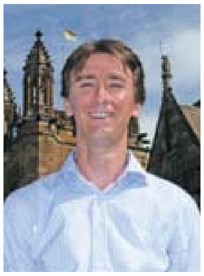
The effect of dust on topsoil variation in the Orange wine region



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Introduction

Vineyards in the Orange wine region in central-west New South Wales are largely based on soils derived from the volcanic rocks basalt/andesite and, to a lesser extent, trachyte. The basaltic/andesitic soils range in colour from brown to red, depending on the age of the parent material. The younger basaltic lava, deposited about 12 million years ago during the eruption of Mount Canobolas, gives rise to the red ferrosol (krasnozem) soil type, while the older volcanic rock – andesitic ash and siltstone deposited about 420 million years ago (Ordovician age; Pogson and Watkins, 1998) – tends to give rise to the brown ferrosol (euchrozem) soil type.

Both types of ferrosol are friable, well-structured, clayey soils that are considered very suitable for a range of viticultural and horticultural crops due to attributes such as structural stability, good water-holding capacity and moderate-to-high chemical fertility. Soils derived from trachyte lava on Mt Canobolas are generally paler in colour, shallower and more acidic and magnesic (in the sub-soil) than the basaltic soils, and therefore are regarded as less desirable for grape production unless ameliorated. Typical amelioration and management strategies for such soil include the deep incorporation of finely divided lime to correct subsoil acidity, and the use of separate drip irrigation valves to manage water use in these low readily available water (RAW) profiles. The ancient Ordovician rock also contains pockets of limestone which once were coral reefs on the edge of active volcanoes. The soil derived from this limestone

Figure 1. An example of the light-grey, silty, structureless topsoil overlying a thin mixed zone (20 centimetres to 30cm in depth), and then the more usual red clay derived from basalt.

tends to be shallow and stony, but free-draining and not acidic, making it suitable for vines.

In certain spatially-restricted locations around the Orange district, however, the well-structured, clayey soil derived from basalt is capped by up to 40 centimetres of pale grey, almost white coloured, silty, structureless soil (see Figure 1). Such topsoils appear in various landscape positions, including mid-slope drainage lines and the crests of some low hills, but tend to occupy areas of land less than 1 hectare in size. In the notes accompanying the soil landscape map for the area (Kovac et al., 1990), these topsoils are not explicitly accounted for, although the suggested presence of 'red podzolic' soils on upper slopes underlain by basalt reflects this pattern of pale topsoil over red, clayey sub-soil. An observation of some landowners who have worked with patches of this pale-coloured topsoil is that vines take distinctly longer to become established on this type of soil profile – young vine performance is often depressed and waterlogging is common under wet conditions. Such waterlogging leads to nitrogen loss through denitrification and the development of a poor habitat for beneficial soil organisms.

Features of the dust-affected topsoils

As a first step towards characterising the features of this somewhat unexpected topsoil, and accounting for its presence in different parts of the landscape around the Orange wine region, we conducted a series of analyses on soil samples from three pairs of sites (Caldwell, Nashdale, Towac) to the north and north-east of Mt Canobolas, which has an elevation of 1395 metres. At each paired site, we examined a soil profile with the grey, silty topsoil and a nearby soil profile lacking the grey, silty topsoil. For each profile, we sampled soil from the top 20cm, and between the depths of 40cm and 50cm. Because we observed this grey, silty topsoil on both hill crests as well as mid-slope positions, and because there is no evidence of the parent rock from which this material is derived, we assumed that it is of aeolian (windblown) origin. A common feature of aeolian dust is a predominance of particles with sizes between 10 micrometres and 100µm, which confers a silty texture. So the analyses we carried out focused on the particle-size distributions of the (assumed) dust-derived and basalt-derived soil horizons and the mineral suites of those horizons.

The results (Table 1) show a clear trend of the grey-coloured topsoil being consistently depleted in clay relative to the underlying

Table 1. Textural and particle size attributes for selected grey and red soil horizons of the Orange wine region.

Paired site	Soil sample*	Field texture grade	Sand# (%)	Coarse silt (%)	Fine silt (%)	Clay (%)
Caldwell	GSS topsoil	silty loam	1	7	84	9
	GSS subsoil	light-medium clay	<1	2	43	55
	RSS topsoil	silty clay loam	1	6	76	16
	RSS subsoil	light-medium clay	1	3	55	41
Nashdale	GSS topsoil	silt loam	2	9	83	6
	GSS subsoil	light clay	<1	4	63	34
	RSS topsoil	silty clay	1	5	75	20
	RSS subsoil	light clay	1	3	58	38
Towac	GSS topsoil	silty clay loam	1	7	85	8
	GSS subsoil	light clay	1	4	69	26
	RSS topsoil	light clay	1	3	62	34
	RSS subsoil	light clay	1	3	61	35

* GSS = grey surface soil, RSS = red surface soil.

\# Sand-sized particles are defined as those with a diameter greater than 100 micrometres; coarse silt particles are 53-100µm; fine silt particles are 2-53µm; clay particles are <2µm.

red-coloured sub-soils, and relative to the topsoils and sub-soils of the wholly red-coloured profiles. Surprisingly, the red, well-structured, clayey sub-soils at all sampling locations are also characterised by substantial fine silt contents, suggesting significant mixing of the topsoil grains with the upper parts of the original red-coloured surface soil. Mechanisms for this mixing include bioturbation (e.g. by earthworms and ants), cultivation and washing of fine grains down the profile via pores and cracks. The mean size of the fine silt-sized particle population in all the topsoils, as measured using a high resolution particle-size analyser, is about 40µm – this size is typical of regionally-sourced dust (source area is tens to several hundreds of kilometres away) transported in moderately strong wind.

In an attempt to further clarify the different origins of the grey- and red-coloured soil horizons, we also identified the main minerals present in each soil type, and the main minerals present in the fine silt-sized fraction of each soil type. The dominant minerals in all topsoils and sub-soils are quartz, feldspars, the clay mineral kaolinite and the iron mineral haematite. The presence of quartz in all samples was a little surprising, as this common mineral is not normally found in large amounts in basalt rock – crushed basalt rock samples from a few kilometres east of Mt Canobolas, and from near Cudal, 20km west of Mt Canobolas, yielded no quartz when analysed for mineral composition. As quartz is the dominant mineral in the fine silt-sized fraction of each of the soils sampled, it seems clear that the aeolian dust has been the source of this mineral, and that soil mixing post-deposition has incorporated quartz into the previously quartz-free, basalt-derived red clay. The presence of small amounts of haematite, a common mineral in basalt rock, in the grey-coloured topsoil also attests to the mixing that has occurred between the dust-derived soil and the basalt-derived soil.

Practical implications for vineyard managers

So what is the significance of this curious quartz-rich topsoil around the Orange wine region to grape production? Although there is little difference in the types of minerals present in the grey and red soil horizons due to post-depositional mixing of silt grains, it is the large difference in clay content that makes these two soil horizon types quite contrasting in physical and chemical character. The silty grey soil is remarkable for its complete lack of aggregation (structure), whereas the clayey red soil is highly aggregated with a well-connected pore network. As discussed by White (2009), such differences in both clay content and soil aggregation will lead to substantial differences in hydrologic properties such as infiltration rate, plant available water, readily available water and deficit available water. In turn, these differences may affect variety selection for certain blocks and/or irrigation strategies for those blocks, depending on the vine growth requirements of the manager. The grey soil is also likely to be more impoverished in plant nutrients than the red soil due to the dominance of the largely inert quartz mineral in the former. While the dominant clay mineral in the red soil, kaolinite, is not a particularly abundant source of plant nutrients, it nevertheless has the ability to retain greater concentrations of elemental nutrients than quartz. Although an investigation of the chemical attributes of these two soil types was not an objective of our preliminary study, it is the next logical step in determining the effect of the silty grey topsoil on vine performance. Similarly, the quantification of the hydraulic properties of these two soil types is also warranted.

In the Australian grapegrowing context, dust deposits have been equally, if not more, important in determining the production potential of soils in some other regions. In the Hilltops and Riverina wine regions in NSW, for example, relatively thick deposits (>1 metre) of red, clayey dust, known as parna, blanket large areas of land and have formed reasonably good soils for crop production. These dust deposits are thought to have occurred about 10,000 to 15,000 years ago when the climate in eastern Australia was distinctly more arid and windy than it is now. It is likely that the pale grey dust deposited onto the ferrosols around Mt Canobolas occurred during this same time period. However, whereas the dust deposited in southern NSW and northern Victoria was sourced from the Mallee region of Vic and eastern South Australia, it is far more likely that the pale grey dust around Mt Canobolas originated from a local source in central-west NSW. The trachyte ridges around the mountain, which were formed at much the same time as the younger basaltic lava flows, and which weather to form shallow, pale coloured soil profiles, are a possible local source of this dust material.

This investigation of a pedological anomaly around the Orange wine region, a pale grey, silty topsoil sitting on top of red clay derived from the underlying basalt, demonstrates the value of an understanding of soil variation in the landscape and the importance of soil assessment when planning intensive viticultural and horticultural enterprises. While the grey, silty soil may not be inferior to the red, clayey soil for the growth of all grape varieties, or for all horticultural crops, it will certainly exhibit quite different physical and chemical properties that may necessitate alternative or precision management practices. Presumably, the depth of the grey topsoil and the depth of rooting of the vine/crop in question will be critical determinants of the overall effect of this dust-derived soil. ■

References

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