4. SOILS

General trends in soils can be observed within the catchment. Red sodic duplex soils with calcareous subsoils predominate in the north, while acidic, gradational and yellow duplex soils predominate in the south. Strongly mottled duplex soils with deep coarse sandy topsoils are common in all granitic areas. On basalts, heavy grey and black clays occur around Kyneton and further north, but south of Tylden red gradational soils predominate. In detail, however, the soils have a complex distribution because of local variation in the soil-forming factors – climate, topography, flora and fauna, time and parent material – and their complex interactions.

Effects of climate and topography

Climate has an important role in soil information, since moisture and temperature are essential for the breakdown and release of minerals from the parent material. Average annual rainfall increases from 450 mm at Rochester in the north to 1,250 mm at Blue Mountain in the south and temperatures decrease in this direction. Higher rainfall increase the leaching of nutrients and soluble salts from profiles in the south, whereas the lower rainfall in the north leaves the subsoils notably sodic and calcareous.

Position in the landscape also influences the drainage, the degree of leaching and the rate of soil loss or accumulation. For example, steep upper slopes are usually well drained and are strongly leached of nutrients and base cations. Broad flat drainage depressions are often poorly drained, but the prolonged moisture availability encourages plant growth and the accumulation of organic matter.

Effects of Flors and Fauna

The flora and fauna in and above the soil are involved in a cyclic movement of nutrients and organic matter through their growth, death and decay. The activity is correlated with turnover of biomass. Plant root development and burrowing activity by soil fauna improve soil aeration and drainage.

Effects of time

Except on young alluvium and on steep unstable slopes, most subsoils show the effects of weathering in past climates and in this sense they are palaeosols or part thereof. Many soils horizons on gentle slopes are highly organised and show specific pedological features, such as kaolinisation, extreme mottling or silicified hardpans, indicating Tertiary weathering.

Effects on parent material

Unconsolidated sediments

Alluvium – material deposited by rivers – is usually extremely variable in grain size and drainage. The nutrient status depends on the minerals received from the parent material in the catchment and the present flood-plains may receive a regular topdressing of silt-size material rich in nutrients from eroded topsoils in the catchment or the less-desirable clay material from eroded subsoils that tend to crust on the soil surface or smother existing vegetation. Seasonal waterlogging can limit productivity on the low-lying areas, but the older river terraces are usually well drained.

Gravel deposits, remnants of Tertiary gravel and sand deposits, occur locally near Bendigo. The coarse material consists of quartz and is often cemented into a dense hardpan by silica and iron oxide. The nutrient level is extremely low.

Consolidated sediments

Tillite has been deposited by glaciers and subsequently hardened. It is usually poorly sorted with a wide range of particle size, although the subsoils have a high clay content and low permeability, thus restricting water penetration to and weathering of the parent material.

Sandstones, slates and shales form alternate layers of sediments. These occur widely in the catchment, comprising approximately 50%. The sandstone component is the more resistant to weathering, but does break down to coarse-textured soils with kaolinitic clays, low in base cations, nutrient reserves and pH. The slate and shale parent materials are variably weathered and have a combination of minerals such as quartz, feldspars, micas and sometimes calcium carbonate, with illite being the main clay mineral; the acid shales weather to kaolin. The steeply inclined bedding facilitates water penetration and therefore deep weathering.

Igneous Rocks

Granodiorite – a coarse-grained, well-jointed material – is made up of quartz, orthoclase and plagioclase feldspars and the muscovite and biotite micas. In the presence of water, chemical weathering beings in the joint planes and attacks the joint blocks spheroidally, leaving corestones of unaltered granite. The quartz tends to remain unaltered, given the soil a coarse sandy texture, but the feldspars are often converted to kaolin and the micas to various clay minerals. Very little iron is present and the clays have a yellow-yellowish brown colour.

Basalt is a dense fine-grained rock that would be quite impermeable except for the extensive jointing that develops during rapid cooling of the lava. Weathering along the joint plains produces characteristic spheroidal patterns in the C horizon. Quartz is not present in basalt and minerals such as the feldspars, calcium-magnesium silicates, magnesium iron silicates and small quantities of apatite weather to form clays and iron oxide with bases being released into solution. The resulting soils are often heavy-textured, dark-coloured and rich in base cations. In well-drained areas with high rainfall, soils have a characteristic bright red colour and high kaolin-halloysite contents, whereas poorly drained soils, particularly in areas with a distinct dry season, have heavy soils dominated by montmorillonite.

Mineralogy
The minerals in the parent material influence the physical and chemical condition of a soil. They include the following.

Quartz (SiO_2) is almost inert. It is most common in sediments and in acid and intermediate igneous rocks, but is not present in the basalts. Quartz sand in soils on basalt is derived from other sources, brought in for example by wind or water.

Feldspars make up the group of alumino-siliate minerals and occur in most igenous and metamorphic rocks, but are not common in unaltered sediments. They are almost as hard as quartz, however, the well-developed cleavage allows water penetration and subsequent alteration. Within the feldspar group the rate of weathering increases from the potash form to the calcium form as follows:

Microcline Orthoclase	potash feldspars: K Na Al SiO
Albite	sodium plagioclase: Na Ca Al Si O
Oligoclase Andesine Labrodorite Bytownite	intermediate feldspars
Anorthite	calcium plagioclase: Ca Na Al Si O

Eventually the feldspars weather to kaolin, but secondary minerals such as sericite or allophane can be formed in the intermediate stages.

Micas are basic aluminium silicates and are common in granites and other igneous and metamorphic rocks. Most sedimentary rocks have small amounts of mica (except for windblown material) because of attrition during transportation. The laminar crystals readily break down into flakes, promoting chemical weathering that releases potassium. Muscovite ($Kal_3Si_3O_{10}(OH)_2$) is more resistant to weathering than biotite ($K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$).

The calcium-magnesium silicates occur in basic igneous and metamorphic rocks, but are rare in sediment. They weather rapidly along the cleavage planes by ion exchange and lattice alteration, mainly to chlorite and other clay minerals with the release of bases into solution. The amphiboles resist alteration more, with basaltic hornblende being the most resistant. The pyroxene group are less resistant to weathering. As well as the macro-nutrients of Ca, Mg and Fe supplied by these silicates, small amounts of the trace elements Zn, Co and Mn are also released during the weathering process.

Olivine is a magnesium iron silicate $(Mg,Fe)_2SiO_4$ occurring in basalt and other basic igneous rocks and is an extremely weatherable mineral. As magnesium is released and the crystal lattice collapses, chlorite and iron oxide remain.

Apatite $Ca_5(PO_4)F$ is present only in soils derived from basalts. Although the mineral is hard and lacks cleavage, it is rapidly attacked and altered in acid conditions. Apatite is a source of phosphorus but unfortunately it is rare in Victorian soils.

Nutrient Status
As a general guide to nutritional status of soils, Table 6 has been extracted from the literature (Leeper 1964; Williams and Raupach 1983).

Table 6 – Major nutrients and organic matter levels in soils

Rating	Total N %	Avail. P p.p.m	K me %	Organic C %	Ca me %	Mg me %
Very low	<0.5	<10	<0.15	<0.59		
Low	0.05-0.09	10-20	0.15-0.20	0.6-1.75	<2	<1.7
Moderate	0.1-0.24	20-45	0.21-0.5	1.76-2.9	>2	>1.7
High	0.25-0.49	45-100	>0.5	3.0-5.8		
Very high	>0.5	>100		>5.8		

Care must be taken when interpreting these ratings for plant growth, since other factors such as pH, soil moisture status, soil texture, nutrient interactions and specific plant requirements may be involved. However, they provide a means of comparing soils.

A relationship between the sum of the exchangeable base cations and the general fertiliser requirements for agriculture was noted in the adjacent Avoca catchment (Lorimer and Rowan 1982). Figure 11 relates the nutrient status to the sum of the exchangeable base cations for the uniform, gradational and duplex soils.

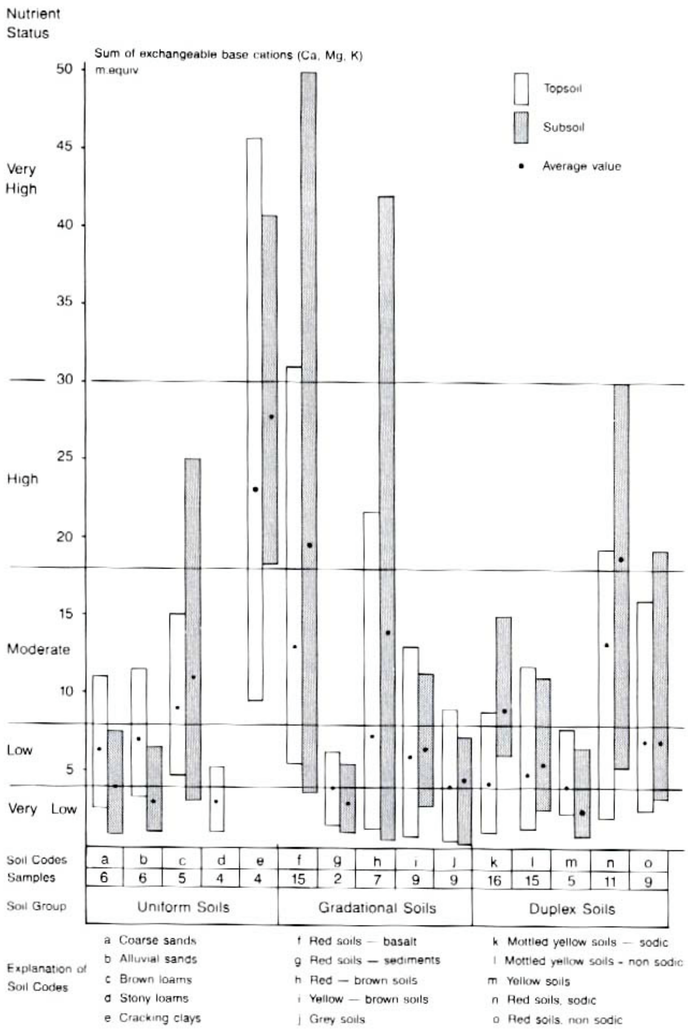

Figure 11 – The nutrient status of soils.

Classification of the Soils

The soils recognised within the catchment have been classified essentially according to the method of Northcote (1979) and Charman (1978). Initial separation is into three primary profile forms:

- Uniform soils – soil profiles dominated by the mineral fraction with small, if any, textural change with depth
- Gradational soils – soil profiles dominated by the mineral fraction and gradually becoming increasingly finer-textured (more clayey) with depth.

- Duplex soils – soil profiles dominated by the mineral fraction and having a pronounced and clearly defined contrast in texture between the A and B horizons.

Each of these has been subdivided according to colour and other factors such as structure, consistence and soil reaction, according to Northcote's Factual Key. Table 7 lists all the soil groups together with their corresponding classifications from Stace *et al*. (1972) and Soil Survey Staff (1975).

Table 7 – Classification of Soils

Primary Profile Form	Soil Type	Site Number	Northcote (1979)	Stace et al. (1968)	Soil Survey Staff (1975)
Soils of uniform texture	Coarse sands	1069 1084, 1099 1030 719, 730	Uc 1.21 Uc 1.41 Uc 4.22 Uc 2.21	Siliceous sands Lithosols Podzols Podzols	Xeropsamment Xerorthent Quartzipsamment Quartzipsamment
	Alluvial sands	1061, 1119 1086, 1088 1097 1083	Uc 1.21 Uc 1.41 Uc 1.43 Uc 2.34	Siliceous sands Siliceous sands Lithosols Humus podzol	Xeropsamment Xeropsamment Xerorthent Quartzipsamment
	Brown loams	1123 1016, 1089 1080 724 1064	Um 1.41 Um 1.43 Um 1.43 Um 4.23 Um 6.11	Lithosols Alluvial soils Lithosols Lithosols Chernozems	Xerorthent Xerofluvent Xerorthent Xerorthent Haploxeroll
	Yellowish brown shallow stony loams	1028 710 1029	Um 2.12 Um 2.21 Um 4.11	Alluvial soils Lithosols Lithosols	Xerofluvent Xerorthent Xerorthent
	Friable clay soils	1082	Uf 6.32	Chocolate soils	Haploxeralf
	Cracking clay soils	1063 1057 1035 1054	Ug 3.2 Ug 5.12 Ug 5.15 Ug 5.25	Grey clays Black earths Black earths Grey clays	Pellustert Pellustert Pellustert Pellustert
Gradational soils	Red gradational soils				
	Basalt	726, 1078, 1081, 1100, 1106, 1111 720, 1077 1096, 1104, 1109	Gn 3.11 Gn 3.12 Gn 3.14	Krasnozems Euchrozems Red podzolic soils	Palexeralf, Acrorthox Rhodustalf, Ulstochrept Palexeralf, Haploxerult
	Rhyolite, sandstones and mudstones	1108 1046, 1073 1113	Gn 4.11 Gn 3.14 Gn 4.11	Krasnozems Red podzolic soils Krasnozems	Palexeralf, Acrorthox Palexeralf, Haploxerult Palexeralf, Acrorthox
	Red-brown gradational soils	727 1037, 1079 1018 711, 1066, 1094 1070	Gn 2.24 Gn 3.22 Gn 3.71 Gn 3.74 Gn 4.34	Yellow earths Brown earths Xanthozems Xanthozems Krasnozems	Palexeralf Dystrochrept, Haplustalf Haplorthox, Haplustult Haplorthox, Haplustult Palexeralf, Acrorthox
	Yellowish brown gradational soils	1047 714, 1019, 1025, 1027, 1112 1020, 1038, 1091	Gn 3.75 Gn 3.84 Gn 3.85	Xanthozems Yellow podzolic soils Yellow podzolic soils	Haplorthox, Haplustult Paleustult, Haploxeralf, Paleustult Paleustult, Haploxeralf, Paleustult
	Grey gradational soils	1067, 1074, soils 1114, 1059, 1095	Gn 3.04, 1092, 1121 Gn 4.51	Humic gleys ?	Paleaquult, Albaquult ?
	Dark gradational soils	1060	Gn 3.42	Prairie soils	Palexeralf, Haplustalf
		1122	Gn 3.43	Prairie soils	Palexeralf, Haplustalf
	Mottled yellow duplex soils				
Duplex soils	Sodic soils	1117	Dy 3.21	Yellow solodic	Haplustalf, Haploxeralf
		728, 729, 1017, 1024, 1034, 1052, 1087, 1124 709, 718, 723, 1045, 1048	Dy 3.41 Dy 3.42	Yellow podzolic soils or Soloths Yellow podzolic soils or Soloths	Haplustalf, Haploxeralf, Natrixeralf Haplustalf, Haploxeralf, Natrixeralf

Primary Profile Form	Soil Type	Site Number	Northcote (1979)	Stace et al. (1968)	Soil Survey Staff (1975)
		1055	Dy 5.41	Yellow podzolic soils and Soloths	Haplustalf, Haploxeralf, Natrixeralf
		1101	Dy 5.42	Yellow podzolic soils and Soloths	Haplustalf, Haploxeralf, Natrixeralf
	Non-Sodic	1120	Dy 3.21	Yellow podzolic soils	Haplustalf, Haploxeralf
		715, 1031, 1032, 1042, 1049, 1050, 1051, 1062, 1076, 1085, 1103	Dy 3.41	Yellow podzolic soils	Haplustalf, Haploxeralf
		1026	Dy 3.42	Yellow podzolic soils	Haplustalf, Haploxeralf
	Yellow duplex soils	1068, 1090	Dy 2.11	?	Haplustalf, Haploxeralf
		725	Dy 2.21	Yellow podzolic soils	Haplustalf, Haploxeralf
		1022	Dy 2.22	Yellow podzolic soils	Haplustalf, Haploxeralf
		717	Dy 2.41	Soloths, yellow podzolic soils	Haplustalf, Haploxeralf
	Red duplex soils				
	Sodic soils	1043	Dr 2.12	Non-calcic brown soils	Rhodexeralf
		721, 1021, 1034, 1053	Dr 2.13	Red-brown earths	Rhodexeralf
		708	Dr 2.23	Red-brown earths	Rhodexeralf
		1033, 1036, 1098	Dr 2.41	Soloths, red solodic soils	Palexeralf, Haploxerult
		707, 1023	Dr 2.42	Soloths, red solodic soils	Palexeralf, Haploxerult
		716, 1044	Dr 3.41	Soloths, red solodic soils	Palexeralf, Haploxerult
		1015, 1040	Dr 2.43	Solodised solonetz, solodic soils	Natrixeralf
		722	Dr 3.43	Solodised solonetz, solodic soils	Natrixeralf
	Non-sodic	1072, 1115	Dr 2.11	Non-calcic brown soils	Rhodoxeralf
		1071	Dr 2.21	Red podzolic soils	Palexeralf, Haploxerult
		1065, 1100	Dr 2.41	Red podzolic soils	Palexeralf, Haploxerult
		1107	Dr 2.42	Red podzolic soils	Palexeralf, Haploxerult
		1102	Dr 3.42(?)	Soloths	?
	Brown duplex soils	1075	Db 2.41	Soloths	Natrixeralf
		1056	Db 4.11	Soloths	Natrixeralf
	Dark duplex soils	1041	Dd 1.42	Soloths	Natixeralf
		1058	Dd 3.13	Soloths	Natrixeralf

For detailed profile descriptions and samples of the major soils in each land system, a backhoe was used to dig a trench approximately 2 x 4 m and up to 2 m deep. Where possible these sites were selected in forested or relatively undisturbed areas. The methods used in the laboratory analysis of the soil samples are outlined in Appendix II.

Uniform Soils
Soils of uniform texture ranging from sands to clays occur on a variety of parent materials and landscape positions. Parent material includes basalt, granodiorite, sedimentary sandstone and mudstone and river gravel, sand and silt deposits. Textures range from coarse sands to heavy clays, and landscape positions include hill crests, open plains and the young alluvial terraces on the valley floors.

Coarse sands
Coarse sands of variable depth occur on the upper slopes and crests of granitic areas, usually among outcropping boulders. Low nutrient status, high permeability and low water-holding capacity limit the growth of most introduced plants. Organic matter accumulation under native vegetation accounts for the unusually high cation exchange capacity and the moderate levels of nitrogen and potassium in the topsoil; however, the remainder of the profile has a low to very low nutrient status (see Figure 11). Agronomic trials conducted by the Victorian Department of Agriculture and Rural Affairs point to deficiencies of phosphorus, calcium, sulphur, molybdenum, copper and zinc. Low productivity may be further reduced by competition from bracken and rabbits. Removal of the protective vegetative cover from the light sandy topsoils by clearing and overgrazing has increased the hazard of erosion by wind and water. Most areas are lightly stocked with sheep on native pastures.

Trees or deep-rooted pasture species survive the droughty soil conditions by tapping water reserves held at depth in subsoils and in the jointed parent material.

Example:

Cobaw land system, Component 1, granodiorite, hill crest

Uc 1.41 – 1/0/55* Site 1099
1:100 000 Map sheet Woodend: 7823, Grid ref 918 797.

A_{11} 0-17 cm dark brown (10YR3/3) loamy coarse sand, apedal, soft (dry), 15% quartz gravel, pH 6.5, clear wavy to:

A_{12} 17-55 cm yellowish brown (10YR5/4) coarse sand, apedal, slightly hard (dry), 10% quartz gravel, pH 6.0; diffuse boundary to:

C 55-95+ cm dark yellowish brown (10YR4/4) loamy sand, apedal, faint common yellow mottles, hard consistence (dry), pH 6.0

* Extended Northcote Key (Charman 1978 p. 87)

Similar soils

Classification	Land System	Compt.	Site No.	1:100 000 Map sheet	Grid ref:
Uc 1.21	Ida	3	1069	7824	985 092
Uc 1.41	Theaden Hill	1	1084	7823	847 783
Uc 2.21	Alexander	2	719	7723	608 998
Uc 2.21	Theaden Hill	4	730	7823	890 862
Uc 4.22	Sargent	1	1030	7724	619 029

Alluvial sands (Siliceous sands)

The flood-plains of most major streams contain young sandy deposits of variable depth. Profile development ranges from accumulation of organic matter at the soil surface through to the development of soil horizons, including a bleached A_2 horizon. Permeability can also be extremely variable depending on the depth and nature of the underlying bedrock and the presence of hardpans or buries soils. Organic matter in the topsoil provides moderate levels of nitrogen and potassium; however, the low levels of phosphorus, calcium and magnesium, the small areas, the flooding hazard and the general low to very low nutrient status (Figure 11) are the main factors restricting land use to the grazing of native pastures.

Example:

Heathcote land system, Component 4, alluvium, upper terrace
Uc 1.21 – 2/0/007 Site 1119
1:100 000 Map sheet Heathcote: 7824, Grid ref 947 127.

A 0-7 cm dark brown (10YR4/3) loamy sand, weak subangular blocky, very friable (moist), pH 6, clear smooth to:

C 7-104 cm yellowish brown (10YR5/4) sand, apedal, very friable (moist), pH 5.5, abrupt smooth to:

$2A_{11}b$ 104-120 cm black (10YR2/1) silty clay loam, apedal, friable (moist); pH 8; clear smooth to:

$2A_{12}b$ 120-146 cm very dark grey (10YR3/1) clay loam, apedal, friable (moist), pH 7.5, gradual smooth to:

$2B_2tb$ 146-180+ cm very dark grey (10YR5/1) sandy clay, weak sub angular blocky, friable (moist).

Similar soils

Classification	Land System	Compt.	Site No.	1:100 000 Map sheet	Grid ref:
Uc 1.21	Cobaw	3	1061	7823	906 788
Uc 1.41	Theaden Hill	2	1086	7823	822 823
Uc 1.41	Theaden Hill	5	1088	7823	868 790
Uc 1.43	Axe Creek	2	1097	7724	661 238
Uc 2.34	Sidonia	3	1083	7823	826 845

Brown Loams

These soils developed on alluvium usually show little or no horizon development other than some organic matter accumulation at the surface. Exceptions are Um 2.12 with a bleached A_2 horizon and Um 6.11 with a structured B horizon. Profiles have a low to moderate nutrient status, with more variation in subsoils than topsoils. To a limited extent, reddish brown loams occur on the steeper basaltic slopes such as scarps and volcanic cones. They are usually shallow and stony. Soil profiles 724 and 1080 have a much higher nutrient status than the rest of the group.

With added phosphate, introduced pastures can be established, but only small areas are involved. The topsoils have a high proportion of fine sand and silt and readily compact when depleted of organic matter.

Example:

Runnymede land system, Component 4, alluvium, lower terrace

Um 1.43-3/0/010 Site 1016
1:100 000 Map sheet: 7824, Grid ref. 782 328.

A 0-10 cm dark brown (7.5YR4/2) loam, weak subangular blocky, very friable (moist), slightly hard (dry), pH 6, diffuse smooth to:

C_1 10-20 cm dark brown (10YR4/4) loam, weak subangular blocky, hard (dry), pH 6, diffuse smooth to:

C_2 20-120 cm dark brown (10YR3/3) loam, weak subangular blocky, friable (moist), pH 6.5, clear wavy to:

C_3 120+ cm very dark brown (10YR2/1) clay loam, weak subangular blocky, friable (moist), pH 6.0.

Similar soils

Classification	Land System	Compt.	Site No.	1:100 000 Map sheet	Grid ref:
Um 1.41	Diogenese	5	1123	7823	855 661
Um 1.43/Db	Redesdale	5	1080	7823	844 977
Um 1.43	Wolfscrag	5	1089	7823	974 974
Um 4.23	Knowsley	3	724	7824	897 196
Um 6.11	Marydale	4	1064	7824	771 224

Yellowish-brown shallow stony loams

Shallow stony loams interspersed with rock outcrop occur on the crests and upper slopes of the steep land on Palaeozoic sediments. Undisturbed topsoils have moderate organic matter contents with moderate nitrogen and potassium levels. The moderately well- structured topsoils become hard-setting when disturbance of the vegetation and soil reduces the organic matter content. The soil is always deficient in phosphorus, calcium and molybdenum. Productivity is low because of the low water-holding capacity and the very low nutrient status (Figure 11) of the shallow soil. As the cation exchange capacity is also very low, these soils have an extremely low potential for improvement.

Similar soils

Classification	Land System	Compt.	Site No.	1:100 000 Map sheet	Grid ref:
Um 2.12	Fryers	3	1028	7723	719 887
Um 2.21	Wombat	1	710	7823	807 575
Um 4.11	Fryers	1	1029	7723	734 873

Friable clays

Friable black clays of variable depth characterise gently dissected basalt to the north and south of Kyneton. The light clay, neutral topsoils are friable and moderately permeable, and have a high to very high nutrient status (Figure 11). Deficiencies of phosphorus, potassium, sulphur or molybdenum sometimes need to be rectified to increase pasture yields. Physical limitations are less extreme than those of the cracking clays; however, slow subsoil drainage, profile shallowness and stoniness restrict agricultural productivity.

Example:

Redesdale land system, Component 4, basalt scarp.
Uf 6.32-5/3/007 Site 1082
1:100 000 Map sheet 7823, Grid ref. 805 001

A_1 0-7 cm dark greyish brown (10YR3/2) light medium clay, strong subangular blocky, very hard (dry), 25% gravel and stones of basalt, pH 7.0, clear wavy to:

B 7-37 cm dark grey (10YR3/1) medium clay, moderate angular blocky, extremely hard (dry), 40% gravel and stones of basalt, pH 7.0

Similar soil

Classification	Land System	Compt.	Site No.	1:100 000 Map sheet	Grid ref:
Uf6.32	Kyneton	4	-	7723	727 778

Cracking clays

Cracking clays occur on basalt and on alluvium in the north – for example, in the Runnymede land system. Self-mulching topsoils overlie heavy clays that range in colour from almost black to light grey. Deep cracks from as the subsoil dries out. Gilgai features are common, and a sporadically bleached A_2 horizon sometimes develops in the depressions (Ug3.2). When dry and cracked, the soils have high infiltration rates and low run-off, but when wet and expanded their characteristics become those of low infiltration and high run-off. This shrink-swell process creates an extremely difficult environment for plant roots and for buildings and roads, which require special foundations.

In general the nutrient status is high, but values tend to be lower in gilgai depressions. Under intensive agricultural use, potassium and nitrogen become deficient and deficiencies of zinc, molybdenum, sulphur and manganese have been recorded. High soluble-salt contents combined with waterlogging or rising water tables can cause salinity problems, particularly in irrigation areas.

Example:

Kyneton land system, Component 5, alluvium, drainage depression

Ug5.12-4/3/023 Site 1057
1:100 000 Map sheet 7723, Grid ref. 679 824

Puff

A_1 0-23 cm dark grey (10YR3/1) light clay, strong subangular blocky, extremely hard (dry), pH 6, clear wavy to:

B 23-107 cm dark grey (7.5YR3/0) medium clay, moderate prismatic, extremely hard (dry), pH 7.5, abrupt irregular:

R hard basalt

Depression

A 0-23 cm dark grey (10YR3/1) clay loam, abundant distinct yellow-brown root hair mottling, strong subangular blocky, extremely hard (dry); pH 5.8, clear wavy to:

B_{21} 23-39 cm dark grey (7.5YR3/0) medium clay, strong subangular blocky, extremely hard (dry), pH 6, clear wavy to:

B_{22} 39-125 cm dark grey (7.5YR3/0) heavy clay, moderate prismatic, extremely hard (dry), pH 8.5, abrupt, broken to:

R hard basalt

Similar soils

Classification	Land System	Compt.	Site No.	1:100 000 Map sheet	Grid ref:
Ug 5.15	Runnymede	1	1035	7824	877 486
Ug 3.2	Marydale	1	1063	7824	781 225
Ug 5.25	Redesdale	2	1054	7823	838 005

Gradational soils

Red gradational soils

Within the catchment, red gradational soils can be divided into two categories based largely on the parent material: basalt; and sandstone-mudstone and rhyolite.

On basalt parent materials, topsoils have loam to clay-loam textures and clay contents increase with depth. Profiles have high ferric oxide contents and are red, friable and freely drained. Clay and organic matter contents in virgin soils account for the high levels of nitrogen and potassium. Phosphorus levels are low. A moderate nutrient status (Figure 11) is common, although the subsoils in the Camel Range land system are calcareous through a combination of calcium-magnesium silicate weathering and the leaching of 'parna' (Butler 1956) to the lower horizons. The soils are generally deep and have excellent physical properties for agricultural land use, although the shallower ones are stony. Nitrogen and phosphorus deficiencies occur soon after clearing, and sulphur, molybdenum and potassium tend to become limiting more slowly.

Example:

Trentham East land system, Component 2, colluvium, outwash slope

Gn 3.11-4/1/027 (Basalt) Site 1111
1:100 000 Map sheet 7723, Grid ref. 649 585

A 0-27 cm dark reddish brown (5YR2/3) clay loam, weak subangular blocky, friable (moist), pH 6.0, clear wavy to:

B_{21} 27-112 cm dark reddish brown (5YR3/4) clay loam, moderate subangular blocky, hard (dry), minor content of parent material gravel and stone, pH 6.0, diffuse wavy to:

B_{22} 112-0184 cm dark reddish brown (2.5YR3/4) light clay, moderate angular blocky, somewhat hard (dry) ferromanganiferous stains, pH 6.0, gradual wavy to:

BC 184+ cm weathered basalt.

Similar soils

Classification	Land System	Compt.	Site No.	1:100 000 Map sheet	Grid ref:
Gn 3.11	Redesdale	4	1081	7823	854 952
Gn 3.11	Pastoria East	1	1106	7823	861 778
Gn 3.11	Kyneton	3	1078	7723	747 680
Gn 3.11	Diogenes	6	726	7823	816 700
Gn 3.11	Trentham East	3	1110	7723	674 636
Gn 3.12	Camel Range	1	720	7824	982 476
Gn 3.12	Camel Range	1	1104	7824	981 463
Gn 3.12	Diogenes	6	1077	7823	826 662
Gn 3.12	Drummond	1	1096	7723	637 784
Gn 3.14	Trentham East	2	1109	7723	680 638
Gn 4.11	Pastoria East	2	1108	7823	816 766

Sandstone-mudstone and rhyolite soils have a similar classification; however, the levels of nitrogen, phosphorus and potassium in the sandy topsoils are the result of accumulated organic matter rather than any influence of clay. When the organic matter content declines, the stony topsoils become hard-setting. Shallow soils and a very low nutrient status (Figure 11) limit land use to native pastures.

Example:

Kimbolton land system, Component 1, sandstone and shale, steep slopes

Gn 3.14-3/0/016 (Sedimentary) Site 1046
1:100 000 Map sheet 7724, Grid ref. 579 212.

A_1 0-10 cm brown (7.5YR5/6) silt loam, apedal, friable (moist), parent material, gravel 20%, stone 40%, pH 5.5, gradual wavy to:
A_2 10-20 cm reddish yellow (7.5YR6/6) silty clay loam, apedal, hard (dry), parent material gravel 20%, stones 30%, pH 5.0, gradual wavy to:
B 20-60 cm red (2.5YR4/8) clay, strong angular blocky, very friable (moist), parent material gravel 15%, stones 10%, pH 5.5, abrupt broken to:
C 60+ cm weathered sandstone and shale.

Similar soils

Classification	Land System	Compt.	Site No.	1:100 000 Map sheet	Grid ref:
Gn 3.84	Kimbolton	1	714	7724	765 138
Gn 3.84	Fryers	2	1027	7723	660 866
Gn 3.84	Glen Cooee	1	1025	7724	669 178
Gn 3.84	Wombat	2	1112	7723	658 767
Gn 3.84	Myola East	1	1019	7824	965 519
Gn 3.85	Wolfscrag	4	1091	7823	864 932
Gn 3.85	Myola East	5	1020	7824	971 529
Gn 3.85	Glenholt	4	1038	7724	629 467

Grey gradational soils

The grey gradational soils are found in the southern half of the catchment on the upper slopes of Ordovician sediments, rhyolite and the platy basalt derived from Spring Hill. Virgin topsoils are acidic (pH 5.0-5.5), with high levels of nitrogen, potassium and organic matter, but deficient in phosphorus. The subsoils have a low nutrient status (Figure 11).

Most soils are about 1 m deep and have non-sodic subsoils.

Example:

Fryers land system, Component 3, shales and sandstones, drainage depressions.

Gn4.64-3/0/058 Site 1095
1:100 000 Map sheet 7723, Grid ref. 620 863

A_{11} 0-6 cm dark greyish brown (10YR3/2) loam, apedal, slightly hard (dry), pH 5.0, abrupt wavy to:
A_{12} 6-30 cm brown (10YR5/3) silty loam, apedal (massive), hard (dry), pH 5.0, gradual wavy to:
A_2 30-58 cm pale brown (10YR6/3) silt loam, common faint yellowish brown mottles, apedal (massive), hard (dry), pH 5.0, diffuse wavy to:
B 58-118 cm light grey (10YR7/1) silty clay loam, abundant distinct yellowish brown mottles, moderate subangular blocky, hard (dry), pH 5.5, clear wavy to:
BC 118-150+ cm light grey (10YR7/2) silty clay loam

Similar soils

Classification	Land System	Compt.	Site No.	1:100 000 Map sheet	Grid ref:
Gn 3.04	James	3	1067	7723	758 001
Gn 3.04	Macedon	2	1074	7823	846 620
Gn 3.04	Wolfscrag	3	1092	7823	936 013
Gn 3.04	Fryers	2	1121	7723	623 801
Gn 4.51	Womgat	3	1114	7723	575 551
Gn 4.51	Glenvue	4	1059	7723	664 691

Dark gradational soils

These soils are confined to minor drainage depressions on basalt. Slightly acidic topsoils overlie neutral or alkaline clay subsoils, which tend to be poorly drained. The nutrient status is very high and the soils are relatively stable.

Example:

Trentham East, Component 4, basalt, drainage depressions

Gn 3.42-4/3/015 Site 1060
1:100 000 Map sheet 7723, Grid ref. 657 574

A 0-15 cm dark grey (10YR3/1) silty clay loam, strong subangular blocky, hard (dry), pH 6.0, clear wavy to:

B_{21} 15-50 cm dark grey (10YR3/1) silty clay, common distinct yellowish brown mottles, moderate subangular blocky, very hard (dry), minor basaltic gravel, pH 7.0, gradual wavy to:

B_{22} 50-88 cm dark grey (10YR4/1) medium clay, abundant distinct brown and grey mottles, moderate subangular blocky, firm (moist), pH 8.0, diffuse smooth to:

BC 88+ cm alluvium

Similar soil

Classification	Land System	Compt.	Site No.	1:100 000 Map sheet	Grid ref:
Gn 3.43	Drummond	3	1122	7723	654 795

Duplex soils

Mottled yellow duplex soils

In the northern half of the catchment, mottled yellow duplex soils are found on a variety of parent materials including sandstones and shales, tillite, alluvium, granodiorite and ancient river gravel-sand deposits. The topsoils, although often hard-setting, have higher infiltration rates than the mottled clay subsoils and this results in perched water tables and poor trafficability during wet periods.

Profiles vary considerably in sodicity. Sodic subsoils are slightly acid to neutral and have a very low to moderate nutrient status (Figure 11). The clays are dispersible and therefore susceptible to tunnel and gully erosion on sloping land.

Leaching is more severe in the non-sodic subsoils, which are acidic and have a low nutrient status throughout. Common deficiencies include phosphorus, nitrogen, calcium, potassium, molybdenum, copper, sulphur and zinc.

Example:

Knowsley land system, Component 3, tillite, drainage, depression.

Dy 3.41-2/0/046 (Sodic) Site 1124
1:100 000 Map sheet 7824, Grid ref. 882 219.

A_{1w*} 0-4 cm dark brown (7.5YR3/4) silt loam, apedal friable (moist), pH 5.5, abrupt smooth to:
A_{11} 4-15 cm dark brown (10YR3/) silt loam, apedal, friable (moist), hard manganiferous concretions (5%), pH 5.5, gradual wavy to:
A_{12} 15-30 cm yellowish brown (10YR5/4) sandy loam, apedal, friable (moist), quartz gravel 1-2%, hard manganiferous concretions (20%), pH 5.5, gradual smooth to:
A_2cb 30-46 cm very pale brown (10YR7/3, 8/2 dry) loamy sand, apedal, very friable (moist), quartz gravel 5%, hard manganiferous concretions 5%, pH 5.5, clear smooth to:
B_2t 46-76 cm light brownish grey (10YR6/2) sandy clay, abundant prominent yellow-brown mottles, weak subangular blocky, smooth ped, firm (moist), quartz gravel 10%, stones 5%, pH 5.8, abrupt wavy to:
C 76-83 cm gravelly coarse sandy loam, abrupt wavy to:
$2B_2$ 83-106+ cm light olive brown (2.5YR5/3) heavy clay, common distinct yellowish brown mottles, strong angular blocky, smooth ped, firm (moist), quartz gravel 10%, stones 2%, organic matter stains, pH 6.5

* w = wash layer

Similar soils

Classification	Land System	Compt.	Site No.	1:100 000 Map sheet	Grid ref:
Sodic soil types					
Dy 3.21	Ida	2	117	7824	958 135
Dy 3.41	Cobaw	2	728	7823	910 833
Dy 3.41	Theaden Hill	4	729	7823	913 860
Dy 3.41	Runnymede	2	1017	7824	851 397
Dy 3.41	White Hills	3	1103	7724	662 253
Dy 3.41	Glen Cooee	2	1024	7727	604 142
Dy 3.41	Glenholt	5	1039	7724	644 455
Dy 3.41	Lonsdale	3	1052	7824	904 271
Dy 3.41	Theaden Hill	4	1087	7823	942 884
Dy 3.42	Sargent	2	718	7723	658 987
Dy 3.42	Knowsley	1	726	7824	893 188
Dy 3.42	Wellsford	3	1045	7824	885 275
Dy 3.42	Kimbolton	3	1048	7724	692 125
Dy 3.42	Glen Cooee	2	709	7724	657 229
Dy 5.41	Lonsdale	2	1055	7824	906 272
Dy 5.42	Axe Creek	1	1101	7724	678 268
Non-sodic soil types					
Dy 3.11	Kimbolton	1	713	7724	766 129
Dy 3.21	Heathcote	3	1120	7824	997 071
Dy 3.41	Sutton Grange	4	715	7724	707 026
Dy 3.41	Sutton Grange	3	1042	7724	644 055
Dy 3.41	Diogenes	2	1076	7823	840 689
Dy 3.41	Sargent	2	1031	7723	687 926
Dy 3.41	Sidonia	1	1062	7823	863 871
Dy 3.41	Sidonia	2	1085	7823	820 741
Dy 3.41	Sutton Grange	1	1049	7724	640 061
Dy 3.41	Sutton Grange	4	1051	7723	672 942
Dy 3.41	Elphinstone	2	1032	7723	635 928
Dy 3.42	Glen Cooee	3	1026	7724	763 202

Yellow duplex soils

Because these soils have low iron contents and are well drained, they are devoid of mottles. Bleached A_2 horizons and sodic B horizons are uncommon. Hard-setting topsoils restrict water entry, causing run-off even on gentle slopes. The nutrient status is very low (Figure 11) and agricultural uses require additions of nitrogen, phosphorus and potassium and frequently molybdenum, sulphur, copper and zinc.

Example:

Ida land system, Component 1, shale and sandstone, steep slopes

Dy 2.11/2/0/014 Site 1068
1:100 000 Map sheet 7824, Grid ref 959 162

A_1 0-14 cm brown (10YR4/3) sandy loam, apedal, slight hard (dry), colluvial gravel 15%, stones (50%), pH 5.0, clear wavy to:
$B_{21}t$ 14-64 cm strong brown (7.5YR5/6) light clay, weak subangular blocky, hard (dry), parent material gravel 20%, stones 10%, pH 5.0, gradual wavy to:
$B_{22}t$ 64-78 cm strong brown (7.5YR5/8) light clay, weak subangular blocky, hard (dry), parent material gravel 10%, pH 5.5, clear wavy to:
C 100+ cm weathered parent material.

Similar Soils

Classification	Land System	Compt.	Site No.	1:100 000 Map sheet	Grid ref:
Dy 2.11	Wolfscrag	1	1090	7823	908 955
Dy 2.21	Wombat	2	725	7723	669 660
Dy 2.22	Muskerry	1	1022	7824	885 418
Dy 2.41	Sutton Grange	3	717	7724	716 024

Red duplex soils

These duplex soils with neutral to alkaline sodic subsoils occur in the north on the Riverine Plain, the gentle slopes on Ordovician sediments and the slopes of the Colbinabbin Range. They have a moderate to high nutrient status (Figure 1) and are used extensively for cropping. In the south with higher rainfall, soils have acidic, non-sodic subsoils with a low nutrient status and are used for grazing on native and introduced pastures. In general, the topsoils are acidic and have a low organic matter content and a low nutrient status.
Phosphorus deficiency occurs throughout the red duplex soils and low levels of available nitrogen and molybdenum are common. Zinc deficiencies occur on the more calcareous soils.

Gypsum is applied to overcome the hard-setting nature of topsoils and to improve the permeability of the more sodic subsoils.

Example:

Axe Creek land system, Component 1, alluvium, terrace

Dr2.41-1/0/043 Sodic Site 1098
1:100 000 Map sheet 7724, Grid ref. 666 209

A_1 0-13 cm dark brown (7.5YR3/3) sandy loam, apedal, slightly hard (dry), pH 6.0, clear wavy to:
A_2cb 13-46 cm brown (7.5YR5/4 – 7/3 dry), bleached loamy sand, apedal, slightly hard (dry), pH 7.0, clear smooth to:
B_2t 43-72 cm reddish brown (5YR4/4) clay, moderate subangular blocky, very hard (dry), pH 6.0, gradual wavy to:

BC	72-100+ cm light brownish grey (10YR6/2) silt loam, weak subangular blocky, common distinct reddish brown mottles, very hard (dry), pH 6.0.

Example:

Glenvue land system, Component 3, basalt, plain

Dr 2.21-2/0/032 – non-sodic Site 1071
1:100 000 Map sheet 7723, Grid ref. 653 690.

A_1 0-18 cm dark reddish brown (5YR3/3) silt loam, weak subangular blocky, soft (dry), parent material gravel 10%, pH 6.0, clear wavy to:
A_2 18-32 cm yellowish red (5YR4/6) silt loam, apedal, hard (dry), parent material gravel 5%, pH 6.0, clear, irregular to:
$B_{21}t$ 32-90 cm dark red (2.5YR3/6) clay, strong angular blocky, smooth ped, hard (dry), parent material gravel 5%, pH 6.0; diffuse wavy to:
B_{22} 90-160+ cm red (2.5YR4/6) clay, moderate angular blocky, hard (dry), parent material gravel 5% and occasional stone, pH 6.0

Classification	Land System	Compt.	Site No.	1:100 000 Map sheet	Grid ref:
SODIC					
Dr 2.12	Glenholt	3	1043	7724	614 452
Dr 2.13	Myola East	2	1021	7825	965 596
Dr 2.13	Myola East	2	1034	7824	967 486
Dr 2.13	Camel Range	2	21	7824	983 492
Dr 2.13	Camel Range	2	1053	7824	961 348
Dr 2.23	Wellsford	2	708	7724	616 250
Dr 2.41	Glenholt	2	1033	7724	635 455
Dr 2.41	Glenholt	1	1036	7724	616 487
Dr 2.42	Runnymede	2	707	7824	821 442
Dr 2.42	Muskerry	2	1023	7824	870 411
Dr 2.43	Muskerry	2	1040	7824	908 386
Dr 2.43	Runnymede	2	1015	7824	780 328
Dr 3.41	Sutton Grange	1	716	7724	714 025
Dr 3.41	Wellsford	2	1044	7724	703 416
Dr 3.43	Knowsley	2	722	7824	883 178
Non-Sodic					
Dr 2.11	Drummond	2	1115	7723	620 731
Dr 2.11	Glenvue	3	1072	7723	663 690
Dr 2.41	Cobaw	2	1100	7823	892 768
Dr 2.41	James	1	1065	7724	528 179
Dr 2.42	Pastoria East	3	1107	7823	824 750
Dr 3.41(?)	White Hills	2	1102	7724	662 251

Brown duplex soils

The brown duplex soils occur on the gentle slopes at the base of Mount Macedon and on the basaltic plains near Drummond and Kyneton. Grazing on introduced pastures is the common form of land use, but the soils on the plains have a higher nutrient status and cropping does occur on rock-free areas.

Example:

Drummond land system, Component 4, basalt, plain

Db 4.11-4/2/025 Site 1056
1:100 000 Map sheet 7723, Grid ref. 657 794

A_{11} 0-7 cm brown (10YR4/3) silt loam, faint root hair mottling, moderate subangular blocky, soft (dry), parent material gravel 3%, pH 5.5, clear smooth to:
A_{12} 7-25 cm dark brown (7.5YR3/2) silt clay loam, common faint reddish brown mottles, moderate angular blocky, very had (dry), ferruginous nodule gravel 15%, stones 5%, pH 6.0; clear smooth to:
$B_{21}t$ 25-61 cm dark yellowish brown (10YR4/4) clay, common distinct reddish brown mottles, strong angular blocky, extremely hard (dry), ferruginous nodules gravel 15%, stones 10%, pH 6.0, gradual wavy to:

B_{23}	113-150 cm light grey (2.5YR7/2) heavy clay, weak prismatic, extremely firm (moist), ferruginous nodules gravel 10%, parent material stones 20%, pH 6.0, abrupt irregular to:
C	weathered basalt

Similar Soil

Classification	Land System	Compt.	Site No.	1:100 000 Map sheet	Grid ref:
Db 2.41	Macedon	2	1075	7823	844 617

Dark duplex soils

These soils occur in some drainage depressions on granite and basalt. The nutrient status is low to moderate for the topsoil and high for the salinity alkaline subsoil, and is characteristic of many soils on alluvium. The magnesium dominance of the exchangeable cations in the lower B horizon is characteristic of solonetz soils (Stace et al. 1972). The dispersive sodic subsoils are prone to gully erosion.

Example:

Sutton Grange land system, Component 3, granodiorite, drainage depressions

Dd 1.42-2/0/036 Site 1041
1:100 000 Map Sheet 7724, Grid ref. 649 033

A_{11}	0-9 cm dark greyish brown (10YR3/2) coarse sandy loam, weak subangular blocky, hard (dry), pH 5, gradual smooth to:
A_{12}	9-19 cm black (10YR2/1) coarse sandy loam, apedal, slightly hard (dry), pH 5.0, clear smooth to:
A_2cb	19-36 cm dark greyish brown, bleached (10YR4/2 moist 7/2 dry) loamy sand, apedal, soft (dry), quartz gravel 20%, pH 6.0, abrupt smooth:
B_{21}t	36-60 cm very dark grey (10YR3/1) clay, moderate prismatic with secondary moderate subangular blocky, extremely hard (dry), pH 7.5, gradual smooth to:
B_{22}t	60-90 cm dark grey (10YR4/1) clay, few distinct yellowish brown mottles, moderate subangular blocky, firm (moist), quartz gravel 10%, pH 8.0, diffuse smooth to:
BC	90-120+ cm dark grey (10YR4/1) clay, common distinct yellowish brown mottles, weak subangular blocky, friable (moist), pH 7.5.

Similar Soil

Classification	Land System	Compt.	Site No.	1:100 000 Map sheet	Grid ref:
Dd 3.13	Kyneton	7	1058	7723	716 778