4. SOILS

SOIL FORMATION

The soils of the study area, in general, have two important features in common. Firstly, almost all the soils are quite clayey, at least in the subsoil if not throughout their profiles. The clayeyness is the result of the nature of the parent rocks in the area, most of which weather to clays and silts. Secondly, a high proportion of the soils are duplex soils. Duplex soils are soils in which loamy, but occasionally sandy, topsoil abruptly overlies a much heavier textured subsoil, ie the topsoil is differentiated texturally from the subsoil. This differentiation. within soils developed on clayey and silty parent materials is due to:

(1) loss of clay in the topsoil by chemical weathering and/or by downward movement of clay particles from the topsoil to the subsoil caused by percolating water. Weathering and downward leaching of clay particles are naturally most intense in the topsoil because it is exposed to the leaching action of rain, fluctuating temperatures, and the effect of living organisms. As an example of the effect of living organisms, certain organic compounds, which are important in the translocation of iron and in the weathering of minerals, are exuded by plant roots or are formed by the rotting of dead organic matter.

(2) enrichment of the topsoil with coarser fractions from nearby sources. (Bishop, *et al*. 1980)

(3) local surface washing of the soil on temporarily bare or disturbed areas during heavy rain storms which can lead to winnowing and selective removal of the finer clay particles and the retention of coarser silt and sand particles as a lag deposit on the surface.

(4) little vertical mixing of soil by burrowing animals or treefall.

Among other factors that play a part in the process of soil formation are the accumulation of humus in the topsoil by the decomposition of dead biological matter, the cycling of plant nutrients by the vegetation, and any contributions of dust, minerals and salts that may reach a site from the atmosphere.

Soil Formation on Basalt

Basalt releases much calcium and will produce only clay and silt when it weathers to soil. It is one of the most common rocks in the area, so that the black clay soils, uniform texture, coarse structure and grey clay soils (Northcote's Ug category) which develop on the basalt, or the alluvium from it, are widespread. The grey clay soils tend to be found on lower slopes, swales and low-lying alluvial terraces, where longer periods of waterlogging compared with the higher slopes, have caused the soil to develop a grey colour. Lateral seepage and runoff from higher lying areas are probably responsible for the enrichment of their subsoils with sodium and, no doubt, also with lime.

The black clay soils, uniform texture, coarse structure occur pre-dominantly on the better drained slopes of the undulating basalt plains. A small amount of sand occurs in these fine textured soils. This sand must have originated elsewhere and been blown or washed onto the basaltic soils.

Although the black and grey clay soils are widespread, duplex soils are most common soils on the basalt plains. Their subsoils can be red, red-brown, or yellow-brown in colour, and they can be calcareous or both calcareous and sodic. Several processes in the formation of soils can lead to the development of a lighter textured topsoil (A horizon) which abruptly overlies a heavy textured subsoil (B horizon); see above discussion. Of these, the addition of some silt and fine sand to the top soil as a surface wash from different geological material on higher ground or as a windblown dust accession, is probably the most important in the development of a duplex soil on the basalt. Obviously, a long time is required before pronounced duplex characteristics can develop in the soil profile.

In some smaller areas on basalt, soils can be found which differ markedly from the black or grey clay soils and the duplex soils. In Romsey land system the typical soil is a red soil which becomes gradually heavier textured with depth and which has a weakly developed structure. Weak structure and earthy fabric - especially in the subsoil - generally occur when the soil loses its active clay minerals either through their continued weathering, to a more inert type or through their removal by leaching. These red gradational soils are the result of intense leaching and weathering of the basalt during an era of warm, humid conditions.

Soil Formation on Granodiorite and Rhyodacite

These igneous and volcanic rocks contain feldspars, micas and dark minerals which weather to clays, as well as quartz and resistant minerals which end up in the sand and silt fraction of the soils forming on these parent rocks. Generally, these rocks occur in the mountainous, high rainfall portions of the study area. Most of the land in the associated land systems (Cobaw, Mt. Macedon and Mt. Disappointment) is well drained. Parent material, good drainage and high rainfall combine to give rise to red gradational soils, with a fine, well developed structure in the subsoil. This structure is the main morphological difference between these soils and the weakly structured, earthy ones in Romsey land system. Although they contain more fresh soil materials, their nutrient status and cation exchange capacity are lower than for the Romsey gradational soils.

Soils that are different from these red gradational soils can also occur on granodiorite or rhyodacite, where special conditions prevail. For example, in the Cobaw land system, stony gradational soils may occur on crests of hills and mountains where natural erosion is more active.

Soils of the Volcanic Plains

The most widespread kind of soil on the volcanic plains is of the duplex soil category, but there are extensive areas of black clay soils of uniform texture, as well as very minor areas of red gradational soils and other soils.
Duplex Soils

In the duplex soils category there are two predominant types:

(a) Mottled Yellow, Grey Sodic Duplex Soils, Coarse Structure

Leaching has not been intensive during the process of soil formation so that free lime is found in some parts of the subsoils of these duplex soils, and sodicity is common to many of them. As a consequence of the sodicity of the subsoils, the clays of this part of the soil profile are often dispersible. If erosion takes place and gullies are formed, the gullying is accelerated and more difficult to treat and stop in the dispersible soil horizons. The propensity for dispersion of sodic soils is to be kept in mind in the digging of drains and ditches and the construction of road batters.

Frequently, the mottled yellow, grey sodic duplex soils are associated with a gilgai microrelief. In the depressions the lower part of the A horizon is slightly bleached and contains more ferruginous concretions (buckshot) than on the mounds. This is consistent with the stronger degree of waterlogging that must occur in the depressions after heavy or prolonged rain. However, both on the mound and in the depression, the permeability of the subsoil is likely to be very low, because on wetting the clay swells, closing the cracks between the coarse blocky peds and the clay, itself, has a low permeability. Seasonal excessive wetness of the soil may restrict farming operations and trafficability across paddocks, as well as cause damage to the pasture from trampling by grazing animals. The clay subsoils also show a pronounced shrink-swell capacity which is to be taken into account in the construction of foundations for houses and roads.

The reaction of these soils changes with depth, from moderately acidic (pH values less than 6) in the surface horizon to alkaline (pH values more than 7) in the subsoil. Their content of soluble salts is low, as the electrical conductivity is generally less than 1000 microsiemens/cm., but in a few samples where this value was exceeded the higher salt content occurred usually in the C horizon on the sampled soil profile. They have much exchangeable calcium and even more exchangeable magnesium.

(b) Red Calcareous Sodic Duplex Soils, Coarse Structure

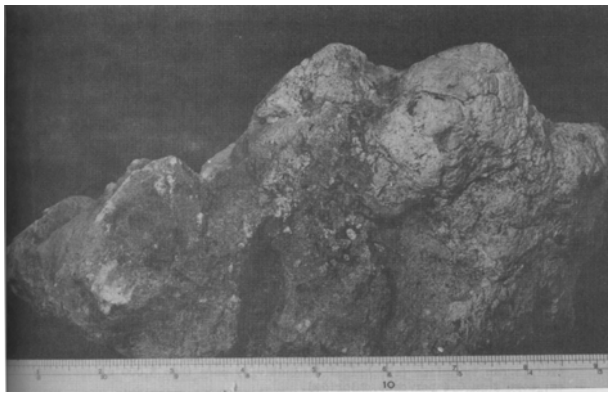
The red calcareous sodic soils tent to occur further west in the survey area where the rainfall is less (200-400 mm) than in the area where the mottled yellow, grey sodic duplex soils are common (600-700 mm precipitation)

Uniform Soils

After the category of duplex soils, the next most common soils of the Volcanic Plains are the black clay soils of uniform texture and coarse structure. A majority of these are self-mulching, that is, upon drying they form a loose surface layer of small granular soil particles. These dark clay soils have a coarse subangular blocky to angular blocky structure, and they show little vertical differentiation in their profiles. The lowest part of the profile may be mottled and greyer than the overlying soil. Free lime commonly occurs in the subsoil in the form of nodules, which can grow to a very large size (Photograph No. 1). The surface soil is

normally slightly acid, but the subsoils are alkaline (pH 8 more).

When wet, these clays become very plastic and sticky and areas with such soils tend to become impassable to vehicles. However, because of their self-mulching properties, these soils are easily cultivated when moisture conditions are right. For this reason it would be desirable to manage them separately from the duplex soils but this is not practical due to the clay soils occurring in small areas surrounded by the suplex soils.



Photograph 1 - Lime concretion

Gradational Soils

Gradational soils occur on some crests and swales, where they are respectively reddish and dark brown. The subsoils are usually mottled. They are also somewhat acid in the surface becoming alkaline with depth.

Soils of the Nillumbik Terrain

In this dissected, hilly terrain, the soils are mainly developed from Silurian and Ordovician sedimentary rock, and from alluvium or colluvium derived from them. The two predominant soil categories are:

mottled yellow, brown sodic duplex soils, coarse structure and shallow stony gradational soils.

Minor kinds of soils than can be found are:

red duplex soils,
grey calcareous sodic clay soils, uniform texture, coarse structure mottled yellow, brown gradational soils,
and
brown sodic gradational soils.

The greater part of the subsoils in these soil types contain enough exchangeable sodium to cause the clay subsoil to disperse on wetting. Consequently, as both factors of steep slopes and dispersible soil material combine, there is a high hazard of tunnel and gully erosion.

Once gullies are formed, the gullying is accelerated and more difficult to treat and stop in the dispersible soil horizons. It is therefore important to prevent land management practices which allow the relatively stable surface soil from being removed or washed away because the surface soil offers the best protection for the subsoil.

Mottled, Yellow Brown Sodic Duplex Soils

The mottled yellow, brown sodic duplex soils occur in a variety of landscape positions, on crests, slopes and swales, wherever erosion and deposition have been minimally active. These duplex soils have A horizons that are sometimes hydrophobic. ie tend to repel water, when they are in a dry condition. As hydrophobic A horizons initially shed more water during heavy storms, there is a greater erosion hazard on these soils than on those which have non-hydrophobic A horizons. After they have been wetted, these A horizons have moderate to high permeability due to the presence of numbers of more or less vertical tubular pores.

The A horizons overlies a blocky, yellow-brown red mottled clay B horizon, which may contain a varying amount of gravel. The top soil tends to be acid grading to neutral to slightly alkaline with depth; soils are

generally non-saline although in depressions the lower part of the soil profile can be saline (electrical conductivity more than 3,000 microsiemens/ cm; more than 0.4 per cent chloride).
Shallow Stony Gradational Soils

On crests and steep slopes, shallow stony gradational soils are common. They generally comprise a hydrophobic, loamy A horizon grading into a clayey, medium blocky, yellow-brown and red mottled B horizon, which is often stony or gravelly. In depressions or slope concavities, soil material tends to accumulate by wash and creep from higher lying sources so that deeper and darker coloured gradational soils with little textural differentiation down the profile, are often found there as well. The soil reaction tends to run from moderately acid (pH 5) in the surface, to slightly acid (pH 6) at depth.

In some localised areas erosion has stripped off part or all of the A horizon, and even part of the B horizon. Where this has happened the remaining soil should be recognised as having been truncated.

Soils of the Mountains and Plateaux

The parent rocks of soils on the mountains and plateaux are diverse. Cambrian, Ordovician and Silurian sedimentary rocks are the most prominent, followed by basalt, granodiorite and rhyolite. All the area receives a high rainfall and, as there is a high proportion of steeply sloping land, drainage, both surface and through the soil, generally tends to be rapid. Conditions for strong leaching of the soils therefore exist and this is reflected in the nature of the soils which are common in the area.

Red gradational soils are the predominant soils, but yellow gradational soils are also extensive. It appears that the red gradational have a well developed fine structure and the yellow gradational a weakly developed structure. Shallow stony gradational soils are common in erosional situations on ridges and steep slopes. Next in importance are the duplex soils of which there are three main kinds: yellow-brown sodic, mottled red sodic with fine structure, and red duplex soils. It is the lower rainfall, elevation and gentler topography of Rockford and Pretty Sally land systems which combine to provide conditions that produce these duplex soils.

Gradational Soils

On the plateaux especially, the red gradational soils are probably very old soils or remnants of very old soils. On steep slopes they are younger. The high rainfall and associated strong vegetative growth of the forest cover, produce much litter so that it is common to find a well developed decomposing litter layer (AO horizon) at the soil surface. The Al horizon below the litter layer is usually a dark coloured clay loam, and below that, a bleached A2 horizon may occur. With depth the texture usually grades into a clay, which has an angular blocky structure. The whole profile is acidic, grading from strongly acid (pH 4) at the surface to moderately acid (pH 5) in the lower parts. The permeability of the soil is high due to the fine cracks, which are more numerous in the subsoil, and the many biogenic pores particularly common in the upper part of the profile. On the average, there appear to be 10 vertical tubular pores per square centimetre cross section. The subsoil colour (B horizon) is red in the best drained positions and becomes yellowish-brown on lower slopes and in swales where drainage is not so good.

Plant roots are able to penetrate these soils to great depth and they are deep and easily worked. Hence these soils are much sought after for certain crops such as potatoes, as well as being highly regarded for vegetable and fruit production.

Duplex Soils

The duplex soils in this high rainfall area are almost without exception well leached and acidic in reaction throughout the profile (pH $_4$ in the surface to pH 5 at depth). Their A horizons are generally loamy, but may contain gravel or coarse sand, and it is common to find ferruginous concretions in them. A bleached Al horizon is sometimes present. The A horizon overlies abruptly a clay to heavy clay B horizon which in some areas contains gravel.

Whilst the subsoil of some of the duplex soils in the Rockford land system, are sodic and therefore unstable, the other duplex soils seem to be non-sodic, and may be expected to be non-dispersible and relatively stable. However, some of these duplex soils occur in scattered areas in the Humevale and Mt. William land systems, where a greater proportion of the land is sloping steeply so that despite the relative stability of the soils, the erosion hazard is high.