World Reference Base for Soil Resources

Field Excursion

Australia, 2012

Part A: Victoria
November 25 – 28

Part B: Tasmania
November 29 – December 1

Field Guide and Report

Draft report (current 28/3/2013)

Edited by Ben Harms

SOIL SCIENCE AUSTRALIA

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Acknowledgements

Soil Science Australia – sponsorship of soil pit digging.

Richard McEwan (Department of Primary Industries, Victoria; *Soil Science Australia* – Federal President) – organisational and technical support, attendance, banjo.

Linda Bennison (*Soil Science Australia* – Executive Officer)
    Web site presence, receipts/payments, administration, salads and organisation – Monday dinner.

Various landholders for property access etc.

Department of Primary Industries, Victoria – laboratory data.

Part B - Tasmania

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    Soil classification, preparation of soil sheets and related handout material,
    soil pit photographs.

Acknowledgements

Sam Rees (Agricultural Resource Management); John McPhee (Tasmanian Institute of Agriculture) – soil information and discussion on soil management.

Tas Vacations – Tour organisation – receipts, bookings etc.

Various landholders for property access etc.

Tasmanian Institute of Agriculture – laboratory data.

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Introduction to the excursion

The World Reference Base for Soil Resources (WRB) is gradually being adopted as a system for correlating various national soil classification schemes and as a means for the communication data on soil types. The development of the WRB has been overseen by special working groups under the auspices of the IUSS. Following the release of the first edition 1998, two conferences and a series of field excursions were organised to test and refine the WRB approach. The second edition (2006, with revisions in 2007) incorporated some adjustments based on these exercises as well as various suggestions contained in peer reviewed soil science journals and books. The third edition is scheduled for release in 2014 at the 20th World Congress of Soil Science in South Korea. Current officers the WRB Working Group are:

Chair: Peter Schad, Germany
Vice-Chair: Cornie Van Huyssteen, South Africa.
Secretary: Erika Micheli, Hungary.

At the 19th World Congress of Soil Science in Brisbane (2010), we were reminded that Australia had never hosted an official visit of the WRB working group. Excursions conducted in Australia in association with the World Congress provided an opportunity to utilise the WRB for the classification of Australian soils. This was a useful exercise for Australian pedologists who up until then had been largely unfamiliar with the scheme. However, it is probably fair to say that the WRB was not well received because of (perceived) difficulties in correlation with the Australian Soil Classification. In particular, it was felt that the WRB fails to cater sufficiently for the wide range of texture-contrast soils present in Australia. However, there was no detailed discussion at a high level about issues associated with the application of the WRB in Australia.

To address this issue, and with considerable encouragement and drive from Peter Schad, an official WRB field excursion in Australia was organised to take place in late 2012. The stated aims of the tour were to:

- Test the WRB soil classification on a range of Australian soils and consider potential adjustments to the WRB to better accommodate these soils.
- Provide an opportunity for Australian soil scientists to gain experience in using the WRB.

It was pointed out that if any changes/amendments to the WRB were proposed to better accommodate Australian soils, these would need to be formalised in 2013 to be incorporated in the next edition of the WRB planned for release in 2014.

Another aim of the tour might have been to also consider potential adjustments to the Australian Soil Classification, especially since one of its stated aims is to "where appropriate use definitions that are compatible with those of major international classification schemes".

In planning for the WRB Excursion, it was decided to make use of a soils tour that had already been organised in association with the Australian and New Zealand Soil Science Conference that was to take place in Tasmania in December 2012. In addition there would be a supplementary tour on the 'mainland' focussing on texture-contrast and sodic soils.

Introduction to the Australian Soil Classification (ASC)

Brief history of soil classification in Australia

Early Australian soil classification systems (Prescott 1931) adopted the zonal concepts proposed by Russian scientists Dokuchaev and Sibirtsev. Stephens followed with various publications, culminating in the Manual of Australian Soils (1953) that listed 40 great soil groups. The *Handbook of Australian Soils* (Stace *et al*., 1968) comprehensively described 43 Great Soil Groups which had many features in common with the 40 Great Groups of the American system.

In the meantime, these systems were criticised because of their focus on soil genesis and their lack of emphasis on profile morphology such as strong texture-contrast features. GW Leeper (1943, 1954) argued that soils should be classified on the basis of soil properties alone without "*guesses as to the soil's origin*". He also pointed out that great soil groups had grown up by accident and that they were not mutually exclusive. The concepts Leeper proposed were picked up by KD Northcote in his *Factual Key for the Recognition of Australian* (first published 1960). This is a bifurcating, hierarchical scheme with five categorical levels. All classes are mutually exclusive and all the keying attributes can be determined in the field. This system was used for mapping the soils of the Australian Continent (the *Atlas of Australian Soils*), the first sheet of was also published in 1960.

There was a reasonably strong attempt to introduce the use of Soil Taxonomy in Australia (especially within the CSIRO Division of Soils from the 1960s to the 1980s) for the purposes of correlation and communication. For a period of time Soil Taxonomy classifications were required for papers published in the Australian Journal of Soil Research. A Guy Smith visit to Australia in 1959 prompted an initial appraisal of the '7th Approximation'. In 1981 there was comprehensive investigation of the applicability of Soil Taxonomy to Australian soils, incorporating an extended visit to Australia by AR Southard and a specially convened workshop in Brisbane. The general conclusions resulting from that workshop were that "*Soil Taxonomy is not a particularly appropriate classification for many Australian soils*" (Moore, 1986).

So for a long time, Australia had two concurrent classification systems in common usage: the Factual Key and the Handbook of Australian Soils. By the 1980s, it was apparent that both schemes were in need of revision. This led to the development a revised Australian system, under the tutelage of Ray Isbell. The first approximation was released in 1989, followed by the first edition of the ASC in 1996. The new system combined concepts from the previous Australian schemes and borrowed some from Soil Taxonomy and the South African system.

Structure of the ASC

The ASC is a general purpose, hierarchical system (order, suborder great group, subgroup, family). A schematic structure of the 14 soil orders in diagrammatic form is shown on the next page.

General principles of the ASC

The guiding principles used to develop the ASC, included the following:

- It should be based on Australian soil data and as far as possible the selected attributes should have significance to land use and soil management.
- It should be based on defined diagnostic attributes, horizons, or materials, the definitions of which, where appropriate, should be compatible with those of major international classification schemes.
- The entity to be classified is the soil profile, with no depth restrictions such as the arbitrary lower limit of 2 m used in Soil Taxonomy.
- Although the soil classification should be based as far as practicable on field morphological data, laboratory data (including soil physical properties) must be used as appropriate.
- The scheme should be based on what is actually there rather than on what may have been present before disturbance by humans. Surface horizons should not be defined in terms of an 'after mixing' criterion as in Soil Taxonomy.
- The scheme should be a multi-categoric one, arranged in different levels of generalisation.
- The scheme should be flexible enough to accept new knowledge as it becomes available - it should be open-ended.

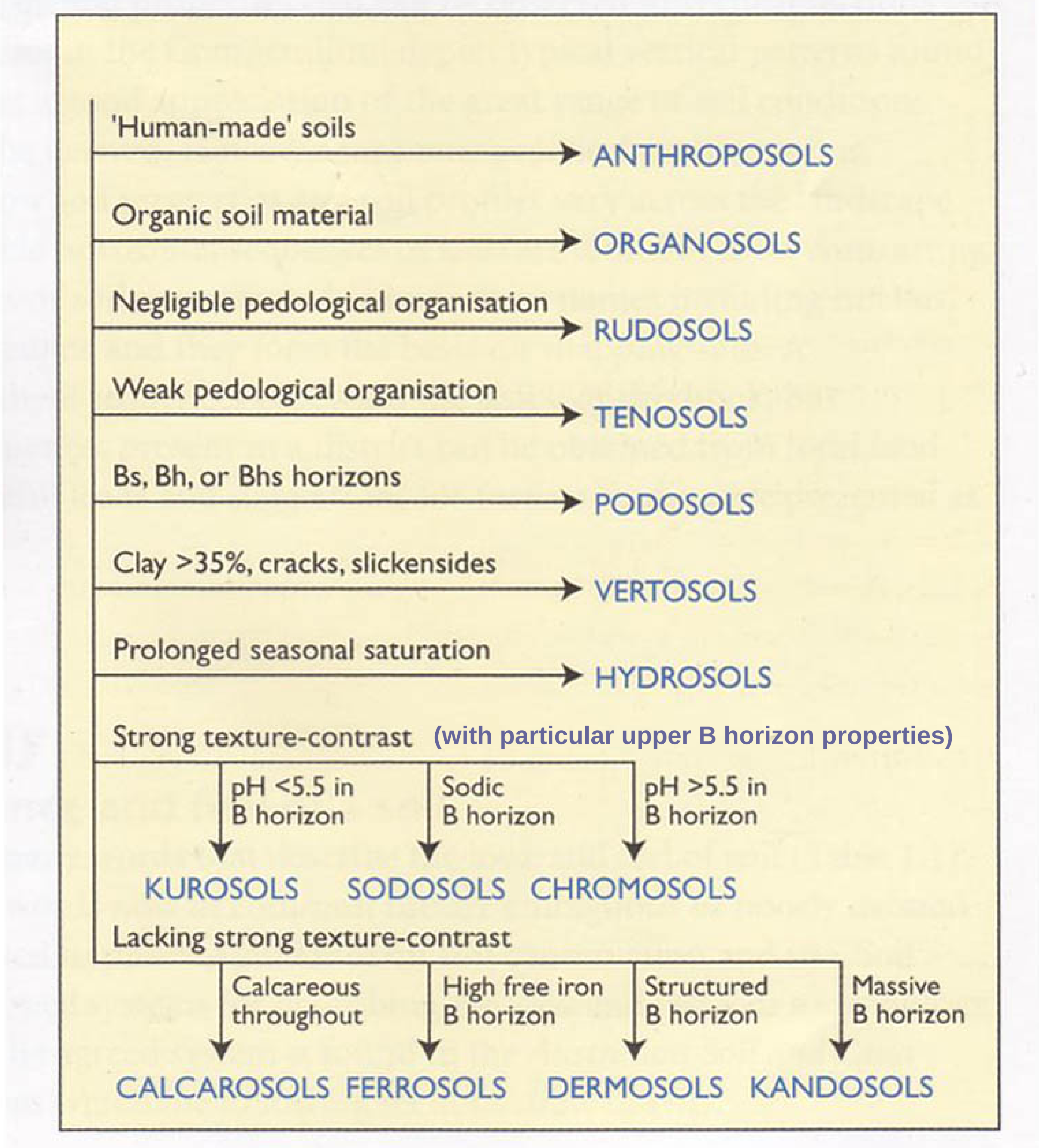
- The classification should give emphasis to relatively stable attributes as differentiae.
- The nomenclature must not be too complex, but be unambiguous.

It is also implicit from the guiding principles that grouping of oils into classes should be based on similarity of soil properties rather than presumed genesis.

The ASC is available for complete download via the Internet. However, an interactive key is available: http://www.clw.csiro.au/aclep/asc_re_on_line/soilhome.htm

Schematic summary of the 14 soil orders of the ASC

This diagram provides an overview of the soil orders, and is not intended to be used as a key.



The general form of the nomenclature is:

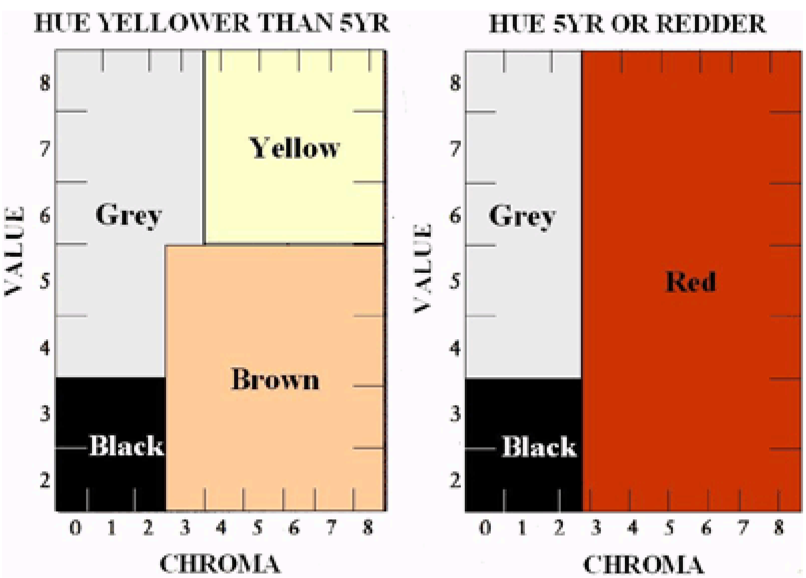
Subgroup, Great group, *Suborder Order*; family.

e.g. Bleached, Eutrophic, *Red Chromosol*; thin, gravelly, clayey, shallow.

This may be shortened as desired (e.g. Red Chromosol)

Some notable features of the ASC:

1. The ASC is designed specifically to describe soil profiles and not areas delineated on a map.
2. While ‘pedological organisation’ is a key underlying principle, related genetic implications are kept to a minimum. For example, the identification of an ‘illuvial B horizon’ (argic/argillic horizon) is not diagnostic; the system does not incorporate any criteria relating to lithological discontinuities (unless it is obvious that the surface material is recently deposited and/or a buried soil is clearly evident).
3. Base saturation (some of bases as a percentage of the CEC) is not used at all in the ASC; but rather Base status referring s to the sum of exchangeable basic cations (Ca, Mg, K and Na) expressed in cmol (+) kg^{-1} clay. This is preferred because the laboratory determination of basic cations is less dependent on laboratory method than is CEC. In addition, many low CEC soils in Australia are fully base saturated, but cannot be considered rich in bases.
   Three classes of base status are defined: Dystrophic - the sum is less than 5; Mesotrophic - the sum is between 5 and 15 inclusive; Eutrophic - the sum is greater than 15. Notes: For fully base saturated soils, base status as defined here will obviously be equivalent to CEC kg^{-1} clay as used in WRB and Soil Taxonomy. Where a laboratory derived clay percentage is not available, it may be approximated from the field texture using the figures given on pp. 118-120 of the Field Handbook.
4. Reducing conditions are not specifically defined or used in the ASC. Hydrosols are defined simply in terms of saturation for prolonged periods; as they do not always display manifestations of reduction and oxidation such as ‘gley’ and ochrous mottles. Another reason for not making reducing conditions mandatory is the well-known difficulty in identifying such conditions, which are often temporal in nature and sporadic in spatial distribution.
5. Mottling is used as a diagnostic property (excluding he use of colour patterns due to mechanical mixing and the inclusion of weathered substrate materials). However, no direct assumptions are made as to whether mottles are indicative of particular current conditions (e.g. ‘stagnic’ or ‘gleyic’ colur patterns of the WRB) or past drainage conditions i.e. whether they are current or relict redoximorphic features.
6. Soil structure is used at the Order level (e.g. in the definition of the Kandosols and Dermosols).
7. Field texture assessment may be used to classify a soil in the absence of laboratory data (using texture classes to approximate clay content). Where there are discrepancies between field texture and laboratory data (after repeat analysis), the “classifiers should use their own judgement based on how they think the soil behaves”.
8. Where required analytical data is not available, the soil may still be classified, with the use of an appropriate ‘confidence code’ e.g. Code 2: “ *No necessary analytical data are available but confidence is fair, based on a knowledge of similar soils in similar environments*”. It is emphasised in the ASC that “*the best place to classify a soil is in the field, where the morphological requirements can readily be checked*”.
9. Subsoil colour is used at the Suborder level. Colour classes are based on the Munsell colour charts as follows:



While it can be argued that soil colour may not always be relevant for soil management, it is such an obvious and easily described soil property that its use in classification should not be overlooked.

10. *Family criteria*. This is the secondary part of the classification, listed after the soil order. The criteria relate to specific characteristics of the soil profile. For the texture-contrast soil orders there are five family criteria: A horizon depth, gravel of surface and A1 horizon, A1 horizon texture, B horizon maximum texture and soil depth.

Note about soil horizon nomenclature.

Australia has retained the use of soil horizon nomenclature basically as defined by Soil Survey Staff (1975). It was not updated as was the USDA system in 1981. The soil horizon nomenclature used in Australia is summarised by McDonald and Isbell in the *Australian Field Handbook* (2009).

The properties of A2 horizons and B2 horizons are used extensively in the ASC. The A2 horizon is defined by colour contrast alone and *generally* corresponds to the E horizon of WRB and Soil Taxonomy. Bleached manifestations of the A2 horizon are particularly important, and these are given clear suffix notation (unlike the international classification systems). A B2 horizon *often* corresponds to a Bt or Bw horizon, however a B2 horizon could have many different suffixes to reflect subordinate characteristics.

Sodicity in the ASC, WRB and Soil Taxonomy

Convincing evidence from numerous Australian studies suggests that an ESP of 6 is useful as a threshold to separate soils with a strong likelihood to disperse and/or have adverse physical properties from those soils with a much lower likelihood. The schema proposed by Northcote and Skene (1972) that soils an ESP of 6-14 be described as 'sodic' and those with an ESP >15 as 'strongly sodic' has thus been widely adopted in Australia, and incorporated into the ASC. Earlier Australian soil classification systems recognised the importance of 'sodium affected soils' and the influence of Na on soil profile morphology (e.g. the columnar structure of the 'solonetz' and 'solodized-solonetz'), but did not specify actual levels of exchangeable Na.

Rengasamy and Olsson (1991) proposed a classification of sodic soils based on soil absorption ration (SAR) and soil EC. Their critical value of SAR >3, as measured in a 1:5 soil water extract, is consistent with an ESP of 6, as the ESP of soil is approximately twice the SAR of a 1:5 extract. While SAR may be theoretically more attractive than ESP as an indicator of sodic soils, there are some problems with its routine determination (Isbell 1995), but the main issue is that there are very few such data available for Australian soils. The Emerson dispersion test (Emerson, 1967) is also widely used in Australia as an indicator of dispersion and Sodicity.

The ESP threshold of 15 adopted in the USA and incorporated into Soil Taxonomy (and subsequently WRB) is regarded as being too high for Australian conditions. As pointed out by Shainberg et al. (1989), the different critical ESP value is "*mainly due to the much higher electrolyte content of tap water in California that was used in the hydraulic conductivity measurements on which the threshold was based*." Isbell *et al.* (1995) add that differences in soil texture between those used in early Australian studies (mainly >40% clay) and the generally lighter-textured soils used in California may help to explain differences in the threshold.

Of particular importance is where sodicity occurs in the soil profile. Although in general terms sodicity usually increases with depth, there is often a sharp increase over short distances at the A-B horizon boundary. A high ESP in the upper part of the B horizon that restricts infiltration and increases susceptibility to erosion is therefore very important factor in the utilisation and potential degradation of texture-contrast soils. For that reason, the Sodosol soil order is defined in terms of the upper 20 cm of the B horizon being sodic. This contrasts with the Solonetz's of WRB in which a natric horizon may start anywhere in the top 100 cm of soil.

In the ASC, sodicity is entirely a subsoil criterion, except for the Vertosols, which have an episodic great group. The restriction of the Sodosol order to subsoils with t pH of ≥5.5 (1:5 water) is based on the premise that below this pH, dispersion is likely to be inhibited by the presence of aluminium. This assumption may need to be changed if more data comes to light.

In the absence of laboratory data, provisional classification can be made on the basis of soil morphology (e.g. presence of columnar or prismatic structure, soapy feel of moist texture bolus, field pH and a field dispersion test). Some caution is required in the use of pH: while sodic soils in Australia are usually strongly alkaline, it cannot be inferred that all strongly alkaline soils are sodic. Please note the confidence levels that can be formally attributed to provisional classifications (see page 7).

Use of sodicity in the ASC:

Order	Great group	Subgroup (the Sodic property is usually combined with another e.g mottling)
Sodosols ESP ≥6 in upper B horizon and pH ≥5.5	Subnatric (ESP 6-14) Mesonatric (ESP 15-25) Hypernatric (ESP>25)	
Kurosols	Natric (ESP ≥6 in upper B horizon)	Sodic (other soils with a B horizon in which at least the lower part is sodic)
Chromosols		Sodic (B horizon in which at least the lower part is sodic)
Dermosols		Sodic (B horizon in which at least the lower part is sodic)
Kandosols		Sodic (B horizon in which at least the lower part is sodic)
Calcarosols		Epihypersodic (ESP >15 in upper 0.5 m of soil) Endohypersodic (ESP >15 below 0.5 m)
Hydrosols	Sodosolic (as for Sodosol definition)	Sodic (other soils with a B horizon in which at least the lower part is sodic)
Vertosols		Episodic (ESP ≥6 in upper 0.1 m) Epihypersodic (ESP ≥15 in upper 0.5 m) Endohypersodic (ESP ≥15 below 0.5 m)

Use of sodicity in the WRB and Soil Taxonomy:

Item	Classif. system	Diagnostics	Notes
Natric horizon	WRB	*Must meet all of the following:* 1 Texture of loamy sand or finer and ≥8% clay in fine earth fraction 2 Must meet the requirements for an argic horizon 3 An increase in clay content within a vertical distance of 30 cm 4 Columnar or prismatic structure in some part of the horizon OR Blocky structure with tongues of an overlying coarser textured horizon in which there are uncoated silt or sand grains, extending 2.5 cm or more into the natric horizon OR Massive appearance. 5 ESP of ≥15% within the upper 40 cm OR more exchangeable (Mg + Na) than (Ca plus exchange acididty; at pH 8.2) within the same depth if ESP ≥15% in some horizon within 200 cm from soil surface 6 thickness requirements	In the WRB, as well as defining the Solonetz RSG, a natric horizon may occur in Cryosols. Requirements for a natric horizon are almost identical to those of Soil Taxonomy (see below)
Natric horizon	ST	*Must meet all of the following:* 1 Thickness requirements (incorporating texture classes) 2 Must meet the requirements for an argillic horizon 3 An increase in clay content (within a vertical distance of 30 cm) of the illuvial horizon compared to the elluvial horizon if it remains 4 Columnar or prismatic structure in some part of the horizon OR Blocky structure with tongues of an overlying coarser textured horizon in which there are uncoated silt or sand grains, extending 2.5 cm or more into the natric horizon. Does not allow for massive appearance. 5 ESP of ≥15% (or SAR of ≥13 in saturated axtract) within the upper 40 cm OR more exchangeable (Mg + Na) than (Ca plus exchange acididty; at pH 8.2) within the same depth if ESP ≥15% (or SAR of ≥13 in saturated axtract) in some horizon within 200 cm from soil surface	In Soil Taxonomy, the natric horizon is used only at the great group level in various suborders of Alfisols, Aridisols, Mollisols, Vertisols (Aquerts only) and Gelisols (Argiorthels only).
Sodic	WRB	Having 15 percent or more exchangeable Na plus Mg on the exchange complex within 50 cm of the soil surface throughout.	Used for all RSGs except Technosols, Cryosols, Podzols, Plinthosols, Nitisols, Ferralsols, Albeluvisols, Alisols, Acrisols, Lixisols, Umbrisols and Arenosols,
Endosodic	WRB	Having 15 percent or more exchangeable Na plus Mg on the exchange complex between 50 and 100 cm from the soil surface throughout.	
Hyposodic	WRB	Having 6 percent or more exchangeable Na on the exchange complex in a layer, 20 cm or more thick, within 100 cm of the soil surface.	
Solodic	WRB	Having a layer, 15 cm or more thick within 100 cm of the soil surface, with the columnar or prismatic structure of the natric horizon, but lacking its sodium saturation requirements.	
Sodic	ST	Defines various subgroups which have an ESP of ≥15% (or a SAR of 13 or more), but the requirements for a natric horizon are not met.	Used for Aridisols, Entisols, Inceptisols and Vertisols.

References and further reading on the Australian Soil Classification:

Isbell RF (2002) *The Australian soil classification*, revised edition, CSIRO: Melbourne.

Isbell RF, McDonald WS, Ashton LJ (1997) *Concepts and rationale of the Australian soil classification*, Australian Collaborative Land Evaluation Program, CSIRO Land and Water: Canberra.

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McKenzie N, Jacquier D, Isbell R, Brown K (2004) *Australian soils and landscapes – an illustrated compendium*. CSIRO: Melbourne.

McDonald RC, Isbell RF (2009) Soil profile. In '*Australian soil and land survey handbook'* (3^{rd} edn), National Committee on Soil and Terrain, CSIRO Publishing: Melbourne.

Moore AW (editor) (1986) The USDA Soil Taxonomy in relation to some soils of eastern Queensland. CSIRO Australia, Division of Soils, Divisional Report No. 84

Rayment GE and Lyons DJ (2011). Soil Chemical Methods – Australasia. CSIRO Publishing: Collingwood, Victoria.

To be updated

Introduction to the World Reference Base

Brief history of soil classification in Australia

The World Reference Base for Soil Resources (WRB) had its genesis in the 1960s as an initiative of the Food and Agriculture Organization of the United Nations (FAO) to have a legend prepared for the Soil Map of the World (FAO-UNESCO, 1971-1988). In the early 1980s there were further initiatives under the auspices of the ISSS (now IUSS) to create a framework for correlating existing soil classification systems (i.e. an International Reference Base, IRB) and to improve the legend for the Soil Map of the World. Various working groups were established to oversee the development of the schema, which officially became the WRB in 1992. It was decided that the revised FAO-UNESCO soil map legend should form the basis for further development of the WRB. The first official edition of the WRB was published in 1998, with the second edition appearing in 2006.

The WRB was never intended to replace national soils classifications, but to primarily serve as a common denominator for communication at an international level. The WRB has become the official reference soil nomenclature and soil classification for the European Commission. Various national systems have taken up elements of the WRB (e.g. China, Czech Republic, Brazil).

Structure of the WRB

- A two tier system consisting of 32 Reference Soil Groups (RSGs) together with a series of qualifiers (prefixes and suffixes). Prefix qualifies comprise those that are typically associated with the RSG (in order of importance) and the intergrades to other RSGs. All other qualifiers are listed as suffixes.
- Specifiers such as Epi-, Endo-, Hyper-, Hypo-, Thapto-, Bathy-, Para-, Proto-, Cumuli- and Ortho- are used to indicate a certain expression of the qualifier.
- All applicable qualifiers must be recorded.

General principles of the WRB:

- The diagnostic horizons, diagnostic properties and diagnostic materials used in the classification should, as much as possible, be observable and measurable in the field.
- The selection of diagnostic characteristics takes into account their relationship with soil forming processes. However, these processes *should not* be used as differentiating criteria.
- The general organisation, as far as possible should focus on diagnostic features that are important for soil management
- Climate parameters are not applied.
- Many RSGs in the WRB are representative of major soil regions so as to provide a comprehensive overview of the world's soil cover.

Example of WRB soil classification:
A soil has a ferralic horizon; texture in the upper part of the ferralic horizon changes from sandy loam to sandy clay within 15 cm. The pH is between 5.5 and 6, indicating moderate to high base saturation. The B horizon is dark red; below 50 cm mottling occurs:

The field classification of this soil is: Lixic Ferralsol (Ferric, Rhodic).

If subsequent laboratory analysis reveals that the cation exchange capacity (CEC) of the ferralic horizon is less than 4 cmolc kg-1 clay:

The soil finally classifies as Lixic Vetic Ferralsol (Ferric, Rhodic).

SIMPLIFIED KEY to Reference Soil Groups (RSGs) of the WRB

1	Soils with thick organic layers	
	i.e. peat and 'muck' soils:	**Histosols**
2	Soils with strong human influence	
	long intensive agricultural use:	**Anthrosols**
	containing many artefacts:	**Technosols**
3	Soils with severely limited rooting depth	
	ice affected soils:	**Cryosols**
	shallow or extremely gravelly:	**Leptosols**
4	Soils influenced by water	
	alternating wet-dry conditions, shrink-swell clays:	**Vertisols**
	flood plains, tidal marshes:	**Fluvisols**
	dense clay subsoil - alkaline and rich in exchangeable Na and/or Mg:	**Solonetz**
	salt enrichment upon evaporation:	**Solonchaks**
	groundwater affected soils:	**Gleysols**
5	Soils determined by Fe and/or Al chemistry	
	allophanes or Al-humus complexes:	**Andosols**
	spodic illuviation i.e. accumulated compounds of OM, Fe and/or Al:	**Podzols**
	accumulation of Fe in hydromorphic conds, potential for irreversible hardening:	**Plinthosols**
	low activity clay, P fixation, strongly structured:	**Nitisols**
	dominance of kaolinite and sesquioxides:	**Ferralsols**
6	Soils influenced by stagnating water (reducing conditions: stagnic colour pattern and/or albic horizon)	
	abrupt textural contrast:	**Planosols**
	structural or moderate textural discontinuity:	**Stagnosols**
7	Dark surface horizons rich in organic matter, high base saturation (mollic)	
	Black surface (Munsell V/C ≤ 3/2), calcic horizon:	**Chernozems**
	Dark brown surface, much secondary carbonate; transition to drier climate:	**Kastanozem**
	May or may not have a calcic horizon; transition to more humid climate:	**Phaeozem**
8	Accumulation of less soluble salts or non-saline substances	
	gypsum:	**Gypsisols**
	silica:	**Durisols**
	calcium carbonate:	**Calcisols**
9	Soils with clay enriched subsoil (i.e. argic horizons)	
	albeluvic tonguing:	**Albeluvisols**
	low base sat. (<50%), high-activity clay (CEC ≥24 cmol/kg clay):	**Alisols**
	low base sat. (<50%), low-activity clay (CEC <24 cmol/kg clay):	**Acrisols**
	high base sat. (≥50%), high-activity clay (CEC ≥24 cmol/kg clay):	**Luvisols**
	high base sat. (≥50%), low-activity clay (CEC <24 cmol/kg clay):	**Lixosols**
10	Relatively young soils or soils with little or no profile development	
	with an acidic dark topsoil:	**Umbrisols**
	sandy soils:	**Arenosols**
	moderately developed soils:	**Cambisols**
	soils with no significant profile development:	**Regosols**

Soil sites examined in Victoria

Stop	Site ID	Location	Geology	ASC	WRB
MONDAY					
1	GP22	Clyde	Aeolian deposits over Tertiary sandstone	Ferric-Sodic, Mesotrophic, Brown Chromosol; thick, slightly gravelly, loamy, clayey, deep.	a. Lixic Plinthosol (Magnesic, Sodic, Hypereutric, Clayic, Novic). b. Cutanic Lixosol (Ferric, Abruptic, Hypereutric, Profondic, Clayic, Sodic, Novic).
2	GP21	Cranbourne (Five Ways)	Quaternary sands and clays	Magnesic, Mottled-Subnatric, Grey Sodosol; thick, non-gravelly, loamy, clayey, deep.	Endogleyic Solonetz (Albic, Abruptic, Ruptic, Magnesic, Clayic)
3	GW02	Tuerong (Pearcedale)	Quaternary alluvium	Bleached-Sodic, Eutrophic, Grey Chromosol; thick, non-gravelly, loamy, clayey, deep.	Alic Endogleyic Solodic Planosol (Albic, Ruptic, Endosodic, Endoclayic, Magnesic)
4	MoP6	Kooyong	Tertiary pedoderm	Bleached-Vertic, Mesotrophic, Brown Dermosol; medium, non-gravelly, clay loamy, clayey, deep.	Alic Endogleyic Vertic Stagnosol (Ferric, Ruptic, Hyposodic, Dystric, Clayic)
TUESDAY					
1	CLRA4	Murradoc	Quaternary alluvium, swamp deposits	Eutrophic, Mottled-Hypernatric Brown Sodosol; medium, non-gravelly, loamy, sandy, clayey, very deep.	Stagnic Solonetz (Albic, Abruptic, Ruptic, Magnesic, Epiarenic, Loamic).
2	Kilgour 1	Drysdale	Neogene (Tertiary) sediments	Calcic, Mottled-Subnatric, Brown Sodosol; medium, non-gravelly, loamy, clayey, deep	Umbric Luvic Pisocalcic Solodic Planosol (Ruptic, Endosodic, Humic, Clayic)
3	SFS 3	Mt Pollock	Basalt with alluvial/colluvial material	Endocalcareous-Endohypersodic, Self-mulching, Grey Vertosol; non-gravelly, fine, fine, deep.	Pisocalcic Stagnic Sodic Humic Vertisol (Manganiferric, Endohyposodic, Mesotrophic)
4	SFS 1b	Inverleigh West	Neogene (Tertiary) sediments	Vertic, Mottled-Subnatric, Brown Sodosol; medium, non-gravelly, loamy, clayey, very deep.	a. Pisocalcic Stagnic Vertic Solonetz (Abruptic, Ruptic, Magnesic, Clayic, Manganoferric) b. Stagnic Sodic Vertisol (Hypereutric, Areninovic)
WEDNESDAY					
1	SFS 22	Shelford West	Neogene (Tertiary) sediments	Eutrophic, Mottled-Mesonatric, Brown Sodosol; medium, gravelly, loamy, clayey, moderate.	Stagnic Solonetz (Albic, Abruptic, Magnesic, Epiarenic, Clayic)
2	CRC 19	Bet Bet, Lexton	Paleozoic metasediments	Bleached-Mottled, Magnesic, Red Kurosol; medium, gravelly, loamy, clayey, moderate.	Cutanic Albic Alisol (Abruptic, Ruptic, Alumic, Clayic, Sodic, Chromic, Magnesic).
3	CRC 20	Bet Bet, Lexton	Colluvial sediments	Eutrophic, Mottled-Subnatric, Brown Sodosol; thick, non-gravelly, loamy, clayey, deep.	Stagnic Solonetz (Albic, Colluvic, Magnesic, Loamic)
4	CRC 21	Bet Bet, Lexton	Paleozoic sediments (deeply-weathered Tertiary surface)	Bleached-Mottled, Mesotrophic, Red Kurosol; thick, moderately gravelly, loamy, clayey, deep.	Albic Cutanic Alisol (Ferric, Abruptic, Alumic, Chromic, Endosodic, Magnesic)

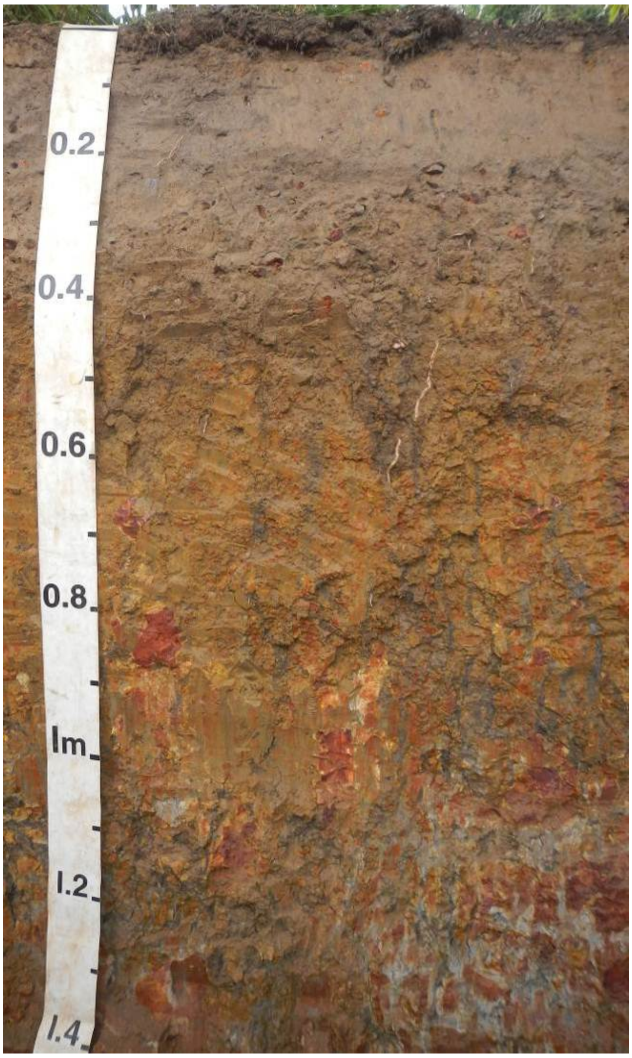
Notes: ASC classifications that have been updated since the original excursion guide as shown in blue. Formative elements not currently available in the WRB (2007 version) are shown in red. Classifications that require adjudication are highlighted in yellow (these are additions to those 'decided' at the pit face).

Soil Sites examined in Tasmania

Soil stop	Site ID	Soil	Geology/parent material	ASC	WRB
THURSDAY					
1	Cressy	*Brumby*	Tertiary lake sediments	Vertic, Subnatric, Grey Sodosol; medium, non-gravelly, loamy, clayey, very deep.	Stagnic Vertic Solonetz (Albic, Abruptic, Magnesic, Epiloamic, Endoclayic)
2	Tamar Ridge	*Legana*	Tertiary sands, clays, gravels	Eutrophic, Mottled-Mesonatric, Brown Sodosol; medium, non-gravelly, clay loamy, clayey, deep.	Stagnic Solonetz (Abruptic, Magnesic, Humic, Epiloamic, Clayic)
		Ecclestone	Jurassic dolerite colluvium overlying Tertiary sediments	This soil was not given a final classification as there was no soil pit for inspection.	
FRIDAY					
3	Forthside	*Burnie*	Tertiary basalt	Haplic, Eutrophic, Red Ferrosol; medium, non-gravelly, clay loamy, clay loamy, very deep.	Lixic Nitisol (Humic, Hypereutric, Rhodic, Endomagnesic, Sodic).
4	Preston	*Yolla*	Tertiary basalt	Humose, Dystrophic , Brown Ferrosol; medium, non-gravelly, clay loamy, clayey, very deep.	Acric Nitisol (Humic, Dystric, Endomagnesic).
SATURDAY					
5	Smithton	*Kana*	Swamp (drained)	Eutrophic, Dermosolic, Redoxic Hydrosol; thick, non-gravelly, clay loamy, clayey, very deep.	Endogleyic Cambisol (Sodic, Humic, Hypereutric, Ruptic, Epiloamic, Endoclayic, Drainic)
		Mella	Holocene sediments - *acid sulfate soil (discussed only)*		
6	Strahan	Beach peat	Holocene sediments	Terric, Acidic, Sapric Organosol; moderate.	Salic Rheic Sapric Histosol (Dystric, Sodic).

Monday – Site 1 | Clyde | GP22

Brief soil description:	Texture-contrast soil profile with zone of ferruginous nodules in subsurface overlying a mottled clay subsoil with fragments of indurated sandstone.
Landscape:	Gently undulating rises
Geology:	Potentially aeolian deposits over Tertiary sandstone
Land use:	Vegetable cropping (pit site on grass verge)
Local name:	*Bittern sandy loam*



Soil description:

Hor.	*Depth (cm)*	
A1	0-5	Dark brown (10YR3/3); sandy loam; pH 7.0; clear change to:
A21	5-25	Brown (10YR5/3) sandy loam; massive. Few ferruginous segregations.
A22jc	25-40	Light yellowish brown (10YR6/4), sporadically bleached ; sandy loam; firm consistence dry; contains many (40%) iron-cemented sandstone and ferruginous nodules; pH 5.8; clear change to:
B21t	40-80	Yellowish brown (10YR5/4) with brownish yellow (10YR6/6) and red (2.5YR4/6) mottles; light medium clay; moderate medium blocky, parting to strong fine sub-angular blocky structure; many distinct cutans; strong consistence dry; pH 6.4; gradual change to:
B22t	80-130	Light grey (10YR7/1), yellowish brown (10YR5/8) and red (2.5YR4/6) mottles; light medium clay; moderate coarse polyhedral structure; strong consistence dry; contains many (30%) iron cemented sandstone fragments; pH 6.2. The red mottles are also indurated.

Surface condition: Loose, soft. Possibly extraneous material.

Note: profile originally described for adjacent pit site. Description here slightly modified to fit the pit observed and photographed on 26/11/2012.

Monday – Site 1 Clyde GP22

Soil profile analysis

Hor.	Hor depth (cm)	pH H_2O	pH $CaCl_2$	EC dS/m	Org C %	Coarse sand %	Fine sand %	Silt %	Clay %	exchangeable cations cmol(+)/kg Ca	Mg	K	Na	Al	H	acidity	ECEC	ESP %	Na+Mg/ CEC %	Base sat.	Base Status (ASC)	Clay activity (ECEC/ clay)	15 bar (WP) v/v	DUL (FC) v/v
A1	0-20	7.0	6.5	0.14	1.6	39	37	5	16	7.70	2.00	0.64	0.30	–	–	–	11	NA	22	100	67	67	6	13
A2	20-40	5.8	4.7	0.05		28	47	10	13	0.97	0.85	0.06	0.07	–	–	–	2		47		15	15	4	13
B21	40-80	6.4	5.5	0.07		9	15	6	72	2.6	7.0	0.10	0.40	–	–	–	10	4	73	100	14	14	25	34
B22	80-120	6.2	5.7	0.10		11	20	6	64	1.10	7.0	0.11	0.98	–	–	–	9	11	87	100	14	14	21	31

Classification diagnostics

Horizon Aust	designation WRB	depth cm	Diagnostic horizons ASC	WRB	ST	Diagnostic properties/materials ASC	WRB	ST
A1	A	0-5			Ochric epipedon			
A2jc	Ec	5-40	Ferric (>20% nodules mostly uncemented)	Not ferric: nodules not weakly cemented and not red.		Sporadic bleach ('j' signification)	Lithological discontinuity with B horizon. However, ratio of CS/FS is ~1.0. This is *novic* material i.e. 'recent' sediments	
B21	Bt	40-80	Clear/abrupt textural B Mottled horizon	Argic horizon (clay skins present) Ferric horizon? or	Argillic horizon	Not sodic (ESP < 6) Base status 5≤15 (mesotrophic)	Abrupt textural change (not mentioned in field synopsis), Magnesic, Lixic (base sat/clay activity) Sodic: Exch. (Na+Mg) >15%	
B22	Btv	80+	Mottled horizon	Ferric *or* Plinthic horizon		Sodic: (ESP ≥6)		Plinthite (only 5% is required for Plinthic subgroups)

Classification

ASC: Ferric-Sodic, Mesotrophic, Brown Chromosol; thick, slightly gravelly, loamy, clayey, deep. The sporadic bleach is not diagnostic (needs to be conspicuous).

WRB:
a. If plinthic horizon present: Lixic Plinthosol (Magnesic, Sodic, Hypereutric, Clayic, , Novic). Suffixes in red are not available in the present edition of WRB.
b. If plinthic horizon not present: Cutanic Lixosol (Ferric, Abruptic, Hypereutric, Profondic, Clayic, Sodic, Novic).

Note: the soil that is classified to RSG level is the 'B horizon' only, covered by novice material. The profile does not fit the central concept of a Lixosol.

ST:
a. If ustic: Very-fine, kaolinitic, subactive, thermic Plinthic Kandiustalfs
b. If xeric: Very-fine, kaolinitic, subactive, thermic Plinthic Palexeralfs

Notes:

Ferric horizon: ASC refers to abundance (>20%) of ferruginous nodules or concretions (mostly uncemented) that may or may not be of pedogenic origin. Does not include mottling.
WRB refers to mottling (>15% coarse red) OR discrete red to blackish nodules (≥5%) – largely uncemented and does not form part of a petroplinthic, pisoplinthic or plinthic horizon

Plinthic horizon: See discussion, next page. Debate about whether the B2t horizon here is plinthic or ferric.

Reducing conditions: Not observed in soil pit, but may possibly exist at certain times of the year in some seasons. Stagnic colour pattern not described.

Issues/comments: Classifying this soil profile on the basis of the B horizon alone is not helpful in terms of the utilisation of this soil, as it is mainly the A horizon that is 'farmed'. The thickness of the novic material is not specified in the classification (i.e. 5≤50). What if novic material is >50cm? How 'new' must novic material be? Quantitative determination of novice material? In the ASC, 'recently deposited material' is defined by the absence of pedological features (e.g. colour changes, presence of segregations/nodules that are both present here). Actual evidence for lithological discontinuity? – in this case no significant different in ration of coarse sand to fine sand
Horizon nomenclature for novic horizon? Should prefix numbers be used to signify different soil materials.

Monday – Site 2	Cranbourne	GP21

Brief soil description: Texture-contrast soil profile with a sandy surface soil abruptly overlying a coarse prismatic structured, strongly mottled and magnesic clay subsoil.

Landscape: Lower lying area on a gently undulating sand plain.

Geology: Quaternary sands and clays.

Land use: Vegetable cropping (pit site on grass verge)

Local name: *Toomuc sandy loam*

Soil description:

Hor.	*Depth (cm)*	
A1	0-20	Brown (10YR5/3); Fine sandy loam; Dark greyish brown (10YR4/2); sandy loam; very weak consistence moist; weak crumb structure; pH 5.6; clear change to:
A2e	20-45	Greyish brown (10YR5/2 moist); conspicously bleached loamy sand; weak consistence moist, firm to very firm dry; pH 5.7; sharp change to:
B21	45-70	Dark greyish brown (10YR4/2) with brownish yellow (10YR6/8) and yellowish brown (10YR5/8) mottles; medium heavy clay; strong medium prismatic to columnar, parting to strong coarse blocky structure; very few coarse manganiferous segregation, some dark organic stains on ped faces; very strong consistence dry; pH 6.1; clear change to:
B22	70-110	Dark greyish brown (10YR4/2) with red (2.5YR4/8) and brownish yellow (10YR6/8) mottles; medium heavy clay; pH 6.4; clear and wavy change to:
2A	110-140	Brownish yellow (10YR6/6) sandy loam (clayey); structureless; contains patches of bleached sand and a few ironstone gravels (1-2 mm size); pH 7.1.
Surface condition:		Hard setting

Note: profile originally described for adjacent pit site and modified slightly here to fit the pit observed and photographed on 26/11/2012.

Monday - Site 2 Cranbourne GP21

Soil profile analysis

Hor.	Hor Depth (cm)	pH H_2O	pH $CaCl_2$	EC dS/m	Org C %	Coarse sand %	Fine Sand %	Silt %	Clay %	exchangeable cations cmol(+)/kg Ca	Mg	K	CEC	Al	acidity	ECEC	ESP %	Na+Mg/ CEC %	Base sat.	Base Status for ASC	Clay activity (ECEC/ clay)		15 bar v/v	DUL (FC) v/v
										%														
A1	0-20	5.6	4.8	0.07	3.9	31.4	36.7	17	10.5	3.1	0.8	0.16	0.15	–	–	4		23		40	40		5.6	19
A2	20-35 (45)	5.7	4.6	<0.05		32	38.4	20.5	10	0.87	0.58	0.09	0.13	–	–	2		43		17	17		3.2	12.7
B21	(45) 35-70	6.1	4.8	0.07		14.6	22.4	17	47.5	0.78	6.9	0.19	0.92	–	–	9	10	89	100	19	19		16.5	28.7
B22	70-110	6.4	5.1	0.09		7.4	35.5	18	43	0.42	6.4	0.14	1.30	–	–	8	16	93	100	19	19		15.1	30.5
2A	110-140	7.1	5.5	<0.05		57.7	23.4	2.5	16.5	0.16	2.6	0.07	0.72	–	–	4	20	94		22	22		5.4	11

Classification diagnostics

Horizon Aust	designation WRB	depth cm	Diagnostic horizons ASC	WRB	ST	Diagnostic properties/materials ASC	WRB	ST
A1	A	0-20			Ochric epipedon			
A2e	E	20-45		Albic		Conspicuous bleach ('e' suffix)	Lithological discontinuity, but this is not novic material.	
B21g	Btg1	45-70	Abrupt textural B horizon. Mottled horizon	Argic horizon?	Argillic horizon	Subnatric – upper B2 with ESP 6≤15.	Gleyic colour pattern Magnesic	
B22g	Btg2	70-110	Mottled horizon	Natric (ESP>15)	Natric horizon	Magnesic (Ca/Mg<0.1)	Gleyic colour pattern	

Classification

ASC: Magnesic, Mottled-Subnatric, Grey Sodosol; thick, non-gravelly, loamy, clayey, deep. Note: the bleach is not included in the classification, as it is 'typical'.

WRB: Endogleyic Solonetz (Albic, Abruptic, Ruptic, Magnesic, Clayic)

ST: Fine, mixed, subactive, thermic Typic Natraqualfs

Russia: Solonetz

Notes:

Magnesic property: In the ASC, this is reserved for soils that have a Ca/Mg ratio of < 0.1 in the major part of the B2 horizon. In WRB, the ratio can be <1.0. Soil Taxonomy does not have exchangeable Mg as a diagnostic property.

Lithological discontinuity: Difference between this and the first site in terms of novic material?
How does Soil Taxonomy deal with the lithologic discontinuity in terms of recognising argillic/natric horizons?

Monday – Site 3 | Moonlit Sanctuary, Tuerong | GW02

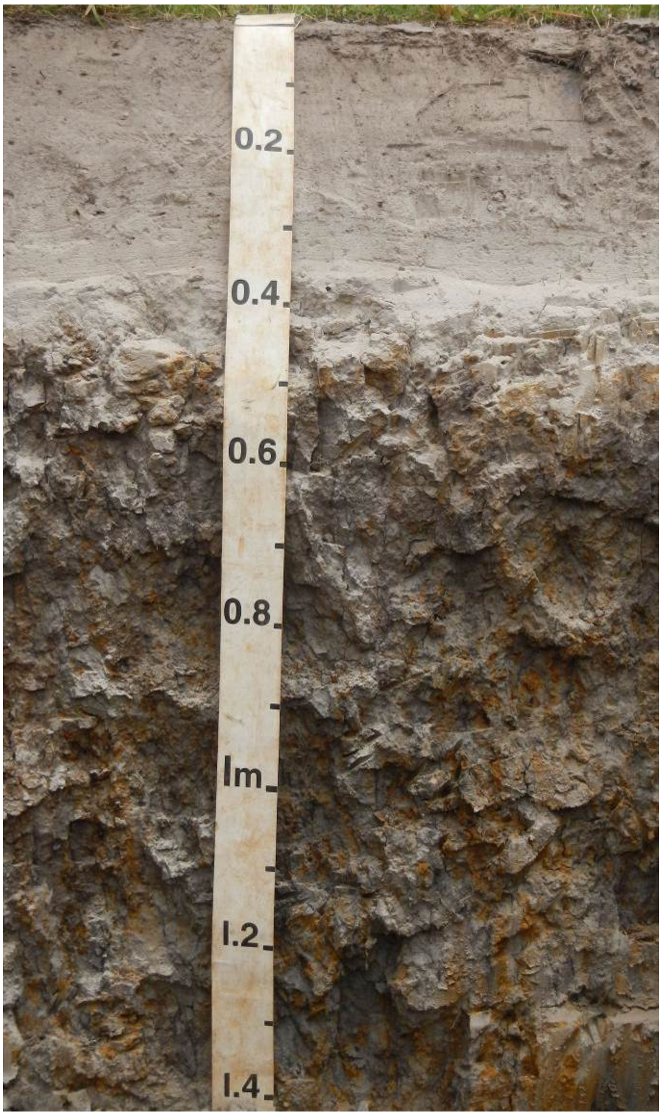
Brief soil description: Texture-contrast soil profile with a sandy surface overlying an acid, strongly structured, mottled, largely non-sodic subsoil.

Landscape: Flood plain, alluvial plain

Geology: Quaternary alluvial deposits

Land use: Conservation area – *Melaleuca ericifolia* (Swamp Paperbark)

Local name: *Pearcedale*



Soil description:

Hor.	*Depth (cm)*	
A11	0-10	Dark greyish brown (10YR4/2); sandy loam; weak fine subangular blocky structure; rough ped fabric; weak consistence, dry; pH 4.8; clear change to:
A12	10-25	Greyish brown (10YR5/2); sandy loam; massive, weak consistence, dry; very few subangular quartz gravel; pH 5.0; gradual change to:
A2e	25-50	Light brownish grey (10YR6/2), light grey (10YR7/2) dry; common medium distinct dark greyish brown (10YR4/2) mottles; sand; massive structure; weak consistence, very few subangular quartz gravel; pH 5.5; abrupt wavy change to:
B21	50-75	Grey (10YR6/1); many coarse distinct strong brown (7.5YR4/6) and brownish yellow (10YR6/8) mottles; medium heavy clay; moderate coarse, medium prismatic structure; smooth ped fabric; very firm consistence, moist; few medium ferro-manganiferous nodules; very few angular quartz gravel; very few distinct organic cutans; pH 5.5; gradual change to:
B22	75-170	Grey (10YR6/1); many coarse prominent yellowish brown (10YR5/6) and brown (7.5YR4/4) mottles; heavy clay; moderate coarse, medium prismatic structure; smooth ped fabric; very firm consistence, moist; few medium ferro-manganiferous nodules; very few angular quartz gravel; very few distinct organic cutans; pH 5.5; gradual change to:
B3	170-180+	Light grey (10YR7/2); many coarse prominent brownish yellow (10YR6/6) and yellowish red (5YR4/6) mottles; heavy clay; moderate coarse, medium prismatic structure; smooth ped fabric; very firm consistence, moist; few medium ferro-manganiferous nodules; very few angular quartz gravel; very few distinct organic cutans; pH 5.5; continuing

Note: profile originally described for adjacent pit site. Slightly modified here to fit the pit observed and photographed on 26/11/2012.

Monday – Site 3 Moonlit Sanctuary, Tuerong GW02

Soil profile analysis

Hor.	Hor Depth (cm)	pH H_2O	pH $CaCl_2$	EC dS/m	Org C %	Coarse sand	Fine Sand %	Silt %	Clay %	exchangeable cations cmol(+)/kg Ca	Mg	K	Na	Al	acidity	ECEC	ESP %	Na+Mg/ CEC %	Base Sat.	Base Status for ASC	Clay activity (ECEC/ clay)	Bulk density Mg/m^2	K sat mm/hr	15 Bar v/v	DUL (FC) v/v	Sat v/v
A11	0-10	4.9	4.2	<0.05		39.3	37.2	12	11	0.71	0.64	<0.05	0.11		6.6	8	1	9	18	13	73	na		4.1	13.7	
A12	10-25	5.0	4.4	<0.05		41.5	38.2	11	10	0.88	0.53	0.120	0.08		5.1	7	1	9	24	16	67	na		3.7	12.1	
A2	25-50	5.4	4.8	<0.05		43.5	40.6	10.5	6	0.35	0.16	<0.05	<0.05		1.5	2	2	10	25	9	34	na		1.3	9.1	
B21	50-75	5.6	4.8	0.08		19.5	15.7	3.5	61.5	2.10	7.60	0.120	0.57		9.7	20	3	41	52	17	33	na		20.5	35.4	
B22	75-170	5.6	5.0	0.08		22	19.5	8	53.5	1.30	7.60	0.100	0.64		8.1	18	4	46	54	18	33	na		19	35.5	
B23	170-180	5.6	5.0	0.08		29	24	9.5	39.5	0.95	6.50	0.070	0.79		5.4	14	6	53	61	21	35	na		14.5	27.3	

Classification diagnostics

Horizon Aust	designation WRB/ST	depth cm	Diagnostic horizons ASC	WRB	ST	Diagnostic properties/materials ASC	WRB	ST
A1	A	0-25			Ochric epipedon			
A2e	E	25-50		Albic	Albic	Conspicuous bleach ('e')	Lithological discontinuity (ruptic)	
B21g	Btg1	50-75	Abrupt textural B horizon Mottled horizon	Argic	Argillic?	Eutrophic (base status >15 in major part of the B2 hor).	Abrupt textural change. Gleyic colour pattern. Solodic – prismatic structure of a natric horizon, but not the Na.	Were clay skins observed here? – not noted on my field sheets Aeric – chroma of 3 or more?
B22	Btg2	75-170	Mottled horizon				Sodic (≥15% Na+Mg)	
B23	Btg3	170-80+	Mottled horizon			Sodic: ESP ≥6		

Classification

ASC: Bleached-Sodic, Eutrophic, Grey Chromosol; thick, non-gravelly, loamy, clayey, deep. Ca/Mg ratio ~0.15 is not enough to be *magnesic*.

WRB: Alic Endogleyic Solodic Planosol (Albic, Ruptic, Endosodic, Endoclayic, Magnesic)

ST: Fine, mixed, semi-active, Aeric Albaqualfs.

Russia: Solod (Gleyic)

Notes:

Field tests demonstrate no dispersion.

ASC: Acidity almost strong enough to be a Kurosol (pH$_W$ must be <5.5). Just 'scrapes in' to a sodic category because ESP of 5.6 is rounded off to 6.

WRB: Lab results show base saturation >50% (i.e. *Luvic* when combined with clay activity >24). However, WRB specifies that both cations and CEC should be done at pH 7.0. The resulting CEC would almost certainly be higher than the ECEC and therefore base saturation would probably be <50%. Hence *Alic*).

Monday - Site 4 | Kooyong Vineyard | MoP 6

Brief soil description: A deep soil profile where the texture grades from a clay loam surface to a medium to heavy clay in the subsoil. Strongly structured, acid, mottled, clay subsoil with low base saturation.

Landscape: Undulating rises.

Geology: Relict deeply weathered Tertiary surface (a ‘pedoderm’ as defined by Brewer, 1970).

Land use: Viticulture.

Soil description:

Hor.	*Depth (cm)*	
A1p	0-12	Dark grey (10YR 4/1); *clay loam fine sandy*; moderate fine blocky structure; very weak (moist) consistence; pH 6.7; clear change to:
A21	12-20	Brown (10YR 5/3 moist); *clay loam fine sandy*; weak (moist) consistence; pH 5.6; clear change to:
A22e/ B1e	20-40	*Light* brownish yellow (10YR 6/*4*, moist); *light medium clay*; rough ped fabric; weak blocky structure; very firm (dry) consistence; few ferromanganiferous nodules; pH 5.6; abrupt change to
B21	40-*60*	*Brown* (10YR 5/3) with *brownish yellow* (10YR 6/6) mottles; medium clay; smooth ped fabric; *strong* coarse sub-angular blocky structure parting to moderate medium sub-angular blocky structure; prominent slickensides; pH 5.7; gradual change to:
B22	*60*-80	Light yellowish brown (2.5Y 6/3) with red (2.5YR 4/8), *brownish yellow* (10YR 6/6) and light brownish grey (10YR 6/2) mottles; medium clay; *strong* coarse sub-angular blocky structure; slickensides; very few ferruginous nodules; pH 5.5
B23	80-120	Light yellowish brown (2.5Y 6/3) with grey (10YR 6/1), *brownish yellow* (10YR 6/6) and red (2.5YR 4/6) mottles; medium heavy clay; strong coarse to very fine polyhedral structure (shiny ped faces); pH 5.5.

Surface condition: Hard setting

Note: profile originally described for nearby pit site. The description here is modified to fit the pit observed and photographed on 26/11/2012 (changes to description are shown in *italics*). Texture of upper three horizons is heavier than originally described. Hence, the profile fails to meet the criteria for ‘strong texture-contrast’ in the ASC and an ‘abrupt textural change’ (WRB). However, the boundary to the strongly structured B horizon is still abrupt. Both classifications are included on the following page for reference.

Note on horizon nomenclature: In Australia, the A2 horizon is a distinct horizon, not just a subdivision of the A horizon and generally correlates to an E horizon (WRB & ST). The A2 hor. can be described in terms of its paler colour alone, although it will often have less silicate clay and organic matter as well. Therefore, in this case, the third horizon still qualifies as an A2 horizon, even though it contains more clay than the A1 horizon. However, it would be equally valid for an Australian pedologist to call it a B1 (i.e. transitional) horizon.

Monday - Site 4 Kooyong Vineyard MoP 6

Soil profile analysis

Hor.	Hor Depth* (cm)	pH H_2O	pH $CaCl_2$	EC (1:5)	Org C %	Coarse sand %	Fine sand %	Silt %	Clay %	exchangeable cations cmol(+)/kg Ca	Mg	K	Na	Al	H	acidity	ECEC	ESP %	Na+Mg/ ECEC %	Base Sat.	Base Status (ASC)	Clay activity (ECEC/ clay)
A1	0-12	6.7	6.1	0.1					30	7.90	2.20	0.150	0.31			6.4	17	2	15	62	35	57
A22	*12-20*	5.6	5.0	0.12					32	1.20	1.30	<0.05	0.25			6	9	3	18	31	9	27
A22e	*20-40*	5.6	4.9	0.08					40	0.94	2.00	<0.05	0.30			6	9	3	25	35	8	23
B21	*40-60*	5.7	4.9	0.11					50	1.60	0.94	0.140	0.82			9.2	13	6	14	28	7	25
B22	*60-80*	5.5	5.0	0.14					50	1.20	1.20	0.190	1.10			11	15	7	16	25	7	29
B23	80-120	5.5	4.9	0.14					55	0.50	0.50	0.090	1.40			11	14	10	14	18	5	25

* Horizon depths changed from original site described to match photographed soil pit. Clay contents (and therefore clay activity) are predicted from field textures

Classification diagnostics

Horizon Aust	designation WRB	depth cm	Diagnostic horizons ASC	WRB	ST	Diagnostic properties/materials ASC	WRB	ST
A1/A21	A	0-20						
A2e	Bt	20-40		Not an albic horizon, as it is not a subsurface horizon from which "clay and free iron oxides have been removed". Also does not meet the requirements for an E horizon (see below).		Conspicuous bleach.		Episaturation
B21g	Bit1	40-60	Mottled horizon	Ferric horizon (based on mottling, not nodules)		Strongly structured (>weak) Mesotrophic (base status 5 ≥ 15 in major part of the B2 hor).	Stagnic colour pattern.	Presumed linear extensibility
B22/3	Bit2	60-120	Mottled			Strongly structured (>weak). Mesotrophic (as above).	Alic (CEC of >24 cmol/kg clay), Dystric (base sat < 50%)	

Classification

ASC: a. as described in soil pit: Bleached-Vertic, Mesotrophic, Brown Dermosol; medium, non-gravelly, clay loamy, clayey, deep.
b. previous description: Vertic, Mottled-Subnatric, Brown Sodosol; medium, non-gravelly, clay loamy, clayey, deep.
WRB: a. no abrupt textural change: Alic Endogleyic Vertic Stagnosol (Ferric, Ruptic, Hyposodic, Dystric, Clayic). Note differences in ferric horizon definition (see Site 1).
b. if abrupt textural change: Alic Vertic Planosol (Ferric, Ruptic, Hyposodic, Clayic). It would be desirable to have laboratory particle size to confirm texture changes.
ST: Fine, mixed, Aeric Chromic, Vertic, Epiaqualfs

Notes on A2 and E horizon definitions, and why an albic horizon (WRB & USDA) is not described here, even though the third horizon qualifies as bleached using Australian criteria:

E horizon (WRB/ FAO): main feature of is loss of silicate clay, iron or aluminium leaving a concentration of sand and silt particles. Usually, but not necessarily paler in colour.

E horizon (Soil Taxonomy/ USDA): as above, but the definition includes the potential loss of organic matter.

A2 horizon (Australia): *alone* or in combination having less organic matter, sesquioxides or silicate clay (compared to the A1 above and the B horizon below). It is usually defined on the basis of its paler colour alone. An A2e (conspicuously bleached A2) horizon generally correlates to an albic horizon (WRB & ST), but not in this particular case.

There is also a slight difference in the way 'albic' or 'bleached' colours are defined. In Australia, the dry colour must have a value of 7 or more (except if the hue is 5YR or redder, when it can be 6), and the chroma may be 4 or less. In WRB and ST, the dry chroma must be 3 or less, and colour values (dry) of 5 and 6 are permitted if the chroma is 2 or less.

Tuesday – Site 1 | Murradoc, St Leonards district | CLRA 4

Brief soil description: Texture-contrast soil profile with a sandy surface overlying a strongly sodic, alkaline subsoil with columnar structure.

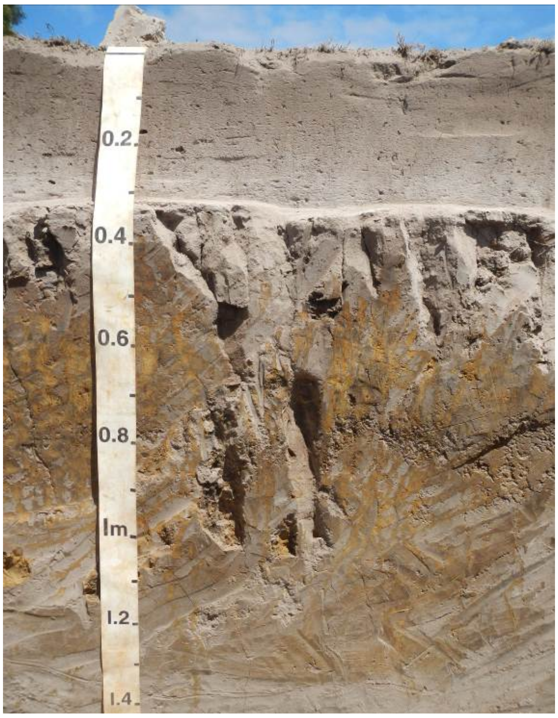
Landscape: Flat plain.

Geology: Quaternary alluvium, colluvium, lagoon and swamp deposits: gravel, sand, silt.

Land use: Grazing.

Above: photographed on 27/11/2012, after rain.

Below: photographed dry on 23/11/2012, with minimal preparation of pit face.



Soil description:

Hor.	*Depth (cm)*	
A1	0-15	Dark grey (10YR4/1); *clayey sand*; weak medium subangular blocky structure; rough ped fabric; weak consistence (dry); pH 5.5; wavy clear boundary to:
A2e	15-30	Light brownish grey (10YR6/2), conspicuous bleach (10YR8/1 dry); *loamy sand*; apedal massive structure; earthy fabric; very firm consistence (dry); pH 6.0; smooth abrupt boundary to:
B21	30-80	Brown (10YR5/3) with many medium distinct orange grey and red (10YR5/6, 10YR4/1, 2.5YR5/6) mottles; light medium clay; strong coarse columnar parting to strong medium angular blocky structure; smooth ped fabric; common prominent clay skins and other cutans; very strong consistence (dry); few (6–60 mm) ferruginous soft concretions; pH 7.0; wavy gradual boundary to:
B22	80-120	Yellowish brown (2.5Y5/4); light medium clay; weak coarse columnar parting to medium and strong medium prismatic structure; smooth ped fabric; few distinct clay skin cutans; strong consistence (dry); pH 8.5; wavy gradual boundary to:
B23/ B3	120-145+	Light yellowish brown (2.5Y6/4) with few large yellow faint mottles; medium clay; weak coarse columnar parting to medium and strong medium prismatic structure; smooth ped fabric; very few faint clay skin cutans; strong consistence (dry); pH 8.5.

Note: original description unaltered for new pit, except for field texture of the A horizon.

In Australia, field descriptions always use field texture. If the USDA/FAO 'rules' are used, the texture of the B horizon here should be described as a loam, as it contains <40% clay (see discussion next page).

Tuesday – Site 1 Murradoc CLRA 4

Soil profile analysis

Hor.	Hor depth (cm)	pH H_2O	pH $CaCl_2$	EC dS/m	Cl %	Coarse sand %	Fine sand %	Silt %	Clay %	exchangeable cations cmol(+)/kg Ca	Mg	K	Na	Al mg/kg	acidity	ECEC	ESP %	Na+Mg/ CEC %	Base Sat.	Base Status (ASC)	Clay activity (ECEC/ clay)
A1	0–15	5.2	4.6	0.12		10.6	62.4	14	7	2.7	1.2	0.57	0.51	12	9.1	14	4	12	35	71	201
A2	15–30	5.7	5.1	<0.05		11.6	68.2	19	3	0.58	0.31	0.1	0.16	<10	2	3	5	15	37	46	126
B21	30–80	7.4	6.4	0.29	0.04	7.4	46.4	8	34.5	3.7	10.0	0.30	4.90			19	26	79	100	55	55
B22	80–120	8.1	7.1	0.41	0.06	6.2	49.9	10	30.5	2.3	8.1	0.3	5.1			16	32	84	100	52	52
B23	120–145	8.1	7.2	0.61	0.11	6.2	49.9	10	30	3.4	12	0.4	8.0			24	34	84	100	78	78

Classification diagnostics

Horizon designation Aust	WRB	depth cm	Diagnostic horizons ASC	WRB	ST	Diagnostic properties/materials ASC	WRB	ST
A1	A	0-15			Ochric epipedon			
A2e	E	15-30		Albic horizon				
B21	Bt1	30-80	Abrupt textural B horizon. Mottled horizon	Argic horizon, Natric horizon	Natric horizon	Hypernatric (ESP > 25) in upper 20 cm.	Stagnic, Luvic, Magnesic	
B22	Bt2	80-120	Mottled horizon			Eutrophic (base status >15)		
B23/B3	Bt3	120+						

Classification

ASC: Eutrophic, Mottled-Hypernatric, Brown Sodosol; medium, non-gravelly, loamy, sandy, clayey, very deep.

WRB: Stagnic Solonetz (Albic, Abruptic, Ruptic, Magnesic, Epiarenic, Loamic). Loamic is not currently an available descriptor in the WRB, because it is the 'default' texture. However, it would be useful here to highlight the fact that the B horizon at this site is not 'clayic'.

ST: Typic Natraqualfs.

Notes:

This is a fairly 'clear cut' case, where there is consistency in how the soil is recognised in the three soil classifications systems, all capturing the essence of the soil profile.

Clay % B horizon: The clayey, intractable B horizons of many Sodosols in Australia have surprisingly low clay contents, and may be less than the 35% normally regarded as being the threshold level for a clay texture (as defined in Australia). However, this does not cause us taxonomic grief, as we can classify/describe on the basis of field texture alone (see notes on the ASC, page 7).

In the WRB, the 'clayic' qualifier is used where there is a 'texture of clay' (in a layer ≥30 cm thick within 100 cm of the soil surface). The percentage of clay is not specified (as it is for vertic properties), however it is not technically correct to have a texture of 'clay' unless there is at least 40% clay (using the FAO texture triangle). The USDA texture triangle is very similar, also specifying 40% clay for a clay texture.

Tuesday – Site 2	Kilgour 1

Brief soil description: Texture-contrast soil profile with a loamy surface overlying alkaline structured clay subsoil with carbonate segregations.

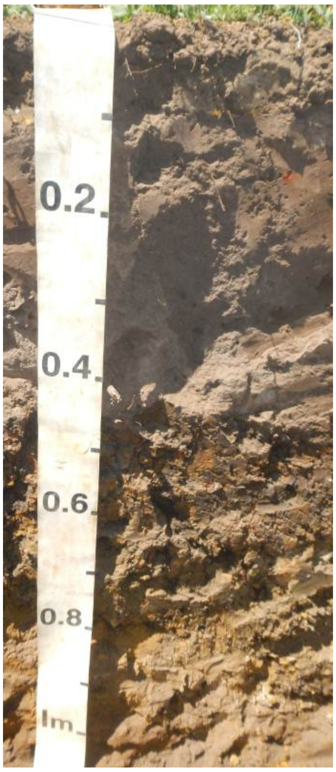
Landscape: Low hills.

Geology: Tertiary (Neogene) sandstone.

Land use: Vineyard ('Pinot grafted on to Merlot').

Above: original soil pit as described (at left)

Below: photographed on 23/11/2012 (two different parts of pit, with bleaching of the A2 (E) horizon evident at left, and organic cutans in the B2 on right)



Soil description:

Hor.	*Depth (cm)*	
A11	0-15	Dark brown (7.5YR3/2); light sandy loam; weak fine subangular blocky structure; rough ped fabric; weak consistence, dry; pH 5.5; clear change to:
A12	15-25	Dark brown (7.5YR3/2); heavy loamy sand; earthy; apedal; weak consistence, dry; common fine ferro-manganiferous nodules; pH 5.5; clear change to:
A2(e)	25-40	Brown (7.5YR5/2); loamy sand; apedal; earthy fabric; weak consistence (dry); common fine ferric nodules; pH 5.5; clear wavy change to:
B2	40-70	Yellowish brown (10YR5/4); many coarse distinct very dark grey (10YR3/1) and yellowish red (5YR5/8) mottles; medium heavy clay; strong coarse to medium angular blocky structure; very firm consistence (mod. Moist); few coarse calcareous soft segregations; many distinct clay cutans, and prominent patches of dark organic cutans; pH 6.5; gradual change to:
B31(k)	70-90	Yellowish brown (10YR5/6); many coarse distinct very dark greyish brown (10YR3/2) and light yellowish (10YR7/3) mottles; sandy clay; moderate coarse to medium angular blocky structure; very firm consistence (dry); many (20-50%) coarse calcareous soft segregations; common distinct clay cutans; many ferruginised sandstone fragments; pH 8.5; gradual change to:
B32(k)	90-130+	Yellowish brown (10YR5/6); many coarse distinct very dark greyish brown (10YR3/2) and light yellowish (10YR7/3) mottles; sandy clay; weak coarse to medium angular blocky structure; very firm consistence (dry); common (10-20%) coarse calcareous soft segregations; some distinct clay cutans; abundant ferruginised sandstone; pH 8.5; continuing……

Strong dispersion was observed in the B3 horizons and moderate dispersion in the B2 horizon

Note: In the second soil pit (lower photos at right), the abundance of calcium carbonate was lower (probably <10%) compared to the original pit (top photo at right)

Tuesday – Site 2 Kilgour 1

Soil profile analysis

Hor.	Hor Depth (cm)	pH H_2O	pH $CaCl_2$	EC dS/m	Org C %	Cse Sand %	Fne Sand %	Silt %	Clay %	exchangeable cations cmol(+)/kg Ca	Mg	K	Na	Al	acidity	ECEC	ESP %	Na+Mg/ ECEC %	Base Sat.	Base Status for ASC	Clay activity (ECEC/ clay)	15 Bar v/v	DUL (FC) v/v	Clay mineralogy (Earth Sciences Latrobe Uni) Calcite1 %	Calcite2 %	Illite1 %	Kaolin %	Quartz %	Smectit. chlorite %	Zinc oxide %
A11	0–15	6.3	5.7	0.014	2.2	72	7	6	11	5.6	1.4	1.4	0.33	<10	5.1	14	2	13	63	79	126	5.3	16.4	5.5	0	13.2	7.1	68.4	4.2	1.6
A12	15–25	5.4	4.8	0.1	1.3	72	10	4	11	2.6	0.66	0.24	0.2	<10	5.4	9	2	9	41	34	83	4.5	14.7							
A2	25–40	5.9	5.2	0.09	0.8	62	25	9	6	2.6	0.61	0.23	0.25	<10	4.8	9	3	10	43	62	142	4.6	14.5							
B21	40–70	6.4	5.6	0.2	1.1	30	2	3	61	11.0	9.00	0.48	1.80	<10	10	32	6	33	69	37	53	23.1	42.4	1.6	1.5	26.4	12.2	43.1	7.1	8.1
B31	70-90	8.7	8.1	0.27		52	6	2	31	6.1	4.7	0.34	1.4			13	11	49	100	40	40	13	23.9							
B32	90-130+	8.8	8.2	0.26		52	6	2	31	4.7	3.5	0.24	1.4			10	14	50	100	32	32			2.5	0	11.7	5.2	72.7	3.4	4.5

PSA in red is inferred

Classification diagnostics

Horizon Aust	designation WRB	depth cm	Diagnostic horizons ASC	WRB	ST	Diagnostic properties/materials ASC	WRB	ST
A1	A	0-25		Not mollic (lack of structure)	Umbric epipedon			
A2(e)	E	25-40		Albic				
B21	Btg1	40-70	Clear textural B. Mottled horizon.	Argic		Subnatric (ESP 6≤15)	Abrupt textural change; lithological discontinuity (fine sand almost 'drops out') Reducing conditions: stagnic colour pattern. Hyposodic.	
B3(k)	Btg2	70-130+	Calcareous horizon – calcic carbonate class (2≥20% soft and <20% hard carbonate)	does not meet the requirements of a Calcic horizon			Pisocalcic: <5% secondary carbonates.	

Classification

ASC: Calcic, Mottled-Subnatric, Brown Sodosol; medium, non-gravelly, loamy, clayey, deep.

WRB: Umbric Luvic Pisocalcic Solodic Planosol (Ruptic, Endosodic, Humic, Clayic). The humic qualifier is not listed as an option for Stagnosols.

ST: Clayey over loamy, mixed, active, thermic, Typic Paleustalfs.

Russia: Agrozem? – does not appear to be analogous with Anthrosol.

Notes:

Stagnic colour pattern: Appears to be 'active': reduced Fe between the peds (O_2 depletion due to relatively high OM) and oxidised Fe in ped interior.

Sodicity/dispersion: Field tests indicate this subsoil is dispersive, but the soil does not meet the requirements for a natric horizon (WRB & ST). The WRB recognises a hyposodic subclass (ESP ≥ 6). Soil Taxonomy has sodic subgroups in some orders, but only if ESP >15%.

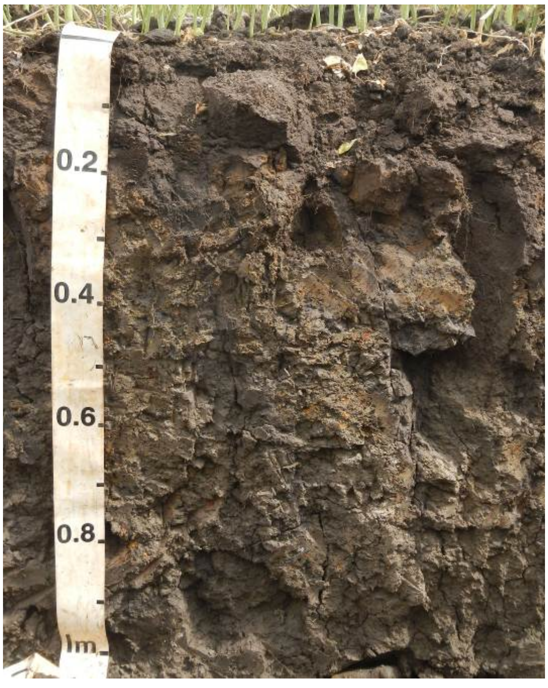
Carbonate diagnostics: The amount of secondary carbonate present in the observed pit was not agreed upon – it was patchy and probably less than in the originally described pit. In the ASC, calcic subgroups of Sodosols are possible with a carbonate concentration of <5% (see ASC glossary – *carbonate classes*), whereas in the WRB a minimum of 5% is specified. In the ASC, there is potentially an inconsistency between the definition of a *calcareous horizon* and two of the diagnostic *carbonate classes*.

Tuesday – Site 3	**Mount Pollock**	**SFS 3**

Brief soil description:	Texture-contrast profile with a thin loamy surface soil overlying a strongly alkaline subsoil with abundant ironstone ('buckshot') and vertic features.
Landscape:	Pediment – lower slope associated with low hill (Mt Pollock). Patches of sheet flow deposits.
Geology:	Quaternary volcanics (basalt). Mount Pollock is a large lava dome with extensive radial lava flows.
Land use:	Cropping (wheat, canola)

Above: soil pit as described (at left)

Below: photographed on 27/11/2012 (see note).



Soil description:

Hor.	*Depth (cm)*	
A1	0-10	Dark brown (10YR 3/3 moist) with dark greyish brown (10YR 4/2 dry) mottles; fine sandy clay loam; weakly pedal; very firm consistence; contains many (20-30%) fine ferruginous nodules (magnetic); pH 6.2:
B21cg	10-75	Dark greyish brown (10YR 4/2) with brownish yellow (10YR 6/6) mottles; fine-gravelly clay; fine polyhedral structure; shiny ped faces; abundant (>50%), fine buckshot; fragments of basalt up to 100 mm diameter; pH 7.4:
B22	75-100	Brownish yellow (10YR 6/6) with dark grey (10YR 4/1) mottles; infill in earthworm channels; sandy clay; much quartz; very few ferruginous nodules; pH 9.1:
B23ss	100+	Weak red (2.5YR 5/2); gravelly clay; abundant (>50%), fine and coarse buckshot; slickensides (50-100 mm) present; pH 9.0.

Note: *For the WRB excursion, it was not possible to locate the soil pit in the same location that was originally described and photographed (above).*

The texture-contrast features described at the original site where not evident at the new pit site, which was quite clearly a Vertosol. However, a detailed description of the soil pit was not obtained.

Soil profile analysis

Hor.	Sample depth (cm)	pH H_2O	pH $CaCl_2$	EC dS/m	Cl %	Coarse sand %	Fine sand %	Silt %	Clay %	exchangeable cations cmol(+)/kg Ca	Mg	K	Na	Al mg/kg	acidity	ECEC	ESP %	Na+Mg/ ECEC %	Base Sat.	Base Status (ASC)	Clay activity (ECEC/ clay)
A1	0-10	6.2	5.6	0.21		15.7	38.4	13.5	28.5	9.70	4.90	0.65	0.81	<10	9.7	26	3	22	62	56	90
B21	20-40	7.4	6.2	0.15		22	19.2	6.5	48.5	6.60	12.00	1.20	2.80		7.3	30	9	49	76	47	62
B22	80-100	9.1	7.8	0.23		16.4	42.2	7.5	32.5	4.00	9.40	0.47	4.30		1.5	20	22	70	92	56	61
B23	100+	9.0	7.9	0.35		13.5	31.1	12	43	5.50	13.00	0.70	6.50			26	25	76	100	60	60

Classification diagnostics based on observed soil pit.

Horizon designation Aust	WRB	depth cm	Diagnostic horizons ASC	WRB	ST	Diagnostic properties/materials ASC	WRB	ST
A1	A	0-5			Mollic epipedon? to 25 cm	Self-mulching (fine surface structure, at least 10 mm thick when dry)	Mesotrophic (base sat. <75% at a depth of 20 cm from the soil surface); Stagnic colour pattern.	
B21	Bt1	5-20					Manganiferric	
B22	Bt2	20-60	Mottled horizon			Endohypersodic (ESP > 15)		
B23	Bt3	60-100	Mottled horizon					

Classification

The following classifications are based on brief observations of the pit, and on the assumption that characteristics of the B2 horizons are similar to the soil described and analysed earlier (e.g. ESP>15 in the B22 horizon, clay content ~40%).

ASC: Endocalcareous-Endohypersodic, Self-mulching, Grey Vertosol; non-gravelly, fine, fine, deep.

WRB: Pisocalcic Stagnic Sodic Humic Vertisol (Manganiferric, Endohyposodic, Mesotrophic)

ST: Fine, smectitic, thermic Ustic Epiaquert.

Russia: Humic, vertic, quasi-gleyic soil (Vertisols/vertosols do not occur in Russia)

Notes:

ASC: The self-mulching characteristic of many Vertosols is recognised at the great group level of the classification. Other options for soil surface condition are epipedal (pedal but not or only weakly self-mulching), crusty or massive.

A ferric horizon is not recognised in Vertosols (although in this case, it was not present as the abundance of nodules at the pit was <20%).

WRB: The humic and mesotrophic qualifiers are estimated (required lab analysis to confirm is not available). Note – can have a sodic prefix and a hyposodic suffix?

Tuesday – Site 4 | Inverleigh West | SFS1

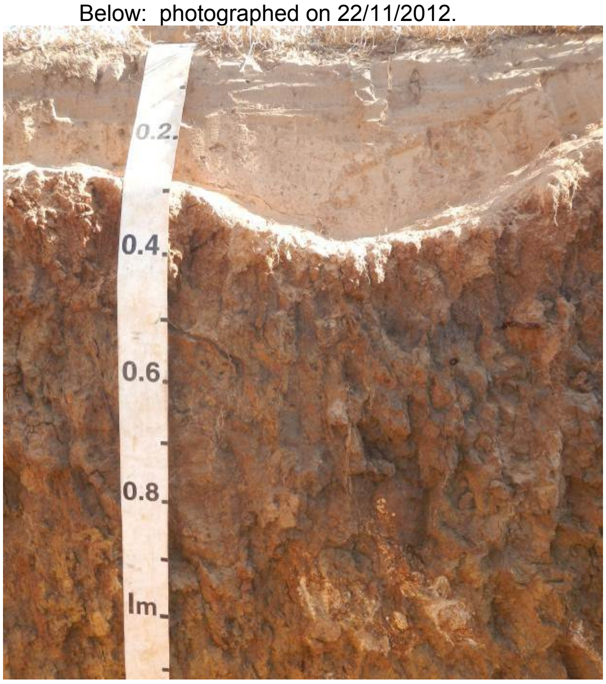
Brief soil description: Strong texture-contrast profile with a bleached sandy loam surface over a mottled strongly alkaline clay subsoil with strong prismatic structure.

Landscape: Alluvial plain (1% slope)

Geology: 'Hanson Plain Sand' (Tertiary alluvial outwash sediments). Overlain by scattered 'Newer Volcanics' (Quaternary basalts) throughout the area.

Land use: Cropping and pastures (Southern farming systems trial site)

Above: photographed on 27/11/2012.
Below: photographed on 22/11/2012.



Soil description:

Hor. *Depth (cm)*

A1 0-10 Very dark grey brown (10YR3/2); light fine sandy loam; weak medium polyhedral parting to fine sub-angular blocky; weak consistence dry; pH 7.0; abrupt smooth change to:

A2e 10-30 *Yellowish brown (10YR5/4 m; 10YR7/3 d)*; very few fine faint orange mottle; fine sandy loam; apedal (massive); firm consistence moderately moist; very few ferromanganese concretions; pH 6.2; sharp wavy change to:

Note: Conspicuously bleached A2 horizon evident in photograph of dry soil (below right).

B21 30-45 Dark yellowish brown (10YR3/4) with many fine red (2.5YR4/6) mottles; medium clay; moderate coarse columnar parting to moderate medium prismatic structure; smooth ped fabric; very strong consistence, dry; very few manganese flecks; pH 7.0; gradual to::

B22 45-80 Dark yellowish brown (10YR4/4); many medium strong brown (7.5YR4/6) and grey (10YR4/1) mottles; heavy clay; moderate coarse columnar parting to strong medium prismatic structure; smooth ped fabric; strong consistence (dry); common manganese concretions; few distinct cutans; abrupt wavy change to:

B23k 80-120 Yellowish brown (10YR5/4); with many fine brownish yellow (10YR6/6) and mottles; heavy clay; Weak coarse columnar parting to strong to medium prismatic structure; smooth ped fabric; very firm consistence, slightly moist; common (>10%) calcareous nodules and soft segregations; few ferromanganiferous concretions, few distinct cutans, few slickensides; pH 7.5; clear change to:

B24 120-160 Yellowish brown (10YR5/4); with many fine brownish yellow (10YR6/6) and mottles; medium heavy clay; moderate medium prismatic parting to medium angular blocky structure; smooth ped fabric; firm consistence, slightly moist; few calcareous nodules (patches); distinct cutans, common slickensides; pH 7.5.

Note: horizon depths and boundaries altered from original description, also slickensides almost absent above 120 cm. Structure of B21 and B22 horizon barely columnar.

Tuesday – Site 4 Inverleigh West SFS1

Soil profile analysis (original sampling depths shown)

Hor.	Hor depth (cm)	pH H_2O	pH $CaCl_2$	EC dS/m	Org C %	Coarse sand	Fine Sand %	Silt %	Clay %	exchangeable cations cmol(+)/kg Ca	Mg	K	Na	Al mg/kg	acidity	ECEC	ESP %	Na+Mg/ ECEC %	Base Sat.	Base Status for ASC	Clay activity (ECEC/ clay)	Bulk density Mg/m^2	K sat mm/hr	15 Bar v/v	DUL (FC) v/v	Sat v/v
A11	0-8	5.8	5.3	0.16	1.60	11.8	64	9	10.5	3.60	0.85	0.92	0.23	<10	2.9	9	3	13	66	53	81					
A12	8-20	5.1	4.5	0.06	0.65	11.6	64.4	11	10.5	1.40	0.37	0.19	0.16	<10	3.9	6	3	9	35	20	57					
B21	20-35	5.7	4.7	0.12		4.8	28.5	7	55.5	6.00	7.50	1.10	1.80		13	30	6	32	56	30	53					
B22	35-65	7	5.9	0.16		4.5	31.6	6.5	56	3.90	11.00	1.20	3.50		8.9	29	12	51	69	35	51					
B23	65-95	8.4	7.5	0.23		4.6	43.2	8.7	41.8	3.70	12.00	1.10	4.80			22	22	78	100	52	52					
B24	95-150	9.2	8.4	0.32		3.4	40.6	7.5	45	3.70	14.00	1.10	5.30			24	22	80	100	54	54					
B3	150-190	9.4	8.6	0.47		2.7	32.1	10	52	4.40	17.00	1.40	7.00			30	23	81	100	57	57					

Classification diagnostics

Horizon Aust	designation WRB	depth cm	Diagnostic horizons ASC	WRB	ST	Diagnostic properties/materials ASC	WRB	ST
A1	A	0-10			Ochric epipedon			
A2e	E	10-30				Conspicuous bleach	Albic	Albic
B21	Bt1	30-45	Sharp textural boundary Mottled horizon	Argic horizon, Natric (based on Mg+Na > Ca)	Argillic	Upper 20 cm of B horizon is subnatric (ESP 6 ≥15)	Magnesic (throughout B hor.) Stagnic colour pattern	
B22	Bt2	45-80	Mottled horizon	Manganoferric	Argillic			
B23k	Bt3	80-120	Mottled horizon	Manganoferric	Argillic/Natric		Pisocalcic	
B24	Bit	120-160	Mottled horizon	Vertic horizon	Argillic/Natric	Vertic properties	Vertic properties	Vertic properties

Classification

ASC: Vertic, Mottled-Subnatric, Brown Sodosol; medium, non-gravelly, loamy, clayey, very deep.

WRB:
a. If all the whole profile is classified: Pisocalcic Stagnic Vertic Solonetz (Abruptic, Ruptic, Magnesic, Clayic, Manganoferric)
b. If surface soil is 'new' i.e. novic Stagnic Sodic Vertisol (Hypereutric, Areninovic) This is possible because the Vertic horizon starts <100 cm from the top of the B horizon i.e. the classified soil.

ST: Fine, smectitic, active, thermic, Vertic Natraqualf (not sure if it is 'aquic')

Russia: Not a Solonetz (lacks columnar structure)?

Notes:

Soil profile: Field dispersion tests carried out on the day of the excursion indicated variability in the nature of the clay observed in the B21 horizon: the reddish more friable clay does not disperse, but the brown blocky clay does disperse. Coarse sand to fine sand ratios do not provide support for a lithological discontinuity between A and B horizons.

ASC Top 20 cm of B horizon is only barely sodic (ESP 6); the classification does not capture the fact that the deeper B horizon is strongly sodic (i.e. ESP >15) – it is only thye top 20 cm of the b horizon that is examined for sodicity.

WRB: 'Manganoferric' needs to be added to list of suffix options available for the Solonetz RSG.

Wednesday – Site 1 | Rocklea (west of Shelford) | SF22

Brief soil description: Strong texture-contrast soil profile with strongly sodic and alkaline subsoil.

Landscape: Undulating plain (slope 1.5%)

Geology: Tertiary (Neogene) sediments (‘*Moorabool Viaduct sands*’)

Land use: Cereal cropping (currently in pasture rotation). This is rated a “good” paddock with satisfactory yields of wheat and canola.

photograph showing pasture at pit location.

Above: photographed on 22/11/2012.

Below: photographed on 28/11/2012 (unprepared face of pit, showing prismatic structure of B21 horizon)

Soil description:

Hor.	*Depth (cm)*	
A1p	0-20	Brown (10YR 4/3 moist) to pale brown (10YR 6/3 dry);fine sandy loam; massive structure; loose at surface; pH 6.0; clear change to:
A2e	20-42	Brown (10YR 5/3 moist); conspicuously bleached (10YR 8/3 dry); sandy loam; massive structure; very few ferromanganiferous concretions; firm consistence (dry); pH 6; sharp and wavy change to:
	Note:	*Thickness of A2 horizon varies from 20-50 cm in this locality.*
B21t	42-80	Yellowish brown (10YR 6/6) with darker (10YR4/3) humus coated ped faces, 30% red (2.5YR4/6) mottles and 10% yellow (10YR6/6) mottles; strong medium heavy clay; coarse (40-100 mm) prismatic structure (few peds with slightly domed tops), parting to strong moderate (20 mm) angular blocky;.organic cutans, pH 7; gradual change to:
B22 (B3)	80-120	Brownish yellow (10YR 6/6) with 10% red (2.5YR4/6) mottles; clay loam, massive, rough ped fabric; pH 9; clear change to:
B23k	120-150	Light yellowish brown (2.5Y 6/3) with 10% faint orange yellowish red (5YR 4/6) mottles; light clay; isolated coarse calcium carbonate soft segregations, visible effervescence with dilute acid; pH 9.

Notes: *Soil pit at slightly different location to the site originally described and sampled (possibly 100 m away). The vertic feaures originally described were not particularly evident in this pit; also there was less calcium carbonate.*

The B22 horizon has a much lower clay content than the horizons above and below, indicating a zone of less weathered sandstone parent material.

Coarse sand to fine sand ratios do not provide support for a lithological discontinuity between A and B horizons.

Wednesday – Site 1 Rocklea (west of Shelford) SF22

Soil profile analysis

Note: sample depths may not match the horizons photographed in the soil pit.

Hor.	Sample depth (cm)	pH H_2O	pH $CaCl_2$	EC dS/m	Cl %	Coarse sand %	Fine sand %	Silt %	Clay %	Ca	Mg	K	Na	Al	acidity	ECEC	ESP %	Na+Mg/ ECEC %	Base Sat.	Base Status (ASC)	Clay activity (ECEC/clay)
										exchangeable cations cmol(+)/kg				mg/kg							
A1p	0–15	6.0	5.6	0.21		14.4	62.7	8	7.5	6.10	1.20	0.500	0.41	<10	6.3	n/a	3	11	57	n/a	n/a
A2e	15–30	5.7	5.3	0.14		16.4	68.4	8.5	5	1.10	0.46	<0.05	0.19	<10	1.7	4	6	19	51	35	69
B21	30–50	7.2	6.4	0.31		5.1	23.1	4	65	4.90	7.80	0.400	4.20			17	24	69	100	27	27
B22	70-90	8.7	7.9	0.54		6.2	35.3	4.5	51	4.60	10.00	0.400	5.70			21	28	76	100	41	41
B23	100-120	9.3	8.6	0.69					50	4.70	9.90	0.400	5.60			21	27	75	100	41	41

Note: High Ca in Ap horizon is probably due to the addition of lime. Therefore ECEC, base status and clay activity are not included in table.
The zone of lower clay content (B22 horizon) evident in the soil pit, is not represented in the analytical data.

Classification diagnostics

Horizon designation Aust	WRB	depth cm	Diagnostic horizons ASC	WRB	ST	Diagnostic properties/materials ASC	WRB	ST
A1	A	0-20			Ochric epipedon			
A2e	E	20-40		Alibic	Albic	Conspicuous bleach (not diagnostic)		
B21	Btg1	40-80	Abrupt textural B Mottled horizon	Argic horizon, Natric horizon	Argillic Natric	Mesonatric: (ESP between 6-25 in the upper B horizon) Eutrophic (throughout B horizons)	Reducing conditions: stagnic colour pattern (red mottles), columnar to prismatic structure.	
B22	Btg2	80-120	Mottled horizon					
B23	Btg3	120+	Mottled horizon					

Classification

ASC: Eutrophic, Mottled-Mesonatric, Brown Sodosol; thick, non-gravelly, sandy, clayey, very deep.

WRB: Stagnic Solonetz (Albic, Abruptic, Epiarenic, Magnesic, Clayic)

ST: Fine, smectitic, thermic Typic Natrustalf

Notes:

Genesis: There seemed to be general agreement at the pit, that in this case there was not a lithological discontinuity between the A and B horizons. Fragments of material from the B horizon were evident in the A horizon. Australian pedologists would not be looking for a lithological discontinuity here, as it is generally understood that such a profile can form by clay illuviation (and probably bioturbation as well), given the huge amount of time over which the soil has been developing.

Wednesday – Sites 2,3,4 — Bet Bet Creek landscape overview

The upper Bet Bet Creek catchment in north-central Victoria is an erosional upland landscape (formed on Palaeozoic metasediments) typified by a high degree of variability in the nature and distribution of soil/regolith materials, landform evolution and salt stores. The catchment (average annual rainfall of 620 mm) is a significant contributor of salts to the Loddon River. Multi-disciplinary work has generated an improved understanding of this landscape by combining studies of landscape evolution, geomorphology, geology, pedology and hydrogeology.

Construction of a dam bank (probably to dam the stream - an activity associated with late 19th Century gold mining practice) in the late 1800's or early 1900s resulted in diversion of the existing stream channel in this upper tributary of the Bet Bet Creek. Following extensive clearing in the first half of the 20th Century, gully and tunnel erosion has accelerated and the former stream channels are now extensively eroded. As this upper tributary stream re-routed itself around the diversion bank it left stranded a former section of the original stream. This has provided the opportunity to observe a relatively undisturbed stream course.
A virtual landscape view can be seen at: http://vro.dpi.vic.gov.au/dpi/vro/nthcenregn.nsf/pages/lwm_virtual-landscape_bet-bet-creek-catchment

Land use change
Construction of a dam bank (probably to dam the stream - an activity associated with late 19th century gold mining practice) in the late 1800s or early 1900s resulted in diversion of the existing stream channel in this upper tributary of the Bet Bet Creek. Following extensive clearing in the first half of the 20th century, gully and tunnel erosion has accelerated and the former stream channels are now extensively eroded. As this upper tributary stream re-routed itself around the diversion bank it left stranded a former section of the original stream. This has provided the opportunity to observe a relatively undisturbed stream course.

The dam wall towards the left of the image would have blocked the original stream, forcing it to divert around it.

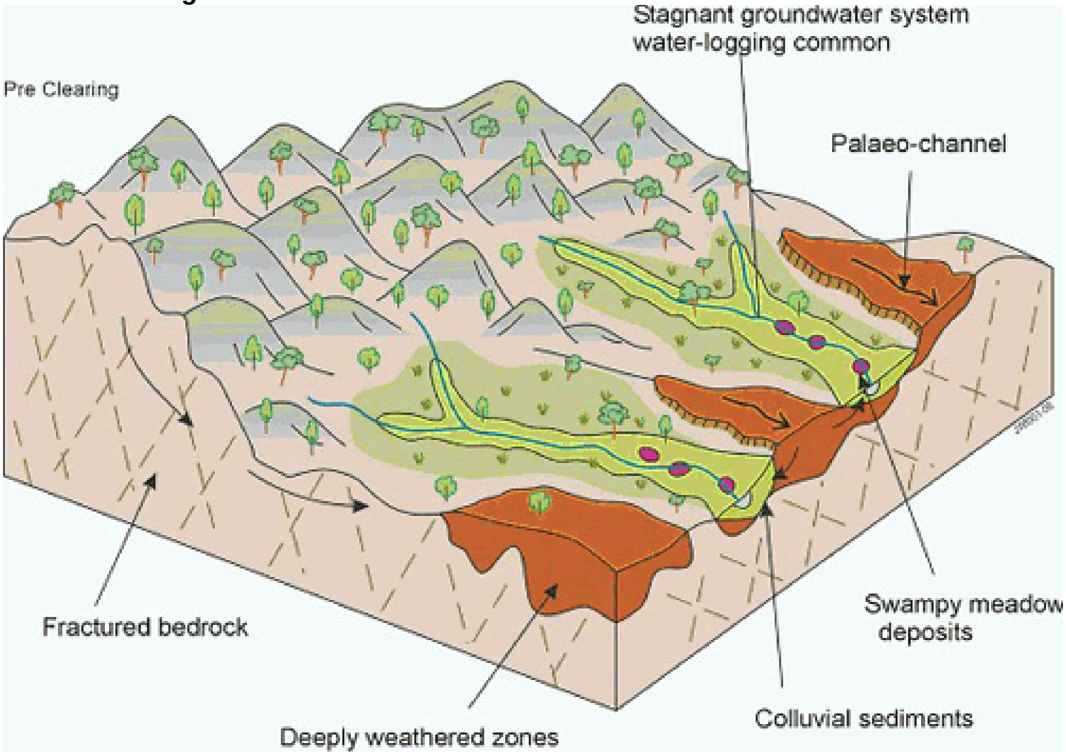
Relict 'chain of ponds' preserved through diversion of the former stream. These ponds were dry when this picture was taken in December 2006 during the drought.

The relict 'chain of ponds' during a wet period (picture taken September 2007).

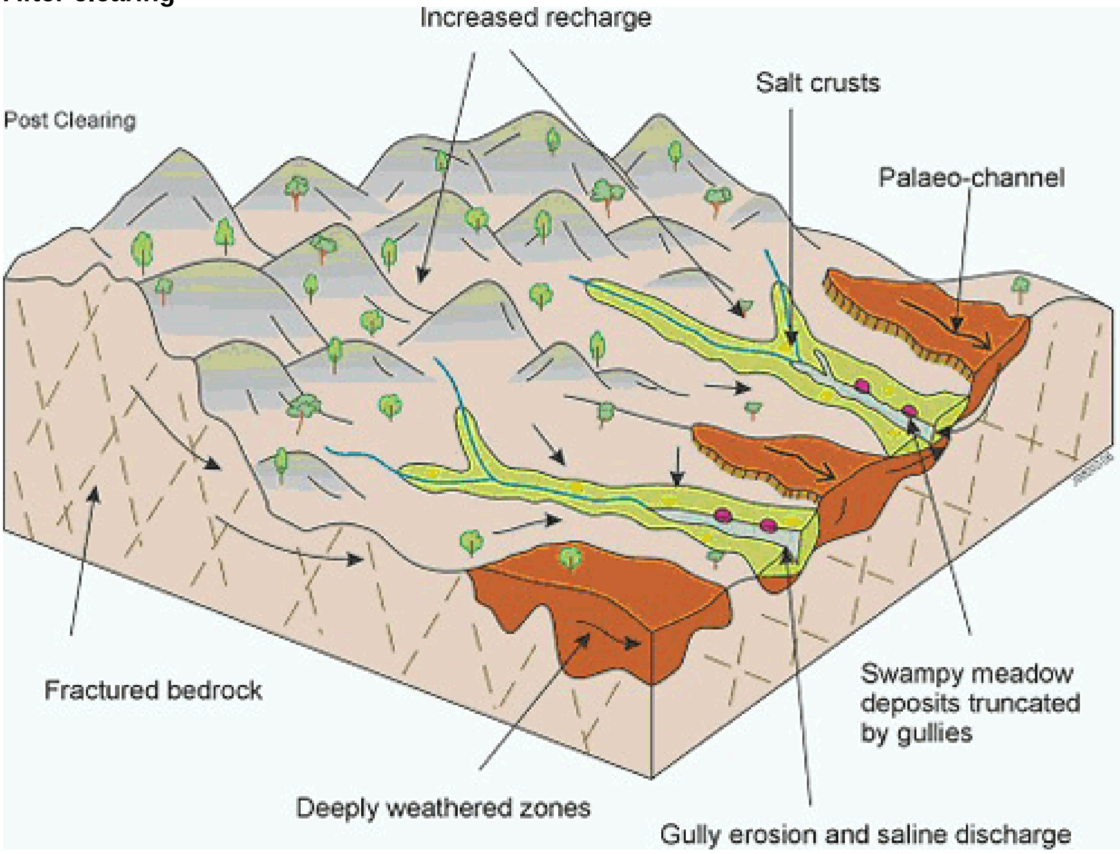
The location of former pond is visible in sections of the eroded stream channel, indicated by dark organic rich material.

Schematic diagrams illustrating the landscape change:

Before clearing



After clearing



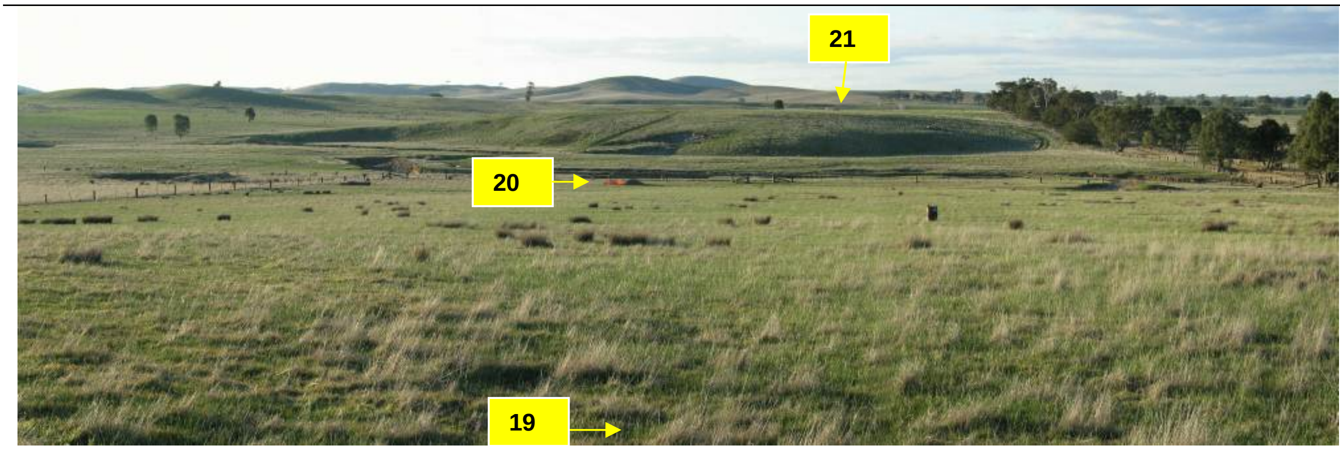
Wednesday – Site 2 Bet Bet Creek 1 (CRC 19 Kurosol)

Brief soil description: Strong texture-contrast profile, strongly acid throughout – loamy surface soil overlying a structured, magnesic clay subsoil

Landscape: Low hills and rises, less deeply-weathered bedrock.

Geology: Cambro-Ordovician metasediments (St Arnaud Group)

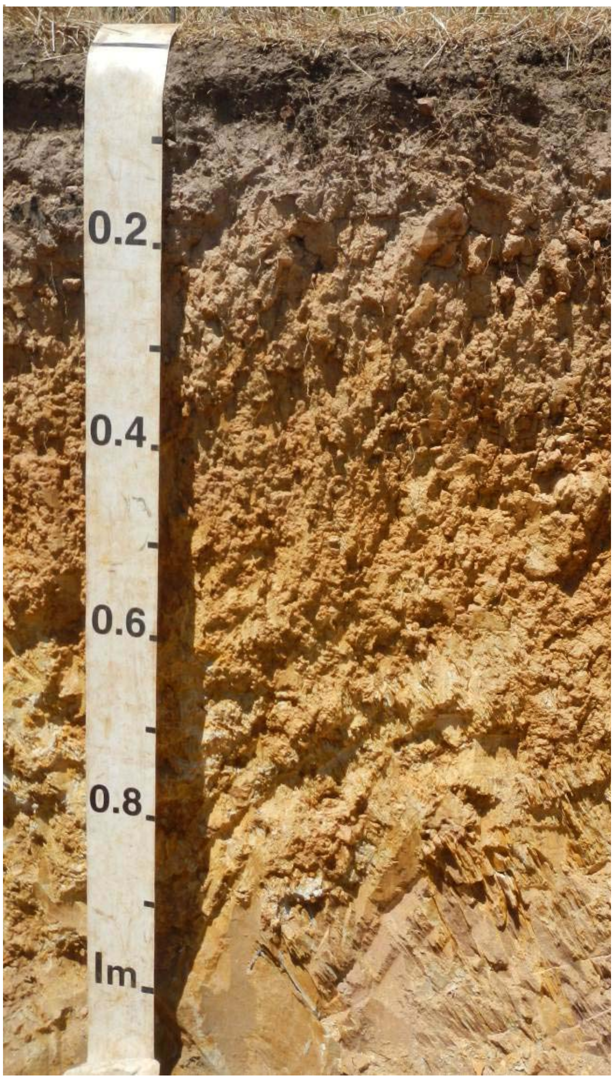
Land use: Grazing paddock (native pastures)



Soil description:

Hor.	*Depth (cm)*	
A1	0-15	Very dark greyish brown (10YR3/2); fine sandy loam; weakly structured; quartz gravel (2-20 mm) common (20%); pH 4.6; clear change to
A2e	15-25	Brown (10YR5/3 moist), very pale brown (10YR7/3) dry; fine sandy loam (gritty); massive; quartz gravel (2-20 mm) common (10-20%); pH 4.8; clear change to:
B21	25-40	Yellowish brown (7.5YR5/6); medium heavy clay; strong coarse polyhedral, parting to medium to fine polyhedral, structure; very firm consistence dry; pH 4.7:
B22	40-60	Yellowish red (5YR5/6) with light brown (7.5YR6/4) mottles (10-20%); medium heavy clay; moderate coarse polyhedral, parting to fine polyhedral structure; pH 4.5; gradual change to:
C	60-130	Light grey (2.5Y7/1) with yellowish brown (10YR5/6) mottles; sandy loam; abundant platy fragments of weathering rock (schist), pH5.4:

Note: In this soil pit, the A2 horizon was conspicuously bleached, but not described as such in the original description for this site.



Soil profile analysis

Hor.	Hor depth (cm)	pH H_2O	pH $CaCl_2$	EC dS/m	Cl %	Coarse sand %	Fine sand %	Silt %	Clay %	exchangeable cations cmol(+)/kg Ca	Mg	K	Na	Al mg/kg	acidity	ECEC	ESP %	Na+Mg/ ECEC %	Base Sat.	Base Status (ASC)	Clay activity (ECEC/ clay)	15 Bar v/v	DUL (FC) v/v
A1	0-15	4.6	3.9	0.08		19	38	24	11													8.6	33.1
A2	15-25	4.8	4.1	<0.05		9	42	28	19	0.86	0.38	0.22	0.150		9	11	1	5	15	8	56	23	27.5
B21	25-40	4.7	4.0	0.1		4	17	21	53	0.79	0.98	0.18	0.420		11	13	3	10	18	4	25	17.1	32.2
B22	40-60	4.5	4.2	0.35		2	10	34	54	0.20	2.30	0.05	0.200	200	8.5	11	2	22	24	5	21	18	35.5
C	60-130	5.4	5.0	0.87		17	21	47	13													7.9	33.7

Classification diagnostics

Horizon Aust	designation WRB	depth cm	Diagnostic horizons ASC	WRB	ST	Diagnostic properties/materials ASC	WRB	ST
A1		0-15			Ochric epipedon			
A2	E	15-25		Albic horizon	Albic	Bleached		
B21t	Bt1	25-40	Clear textural B horizon	Argic horizon		pH <5.5, strongly acid	Alic (base saturation <50% and CEC/clay >24)	
B22t	Bt2	40-60	Mottled horizon (>10% mottling)			Magnesic	Alic (CEC at pH 7 would be higher, and therefore clay activity higher i.e. >24). Stagnic colour pattern – relict.	
C	C	60-130						

Classification

ASC: Bleached-Mottled, Magnesic, Red Kurosol; medium, slightly gravelly, loamy, clayey, moderate. [Major part of the B2 horizon is magnesic]

WRB: Cutanic Albic Alisol (Abruptic, Ruptic, Alumic, Clayic, Sodic, Chromic, Magnesic). [Magnesic is currently not an option for the Alisol WRB]

ST: Clayey over loamy, illitic over mixed, subactive, thermic, Kanhaplic Haplustults ["not quite a Kandic horizon"]

Russia: 'Yellow soil'

Notes:

Soil profile: There was some debate at this profile about the origin of the clay material in the subsoil as the substrate rock seems to have low clay forming potential (13% clay in the C horizon), and what thickness of soil would be required to concentrate the clay?
This profile and the following one (CRC-20) have a higher silt component than other soils observed on this excursion, although it was not described in the field textures.

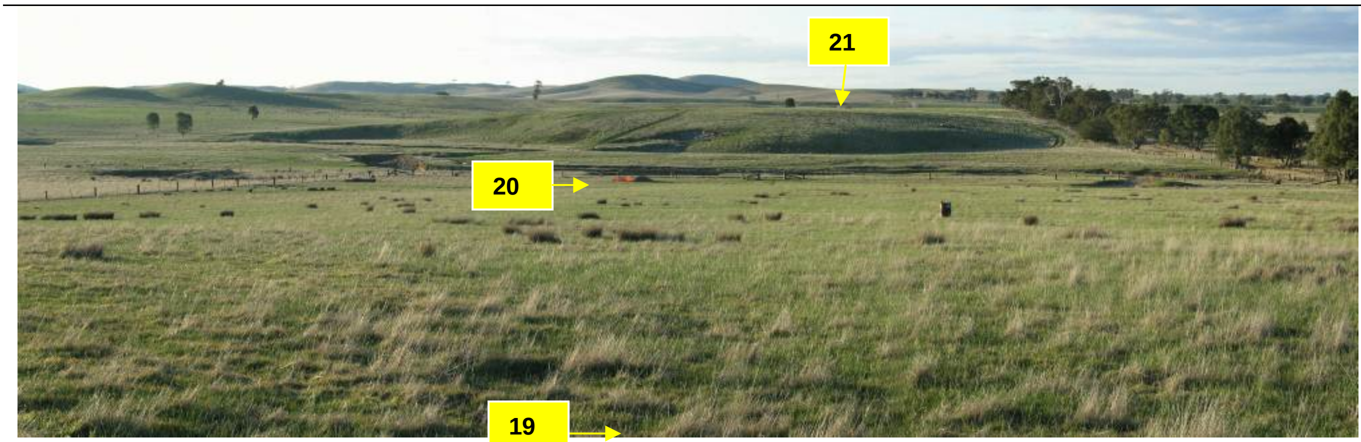
Wednesday – Site 3 Bet Bet Creek 2 (CRC 20 Sodosol)

Brief soil description: Strong texture-contrast profile with a strongly acid and bleached loamy surface soil overlying a sodic clay subsoil that grades from acid to alkaline.

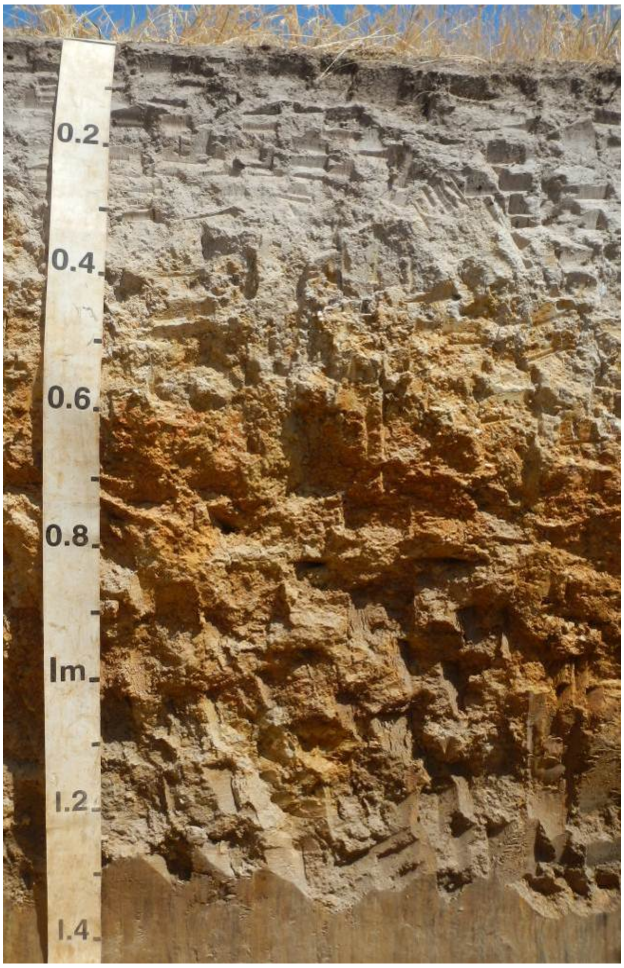
Landscape: Lower slope (terrace)

Geology: Alluvial/colluvial sediments (sourced mainly from St Arnaud Group metasediments)

Land use: Grazing paddock (native pastures)



Soil description:



Hor.	*Depth (cm)*	
A1	0-20	Very dark greyish brown (10YR3/2); fine sandy loam; weakly structured; pH 4.6; hard setting surface; clear wavy change to:
A2e	20-40	Pale brown (10YR6/2), conspicuously bleached; fine sandy loam (silty); massive and extremely hard (very strong consistence) – dry; pH 5.0; clear change to:
B1	40-60	Strong brown (7.5YR5/6) with light grey (10YR7/1) mottles; fine sandy light clay; weak coarse prismatic, parting to moderate coarse blocky structure; very firm consistence (dry); moderate (25%) amount of quartz fragments (2-20 mm); pH 5.1; gradual change to:
B2	60-100	Yellowish brown (10YR5/6) with strong brown (7.5YR5/8) mottles, slight red (10R4/8) mottle; light clay (fine sandy); moderate coarse prismatic, parting to moderate coarse blocky structure; cutans and minor slickensides; strong consistence (dry); quartz gravel (2-10 mm) common (20%): pH 6.2, gradual change to:
D1	100-130	Strong brown (7.5YR5/6) with brownish yellow (10YR6/6) mottles; sandy clay loam; massive; many (40%) quartz fragments (2-10 mm in size) – layered; pH 7.8; gradual change to:
D2	130-170	Light grey (10YR7/1) with brownish yellow (10YR6/6) mottles; light medium silty clay; moderate coarse angular blocky structure; very firm consistence (moist); some manganese staining; pH 7.5.

Note: *Depth of horizon boundaries different to original description.*

Strong dispersion was observed in the B2 horizon and moderate dispersion in the B1 horizon.

Wednesday – Site 3 Bet Bet Creek 2 (CRC 20 Sodosol)

Soil profile analysis

Hor.	Hor depth (cm)	pH H_2O	pH $CaCl_2$	EC dS/m	Cl %	Coarse sand %	Fine sand %	Silt %	Clay %	exchangeable cations cmol(+)/kg Ca	Mg	K	Na	Al mg/kg	acidity	ECEC	ESP %	Na+Mg/ ECEC %	Base Sat.	Base Status (ASC)	Clay activity (ECEC/ clay)	15 Bar v/v	DUL (FC) v/v
A1	0-10	4.6	4.0	0.13		12	47	28	8													8.8	31.5
A21	20-25	5.0	4.2	<0.05		6	53	25	13													4.5	24.7
A22e	25-35	4.9	4.3	0.11		9	48	26	12													4.9	20.2
B1	35-55	5.1	4.5	0.31		7	48	23	21	2.40	3.80	0.16	1.2		3.4	11	11	46	69	36	52	8	19.2
B2	55-85	6.2	5.3	0.28		9	49	15	26	0.68	3.40	0.15	2.0		3.5	10	21	55	64	24	37	10.1	20.6
D1	85-130	7.8	6.9	0.4		31	41	12	15													6.4	18.2
D2	130-170	7.5	6.9	0.99		1	23	39	35	0.20	6.50	0.20	3.6			11	34	96	100	30	30	17	43.3

exchangeable cations are from an adjacent core

Classification diagnostics [depths match the photographed profile, and are slightly different to analysed depths (above)]

Horizon Aust	designation WRB	depth cm	Diagnostic horizons ASC	WRB	ST	Diagnostic properties/materials ASC	WRB	ST
A1	A	0-20						
A22e	E	20-40		Albic		Conspicuously bleached		
B1	Bt	40-60	Clear textural B horizon (field textures).	Argic/natric	Argillic horizon	Eutrophic	Magnesic	
B2	Btg	60-100	Mottled horizon	Natric		Eutrophic	Stagnic colour pattern	
D	C	100-170				Magnesic		

Classification

ASC: a using field textures: Eutrophic, Mottled-Subnatric, Brown Sodosol; thick, non-gravelly, loamy, clayey, deep.

b using laboratory PSA Bleached-Sodic, Eutrophic, Brown Dermosol; thick, non-gravelly, loamy, clayey, deep.

WRB: Stagnic Solonetz (Albic, Colluvic, Magnesic, Loamic)

ST: Fine, loamy, mixed, active, thermic, Typic Natrustalfs.

Russia: Solod

Notes:

ASC: The laboratory particle size analysis (21-26% clay) does not seem to support the clay textures determined in the field. The ASC specifies that in such a case, the assessments should be repeated if possible (as has been done here). If these remain unchanged, the classifiers can use their own judgement based on how the soil behaves. In this case, field textures seem more in line with the profile characteristics (e.g. restricted drainage into the 'clayey' subsoil resulting in a bleached A2 horizon). It is possible that the relatively high silt content confounded the laboratory determination.

Horizon nomenclature: In Australia, the B1 horizon is a transitional horizon in which properties are dominated by the underlying B2 horizon. Similarly a B3 horizon is transitional (with dominating properties), usually to an underlying C horizon. The 'D' horizon is recognised (usually in stratified soils) by the contrast in pedological organisation between it and the overlying horizon.

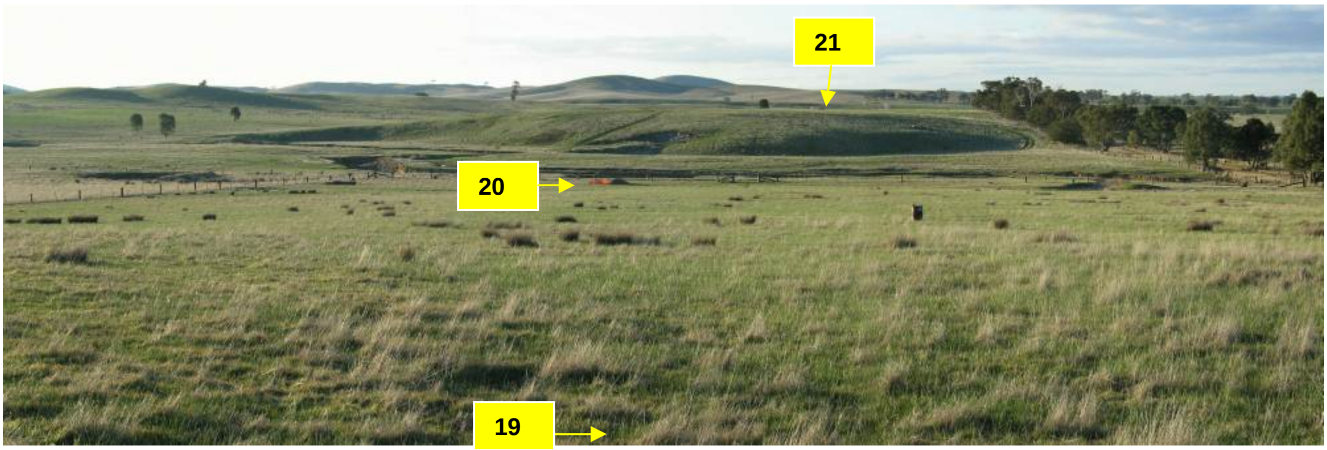
Wednesday – Site 4 Bet Bet Creek 3 (CRC 21 Kurosol)

Brief soil description: Strong texture-contrast profile, strongly acid throughout – loamy surface soil over a structured, magnesic clay subsoil

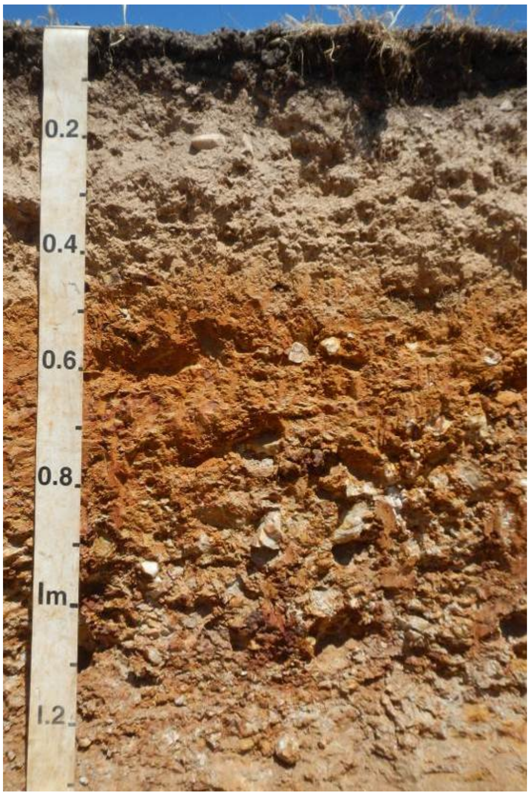
Landscape: Broad level crest of low rise (peneplain)

Geology: Deeply-weathered Cambro-Ordovician metasediments. White Hills Gravel (Neogene) remnant.

Land use: Grazing paddock



Soil description:



Hor.	*Depth (cm)*	
A1	0-10	Very dark greyish brown (10YR3/2); sandy loam; weak blocky structure; weak consistence moist; quartz gravel (2-10 mm) common (20%); pH 4.7; clear change to:
A2e	10-40	Light yellowish brown (10YR6/4), conspicuously bleached (10YR7/3d); sandy loam; massive; firm consistence (dry); quartz gravel (2-10 mm) abundant (50%) with some angular quartz fragments (40 mm); pH 4.9; abrupt change to:
A3	40-45	Reddish yellow (7.5YR6/6); fine sandy clay loam (gritty); massive; quartz fragments (2-10 mm) common (20%); pH 5.0; discontinuous horizon; abrupt change to:
B21	45-70	Yellowish red (5YR5/8) with yellowish brown (10YR5/6) mottles; medium heavy clay; sub-plastic; strong medium sub-angular blocky, parting to strong fine sub-angular blocky structure; shiny-faced peds (cutans); very firm consistence dry; iron segregations present; contains very few (<2%) quartz fragments (2-20 mm in size); pH 4.8; gradual change to:
B22	70-90	Brownish yellow (10YR6/6) with dark red (2.5YR4/6) and light brownish grey (2.5Y6/2) mottles; heavy clay; strong medium, parting to strong fine sub-angular blocky structure; shiny-faced peds (cutans); strong consistence dry; contains some fine manganese stains and iron segregations; contains very few (<2%) quartz fragments (2-60 mm); pH 4.8:
B3	90-120+	Yellowish brown (10YR5/8) with dark red (10R3/6) mottles; medium heavy clay; strong coarse angular blocky, parting to strong very fine angular blocky structure; firm consistence (moist); abundant coarse fragments of weathering rock; pH 5.0.

Note: Depth of horizon boundaries and horizon nomenclature amended from original description.

Field tests revealed no dispersion of the clay aggregates in any of the horizons.

Wednesday – Site 4 Bet Bet Creek 3 (CRC 21)

Soil profile analysis

Hor.	Sample depth (cm)	pH H_2O	pH $CaCl_2$	EC dS/m	Cl %	Coarse sand %	Fine sand %	Silt %	Clay %	exchangeable cations cmol(+)/kg Ca	Mg	K	Na	Al mg/kg	acidity	ECEC	ESP %	Na+Mg/ ECEC %	Base Sat.	Base Status (ASC)	Clay activity (ECEC/ clay)	15 Bar v/v	DUL (FC) v/v
A1	0-10	4.7	4.0	0.06		28	51	8	N/A	2.1	0.44	0.31	0.1	27	9.3	12	1	4	24			6.4	16.9
A2e	10-35	4.9	4.4	<0.05		25	56	12	6	0.53	0.19	0.13	0.09	44	3.5	4	2	6	21	16	74	2.4	14
A3	35-42	5.0	4.3	0.05		12	50	21	15	0.56	0.55	0.16	0.22	130	5.2	7	3	12	22	10	45	7.2	18.3
B21	42-70	4.8	4.1	0.09		2	12	4.5	79	0.97	3.2	0.29	0.47	620	16	21	2	18	24	6	26	26.3	37.7
B22	70-90	4.8	4.1	0.06		3	21	12	64	0.35	2.9	0.21	0.38	650	13	17	2	19	23	6	26	21.7	33.8
B3	90-100	5.0	4.0	<0.05					50	0.12	2.9	0.15	0.34	610	12	16	2	21	23	7	31	16.4	30.4

Classification diagnostics [depths match the photographed profile, and are slightly different to analysed depths (above)]

Horizon Aust	designation WRB	depth cm	Diagnostic horizons ASC	WRB	ST	Diagnostic properties/materials ASC	WRB	ST
A1	A1	0-10						
A21e	E	10-40		Albic	Albic			
A3	EB	40-45						
B21	Bt1	45-70	Abrupt textural B, Mottled horizon	Argic		Mesotrophic (base status 5≤15)	Alumic (Al saturation >50%) Magnesic	
B22	Bt2	70-90	Mottled horizon	Ferric		Mesotrophic	Alumic	
B3	BC	90-120	Mottled horizon	Ferric		Magnesic		

Classification

ASC: Bleached-Mottled, Mesotrophic, Red Kurosol; thick, moderately gravelly, loamy, clayey, deep.

WRB: Albic Cutanic Alisol (Ferric, Abruptic, Alumic, Chromic, Endosodic, Magnesic)

ST: Plinthic Haplustult

Russia: “Mixed lithologies, stratified”. Phaeozem.

Notes:

ASC The exchange complex in the subsoil is Mg dominated, but does not qualify as ‘magnesic’ because the Ca.Mg ratio is not <0.1 in the major part of the B2 horizon.

Soil stop 1	Cressy Research Station
Brief soil description:	Texture-contrast soil with sandy loam surface soil over neutral to alkaline sodic clay subsoil.
Landscape:	Flat plain
Geology:	Tertiary lake sediments
Land use:	Irrigated cropping
Local name:	*Brumby sandy loam*

.

Fresh pit (above); Thurs 29/11/2012 (below)

Soil description:

Horizon	*Depth (cm)*	
A1	0-16	Brown (10YR5/3); fine sandy loam; moderate fine subangular blocky structure; very firm consistence (dry); few fine distinct dark yellowish brown mottles; many very fine roots; sharp smooth boundary to
A2e	16-27	Light brownish grey (10YR6/2) moist; *light grey (10YR 7/2) dry*; fine sandy loam; massive; moderately strong consistence(dry); few fine distinct dark yellowish brown mottles; very few medium iron/manganese soft segregations; common very fine roots; sharp smooth boundary to:
B21	27-60	*Dark greyish brown (10YR 4/2)*; heavy clay; moderate coarse prismatic structure; very firm consistence (moist); few medium faint dark yellowish brown mottles; *few ferruginous and manganiferous soft segregations*; common distinct slickensides few very fine roots; gradual smooth boundary to:
B22	60-150	Olive brown (2.5Y4/4); heavy clay; massive; very firm consistence (moist); very few medium iron/ manganese soft segregations; *few medium faint yellow mottles*; few faint slicken sides; clear smooth boundary.
C	150-180+	Dark yellowish brown (10YR4/4); sandy clay; massive; moderately weak consistence (moist); common coarse distinct yellowish brown mottles.

Surface condition: Hard setting, surface crust, worm castes.

Soil stop 1 — Cressy Research Station

Soil profile analysis

Hor.	Hor. depth (cm)	Sample depth (cm)	pH H_2O	pH $CaCl_2$	EC dS/m	Tot Org C %	Particle size analysis Sand %	Silt %	Clay %	exchangeable cations cmol(+)/kg Ca	Mg	K	Na	Al	acid.	ECEC	ESP %	Na+Mg/ ECEC %	Base Sat.	Base Status for ASC	Clay activity ECEC/ clay	Bulk density Mg/m^2	K sat mm/hr	15 Bar v/v	DUL v/v	Sat v/v
A1	0-16	0-8	5.3	4.3	0.06	1.56	67.0	10.0	23.0	2.95	0.61	0.11	0.20	.0.15		4	5	21	100	17	17	1.44	8.48	0.08	0.37	0.45
A2e	16-27	22-27	5.9	4.4	0.02	0.42	65.0	13.0	22.0	2.03	0.97	0.08	0.24	0.06		3	7	36	100	15	15	1.65	18.39	0.06	0.28	0.36
B21	27-60	32-47					23.4	6.5	70.2	9.61	10.20	0.38	1.44	0.10		22	7	54	100	31	31					
		40-46	6.2	5.0	0.06	0.74																1.18	3.60	0.38	0.55	0.56
		47-60					33.8	9.5	56.6																	
B22	60-150	70-76	7.2	6.3	0.15	0.49																1.41	1.05	0.35	0.45	0.46
		70-100					30.8	10.2	59.1	9.99	13.65	0.28	3.32	0.00		27	12	62	100	46	46					
C	150+	150-175					30.8	10.2	59.1	6.29	7.87	0.17	3.21	0.16	0.25	18	18	63	99	30	30					
		175-200					30.8	10.2	59.1	7.43	9.92	0.21	4.12	0.09	0.14	22	19	65	99	37	37					

Classification diagnostics

Horizon Aust	designation WRB	depth cm	Diagnostic horizons ASC	WRB	ST	Diagnostic properties ASC	WRB	ST
A1	A	0-16						
A2e	E			Albic horizon		Conspicuous bleach	Reducing conditions (some time during year) Abrupt textural change	
B21	Bt1		Abrupt textural B horizon	Natric horizon [Na+Mg >Ca+exch. Acidity and ESP>15 at some depth]	Natric	Grey colour (upper B hor) Subnatric (ESP 6 - <15 in upper 20 cm of B2) Vertic properties Base status >15 (eutrophic)	Stagnic colour pattern Magnesic, Vertic properties	
B22	Bt2						ESP>15 in deep subsoil	

Classification

ASC: Vertic, Subnatric, Grey Sodosol; medium, non-gravelly, loamy, clayey, very deep.

WRB: Stagnic Vertic Solonetz (Albic, Abruptic, Magnesic, Epiloamic, Endoclayic)

ST: Very-fine, smectitic, active, mesic Vertic Natraqualfs

Notes:

Soil stop 2 — Tamar Ridge Estate (Kayena vineyard)

Brief soil description: Sandy loam surface soil overlying strongly acid, mottled and sodic clay subsoil.
Landscape: Low hills.
Geology: Tertiary sands, clays, gravels
Land use: Viticulture
Local name: *Legana* association

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Soil description:

Note- this description will need to be amplified on site.

Horizon	*Depth (cm)*	
A11p	0-10	Black (10YR 2/1), structured, sandy loam.
A12p	10-22	Dark brown (10YR 3/3), structured, sandy loam. Abrupt change to:
B21t	22-42	Dark yellowish brown (10YR 4/4), mottled, light clay
B22	42-60	Dark yellowish brown (10YR 4/4), mottled, light medium clay
2B23	60-90	Yellowish brown (10YR5/6); mottled, light medium clay.
2B24	90-130	Light brownish grey (2.5Y6/3), mottled, light medium clay.

Surface condition:

Soil stop 2 Tamar Ridge Estate (Kayena vineyard) - *Legana*

Soil profile analysis

Hor.	Hor. depth (cm)	pH H_2O	pH $CaCl_2$	EC dS/m	Total OCC %	Sand %	Silt %	Clay %	exchangeable cations cmol(+)/kg Ca	Mg	K	Na	Al	H	acid.	ECEC	ESP %	Na+Mg/ CEC %	Base Sat.	Base Status (ASC)	Clay activity (ECEC/ clay)
A11p	0-10	7.1	6.2	0.18	3.99			15	15.90	3.40	1.20	2.08	0.0	0.0	0.0	23	9	24	100	151	151
A12	11-22	6.6	5.8	0.24	3.88			15	10.40	3.79	0.50	2.12	0.0	0.0	0.0	17	13	35	100	112	112
B21	23-42	6.1	5.3	0.11	1.48			38	3.25	3.60	0.21	2.15	0.14	0.0	0.14	9	23	62	99	24	25
B22	42-60	5.3	4.8	0.25	0.65			43	1.05	3.30	0.07	2.17	0.32	0.06	0.38	8	31	76	95	15.3	16
2B23	60-90	5.5	4.9	0.39	0.45			43	0.91	8.52	0.06	2.94	0.19	0.01	0.20	13	23	91	98	29	29
2B24	90-130	5.2	4.7	0.45	0.24			43	0.56	8.58	0.08	3.45	0.20	0.02	0.22	13	27	93	98	29	30

Note: clay content implied from field texture

Classification diagnostics

Horizon Aust	designation WRB	depth cm	Diagnostic horizons ASC	WRB	ST	Diagnostic properties/materials ASC	WRB	ST
Ap	Ap			Does not meet thickness requirements for *mollic*				
B21			Abrupt textural B horizon Mottled horizon	Argic horizon Natric horizon Ferric horizon		Brown colour (upper B hor) Mesonatric (ESP 15-25 in upper 20 cm) Base status >15 (eutrophic) Mottled	Reducing conditions (some time during year) Magnesic, stagnic colour pattern? Abrupt textural change Humic (3.2% OC to depth of 50 cm)	
B22			Mottled horizon	Ferric horizon		Mottled	Lixic	
2B24		90-130				Magnesic		

Classification

ASC: Eutrophic, Mottled-Mesonatric, Brown Sodosol; medium, non-gravelly, clay loamy, clayey, deep.

WRB: Stagnic Solonetz (Abruptic, Magnesic, Humic, Epiloamic, Clayic)

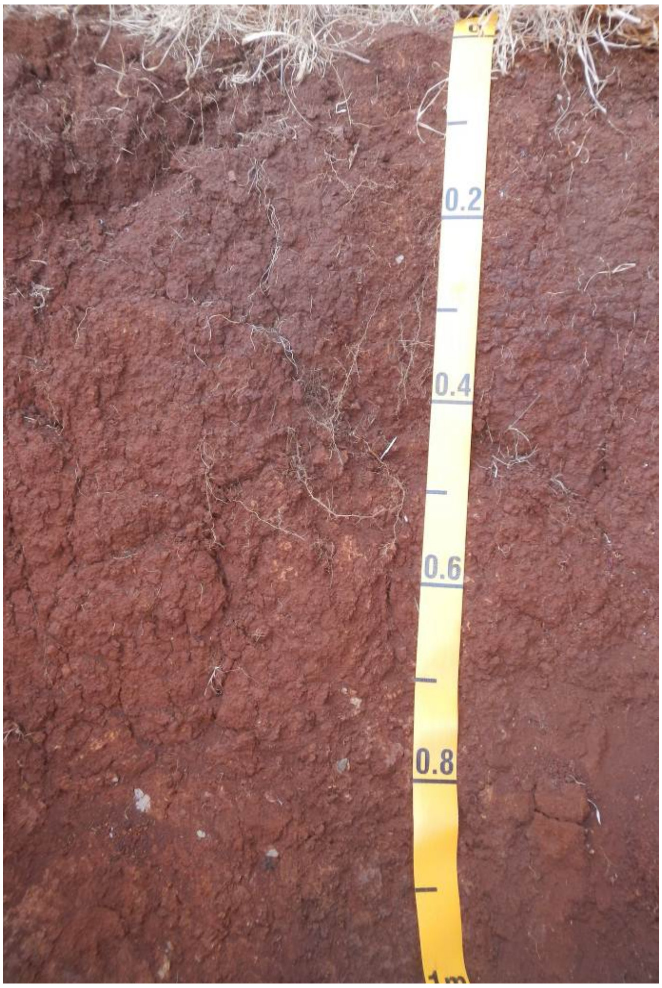
ST:

Notes:

ASC Previously the A horizon had been describe as humose (i.e. OC >4%), however that had been assuming organic carbon had been derived using the Walkley-Black method. However, a total combustion method had been used.

Soil stop 3 — Forthside Research Station

Brief soil description: Deep, well-drained, acid, red non-cracking clay loam to clay soil.
Landscape: Rolling low hills, slope 24%
Geology: Tertiary basalt.
Land use: Cropping (spring/summer crops), often irrigated in area.
Local name: *Burnie* clay loam



Soil description:

Hor.	*Depth (cm)*	
A11p	0-6	Dark reddish brown (2.5YR2/3); clay loam; weak,10-20 mm, polyhedral structure; earthy fabric; very weak consistence (dry); normal plasticity; non-sticky. Abrupt, wavy change to
A12	6-28	Dark reddish brown (2.5YR3/4); clay loam; moderate polyhedral structure, 20-50 mm parting to 5-10 mm, earthy fabric; few (<1 per 100mm^2) very fine (0.075-1mm) macropores, weak consistence (dry); very plastic, normal plasticity; 0-2%, fine gravelly, 2-6mm angular basalt fragments. Abrupt, wavy change to –
B21t	28-77	Reddish brown (2.5YR4/3); clay loam; moderate angular blocky structure, 20-50 mm, parting to *strong 5-10 mm* polyhedral; *smooth-ped fabric*; common (1-5 per 100mm^2) very fine (0.075-1mm) macropores, weak consistence (mod. moist); moderately plastic; normal plasticity; slightly sticky; 0-2% medium gravelly, 6-20mm, angular basalt fragments; distinct cutans, 10-50% of ped faces or walls coated; very few (0 - 2 %), manganiferous, concretions (2 -6 mm); few, very fine (0-1mm) roots. Clear, wavy change to –
B22t	77-105	Red (2.5YR4/6); clay loam; moderate angular blocky structure, 50-100 mm, parting to *strong 5-10 mm* polyhedral; *smooth-ped fabric*; common (1-5 per 100mm^2) fine (1-2mm) macropores, weak consistence (mod. moist) ; moderately plastic; normal plasticity; Slightly sticky; 0-2% medium gravelly angular, basalt fragments; distinct cutans, 10-50% of ped faces or walls coated.

Surface condition: cultivated, 0-2% angular basalt gravel.

Note: *The field textures described here seem to indicate a lower clay content than shown in particle size analysis. This is because the clay present is unplastic (or 'subplastic'). In such cases, two soil textures should be determined – after initial working up of the soil sample into a bolus; and again after prolonged kneading (>10 minutes) of the bolus, when the soil will almost certainly appear more plastic and 'clay-like'.*

Description above slightly modified (shown in italics) after inspection on the excursion: polyhedral structural units are finer (<10 mm), and the fabric of peds is smooth.
The presence of weathered bedrock (from about 80 cm) in this soil is relatively shallow for this soil type/area.

Stop 3, Soil 4 Forthside Research Station

Soil profile analysis

Hor.	Sample depth (cm)	pH H_2O	pH $CaCl_2$	EC dS/m	Org C %	Sand %	Silt %	Clay %	exchangeable cations cmol(+)/kg Ca	Mg	K	Na	Al	acidity.	ECEC	ESP %	Na+Mg/ ECEC %	Base Sat.	Base Status for ASC	Clay activity (ECEC/ clay)	'free' Fe/Al Cit Al	Cit Fe	'active' Fe/Al Oxal Al	Oxal Fe	Fe-ox/ /Fe-cit
A11p	0-7	6.5	5.6	0.08	2.04	12	26	62	13.10	5.13	2.61	0.33		0.06	21	2	26	100	34	34					
A12	9-17	6.5	5.6	0.07	2.9	10	24	64	12.61	4.94	1.54	0.37		0.07	20	2	27	100	29	30					
B21	28-50	6.1	5.8	0.06	1.09	15	20	62	8.35	2.43	0.15	0.44		0.08	12	4	25	99	18	18	1.3	10	0.7	0.6	0.06
B21	50-75	5.8	5.6	0.07	0.76	10	17	68	5.76	6.28	0.13	0.33		0.08	13	3	52	99	18	19					
B22	77-105	5.0	4.7	0.08	1.1	10	17	62	4.19	4.86	0.15	0.24		0.30	10	3	52	97	15	16	1.1	8.4	0.6	0.5	0.06

Note: particle size analysis shown in red is from graphs of historical profiles (see other tour handout).

Classification diagnostics

Horizon Aust	designation WRB	depth cm	Diagnostic horizons ASC	WRB	ST	Diagnostic properties/materials ASC	WRB	ST
A1		0-28						
B21t	Bt1	28-77		Nitic horizon. Not Ferralic, as the ECEC (cmol(+)/kg clay is too high (>12)		No strong texture-contrast No vertic properties free iron (citrate-dithionate Fe) >5% Eutrophic (base status >15) – major part of B horizon	Sodic (Na+Mg/ECEC)>15 Eutric Lixic (base sat >50, low clay activity.	
B21t		77-105				Mesotrophic (base status 5≤15)	Magnesic Eutric	

Classification

ASC: Haplic, Eutrophic, Red Ferrosol; medium, non-gravelly, clay loamy, clay loamy, very deep.

WRB: Lixic Nitisol (Humic, Hypereutric, Rhodic, Endomagnesic, Sodic). *Magnesic and sodic are not currently options for Nitisols ('endo' signifies that the magnesic property starts below 50 cm depth).*

ST: Very-fine, kaolinitic, mesic Rhodic Paleudalf.

Notes:

WRB: Results for water dispersible clay at this site are not available. However, mineralogical studies on Australian Ferrosols have indicated that all of them are kaolin dominant with variable amounts of goethite (dominant), gibbsite, hematite, and halloysite; with water dispersible clay usually <1%.

ST Not an Oxisol as the clay activity is too high (>12 cmol(+)/kg) and almost certainly will have >10% weatherable minerals in the fine sand fraction.

Stop 4, Soil 5 — Preston

Brief soil description: Deep, well-drained, strongly acid, red non-cracking clay soil.
Landscape: Rolling hills, slope 15%
Geology: Tertiary basalt.
Land use: pasture
Local name: *Yolla* clay loam

Soil description:

Hor.	*Depth (cm)*	
A1	0-13	Very dark brown (10YR2/2); clay loam; strong very fine granular structure; very weak consistence (moist); abundant very fine roots; abrupt smooth boundary.
B21	13-37	Dark yellowish brown (10YR3/4); light clay; strong fine and very fine subangular blocky structure; moderately weak consistence (dry); abundant very fine roots; clear smooth boundary.
B22	37-55	Dark brown (7.5YR3/4); medium clay; strong fine and medium polyhedral structure; moderately firm consistence (dry); common very fine roots; clear smooth boundary.
B23	55-70	Dark brown (7.5YR3/4); medium heavy clay; strong fine polyhedral structure; moderately firm consistence (dry); common very fine roots; clear smooth boundary.
B24	70-100	Dark brown (7.5YR4/4); medium heavy clay; strong fine and medium polyhedral structure; moderately firm consistence (dry); few very fine roots; clear smooth boundary.
B3	100-120+	Dark brown (7.5YR4/4); light clay; moderate fine and medium polyhedral structure; very firm consistence (dry); very few fine faint strong brown (7.5YR5/8) mottles; very few fine manganiferous soft segregations; no roots.

Surface condition: Soft. Had originally been described as ‘snuffy’, but this was not evident at the site.

Stop 4, Soil 5 Preston

Soil profile analysis

Hor.	Hor depth (cm)	pH H_2O	pH $CaCl_2$	EC dS/m	Org C %	Sand %	Silt %	Clay %	exchangeable cations cmol(+)/kg Ca	Mg	K	Na	Al	acidity	ECEC	ESP %	Na+Mg/ ECEC %	Base Sat.	Base Status (for ASC)	Clay activity (ECEC/ clay)	Cit. Al	Cit. Fe	Oxal. Al	Oxal. Fe	Fe-ox/ /Fe-cit
A	0-13	5.5	4.7	0.12	6.10	9	19	56	9.30	6.20	1.30	0.20		–	17	1	38	–	30	30	–	–	–	–	–
B21	13-37	5.2	4.2	0.05	1.96	10	13	70	2.00	1.70	0.70	0.10		–	4	2	41	–	6	6	–	–	–	–	–
B22	37-55	5.2	4.2	0.03	1.64	12	13	70	1.50	1.30	0.40	0.10		22.4	26	<1	5	13	5	37	1.4	9.0	0.6	1.0	0.11
B23	55-70	5.2	4.2	0.02	1.27	12	13	70	1.20	1.20	0.30	0.10		7.3	10	1	13	27	4	15	1.3	8.9	0.6	0.9	0.10
B24	70-100	5.2	4.2	0.02	0.94	12	13	70	1.10	1.50	0.20	0.10		7.3	10	1	16	28	4	15	–	–	–	–	–
B3	100-120	5.1	4.2	0.02	0.71	12	13	70	0.90	1.50	0.10	0.10		–	–	–	–	–	–	–	–	–	–	–	–

Note: particle size analysis shown in red is from graphs of historical profiles (see other tour handout).

Classification diagnostics

Horizon Aust	designation WRB	depth cm	Diagnostic horizons ASC	WRB	ST	Diagnostic properties/materials ASC	WRB	ST
A1	A		Humose (OC > 4% in top 20 cm)		? epipedon			
B21	Bt	13-37		Argic horizon	Argillic horizon	Mesotrophic (base status 5≤15) strongly acid (pH<5.5)	Shiny peds	
B22	Bo1	37-55		Nitic horizon – peds are 'nutty and shiny'; extractable-Fe results (citrate-dithionite/ acid-oxalate) results.	Argillic	free iron (citrate-dithionate Fe) >5% Mesotrophic (base status 5≤15)		
B23– B24	Bo2-3	55-100+		Not Ferralic (ECEC/clay) is >12 cmol(+)/kg clay	Kandic	Dystrophic (base status <5) Strongly acid (pH<5.5)	Acric (base sat <50, low clay activity. Magnesic.	

Classification

ASC: Humose, Dystrophic , Brown Ferrosol; medium, non-gravelly, clay loamy, clayey, very deep. *Original classification as 'snuffy' at the sub group level has been changed.*

WRB: Acric Nitisol (Humic, Dystric, Endomagnesic). *Magnesic is not currently an option for Nitisols ('endo' signifies that the magnesic property starts below 50 cm depth).*

ST: Very-fine, parasesquic, mesic, Ultic Hapludalfs.

Notes:

WRB B21 horizon not a nitic horizon as clay increase from 56 to 70% clay is a >20% (relative).
B horizons generally do not meet the requirements for a Ferralsol.

ST Why is this not an Ultisol – meets base saturation requirements.

Stop 6 - Soil 6 Smithton

Brief soil description: A wet soil with a ‘puggy’ surface – gradual increase in clay texture with depth.

Landscape: Drained swamp, flat. Saturated for at least 2-3 months in most years.

Geology: Holocene sediments.

Land use: Grazing pasture.

Local name: *Kana* clay loam.

Soil description:

Hor.	*Depth (cm)*	
A11	0-15	*Dark greyish brown (10YR4/2); fine sandy clay loam*; moderate very fine subangular blocky structure; moderately weak consistence (moist); many very fine roots; clear smooth boundary.
A12g	15-34	Dark greyish brown (10YR4/2); *clay loam*; *moderate* fine subangular blocky structure; moderately firm consistence (moist); common medium prominent strong brown (7.5YR4/6) mottles; few very fine roots; clear smooth boundary to:
*B21*g	34-55	Greyish brown (10YR5/2); light clay; *strong medium angular blocky structure*; *smooth ped fabric* very firm consistence (moist); common medium prominent strong brown (7.5YR5/6) mottles; few very fine roots; clear smooth boundary to:
*B22*g	55-105	Greyish brown (2.5Y5/2); *light medium clay*; *moderate medium angular blocky structure*; very firm consistence (moist); few medium prominent strong brown (7.5YR5/6) to yellowish red mottles; gradual smooth boundary to:
C2g	105-130	Dark grey and grey (N4 + N5); heavy clay; *moderate structure*, moderately firm consistence (moist); few fine distinct light olive brown (2.5Y5/4) mottles.

Surface condition: Puggy (‘puggic’) – prominently uneven surface consisting of small mounds and depressions, caused by cattle grazing.

Notes: the soil inspected on the excursion (photographed right0 displayed significantly more structure than had originally been described. Field textures were also revised. The description has been amended, with changes shown in italics.

Acid sulfate soils occur in the area – acid drainage is detected in drains – black sludgy material (‘monosulfidic’) and red iron-precipitates.

Soil site 5 Smithton

Soil profile analysis

Hor.	Hor. depth (cm)	pH H_2O	pH $CaCl_2$	EC dS/m	Org C %	Sand %	Silt %	Clay %	exchangeable cations cmol(+)/kg Ca	Mg	K	Na	Al	H	acidity	ECEC	ESP %	Na+Mg/ ECEC %	Base Sat.	Base Status for ASC	Clay activity (ECEC/ clay)
A11	0-15	5.8	4.9	0.09	3.48			25	7.08	3.17	0.28	0.24	0.07	0.1	0.17	11	2	31	98	43	44
A12g	15-34	5.4	4.6	0.12	2.07			30	4.65	2.35	0.13	0.23	0.17	0.1	0.27	8	3	34	96	25	25
B21g	34-55	6.0	5.2	0.11	1.37			38	5.75	3.1	0.37	0.24	0.06	0.06	0.12	10	3	35	99	25	25
B22g	55-105	7.1	6.4	0.2	0.23			45	5.51	3.31	0.31	0.26	< 0.01	0.01	0.01	9	3	38	100	21	21
C2g	105-130	7.1	6.6	0.27	0.14			50	9.71	5.68	0.29	0.56	< 0.01	<0.01	<0.01	16	4	39	100	32	32

Note: clay content implied from field texture, revised after the field visit.

Classification diagnostics

Horizon designation Aust	WRB	depth cm	Diagnostic horizons ASC	WRB	ST	Diagnostic properties/materials ASC	WRB	ST
A11	A1	0-15			not Mollic/ Ochric			
A12g	A2	15-34			Cambic		Loamic, Eutric	
B21g	Bw	34-55		Argic horizon Cambic horizon	Cambic	Mottles (strong brown/ orange). Strong structure. Eutrophic.	Eutric	Aquic conditions (chroma of 2 or less with redox concentrations)
B22g	Bg	55-105		Gleyic horizon		Mottles (yellowish red)	Clayic, Eutric	

Classification

ASC: Eutrophic, Dermosolic, Redoxic Hydrosol; thick, non-gravelly, clay loamy, clayey, very deep.

WRB: Endogleyic Cambisol (Sodic, Humic, Hypereutric, Ruptic, Epiloamic, Endoclayic, Drainic)

ST: Fine, mixed, subactive, non-acid, mesic Mollic Endoaquepts.

Notes:

ASC: At the order level, Hydrosols are defined purely in terms of wetness ['the greater part of the profile is saturated for prolonged periods (2-3 months) in most years] and not on the basis of colour or any redoximorphic features. The Great Group recognises the profile morphology that would otherwise be used to classify the soil at Order level, in this case 'Dermosolic'.

WRB Cannot be classified as a Gleysol as the gleyic colour pattern is not evident in the upper 50 cm. The soil could be classified as a Luvisol, based on texture change alone (in the absence of clay skins). However, given the landscape position and the alluvial nature of the soil material, it was felt that Cambisol was the most suitable category. Cambisols are 'moderately developed' soils showing evidence of alteration (e.g. higher colour value or chroma and presence of soil structure) compared to the underlying horizons. Drainic is not a suffix currently available for Cambisols (but can it exist without a histic horizon?). Epiloamic also not on list.

ST Aquic conditions are recognised in the upper 50 cm of soil. Although the soil does not have a mollic epipedon, the mollic subgroup is allocated on the basis of the color value being 3 or less in the upper 15 cm of soil. If this is not present, it would be a Typic Endoaquept.

Soil site 6 — Strahan - ocean beach peat

Landscape Coastal dune – former interdune swamp.
Geology: Holocene sediments.
Land use: Coastal reserve.

Photograph of dune looking south, 1/12/2012

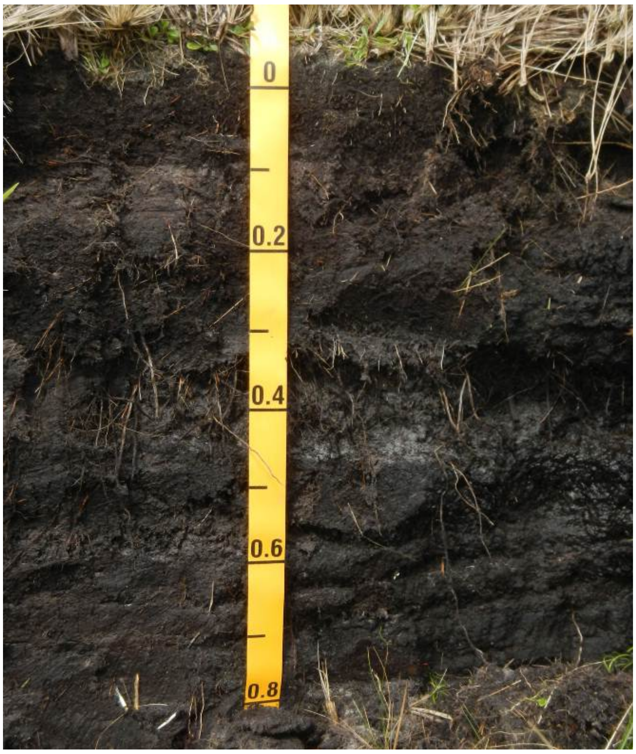
Soil description:

Hor.	*Depth (cm)*	
P2	0-36	Black (10YR2/0); sapric peat (strongly decomposed); massive; very weak consistence (moist); common fine roots; clear smooth boundary.
2C	36-67	Light brownish grey (10YR6/2); coarse sand; single grain structure; soft; few medium roots; clear smooth boundary.
3P2	67-98	Black (2.5Y2/0); loamy peat; massive; soft; few medium roots; clear smooth boundary.
4C	98-130	Black (2.5Y2/0); loamy sand; massive; soft.
	Note:	*Portion of dune photographed (right) has thicker peat layers than the profile originally described.*

Photograph of dune looking north, 1/12/2012

Note: the frontal dune has been eroded, leaving the original interdune peat exposed to the ocean.

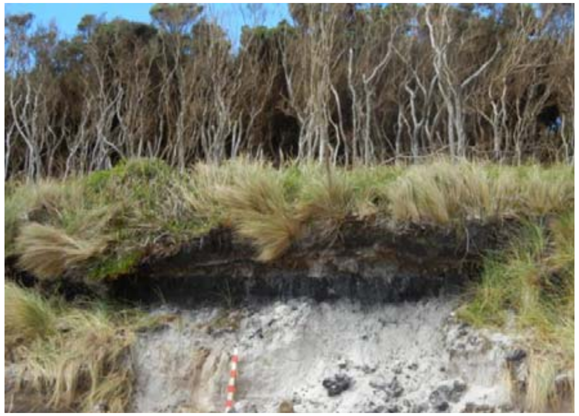
Above: profile as described (left) and analysed.
Below: different portion of dune, photographed on 1/12/2012.



Soil site 6 — Strahan - ocean beach peat

Soil profile analysis

another photograph of the profile originally described and sampled →



Hor.	Hor depth (cm)	pH H_2O	pH $CaCl_2$	EC dS/m	Total OC %	PSA %	exchangeable cations cmol(+)/kg Ca	Mg	K	Na	Al	H	acidity	ECEC	ESP %	Na+Mg/ CEC %	Base Sat.
P2	0-36	4.0	3.8	14.8	16.7		1.55	4.15	0.27	3.40	0.24	0.36	0.6	10	31	68.8	85
2C	36-67	4.8	4.0	0.22	0.62		0.26	0.38	0.02	<0.10	0.13	0.10	0.23	1	8	46.5	87
3P2	67-98	4.3	3.7	0.81	4.72		0.41	0.87	0.03	0.25	0.46	0.47	0.92	3	10	45.2	63
4C	98-130	4.8	4	0.19	1.48		0.19	0.36	0.02	<0.10	0.28	0.25	0.53	1	6	31.4	46

The mineral fraction has not been analysed for this profile, however it is unlikely to have a high clay content as the peat has formed in a sand dune environment, and the organic materials are stratified with layers of sandy material.
The base saturation would be lower (<50%?) if CEC was measured at pH 7.0.

Classification diagnostics

Horizon Aust	designation WRB	depth cm	Diagnostic horizons ASC	WRB	ST	Diagnostic properties/materials ASC	WRB	ST
P2 (hemic/sapric peat)	Ha or He	0-36		Histic horizon Salic horizon		Organic materials (≥12% OC if mineral fraction has no clay). Strongly acid (pH <5.5)	Organic material (≥ 12% OC). Groundwater influence (rheic). Dystric (base sat. <50%, assum.)	Organic material pH < 4.5 (dysic)
2C	2C	36-67				Unconsolidated mineral material ('terric')		Mineral soil material
3P2	3Ha	67-98				Technically not organic material (<12% OC)		
4C	4C	98-130						

Classification (classifying the profile inspected on the excursion, and using the analytical data provided as a guide).

ASC: Terric, Acidic, Sapric Organosol; moderate. [Note: family class 'moderate' refers to the cumulative thickness of the organic materials (0.5-<1.0 m).

WRB: Salic Rheic Sapric Histosol (Dystric, Sodic). NB 'laxic' (bulk density <0.8 kg/dm^3) not used for Histosols.

ST: Sandy, siliceous, dysic Terric Haplosaprists

The profile originally described and analysed is only marginally an Organosol/Histol because fails to meet the cumulative depth requirements for organic material, and the 3P (3Ha) horizon is not strictly organic material. However, there seems little doubt that the profile inspected on the excursion would meet the requirements, which are:

Organic material: 40 cm of organic materials (if sapric/hemic) required: WRB – cumulatively within 100 cm of the soil surface.
ASC – cumulatively within 80 cm (ASC)
ST – as for ASC, but not explicitly specified in Key(?). Any mineral horizons to be <10 cm thick.

% organic C: ASC and ST (apparently) use a sliding scale (graphical interpretation) depending on clay content of mineral fraction, range from 12% (no clay) to 18% (60% clay). WRB has an equation that incorporates the clay content of the mineral fraction.

The WRB allows for Tidalic Histosols (flooded by tidewater, but not covered by water at mean low tide. The ASC excludes soils that are regularly inundated by saline tidal waters.

The Australian Soil Classification (ASC) – Key to soil orders

The material below is arranged to give the simplest way of identifying a particular soil in terms of the Orders, and is not a complete definition of each Order. Work successively through the key until an apparent identification is made, then check the full definition of the Order by clicking on the highlighted name. Words or phrases in *italics* are defined in the Glossary.

A. Soils resulting from human activities.
   ANTHROPOSOLS

B. Soils that are not regularly inundated by saline tidal waters and either:
   1. Have more than 0.4 m of *organic materials* within the upper 0.8 m. The required thickness may either extend down from the surface or be taken cumulatively within the upper 0.8 m; **or**
   2. Have *organic materials* extending from the surface to a minimum depth of 0.1 m; these either directly overlie rock or other *hard* layers, partially weathered or decomposed rock or saprolite, or overlie fragmental material such as gravel, cobbles or stones in which the interstices are filled or partially filled with organic material. In some soils there may be layers of *humose* and/or *melacic horizon* material underlying the *organic materials* and overlying the substrate.

   ORGANOSOLS

C. Other soils that have a Bs, Bhs or Bh horizon (see *Podosol diagnostic horizons*).

   These horizons may occur either singly or in combination.

   PODOSOLS

D. Other soils that:
   1. Have a clay field texture or 35% or more clay throughout the solum except for thin, surface crusty horizons 0.03 m or less thick, **and**
   2. Unless too moist, have open cracks at some time in most years that are at least 5 mm wide and extend upward to the surface or to the base of any plough layer, self-mulching horizon, or thin, surface crusty horizon, **and**
   3. At some depth in the solum, have slickensides and/or lenticular peds.

   VERTOSOLS

E. Other soils that are saturated in the major part[1] of the solum for at least 2-3 months in most years (ie. includes tidal waters).

   HYDROSOLS

F. Other soils with a *clear or abrupt textural B horizon* and in which the major part[1] of the upper 0.2 m of the B2 horizon (or the major part of the entire B2 horizon if it is less than 0.2 m thick) is *strongly acid*.

   KUROSOLS

G. Other soils with a *clear or abrupt textural B horizon* and in which the major part[1] of the upper 0.2 m of the B2 horizon (or the major part of the entire B2 horizon if it is less than 0.2 m thick) is *sodic* and is not strongly subplastic.

   SODOSOLS

H. Other soils with a *clear or abrupt textural B horizon* and in which the major part[1] of the upper 0.2 m of the B2 horizon (or the major part of the entire B2 horizon if it is less than 0.2 m thick) is not *strongly acid*.

CHROMOSOLS

I. Other soils that:

Are either *calcareous* throughout the solum - or calcareous at least directly below the A1 or Ap horizon, or within a depth of 0.2 m (whichever is shallower). Carbonate accumulations must be judged to be pedogenic, ie. are a result of soil forming processes *in situ* (either current or relict) in contrast to fragments of calcareous rock such as limestone or shell fragments. See also *calcrete*.

CALCAROSOLS

J. Other soils with B2 horizons in which the major part[1] has a free iron oxide content greater than 5% Fe in the fine earth fraction (<2 mm). Soils with a B2 horizon in which at least 0.3m has *vertic properties* are excluded (see also Comment and footnote in Ferrosols).

FERROSOLS

K. Other soils with B2 horizons that have structure more developed than weak[2] throughout the major part[1] of the horizon.

DERMOSOLS

L. Other soils that:
1. Have well-developed B2 horizons in which the major part[1] is massive or has only a weak grade of structure, (compare with *tenic B horizon* and *cemented pans*), **and**
2. Have a maximum clay content in some part of the B2 horizon which exceeds 15% (ie. heavy sandy loam, SL+).

KANDOSOLS

M. Other soils with negligible (rudimentary) pedological organisation apart from the minimal development of an A1 horizon or the presence of less than 10% of *B horizon* material (including pedogenic carbonate) in fissures in the parent rock or saprolite. The soils are apedal or only weakly structured in the A1 horizon and show no pedological colour change apart from darkening of an A1 horizon. There is little or no texture or colour change with depth unless stratified or buried soils are present. *Cemented pans* may be present as a substrate material.

RUDOSOLS

N. Other soils. **TENOSOLS**

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[1] The 'major part' means the requirement must be met over more than half the specified thickness. Analyses or estimates should be used from horizons or subhorizons that subdivide the profile, or if the subhorizons are not recognised, then from subsamples of the relevant horizons.

[2] It is common experience that pedologists are inclined to use the phrase 'weak to moderate' when they are in doubt as to the grade of the structure. If such a designation is used it will result in the soil being classed as a Dermosol.

The Australian Soil Classification (ASC) – glossary of terms

This glossary does not attempt to define all morphological terms used in the classification. It mainly deals with those that are not defined in the Field Handbook (McDonald et al. 1990). Where applicable all definitions are consistent with usage in the Field Handbook.

Andic properties

These occur in soils which contain significant amounts of volcanic glass and short-range-order minerals such as allophane. Chemical tests and *Soil Taxonomy* requirements are given in Soil Survey Staff (1994).

Argic horizon

An argic horizon is a subsoil horizon(s) consisting of distinct lamellae, usually 5 to 10 mm thick but occasionally up to 0.1 m or greater. They occur as sharply defined, horizontal to subhorizontal layers which are appreciably more clayey than the adjacent sandy or sandy loam soil material. Consistence strength is stronger, and colour is usually darker and redder or browner than the adjacent soil.
The most common known occurrences are in the mallee dune landscapes of Victoria-South Australia.

B horizons

In the *Field Handbook* (p.105) B horizons are defined, in part, as having a concentration of silicate clay, iron, aluminium, organic material, or several of these. There is no mention of carbonate in the definition, although elsewhere (p.108) the subscript k is used to denote an accumulation of carbonate, as in B2k. In contrast, Soil Survey Division Staff (1993) now has the following criteria as a requisite for a B horizon: "illuvial concentration of silicate clay, iron, aluminium, humus, carbonates, gypsum, or silica, alone or in combination". This definition is used in this classification.

In some shallow, stony soils B horizon material may only be present in fissures within the parent rock or saprolite. In such cases there should be 50% or more (visual abundance estimate) of B horizon material for it to qualify as a B horizon for the purposes of this classification (See also "What do we classify" and *transitional horizons*).

Base status

This refers to the sum of exchangeable basic cations (Ca, Mg, K and Na) expressed in cmol (+) kg^{-1} clay. This sum is obtained by multiplying the sum of the reported basic cations (which are determined on a soil fine earth basis) by 100 and dividing by the clay percentage of the sample. Where this is not available it may be approximated from the field texture using the figures given on pp. 118-120 of the *Field Handbook*. Three classes are defined: *Dystrophic* - the sum is less than 5; *Mesotrophic* - the sum is between 5 and 15 inclusive; *Eutrophic* - the sum is greater than 15. An estimate of the sum of basic cations for the *B horizon* of an individual soil may be obtained from its classification if the *B horizon* maximum texture is recorded in the family criteria.

Bauxitic horizon

One which contains more than 20% (visual abundance estimate) of bauxite nodules or concretions which are mostly uncemented, and has a minimum thickness of 0.1 m.

Calcareous

Presence of carbonate segregations or fine earth (soil matrix) effervescence with 1M HCl.

Calcareous horizon

An horizon that is usually identified as a Bk, BCk, 2Bk or 2BCk horizon, or one containing fragments of a cemented (suffix 'm') equivalent of these horizons. As noted in the *Field Handbook*, the suffix k is usually recorded only if there are >10% of the calcareous segregations. However in soil with no carbonate except for one horizon with few (2-10%) segregations, this could be designated with a suffix k. See also *calcrete*, *calcrete pan* and *cemented pans*.

Calcrete

In the *Field Handbook* calcrete is described as both a pan (ie. a soil horizon, such as Bkm) and as a substrate material. However, the definition is the same in both cases, viz 'any cemented terrestrial carbonate accumulation that may vary significantly in morphology and degree of cementation'. The latter may be regarded as indicating the material must be *hard*. According to this broad definition, calcrete can obviously encompass a wide range of calcareous material although not the common soft segregations of finely divided carbonate, nor accumulations of pedogenic carbonate in the form of discrete nodules or concretions. Unfortunately, the term has been widely used in southern Australia for an almost infinite variety of forms of calcium carbonate. For the purposes of this classification, the term is used strictly as defined in the *Field Handbook*. See also *calcrete*, *calcrete pan* and *cemented pans*.

Calcrete pan

A moderately, strongly or very strongly cemented layer of *calcrete* which is either continuous, or if discontinuous or broken, consists of at least 90% of *hard* calcrete fragments, most of which are > 0.2 m in smallest dimension.

Carbic materials

Organic debris that has accumulated by colluvial and alluvial processes when torrential rain occurs following extensive bushfires. The material has a low bulk density (<1 t m-3) and consists of variably carbonised plant remains, ranging from little-altered vegetative material to charcoal and humified plant debris. Small amounts of mineral soil are also usually present. The main difference from *organic materials* is the much lower degree of plant decomposition, ie. an absence of material that could be classed as *peat*.

Carbonate classes

The following table is a summary of the classes used in the classification for various kinds and amount of calcium carbonate.

	soft carbonate	**hard carbonate**
Hypocalcic	>0 & <2%	<20%
Calcic	2-20%	<20%
Hypercalcic	>20%	<20%
Supracalcic	>=0%	20-50%
Lithocalcic	>=0%	>50%

Cemented pans

In the *Field Handbook* a pan is defined as an indurated and/or cemented soil horizon and thus horizons such as Bcm, Bkm and Bqm could be interpreted to represent strongly developed *B horizons*, with consequent effects on the classification of some soils, eg. Kandosols and Tenosols. The *Field Handbook* also recognised that it can be difficult to determine if materials such as *calcrete*, ferricrete, silcrete etc. are indeed soil horizons or are better identified as substrate materials, ie. do not show pedological development or are paleo-features.

To avoid the above problem, cemented pans such as *calcrete*, silcrete, *red-brown hardpan*, ferricrete, *petroferric horizon* and *petroreticulite* are recognised as diagnostic substrate features and hence excluded as criteria of *B horizon* development. Note that the *Podosol diagnostic horizons* are not regarded as substrate materials.

Clear or abrupt textural B horizon

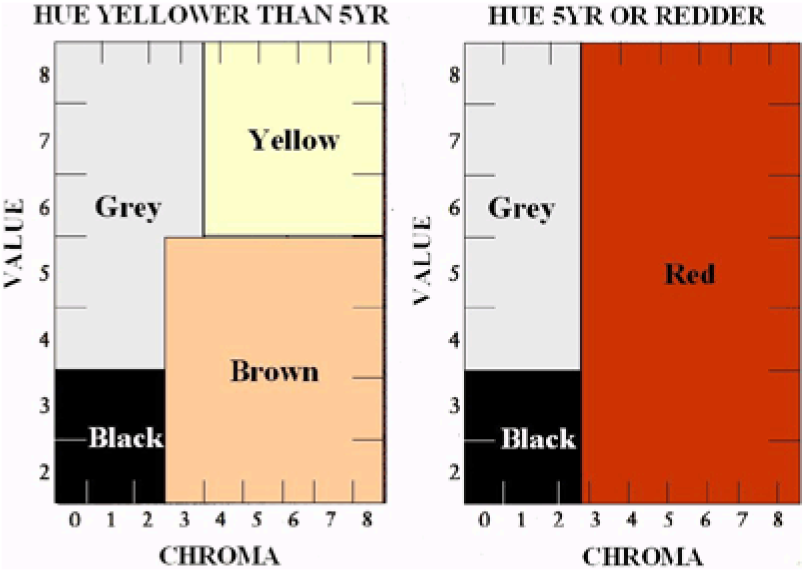
The boundary between the horizon (normally a B2t) and the overlying horizon (which must be thicker than 0.03 m and is normally an A but occasionally a B1 horizon) is clear, abrupt or sharp and is followed by a clay increase giving a strong texture contrast:

a. If the clay content of the material above the clear, abrupt or sharp boundary is less than 20%, (and/or has a field texture of sandy loam or less) then the clay content immediately below must be at least twice as high. However, there must be a minimum of 20% clay (and/or a minimum field texture of sandy clay loam) at the top of the *B horizon*.
b. If the material above the transition has 20% clay or more but less than 35% clay (and/or has a field texture of sandy clay loam or greater but less than light clay), then the material below must show an absolute increase of at least 20% clay, eg. 25% increasing clearly, sharply or abruptly to at least 45%, (and/or a field texture of light medium clay or greater). Note that a clear or abrupt textural change is not allowed within the clay range.

Note: The field textures listed in (a) and (b) above must be regarded only as guidelines. Some discrepancies may arise in soils with high organic matter, silt, fine sand or soft carbonate contents, and in soils with strongly subplastic *B horizons*. If there are apparent discrepancies between field texture and laboratory data, the first step is to repeat the assessments if possible. If these remain unchanged the classifiers should use their own judgement based on how they think the soil behaves. In some such cases field textures may be a better guide to soil behaviour than particle size data.

Note also that the above definition is not directly equivalent to that of the duplex primary profile form of the *Factual Key* (Northcote, 1979).

Colour classes



Densipan

An earthy pan which is very fine sandy (0.02-0.05mm). Fragments, both wet and dry, slake in water. Densipans are less stable on exposure than underlying or overlying horizons.

Dystrophic

Base status is less than 5 cmol (+) kg^{-1} clay.

ESP (Exchangeable sodium percentage)

Since the review by Northcote and Skene(1972), an *ESP* of 6 has been widely used in Australia as a critical limit for the adverse effects of sodicity. *ESP* is conventionally defined as exchangeable sodium expressed as a percentage of the cation exchange capacity (CEC) - both usually determined in Australia at *pH* 7 or 8.5. In acid soils, particularly those with variable charge colloids, CEC at *pH* 7 or 8.5 will normally be higher than that determined at the soil *pH*. Hence it is more realistic to determine the effective cation exchange capacity (ECEC) (method 15J1 of Rayment and Higginson 1992), or to use an unbuffered method to determine CEC, and to use these values to calculate *ESP* in soils with *pH* around 5.5 or less. See also Comment after definition of Kurosols (p. 64).

In some dystrophic soils, problems can arise when low levels of exchangeable sodium give rise to relatively high *ESP* values. In such cases there is insufficient evidence that *ESP* values greater than 6 have a deleterious effect on soil physical properties equivalent to that in less acid soils with higher base status. Further experience may indicate a need for a minimum level of exchangeable sodium to be introduced.

A related problem is the sensitivity of the analytical procedures when values for exchangeable cations and CEC and ECEC are very low. It is probably not advisable to calculate *ESP* when the CEC or ECEC is 3 cmol (+) kg^{-1} or less and exchangeable sodium is 0.3 cmol (+) kg^{-1} or less. As an indicator of sodicity, such calculations are likely to be quite misleading.

Finally, it must be remembered that the effect of *ESP* on behaviour such as dispersion is also influenced by other soil properties such as organic matter content, clay mineralogy, cation composition, sesquioxide content, and particularly electrolyte concentration of the soil and of any applied irrigation water.

Eutrophic

Base status is greater than 15 cmol (+) kg^{-1} clay.

Ferric horizon

One which contains more than 20% (visual abundance estimate) of ferruginous nodules or concretions which are mostly uncemented, and has a minimum thickness of 0.1 m. Most of the nodules contain at least some manganese, and in some situations the majority (if not all) of the nodules may be transported from elsewhere.

Gravel

This refers to the amount (visual abundance estimate) of gravel-sized (>2 mm) materials that occur on the surface and in the A1 horizon and include *hard* (when moist) coarse fragments and segregations of pedogenic origin. The most common examples of the latter are carbonate and ferruginous nodules and/or concretions.

Gypsic horizon

One which contains more than 20% of visible gypsum that is apparently of pedogenic origin, and has a minimum thickness of 0.1 m. Where the upper boundary of the gypsic horizon first occurs below 1 m depth it is disregarded in the classification.

Hard

In the classification *hard* is used as a general term to indicate strength. *Hard* nodules or segregations means their strength is such that they cannot be broken between the thumb and forefinger; ie. strong in the *Field Handbook* (p. 147). When referring to pans *hard* means moderately cemented or stronger (*Field Handbook* p. 143). When referring to substrate material *hard* means moderately strong or stronger (*Field Handbook* p. 156).

Humose horizon

This is a humus-rich surface or near surface horizon that is 0.2 m or more thick and has insufficient organic carbon to qualify as *organic material*. The average value for the humose horizon is more than 4% organic carbon [Walkley-Black x 1.3 or a total combustion method (Rayment and Higginson 1992, Methods 6A1 or 6B2).] (but less than 12%) if the mineral fraction contains no clay, or 6% or more organic carbon (but less than 18%) if the mineral fraction contains 60% or more clay; with proportional contents of organic carbon between these limits (see Fig. 2). Approximate loss-on-ignition values are given under *organic materials* below.

This definition is based on that used in England and Wales (Avery 1990).

If the humose surface layer is less than 0.2 m it will not be specifically recognised as a separate texture at the family level but will be assigned to the relevant mineral soil texture class eg. sandy, loamy, etc. The one exception occurs in the Leptic Tenosols where a subhumose subgroup is provided.

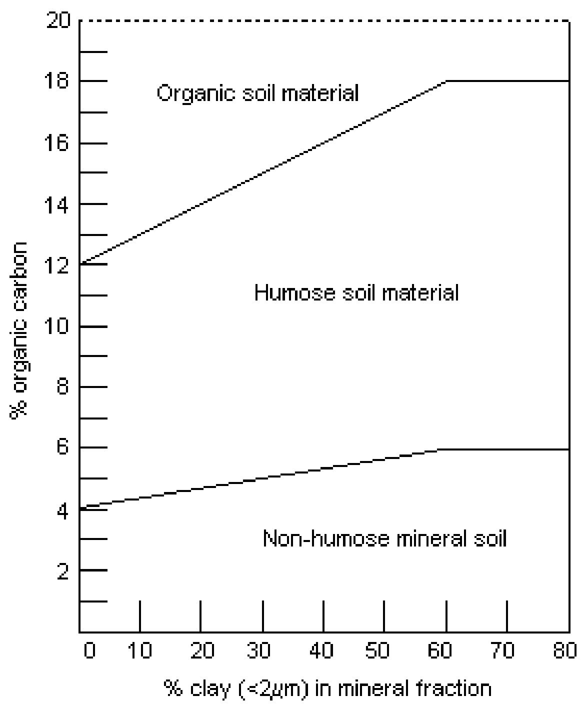


Figure 2. Limits of organic and humose soil materials (after Avery 1990).
The dashed line is used for materials seldom saturated with water.

Manganic horizon

One which contains more than 20% (visual abundance estimate) of black manganiferous nodules or concretions which are mostly uncemented, and has a minimum thickness of 0.1 m. Most nodules also contain some iron.

Marl

A loose, earthy material consisting chiefly of an intimate mixture of clay and calcium carbonate, commonly formed in freshwater lakes. The carbonate content may range from about 30 to 90% (Bates and Jackson 1987).

Melanic horizon

This is a dark surface or near surface horizon that has insufficient organic carbon to qualify as a humose horizon, and has little if any evidence of stratification. It has all of the following properties:

a. moist colour is black throughout (ie. value 3 or less and chroma 2 or less - see *Colour classes*) and dry colour value is 5 or less.
b. a minimum thickness of 0.2 m (in soils with a *clear or abrupt textural B horizon* the minimum thickness must be present within the A horizon)
c. the major part of the horizon has more than a weak grade of structure in which the most common ped size is 10-20 mm or less. This condition may be waived for an Ap horizon or when dry consistence strength is weak or less.
d. *pH* (1:5 H_2O) is 5.5 or greater throughout the major part of the horizon.

Melacic horizon

As for *melanic horizon* but *pH* (1:5 H_2O) is less than 5.5 and there is no structure requirement.

Mesotrophic

Base status is between 5 and 15 cmol (+) kg^{-1} clay inclusive.

Mottled horizon

An horizon in which mottle abundance is greater than 10% (visual abundance estimate) and contrast between colours is distinct to prominent. Colour patterns due to biological or mechanical mixing, and inclusions of weathered substrate materials, are not included. As pointed out (see Comment - Hydrosols), mottling does not necessarily imply that oxidising and reducing conditions are currently occurring in the soil in most years.

Organic materials

These are plant-derived organic accumulations that are either:

a. saturated with water for long periods or are artificially drained and, excluding live plant tissue, (i) have 18% or more organic carbon [Walkley-Black x 1.3 or a total combustion method. (Rayment and Higginson 1992, Methods 6A1 or 6B2).] if the mineral fraction is 60% or more clay, (ii) have 12% or more organic carbon if the mineral fraction has no clay, or (iii) have a proportional content of organic carbon between 12 and 18% if the clay content of the mineral fraction is between zero and 60% (see Fig. 2); **or**
b. saturated with water for no more than a few days and have 20% or more organic carbon.

This definition is the same as that used in *Soil Taxonomy* and is very similar to that used in England and Wales (Avery 1990).

Loss-on-ignition (LOI) may be used as an estimate of organic carbon. For non-calcareous soils, the relationship between organic carbon and LOI was found by Spain *et al*. (1982) to be influenced by clay content. For the range of organic carbon contents of interest, approximate conversions are:

	Clay (%)	**LOI**
when clay is	< 20%	LOI = 2.0 x organic carbon
	20-60%	LOI = 2.3 x organic carbon
	> 60%	LOI = 2.7 x organic carbon.

Peat

As noted in the *Field Handbook*, peats may be assessed by examining the degree of decomposition and distinctness of plant remains. This may be assisted by using a modification of the von Post field test (see Avery, 1990 p.90), in which a sample of the wet peat is squeezed in the closed hand and the colour of the liquid expressed, the proportion extruded between the fingers, and the nature of the plant residues are observed.

- **Fibric Peat.** Undecomposed or weakly decomposed organic material; plant remains are distinct and identifiable; yields clear to weakly turbid water; no peat escapes between fingers.
- **Hemic Peat.** Moderately to well-decomposed organic material; plant remains recognisable but may be rather indistinct and difficult to identify; yields strongly turbid to muddy water; amount of peat escaping between fingers ranges from none up to one-third; residue is pasty.
- **Sapric Peat.** Strongly to completely decomposed organic material; plant remains indistinct to unrecognisable; amounts ranging from about half to all escape between fingers; any residue is almost entirely resistant remains such as root fibres and wood.

Peaty horizon *(P and O2 horizons in Field Handbook)*

This is a surface or near surface layer of *organic materials* at least 0.2 m thick overlying mineral soil and which does not qualify as an Organosol. Such soils are designated as a peaty subgroup. In cases where the soil has a surface layer of *organic materials* less than 0.2 m thick but does not qualify for an Organosol (eg. as in Definition (ii) of Organosols), it will be recognised at the family level as having a peaty 'texture'. The one exception occurs in the Leptic Tenosols where a subpeaty subgroup is provided. In the peaty and subpeaty subgroups there will be a repetition of texture at the family level.

Petroferric horizon

Ferruginous, ferromanganiferous or aluminous nodules or concretions cemented in place into indurated blocks or large irregular fragments.

pH

Unless otherwise specified, *pH* refers to 1:5 H_20 (pH_w). Approximate equivalents for pH_w and pH_{Ca} (1:5 soil: 0.01M $CaC1_2$) for the critical *pH* values used in the classification are as follows: (based on regressions given by Ahern *et al*. (1995) for large numbers of Queensland surface and subsoil samples)

- pH_w of 5.5 is approximately equivalent to pH_{Ca} of 4.6
- pH_w of 4.0 is approximately equivalent to pH_{Ca} of 3.5

Petroreticulite horizon

A *reticulite horizon* (see below) that is always indurated in the greater part both before and after exposure.

Podosol diagnostic horizons

The various *B horizons* defined below consist of illuvial accumulations of amorphous organic matter-aluminium and aluminium-silica complexes, with or without iron in various combinations. Although some may qualify as *cemented pans*, they are not to be regarded as substrate materials.

Bs horizons. The usually bright colours indicate that iron compounds are strongly dominant or co-dominant and there is little evidence of organic compounds, apart from a few usually discontinuous patches in the upper *B horizon* or a thin band (< 0.05 m thick) at the A2/B junction. The upper boundary of the *B horizon* may be very uneven but otherwise the horizons are relatively uniform laterally. Iron concentrations may increase or decrease with depth. No *strongly coherent Bs horizons* have been recorded. Bs horizons may be non-reactive or give only a weak response to the *reactive aluminium test*. As a guide, Bs horizons usually have a hue of 5, 7.5 or 10YR, a value of 4 or 5, and a chroma of 4 - 8. **The main feature distinguishing a Bs horizon from a *tenic B horizon* is some weak and irregular development of organic accumulations which extend laterally although discontinuously.**

Note that the presence of a *thin ironpan* (placic horizon), which will be designated as Bsm, is not to be regarded as a Podosol diagnostic horizon because it may also occur in the *B horizon* of other soils, eg. Tenosols and Kandosols, and may also be present in C horizons or even parent rocks.

Bhs horizons. Iron and organic compounds are both prominent with the organic compounds distributed as streaks, patches or lumps so that concentrations of iron, aluminium and organic compounds have marked spatial variation. Such horizons may contain firm lumps of organic compounds but otherwise are *weakly coherent* and highly permeable, or they may be *strongly coherent* throughout, or contain *strongly coherent* subhorizons or pans. Bhs horizons always contain significant amounts of oxalate-extractable iron and aluminium and frequently silica, ie. imogolite-allophane complex is usually present in significant amounts and the horizons give a moderate to very strong response to the *reactive aluminium test*. As a guide, Bhs horizons usually have a hue of 2.5YR to 10YR, and value/chroma of 3/3, 3/4, 3/6, 4/3 or 4/4.

Bh horizons. Organic-aluminium compounds are strongly dominant with little or no evidence of iron compounds. Such horizons have a uniform appearance laterally and are relatively uniform vertically although concentrations of carbon and aluminium and the degree of coherence or cementation may change with depth. The horizons may be *weakly* or *strongly coherent*, or contain *strongly coherent* or cemented sub-horizons or pans, or overlie other kinds of pans or clay D horizons. Bh horizons are non-reactive or give only a weak response to the *reactive aluminium test*. Colours are usually dark with values <4 and chromas <3. In typical Bh horizons the sand grains are uncoated and the organic-aluminium complex is precipitated between the grains (Farmer *et al*. 1983).

Bh/Bhs horizons. These have a subhorizon, dominated by organic and aluminium compounds with relatively low iron (Bh), overlying the major horizon with prominent organic and iron compounds (Bhs). The dark horizon (Bh) may undulate but is usually discontinuous, and rests on or grades into a Bhs with a range in consistence as described above.

Bh/Bs horizons. The dark Bh horizon may be *weakly* or *strongly coherent*, but is usually discontinuous and grades quickly to a brightly coloured and *weakly coherent* Bs horizon.

Basi horizons. These are brown, yellow-brown or pale brown cemented horizons that immediately underlie Bh horizons in some poorly drained Podosols. Despite their colour these horizons have low contents of acid oxalate-extractable iron but significant amounts of oxalate-extractable aluminium and silica. The cementing agency appears to be an imogolite-allophane complex with some organic-aluminium compounds. These horizons give a rapid strong or very strong response to the *reactive aluminium test*. Because of their bright colour and cementation many of these horizons have been included as ortstein in the past.

Bh/Basi horizons. Typical Bh horizons dominated by organic-aluminium compounds which may be *weakly coherent* or cemented and overlie a cemented *Basi* horizon.

Pipey B horizons are characterised by pipes of bleached A2 horizon that penetrate both vertically and sometimes laterally > 50 cm into the *B horizon*, giving a tongued boundary on a profile face. The pipes are usually enclosed by dark organic compounds forming the pipe walls of Bh or Bh/Bhs materials which usually have a weak to firm consistence strength (ie. force 2-3) and are brittle when dry. The bleached A2 material consists of clean quartz grains that have lost any oxide coatings. In 'giant' Podosols the pipes may penetrate > 6 m into the *B horizon*.

Reactive aluminium test *(Hewitt 1992).*

This test indicates the presence of reactive hydroxy-aluminium groups, as occur for example in allophane and aluminium-humus complexes (Milne et al. 1991).

Using the procedure of Fieldes and Perrott (1966), 1 drop of saturated sodium fluoride solution is placed on a small test sample of soil, which has been smeared on to a filter paper treated with phenolphthalein indicator. The soil sample must be field moist. For classification, the reactivity of the soil sample is placed into one of the following classes.

Red-brown hardpan

An earthy pan which is normally reddish brown to red with a dense yet porous appearance. It is very *hard*, has an irregular laminar cleavage and some vertical cracks, and varies from less than 0.3m to over 30 m thick. Wavy black veinings, probably manganiferous, are a consistent feature while other more variable features include bedded and unsorted sand and gravel lenses and, less commonly, off-white veins of calcium carbonate. The red-brown hardpan appears to occur either as a cemented sediment or a cemented palaeosol (Wright 1983). It is one of a variable group of silica pans generally known as duripans (Soil Survey Staff 1994) that commonly occur in currently arid climates.

Reticulite horizon

This is intended for strongly developed reddish, yellowish and greyish or white, more or less reticulately mottled horizons that can be hand-augered or cut with a spade. Ferruginous nodules or concretions may be present but are not diagnostic. When moist the material usually has at least a firm consistence strength, but following exposure the material may irreversibly harden. At depth it may grade into mottled saprolite.

Sodic

The *ESP* of the fine earth soil material is 6 or greater.

Soil depth

One of the most important features of a soil is its depth or thickness, but it is frequently difficult to determine the lower limit of soil. For many purposes, depth of soil is considered to be synonymous with the rooting depth of plants, but because this may vary widely it is not always a suitable criterion. Thickness of solum (A + *B horizon*) is a measure that is useful in many soils, although it may be difficult in some soils to distinguish B from C horizon.

At the Family level, *soil depth* will be taken to mean either thickness of solum or depth to a *cemented pan*. In a particular soil it will be evident from the classification which criterion is used. However, depth to a *thin ironpan* will not be used because of the extremely irregular and convolute nature of most of such pans.

Strongly acid

pH of the fine earth soil material is as follows:

- pH_w (1:5 H_20) is less than 5.5 or
- pH_{Ca} (1:5 soil : 0.01M $CaCl_2$) is less than 4.6.
- $pH_w < 5.5$ should be used as the critical limit when it is available.

Strongly coherent B horizon

These are Podosol *B horizons* in which the consistence strength ranges from very firm to strong throughout (ie. force 4-5), or they contain subhorizons with these properties. Included are pan-like materials that have been variously described as ortstein, coffee rock or sandrock. The consistence properties are usually independent of soil water status.

Sulfidic materials

A subsoil, waterlogged, mineral or organic material that contains oxidisable sulfur compounds, usually iron disulfide (eg. pyrite, FeS_2), that has a field *pH* of 4 or more but which will become extremely acid when drained. Sulfidic material is identified by a drop in *pH* by at least 0.5 unit to 4 or less (1:1 by weight in water, or in a minimum of water to permit measurement) when a 10mm thick layer is incubated at field capacity for 8 weeks. For a quick screening test that is not definitive, a 10 g sample treated with 50 ml of 30 % H_20_2 will show a fall in *pH* to 2.5 or less. **Caution:** H_20_2 is a strong oxidant and sulphides and organic materials will froth violently in a test tube which may become very hot.

Note: This definition is similar to that in Soil Taxonomy (Soil Survey Staff, 1994) but modified slightly by Dr David Dent, University of East Anglia and colleagues in CSIRO Division of Soils.

Sulfuric materials

Soil material that has a *pH* less than 4 (1:1 by weight in water, or in a minimum of water to permit measurement) when measured in dry season conditions as a result of the oxidation of sulfidic materials (defined above). Evidence that low *pH* is caused by oxidation of sulfides is one of the following:

- yellow mottles and coatings of jarosite (hue of 2.5Y or yellower and chroma of about 6 or more).
- underlying sulfidic material.

Note: This definition is similar to that in Soil Taxonomy (Soil Survey Staff, 1994) but modified slightly by Dr David Dent, Bureau of Resource Sciences and colleagues in CSIRO.

Tenic B horizon

A usually weakly developed B2t, B2w or other *B horizon* (in terms of contrast between A horizons above and adjacent horizons below) of texture and/or colour and/or structure and/or presence of segregations of pedogenic origin (including carbonate). It usually is slightly different from the underlying horizon (excepting buried soils) in terms of a higher chroma, redder hue or higher clay content, but structure should be no more than weak grade and mottles or sesquioxidic segregations of pedogenic origin other than *hard* ferromanganiferous nodules or concretions should not exceed 10% in the major part of the horizon.

In many shallow stony soils, the *tenic B horizon* may be present only between rock fragments or in rock fissures (50% or more by visual abundance estimate). Where present in soils formed from sediments, weak evidence of stratification may be present. Weakly developed *argic horizons* may be present in some tenic *B horizons*. (See also *B horizons* and *transitional horizons*.).

In some soils underlain by a *red-brown hardpan* where there is no discernible A1 horizon and no underlying C horizon, it is difficult to identify a *B horizon* if there is little or no colour change or increase in texture or development of structure. Such layers of uniform soil materials without identifiable overlying or underlying horizons may be considered as a *tenic B horizon* if there is no evidence of alluvial stratification or aeolian cross-bedding within them.

Tephric materials

These consist dominantly of tephra - unconsolidated, non-weathered or only slightly altered primary pyroclastic products of explosive volcanic eruptions. They include ash, cinders, lapilli, scoria, pumice and pumice-like vesicular pyroclastics. Volcanic bombs may occur, and some exotic ejecta such as limestone fragments.

Thin ironpan

Commonly a thin (2-10mm) black to dark reddish pan cemented by iron, iron and manganese, or iron-organic matter complexes. Rarely 40mm thick. It has a wavy or convolute form and usually occurs as a single pan. It is also known as a placic horizon (Soil Survey Staff 1994).

Transitional horizons

There are slight differences in the definitions of these horizons between the *Soil Survey Manual* (Soil Survey Division Staff 1993) and the *Field Handbook*. The definition used in this classification is that used in the *Soil Survey Manual*, viz:

- *Horizons dominated by properties of one master horizon but having subordinate properties of another eg. BC.* The first symbol indicates that the properties of the horizon so designated dominate the transitional horizon.
- *Horizons with two distinct parts that have recognisable properties of the two kinds of master horizons indicated by the capital letters eg. C/B.* The first symbol is that of the horizon with the greater volume. Most of the individual parts of one horizon component are surrounded by the other.

Unconsolidated mineral materials

This term is used to describe various unconsolidated materials below the solum, such as some C horizons, buried soils, sedimentary deposits of alluvial, colluvial or aeolian origin, and transported ferruginous nodules or concretions, such as occur in some *ferric* and *bauxitic horizons*.

Vertic properties

Soil material with a clayey field texture (ie. light clay, medium clay, heavy clay) or 35% or more clay, which cracks strongly when dry and has slickensides and/or lenticular peds. See also Comment following the definition of Vertosols.

In several countries, physical measurements are being used in soil classification to help define classes of shrink-swell clay soils. In South Africa (Soil Classification Working Group 1991), the definition of a vertic A horizon (which is the definitive feature of soils equivalent to Vertosols) includes either slickensides or a plasticity index greater than 32 (using the SA Standard Casagrande cup to determine liquid limit) or greater than 36 (using the British Standard cone to determine liquid limit). Cracking is regarded as an accessory property, as is linear shrinkage which is stated to be usually greater than 12%.

Soil Taxonomy relies solely on morphology for the definition of Vertisols (as does FAO-Unesco 1990), but in the definition of vertic subgroups in *Soil Taxonomy* (Soil Survey Staff 1999) a linear extensibility [The linear extensibility (LE) of a soil layer is the product of the thickness, in centimetres, multiplied by the COLE of the layer in question. The LE of a soil is the sum of these products for all soil horizons (Soil Survey Staff 1999).] of 6 cm or more is offered as an alternative to the usual morphological requirements of cracks, and slickensides or wedge-shaped aggregates. However, the 6 cm minimum applies to the soil in the upper 100 cm of the profile, or the depth to a lithic or paralithic contract, whichever is shallower. This hardly seems appropriate to a common Australian situation where thick sandy A horizons overlie shrink-swell *B horizons*, particularly as in most engineering situations topsoils tend to be removed.

In Australia, COLE is seldom determined other than for research purposes and hence there is no appropriate data base of representative Australian clay soils. In contrast, standard engineering tests (Atterberg limits and linear shrinkage) are widely used by engineers and some soil conservation departments. Unfortunately, it is often not possible to relate the test values to specific kinds of soil, let alone the presence or absence of morphological features such as slickensides and lenticular peds. One relevant paper is that of Mills *et al*. (1980) who found in a study of 14 clay subsoils (three of which were Vertosols) in New South Wales that linear shrinkage was an appropriate method to predict shrink-swell activity but this was not related to morphology. Critical linear shrinkage limits of Mills *et al*.(1980) and for several other engineering authorities are given by Hicks (1991). Linear shrinkage values of 12-17% are rated as being marginal or moderate, with greater than 17% rated as a critical or high shrink-swell potential. However, Holland and Richards (1982) suggest that in arid and semi-arid climates, where pronounced short wet and long dry periods lead to major moisture changes, the linear shrinkage lower limits for moderate and high shrink-swell potential be 5% and 12% respectively.

McKenzie *et al*. (1994) have suggested that because the natural soil fabric is destroyed in the standard linear shrinkage test, the results can be difficult to relate to field behaviour. They have developed a rapid modified linear shrinkage test in which disruption to the natural soil fabric is reduced. This method was found to be a good predictor of COLE (r^2 = 0.88) with the slope of the regression line close to unity. The standard linear shrinkage was found to be a weaker predictor of COLE (r^2 = 0.79). In the 26 samples used, (that included two Vertosol profiles), the value for the standard linear shrinkage was always equal to or greater than the modified method.

There is obviously a need for further testing of all shrinkage methods on a wide range of Australian soils, and in particular to relate values to field morphology, as the latter may not always be a reliable guide to shrink-swell behaviour, particularly if salt and carbonate contents are high. McGarry (1995) has reviewed the various methods currently used to measure soil shrinkage.

For present classification purposes it is difficult to give firm guidelines. In the interim, a linear shrinkage of about 8% or greater by the modified version or about 12% or greater by the standard linear shrinkage (and/or a plasticity index > 32-36) will help differentiate soils with vertic properties from others.

Weakly coherent B horizon.

These are Podosol *B horizons* in which the consistence strength ranges from loose to firm (ie. force 0-3), although they may contain firm to very firm lumps (ie. force 3-4) associated with accumulations of organic compounds, and occasionally there may be some *hard* sesquioxide nodules present. They do not contain pans of any kind.

The 'plinthite' conundrum

General concept of a plinthic horizon (WRB): *a subsurface horizon that consists of an Fe-rich (in some cases also Mn-rich), humus-poor mixture of kaolinitic clay (and other products of strong weathering, such as gibbsite) with quartz and other constituents, and which changes irreversibly to a layer with hard nodules, a hardpan or irregular fragments on exposure to repeated wetting and drying with free access of oxygen.* The reference to irreversible hardening is critical to the definition. The Soil Taxonomy definition of plinthite is similar (see Appendix __). It is noted in WRB and ST that the plinthic materials do not harden irreversibly as a result of a single cycle of drying and rewetting but repeated wetting and drying will change them irreversibly to hard nodules, a hardpan (ironstone) or irregular fragments. . Curiously in ST, plinthite can occur in any horizon (from the epipedon to the C horizon) – surely epipedal occurrences would normally be restricted to the hard ('petro') forms.

The term plinthite was first introduced in 1960 (Soil Survey Staff) when the pre-cursor to Soil Taxonomy was published. This was possibly an attempt to remove confusion resulting from loose usage of the older term 'laterite'. Unlike WRB, Soil Taxonomy still mentions the connection of plinthite with laterite: "*It is one form of the material that has been called laterite*". "*Much that has been called laterite is included in the meaning of plinthite. Doughy and concretionary laterite that has not hardened is an example. Hardened laterite, whether it is vesicular or pisolitic, is not included in the definition of plinthite*." However, Soil Taxonomy does not refer anywhere to '*petro*plinthite', so does not distinguish between hard and soft forms.

The ASC does not refer to 'plinthite' or 'plinth' subgroups at all. The reasons for this have not been made explicit, either in the ASC book or the companion 'concepts and rationale' book (Isbell et al, 1997). It was obviously felt that the materials regarded as 'plinthic' in other classifications could be catered for by the 'mottled', 'ferric', 'petroferric', 'reticulite' and/or 'petroreticulite' horizons. In addition, there is the obvious problem of field identification of plinthite, especially the time (up to a year?) that is be required to confirm whether or not it hardens irreversibly.

Some of Ray Isbell's (and colleagues) opinions about plinthite are contained in Moorman (1985) and Isbell (1983). Generally it was felt that that there needed to be improvement in the definition of plinthite (developing concepts along the lines of Daniels, 1978). Isbell felt that plinthite should generally be regarded as a subsolum feature – "*it would be fairly rare in Australian soils of my experience to find plinthite within 1.25 m of the surface*". Furthermore, he stated that it should not be used at a high level of classification, as it could only be regarded as a "*subsidiary soil material, the value of which as a diagnostic characteristic is confused by the fact that all sorts of transitions between the fully hardened (laterite) and the still soft (plinthite) forms exist vertically in profiles and even laterally in the same horizons".*

The ASC 'reticulite horizon' and 'petroreticulite' horizons are not intended to be a substitute for 'plinthite'. The general concept of a reticulite horizon (Isbell et al, 1997) is that it is *a special type of mottled horizon, notable for its thickness (up to several metres) and its coarse reticulate mottling*. It *often grades into mottled saprolite and hence could be regarded as a subsolum feature* i.e. it is usually below the B2 horizon in what we call a B3 horizon or C horizon.

The South African experience is also extremely interesting in this context (Fey 2010, _____): They recognise and define both 'soft plinthite' and 'hard plinthite', but not a material that hardens irreversibly upon exposure to repeated wetting and drying.

A continuum for iron-rich materials as defined by WRB: (see table next page for detailed definitions)

Concept:	Large mottles or discrete nodules	➔	Firm to weakly cemented mottles/nodules	➔	Extremely hard (indurated) platy sheets or nodules.
Materials/ horizons	Ferric materials Ferric horizon	➔	Plinthite Plinthic horizon	➔	Petroplinthite/pisoplinthite – materials and horizons.
Field ID:	>15% coarse mottles or >5% discrete nodules; <15% (by volume) of mottles/nodules that have the capacity to harden irreversibly		Mottles /nodules in platy, polygonal, vesicular or reticulate patterns. ≥15% (by volume) of mottles/nodules that have the capacity to harden irreversibly; <40% indurated material.		Extremely hard; typically rusty brown to yellowish brown; massive, nodular, reticulate, platy or columnar pattern that encloses non-indurated material.
Behaviour in perennially moist soil:	Soft to very firm.		Firm to very firm, but can be cut with a spade.		Broken or shattered with a spade or hammer.

APPENDIX THREE - Ferric materials and plinthite – definitions and correlations

Item	Classif. system	Diagnostics	Notes / Relationships with other horizons	Synonyms / correlation
Ferric horizon	WRB	1. has one or both of the following: a. 15 percent or more of the exposed area occupied by coarse mottles with a Munsell hue redder than 7.5 YR and a chroma of more than 5, moist; OR b. 5 percent or more of the volume consisting of discrete reddish to blackish nodules with a diameter of 2 mm or more, with at least the exteriors of the nodules being at least weakly cemented or indurated and the exteriors having redder hue or stronger chroma than the interiors; AND 2. does not form part of a petroplinthic, pisoplinthic or plinthic horizon; AND 3. has a thickness of 15 cm or more.	If the amount of weakly-cemented nodules or mottles reaches 15 percent or more (by volume) and these harden irreversibly to hard nodules or a hardpan or to irregular aggregates on exposure to repeated wetting and drying with free access of oxygen, the horizon is considered to be a plinthic horizon. Therefore, ferric horizons may, in tropical or subtropical regions, grade laterally into plinthic horizons. If the amount of hard nodules reaches 40 percent or more, it is a pisoplinthic horizon.	~ Ferric horizon (ASC) ~ Mottled horizon (ASC)
Ferric horizon	ASC	One which contains more than 20% (visual abundance estimate) of ferruginous nodules or concretions which are mostly uncemented, and has a minimum thickness of 0.1 m. Most of the nodules contain at least some manganese, and in some situations the majority (if not all) of the nodules may be transported.		~ Ferric horizon (WRB) ~ Plinthic horizon (WRB) ~ Pisoplinthic horizon (WRB) ~ Soft plinthic B horizon (Sth Africa)
Mottled horizon	ASC	An horizon in which mottle abundance is greater than 10% (visual abundance estimate) and contrast between colours is distinct to prominent. Colour patterns due to biological or mechanical mixing, and inclusions of weathered substrate materials, are not included. As pointed out (see Comment - Hydrosols), mottling does not necessarily imply that oxidising and reducing conditions are currently occurring in the soil in most years.	The platy, polygonal or reticulate patterns of mottling characteristic of 'plinthite' (WRB) are not part of the definition.	~ Ferric horizon (WRB) Includes mottling associated with a Stagnic or Gleyic colour pattern (WRB)
Plinthic horizon 'plinthite'	WRB	1. has within 15 percent or more of the volume, single or in combination: a. discrete nodules that are firm to weakly cemented, with a redder hue or stronger chroma than the surrounding material, and which change irreversibly to strongly cemented or indurated nodules on exposure to repeated wetting and drying with free access of oxygen; OR b. mottles in platy, polygonal or reticulate patterns that are firm to weakly cemented, with a redder hue or stronger chroma than the surrounding material, and which change irreversibly to strongly cemented or indurated mottles on exposure to repeated wetting and drying with free access of oxygen; AND 2. does not form part of a petroplinthic or pisoplinthic horizon; AND 3. has both: a. 2.5 percent (by mass) or more citrate-dithionite extractable Fe in the fine earth fraction or 10 percent or more in the nodules or mottles; AND b. a ratio between acid oxalate (pH 3) extractable Fe and citrate-dithionite extractable Fe of less than 0.10; AND 4. has a thickness of 15 cm or more.	If the plinthic horizon hardens to a continuous sheet (which later may be broken or fractured), it becomes a petroplinthic horizon. If nodules reach 40 percent or more of the volume and harden separately, it becomes a pisoplinthic horizon. If the nodules or mottles that harden on exposure to repeated wetting and drying do not reach 15 percent of the volume, it may be a ferric horizon if it has 5 percent or more nodules or 15 percent or more mottles fulfilling certain additional requirements.	~ Ferric horizon (ASC) ~ Mottled horizon (ASC)
Pisoplinthic horizon 'pisoplinthite'	WRB	1.has 40 percent or more of the volume occupied by discrete, strongly cemented to indurated, reddish to blackish nodules with a diameter of 2 mm or more; and 2. has a thickness of 15 cm or more.	A pisoplinthic horizon results if a plinthic horizon hardens in the form of discrete nodules. The hardness and the amount of the nodules separate it also from the ferric horizon.	~ Ferric horizon (ASC)
Petroplinthic horizon 'petroplinthite'	WRB	1. Is a continuous, fractured or broken sheet of connected, strongly cemented to indurated a. reddish to blackish nodules; or b. reddish, yellowish to blackish mottles in platy, polygonal or reticulate patterns; AND 2. has a penetration resistance of ≥4.5 MPa in ≥50% or more of the volume; AND 3. has a ratio between acid oxalate (pH 3) extractable Fe and citrate-dithionite extractable Fe of less than 0.10; AND 4. has a thickness of 10 cm or more. * may enclose non indurated material	Petroplinthic horizons are closely associated with plinthic horizons from which they develop. In some places, plinthic horizons can be traced by following petroplinthic layers, which have formed, for example, in road cuts. The low ratio between acid oxalate (pH 3) extractable Fe and citrate-dithionite extractable Fe separates the petroplinthic horizon from thin iron pans, bog iron and indurated spodic horizons as occurring in, for example, Podzols, which in addition contain a fair amount of organic matter.	Petroferric horizon (ASC) Hard plinthite B horizon (Sth Africa) Ferricrete (Fitzpatrick, pers.comm. 2012)
Petroferric horizon	ASC	Ferruginous, ferromanganiferous or aluminous nodules or concretions cemented in place into indurated blocks or large irregular fragments.	No defined genetic relationship with plinthic horizon (ASC)	~ Petroplinthic horizon (WRB) ~ Hard plinthic B horizon (Sth Africa)

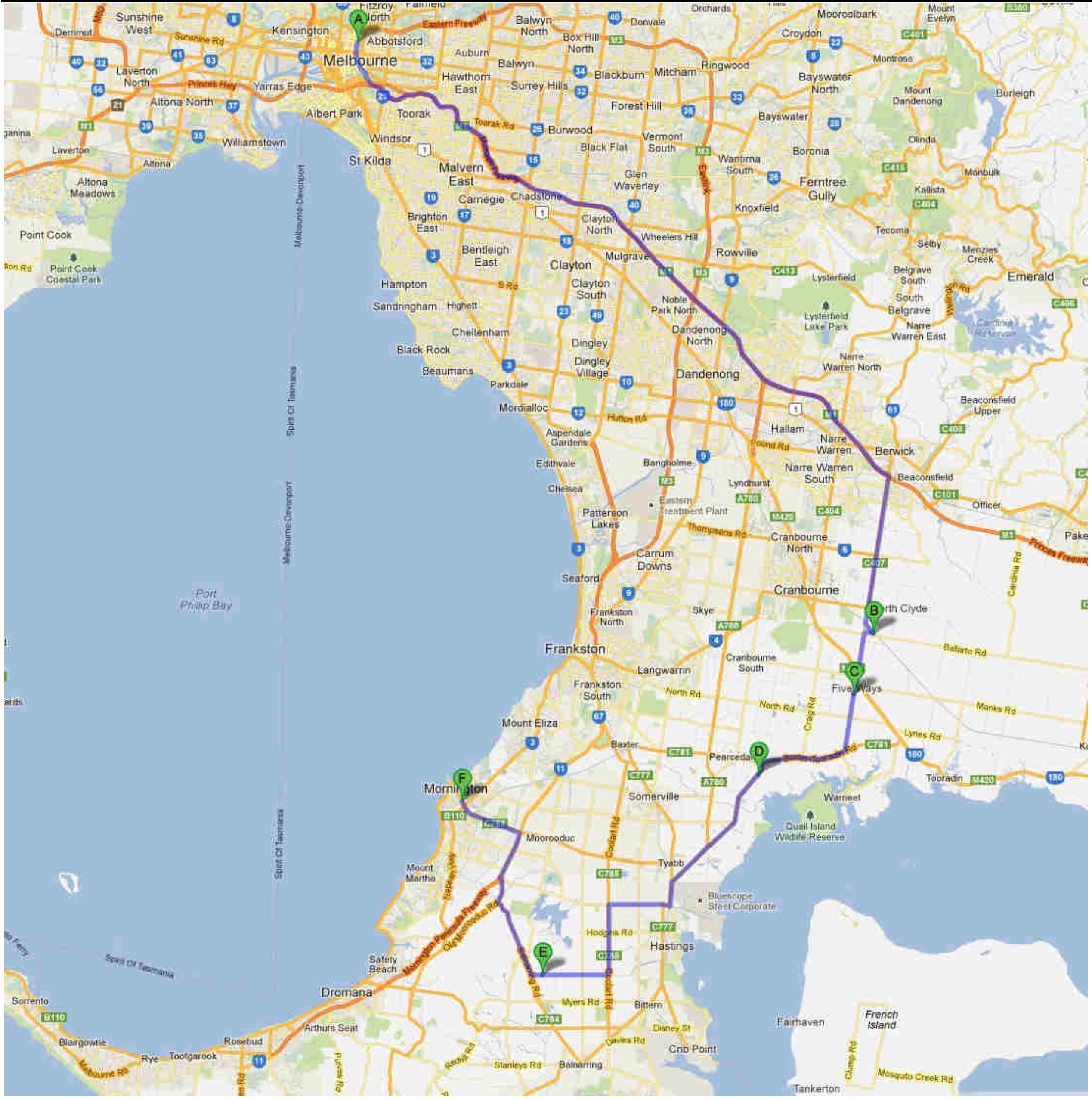
APPENDIX THREE - Ferric materials and plinthite – definitions and correlations

Item	Classif. system	Diagnostics	Notes / Relationships with other horizons	Synonyms / correlation
Soft plinthic B horizon	South Africa	Has undergone localisation and accumulation of iron and manganese oxides under conditions of a fluctuating water table to give many (more than 10% by volume of the horizon) distinct reddish-brown, yellowish-brown and/or black mottles, with or without hardening to form sesquioxide concretions;Has grey colours caused by gleying either in the horizon itself or immediately beneath it;Has, in the non-concretionary parts of the horizon, a loose, friable or slightly firm consistence; the horizon is non-indurated and can be cut with a spade when wet, even though individual mottles may have hardened irreversibly to form concretions;	*"Hardening upon exposure to repeated wetting and drying is not only impossible to determine in the field, but is a property largely based on myth, derived from both mineralogical error and circumstantial field observation rather than sound evidence. Although 'irreversible hardening' may have been verified on occasions since the process was first described by Buchanan, there are simply no reports of this being done routinely enough to establish it as a property warranting inclusion as a defining diagnostic"* (Martin Fey, 2010).	~ Ferric horizon (WRB)~ Plinthic horizon (WRB)~ Pisoplinthic horizon (WRB)~ Ferric horizon (ASC)
Hard plinthic B horizon	South Africa	Consists of an indurated zone of accumulation of iron and manganese oxides which cannot be cut with a spade, even when wet.	No defined genetic relationship with soft plinthic horizon (Sth Africa)	~ Petroplinthic horizon (WRB) Ferricrete (Fitzpatrick, 1982)
Reticulite horizon	ASC	Strongly developed reddish, yellowish and greyish or white, more or less reticulately mottled horizons that can be hand-augered or cut with a spade. Ferruginous nodules or concretions may be present but are not diagnostic. When moist the material usually has at least a firm consistence strength, but following exposure the material may irreversibly harden. At depth it may grade into mottled saprolite.	A potential 'hardening process' is not part of the definition. It is therefore not implied that a reticulate horizon transforms into a petroreticulate horizon on 'drying out'.	Correlates to plinthite with reticulate mottling, but not to the range of plinthite materials implied in WRB and ST; or soft plinthite (Sth Africa). .
Petroreticulite horizon	ASC	A reticulite horizon that is always indurated in the greater part both before and after exposure.		~ Petroplinthic horizon (WRB)

Item	Classif. system	Diagnostics / comments	Synonyms / correlation
Cemented pans	ASC	In the Australian 'field handbook' a pan is defined as an indurated and/or cemented soil horizon and thus horizons such as Bcm, Bkm and Bqm could be interpreted to represent strongly developed B horizons, with consequent effects on the classification of some soils, eg. Kandosols and Tenosols. The Field Handbook also recognised that it can be difficult to determine if materials such as calcrete, ferricrete, silcrete etc. are indeed soil horizons or are better identified as substrate materials, ie. do not show pedological development or are paleo-features. *To avoid the above problem, cemented pans such as calcrete, silcrete, red-brown hardpan, ferricrete, petroferric horizon and petroreticulite are recognised as diagnostic substrate features and hence excluded as criteria of B horizon development.*	The petroferric horizon (ASC) is one type of cemented pan.
Plinthite	Soil Taxonomy	An iron-rich, humus-poor mixture of clay with quartz and other minerals. It commonly occurs as dark red redox concentrations that usually form platy, polygonal, or reticulate patterns. Plinthite changes irreversibly to an *ironstone hardpan* or to irregular aggregates on exposure to repeated wetting and drying, especially if it is also exposed to heat from the sun. The lower boundary of a zone in which plinthite occurs generally is diffuse or gradual, but it may be abrupt at a lithologic discontinuity. Plinthite may occur as a constituent of a number of horizons, such as an epipedon, a cambic horizon, an argillic horizon, an oxic horizon, or a C horizon. It is one form of the material that has been called laterite. It normally forms in a horizon below the surface, but it may form at the surface in a seep area at the base of a slope. *No specific diagnostics are described (in terms of thickness, % soil volume, % mottling/nodules or soil tests). Reticulate mottling is described as evidence of plinthite (field handbook).*	~ 'Plinthite' (WRB) - defined in the context of a plinthic horizon.
Petroferric contact	Soil Taxonomy	A boundary between soil and a continuous layer of indurated material (i.e. *ironstone)* in which iron is an important cement and organic matter is either absent or present only in traces. The indurated layer must be continuous within the limits of each pedon, but it may be fractured if the average lateral distance between fractures is 10 cm or more.	
Ironstone	Soil Taxonomy	Fe-indurated material that forms as layer(s) in a pedon (petroferric contact) OR the hardpan product of plinthite hardening. *Note - not formally defined in ST. Therefore synonymous with petroplinthite.*	Ferricrete (Australia) Petroplinthite (WRB)?
Ironstone	WRB	Mentioned in the 'guidelines for soil description' as a product of plinthite hardening; and also as a sedimentary rock.	Ferricrete
Ferricrete	Aust. 'field handbook'	indurated material rich in hydrated oxides of iron (usually goethite and hematite) occuring as cemented modules and/or concretions, or as massive sheets. This material has been commonly referred to in local usage around Australia as laterite, duricrust or ironstone.	not defined in either the Keys or Field handbooks of relating to WRB/ST.
Ferricrete	Aust.CRC LEME	as above, but emphasising *in-situ* cementation and the fact that the 'the fabric, mineralogy and composition of the cemented materials may reflect those of the parent (regolith) material'.	

Appendix 5: Itinerary and tour maps - Victoria

Date/Time	**Activity**	**Location**	travel time
Sun 25th Nov.	**Accommodation – Downtowner on Lygon** 66 Lygon Street, **Carlton** Vic 3053. ph 03-9663 5555 No Dinner is provided as part of the tour		
Mon 26th Nov.			
0645	Breakfast at Downtowner Motel		
0800	depart Downtowner Motel		
0900	**Site 1 Brown Chromosol** *(Planosol)*	Clyde	1 hour
1100	**Site 2 Grey Sodosol** *(Planosol/Solonetz)*	Cranbourne East (Five Ways)	10 mins
1230	Lunch - Moonlit Sanctuary	Pearcedale	10 mins
1400	**Site 3 Grey Chromosol** *(Luvisol)*	Moonlit Sanctuary	
1600	**Site 4 Brown Sodosol** *(Planosol/Alisol)*	Kooyong Vineyard	30 mins
1830	Arrive Mornington Motel (accommodation) 334 Main Street, Mornington Vic ph 03-5975 3711		20 mins
2000	Dinner		
2130	Discussion session?		
Tues 27th Nov.			
0730	Depart Motel		
0815	Breakfast at Sorrento		45 mins
0900	Ferry crossing to Queenscliff		40 mins
1000	**Site 1 Brown Sodosol** *(Solonetz)*	Murradoc	20 mins
1130	**Site 2 Brown Sodosol** *(Planosol/ Stagnosol/ Regosol)*	Kilgour Winery	10 mins
1300	LUNCH		
1500	**Site 3 Brown Sodosol** *(Vertisol/ Regosol)*	Mt Pollock	1 hour
1630	**Site 4 Brown Sodosol** *(Solonetz)*	Inverleigh West	25 mins
1830	Arrive Warrambeen Landcare Centre (accommodation and dinner) Rokewood Road, Shelford, 3329 ph 03-52813329		20 mins
Wed 28th Nov.			
0810	Depart Warrambeen		
0845	**Site 1 Brown Sodosol** *(Solonetz)* depart 0945	Shelford West	35 mins
1130	Arrive Bet Bet Creek, near Lexton		1hr 30 mins
	Bet Bet Site 1 – Kurosol		
	Bet Bet Site 3 – Sodosol		
	Bet Bet Site 8 – Magnesic Kurosol		
1530	Depart Bet Bet Creek		
1730	Arrive Melbourne Airport (7pm departure for those going on to Launceston)		2 hours



Day 1 Map

A – Start (Downtowner, Carlton)

B – Soil site 1: Clyde

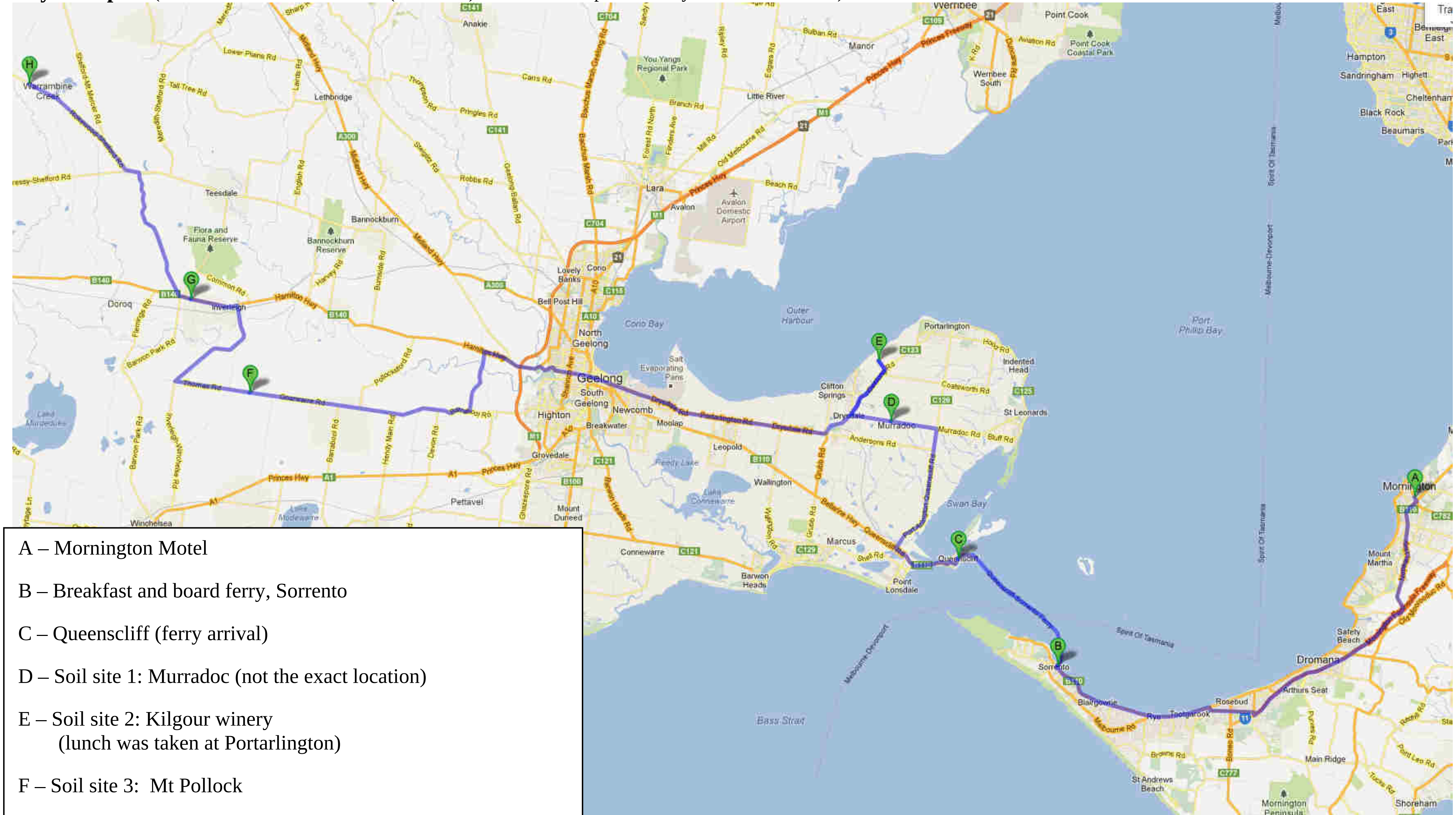
C – Soil site 2: Cranbourne East

D – Lunch and Soil site 3 – Moonlit Sanctuary

E – Soil site 4: Kooyong Vineyard

F – Mornington Motel

Day 2 Map (Note: Location for Soil Site 1 (Murradoc) does not correspond exactly to Site D as shown)



A – Mornington Motel

B – Breakfast and board ferry, Sorrento

C – Queenscliff (ferry arrival)

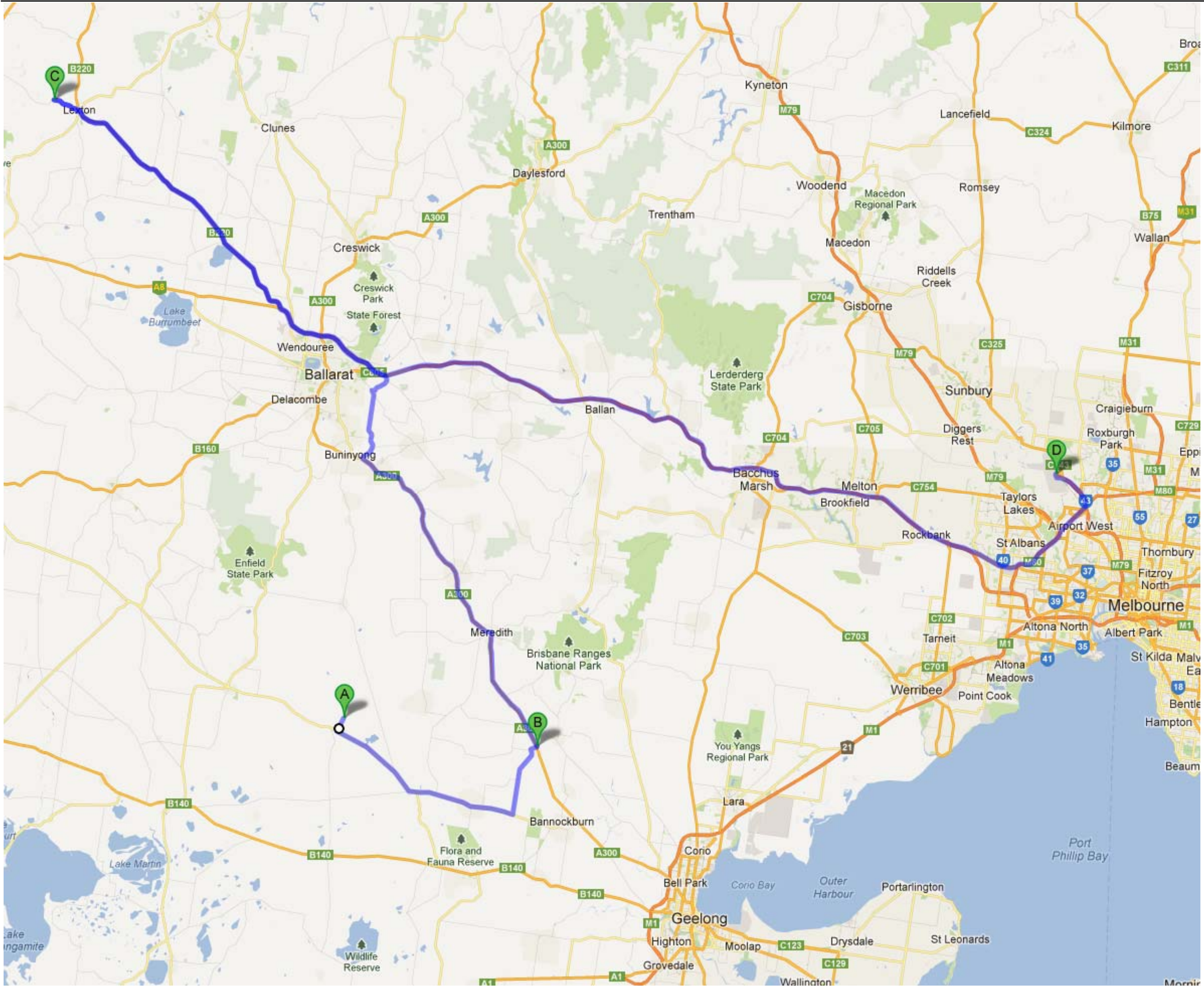
D – Soil site 1: Murradoc (not the exact location)

E – Soil site 2: Kilgour winery
(lunch was taken at Portarlington)

F – Soil site 3: Mt Pollock

G – Soil site 4: Inverleigh West

H – Warrambeen Landcare Centre (dinner and accommodation)



Day 3 Map

A – Warrambeen

B – Soil site 1: Shelford West

C – Soil sites 2,3,4: Bet Bet Creek, Lexton.

D – Melbourne Airport

WRB Field Excursion, Victoria, Australia, November 25-28, 2012. Attendance List.

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