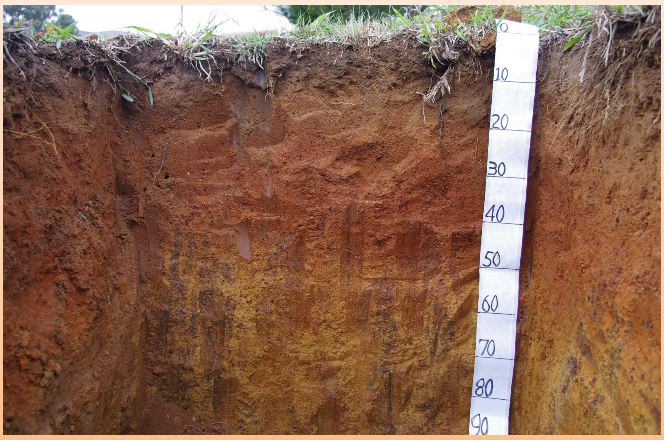
NATIONAL SOILS CONFERENCE
Canberra 18-23 November 2018



Conference Tour, Wednesday 21 November, 2018

Winery Soils of the Yass Valley, NSW

Tour leaders: Peter Fogarty and Richard Greene

SOIL SCIENCE AUSTRALIA

Contents

Front cover: Stop 2 aeolian material at Yass River Crossing and Stop 3 Clonakilla Red Chromosol containing parna

Itinerary for Soil-winery field trip Wednesday 21st November 2018

8:45	Assemble at rear entrance of Hyatt Hotel
9:00	Bus departs rear entrance Hyatt Hotel
9:30	Stop 1, McIntosh Circuit, Murrumbateman, NSW: Road side exposure of soil with aeolian input; Peter Fogarty and Richard Greene to lead discussion.
10:30	Stop 2: Old Hume Highway at Yass River crossing -road side cutting exposure of aeolian deposit. Peter and Richard to lead discussion. Morning tea.
12:30	Stop 3 Clonakilla Winery, Murrumbateman: Welcome by Tim Kirk, owner and winemaker, inspect two soil profiles in vineyard, Richard, Peter and Tim to lead discussion. Lunch at the cellar, talk on wines and wine tasting, Tim Kirk.
15:00	Stop 4 Gallagher vineyard, Dog Trap Rd, Jeir: Welcome by Greg Gallagher, owner and winemaker, then inspect soil pit in vineyard, Richard and Peter to lead discussion. Talk at the cellar on wines and wine tasting by Greg Gallagher.
17:30	Arrive back at Canberra Hyatt Hotel.

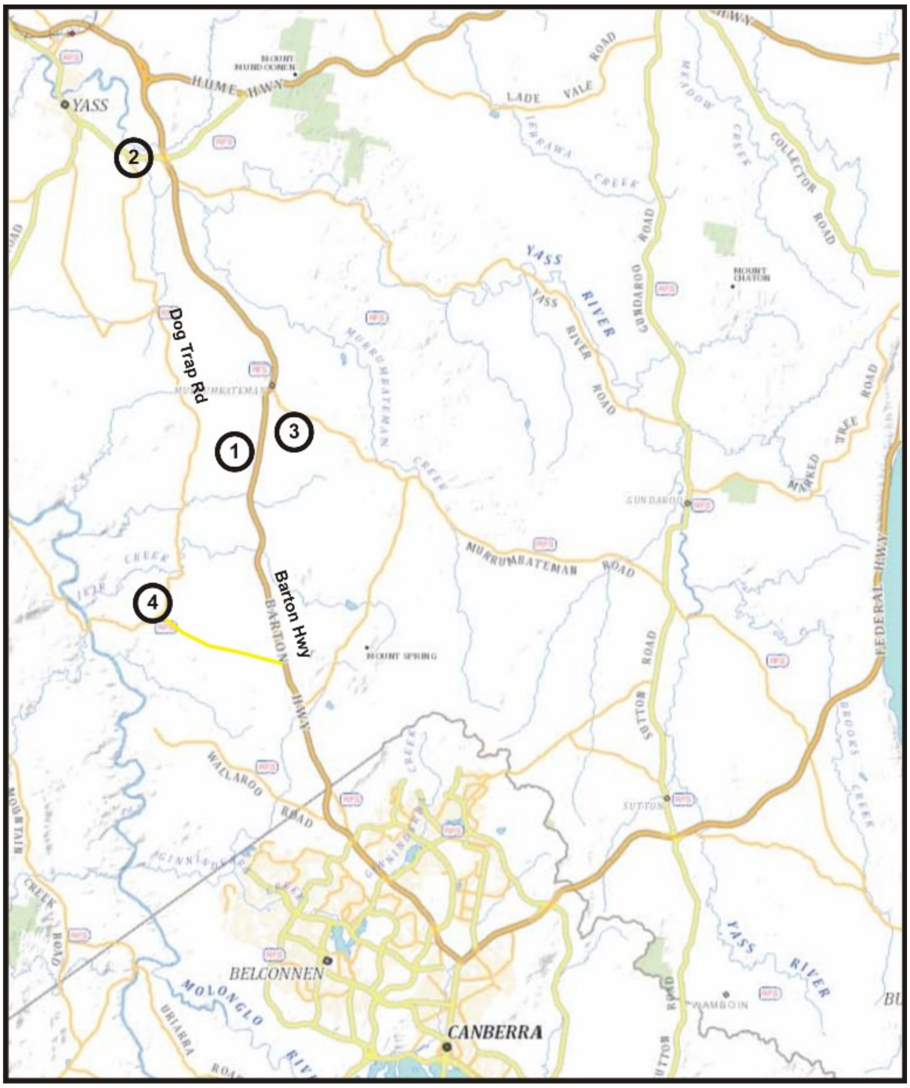


Figure 1. Map of soil-winery tour of Yass Valley, NSW.

Introduction and aims of field trip

Terroir is a term used to define the features of a wine growing region that reflect the region's physical qualities such as climate, geology, topography, and soils. There is an increasing interest in understanding the overall role of soil properties in determining the quality of wine from vineyards (Bramley et al. 2011).

The overall aim of this winery soils tour is to relate the terroir of the Yass Valley, in particular the soils which have a significant input of aeolian materials, to the quality of wine produced on these soils. Before learning about the soils at two vineyards selected for this tour, we will visit two roadside stops (Stops 1 and 2) to give you some background to the deposition of aeolian materials in the soils in the region. We will then visit two of Canberra's best known vineyards, Clonakilla (Stop 3) and Gallaghers (Stop 4) , and learn more about the age old debate about how important the soil (or, as the French would say, the 'Terroir') is for making a great wine. At Stop 3 we will examine two soil profiles, a Red Chromosol and a Yellow Chromosol at the top and bottom respectively of a soil catena, both having strong evidence for parna, whilst the profile at Stop 4 (a sandy Tenosol) has no evidence of parna.

General background to the geology and soils in the Yass valley, NSW

The Murrumbateman region in the Yass Valley is situated approximately 50 km north of Canberra (Figure 1). is a well-established "cool climate" wine region having a relatively dry temperate climate, with an average yearly rainfall 652 mm, and average high and low temperatures of 21° C and 7° C respectively. Evaporation in summer exceeds rainfall by 600-800mm. During the warm dry summers the water requirements of the vines are supplemented by irrigation.

Agriculture, in particular irrigated viticulture, is very important for the economic livelihood of the Yass Valley of NSW that we are visiting on this trip. There are thirty two vineyards in the Canberra Region, and around half are in the Murrumbateman area.

Vineyard soils in this area are largely derived from dacite geology (Figure 2). The rocks have weathered to form soils ranging from well drained deep Red Chromosols on mid and upper slopes, with imperfectly drained Yellow Chromosols and Sodosols on lower slopes. Tenosols and Kandosols are typical of localized areas of steeper slopes and stony hillcrests. There is also evidence for a contribution of windblown (aeolian) fine silt to the development of vineyard soils in the region. These aeolian deposits (also named "parna" by Butler and Hutton (1956)) which overlay the parent geology have been highlighted in previous studies in the local region (Melis and Ackworth 2001, Walker et al. 1988).

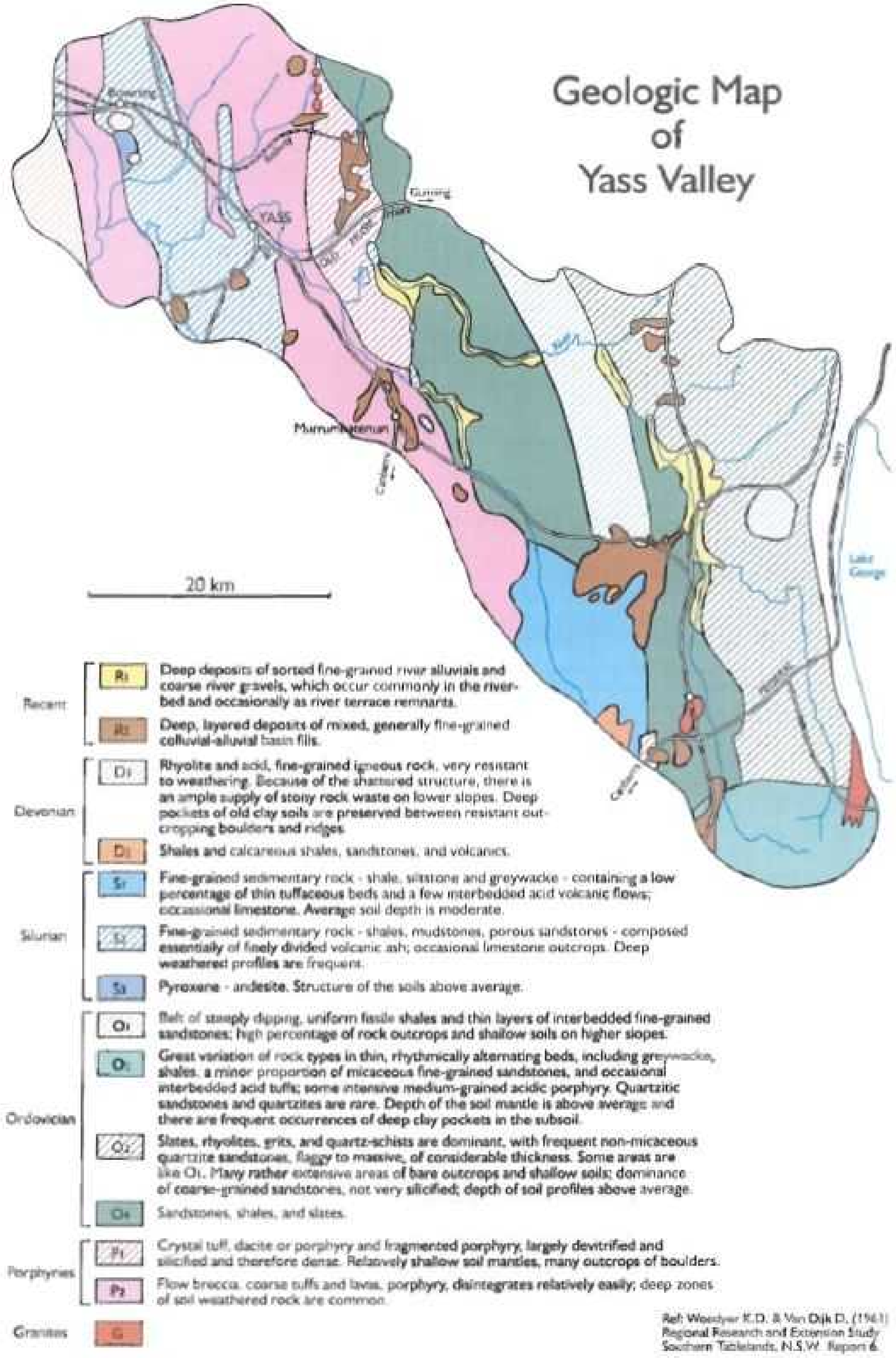


Figure 2. Regional geology

Evidence for aeolian deposition in the Yass Valley, NSW

The Yass Valley is directly in the path of aeolian materials transported in an easterly direction across SE Australia (Figure 3), and from previous work (Walker et al., 1988), there is strong evidence for aeolian deposits in the soils of the Yass Valley of NSW. A previous conference in 1998 (Scott et al. 1998) took a field trip to various sites in the Yass Valley to study aeolian deposits across the range of major geologies in the area, including granites, metasediments , Tertiary terraces and dacite. The guide for this 1998 field trip has been extensively used for subsequent studies of aeolian materials in the Yass Valley.

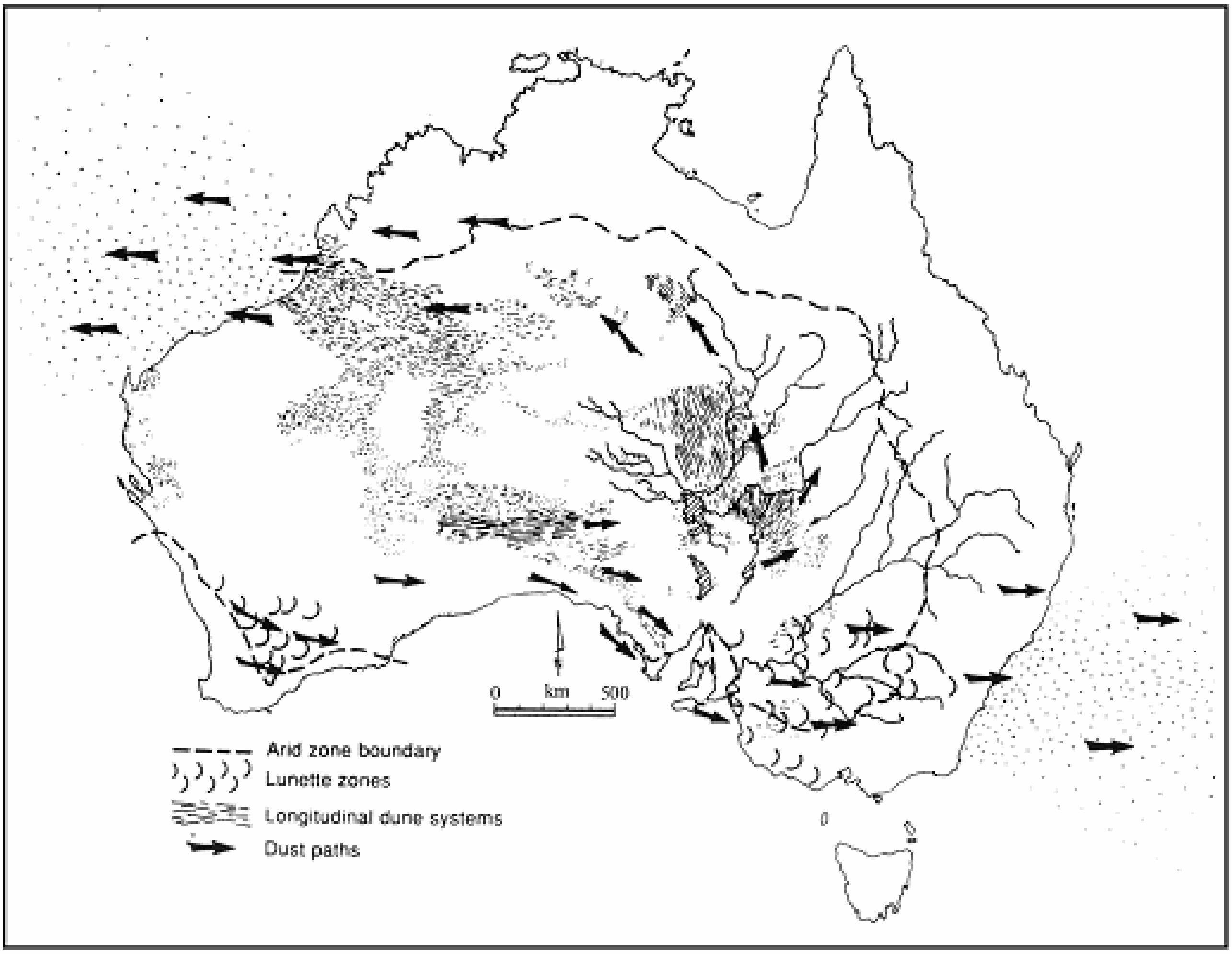


Figure 3. (adapted from Bowler 1976) clearly shows how the Yass Valley is directly in the path of aeolian materials transported in an easterly direction across SE Australia.

The aeolian input to soils in the area improves the water holding capacity, drainage and fertility of vineyard soils. Particle size data, and some chemical data, used as evidence for this material, will be presented for each of the stops. Present annual dust deposition rates for southeast Australia are reported by McTainsh & Lynch (1996) to be in the order of 31-44 t/km^2/yr. Hesse *et al*. (2003) present rates of 20-50 t/km^2/yr on the Central Tablelands of NSW, and indicate rates of deposition were between 1.5 and 3 times higher during the last glacial maxima when the climate was drier, cooler and more windy.

Due to the potential accumulation of long-distance, regional and local dust particles, a variety of aeolian depositional environments and morphologies are possible. In arid and semi-arid zones (regions (i) and (ii) in Figure 4) (Greene et al. 2009), locally-sourced dust commonly accumulates as saltated aggregates in landforms such as lunettes on the leeward (downwind) side of deflated lake beds or in dunes adjacent to alluvial channels (Chen, 1997), while finer-grained dusts have been identified as clay lamellae trapped in sand dunes (Chen *et al*., 2002). Extensive accumulations of remotely sourced dust were first recognised by Butler (1956) as (parna) sheets blanketing the Riverine Plain landscape of southern NSW. He suggested that the parna presently observed in these landscapes was transported as silt-sized clay aggregates, sourced primarily from the dune fields of western Victoria and NSW.

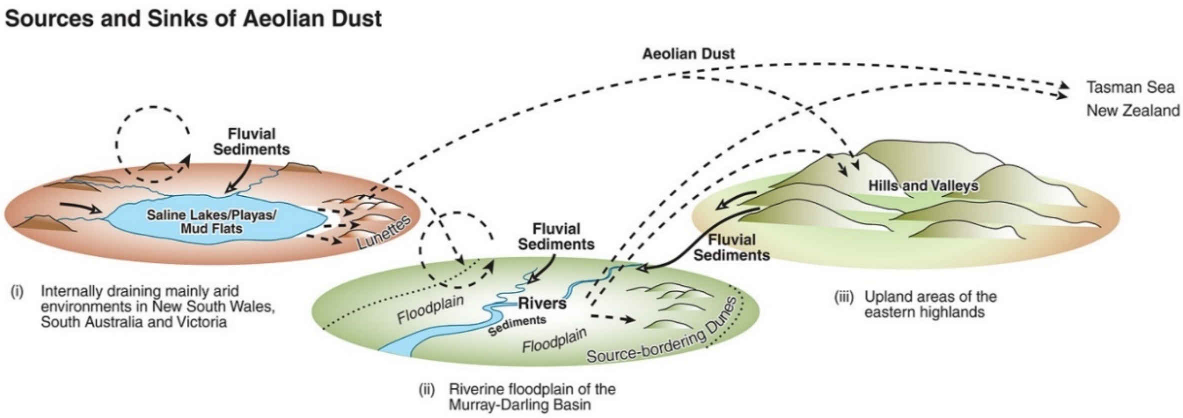


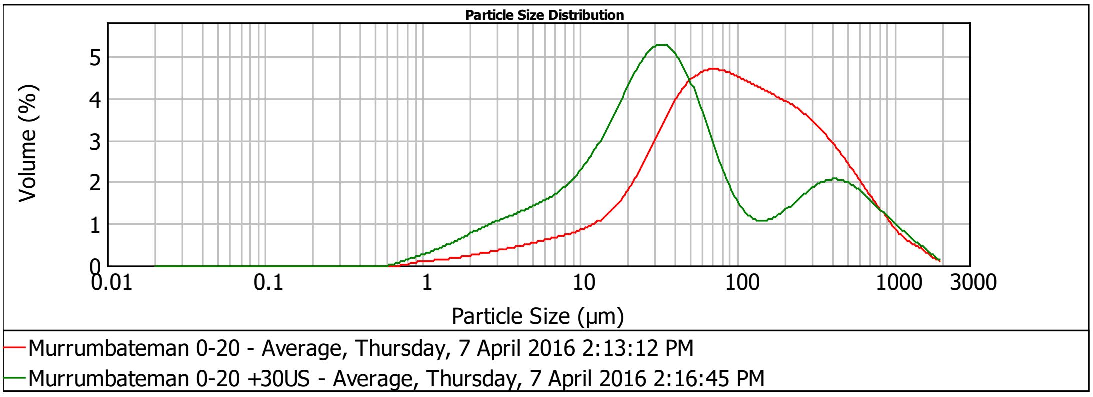
Figure 4. Conceptual model for sources and sinks of Aeolian deposits (Greene et al. 2009)

STOP 1: Roadside cut of aeolian (parna) deposit at McIntosh Crt., Murrumbateman

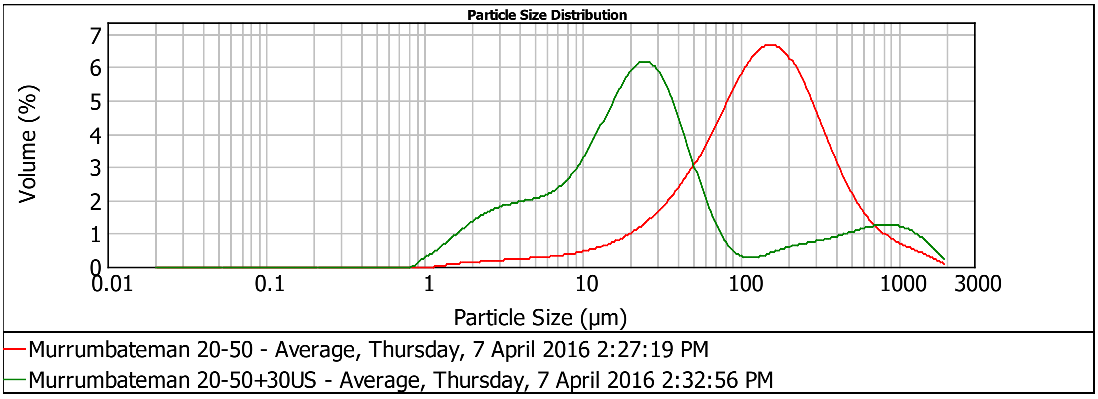
depth	colour	texture	structure
0-20cm	Dark grey brown, unbleached	Clay loam	Massive
20-70cm	Strong brownish red	Medium clay	Strong fine polyhedral
70cm+	Light yellow brown, mottled due to weathering	Dacite saprolite	Massive

Particle size data for soil horizons at MacIntosh Cct, Murrumbateman

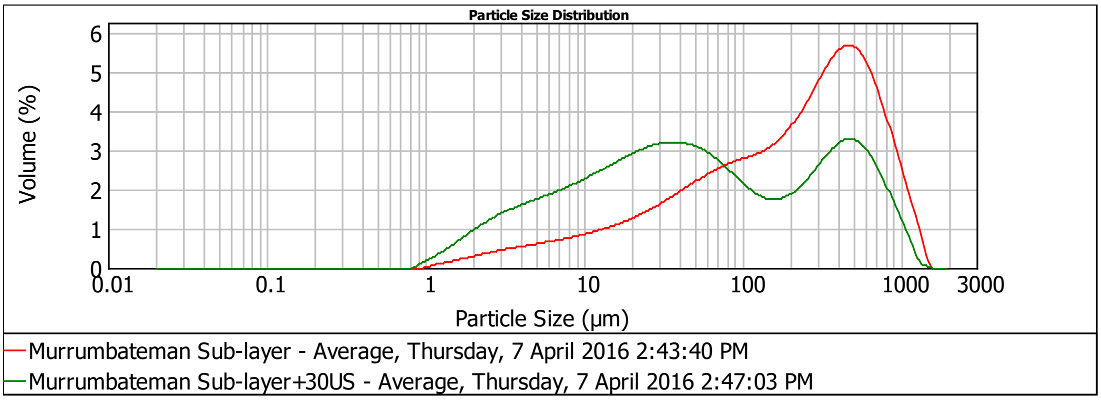
0-20 cm



20-50 cm



70-90 cm



STOP 2: Yass River Crossing aeolian stratigraphy exposure

(notes from Proc. of ANU Symposium on aeolian Dust Field Guide, Nov 1998)

3. YASS RIVER SITE: **R. GATEHOUSE**

Location:	34° 52' 06" S 148° 57' 22" E
Elevation:	520m
Bedrock:	Dacite
Aeolian component:	At least 1.4m of aeolian material

The Yass River profile is a 3-5m thick sequence of layered soils on bedrock in a road cutting on a hill crest (elevation 520m) near Villa Nuova homestead on the Yass Valley road 5km south east of Yass (Figures 11 and 12).

Figure 11. Soil profile, P1, Yass River.

Profile Characteristics

The sequence consists of superimposed soil profiles, which include a modern soil and one or more palaeosols. The modern soil disconformably overlies a hardpan layer which forms the upper surface of the palaeosol at 140cm depth (Figures 11 and 12). The hardpan parallels the surface topography, but the thickness and lateral continuity of the hardpan is obscured in places along the exposure because of collapse. The upper hardpan overlies a yellow clay layer of varying thickness, and this clay layer in turn overlies a second hardpan that sits directly on dacitic saprolite.

The modern soil has formed in transported material. It is hypothesised that the material contains a significant aeolian component that includes both far travelled and locally derived dust, indicated by a bimodal distribution of particle sizes in the soils (Figure 13). There is a major disconformity between the modern soil and the underlying palaeosol. At the eastern end of the exposure, the disconformity is a sharp contact between a 10cm thick mottled gray and red clay layer and the hardpan. Further along the section a bleached horizon becomes evident above the hardpan (this is more noticeable where the hardpan has collapsed). At the western end of the section, a stoneline of river gravel occurs between the saprolite and the palaeosol.

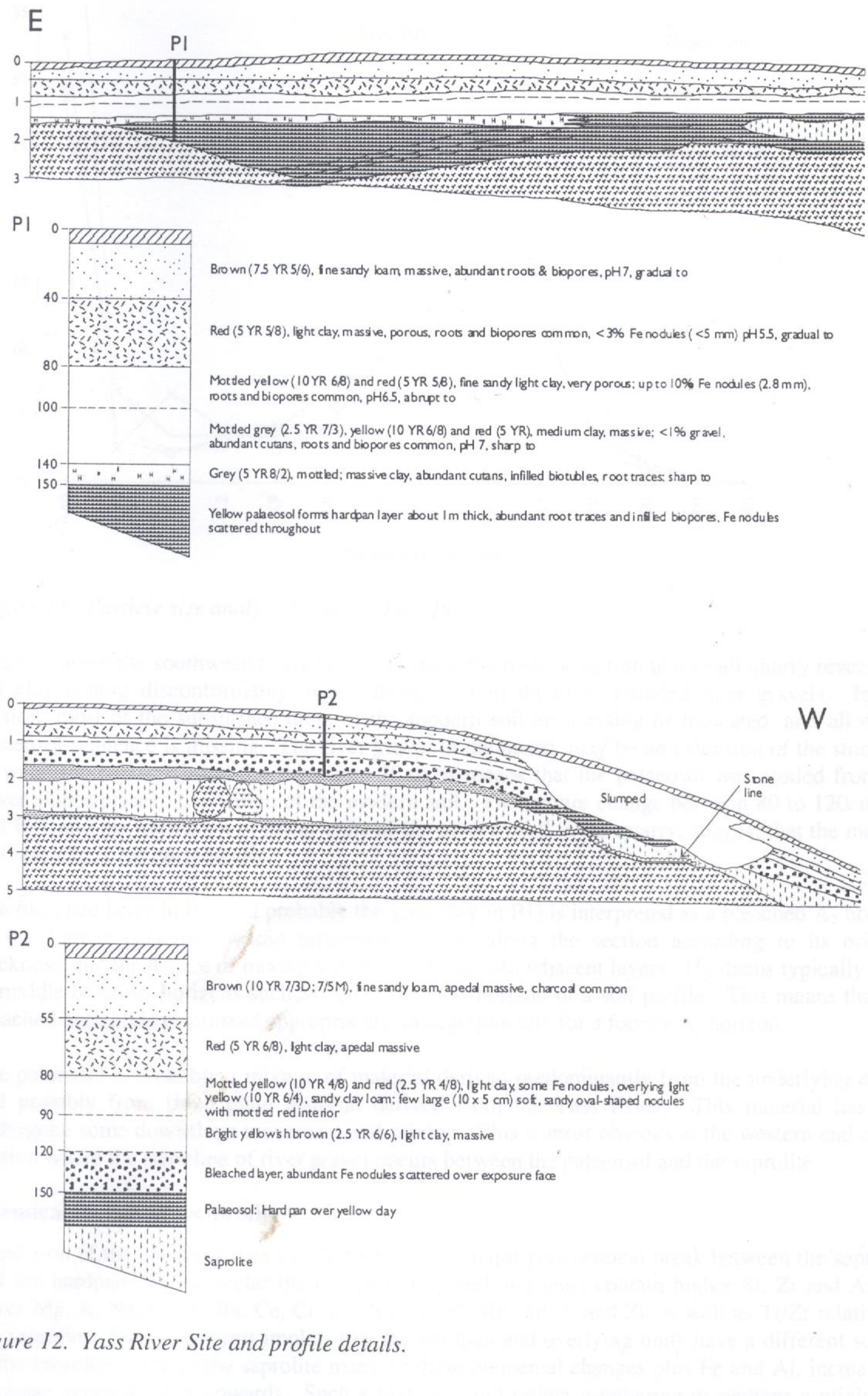


Figure 12. Yass River Site and profile details.

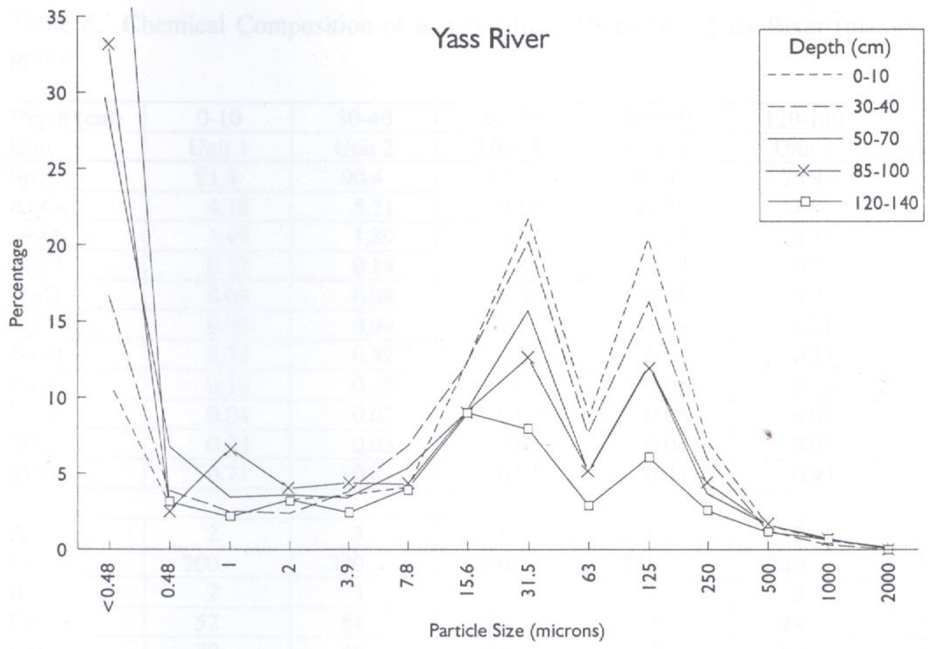


Figure 13. Particle size analysis for soils, Yass River.

Midway down the southwestern embankment (near the river) a section in a small quarry reveals the red clay resting disconformably over a deposit (>1m thick) of rounded river gravels. In this section, most of the subsurface units of the modern soil are missing or truncated, and all of the palaeosol sequence is missing. The river gravel in the quarry may be an extension of the stoneline between the palaeosol and the saprolite. If so, it means that the palaeosol was eroded from the lower slopes prior to deposition of the modern soil. The texture change between 80 to 120cm (P1 and P2), and the truncation of lower units of the modern soil in the quarry, suggest that the modern soil was deposited episodically.

The bleached layer in P2 (and probably the grey clay in P1) is interpreted as a bleached A_2 horizon of the former palaeosol whose properties change along the section according to its original thickness, and the degree of mixing and overprinting with adjacent layers. Hardpans typically form in middle or lower horizons such as in the upper B horizon of a soil profile. This means that the bleached horizon is positioned appropriately stratigraphically for a former A_2 horizon.

The palaeosol is probably a mixture of material derived predominantly from the underlying dacite and possibly from flood plain material derived from the Yass River. This material has also undergone some downslope movement and mixing. This is most obvious at the western end of the section where the stoneline of river gravel occurs between the palaeosol and the saprolite.

Chemical factors of the profile

Inspection of the chemical data (Table 6) reveals a major geochemical break between the saprolite and the hardpan. In particular the hardpan and overlying units contain higher Si, Zr and As but lower Mg, K, Na, Ca, P, Ba, Ce, Cr, La, Nd, Ni, Pr, Rb, Sn, Y and Zn as well as Ti/Zr relative to the saprolite. Such a contrast implies that the hardpan and overlying units have a different source to the saprolite. Above the saprolite many of these elemental changes plus Fe and Al, increase or decrease systematically upwards. Such a feature could reflect weathering or perhaps a mixing of surficial material with increasing amounts of saprolite-derived material.

Table 6. Chemical Composition of material from P1 profile, Yass River (majors, wt%; minors, ppm)

Depth (cm)	0-10	30-40	50-70	80-100	120-140	Psol	Dacite
Unit	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Hardpan	Saprolite
SiO_2	91.9	90.4	84.0	82.4	76.9	85.9	69.8
Al_2O_3	4.18	5.21	9.55	10.7	14.0	7.41	14.6
Fe_2O_3	1.49	1.89	3.67	4.21	5.74	7.41	4.88
MgO	0.17	0.19	0.35	0.37	0.71	0.35	1.82
MnO	0.08	0.08	0.02	0.01	0.01	0.02	0.04
K_2O	0.95	0.99	1.15	1.09	1.21	1.25	4.10
Na_2O	0.32	0.32	0.21	0.17	0.23	0.5	1.91
CaO	0.10	0.10	0.07	0.08	0.18	0.10	2.03
P_2O_5	0.04	0.03	0.0.5	0.06	0.02	0.04	0.13
SO_3	0.03	0.03	0.05	0.04	0.03	0.04	0.01
TiO_2	0.71	0.81	0.91	0.93	0.94	0.95	0.70
As	2	3	5	6	9	7	<1
Ba	200	230	230	240	280	320	690
Br	2	3	3	5	3	1	3
Ce	52	61	66	69	44	45	96
Cr	70	48	66	75	88	60	98
Cu	7	10	20	19	18	11	20
Ga	4	6	11	13	18	9	19
Ge	<1	<1	2	<1	2	<1	1
La	22	24	25	25	24	20	34
Nb	12	13	15	15	16	15	14
Nd	20	21	25	22	19	18	45
Ni	7	8	14	16	22	9	26
Pb	16	14	20	23	22	31	40
Pr	3	2	6	<1	2	3	7
Rb	50	58	80	82	92	64	170
Sb	0.4	0.4	0.6	0.2	0.6	0.5	0.3
Sn	2	2	3	3	4	3	4
Sr	28	33	41	40	60	43	147
Th	11	11	13	14	15	14	17
U	4	3	6	5	3	5	4
V	14	26	69	74	124	75	129
Y	24	27	28	28	24	22	40
Zn	28	24	38	39	46	32	70
Zr	680	630	580	560	470	570	170
Ti/Zr	6.3	7.7	9.5	9.9	12.1	10.0	24.5

STOP 3: Clonakilla vineyard, Murrumbateman

Profile 1: Red Chromosol, mesotrophic, haplic

Landform: upper hillslope

Parent material: dacite geology with aeolian accessions

Drainage: well drained, no seasonal saturation, high infiltration, minimal runoff

Land use: vineyard

Soil description: A strong texture contrast profile comprising a thin organic loam grading to a light red brown unbleached loam, weakly structured A2. Clear change at 20-25cm to red medium clay B2 horizon, strongly structured with fine polyhedral peds, clear boundary to reddish brown mottled B3 medium to heavy clay deeper subsoil.

Profile morphology

Horizon	Depth	Colour	Mottle	Texture	Structure			Consistence	Coarse Frags %	Segregati ons	B'dry
					Grade	Shape	Size				
A1	0-6	2.5YR 2/4 V dk br	0	L	wk	crumb	2-5	sm wk	0	0	
A2	6-22	2.5YR 4/6 Br red	0	L	wk	sabl	10-20	sm firm	0	0	gradual
B2	22-46	10R 4/8 Dk. red	0	mC	strong	poly	5-10	sm firm	0	Few fe	Clear
B3	46-90	5YR 5/8 Red br	R & RB, dist. common	hC	mod	sabl	10-20 5-10	d v firm	0	Com. fe coatings on cleavage planes	clear

Particle size and physical properties

	Particle size composition %					Disp %	EAT	Field Cap	Wilt Pt	AWC
	Clay	Silt	F. sand	C. sand	Gravel			%	%	%
10-20	12	21	27	33	7	44	3(1)	16	5	11 (10-13) [1]
30-40	47	10	14	27	2	15	5	24	16	8 (8-14)
60-80	67	10	14	9	0	34	3(1)			

Analytical data from Scone SCS lab

[1] comparison with data from Moore et al 1998 quoted in Hazelton and Murphy

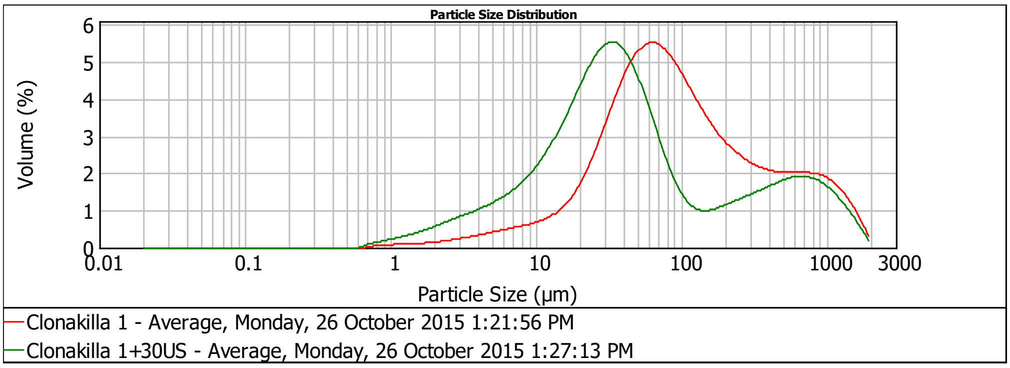
Chemical properties

	Exchange properties cmol/kg						EC	pH	pH
	CEC	Na	K	Ca	Mg	Al	dS/m	(w)	($CaCl_2$)
10-20	5.1	0.1, 1%	0.2	1.0	1.0	<0.5	0.01	5.3	4.4
30-40	14.3	0.3, 2%	0.5	2.3	6.6	<0.5	0.02	6.2	5.1
60-80	17.1	0.89, 5.2%	0.3	4.7	11.0	<0.5	0.06	7.0	5.8

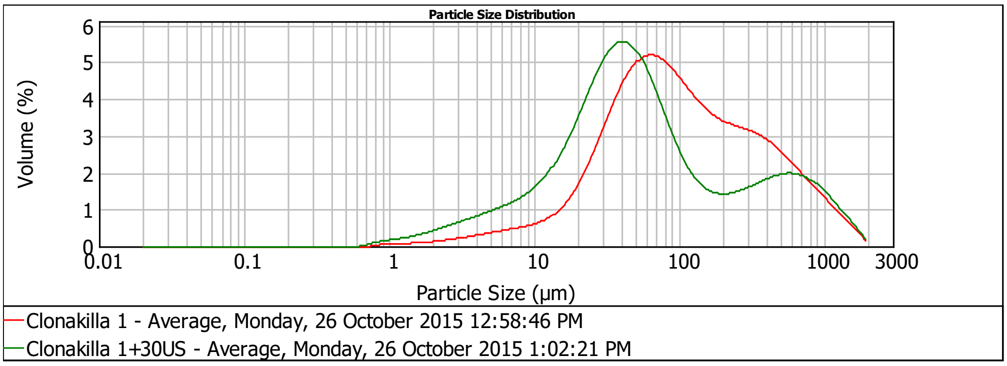
Analytical data from Scone SCS lab

Particle size data for soil horizons at Clonakilla Profile 1

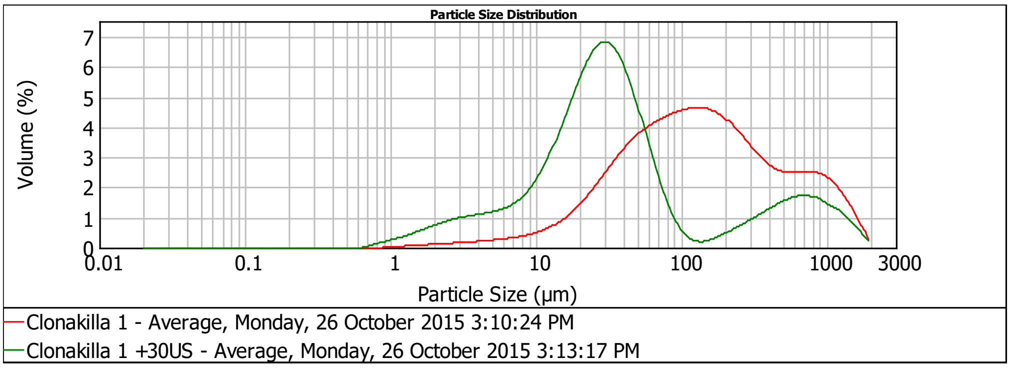
Clonakilla 1: 0-5 cm



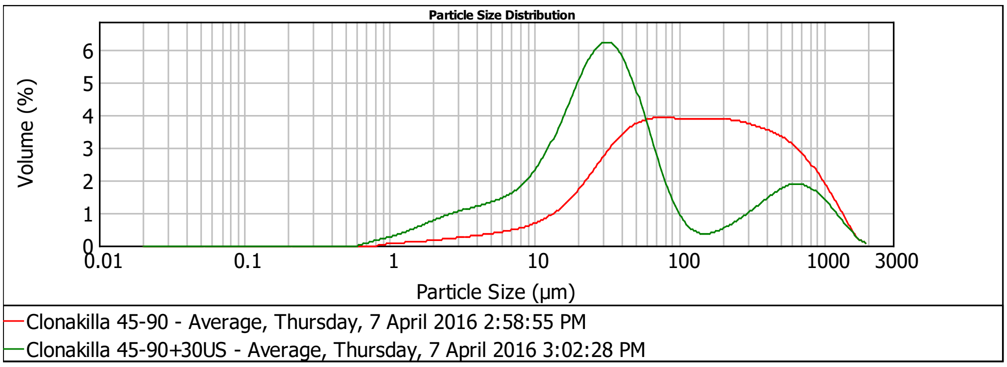
Clonakilla 1: 5-20 cm



Clonakilla 1: 25-40 cm



Clonakilla 1: 45-90 cm



Profile 2: Yellow Chromosol, mesotrophic, bleached-mottled

Landform: drainage swale

Parent material: dacite geology with aeolian accession (?)

Drainage: imperfectly drained, short periods of saturation seasonally

Land use: vineyard

Soil description: a strong texture contrast profile comprising a pronounced organic loam grading to a strongly bleached, massive A_2. Sharp boundary at 35-40cm to yellow mottled clay loam then light clay subsoil, moderately structured with subangular blocky medium and fine sized peds. Grades to highly weathered bedrock at 90cm+.

Profile morphology

Horizon	Depth	Colour	Mottle	Texture	Structure			Consistence	Coarse Frags %	Segregations	B'dry
					Grade	Shape	Size				
A1	0-16	7.5YR 3/4	0	L	mod	granular	2-5	sm firm	0	0	
A2	16-38	7.5YR 7/2	R & Y, dist few	SiL	massive	-	-	sm firm	0	0	Gradual
B1	38-75	10YR 5/8 YB	R & RB, dist. common	CL	mod	sabl	5-10	dry v firm	0	Com fe coatings and soft nods	Clear
B2	75-90	10YR 6/8 YB	R & RB, dist. common	lC	mod	sabl	10-20	dry v firm	0	Few fe coatings and soft nods	Gradual

Particle size and physical properties

	Particle size composition %					Disp	EAT	Field Cap	Wilt Pt	AWC
	Clay	Silt	F. sand	C. sand	Gravel	%		%	%	%
10-30	9	34	27	27	2	65	3(1)	21	5	16 (10-13)[1]
50-70	25	20	26	26	1	33	5	20	9	11 (~10)
80-100	36	12	14	14	10	37	5	25	14	11 (9-14)

Analytical data from Scone SCS lab

[1] comparison with data from Moore et al 1998 quoted in Hazelton and Murphy

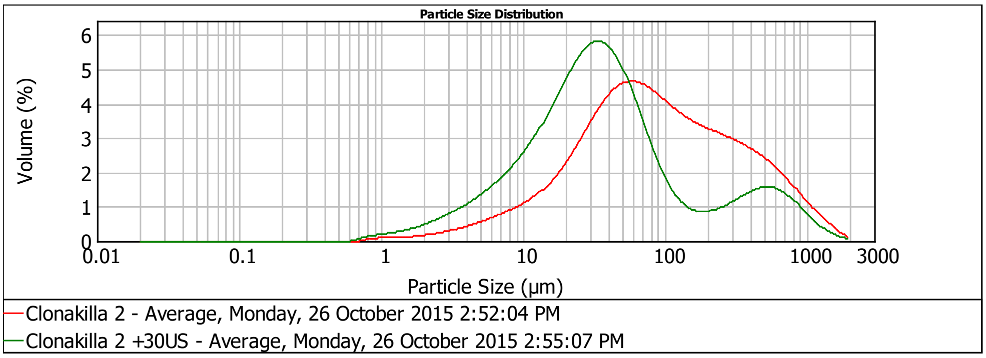
Chemical properties

	Exchange properties cmol/kg						EC	pH	pH
	CEC	Na, ESP	K	Ca	Mg	Al	dS/m	(w)	($CaCl_2$)
10-30	5.1	0.0, 0%	0.1	1.5	1.0	<0.5	0.01	5.8	4.8
50-70	10.2	0.1, 1%	0.1	2.9	3.1	<0.5	0.01	6.4	5.2
80-100	17.3	0.3, 1%	0.1	3.8	7.3	<0.5	0.01	6.9	5.9

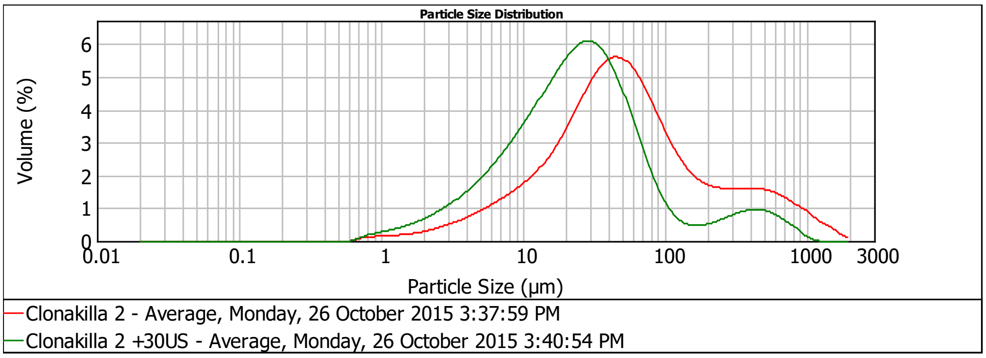
Analytical data from Scone SCS lab

Particle size data for soil horizons at Clonakilla Profile 2

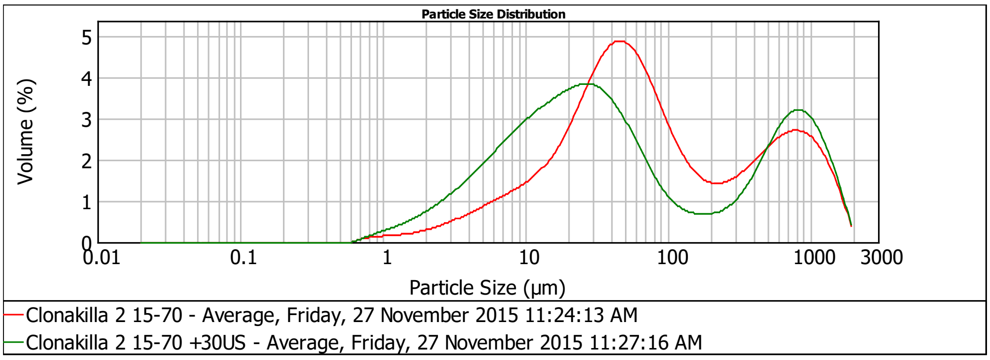
Clonakilla 2: 0-5 cm



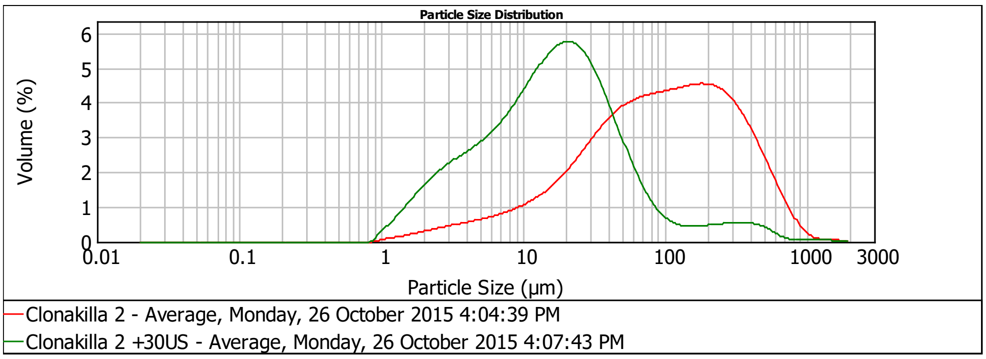
Clonakilla 2: 5-15 cm



Clonakilla 2: 15-70 cm

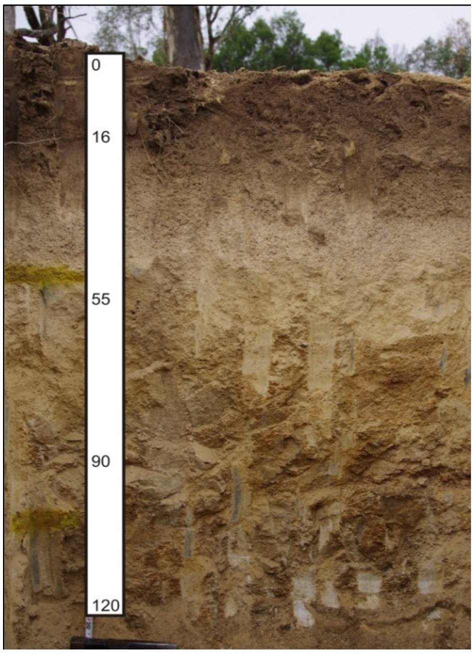


Clonakilla 2: 70-100 cm



STOP 4: Gallagher Vineyard, Dog Trap Rd, Jeir

Bleached orthic Tenosol



Landform: upper hillslope

Parent material: dacite geology

Drainage: imperfectly drained, occasional seasonal saturation

Land use: vineyard

Soil description: a weakly developed profile comprising a thin A1 grading to a bleached A2, both sandy loam texture, A2 massive structure. Sharp boundary to saprolitic B horizon, component of weathered rock increases between 50 and 80cm.

Profile morphology

Horizon	Depth	Colour	Mottle	Texture	Structure			Consistence	Coarse fragments	Segregations	B'dry
					Grade	Shape	Size				
A1	0-16	10YR 4/4 Dk GB	0	S Loam	wk	granular	2-5	M soft	0	0	
A2	16-55	10YR 6?2 GB	0	L sand	massive	-	-	Sm vfirm	0	0	Gradual
B/C	55-90	10YR 5/2 GB	0	L sand	massive	-	-	D tough	0	Large fe coatings on cleavage planes	clear

Particle size and physical properties

	Particle size composition %					Disp	EAT	Field Cap	Wilt Pt	AWC
	Clay	Silt	F. sand	C. sand	Gravel	%		%	%	%
15-25	11	19	16	49	5	55	3(1)	17	6	11 (5-6) [1]
40-50	10	21	15	49	5	40	5	17	8	9 (5-6)

Analytical data from Scone SCS lab

[1] comparison with data from Moore et al 1998 quoted in Hazelton and Murphy

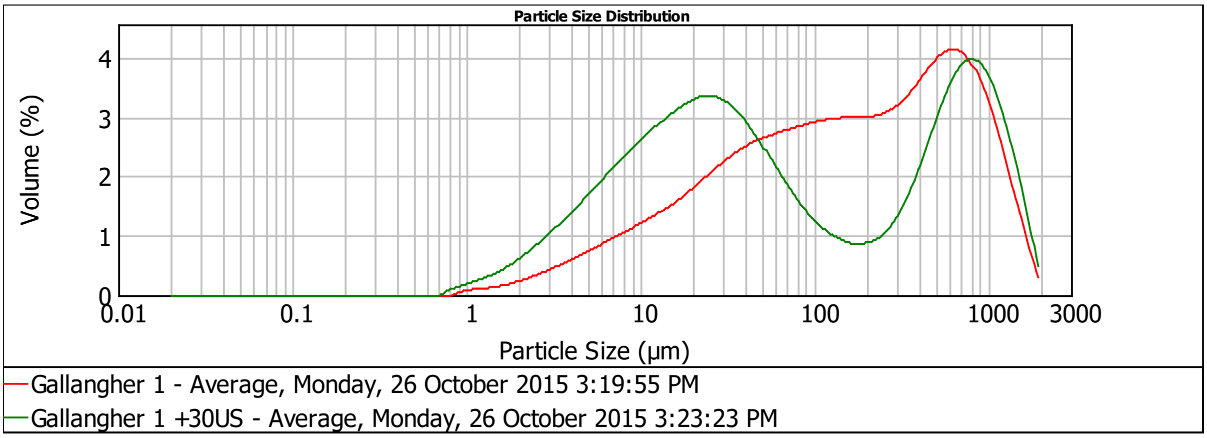
Chemical properties

	Exchange properties cmol/kg						EC	pH	pH
	CEC	Na, ESP	K	Ca	Mg	Al	dS/m	(w)	($CaCl_2$)
15-25	7.1	0.0, 0%	0.5	2.4	1.2	<0.5	0.01	5.5	4.5
40-50	15.1	0.1, 1%	0.3	6.4	4.2	<0.5	0.01	5.9	4.8

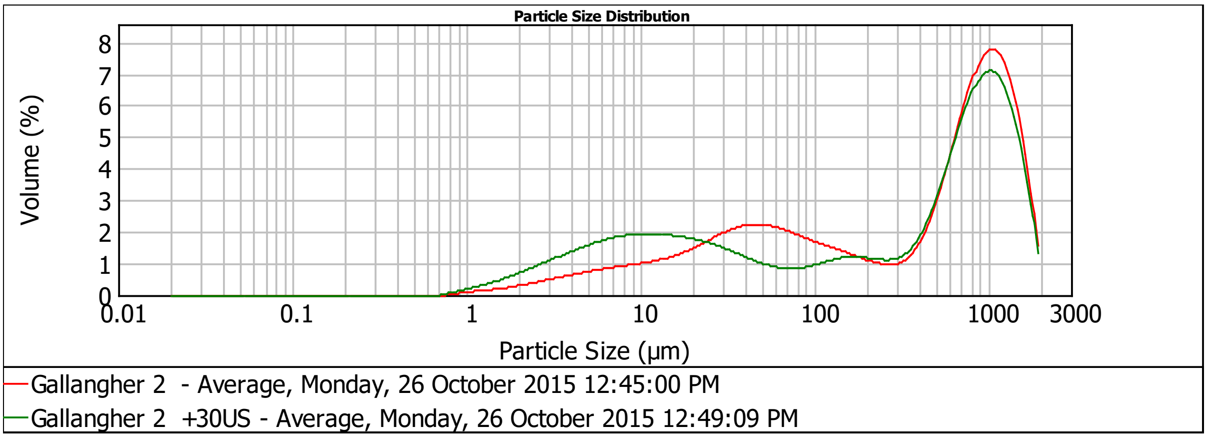
Analytical data from Scone SCS lab

Particle size data for soil horizons at Gallagher Vineyard

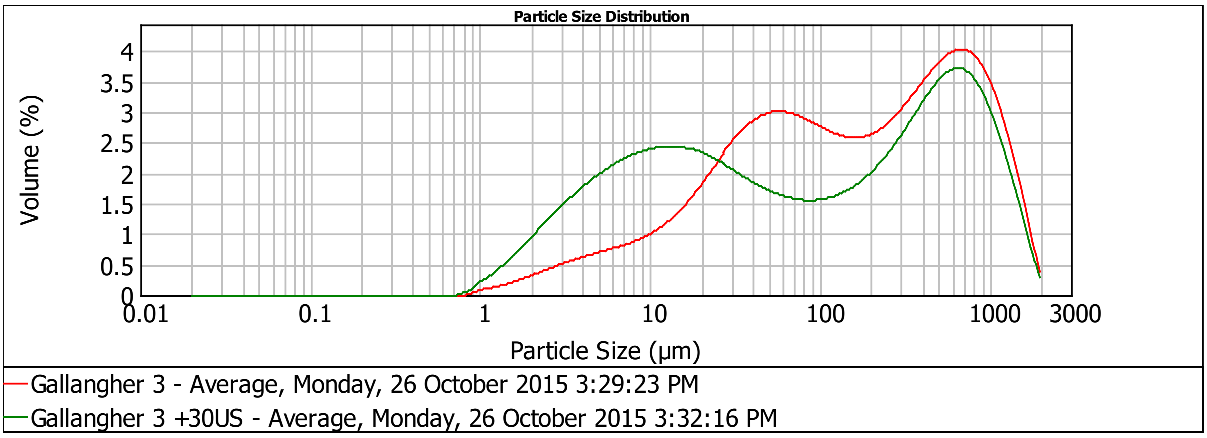
Gallagher 0-5 cm



Gallagher 5-30 cm



Gallagher: 40-90 cm



Discussion of data confirming aeolian materials and their linkage to wine quality

The two profiles at McIntosh Crt. and the Yass R. crossing (Stops 1 and 2 resp.) both have strong evidence for the presence of aeolian material. The 20-70 cm layer at McIntosh Crt and the modern soil above the paleosol at the Yass R. cutting both have a psa with a strong bimodal character, indicating both near and distant transported material. Similarly the results of the psa measurements on the 25-40 cm horizon of parna material from the profile 1 (Red Chromosol) at the Clonakilla vineyard depict a very clear bi-modal distribution, which changes after the application of ultrasonics to show a strong peak at 20-30 µm. Some of this characteristic is also weakly developed in the Yellow Chromosol profile lower in the catena. The peak 20-30 µm is taken as evidence for the occurrence of strongly aggregated clay material referred to as "parna" by Butler and Hutton (1956).

However, the psa measurements of the 40-90 cm horizon of non-parna material from the profile at the Gallagher vineyard showed very little evidence after ultrasonics of a strong peak, indicating very little strongly aggregated clay, and thus confirming the absence of parna.

The cause and effect link between soil texture and wine character comes through the degree of moisture stress the plant encounters during the growing season. As texture or particle size determines the size of the micro-pores and the size of the micro-pore determines how hard a plant needs to work to extract water, the pore structure will set the level, or at least the range of stress levels, the plant will encounter when extracting water from the soil.. Stress in plants is well known to trigger production of various secondary metabolites many of which can affect the character of wine, some of the best known being tannins. Hence there is a direct link between texture (influenced by parna/loess deposition and clay accumulation) and wine character.

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