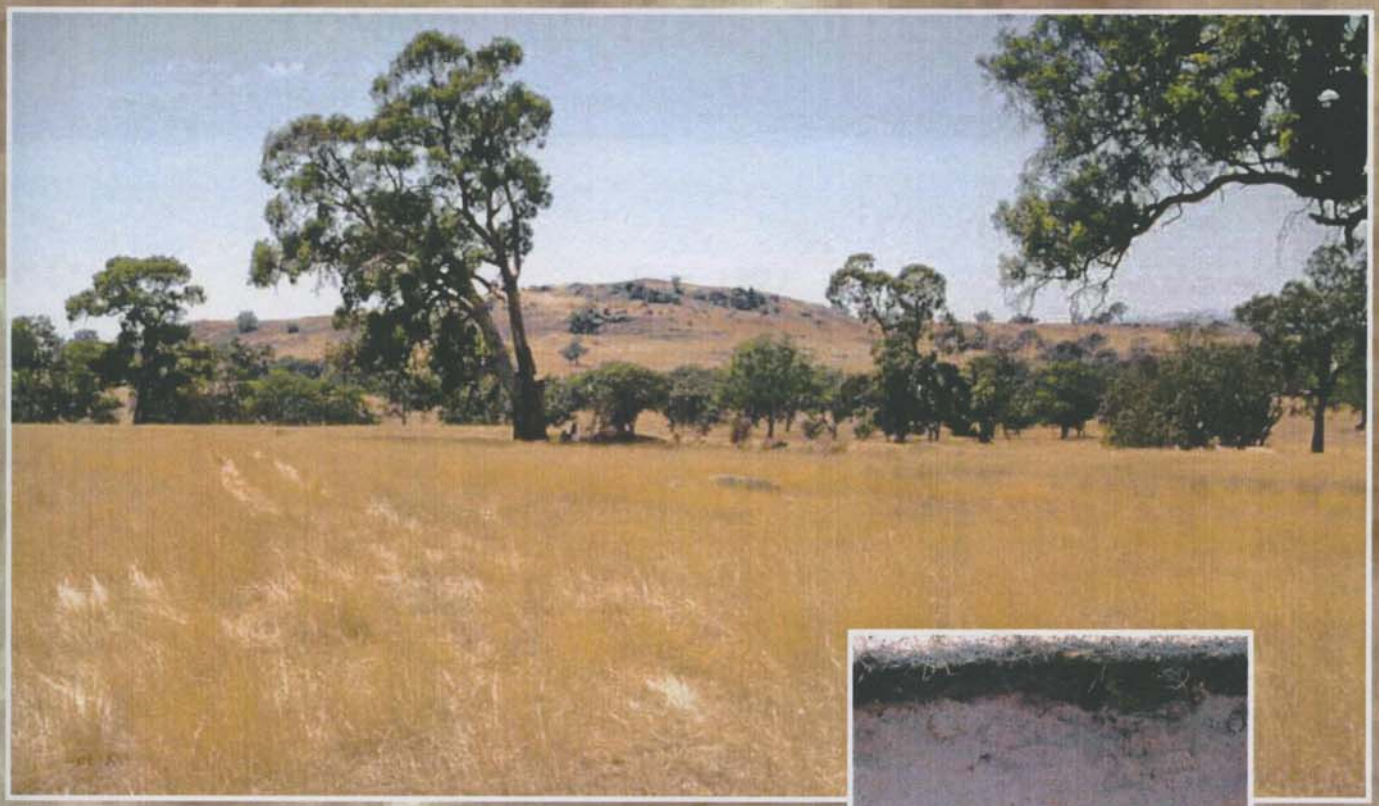
Sutton Grange Landcare Group

Common Soil Types and Landforms

June 1997



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SUTTON GRANGE LANDCARE GROUP

COMMON SOIL TYPES AND LANDFORMS

June, 1997

Centre for Land Protection Research Bendigo
Department of Natural Resources and Environment

Martin Bluml
Grant Boyle

Contents

Introduction

The purpose of this report is to provide landholders with detailed information regarding important soil types and landforms in the Sutton Grange Landcare Group Area. The information can be utilised as a guide to improve on farm management and farm productivity. The report highlights the major constraints to agricultural production imposed by soil conditions and existing landforms, and comments on major forms of land degradation present.

To ensure that representative soil types and landforms were selected for detailed assessment, site selection was undertaken by experienced land inventory staff from the Centre for Land Protection Research. This involved selecting sites which represented land systems identified by Lorimer & Schoknecht (1987) in 'A study of the land in the Campaspe River Catchment'.

Please note: the physical and chemical analysis of soils presented in Appendix A&B are specific to each individual pit location, further soil testing is recommended for management of other properties or paddocks. Pit locations are marked in Figure 1. Land Systems of the Sutton Grange Landcare Group Area.

1. Overview of the Geology and Soils.

The Sutton Grange Landcare Group Area occurs within the Western Highlands of Victoria. The landforms and soils visible today have formed in response to periods of significant marine deposition, igneous intrusion, faulting and folding, uplift and erosion, volcanism and recent alluvial deposition. The landforms and soils have been linked to the land systems presented in 'A study of the land in the Campaspe Catchment' by Lorimer & Schoknecht, 1987.

The oldest geological formations in the area come from the Ordovician period over 395 million years ago. During the Ordovician, deep marine sediments were deposited along the eastern coastline. The deposition of these marine sediments continued into the lower Devonian period.

The middle to upper Devonian period was notable for considerable uplift, folding and faulting of the marine sediments, and extensive igneous activity forming the granitic complex at Harcourt. The Harcourt complex was formed when granitic magma intruded into the overlying Ordovician sediments. The magma then cooled and solidified forming the large granite batholith. Continued uplift and erosion of the overlying sediments then led to the exposure of the granitic surface.

The intrusion of the Harcourt granite was responsible for considerable metamorphism and uplift of Ordovician sediments. This lead to the development of a prominent ridgeline running from Big Hill to Metcalfe. This landform is commonly referred to as a metamorphic aureole.

A long interval then occurred, where extensive erosion rather than igneous or sedimentary activity followed. This interval lasted from the Carboniferous period through to the Cretaceous period over 65 million years ago.

The Tertiary period saw renewed igneous activity and uplift which persisted until the lower Quaternary period 1.8 million years ago. During the lower Quaternary, basaltic lavas flowed from volcanoes to the south, following the Campaspe and Coliban River corridors, while uplift rejuvenated stream activity and erosion. Significant stream activity and erosion have removed much evidence of the once extensive basalt flows, and has contributed to the development of recent alluvial deposition along rivers and streams.

1.1 Quaternary Volcanics.

Olivine basalt was deposited by lava flows which followed river corridors such as the Coliban and Campaspe Rivers. The basalt terrain is comprised of elevated rocky plains, steep scarps, and moderate to gentle slopes. The elevated basalt plains are usually broken by drainage lines, often leaving only small isolated remnants behind. Two distinct soil types occur on the volcanic terrain.

The slightly undulating, elevated basalt plains often contain uniform grey cracking clay soils of variable depth, or red gradational soils of shallow depth. The elevated plateau may be free of surface rock in some localities.

At the edge of the basalt plain, a narrow, steep rocky scarp is usually present. Below the scarp are steep to gentle slopes with shallow, red gradational soils. In very shallow situations, red uniform clay loam soils may be found. Surface rock is common on the steep and moderate slopes- The basalt cap is thin or absent at

the edge of the plain and contact with underlying sedimentary or granite materials may occur.

The basalt plains and scarps are represented by the Redesdale land system in Figure 1.

1.2 Devonian granite/granodiorite.

Devonian granite and granodiorite has intruded into Ordovician sediments to form what is commonly referred to as the Harcourt Granite. The Harcourt Granite extends from the Big Hill Range near Bendigo, south to Elphinstone and Metcalfe. The granite terrain is diverse, with undulating plateaus, steep to moderate rocky hills, gentle rises and broad drainage lines. Granite tors and boulders are characteristic of the steep and rugged granite terrain.

Rocky crests with steep and moderate rocky slopes dominate the steep granitic terrain. These slopes may contain shallow uniform soils where rock outcrops, and yellow duplex soils where the soil profile deepens. On many steep slopes, sheet erosion has removed the shallow dark topsoil which is normally present- This landform is represented by the Sargent land system in Figure 1.

Gentle undulating hills and rises cover the majority of the Landcare Group Area. Rock outcrop is usually limited to the crests. Soil depth often exceeds 1.5m with bleached and mottled yellow duplex soils common. In small drainage depressions, deep versions of the bleached and mottled yellow duplex soils often occur. This landform is represented by the Sutton Grange land system in Figure 1.

Along major creek lines, small river terraces or flats may form containing deep uniform loams. Often these soils contain sand lenses at depth.

Sheet and gully erosion are serious problems in the granitic terrain due to sandy topsoils, steep slopes and poor vegetative cover. Landslip may occur on very steep slopes. Salting also occurs in isolated drainage depressions where springs and dams result in restricted drainage and waterlogging.

1.3 Ordovician sediments.

Much of the steep sedimentary terrain has been formed through uplift, folding and faulting associated with the intrusion of granitic rock below the Ordovician sediments.

Where granitic magma has made direct contact with the sedimentary rock, the heat associated with the upwelling granitic magma has baked and hardened the sedimentary rock. The metamorphosed rock is less susceptible to weathering and has seen the development of the prominent ridgeline which marks the metamorphic aureole.

The metamorphic aureole is characterised by prominent, narrow rocky crests with steep to moderate slopes. Soils are generally shallow and contain a high amount of stone and gravel. Red gradational and red duplex soils are common, with uniform loams present where rock outcrops . The James land system represents the metamorphic aureole in Figure 1.

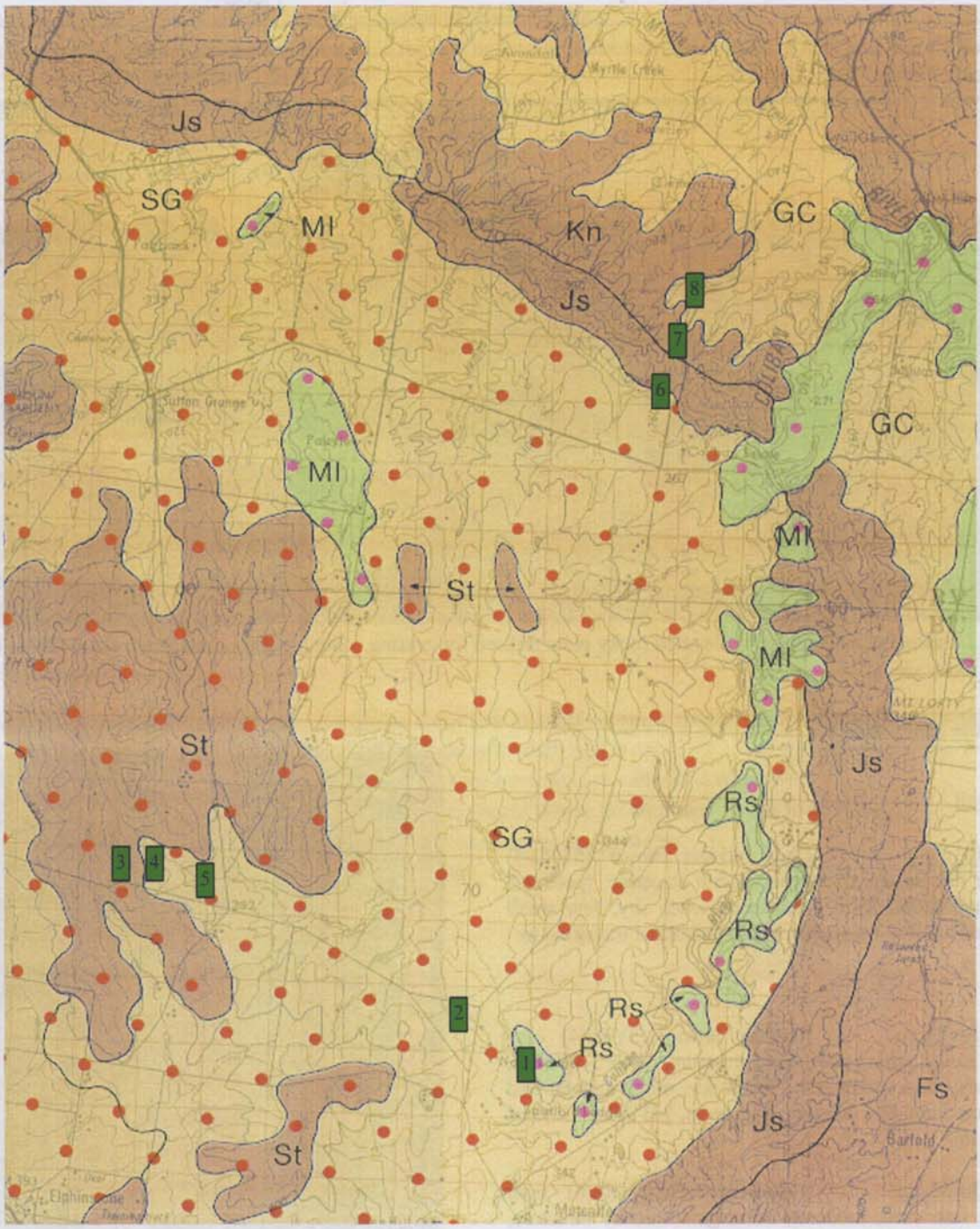
The rocky crests and steep dissected slopes which occur close to the aureole may still show some evidence of metamorphism. Soils depth varies markedly due to the steep terrain and tightly folded and faulted sediments. In general, stony uniform sandy loams are common where depth to rock is shallow. Weak structured, stony gradational soils and yellow duplex soils dominate where soil depth increases, especially when moderate slopes are encountered. Surface stone is common on all crests and steep to moderate slopes. The Kimbolton land system represents this landform in Figure 1.

Away from the aureole, low undulating hills with gentle crests and broad drainage depressions occur. Soils of the low, undulating hills show less variation and soil depth regularly exceeds 1.5 m in drainage lines. Soils present on gentle crests are mostly yellow duplex with uniform or gradational soils present where soils are shallow or rock outcrops. Bleached and mottled yellow duplex soils dominate the gentle slopes and broad drainage depressions of the low, undulating hills. Surface stone is less common. The Glen Cooee land system represents this landform in Figure 1.

Various land degradation problems exist within the sedimentary terrain. In the steeper terrain, sheet erosion and gully erosion are common where vegetation cover is sparse. The presence of highly fractured rock outcrop and shallow stony soils also contributes to local and regional groundwater recharge.

In the low, gently undulating terrain, gully erosion is widespread, while waterlogging and salting are common along drainage lines and below leaking dams. In these situations, Spiny Rush is a good indicator of waterlogging and salinity.

FIGURE 1- LAND SYSTEMS IN THE SUTTON GRANGE LANDCARE GROUP AREA



LEGEND - Land Systems

Pit Sites

Symbol	Name	Geology	Landform
Rs	Redesdale	Quaternary volcanics	Elevated plains & steep scarps
Js	James	Metamorphosed sediments	Steep hills & prominent rideglines
SG	Sutton Grange	Devonian granite	Rises & hills with gentle slopes
St	Sargeant	Devonian granite	Moderate to steep hills
Gc	Glen Cooee	Ordovician Sediments	Rises & hills with gentle slopes
Kn	Kimbolton	Ordovician sediments	Moderate to steep hills

source: Lorimer, M.L. & Schoknecht, N.S. (1987)

SITE 1: Quaternary Volcanics	**Property:** Ross Mactier "North Lodge"
Aust Soil Class: Red FERROSOL **Northcote Factual Key:** Gn4. 1 2	**Land System:** Redesdale **Grid Ref:** 270 800/5893 250

General Landform Description: Elevated rocky plain utilised for grazing. Site located on moderate slope (25%) below the elevated rocky plain.

Soil Profile Morphology:

Surface soil

Al 0-10 cm Dark reddish brown (5YR3/4) *clay loam fine sandy*, strong polyhedral structure, (peds 2-5 mm), rough fabric, firm consistence when dry, few small subrounded basaltic fragments, pH 5.6. Gradual transition to:

Subsoil

B21 10-30 cm Reddish brown (5YR4/4) *clay loam fine sandy*, strong polyhedral structure, (peds 5-10 mm), rough fabric, firm consistence, when dry, many angular and rounded medium size basaltic fragments, pH 6.2. Gradual transition to:

B22 30-60 cm Yellowish red (5YR4/6) *light clay* with fine sand, moderate subangular blocky structure, (peds 20-30 mm), rough fabric, very firm to strong consistence when dry, many angular and rounded large basaltic fragments, pH 6.7. Wavy transition to:

D1 60-70 cm Reddish yellow (7.5YR6/6) moist, pink (7.5YR7/4) dry, *clayey coarse sand*, massive structure, many small subangular and rounded granitic fragments. Sharp transition to:

D2 70-150+ cm Light grey (2.5Y7/2) *heavy clay* with coarse sands, few distinct medium size brownish yellow mottles, moderate prismatic structure, smooth fabric, (peds 5-10 mm), strong consistency when moist, pH 7.0

Key Profile Features:

- High inherent fertility (based on the sum of exchangeable basic cations).
- Moderate to strongly structured soils (favourable for root and water movement).
- Well drained.
- High content of stone and boulders.
- High level of iron oxides.
- Lack of strong texture contrast between topsoil and subsoil

Soil Profile Characteristics:

Horizon	pH	Salinity	Sodicity	Dispersion
Surface (Al horizon)	Moderately acid	Low	Non sodic	Low
Upper subsoil (B21 horizon)	Slightly acid	Very low	Non sodic	Low
Lower subsoil (B22 horizon)	Neutral	Very low	Non sodic	Very Low

Limitations for Agriculture:

Surface (A) horizons

- Surface horizons are well drained and may suffer from low available water capacity in dry years. High wilting point (22%) indicates that plants will be unable to utilise light rain when soil is dry.
- Soil structure decline and compaction will occur if surface horizons are cultivated when wet.
- Surface horizons are at risk of severe erosion on steeper slopes where groundcover is less than 30%.
- Surface stone and boulders will restrict the establishment of crops and pastures.
- Moderately acid surface soils may effect pasture growth.

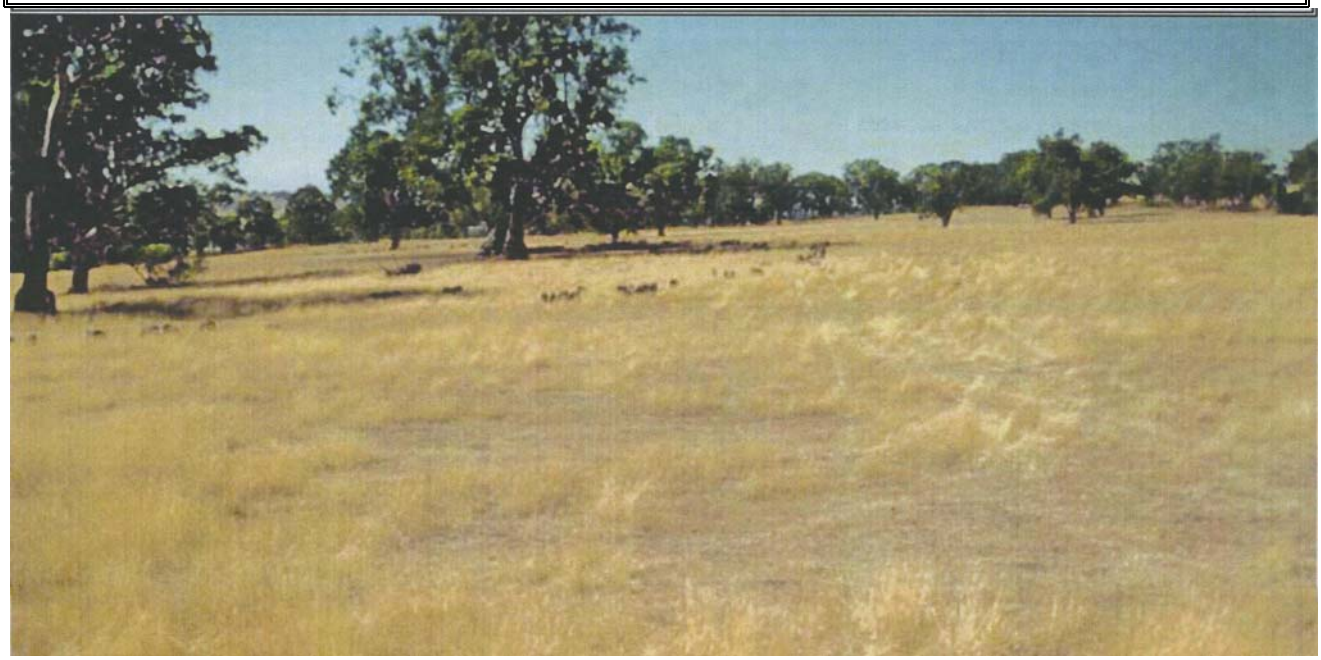
Subsoil (B) horizons

- When subsoil is exposed, sheet erosion will occur.
- Less permeable granitic clay underlies the basalt subsoil.

Comments from Landholder:

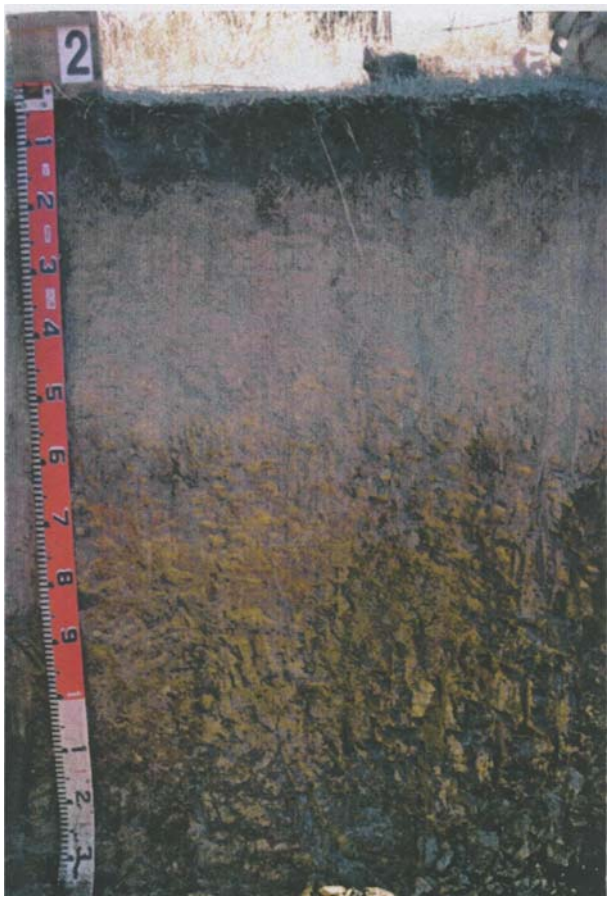
- 1995 2t/ha lime
- 1994-97 250kg/ha single super
- 1970-93 125kg/ha single super

SITE 2: Devonian Granite	**Property:** Ross Mactier "North Lodge"
Aust Soil Class: Yellow KUROSOL **Northcote Factual Key:** Dy3.42 (yellow duplex)	**Land System:** Sutton Grange **Grid Ref:** 296 812 / 5893 450



General Landform Description: Gentle rises utilised for grazing, site located on 3% slope.

Soil Profile Morphology:



Surface soil

Al **0-10** cm Very dark greyish brown (10YR3/2) *sandy loam*, weak subangular blocky structure, (peds 20-50 mm), rough fabric, weak consistence when dry, pH 5.0. Clear transition to:

A21 10-35 cm Brownish yellow (10YR6/6) moist, very pale brown (10YR8/3) dry, *sandy loam*, massive structure, rough fabric, firm consistence when dry, many small (2-6 mm) subrounded quartz fragments, pH 5.1. Gradual transition to:

A22 35-45 cm Very pale brown (10YR7/4) moist, pinkish white (7.5YR8/2) dry coarse *sandy clay loam*, reddish yellow mottles are common, massive structure, rough fabric, very firm consistence when dry, many small (2-6 mm) subrounded quartz fragments. Abrupt transition to:

Subsoil

B21 45-75 cm Light yellow brown (10YR6/4) *medium clay*, many red and orange mottles, strong prismatic structure, (peds 50-100 mm breaking to 10-20 mm), smooth fabric, strong consistence when moist, many small (2-6 mm) subrounded quartz fragments, pH 5.6. Gradual transition to:

B22 75-90 cm Light yellowish brown (10YR6/4) *silty clay loam*, red orange and yellow mottles are common, weak to moderate slickensides subangular blocky structure, (peds 50-100 mm breaking to 10-20 mm), smooth fabric, weak consistence when moist, many small (2-6 mm) subrounded quartz fragments.

BC 90-130+ cm Light grey (2.5Y7/2) lenticular structured *weathered granitic horizon.*

Key Profile Features:

- Strong texture contrast between topsoil and subsoil
- Poorly structured topsoils
- Bleached A2 horizon

Soil Profile Characteristics:

Horizon	pH	Salinity	Sodicity	Dispersion
Surface (Al horizon)	Strongly acid	Low	Non sodic	Very low
Sub-surface (A21 horizon)	Strongly acid	Very low	Strongly sodic	Low
Upper subsoil (B21 horizon)	Moderately acid	Very low	Strongly sodic	Very low

Limitations for Agriculture:

Surface (A) horizons

- Organic carbon levels indicate that organic matter content of the topsoil is low. Organic matter contributes to the development of soil structure, fertility and water holding capacity.
- Topsoils have a low inherent fertility (based on the sum of exchangeable basic cations). This is the result of extensive leaching of the sandy topsoils.
- Moderate levels of aluminium (57-63 mg/kg in Al&A2 horizons) may effect sensitive plant species.
- Impeded drainage in the B horizon leads to waterlogging of the A2 horizon and leaching of organic matter and soil nutrients from the topsoil.
- Vehicle access may be limited in wet months as the bleached A2 horizon becomes waterlogged and spewy.

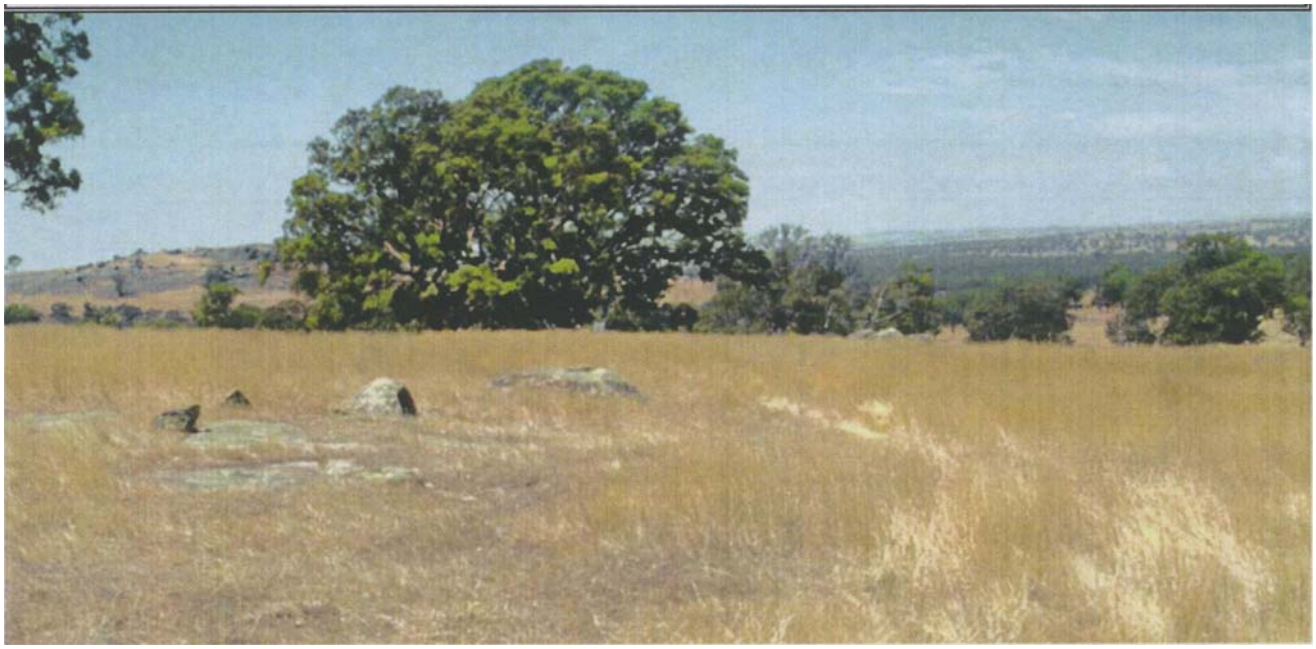
Subsoil (B) horizons

- Mottling in the subsoil indicates impeded drainage.
- Subsoils are susceptible to gully erosion when surface horizons are removed, due to considerable slaking in the upper B horizon.

Comments from Landholder:

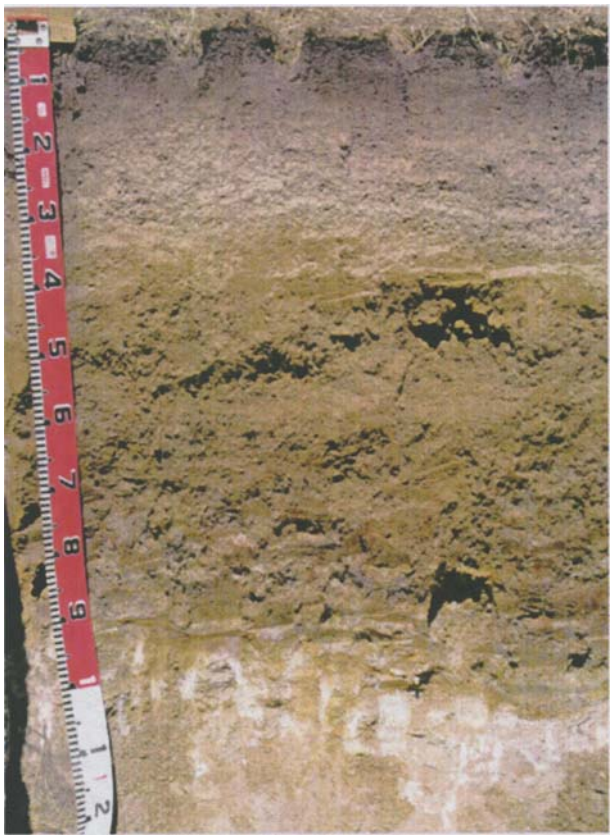
- 1995 2 t/ha lime
- 1994-97 250 kg/ha single super
- 1970-93 125 kg/ha single super

SITE 3: Devonian Granite	**Property:** Jock MacRae "Eilan Donan"
Aust Soil Class: Yellow KUROSOL **Northcote Factual Key:** Dy3.41 (yellow duplex)	**Land System:** Sargent **Grid Ref:** 264 751 / 5895 551



General Landform Description: Steep rocky crests and slopes utilised for grazing, site location on granite crest (5%).

Soil Profile Morphology:



Surface soil

Al **0-10** cm Very dark greyish brown (10YR3/2) *sandy loam10*YR3/2subangular blocky structure, (peds 5-10 mm), rough fabric, few small quartz fragments, pH 4.9. Clear transition to:

A2 10-30 cm Light brownish grey (2.5Y6/2) moist, very pale brown (10YR8/2) dry, *coarse sandy loam*, massive structure, rough fabric, many small to medium size rounded quartz fragments, pH 5.2. Abrupt transition to:

Subsoil

B21 30-65 cm Light yellowish brown (10YR6/4) *light medium clay*, red mottles present, moderate to strong subangular blocky structure (peds 10-20 mm breaking to 5-10 mm), smooth fabric, very firm consistence when moist, many small rounded quartz fragments, pH5.5. Gradual transition to:

B22 65-100 cm Yellowish brown (10YR5/6) *light medium clay*, red grey and yellow mottles present, moderate to strong subangular blocky structure, (peds 10-20 mm breaking to 5-10 mm), weak consistence when moist.

C 100+ cm *Weathered granitic rock.*

Key Profile Features:

- Strong texture contrast between topsoil and subsoil
- Significant rock outcrop
- Shallow soils common
- Poorly structured topsoils
- High coarse sand content.
- Conspicuously bleached A2 horizon

Soil Profile Characteristics:

Horizon	pH	Salinity	Sodicity	Dispersion
Surface (Al horizon)	Very strongly acid	Very low	Non sodic	Very low
Sub-surface (A2 horizon)	Strongly acid	Very low	Sod(34-230	High
Upper Subsoil (B21 horizon)	Strongly acid	Very low	Sodic	Very low

Limitations for Agriculture:

Whole profile

- Strongly acid topsoils and subsoils may affect pasture growth.
- Levels of aluminium throughout strongly acid profile (84-230 mg/kg) may affect sensitive plant species.

Surface (A) horizons

- Very shallow sandy soils are present where rock outcrops at or near the surface. These shallow sandy soils have limited water and nutrient holding capacity. The wilting point for the surface soil indicates that plants can utilise light rainfalls, however moisture stress will soon follow.
- Soils are subject to severe sheet erosion on steeper slopes.
- Organic carbon levels indicate that organic matter content of the topsoil in low. Organic matter contributes to the development of soil structure, fertility and water holding capacity.
- The topsoils have a low inherent fertility (based on the sum of exchangeable cations). This is the result of extensive leaching of the sandy topsoils.
- High dispersibility, particularly in the A2 horizon, may result in sheet erosion where the topsoil is disturbed.

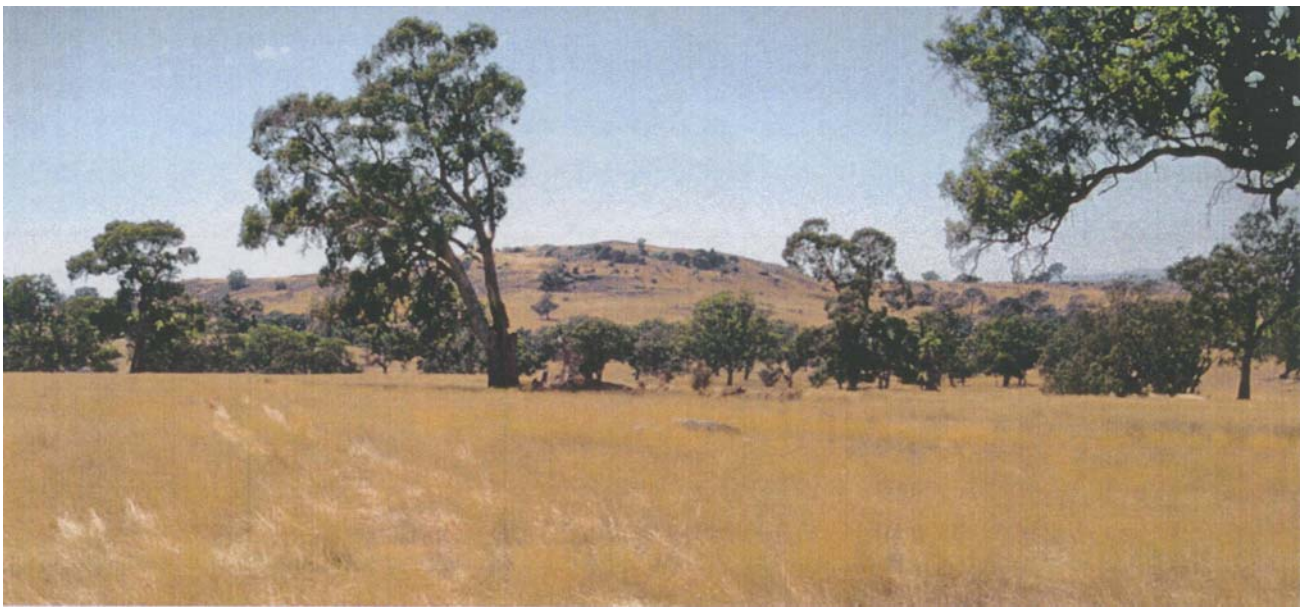
Subsoil (B) horizons

- B horizon may be absent where rock outcrop occurs.
- A substantial zone of weathered granitic1939k may underlie the subsoil at shallow depth.

Comments from Landholder:

- Pasture response to single super has been dependent upon the Autumn break.
- 1996 100 kg/ha single super
- 1993 100 kg/ha single super
- 1991 100 kg/ha single super
- Pre 1989 100 kg/ha single super

SITE 4: Devonian Granite	**Property:** Jock MacRae "Eilan Donan"
Aust Soil Class: Yellow KUROSOL **Northcote Factual Key:** Dy3.41 (yellow duplex)	**Land System:** Sargent **Grid Ref:** 265 010/ 5895 450



General Landform Description: Moderate slopes utilised for grazing, site location on moderate slope (10%) with occasional rock outcrop.

Soil Profile Morphology:

Surface soil

Al **0-10**cm Very dark brown (10YR2/2) *sandy loam*, weak subangular blocky structure, rough fabric, weak consistence when dry, few small subrounded quartz fragments, pH 5.0. Clear transition to:

A2 **10-60** cm Light yellowish brown, (10YR6/4 moist), white (10YR8/1 dry) *coarse sandy loam*, massive structure, rough fabric, firm consistence when dry, small quartz subrounded fragments are common, pH 5.6. Clear transition to:

A22 60-70 cm Light yellowish brown (2.5Y6/4 moist), very pale brown (10YR8/2 dry) *coarse sandy clay loam*, massive structure, rough fabric, very firm consistence when dry, abrupt transition to:

Subsoil

B21 70-90 cm Pale brown (10YR6/4) *medium clay*, many prominent red and yellow medium size mottles, moderate subangular blocky structure, (peds 50-100 mm breaking to 10-20 mm), smooth fabric (slickensides), weak consistence when moist, few coarse fragments, pH 6.0. Gradual transition to:

B22 90-130+ cm Light brownish grey (10YR6/2) *medium clay*, many prominent red and yellow medium size mottles, moderate to strong lenticular and subangular blocky structure, (peds 50-100 mm breaking to 10-20 mm), smooth fabric (slickensides), weak consistence when moist, few coarse fragments.

Key Profile Features:

- Strong texture contrast between topsoil and subsoil.
- Poorly structured topsoils.
- Conspicuously bleached A2 horizon.
- Occasional rock outcrops.
- High coarse sand content.

Soil Profile Characteristics:

Horizon	pH	Salinity	Sodicity	Dispersion
Surface (Al horizon)	Strongly acid	Low	Non sodic	Very low
Subsurface (A2 horizon)	Moderately acid	Very low	Non sodic	Low
Upper Subsoil (B2 horizon)	Moderately acid	Very low	Sodic	Very Low

Limitations for Agriculture:

Whole profile

- Moderate to strongly acid topsoils and subsoils may affect pasture growth.

Surface (A) horizons

- Organic carbon levels indicate that organic matter content of the topsoil is low. Organic matter contributes to the development of soil structure, fertility and water holding capacity.
- The topsoils have a low inherent fertility (based on the sum of exchangeable cations). This is the result of extensive leaching of the sandy topsoils.
- Considerable slaking in the A2 horizon, may result in sheet and gully erosion where the topsoil is disturbed.
- Very shallow sandy soils are present where rock outcrops at or near the surface. These soils have a very poor productive capacity, and are subject to severe sheet erosion on steeper slopes.
- Impeded drainage in the B horizon leads to saturation of the A2 horizon and leaching of organic matter and soil nutrients from the topsoil.
- Vehicle access may be limited in wet months as the bleached A2 horizon becomes waterlogged and spewy.

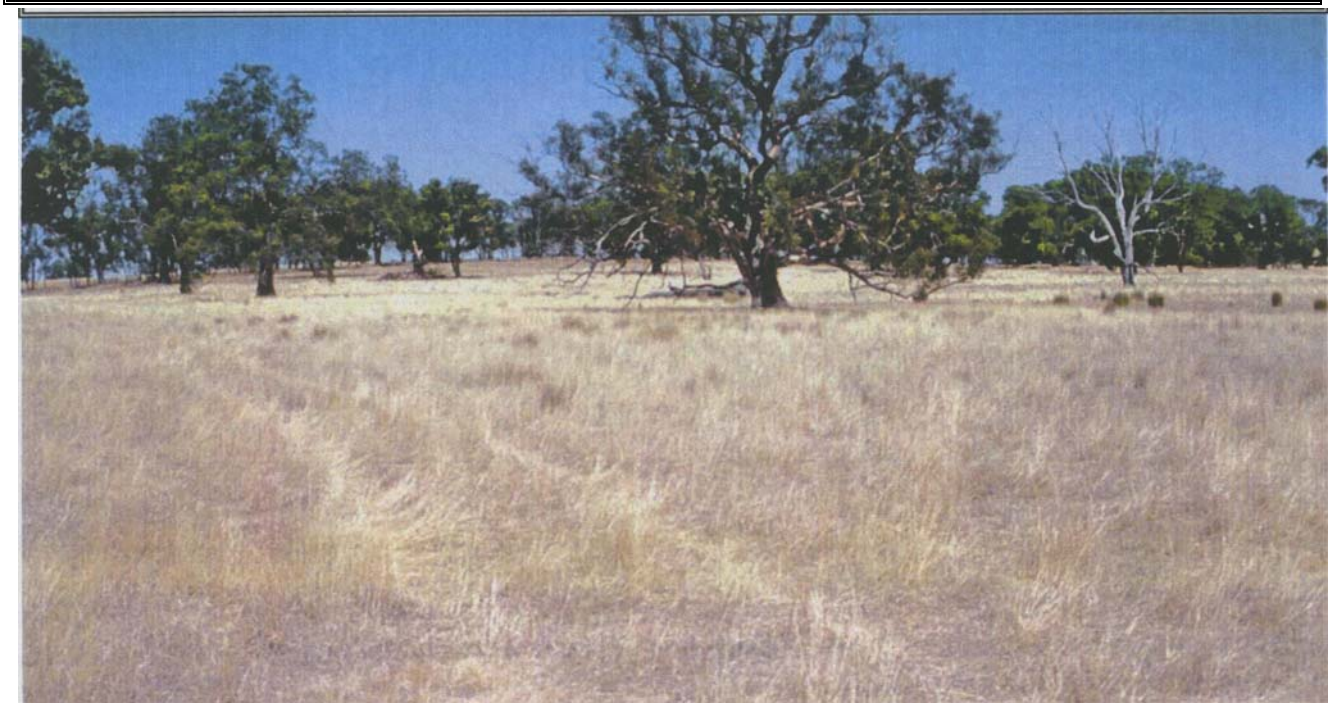
Subsoil (B) horizons

- Mottling in the subsoil indicates impeded drainage.
- Subsoils are susceptible to gully erosion due to considerable slaking and sodicity in the upper B horizon.
- A substantial zone of weathered rock may underlie the subsoil at shallow depth.
- High levels of exchangeable magnesium may result in nutrie1939mbalance (eg. calcium deficiency).

Comments from Landholder:

- Pasture response to single super has been dependent upon the Autumn break.
- 1996 100 kg/ha single supSubsurface (A2
- 1993 100 kg/ha single super
- 1991 100 kg/ha single super
- Pre 1989 100 kg/ha single super

SITE 5: Devonian Granite	**Property:** Jock MacRae "Eilan Donan"
Aust Soil Class: Brown KUROSOL **Northcote Factual Key:** Dy3.42 (yellow duplex)	**Land System:** Sargeant **Grid Ref:** 266 150 / 5895 325



General Landform Description: Undulating low hills, utilised for grazing, site located on gentle slope (5%).

Soil Profile Morphology:

Surface soil

Al 0-20 cm Very dark greyish brown (10YR3/2) *sandy loam*, weak subangular blocky structure, rough fabric, weak consistence when dry, few small subrounded quartz fragments, pH 4.6. Clear transition to:

A2 20-50 cm Pale brown (10YR6/3 moist), light grey (10YR7/2 dry) *coarse sandy loam*, massive structure, rough fabric, firm consistence when dry, small quartz subrounded fragments are common, pH 4.9. Abrupt transition to:

Subsoil

B21 50-80 cm Yellowish brown (10YR5/4) *medium clay*, many prominent red and yellow medium size mottles, moderate subangular blocky & polyhedral structure, (peds 10-20 mm breaking to 5-10 mm), smooth fabric (slicken sides), weak consistence when moist, few coarse fragments, pH 5.6. Wavy transition to:

BC 80-120+ cm *medium clay* and weathered parent material.

Key Profile Features:

- Strong texture contrast between topsoil and subsoil.
- Poorly structured topsoils
- Bleached A2 horizon
- High coarse sand content in surface horizons.

Soil Profile Characteristics:

Horizon	pH	Salinity	Sodicity	Dispersion
Surface (Al horizon)	Very strongly acid	Low	Non sodic	Very Low
Sub-surface (A2 horizon)	Very strongly acid	Very low	Sodic	Low
Upper Subsoil (B21)	Moderately acid	Very low	Non sodic	Very Low

Limitations for Agriculture:

Whole profile

- Moderate to very strongly acid topsoils and subsoils may affect pasture growth.

Surface (A) horizons

- Organic carbon levels indicate that organic matter content of the topsoil in low. Organic matter contributes to the development of soil structure, fertility and water holding capacity.
- Moderate levels of aluminium (78-92 mg/kg) may effect sensitive plant species.
- The topsoils have a low inherent fertility (based on the sum of exchangeable basic cations). This is the result of extensive leaching of the sandy topsoils.
- Partial slaking in the A2 horizon, may cause sheet and gully erosion if the topsoil is disturbed.
- Impeded drainage in the B horizon leads to saturation of the A2 horizon and leaching of organic matter and soil nutrients from the topsoil.
- Vehicle access may be limited in wet months as the bleached A2 horizon becomes waterlogged and spewy.

Subsoil (B) horizons

- Mottling in the subsoil indicates impeded drainage.
- A substantial zone of weathered rock ma1939derlie the subsoil at shallow depth.

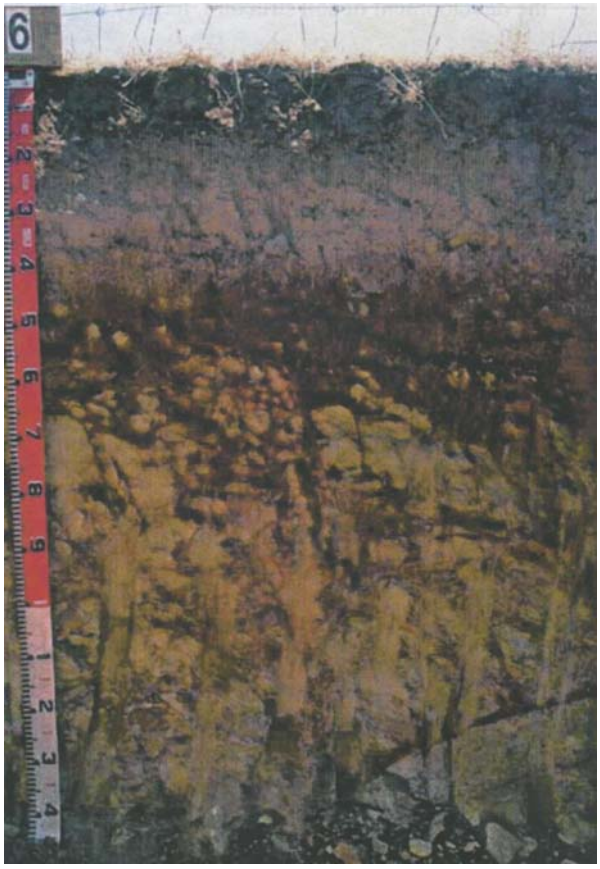
Comments from Landholder:

- Pasture response to single super has been dependent upon the Autumn break.
- 1996 100 kg/ha single super
- 1993 100 kg/ha single super
- 1991 100 kg/ha single super
- Pre 1989 100 kg/ha single super

SITE 6: Ordovician sediments (metamorphosed)	**Property:** B & T James "Coliban Estate"
Aust Soil Class: Red KUROSOL **Northcote Factual Key:** Dr2.41 (red duplex)	**Land System:** James **Grid Ref:** 272 775 / 5903 750

General Landform Description: Steep crests and slopes of the metamorphic aureole utilised for grazing, site is located on an upper slope (15%).

Soil Profile



Morphology:

Surface soil

Al 0-15 cm Brown (7.5YR4/2) *loam fine sandy,* weak subangular blocky structure (peds 10-20 mm), rough fabric, firm consistence when dry, small angular sedimentary and quarts fragments are common, pH 5.2. Clear transition to:

A2 **15-40** cm Pink (7.5YR7/4 moist), very pale brown (10YR8/3 dry) *fine sandy loam,* massive structure, rough fabric, medium size angular sedimentary fragments are common, pH 5.2. Abrupt transition to:

Subsoil

B2 **40-60 cm** Dusky red (2.5YR4/4) *light medium clay,* moderate to strong polyhedral structure, (peds 10-20 mm breaking to 5-10 mm), smooth fabric, firm to very firm consistence when moist, many small angular sedimentary fragments, pH 5.1. Sharp wavy transition to:

C **60-140+ cm** *Weathered parent material.*

Key Profile Features:

- Shallow soils
- Poorly structured topsoils
- High sand, gravel and stone content
- Extensive rock outcrop

Soil Profile Characteristics:

Horizon	pH	Salinity	Sodicity	Dispersion
Surface (Al horizon)	Strongly acid	Low	Non sodic	Low
Sub-surface (A2 horizon)	Strongly acid	Very low	Non sodic	Low
Subsoil (B2)	Strongly acid	Very low	Non sodic	Very Low

Limitations for Agriculture:

Whole Profile

- Strongly acid topsoils and subsoils may affect pasture growth.
- Plant available water capacity is low.
- Aluminium toxicity throughout profile (76-240 mg/kg) may affect sensitive plant species.

Surface (A) horizons

- The topsoils have a low inherent fertility (based on the sum of exchangeable basic cations). This is the result of extensive leaching of the sandy, gravelly topsoils.
- Sandy topsoils are susceptible to sheet erosion, particularly where sheep camp and less than 30% vegetation cover is present.

Subsoil (B) horizons

- Subsoils may be absent where extensive rock outcrop occurs.
- High levels of exchangeable magnesium may result in nutrient imbalance (e.g. calcium deficiency).
- Rock underlies the subsoil at shallow depth.

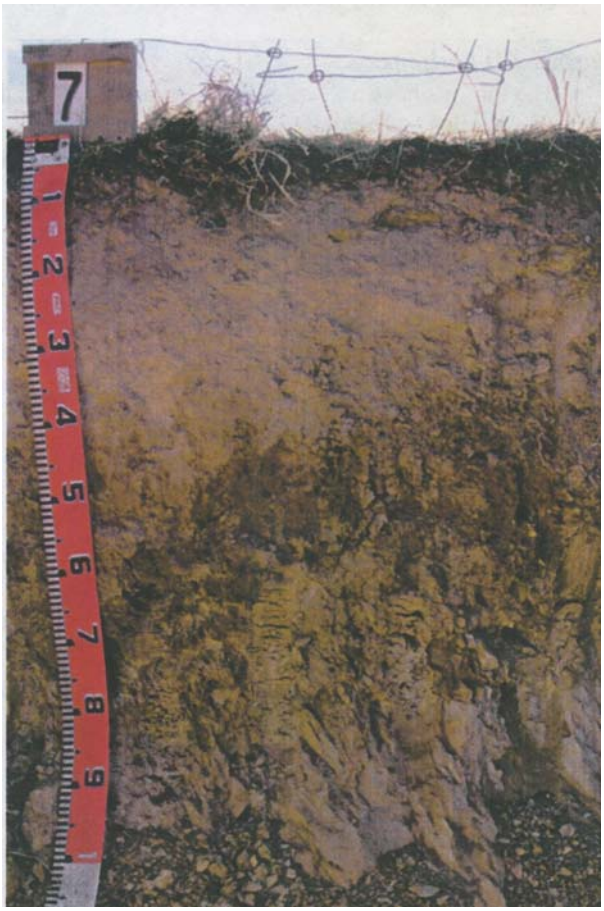
Comments from Landholder (paddock history)

- 1996 75 kg/ha Go13%Ph19390 18% P
- 1995 75 kg/ha p13%Pre sulphate 9% P
- 1994 sown to Trikkala Clover, Australian Phalaris and Porto Cocksfoot (Cocksfoot established better during drought)
- 1994 150 kg/ha single super & molybdenum 18% P
- 1989 50 kg/ha Gold Phos 10 18% P
- 1965 chisel seeded and sown with sub clover and cocksfoot (cocksfoot did not persist)

SITE 7: Ordovician sediments	**Property:** B & T James "Coliban Estate"
Aust Soil Class: Brown SODOSOL	**Land System:** Kimbolton
Northcote Factual Key: Dy3.42 (yellow duplex)	**Grid Ref:** 272 875 / 5904 600

General Landform Description: Steep to moderate rolling hills utilised for grazing.

Soil Profile Morphology:



Morphology: Surface soil

A1 0-5 cm Very dark greyish brown (10YR3/2) *sandy loam*, weak subangular blocky (peds 10-20 mm), rough fabric, weak consistence when dry, medium size angular quarts fragments are common, pH 5.1. Clear transition to:

A2 5-40 cm Reddish yellow (7.5 YR6/6 moist), pink (7.5YR8/4 dry) *fine sandy clay loam*, weak subangular blocky structure, (peds 20-50 mm braking to 1020 mm), rough fabric, very firm consistence when dry, many medium size angular sedimentary fragments, pH 5.4. Clear transition to:

Subsoil

B2 40-65 cm Strong brown (7.5YR5/6) *medium clay*, strong subangular blocky structure, (peds 10-20 mm breaking to 5-10 mm), smooth fabric, firm consistence when dry, many medium size angular sedimentary fragments, pH 6.0. Abrupt transition to:

C 65+ cm *Weathered parent material.*

Key Profile Features:

- Shallow soils.
- Poorly structured topsoils.
- High sand, gravel and stone content.
- Rock outcrop.
- Conspicuously bleached A2 horizon.

Soil Profile Characteristics:

Horizon	pH	Salinity	Sodicity	Dispersion
Surface (Al horizon)	Strongly acid	Low	Sodic	Very Low
Sub-surface (A2 horizon)	Strongly acid	Very low	Sodic	High
Subsoil (B2 horizon)	Moderately acid	Very low	Sodic	High

Limitations for Agriculture:

Whole Profile

- Strongly acid topsoils and subsoils may affect pasture growth.
- Plant available water capacity is low.
- Aluminium levels throughout profile (82-190 mg/kg) may affect sensitive plant species.

Surface (A) horizons

- The topsoils have a low inherent fertility (based on the sum of exchangeable basic cations). This is the result of extensive leaching of the sandy, gravelly topsoils.
- Impeded drainage in the B horizon leads to saturation of the A2 horizon and leaching of organic matter and soil nutrients from the topsoil.
- Sodic topsoils are susceptible to severe sheet erosion due to partial slaking and dispersion, particularly where sheep camp and less than 30% vegetation cover is present.

Subsoil (B) horizons

- Subsoils may be absent where extensive rock outcrop occurs.
- When exposed, the sodic subsoils are susceptible to partial slaking and high dispersion leading to gully erosion.
- Rock may underlie the subsoil at shallow depth.
- High levels of exchangeable magnesium may result in nutrient imbalance (eg. calc13% deficiency).
- Sodic and dispersive subsoils will restrict root and water movement in subsoil.

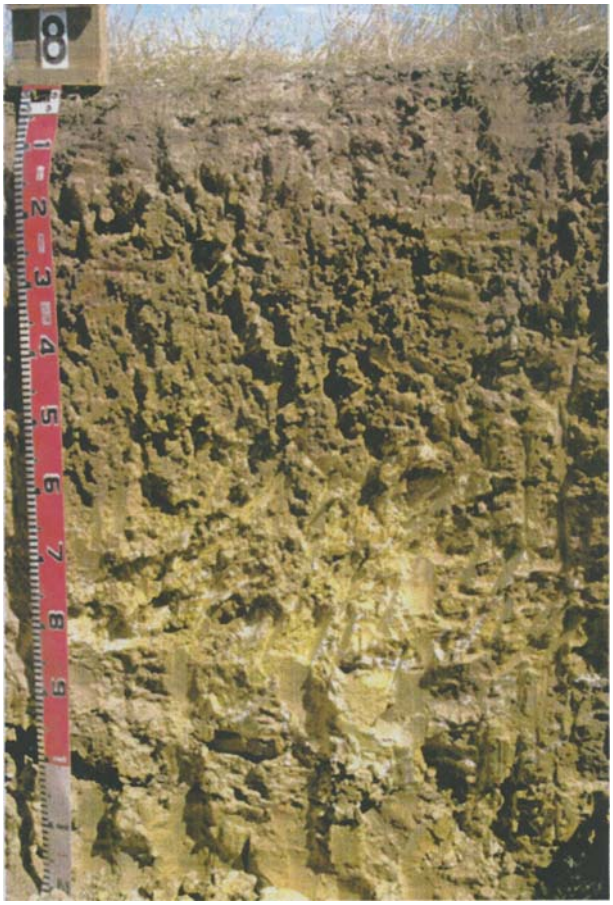
Comments from Landholder (paddock history)

- 1996 76 kg/ha Gold Phos 10 18% P
- 1994 50 kg/ha Pastursul & molybdenum 18% P
- 1993 100 kg/ha single super 9%P
- 1989 50 kg/ha Gold Phos 10 18%P
- 1964 chisel seeded and sown with sub clover and Australian Phalaris

SITE 8: Ordovician sediments	**Property:** Doug Batty "Grange Grove"
Aust Soil Class: Yellow SODOSOL **Northcote Factual Key:** Dy3.43 (yellow duplex)	**Land system:** Glen Cooee **Grid Ref:** 273 375 / 5904 700

General Landform Description: Undulating low hills utilised for grazing, site location on very gentle lower slope (3%),

Soil Profile Morphology:



Surface soil

A1 0-5 cm Dark brown (10YR3/3) *fine sandy loam*, moderate subangular blocky structure, (peds 5-10 mm), rough fabric, very firm consistence when dry, pH 5.8. Clear transition to:

A2 5-15 cm Brown (7.5YR5/4 moist), pale brown (10YR6/3 dry) *fine sandy clay loam*, many medium tYR6/3) coarse faint orange mottles, massive structure, rough fabric, strong consistence when dry, few small coarse fragments, pH 6.1. Abrupt transition to:

Subsoil

B21 15-40 cm Reddish yellow (5 YR6/8) *medium clay*, many medium to very coarse distinct orange and red mottles (10YR6/3); moderate angular blocky to polyhedral structure, (peds 20-50 mm breaking to 5-10 mm), smooth fabric, strong consistence when dry, pH 6.2. Gradual transition to:

B22 40-50 cm Brownish yellow (10YR6/8) *me3.6. clay*, few to many medium to 100+ coarse faint red mottles, moderate angular blocky to polyhedral structure, (peds 20-50 mm breaking to 10-20 mm), smooth fabric, strong consisten when dry, pH 8.6. Abrupt transition to:

BC 50-100+cm *Weathered parent material.*

Key Profile Features:

- Poorly structured topsoils.
- Bleached A2 horizon:

Soil Profile Characteristics:

Horizon	pH	Salinity	Sodicity	Dispersion
Surface (Al horizon)	Moderately acid	Low	Sodic	Very low
Sub-surface (A2 horizon)	Slightly acid	Low	Strongly sodic	High
Upper Subsoil (B21 horizon)	Slightly acid	High	Strongly sodic	Very High

Limitations to Agriculture:

Surface (A) horizons

- Moderately acid topsoils may affect pasture growth.
- Organic carbon levels indicate that the organic matter content of the topsoil is low in the A2 horizon. Organic matter contributes to the development of soil structure, fertility and water holding capacity.
- Partial slaking and dispersion in the strongly sodic A2 horizon may cause sheet and gully erosion when exposed.
- Impeded drainage in the **B** horizon leads to saturation of the A2 horizon and leaching of organic matter and soil nutrients from the topsoil.

*Subsoil **(B)** horizons*

- When exposed, the strongly sodic subsoil is extremely susceptible to gully erosion, this is due to partial slaking and rapid dispersion.
- The strongly alkaline subsoils indicate that nutrients such as phosphorus, iron, manganese and zinc may be poorly available to deep rooted plants.
- High levels of exchangeable sodium and magnesium may result in nutrient imbalance (eg. calcium deficiency, sodium toxicity).
- High levels of soluble salts in the subsoil may limit the growth of sensitive plants.
- Sodic and dispersive subsoils will restrict root and water movement in subsoil.
- A substantial zone of weathered sedimentary rock may underlie the subsoil at moderate depth.

Comments from Landholder (paddock history)

- 3 bags/ac single super every 3rd year

3. Acknowledgments

This work would not have been possible without the support of the National Landcare Program.

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APPENDIX A CHEMICAL LABORATORY RESULTS

Site Number	1:5 Water Suspension				Al+++ KCl Exchange mg/kg	Exchangeable H+ meq/100g	Total Soluble Salts %	Olsen P mg/kg	K Calc. mg/kg	S mg.kg	Oxidizable Org. Carbon %	Exchangeable Bases				Sum of Four Cations meq/100g	Gravi water pF 4.2%
	Horizon	Horizon Depth cm	pH $CaCl^2$	EC ds/,								Ca++ meq/100g	Mg++ meq/100g	Na+ meq/100g	K+ meq/100g		
SG1	Al	0-10	5.2	0.14	< 10		0.05	5.1	117	36	3.7	13	5.6	0.34	0.30	19.3	22.6
SG1	B21	10-30	5.6	0.06			0.02	2.4	78	17	1.5	12	6.4	0.29	0.20	18.9	19.9
SG1	B22	30-60	5.7	< 0.05		13	0.02					12	7.8	0.31	0.21	20.4	24.5
SG1	D2	70-90	6.2	0.07			0.02					11	7.7	0.20	0.19	19.1	
SG2	Al	0-10	4.5	0.09	57		0.03	9.2	62	17	1.7	1.6	0.38	0.13	0.16	2.3	7.3
SG2	A21	10-35	4.4	0.06	63		0.02	3.1	27	6	0.39	0.37	0.38	0.24	0.07	1.1	5.7
SG2	B21	45-75	4.9	0.32	13	6.3	0.10					< 0.1	3.5	1.2	0.10	4.9	16.4
SG3	Al	0-10	4.2	<0.0	84		0.02	4.2	35	7	3 6	1.1	0.24	0.10	0.09	1.6	7.9
SG3	A2	10-30	4.3	< 0.0	66		0.02	4.1	23	6	0.56	0.3	0.09	0.07	0.06	0.6	3.0
SG3	B21	30-65	4.1	< 0.0	230	12	0.02					0.6	2.1	0.28	0.10	3.1	20.8
SG4	Al	0-10	4.3	20.3	41		0.02	4.1	43	3	2.3	1.7	0.63	0.13	0.11	2.6	6.4
SG4	A2	10-60	4.7	< 0.0	10		0.02	< 1	19	6	013	0.65	0.36	0.05	0.05	1.1	2.5
SG4	B21	70-90	4.9	0.07		12	0.02					0.53	12	1.50	0.23	14.3	28.3
SG5	Al	0-20	4.0	0.07	78		0.02	2.9	70			1.2	0.34	0.06	0.18	1.8	4.5
SG5	A2	20-50	4.3	< 0.0	51		0.02	1.8	23	< 3	0.36	0.27	0.07	< 0.0	0.06	0.5	1.7
SG5	B21	50-80	4.5	< 0.0	92	13	0.02					3.6	6.6	50-30	0.24	10.7	
SG6	Al	0-15	4.3	0.06	76		0.02	5.6	289	7	2.3	2.0	0.76	0.10	0.74	3.6	7.2
SG6	A2	15-40	4.2	< 0.0	170		0.02	< 1	74	4	0.45	0.87	0.93	0.06	0.19	2.1	8.7
SG6	B2	40-60	4.1	< 0.0	240	12	0.023.7					0.63	4.6	0.11	0.29	5.7	
SG7	Al	0-5	4.3	0.14	82		0.05	20	321	15	5.9	2.7	2.2	0.51	0.832	6.3	15.7
SG7	A2	5-40	4.2	< 0.0	190		0.02	< 1	156	6	0.79	0.23	1.4	0.22	0.40	2.3	11.6
SG7	B2	40-65	4.7	0.08		11	0.03					0.12	7.2	1.1	0.57	9.0	20.4
SG8	Al	0-5	4.9	0.11			0.04	3.3	184	16	4.7	3.2	3.6	0.76	0.47	8.1	14.5
SG8	A2	5-15	4.9	0.0			0.02	< 1	5	4	1.0	1.2	1.7	0.51	0.15	3.6	6.9
SG8	B21	15-40	5.3	0.29		8.2	0.09					0.68	5.8	2.7	0.32	9.5	13.2
SG8	B22	40-50	7.6	0.63			0.19					0.4	5.5	3.7	0.30	9.9	

APPENDIX B PHYSICAL LABORATORY RESULTS

Site Number	Laboratory Number	Horizon	Horizon Depth cm	Particle Size Distribution							Emerson Class
				Gravel >2mm %	Coarse sand %	Fine sand %	Silt %	Clay %	Acid Treatment %	Total Fine Earth %	
SG1	970009	Al	0-10	15	6.3	16.2	30.0	32.0	3.2	87.7	E3(1)
SG1	970010	B21	10-30	15	7.7	37.7	30.5	35.0	1.9	92.2	E3(1)
SG1	970011	B22	30-60		4.8	15.3	23.5	50.0	1.5	95.1	E7
SG1	974.32	D2	70-90		24.0	10.7	12.0	49.5	0.9	97.1	E7
SG2	970013	Al	0-10	5	45.1	19.7	16.0	13.5	0.9	95.2	E8
SG2	970014	A2	10-35	<5	50.9	18.6	16.0	13.5	0.2	99.2	E3(1)
SG2	970015	B21	45-75		26.2	9.8	15.5	47.0	0.2	98.7	E6
SG3	970016	Al	0-10	<5	32.0	36.9	12.0	10.5	1.0	92.4	E8
SG3	970017	A2	10-30	20	44.7	33.2	10.5	9.0	0.4	97.	E2(1)
SG3	970018	B21	30-65		15.7	14.6	5.0	63.5	0.1	98.9	E
SG4	970019	Al	0-10	5	44.3	29.1	11.5	8.5	0.8	94.2	E8
SG4	970020	A2	10-60	25	53.7	27.7	10.5	7.0	0.3	99.2	E3(1)
SG4	970021	B21	70-90		6.4	6.8	7.0	76.0	0.3	96.5	E6
SG5	970022	Al	0-20	< 5							
SG5	970023	A2	20-50	10							E3(1)
SG5	970024	B21	50-80								E8
SG6	970025	Al	0-15	10	14.5	48.4	17.0	15.0	0.7	95.6	E3(1)
SG6	9700243.4	A2	15-40	10	11.8	40.1	19.5	27.5	0.2	99.1	E3(2)
SG6	970027	B2	40-60		4.0	21.1	12.5	62.0	0.3	99.9	E6
SG7	970028	Al	0-5	5	16.2	29.6	21.5	20.5	2.0	89.8	E8
SG7	970029	A2	5-40	< 5	10.6	18.4	31.5	38.0	0.2	98.7	E3(4)
SG7	970030	B2	40-65		3.0	6.4	24.5	64.5	0.0	98.4	E3(4)
SG8	970031	Al	0-5	20	10.4	309	19.0	30.0	1.7	92.0	E6
SG8	970032	A2	5-15	5	14.3	46.1	19.5	18.5	0.5	98.9	E2(1)
SG8	970033	B21	15-40		3.8	26.0	15.0	54.0	0.3	99.1	El
SG8	973.34	B22	40-50								

APPENDIX C GLOSSARY OF SOIL TERMS

ACIDIFICATION: The process whereby soils become acidic over a period of time as a result of the parent material; the addition of nitrogen to the soil by either fertiliser or legumes (where nitrogen is converted to nitrate), and/or the leaching of the soil by rainfall.

AEOLIAN: A geomorphic process whereby soil forming material is transported and deposited by wind.

ANGULAR BLOCKY STRUCTURE: A cube-shaped ped bounded by six faces.

ANTHROPOSOLS: A Soil Order of the Australian Soil Classification (Isbell, 1996). This order includes man-made soils e.g. mine spoil.

APEDAL: Soils in which peds are not apparent when the soil is moderately moist.

AUSTRALIAN SOIL CLASSIFICATION (Isbell, 1996): A soil classification recently developed by Ray Isbell. The classification scheme operates using a hierarchical system and is based on Australian soils data that is significant with regard to land management. The general form of the nomenclature is: Subgroup, Great Group, Suborder, Order; family (eg. Bleached, Eutrophic, Red CHROMOSOL; thick, sandy)

BASE STATUS: Is a ratio relating the major nutrient cations (Ca, Mg, K and Na) to the clay percentage in the soil. It is used as an indicator of soil fertility and is expressed in cmol (+) kg^{-1} clay. It is calculated by multiplying the sum of the reported basic cations by 100 and dividing by the clay percentage of the sample. Three classes are defined: **dystrophic -** if the sum is less than 5; **mesotrophic -** if the sum is between 5 and 15 inclusive; and **eutrophic** if it is greater than 15. It is used for some Great Group distinctions within the Australian Soil Classification (Isbell, 1996).

BLEACHED HORIZON: Horizons that are paler than adjacent horizons and are best seen when the soil is dry. A bleach is generally associated with the A2 horizon, although it is not restricted to it. It generally occurs over a much less permeable subsoil, pan or hard rock. A conspicuously bleached horizon is one in which 80% or more of the horizon is bleached, whereas a sporadic bleach occurs irregularly throughout the horizon or as blotches at the interface of the A and B horizons (Northcote, 1979). This horizon is the most leached part of a soil . Organic matter, clay, iron, aluminium and nutrient elements have been removed leaving an accumulation of silica, which gives the horizon its whitish colour. Field observations have established that bleached horizons are often saturated with water, and their occurrence is usually an indication of periodic waterlogging. This can indicate sodic subsoils where there is a strong texture contrast between A and B horizons.

BUFFERING CAPACITY: The soils ability to resist change in pH. Soils with a high clay and organic matter content have a higher buffering capacity and can tolerate the addition of acidifying fertilisers over an extended period, or at a higher rate of addition without becoming too acid. But, once it is acid, the soil will require a large amount of lime or dolomite to reverse the effect. The amount of lime or dolomite required varies from soil to soil depending on the pH (Baker and Eldershaw, 1993).

CALCAREOUS: Used as a descriptive term in the Australian Soil Classification (Isbell, 1996). It describes a soil that has sufficient calcium carbonate to cause effervescence on the application of a few drops of hydrochloric acid.

CALCAROSOL: A Soil Order of the Australian Soil Classification (Isbell 1996). These soils are either calcareous throughout the solum (or at least directly below the A 1 horizon or at a depth of 0.2m, which ever is shallower) and do not have clear or abrupt textural B horizons. The carbonate must have resulted from soil forming processes.

CALCRETE: Any layer of cemented carbonate accumulation layer. The material must be hard. This definition does not describe the common soft carbonate nor the carbonate accumulated in nodules or concretions. This term is used to describe a number of soils in the Australian Soil Classification (Isbell, 1996).

CEC (CATION EXCHANGE CAPACITY): Is the measure of the capacity of a soil to hold the major cations: calcium, magnesium, sodium and potassium (including hydrogen, aluminium and manganese in acid soils). It is a measure of the potential nutrient reserve in the soil and is therefore an indicator of inherent soil fertility. An imbalance in the ratio of cations can result in soil structural problems. High levels of individual cations (e.g. aluminium and manganese) can also be toxic to plants.

CEMENTED: (Indurated) Substances such as humus, calcium carbonate, and the oxides of silicon, iron and aluminium can bind soil particles together in a hard brittle mass- This hardened state persists even when wet.

CHROMOSOL: Soil Order of the Australian Soil Classification (Isbell, 1996). Soils with a clear or abrupt textural B2 horizon where the pH is 5.5 (water) or greater in the upper B2 horizon. This B2 horizon is often brightly coloured.

COFFEE ROCK: A compacted, cemented or indurated layer within the profile, which is comprised of humus and iron oxides.

COLOUR: Soil colour is assessed in a moist condition using a Munsell Colour Chart (Munsell Colour Company, 1975) to assess the dominant colour. Secondary colours, bleaches and mottles are also recorded. Colour provides a useful indication of a number of profile attributes. Dark surface soils, for instance, indicate a high level of organic matter. In subsurface horizons (i.e. A2), bleached colours indicate low levels of plant nutrients and that seasonal or periodic waterlogging occurs- In subsoils, the colour sequence from red to brown and yellow to grey colours, indicate a sequence from well aerated and well drained soils to poorly aerated and poorly drained soils.

COLUMNAR STRUCTURE: Soil particles are arranged around a vertical axis with flat faced peds. The tops of the columns have clearly defined domes. Columnar structure is often associated with subsoil sodicity.

COMPACTION: The process whereby soil density is increased as a result of tillage, stock trampling and/or vehicular trafficking. Compaction can lead to lower soil permeability, poorer soil aeration resulting in increased erosion hazard and poorer plant productivity. Deep ripping and conservation tillage can alleviate the condition.

CONSISTENCE: relates to the texture and structure of a soil and is a measure of its workability and stability (e.g. friable soils are easier to work than hard soils). Consistence is measured by the resistance of a ped to deformation between the thumb and forefinger, measured on a scale of 1 (small force required) to 7 (rigid force required). This varies depending on the soil water content.

0	= Loose	no force required, separate particles such as loose sand,
1	= Very weak	very small force,
2	= Weak	small but significant force,
3	= Firm	moderate or firm force,
4	= Very firm	strong force but within the power of the thumb and forefinger,
5	= Strong	beyond power of thumb and forefinger but crushes underfoot on hard flat surface with small force,
6	= Very strong	crushes underfoot on hard flat surface with full body weight applied slowly,
7	= Rigid	cannot be crushed underfoot by full body weight applied slowly.

CRUMB STRUCTURE: Rounded p1996) less than 12 mm in diameter which are unstable and tend to crumble into smaller units. This type of structure is associated with surface horizons.

CRUSTY: Soils with a massive or weakly structured surface crusty horizon (3 cm or less thick) which is often lower in clay content than the underlying structured clay which is not self-mulching. This term is used as a Great Group definition for Vertosols in the Australian Soil Classification (Isbell 1996)

DERMOSOLS: Soil Order of the Australian Soil Classification (Isbell, 1996). Soils which have B2 horizons with structure more developed than weak throughout the major part of the horizon, and which also lack a strong texture contrast between the A and B horizons.

DISPERSIBLE SOILS: Soils that are structurally unstable and disperse in water into basic particles i.e. sand, silt and clay. Dispersible soils tend to be highly erodible and present problems for earth works (See SODICITY).

DISPERSION: is when the clay particles form a cloud around an aggregate placed in water. These soils generally have a high exchangeable sodium percentage. (See DISPERSION in Appendix A; or DISPERSIBLE SOILS - Appendix B).

DUPLEX PROFILE FORM: A Primary Profile form of the Northcote Factual Key (1979) classification. It describes a soil where there is a sharp contrast in the texture between the A and B horizons (often sandy or loamy surface horizons with a sharp to clear boundary to clay subsoils). Duplex soils are given the notation "D".

EARTHS: A Great Soil Group (Stace *et al,* 1968) description defining a variable group of soils which are porous and sandy textured. They usually have an acidic trend (i.e. the pH decreases with depth), weak profile differentiation, diffuse horizon boundaries, an increase in clay content with depth and no A2 horizon-

EC (ELECTRICAL CONDUCTIVITY): A measure of the conduction of electricity through water, or a water extract of soil. The value can reflect the amount of soluble salts in an extract and therefore provide an indication of soil salinity. Saline soils are defined as those with an EC of greater than 1.5 dS/m for a 1:5 soil water extract and greater than 4 dS/m for a saturation extract (See **SALINITY).** It can be interpreted in terms of the salinity tolerance of plants. Soil texture needs to be considered in this interpretation.

ESP (EXCHANGEABLE SODIUM PERCENTAGE): Is calculated as the proportion of the cation exchange capacity occupied by the sodium ions and is expressed as a percentage. Sodic soils are categorised as soils with an ESP of 6-14%, and strongly sodic soils have an ESP of greater than 15% (See **SODICITY).**

FABRIC: Describes the appearance of the soil material (under a hand lens). The difference between fabrics is associated with the presence or absence of peds, the luster of the ped surface and the presence, size and arrangement of pores in the ped. Fabric is described based on:

EARTHY (or porous) (E): The soil material is coherent and characterised by the presence of pores, but few if any peds. Soil particles are coated with oxides and/or clay particles are clumped around the pores.

SANDY (G): Soil material is coherent, with few if any peds. The closely packed sand grains provide the appearance of the soil mass.
ROUGH-PED FABRIC (R): Peds are evident and characteristically more than 50% of the peds are rough-faced, that is, they have relatively porous surfaces. They tend to have less clearly defined faces than smooth faced peds- SMOOTH-PED (S): Peds are evident and more than 50% of them are dense and smooth faced, although the degree of luster varies.

FACTUAL KEY (NORTHCOTE, 1979): A soil classification system used in Australia which groups soils into recognisable profile forms. These are based on visible morphological properties and simple chemical properties of a soil and are labeled using an alphanumeric code. Further details can be found in Northcote (1979).

FERROSOLS: Soil Order of the Australian Soil Classification (Isbell, 1996). These soils lack strong texture contrast and have a B2 horizon with structure more developed than weak, **and** a B2 horizon with a fine earth fraction which has a free iron oxide content greater than 5% Fe (as opposed to a **DERMOSOL).**

FIELD CAPACITY (FIELD MOISTURE CAPACITY): The percentage of moisture remaining in a soil horizon 2-3 days after being saturated (by rainfall or irrigation) and after free drainage has ceased.

FLUVIAL: A geomorphic process whereby soil forming material is transported and deposited by flowing river water.

GILGAI: Surface undulations in the soil, forming small rises or ridges and depressions.

GRADATIONAL PROFILE FORM: A Primary Profile Form of the Factual Key (Northcote, 1979). It describes a soil with a gradual increase in texture (i.e. becomes more clayey) as the profile deepens. Gradational soils are given the notation

GRANULAR STRUCTURE: Rounded peds that are porous, stable and less than 12 mm in diameter. They usually occur in the surface horizons.

GREAT SOIL GROUPS (Stace *et al.,* 1968): A soil classification system which is based on the description of soil properties such as colour, texture, structure, drainage, lime, iron, organic matter and salt accumulation, as well as on theories of soil formation. The profile to be classified is assigned to a Great Soil Group based on its description. The system is limited in that central concepts are inadequately defined making confident identification of some described profiles difficult.

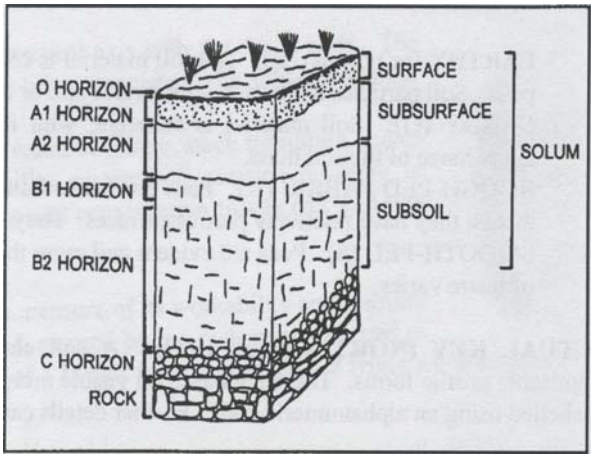
GREY, BROWN AND RED CALCAREOUS SOILS: These soils are shallow, soft, powdery or weakly structured loams to light clays containing finely divided carbonates throughout the profile and showing very little horizon development. The tend to develop from highly calcareous rocks which underlie them at depths up to 50 cm. Fragments of limestone may also be found in the profile. The surface texture may be a loam or a clay loam, with a weak platey or a fine blocky structure. Below this the structure is massive or more clayey with a medium blocky structure of rough faced peds. The clay content tends to increase about one texture class throughout the profile.

GREY, BROWN AND RED CLAYS: Great Soil Group Classification, Stace *et al,* (1963). This is a broad group of soils which have a moderate to very deep profile. These soils crack deeply on drying and have a high clay content throughout. Subsoil clays range from grey to brown or red in colour gradually becoming paler with increasing depth. In Victoria, these soils are typically alkaline throughout most of the profile and carbonates may also be present.

GYPSUM: A naturally occurring soft crystalline material which is a hydrated form of calcium sulphate. Deposits occur naturally in inland Australia. Gypsum contains approximately 23% calcium and 13% sulphur. It is used to improve soil structure and reduce crusting in hard setting clayey soils.

HARD: A general term indicating strength, used to describe a number of soils in the Australian Soil Classification (Isbell, 1996). Hard nodules or segregations cannot be broken between thumb and forefinger (i.e. strong in the Yellow Field Handbook, pg 147). Pans are classified as hard if they are moderately cemented or stronger (Yellow Field Handbook, pg 143). The substrate is classed as hard if they are moderately strong or stronger (Yellow Field Handbook, pg 157).

HARDSETTING: The condition of a dry surface which is compact and hard with no apparent pedal development. These soils are not disturbed by pressure of a forger. These harder setting soils tend to result in high runoff.



HORIZONS: A layer within the soil profile having morphological characteristics and properties (e.g. colour, texture, and structure) differing from the layer above and/or below it.

1) The **0 horizon** consists of plant material in various stages of decomposition, which has accumulated above the soil surface (A horizon). The 0 horizon can be subdivided into:
   i) 01 horizon: undecomposed organic material e.g. leaves and twigs.
   ii) **02** horizon: organic debris in various states of decomposition.
2) The **A horizon** consists of one or more surface mineral horizons and can be subdivided into:
   i) **Al** horizon: this is the mineral horizon at or near the surface, usually with some accumulation of organic matter making the colour darker than the underlying horizon. This horizon is usually high in biological activity. The Al horizon can be further subdivided into the A 1 horizon: more organic matter, darker colour with relatively high amounts of biological activity; Al2 horizon varies in colour (i.e. hue, value or chroma) usually lighter, but not pale enough to be an A2 horizon. A13 and A14 horizons are further options if necessary.
   ii) **A2** horizon: this is the mineral horizon having either: less organic matter; less sesquioxides; and/or less silicate clays than the surrounding horizons. It can be differentiated from the Al by its paler colour. The A2 can be differentiated from the B horizon by its colour value being 1 unit higher than the B, chroma units being 2 lower than the B horizon, by a coarser texture in the A2 horizon than the B, or a combination.
   iii) **A3** horizon: this is a transitional horizon between the A and B horizon which is dominated by A horizon properties.
3) The **B horizon** consists of one or more mineral soil layers characterised by one or more of the following: a concentration of silicate clays, iron, aluminium, and/or organic matter; a structure and/or consistence unlike the A horizon or any horizon below; stronger colours (i.e. higher chroma and/or redder hue) than the above or below horizon. The B horizon is subdivided into:
   i) **B1** horizon: the transition between the A and B horizons where the underlying B2 horizon properties dominate (as opposed to the A horizon properties).
   ii) **B2** horizon: the dominant feature is one of the following: an alluvial, residual or other concentration of silicate clays, iron, aluminium, or humus; maximum development or pedological organisation within the profile i.e. different structure; consistence and/or stronger colours than the A horizon or any horizon below. The B2 horizon can be further divided into subhorizons: B21, B22, and B23 horizons.
   iii) **B3** horizon: a transition between B and C where the B2 horizon characteristics dominate.
4) The **C horizon:** the layer below the solum (A and B horizons) that consists of consolidated or unconsolidated parent material that is not significantly affected by soil forming processes. It is easily recognised by its lack of soil characteristic development and its visible geologic structure.

HUMOSE: The relatively resistant, usually dark brown to black fraction of soil organic matter, peat or compost which forms as a result of biological decomposition of organic material.

INFILTRATION: The movement of water through the soil surface. Soils with a high infiltration capacity allow more rain to enter the soil than soils with a low capacity. Runoff will occur when the rate of rainfall exceeds the soil's infiltration capacity. Surface soil structure and texture are important determinants of the infiltration capacity of a soil.

KANDOSOLS: A Soil Order of the Australian Soil Classification (Isbell, 1996). These soils lack strong texture contrast and have massive or only weakly structured B horizons. The B2 horizon is well developed and has a maximum clay content in some part of the B2 horizon which exceeds 15%. They are also not calcareous throughout.

KRASNOZEM: A Great Soil Group (Stace *et al*, 1968). These soils are typically red, deep, well-structured, acid and porous soils. They have relatively high clay contents and tend to display a gradual increase in clay with depth.

KUROSOLS: A Soil Order of the Australian Soil Classification (Isbell, 1996). These soils have a clear or abrupt textural B horizon which is strongly acidic i.e. less than 5.5 (water) in the upper B2 horizon.

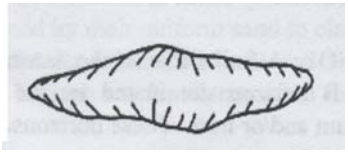
LACUSTRINE: A geomorphic process whereby soil forming material is deposited in lakes.

LATERITE: Refers to a soil profile with horizon/s rich in iron oxides. This is usually associated with deeply weathered profiles. The process whereby Laterite is formed is referred to as **laterization.** Laterization occurred especially in the early Tertiary period when Australia experienced a warm, wet climate.

LATERITIC PODSOLIC: Great Soil Group Classification, Stace *et al.,* (1968). These soils are strongly leached with a strong texture contrast between thick sandy A horizons and mottled yellow-brown and red clay B horizons. Nodular pisolitic or massive ironstone occurs at the base of the bleached A2 horizon and in the upper B2 horizon. The pH trend is acid throughout the profile.

LEACHING: The removal in solution of soluble minerals and salts as water moves through the profile.
LEVEE: A natural levee is a deposit of alluvium which is raised above the general level of the banks of a stream and its flood plain. Man-made levees may be constructed along the course of a river or stream in order to contain flood waters.

LENTICULAR STRUCTURE: Soil particles are arranged around an elliptical or circular plane and bounded by curved faces i.e. lens shaped. This structure often occurs in subsoils of Vertosols and can be associated with slickenside development.



LIME: A naturally occurring calcareous material used to raise the pH of an acidic soil and/or supply calcium for plant growth. It is effective for treating acidic soils.

LUNETTES: Crescent shaped aeolian deposits of fine sediment located on the eastern sides (or the lee sides) of lake beds or playas in semi-arid areas of southern Australia.

MASSIVE: This term applies to soil horizons which appear to be coherent or solid and devoid of peds. It should be greater than 6 mm in thickness. When displaced, the soil separates into fragments which may be crushed into individual particles.

MOTTLING: The presence of more than one soil colour in a horizon. The soil may differ in colour either within peds or aggregates, or between them. Mottling occurs as blotches or streaks of subdominant colour throughout the main (i.e. matrix) colour. It does not refer to stains or coloured deposits on ped faces. Mottling is often an indication of poor profile drainage but may be caused by the weathering of parent material. Diffusely mottled implies that neighbouring colours are only slightly different.

MYCORRHIZAE: These are soil fungi which act as rootlets and increase the amount of nutrients (particularly phosphorus and zinc) available to plants. Fallowing, excessive tillage and soil fumigation can cause mycorrhiza to die out. Some plants such as rapeseed do not need mycorrhiza and therefore they tend to die out of the soil. Plants growing with mycorrhiza are generally healthier and more resistant to root disease and root rot.

NUTRIENT STATUS: This is calculated as the sum of exchangeable calcium, magnesium and potassium (in milliequivalents per 100g) and can be used as a rough guide to availability of nutrients in general. The categories used are: very low (0 - 3.9); low (4 - 7.9); moderate (8 - 17.9); high (>18) (Lorimer and Rowan, 1982).

ORGANIC MATERIALS: Plant derived organic accumulations.

ORGANOSOLS: A Soil Order of the Australian Soil Classification (Isbell, 1996). Soils that are dominantly made up of organic materials.

PANS: Hard or cemented layers interfering with water and root penetration.

PARENT MATERIAL: The rock from which a soil profile develops.

PARTICLE SIZE ANALYSIS: The measurement of the relative amounts of coarse sand, fine sand, silt and clay size particles in a soil sample (as determined in the laboratory). Also called 'mechanical analysis'.

PED: The natural unit of soil structure formed by the soil's tendency to fracture along planes of weakness.

pH (SOIL): A measure of soil acidity and soil alkalinity on a scale of 0 (extremely acidic) to 14 (extremely alkaline), with a pH of 7 being neutral. It gives an indication of the availability of plant nutrients and relates to the growth requirements of particular crops. Acid soils are usually deficient in necessary nutrients eg. calcium and magnesium.

PLANT AVAILABLE WATER CAPACITY (PAWC): The amount of soil water that can be extracted by the plant. It is defined as the difference in soil moisture content between the field capacity and the wilting point (See **FIELD CAPACITY** and **WILTING** POINT). It is expressed as millimetres of plant-available water within the root zone.

PLASTIC LIMIT: The water content of the soil above which the soil will compress and shear when compacted; i.e. structural degradation occurs.

PLASTIC SOILS: A soil capable of being moulded or deformed permanently in shape without a change in volume, rebound or texture.

PLATY STRUCTURE: (laminar) Peds are layered in plate-like sheets. This type of structure is usually associated with soils which have been subjected to compaction and does not normally occur in undisturbed soil profiles.

PODOSOL: A Soil Order of the Australian Soil Classification (Isbell, 1996). These soils have a B horizon dominated by the accumulation of compounds of organic matter, aluminium and/or iron. These horizons may occur individually or in combination within a profile.

POLYHEDRAL STRUCTURE: Soil particles arranged around a point and bounded by more than six relatively flat but dissimilar faces-

POROSITY (SOIL): The degree of pore space in a soil (i.e. the percentage of the total space between solid particles).

PRISMATIC STRUCTURE: Soil particles are arranged around a vertical axis and bounded by relatively flat faces. The top of the prisms are also relatively flat. Prismatic structure is often associated with subsoil sodicity.

PROFILE: The vertical section of the soil from the soil surface down through the horizons including the parent material. It consists of two parts: the solum, and the parent material.

RED-BROWN EARTHS: Great Soil Group Classification, Stace *et al.,* (1963). The characteristic features are: grey-brown to red-brown loamy sand to sandy clay loam A horizon which is weakly structured to massive; an abrupt to clear boundary between the A and B horizons; a brighter brown to red clay B horizon with a well developed medium prismatic to blocky structure. The surface soil is moderately thick and mildly acid to neutral, and the B horizons are usually alkaline and may contain carbonates. These soils are typical of semiarid to subhumid climates and develop on various parent materials.

RED CLAYS: See **GREY, BROWN AND RED CLAYS.**

RUDOSOLS: A Soil Order of the Australian Soil Classification (Isbell, 1996). These soils have limited pedological organisation apart from minimal development of the Al horizon.

SALINITY: A measure of the total soluble salts in a soil. A saline soil is one with an accumulation of free salts at the soil surface and/or within the profile affecting plant growth and/or land use. It is generally attributed to changes in land use or natural changes in drainage or climate which affects the movement of water through the landscape. Salinity levels of soil or water can be tested using Electrical Conductivity (see **EC).**

SAPROLITE: Decomposed rock that has maintained characteristics that were present as an unweathered rock.

SEGREGATIONS: Accumulations of minerals in the soil due to the concentration of constituents. They occur as a result of chemical or biological action. They can develop *in situ* by either current or relict pedogenic processes. Segregations are described by their nature, abundance and form:

1) **Nature:** for example, calcareous (carbonate), gypseous (gypsum), manganiferous (manganese) and ferromanganiferous (iron-manganese).

2) **Abundance:** for example,

• Very few	(Trace and Occasional)	<2%
• Few	(Slight)	2-10%
• Common	(Light)	10-20%
• Many	(Moderate)	20-50%
• Very many	(Heavy)	>50%

3) Form: for example,

• C concretions	Spheroidal formations (concentric in nature).
• N nodules	Irregular rounded formations (not concentric or symmetric). Can have a hollow interior.
• F fragments	Broken pieces of segregations.
• X crystals	Single or complex clusters of visible crystals.
• S soft segregations	Finely divided soft segregations. They contrast with surrounding soil in colour and composition but are not easily separated from the soil as separate bodies.

SELF-MULCHING: A structural condition of soils, notably found in the surface soils of Vertosols, where there is a high degree of pedality and the peds naturally fall apart as the soil dries to form a loose surface mulch.

SILICEOUS SANDS: These are a broad group varying in colour but are characterised by their uniform sand to clayey sand texture, deep profiles, massive single-grain structure and the absence of any distinct horizons except for a minimal accumulation of organic matter in the Al horizon, making it slightly darker. This horizon can be absent when there is no vegetation to hold it in place.

SLAKING: The breaking down of soil aggregates when immersed in water into smaller sized micro-aggregates. These aggregates may subsequently disperse (See **DISPERSIBLE SOILS).**

SLICKENSIDES: Subsoil structural features which develop as a result of two masses moving past each other, polishing and smoothing the surfaces. These are common in Vertosols.

SODICITY: Is a measure of exchangeable sodium in relation to other exchangeable cations. It is expressed as the Exchangeable Sodium Percentage (See **ESP).** A sodic soil contains sufficient exchangeable sodium to interfere with the growth of plants, including crops. A soil with an ESP greater than 6 is generally regarded as being a sodic soil in Australia (Northcote and Skene, 1972). ESP levels are further classified in the Australian Soil Classification (Isbell, 1996).

SODOSOL: A Soil Order of the Australian Soil Classification (Isbell, 1996). These soils have a clear or abrupt textural change between A horizons and sodic B horizons. Soils with a subplastic B2 horizon are excluded.

SOLODIC SOIL: Great Soil Group, Stace *et al.,* (1968). These soils have a strong contrast between the texture of the A and B horizons and a bleached A2 horizon (which may contain a few sesquioxidic nodules). The A horizons are usually acidic and the B horizons are alkaline grading to strongly alkaline at depth. The B horizon has medium to coarse blocky peds (which may be arranged in a coarse columnar fashion). These soils are typical in semi-arid and subhumid climatic zones and tend to be very dense soils with low permeability. The difference between solodic soils and solodized solonetz soils occurs in the structure of the B horizon: solodics have a medium to coarse blocky structure whereas solodized solonetz soils have a coarse columnar structure with clearly defined domes on the tops of the columns.

SOLODISED SOLONETZ: Great Soil Group, Stace *et al.,* (1968). These soils are identical to solodic soils except for the structure of the B horizon: solodics have a medium to coarse blocky structure and solodized solonetz have a coarse columnar structure with clearly defined domes on the tops of the columns.

SOLONETZ SOILS: Great Soil Group, Stace *et al.*, (1968). Typically, there is weak differentiation between the A horizons. The A2 horizon may be sporadically bleached just above the clay subsoil. There is an abrupt boundary and a strong texture contrast between the A and B horizons. Surface soils are typically neutral to alkaline with a strongly alkaline subsoil. The subsoil clays are high in sodium and magnesium ions and usually have a prismatic structure.

SOLONIZED BROWN SOILS: These soils have large amounts of calcium and magnesium carbonates in the profile. Soil properties show gradual change down the profile; the most evident is the increase in carbonates down the profile. Texture becomes finer with depth, and the pH changes from a neutral/slightly alkaline surface horizon to an alkaline subsoil. The soluble salt content of the subsoil also increases significantly. Dark manganiferous nodules can also occur in the subsoil.

SOLOTH: Great Soil Group, Stace *et a/.*, (1968). Similar to a solodic soil but acidic throughout the profile. Tends to be a more typical soil of the humid regions where the exchangeable cations in the B horizon of the solodized soils are leached.

SOLUM: The horizons, that is the A and B horizons, which have developed from the parent material by the processes of soil formation (See **HORIZONS** diagram).

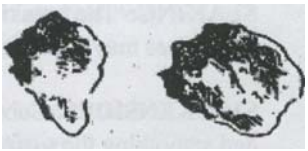
STRUCTURE: Describes the way the soil particles are arranged to form soil peds. Peds are units of soil structure which are separated from each other by natural planes of weakness. They differ from clods which are formed as a result of soil disturbance such as ploughing.

Structure is defined by three characteristics: grade, size and type.

1. **GRADE** measures the degree of development and the distinctiveness of the peds. It varies depending on the soil water status and can be divided into five groups: 1) **SINGLE GRAIN,** loose and incoherent mass of individual particles;
2. **MASSIVE,** when displaced the soil separates into fragments which may be crushed into ultimate particles;
3. **WEAK,** peds indistinct;
4. **MODERATE,** peds are well formed and visible but not distinct in undisplaced soil, adhesion between peds is usually firm and when displaced between one third and two thirds of the soil material consists of peds, and;
5. **STRONG,** peds distinct in undisplaced soil, adhesion between peds is firm, and when displaced, two-thirds or more of the soil material consists of peds.
6. **SIZE** is measured and described based on the average least dimension of the peds. A guideline is provided in the Australian Soil and Land Survey Field Handbook (Yellow Book) pages 126 to 131.
7. **TYPE** of structure has been described throughout the glossary. For example, platy, prismatic, columnar, angular blocky, subangular blocky, polyhedral and lenticular.

A number of different grades and sizes of peds may occur within a horizon. This is referred to as compound pedality. An example of this is when prismatic structure exists which then breaks down into smaller blocky peds.

SUBANGULAR BLOCKY STRUCTURE: A ped bound by six faces intersecting with round edges (i.e. like a rounded cube).



SUBPLASTIC: These soils have a consistence or textural property suggesting less clay sized particles than the soil actually contains. The soils increase in field texture after 10 minutes of kneading i.e. the soil texture becomes more clayey and harder to work. It is a feature of relatively deep subsoils and much energy is required to break down the soil aggregates. Also, these soils do not shrink/swell greatly when wet.

SUBSOIL: The B horizon and their subdivisions, excluding the C horizon (See **HORIZONS** diagram).

SURFACE CRUST: Soils with a massive or weakly structured surface crust which is lighter in texture than the underlying pedal clay. This condition should not be confused with self-mulching behaviour.

TENOSOLS: Soil Order of the Australian Soil Classification (Isbell, 1996). These soils generally have weak pedological organisation throughout the profile apart from an A horizon. They display more profile development than Rudosols which may include a weakly developed B horizon with 15% clay or less (See Isbell, 1996, for a detailed definition).

TEXTURE (FIELD): Field texture is determined by measuring the behaviour of a small handful of soil when moistened and kneaded (1-2 minutes) until it does not stick to the hand. It provides an estimate of the relative amounts of coarse sand, fine sand, silt and clay size particles. Soil texture influences many soil physical properties such as water holding capacity and

hydraulic conductivity. Numerous soil properties affect the determination of texture such as type of clay minerals, organic matter, carbonates, etc. Texture is determined by the behaviour of the moist bolus and length of the ribbon when sheared between thumb and forefinger, as described by McDonald *et al.*, (1990) in the discussion of **TEXTURE** in Appendix A.

TSS (TOTAL SOLUBLE SALTS): A measure of the soluble salts in the soil (mainly sodium chloride, sulphate and carbonate). It is a calculated value derived using the Electrical Conductivity reading (See EC) where, Total Soluble Salts % = Electrical Conductivity (dS/m) x 0.33. TSS needs to be considered relative to profile water movement.

UNIFORM PROFILE FORM: A Primary Profile Form of the Factual Key Classification, (Northcote, 1979). These soil profiles have limited, if any texture change throughout the profile. There is generally no textural boundaries found within the profile, except for possibly a surface crust. Uniform soils are given the notation "U"-

VERTIC PROPERTIES: This term is used to describe a subsoil with a field texture of 35% or more clay which experiences significant shrinking and swelling resulting from drying and wetting. This often results in the development of features such as surface cracking and gilgai formation. Evidence of vertic properties include the presence of slickensides and/or lenticular peds in the subsoil. The amount of swelling is dependent on the type of clay present. These features are of significant importance for engineering purposes such as road construction. This term is used as a Subgroup definition for a number of Soil Orders in the Australian Soil Classification (Isbell, 1996).

VERTOSOLS: A Soil Order of the Australian Soil Classification (Isbell, 1996). These are clay soils with shrink/swell properties that display strong cracks when dry and have slickensides and/or lenticular structural aggregates at depth.

WATER REPELLENT: Soils that are fairly resistant to wetting (from a dry state). It is a condition usually associated with sandy surface horizons and is generally caused by organic coatings on sand grains.

WILTING POINT: (Measured at approximately pF 4.2) It defines the amount of water remaining in the soil when a plant wilts and does not respond to added water.