ORIGIN OF THE COONAWARRA RIDGE

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2002

The Coonawarra area is perhaps the best-known premium wine region in Australia but there has been extensive debate as to the extent of the region. The initial boundary was based on the old State 'hundreds' map sheets for Penola and Comaum and this mainly reflected historic considerations. This determination of the boundary partly addressed the criteria for a wine region in reflecting social considerations but failed to consider biophysical criteria such as geological formations, terrain, and climate.

The criteria for identifying wine regions developed in Australia reflect the European circumstances of a close link between geology and soils. The recent glaciation in the Northern Hemisphere stripped most old soils and many of the existing soils are young and have derived from the underlying geological material. This European experience has resulted in the Australian indications for wine regions referring to geological formations as a surrogate for soils.

The Coonawarra Wine Region Boundaries were proposed by established growers and reflected a desire to justify their vision of the region. Effort therefore focused on finding reasons why Coonawarra differed from surrounding areas rather than identifying similarities and differences in factors affecting viticulture in the broader region. This, and the focus on geology in the indications criteria, initially resulted in attempts to justify the interim boundary on, inter alia, the basis of the uniqueness of the Coonawarra geology. As the premium associated with Coonawarra is equated with terra rossa soils the discussion centred on how the terra rossa soils at Coonawarra differed from any surrounding red soils because of their derivation from the underlying geology.

This article discusses the development of the soils around Coonawarra and presents the proposition that the terra rossa soils have derived from aeolian deposits rather than the underlying Mt Gambier limestone geological formation.

Origin of Formations

The current surface of the Coonawarra region is largely derived from beach ridge formations that represent coastal sand dunes formed by a combination of wave and wind. The sequence of ridges is due to the recession of the coastline associated with gradual uplift of the land. The beach ridge formations are extensive and extend from Mildura to the current coastline. They cover most of western Victoria and SE South Australia, and in South Australia are mainly underlain by the Mt Gambier limestone formation.

The beach ridges have been variously modified since their formation thereby producing varied terrain. The parabolic shape of the large dunes in the Big Desert arises where sand is blown into vegetation and this formation depends on an abundant supply of sand. The dunes in the Sunset Country are largely parallel as arises where a limited sand supply results in the nose of the parabolic formation 'blowing out'. While sand dunes dominate, these areas contain significant occurrences of clay soils and dispersed clay occurs deep in the profiles of high dunes.

The land between the Sunset Country and the Big Desert essentially represents an undulating sand plain where most of the sand has been stripped by wind erosion. Loam and clay are prominent, as are clacareous sheets that appear to represent pans from prior soil profiles.

The issue with all soils in areas formed from the beach ridges, including Coonawarra, relates to the origin of the clay. In the Mallee region of NW Victoria the clay is said to be marine in origin but the formation process for beach ridges essentially excludes clay. The clay was not present in the original beach ridge formation. There is also an issue with calcium as the calcium associated with the shells of marine organisms would be expected to have been leached from the system a long time ago. The calcium at Coonawarra has been assumed to derive from the underlying Mt Gambier formation but the calcareous sheets in the Mallee region cannot have been derived in this way.

While the sand derives from beach ridges and the clay is assumed to be marine in origin the soils of the Mallee region are generally regarded as being aeolian deposits. This conclusion arises from studies that identified five major periods of aeolian deposition of clay and calcium across SE Australia (Butler & Churchward, 1993). The calcium was present as gypsum on some occasions and lime on others. This episodic deposition has resulted in sequences where new soil profiles have been formed over old profiles, and a vertical sequence of up to three profiles is observable in some locations.

The aeolian deposits are thought to have largely derived from the Great Australian Bight during periods of low sea level associated with ice ages. Rapid drying of the bare saline clay surface results in efflorescence of the calcium (formation of very fine particles rather than crystals) on the surface and this powder is blown away by wind. The proportion of calcium to clay in the aeolian material is around 80 to 90% due to the fineness of the calcium particles.

The aeolian deposits over SE Australia reflect major climatic events that affected the entire earth but the underlying process is still observable on a local scale in the Sunset Country. Local wind erosion from dry lake beds and local deposition produces a distinctive formation on the leeward edge of ephemeral lakes that has a thin layer of clay overlying pure gypsum. As many of these lakes are circular the formation often takes a crescentic shape and is referred to as a lunette (Bowler, 1983).

Coonawarra is located in an interdunal area that would initially have been a fringing coastal swamp. Such swamps typically contain freshwater and develop humic soils. The subsequent uplift would have resulted in intermittent drying of the lake providing the opportunity for the development of a lunette on its eastern edge. The position and nature of the Coonawarra Ridge are consistent with its having been formed as a lunette with the southern and northern ends having been degraded through wind erosion. Additional features associated with its formation as a lunette include the uniform clay composition of the soil material and the presence of unconsolidated nodular and powdery limestone at the base of the soil profile.

Alternate explanations for the origin of the Coonawarra ridge revolve around the weathering of the underlying Mt Gambier limestone. To account for the clay in the soil this requires that the limestone contain significant inclusions of material other than limestone. While terra rossa soils can derive in this way difficulties arise as the Coonawarra terra rossa soil only contains fine particles (no sand) and the surface of the Mt Gambier formation does not contain obvious inclusions of particulate matter. It is also difficult to account for the occurrence of powdery limestone in the profile.

Soil Formation in the Coonawarra Region

Sand dunes were formed on the Mt Gambier formation and gaps between dunes developed as interdunal swamps. Following the observations at Coolooah in SE Queensland (Walker et al., 1981), initial weathering of the dunes resulted in leaching of the calcium associated with shells and the development of a band in the soil (B horizon) cemented and coloured by aluminium and iron oxides and organic matter. With time this band is leached through the sand until reaching an impermeable barrier / water table.

Aeolian deposition of clay and calcium on the sand changes this pattern but the leaching process is analogous. In the reasonably high rainfall of Coonawarra calcium is the first to be leached due to its solubility, and it tends to precipitate at the base of the profile. Clay is gradually eluviated through the sand and in areas of deep sand forms a distinct layer between the underlying limestone and surface sand. These soils are referred to by Blackburn (1959) as podzols.

The eluviated clay remains close to the surface in areas with shallow sand and/or high levels of clay deposition. Blackburn (1964) identifies these soils as solodized solonetz. These soils grade into terra rossas where the clay and calcium are deposited on limestone or shallow sands. The solodized solonetz soils characteristically contain appreciable sand in the A horizon.

The rendzina soils differ from the terra rossas by way of depth and the ratio of free iron oxide to organic matter (Stace, 1956). The shallow depth of the rendzina soils in the Coonawarra region results in seasonal waterlogging (identified as groundwater rendzinas by Blackburn, 1959) and this hydrates the soil and inhibits the breakdown of organic matter. The shallow depth of the rendzina soils also allows cycling of calcium to the soil surface so that limestone nodules occur throughout the entire soil profile.

Distribution of Soils in the Coonawarra Region

The results of Blackburn (1959, 1964) represent a good implementation of soil survey with the technology then available. His map reflects an interpretation of soil landscapes using visual interpretation of aerial photography. Soil description was by way of soil types with the diversity of soils being accommodated within a classification that identified typical or characteristic soils on the basis of their appearance.

New techniques are available that provide objective and quantitative means of mapping and describing soils by way of soil properties as well as profile development. Airborne measures of gamma radiation (radiometrics) provide quantitative mapped information that reflects the origin and weathering of the surface material and therefore maps patterns relevant to soils. The measurement of soil properties, such as pH, oxidation-reduction potential and salinity directly provides information relevant to viticulture and other land uses.

The relevance of the radiometric data to soils can readily be interpreted in the Coonawarra region as the system is composed of differing mixtures of the same materials, namely sand, clay and limestone. The sand and limestone have very low radiometric emissions thus the variation in signal is mainly associated with variations in the amount, depth and nature of the clay. As all the clay has the same origin, variations in the nature of the clay relate to the degree of in-situ weathering.

The aeolian clay has high levels of iron and this is reflected in the radiometrics by high levels of thorium. High clay content is indicated by high levels of thorium as well as total count. Young clay characteristically has high levels of potassium hence the relative levels of thorium and potassium indicate the degree of weathering. Low potassium relative to thorium indicates a high level of leaching.

The regional soil variation map (Fig.1) was produced from two adjoining radiometric surveys flown to different specifications. The variation in soils was mapped by classifying the data to identify areas having similar radiometric properties. The soil properties associated with the patterns or classes are determined by field sampling.

The prominence of sand in the profile results in the podzolic soils having low radiometric emissions while emissions are moderate for the terra rossas and highest for the rendzinas. The terra rossa and rendzina soils are further discriminated by the relative levels of potassium and thorium emissions. Both the terra rossa and rendzina soils have high thorium associated with the clay but potassium levels are lower in the terra rossa soils. This lower potassium relative to thorium indicates a higher a level of leaching.

The Coonawarra ridge comprises the bulk of the terra rossa soils around the Coonawarra village and represents a remnant lunette developed on the eastern edge of a historic ephemeral lake. The lakebed is now a plain with rendzina soils. The podzolic soils to the east of the Coonawarra ridge represent weathered coastal sand dunes with the aeolian deposits of clay having been eluviated through the profile. Much of the area with podzolic soils to the east of the Coonawarra ridge has subsided due to geological faulting.

Terra Rossa Soil Properties

Properties for six profiles of red soils, three each at Coonawarra and Wrattonbully (Table 1) indicate a gradational texture profile of red clay. The soil is underlain by limestone but the calcareous material at the base of the profile is nodular and/or powdery and interspersed with clay. The terra rossa profiles are typically more than 30 cm deep.

Table 1 (A) Means and standard errors for horizon thickness and texture for red soils sampled at Wrattonbully and Coonawarra. (B) Significant effects for location and horizon for soil texture and horizon thickness.

A

	Thickness (cm) SE 0.05	Texture Grade SE 0.49	Texture Description
A1	7.8	13.2	Silty Loam
A2	18.5	15.8	Clay Loam
B1	21.3	20.7	Medium Clay
B2		20.8	Medium Clay

B

	Texture	Horizon Thickness
Location	0.46	0.88
Horizon	<0.01	<0.01
Location x Horizon	0.60	0.30

A profile for a terra rossa soil (Fig. 2) illustrates the occurrence of lenses of clay between layers of powdery/nodular lime. Lateritic nodules can occur in the B horizon. All profiles are gradational and can exhibit considerable profile differentiation. The occurrence of powdery limestone, the clay lenses within it, and the absence of any coarse material indicate that the lime is unlikely to have derived from the underlying limestone formation.

The terra rossa soils on the Coonawarra ridge represent premium areas for viticulture due to their high permeability to air and water, their high water holding capacity and their high level of weathering. Their permeability arises from the high levels of calcium flocculating the clay. The water holding capacity and characteristics arise from the high clay content. The high weathering arises from the initial source of the clay and its subsequent leaching in the lunette formation. The terra rossa soil provides an environment that prevents excessive growth but promotes the development and survival of vines without their experiencing undue stress.

Conclusions

The Coonawarra ridge is a distinct geomorphic feature in being associated with the historic lake but the materials comprising the soils on the Coonawarra Ridge are present throughout the entire region. Soils that provide equivalent conditions for viticulture are much more extensive elsewhere in the region but are not present as a single feature and show a higher degree of intergrading with other soil types than on the Coonawarra ridge.

References

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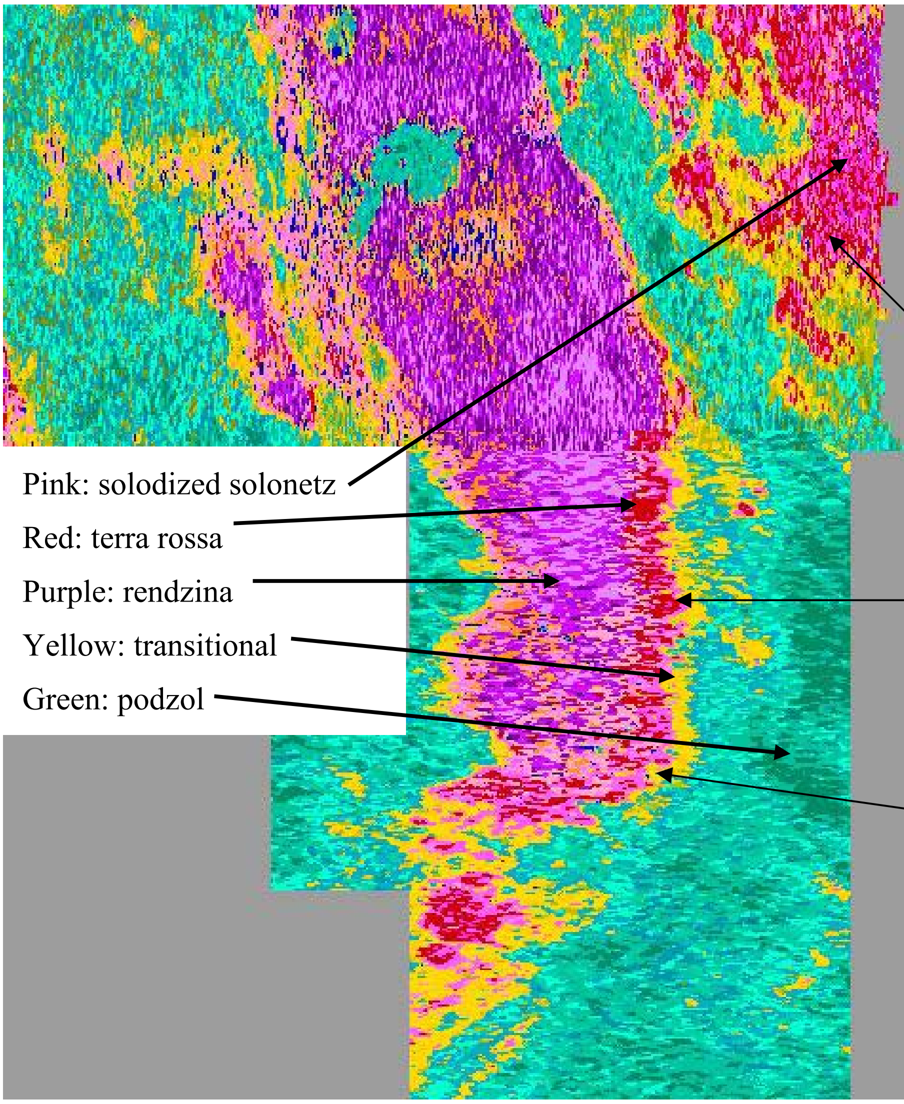

Fig. 1

Classified radiometrics mapping patterns of soil variation around Coonawarra

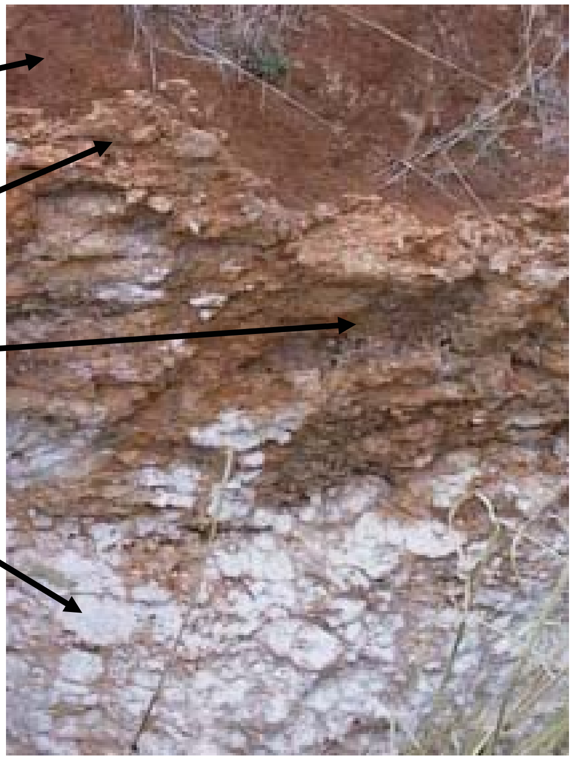

Fig. 2 Terra rossa profile from Coonawarra