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# The Geological Controls in Coonawarra

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ABSTRACT *The special feature of the Coonawarra district for the production of quality wines is not the famous Terra Rossa but the underlying limestone. This is an unusual solution-breccia with ideal drainage for holding and providing moisture to the vines.*

## Introduction

Coonawarra is now one of the most famous wine districts in the world. The setting is succinctly stated by Stevenson (1988): the Coonawarra's vines grow on red earth, or Terra Rossa, over a limestone subsoil with a high water table and this combination, together with its unique climate results in the lowest heat summation in mainland Australia (1205 °C degree days).

The geological features, on which much emphasis has often been placed, are always said to be the Terra Rossa, the limestone subsoil and the high water table. The importance of the first two is never properly explained, or not explained at all, whilst the water table has often been misunderstood.

## Terra Rossa

Although there is no published detailed geological map of the Coonawarra district, the general geology is well known, and there is a simple soil map in John (1990), from which Figure 1 is adapted. The Terra Rossa (sometimes spelt Terra Rosa) soils form a north–south strip some 16 km long, and approximately 4 km wide, from Penola northwards, lying parallel to the coast, which is some 65 km to the west. There are similar soils, with vineyards, at Padthaway, about 90 km north of Coonawarra (Anonymous, 1989). The soils to the west of the Terra Rossa strip are "groundwater rendzina-type, black and very fertile, subject to water logging" (Anonymous, 1989). To the east the soils are sandier and overlie a clay subsoil.

The Terra Rossa immediately beneath the surface is exposed in a trench several metres deep in the vineyards of Rouge Homme at Coonawarra itself on the east side

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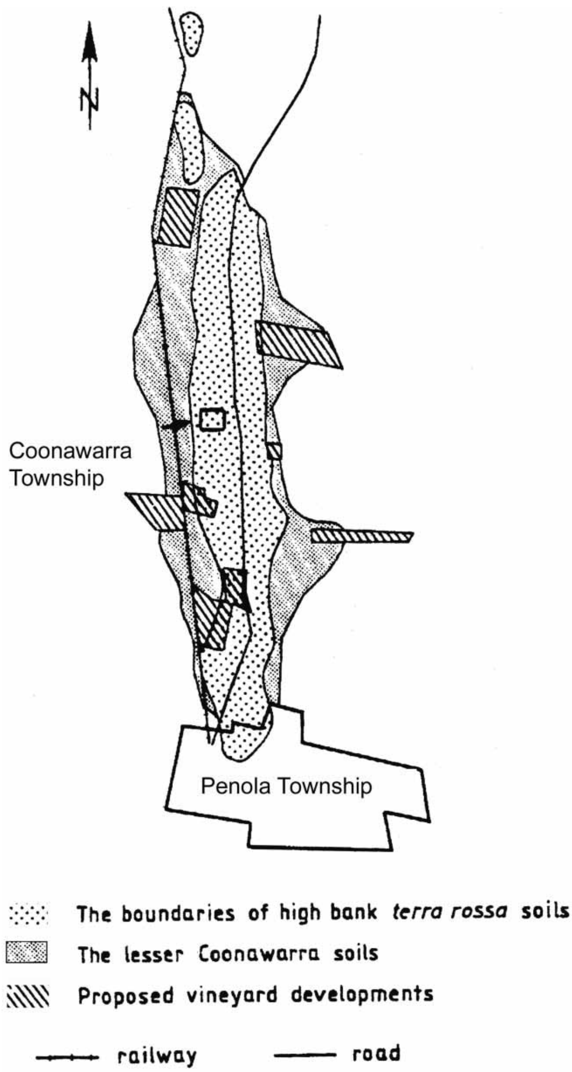


**Figure 1. Sketch soil map of Penola–Coonawarra area; adapted from John (1990).**

of the John Riddock Road (Figure 2). It is one of the typical varieties of laterite. This is a type of soil-rock formed in areas where river drainage is poor. The result is that rain-water first weathers the surface rock chemically, and then removes the more soluble components by downward solution instead of removing the weathered material mechanically in streams, as is seen in many temperate parts of the world. The resultant soil will be rich in the least soluble oxides of the elements common in rocks, namely those of Fe, Al and Ti. The types of clay minerals present will depend on the weathering temperature and the amount of rainfall (Duchaufour, 1982). In the earlier stages of formation, the laterite will still contain some $SiO_2$, as quartz or in clay minerals. In mature laterites even the $SiO_2$ is leached out and the rock is composed predominantly of oxides of Fe and Al. Because the Terra Rossa is an oxic environment, the iron oxide

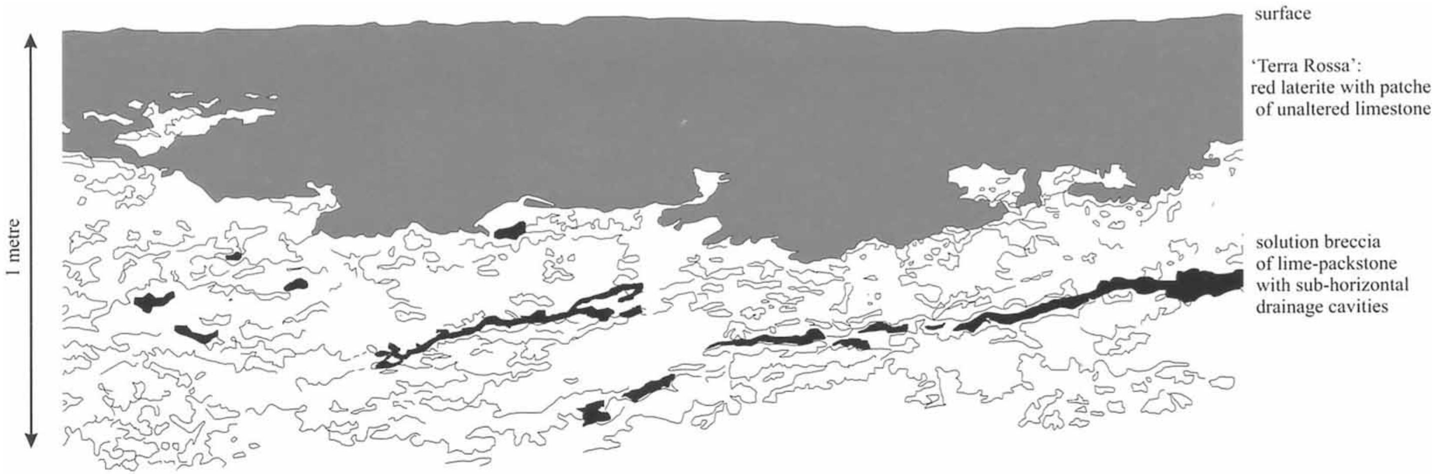


**Figure 2. Drawing of the laterite on limestone solution-breccia profile at Rouge Homme, Coonawarra; based on field sketches and photographs.**

formed is ferric, usually haematite ($Fe_2O_3$). This bright red mineral is the origin of the soil colour.

Whole-rock semi-quantitative X-ray diffraction analysis indicates that the mineralogical composition of the laterite is as shown in Table 1. Apart from the high quartz content, this mineralogy is typical for a laterite. The proportions of clay minerals are very low, even in the clay-size fraction (the portion of the laterite that is $<4\ \mu m$), which is also dominated by quartz, with subordinate illite, kaolinite, cristobalite and haematite (Figure 3). The absence of goethite from the clay-size fraction indicates that it must occur within grains $>4\ \mu m$. In fact, there is a visible concentration of grains and granules of goethite at the bottom of the laterite profile. The clay-size fraction makes up a very small proportion of the rock: barely enough to hold the grains together in the walls of the trench, though at the top (ground level) there is more clay than in the trench. John (1990, p. 11) describes the Terra Rossa soils of Coonawarra as "generally shallow, medium clay loams of average fertility, well structured and particularly well drained". At the Rouge Homme vineyard there is sufficient clay in the surface-soil to show desiccation cracking from drying out after rain, but this soil is only a few centimetres thick.

A trench a few metres wide and about 20 m long may not be fully representative of the district, but it is probably sufficiently typical to draw some general conclusions. Ignoring pipes of lateritisation into the underlying limestone-breccia, the thickness of the laterite ranges from 0 to 0.8 m thick. The base undulates so markedly that there is no real typical thickness, but 0.3 to 0.4 m is of the right order (Figure 2). The small pinnacles of limestone that here reach the surface can be seen elsewhere in the vineyards of the district. They now show up more as local concentrations of pebbles of limestone, any original little platforms having been broken up by cultivation.

## Nourishment in Coonawarra

There has been limited research on the depths from which vine roots extract nourishment, as distinct from water. However, it is agreed that nourishment is mainly obtained from the top 0.6 m, and particularly from the top 0.3–0.4 m, provided that there is moisture (Humbrecht, 1987; Northcote, 1988; Jackson, 1994), although it can be much deeper during a dry season (Trambouze and Voltz, 1997). Therefore Coonawarra vines will be obtaining much of their nourishment from the laterite when it is moist. There are roots visible in the sides of the trench, which from their size must extend several metres below the base of the trench, which is itself approximately 2 m below ground-level. Of the three major nutrients needed (potassium,

**Table 1. Whole-rock semi-quantitative x-ray diffraction analysis of the laterite from Rouge Homme, Coonawarra**

| Mineral | Composition | Abundance (%) |
|---|---|---|
| Quartz | Silica | 72 |
| Goethite | Ferric iron hydroxide | 11 |
| Haematite | Ferric iron oxide | 8 |
| K feldspar | Potassium aluminosilicate | 4 |
| Illite and mica | Potassium-bearing clay | 3 |
| Smectite | Swelling clay, variable composition | 2 |
| Kaolinite | Clay (simple aluminosilicate) | Trace |
| Cristobalite | Disordered silica | Trace |

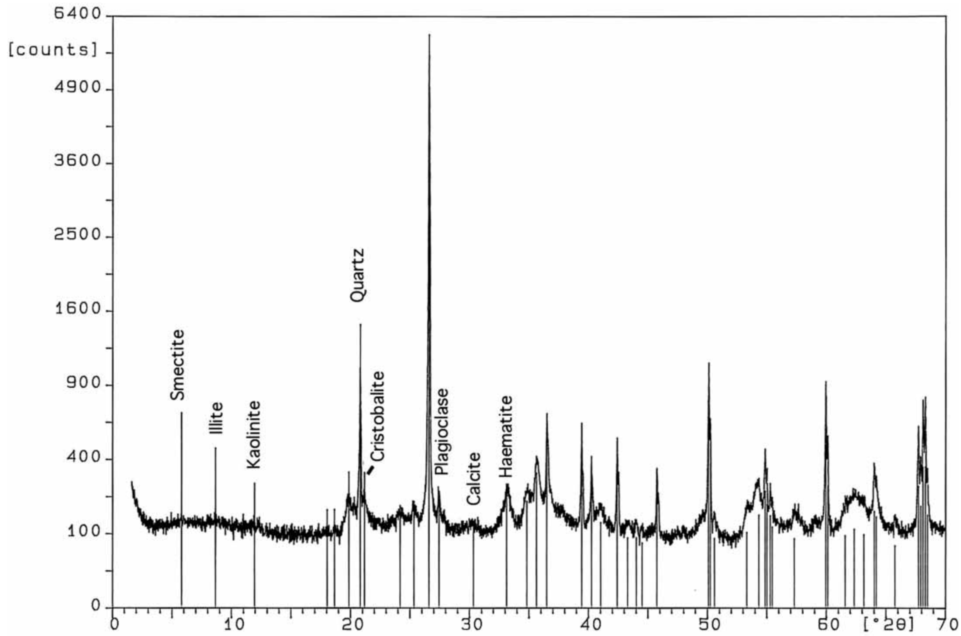


**Figure 3. X-ray diffraction trace of a clay-bearing sample of laterite from Rouge Homme, Coonawarra. The lines indicate the positions of mineral reflections and the mineral names denote the reflections used in the semi-quantitative analysis.**

nitrogen and phosphorous) the potassium could be derived from K feldspar, illite or mica. Since potassium is taken up directly as the K+ ion from solution, some of it could be derived from illite in the underlying limestone solution-breccia. Phosphorous (always in the form of phosphate) is often low in acid soils, but as phosphates may be adsorbed by iron oxides they can be preserved in Terra Rossa soils. Thus the phosphate content of these soils is often not as low as might be expected (McFarlane, 1976). The phosphate content of the fine fraction of laterites in south-west Australia is consistently around 0.01% (Robson and Gilkes, 1981). The element that will be in short supply is nitrogen because of the very low humous content of a lateritic soil. Although vines need less nitrogen than most agricultural crops (Jackson, 1994), there is a widespread nitrogen deficiency in Australian vineyards (Gladstone, 1992). Coonawarra is no exception to this.

## The Limestone and its Drainage

Underlying the Terra Rossa is a limestone. Rogers (1995) has mapped this as a part of the Upper Pleistocene Padthaway Formation that covers a large part of south-east South Australia. This formation is composed of lacustrine and lagoonal dolomites, limestone, claystone and sandstone. At Coonawarra itself the limestone is grain-supported with white mud between the grains, visible in hand specimen, i.e. it is a lime-packstone in the Dunham Classification (Dunham, 1962). The overall colour is white to off-white with variable, but very pale, brown iron oxide staining. There is an obvious porosity where grains have been leached out. Scattered small patches of sparry calcite are visible under a hand lens. Indeed, the Padthaway Limestone has

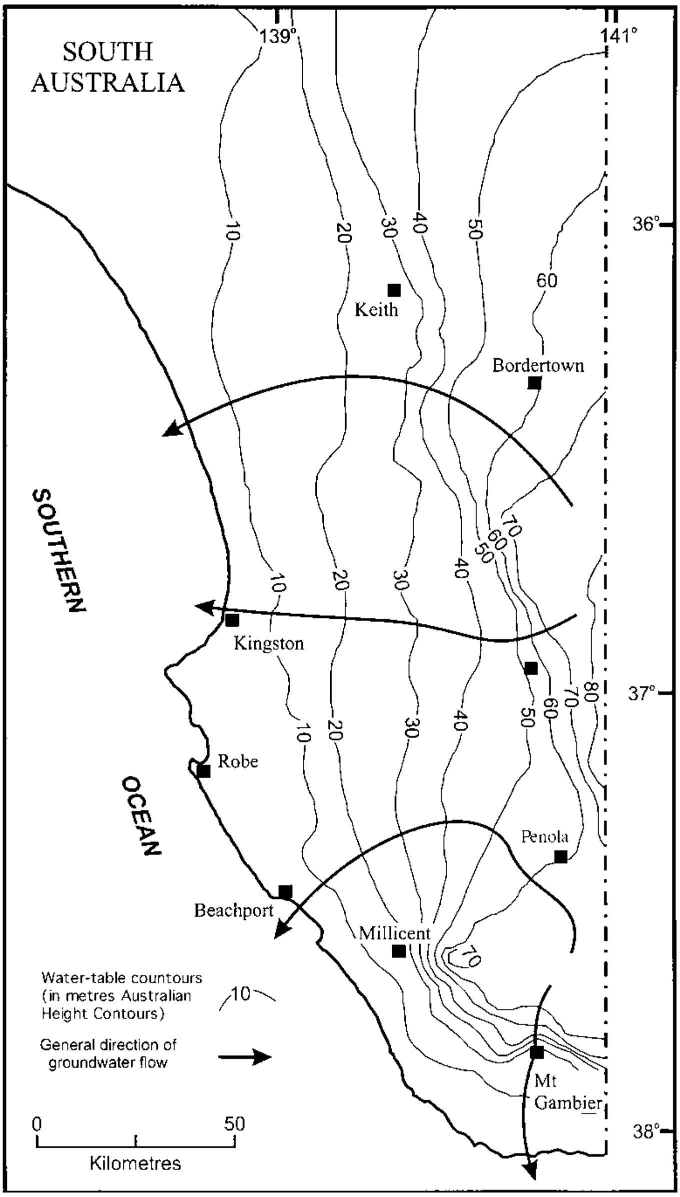


**Figure 4. Regional water table contours of the unconfined aquifer in the far South Australia; adapted from Rogers (1995).**

undergone extensive solution so that what one sees now is a collapsed limestone solution-breccia. Only 2 m is exposed in the trench (Figure 2), but it is probable that the solution effects continue for several metres further down. The resultant rock shows a wide range of particle sizes, from clay and fine sand-grade grains of limestone up to boulders of limestone. The porosity of the limestone-breccia will therefore vary widely over a small distance. We estimate from visual observation that the overall porosity is high, perhaps $\geq$30%. This is a much higher porosity than should be encountered in the unaltered limestone. The matrix permeability is likewise inferred to be highly variable. Some of the pebbles and boulders of unaltered limestone with limited solution porosity will have very low matrix permeability, probably no more than 5 milli-Darcies, while the patches of limestone-sand will have high matrix permeabilities, possibly $>100$ milli-Darcies. This contrast is minor compared with the anticipated permeability of major vertical joints and subhorizontal bedding planes, all enlarged by solution. Gaps of several centimetres are common, and permeabilities of $>1$ Darcy are anticipated. Thus the drainage conditions at Coonawarra are ideal for vines and are remarkably similar to those in true chalks, as described by Hancock and Price (1990). The Terra Rossa has a high mass-permeability and will allow any excess rainfall to penetrate the underlying, also highly permeable, limestone. Hence after even very heavy rainfall, excess water will drain away. It follows from this that the limestone solution-breccia will hold moisture for the vines, during even months of no rainfall. The annual rainfall in Coonawarra is around 650–660 mm. It falls between April and December, particularly during the winter months, while the harvest coincides with a dry period (Kidd, 1983; John, 1990). Although some growers do irrigate, it is clear from the above that irrigation should only be necessary in Coonawarra for the establishment of new vines, and possibly to ensure the take-up of nitrogenous manure.

## The Water Table

The natural water table of the unconfined aquifer at Penola lies at 60 m Australian Height Datum (Figure 4). This falls very slightly as one goes north of Penola, though probably by not more than about 3 m (Rogers, 1995). Benchmarks on the National Topographic Map 1:250 000 series, sheet SJ54-6, also show a slight fall northwards from Penola (61 m), through Coonawarra (58 m) to south of Father Woods Broom (57 m). Theoretically, the water table should be reached only about 1 m below the surface of the ground. In fact, the bottom of the 2 m trench at Coonawarra was completely dry in April 1997. According to John (1990) the water table now lies approximately 6 m beneath the surface. This lowering of the water table is the result of the drains put in around Penola–Coonawarra, particularly the drain aligned north–south around 4 km west of the Penola–Coonawarra road. West of this drain are intermittent ponds; even to the east of it there can be boggy lakes the year round.

Popular accounts of Coonawarra have sometimes assumed that the vines obtain their moisture directly from this high water table. This assumption has probably been enhanced by the belief that the water table is still only 1–1.5 m below the surface, whereas in reality it is considerably lower. In fact, as John (1990, p. 12) has succinctly put it, "vines do not directly tap this aquifer; it would be counter productive if they did". The real importance of this underground water has been as a supply for irrigation, notably valuable in a land where water has often been a limiting factor on development. At Penola the salinity is around 1000 mg $l^{-1}$, low enough for the water to be suitable for domestic use (Rogers, 1995). Along the Coonawarra ridge it can be even lower, 650–700 mg $l^{-1}$, and it is possible to pump 500 000 l $h^{-1}$ (Anonymous, 1989). Clearly there may be a temptation to use this supply for irrigation simply to increase production, rather than to allow the vines to tap the aquifer and abstract only as much water as they require.

## Conclusions

The special feature of Coonawarra that makes it such a good district for producing wines is not the Terra Rossa, but the underlying unusual limestone. This limestone has undergone extensive dissolution and collapse so that it is no longer plain Padthaway Limestone, but a limestone solution-breccia of boulders, pebbles, granules and sand-sized particles of limestone jumbled together with some residual clay in the matrix. Much of this solution has been along joints and bedding planes that are now much enlarged. This limestone breccia has an ideal drainage for viticulture. Excess rain drains away fast, but the variable porosity and permeability in the mass of the rock holds moisture for the vines to draw on as and when required.

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**References**

ANONYMOUS (1989) Coonawarra. Regional report. *Wine Industry Journal*, November, 1989, 257–276.

DUCHAUFOUR, P. (1982) *Pedology, Pedogenesis and Classification*, English edition translated by T. R. Paton, London: Allen and Unwin.

DUNHAM, R.J. (1962) Classification of carbonate rocks according to depositional texture, in: HAM, W.E. (ed.) *Classification of Carbonate Rocks*, American Association of Petroleum Geologists Memoir, 1, 108–121.

GLADSTONE, J. (1992) *Viticulture and Environment*, Adelaide: Winetitles.

HANCOCK, J.M. and PRICE, M. (1990) Real chalk balances the water supply, *Journal of Wine Research*, 1, 45–60.

HUMBRECHT, O. (1987) *Terroir et qualité influence du milieu viticole sur la vigne et les caractéristiques organoleptiques des vins*, Colmar: Institute Nacional de la Recherche Agronomique.

JACKSON, R.S. (1994) *Wine Science*, San Diego, CA: Academic Press.

JOHN, P.G. (1990) Wine making expectations for premium Coonawarra dry red styles, *Proceedings of the 7th Australian Wine Industry Technical Conference*, 11–15.

KIDD, C.H. (1983) General description of Coonawarra, in: LESTER, D.C. and LEE, T.H. (eds) *Coonawarra Viticulture*, proceedings of a seminar by the Australian Society of Viticulture and Oenology, Coonawarra, June, 5–6.

MCFARLANE, M.J. (1976) *Laterite and Landscape*, London: Academic Press.

NORTHCOTE, K.H. (1988) Soils and Australian viticulture, in: COOMBE, B.G. and DRY, P.R. (eds) *Viticulture*, 1 (Resources), Adelaide: Winetitles, 61–90.

ROBSON, A.D. and GILKES, R.J. (1981) Fertiliser responses (N, P, K, S micronutrients) on lateritic soils in southwestern Australia—a review, in: BANERJEE, V.R., APPAHADHANALU, K., VENKATESH, V. and RAMAM, P.K. (eds) *Lateritisation Processes (Proceedings of the International Seminar on Lateritisation Processes, Trivandrum, India, December 1979)*, Rotterdam: A. A. Balkema, 381–390.

ROGERS, P.A. (1995) Geology of south-east Australia, 2nd edn, Adelaide: South Australia Geological Survey, Special Map, 1:500 000.

STEVENSON, T. (1988) *Southeby's World Wine Encyclopedia*, London: Dorling Kindersley.

TRAMBOUZE, W. and VOLTZ, J. (1997) Caracterisation des relations hydriques sol/vigne dans un terroir languedocien, *Les Terroirs Viticoles*, Colloque International, July 1996, Angers, France, Angers: Institut National de la Recherche Agronomique, 164–169.