quaternary, when aeolian, fluvial and colluvial materials of varying mineral composition and grain size have been moved within the landscape (see, for example, the Coonawarra area as described in Mee *et al.* 2004).

The arrival of European settlers some 200 years ago has led to further dramatic changes in the landscape. Soil erosion is now a major problem in Victoria, affecting many areas in the Western Uplands (Figure 1), and particularly the northern margin of the Western Uplands with the Riverine Plains. Soils in these areas are commonly shallow podsol with dispersive clay B-horizons beneath a thin silty to sandy A-horizon. Shallow groundwater and soil water may have high salinity, usually explained as due to clearing of original native forest and woodland over the last 200 years. The effects of European farming practices, including ploughing and the introduction of grazing hoofed animals, have also affected soils. In central Victoria extensive mining activity in the 19th century has destabilised surface alluvial deposits. These new human activities led to sheet erosion, tunnelling (piping) and gully erosion becoming widespread in the mid-20th century in Victoria (Joyce *et al.* 2003). Today, due to better farming practices, and costly remedial works such as contour ploughing and ripping, construction of contour banks, planting of trees and grasses, filling of gullies and fencing-out of farm animals, soil erosion is less obvious, but can still be a major problem.

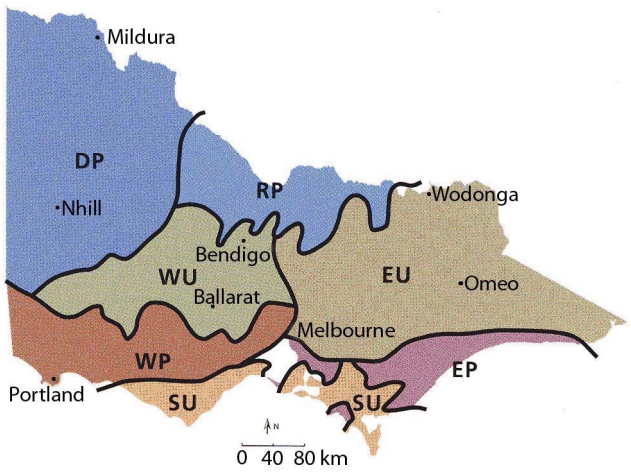


**Figure 1:** Geomorphic regions of Victoria (Joyce *et al.* 2003); DP=Northwest Dunefields and Plains, RP=Riverine Plains, WU=Western Uplands, EU=Eastern Uplands, SU=Southern Uplands, WP=Western Plains, EP=Eastern Plains.

Fortunately the main vineyard areas of the Western Uplands of Victoria are not in areas susceptible to major landsliding. This is because the vineyards are commonly planted on low slopes or flat areas, and are in a region of relatively low rainfall. However vineyard areas are susceptible to soil erosion by gullying in colluvium, and sheet erosion of thin topsoils, and these processes are accentuated by the salinisation of shallow

groundwater systems along the margin of the Western Uplands.

## APPLYING REGOLITH STUDIES TO WINE REGIONS IN CENTRAL VICTORIA

The concept of *terroir* provides a useful approach to considering the relationship of certain factors to wine production. White (2003) suggests *terroir* includes soil, local climate, cultural practices and (grape) variety, and points out that most emphasis in studies of wine growing has been on climate, with the factor of soil often neglected. He defines *terroir viticole* to include soil, climate, and topography, vine variety and rootstock, and human activity including winemaking and history.

The International Association of Geomorphologists Working Group on *terroirs viticoles* suggests the term was born in French viticulture and wine production, and normally includes the rock, the soil, slope, and climate, and also human activity such as cultivation and processing.

Both White (2003) and Mackenzie (2002) stress the importance of soil as part of *terroir*, but do not consider the major role of regolith in some regions of Australia. One such region is the Western Uplands of Victoria.

In the Western Uplands of Victoria, particularly on the northern slopes of these Uplands, several wine regions are found. The wine produced might be expected to relate to the *terroir*—i.e., dependent on the climate (a Mediterranean type with annual rainfall, mostly in winter, of 500 to 700 mm), the slope (generally moderate), and the soil and regolith (often contrasting and complex).

Two wine regions whose *terroir* can be related to regolith studies are the ***Bendigo*** region (which is described on the new Bendigo 1:100,000 regolith map of Kotsonis & Joyce 2003) and the ***Pyrenees*** region (described on the unpublished Beaufort 1:100,000 regolith map of Dimas 1998). On the flat to gentle slopes favoured for vineyards in these two regions, slope processes are confined to colluvial creep, and gullying and sheet erosion, often under the influence of salinisation (Figure 2).

**Figure 2:** Gullying in slope mantle of colluvium, with floor of gully exposing regolith developed on Palaeozoic bedrock, Pyrenees region, Victoria.

The landscape history of the two regions has had a major influence on their *terroir*. The two areas preserve the imprint of past deep weathering of the bedrock, often to depths of 30 to 50 m, and of partial stripping of this regolith in places, in response to changing climate and vegetation, and to neotectonic uplift (Kotsonis & Joyce 2003). Reworking of the regolith over long periods of time has led to the formation of extensive thin slope deposits, and the deposition of gravels, sands, and clays along the valleys, and similar deposits occur at higher elevations in the landscape, marking earlier drainage systems. These deposits have been extensively mined, and mapped, in the search for alluvial gold in the 19th century.

The soils of the two wine regions have developed on a parent material of regolith which itself formed on Palaeozoic sedimentary rock. The regolith has sometimes been partly stripped down to fresher bedrock. Over long periods of time, including for most of the Tertiary, soils have been formed, eroded, altered and leached. On slopes, colluvial mantles one to several metres thick are common, made up of bedrock clasts, quartz pebbles and weathered bedrock in the form of clay and sand. In addition aeolian processes, particularly during the most recent cold period some 20,000 years ago, have added material to the soil, most obviously to the A horizon. Human activity including mining has led to added mantles of silt and fine sand on lower slopes and especially along drainage lines (Joyce *et al.* 2003).

The mantle of soil and regolith in which the vines grow is often thin, and reworked by ancient and modern slope transport, in particular by creep, but sometimes by minor landsliding. The soil is commonly a shallow mixture of weathered products and partly-weathered rock fragments (Figure 3). The roots of the vines may be growing in material composed of more than one rock type, e.g., granite and also metasediments from a surrounding aureole, and the rock fragments can be fresh or weathered or both.

The ***Bendigo*** region has a rainfall of 500 to 600 mm and an elevation of 200 to 400 m above sea level. The

soils are mostly duplex or two-layer soils, podsolic (acidic) on granite, and solodic (neutral) on Cambrian-Ordovician sedimentary and metamorphic rocks, and lithosols occur on steeper eroded slopes (Kotsonis & Joyce 2003).

The Bendigo wineries are planted on the granite slopes of the Harcourt region to the south of the city of Bendigo, along the low slopes and drainage lines to the northwest of Bendigo, further west on the edge of the uplands where it meets the Riverine Plains at Bridgewater, and also much further west again on the granites around Kingower.

At the Harcourt Valley vineyard granite bedrock outcrops on the foot of the slope, and shows exfoliation sheeting and joint blocks; the fresh rock is progressively overlain upslope by granite saprolite, with a colluvial mantle of granitic material even further upslope (Figure 4). The Bridgewater vineyard, on flat terraces on the margin of the Riverine Plains (Figure 1) grows the *"reds… (on) heavier clay soils, …whites (on) lighter free-draining soils"* (Hardy 2001).

***The Pyrenees*** region has a rainfall of 600 to 700 mm and is 300 to 500 m above sea level, but the rock types and soils are similar to those of the Bendigo region.

The Pyrenees wineries region, when seen from the east near the town of Avoca on the north-flowing Avoca River, is a long blue ridge which marks the eastern margin of the bedrock plateau of The Pyrenees. The Pyrenees vineyards are found at the foot of the plateau and extending across the lower slopes; further Pyrenees vineyards are along the lower slopes, terraces and floodplain of Mountain Creek, a valley in the Moonambel area that marks the northern margin of the plateau of The Pyrenees.

**Figure 3:** Roots concentrated at the contact between bedrock colluvium (with quartz fragments) above the underlying red saprolite developed on Palaeozoic bedrock – contact at pointer; Warrenmang vineyard, Pyrenees region, Victoria.

**Figure 4:** Downslope on colluvial mantle and granite regolith, looking northeast, Harcourt Valley vineyard, Bendigo region, Victoria.

Taltarni is a large vineyard near Mountain Creek on *"well-drained sandy loams interspersed with broken down quartz"* (Hardy 2001). Just to the west, at 350 m above sea level, Dalwhinnie vineyard's *"giant bowl"* (Hardy 2001) faces east, with colluvium-mantled slopes overlying weathered Palaeozoic slate. The steeper upper slopes produce a severe water stress on vines, but growth is lusher on the flatter areas below (Figure 5). *"The soils are clay and quartz based… (with) good moist clay about half a metre below the surface"* (Dunstan 1992). By contrast the nearby small Summerfield vineyard is on the low terraces and floodplain of Mountain Creek, and the owner sometimes *"loses most of his crop to frost"* (Hardy 2001), a problem now countered by overhead irrigation on cold nights (Dunstan 1992).

At the adjacent Warrenmang vineyard, a roadside section clearly illustrates how the soil in which vines grow in northern Victoria may often be made up of just a metre or less of colluvial slope mantle. Roots can be seen concentrated at the contact between bedrock colluvium, and there is a sharp break to the smooth upper surface of the underlying red saprolite formed on the Palaeozoic bedrock; the vine roots generally fail to penetrate the saprolite (Figure 3).

The Mount Avoca vineyard lies *"in the foothills of the Pyrenees. The soil is quartz gravel in which a thin grey topsoil overlays a friable clay"* (Dunstan 1992). The vines grow on a flat-topped ridge with much quartz gravel, probably representing a former stream deposit of the type found along upper slopes throughout the region.

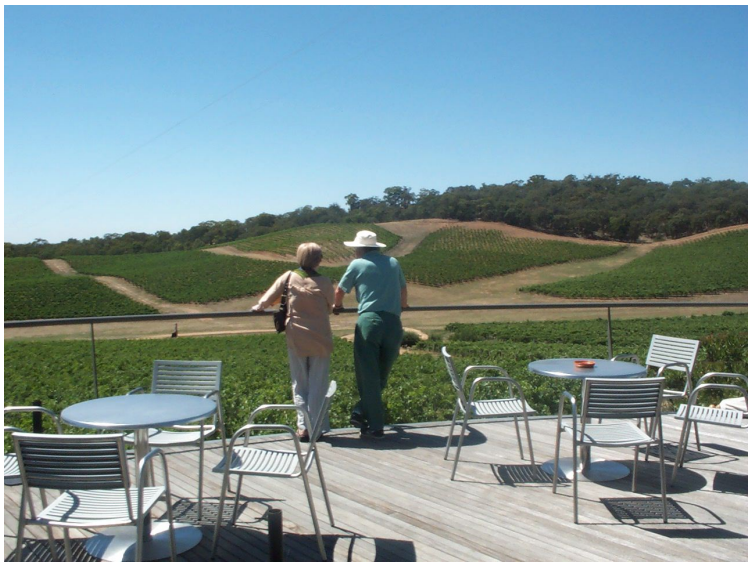

**Figure 5:** Vines on the flat, and above on the colluvial-mantled east-facing slopes, at Dalwhinnie vineyard, Pyrenees region, Victoria.

## CONCLUSIONS

In vineyard regions in any country it is not sufficient to study only climate, soil type, slope angle and aspect. Recognising and understanding the full regolith profile below a vineyard region is necessary to understand the origin of the surficial layer, often shallow, in which the roots of the grape vines grow. This root zone may be just a thin colluvial layer from upslope but can also include part of the underlying saprolite formed on bedrock.

Regolith studies in central Victoria are helping develop a better understanding of slope dynamics, landslides and soil erosion. An understanding of landscape evolution based on regolith studies can be used to investigate the concept of *terroir* in northern Victorian vineyards.

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