THE SOILS OF THE EASTERN TRANSVAAL SUGAR INDUSTRY

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Abstract

The physiography, geology and soils of the Eastern Transvaal sugar industry are described. Because irrigation is essential to sugarcane production in the area, the physical properties of the soils—derived from Swaziland schists and shales, Basement gneisses, Karroo basalt, diabase and alluvium—are emphasized.

Introduction

A survey of the soils of this industry was made during 1969, and the information obtained supplements the data collected by Maud and Von der Meden[5].

The objectives of the survey were to map the parent materials on each farm at 1:6 000 scale, and to shed more light upon some agriculturally significant aspects of the soils:

(a) total available moisture holding capacity, because of its relevance to irrigation design;

(b) water movement through soil in terms of slowly permeable layers, because of its importance in the development of waterlogging under irrigation, and in the provision of adequate drainage;

(c) the likelihood of the development of saline and alkali conditions under irrigation.

In addition, the various kinds of soil occurring on each parent material were identified (but not mapped), and some of their chemical properties determined in the laboratory. Although the total area under cane is 9 811 hectares, the total area surveyed amounted to more than 24 000 hectares.

By identifying and naming the soils which occur in the area, it will be possible to make use of any agronomic results obtained on similar soils elsewhere in South Africa. The nomenclature used in this article conforms with that of Van der Eyk, MacVicar and De Villiers[7]; detailed definitions and coloured illustrations of the soils are given by these authors. The soils which are not described by Van der Eyk *et al* are indicated accordingly in this article. Available moisture capacity data given here are estimates based on measurements made elsewhere by Von der Meden and reported in the Experiment Station's annual report for 1968-69[1]. Estimates of desirable water application rates are based on a few observations made on existing schemes. An aide memoire to the soils is given in Table I.

Physiography

The north-south trending Lebombo mountain range, composed of easterly dipping or tilted rhyolitic volcanic lavas, separates the Mozambique coast plain from an inland plain, known as the Lowveld, of which the Kruger National Park and the Swaziland Lowveld are a part.

Proceeding inland from Komatipoort (see Fig 1), the Crocodile, Komati and Lomati rivers have cut a plain, 150-380 m above sea-level, across basalt and sediments of the Karroo System, and across the granitic Basement Complex, and the less resistant metamorphic rocks of the Swaziland System. This plain stretches inland as far as Kaapmuiden in the Crocodile catchment and for a considerable distance up the Lomati valley.

The chief resistance to planation has been offered by the more siliceous rocks (quartzites, cherts of the Fig Tree and Moodies Series) of the Swaziland System, producing what is known as the Barberton Mountain Land which rises to heights of more than 1 200 m. The eastward extension of this Mountain Land juts from Kaapmuiden in the west and terminates east of Hectorspruit, where the Swaziland rocks abut against planed Ecca sediments (see Fig. 1). This extension of the Mountain Land forms the jagged range which separates the Crocodile from the Lomati plains. The less resistant rocks of the Fig Tree Series (shales and schists) form the valley floors in the Mountain Land.

The Kaap river joins the Crocodile at Kaapmuiden. The upper Kaap has planed the softer granite of the Barberton amphitheatre (760 m above sea-level), but traverses the resistant rocks of the Barberton Mountain Land through a narrow and steep-sided valley before emerging on to the Lowveld plain at Kaapmuiden. The upper Crocodile valley (Schagen-Kaapmuiden) ranges from 480-840 m above sea-level and is hilly.

The vegetation of the lower Crocodile and Lomati plains was described by Acocks[2] as Lowveld. It has a mean annual rainfall in the range 500-700 mm (Weather Bureau[8]), hot summers and mild winters. Not conducive to intense weathering and leaching, these semi-arid conditions are the reason for the not infrequent occurrence of soils with free lime.

Also described as Lowveld by Acocks, the Barberton granite amphitheatre, and the Nelspruit-Crocodile valley receive a mean annual rainfall of 650-800 mm, while the Schagen-Nelspruit valley receives 760-1 000 mm.

In each locality, rainfall tends to be higher at higher altitudes, and higher on southern than on northern slopes. Thus, the Barberton Mountain Land and the range that divides the Kaap from the Crocodile catchments receive more than 760 mm and, in parts, more than 1 000 mm *per annum*. The vegetation of this land was described by Acocks as Lowveld Sour Bushveld. Weathering forces and leaching have been moderately severe, but the steepness of the terrain has prevented the development of deep soils.

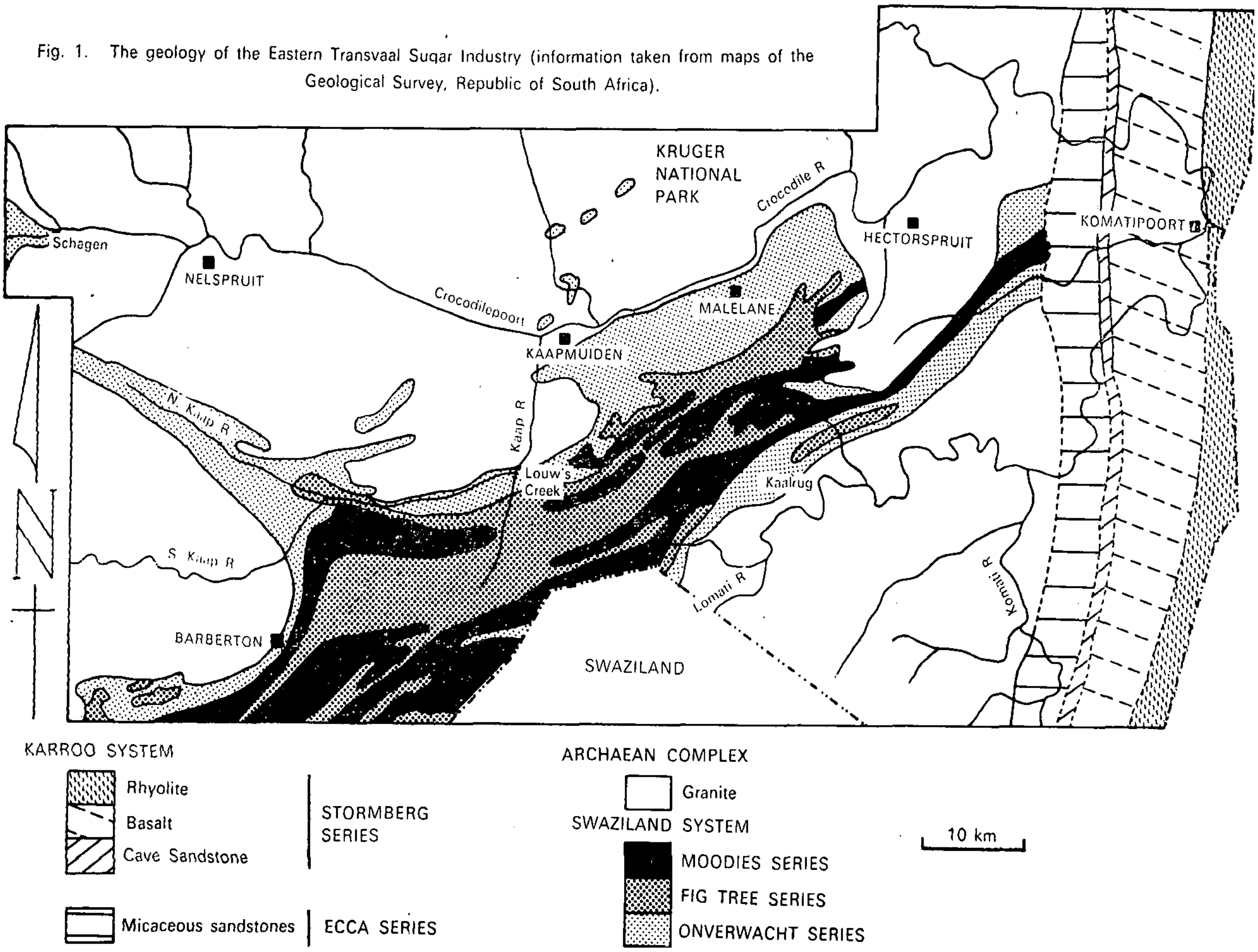

Fig. 1. The geology of the Eastern Transvaal Sugar Industry (information taken from maps of the Geological Survey, Republic of South Africa).

Geology

Swaziland System

This is a folded succession of volcanics and sediments of early pre-Cambrian age (some 3 000 million years old) which were deposited on a platform of gneiss known as Nelspruit granite. The System is divided into four Series, in all of which diabase intrusions are found: Onverwacht, Fig Tree, Moodies and Jamestown Series.

According to Haughton[4] there were two separate periods in early pre-Cambrian times during which mountains were formed in this area by folding and thrusting. The first caused the metamorphism of the pre-Swaziland sediments and intrusives to form the Ancient Gneiss Complex and the associated granodioritic gneisses. The second was post-Moodies in age causing the folding and metamorphism of Swaziland rocks in addition to affecting the pre-Swaziland basement gneisses.

The relationship between the Onverwacht, the oldest member of the Swaziland System, and the Jamestown Series, the youngest member, is uncertain, there being considerable argument (Haughton[4]) in favour of regarding most Jamestown rocks as being part of the Onverwacht Series. The Jamestown Series is considered to represent a post-Moodies igneous intrusive complex comprising an earlier basic phase and a later acid phase (Haughton). For the purposes of this article, the Jamestown Series is omitted; its basic phase is described with the rocks of the Onverwacht Series, while the acid phase, namely the Kaap Valley granite, is included under the granite heading.

Onverwacht Series consists of basic lavas largely altered to serpentinite, carbonate and talc schists, and various types of amphibole schist. However, the younger part of this Series contains rocks such as quartz and felspar porphyry, rhyolite, shale and chert, which are more resistant to weathering than its older, basic components; these more resistant members generally form high-lying ground.

Cane land on Onverwacht Series is mainly confined to the easily weatherable, basic elements which give rise to red clay soils. The Series tends to skirt the range of mountains which separates the Lomati from the Crocodile plain. It is also represented on several farms at Schagen: ML17, ML41, ML44 and ML45.*

Fig Tree Series is composed of shales, slates and graywacke, but includes horizons of banded chert, ironstone and jasper; schists and lavas have also been reported in it. The resistant rocks, together with the Moodies Series, form the high-lying Mountain Land, while the less resistant rocks tend to occupy the valley floors. The latter include shales, graywacke (roadside on ML49) and talcose and carbonate

*Sugarcane quota numbers are given for those who have access to the 1:6 000 parent material maps.

schists. Shallow brown soils are formed from shales, red (occasionally black) clays from basic rocks, and red loams in mixed drift from basic rocks and sediments.

Moodies Series consists largely of resistant quartzites and sandy shales. Very little cane is grown on this land, which is generally confined to the high mountain ranges. The soils are acid grey sands and loams.

Granite

Apart from an intrusion of *Mpageni granite* in the Crocodilepoort, the granite of the Lomati plain, the lower Kaap Valley and the upper Crocodile Valley (Schagen—Crocodilepoort) it known as *Nelspruit granite* (Haughton[4]). It comprises biotite gneisses and biotite-hornblende gneisses associated with which are grey granodioritic and hornblende-granodioritic gneisses. In addition, this granite carries xenoliths of basic Onverwacht rocks. With its lithological make-up varying from a biotite gneiss to a hornblende-granodiorite gneiss, the Nelspruit granite produces grey sandy soils on its acid components, and red loams on its more basic components.

Salisbury Kop granite at Hectorspruit tends to be coarser grained than the Nelspruit granite. Potash felspars are subordinate to soda felspars (Haughton[4]). The soils derived from it are characteristically grey sands, but syenitic rocks (Du Toit[3]) are responsible for some red loams.

Kaap Valley granite in the Barberton amphitheatre is mainly a hornblende-granodiorite gneiss with fairly widespread biotite. Red loams are thus a frequent occurrence.

Karroo System

Sediments and volcanics of the Ecca and Stormberg Series occur as an easterly-dipping, north-south trending belt in the Komatipoort area.

A belt of *Middle Ecca* sediments (mainly fine-grained micaceous sandstones giving rise to solonetz soils, namely Estcourt soil series) abuts against granites and Swaziland rocks in the west.

Eastwards, the Middle Ecca is followed by a narrow, possibly discontinuous belt of *Cave Sandstone* (giving rise to grey fine sands), a wide belt of *basalt* (red clays) and finally the resistant rhyolitic lavas that constitute the Lebombo mountain range.

Diabase intrusions

These are found in greater or lesser number in all the geological formations of the area. The most notable occurrences are to be found on the Barberton plain as dykes, where they give rise to red clays, and on the farms ML19, ML67, ML118 and ML-NB1 on the Lomati plain, where they have produced red and black clays.

Alluvium and colluvium

Alluvial remnants in the form of pebbles at the soil-rock interface are found in some upland soils of the Lomati and Crocodile plains. A few instances of large boulder beds without a soil covering were encountered near the major rivers. However, alluvial soils are now largely confined to narrow, discontinuous strips adjacent to rivers. They are of two kinds. The first, namely the recent terrace, borders immediately upon the river, and consists of grey sands and loams with alluvial stratification. Being older on sub-recent terraces further back from the river, the second kind has undergone marked soil development giving rise to red loams and hydromorphic soils (i.e. poorly drained) of one kind or another.

In favourable topographic situations such as prevail in parts of the Kaap and Louw's Creek valleys and at Kaalrug, colluvial deposits (gravity drift), often of great thickness (ML70), occur at the foot of steep slopes. Red clays and loams are the main kinds of soil which have formed in this colluvium.

Soils

The soils are described according to the parent materials from which they have been formed. The maps (1:6 000 scale) showing the distribution of these parent materials are housed at the S.A.S.A. Experiment Station, Mount Edgecombe.

Swaziland basic rocks

The basic elements of the Swaziland System, found mainly in the Onverwacht and Fig Tree Series together with intrusive diabase, have produced red soils, the majority of them blocky clays, but some are red loams, probably formed in drift mixtures from basic and quartzose rocks. Red loams, it should be noted, are also found on granodiorites (mapped as granite) and alluvium. An instance of a black clay (Rydalvale series) on Swaziland basic rocks was found on ML106. About 38,52 per cent of the area under cane belongs in this map unit.

Red clays

The great majority of these soils belong in the Glendale and Argent series. The former predominates in the drier parts of the region, while the latter is the dominant member at Schagen, and on the land lying between the Kaalrug mountains and an imaginary line between ML28 and ML65.

The Glendale series is moderately permeable, has an intake rate of 3-7 mm/hr, and an available moisture capacity of about 1,5 mm/cm. The soil is slightly acid, rich in Ca and Mg, and has fair reserves of K. Values for the exchange capacity of the clay vary from 30-60 me % indicating a high proportion of 2:1 lattice clays. The presence of montmorillonite is indicated by the soil cracking which can be observed in cane fields. Should alkali conditions develop, this montmorillonite will cause a marked reduction in permeability. The hazard of salinity is moderate, except in level or concave situations, where it is high. Depth to weathering rock varies from a few centimetres on stony ridges to about 150 cm on undulating plains such as that at Malelane. Occasionally the clay content of the soil is high enough for it to qualify as Shortlands series. Pebble layers above the weathered rock are not uncommon. In colluvial positions, for example at Louw's Creek, the series can be very deep indeed. The presence of lime in these red clays—in the drier parts of the Lowveld (ML24 and the N-E portion of ML86)—marks the presence of the Sunvalley series. The latter is similar to the Glendale, except that the montmorillonite content is usually higher, and the hazard of salinity is higher.

The wetter climate of the southern slopes of the Kaalrug mountains and at Schagen is responsible for the presence of the Argent series, the leached version of the Glendale. Exchange capacity of its clay varies from 13-30 me % indicating kaolinite and illite, and consequently the soil has better physical properties than the Glendale: it is more permeable, and has a slightly higher intake rate and available moisture capacity. While the soil is often very deep at Kaalrug, it is generally shallow at Schagen. The soil is slightly acid and it is unlikely that leaching has been severe enough to cause Ca and Mg deficiencies in the near future. Compared with the Glendale series, the hazard of salinity on this soil is low. Occasionally the clay content is high enough for it to qualify as Richmond series.

Red loams

The comparatively few red loams found in this map unit belong to the Shorrocks series and to the Msinga series, the leached version of the Shorrocks. They usually occur at the foot of steep slopes formed in part by quartzose rocks. The Msinga series occurs on the upper slopes of ML70.

These soils are usually deep, have an available moisture capacity of about 1.7 mm/cm and an intake rate of 7 mm/hr or higher. They have fair reserves of bases and the salinity hazard is low.

Swaziland shales and limestone

Examples of shales may be observed on ML68, ML80 and ML86. They give rise to brown shaly soils a few centimetres thick belonging to the sandy clay loam or clay loam phase of the Mispah soil series. The fine-grained limestone on ML72 containing calcite, dolomite, chlorite and talc has produced the Muden series (calcareous), shallow sandy clay loam phase. These soils are rich in Ca and Mg, and have a low (35-40 mm) total available moisture capacity. The hazard of salinity is moderately high. About 0.55 per cent of the area under cane belongs in this map unit.

Swaziland quartzite and quartz-sericite schist

Soils from quartzite (ML25, ML57, ML58) are grey, permeable sandy clay loams (Mispah series) 30-60 cm thick with an available moisture capacity of about 1,4 mm/cm. They are moderately acid with fairly low reserves of Ca and Mg. The spotted quartz-sericite schist (large granules of quartz in a fine ground-mass of quartz, felspar and sericite) on ML85 gives rise to a similar soil. These soils are unlikely to have a large capacity for mineralizing nitrogen. The exchange capacity of the clay ranges from 15-40 me %, indicating the presence of illite and kaolinite. This map unit covers about 0,07 per cent of the area under cane.

Granite

Varying in composition from biotite gneiss to hornblende-granodiorite gneiss, the parent material has given rise to grey sandy soils, and less commonly to red loams. The map unit covers about 20,09 per cent of the area under cane.

Red loams

The dominant red soil on granitic rocks is the Shorrocks series, gritty and usually less than 120 cm thick. Examples can be seen on ML92 near Barberton, on ML77 and ML143 in the Kaap Valley and on ML115 in a road cutting between Hectorspruit and the Swaziland turn-off. In the moister area between Nelspruit and Schagen (ML43), the red loams in the granite map unit are mainly Msinga series, a leached analogue of the Shorrocks. In the Msinga the exchange capacity of the clay ranges from 15-25 me %, indicating a dominance of kaolinite; the range in Shorrocks is 30-60 me %, indicating the presence of illite and montmorillonite.

Infiltration rate on these soils is in the order of 7 mm/hr or higher, and their available moisture capacity is in the region of 1,5-1,7 mm/cm. They are permeable soils of variable thickness overlying weathered, often porous rock. The soils are moderately rich to rich in Ca and Mg, while K reserves are moderate. The hazard of salinity is low, but poor management can cause saline conditions to develop in the Lowveld.

Grey soils

The dominant grey soils and their horizons are shown in Fig. 2. Weathering of the gneiss has produced a grey sand of variable thickness which overlies weathered rock, a slowly permeable clay, or an iron concretionary horizon.

The sand overburden has a clay content varying from 3-12 per cent, but figures of 6-9 per cent are most common. Although medium and coarse sands occur, coarse seems to predominate. Where the sand covering is thick, the top 20 cm has a browner colour (0,5-1,3% organic carbon) than the underlying sand, which presents a bleached appearance (less than 0,5% organic carbon). Available moisture capacity is in the range 0,6-1,0 mm/cm. Rates of water application exceeding 9 mm/hr are not generally recommended. These sands are generally poorly supplied with bases, particularly in the Schagen-Nelspruit area, but the underlying material—rock or clay—is usually well supplied. Soil reaction is slightly acid: values less than pH 5,5 (water) have not been recorded and consequently harmful amounts of aluminium are unlikely to be encountered. K-fixation could occur in these soils. Judging by the exchange capacity of the clay in these sands (25-60 me %), the clay fraction is dominated by 2:1 lattice clays. Being sands, there exists the possibility that they need larger than normal applications of nitrogen. Particularly where the sand overburden is deep (Kusasa*, Grovedale*, Katarra series) the hitherto partially explained growth problems (nematode damage is presently thought to be an important cause) associated with sands could be encountered. The sandy topsoil of Killarney series, a vlei soil, can have more than 15 per cent clay.

Where the soil simply consists of a sand topsoil on weathered rock, the series is Mispah sand. Where the soil consists of a deeper sand (up to 160 cm thick)

*Not defined by Van der Eyk *et al* (1969).

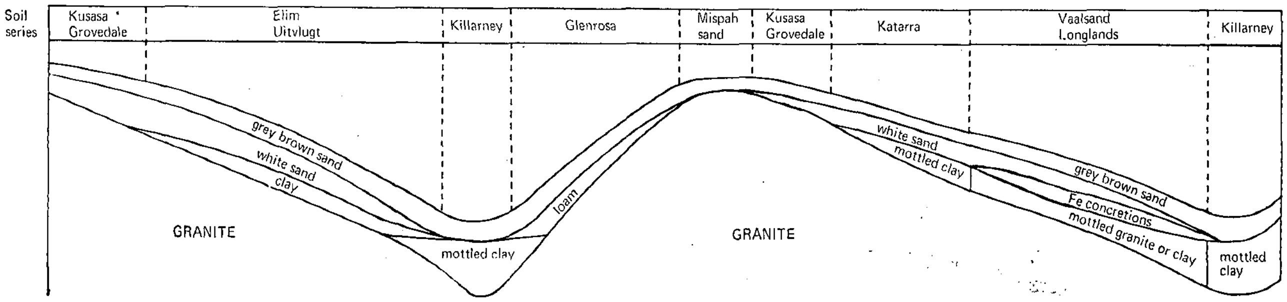

Fig. 2. Grey soils on granite: horizonation and soil-landscape relationships.

on rock, the series are Grovedale (0-6% clay) and Kusasa* (6-15% clay). The hazard of salinity in these soils is low.

The Elim (0-6% clay in topsoil) and Uitvlugt (6-15% clay in topsoil) series have a sand topsoil up to 45 cm thick lying abruptly on a heavy, slowly permeable, brown clay. The latter may be very thick, or it may be only 18-25 cm thick on weathered granite. These soils are known as solonetz, and occur in mid- and lower-slope positions. The subsoil clay and weathered granite is calcareous and, in the virgin state, sometimes saline and often alkali (reaction greater than pH 8,5). Subsoil permeability is restricted leading easily to waterlogging, while the hazard of salinity and alkali is very high; they are not the best of soils to irrigate.

Also occurring in mid- and lower-slope positions, the Katarra series has a sand layer 45-160 cm thick which lies abruptly on a heavy, slowly permeable clay. Because it experiences watertables in the natural state, the subsoil clay is mottled (gleyed). The morphology of the soil and the presence of an intermittent watertable indicate a need for artificial drainage. The subsoil clay is not calcareous but, although not as prone to it as the solonetz, the salinity hazard is moderately high.

Occurring in mid- and lower-slope positions, the Longlands (medium sand dominant) and Vaalsand (coarse sand dominant) have a sand layer 30-100 cm thick overlying a layer of iron concretions which, in turn, either overlies mottled weathered granite or a gleyed (mottled) clay. The iron concretions indicate an intermittent watertable which suggests that artificial drainage would probably be required under irrigated conditions. The soil is non-calcareous, and the hazard of salinity is moderately high.

The Killarney series occurs in lower-slope and bottomland situations. It has a grey topsoil loam or sand 20-45 cm thick lying on a heavy, very slowly permeable, gleyed (mottled) clay. The latter is deep, often calcareous, and has an available moisture capacity of about 1,1 mm/cm. The salinity hazard is very high, and the need for artificial drainage is clear.

The Glenrosa series, a sand or loam which overlies a moderately permeable sandy clay loam horizon before merging to weathered granite, is a rare upland soil in this region.

Under irrigation the grey soils on granite will require efficient water application, drainage and control of salinity and alkali because of

(a) the low TAM of many soils,
(b) the hazard of crop damage due to wetness caused by slowly permeable subsurface horizons, some of which show evidence of wetness in the virgin state, and
(c) the hazard of salinity and alkali. The comments about salinity and alkali are made in the context of a rock type well supplied with sodium, and the Lowveld climate which has not drastically depleted the weathered rock of soluble salts. Irrigation of the upper slope will cause percolating water to pick up sodium salts from the weathered rock and deposit them in lower-slope soils. The efficient drainage of mid- and lower-slope soils, and of all soils with restricted subsoil permeability, wherever they may occur, is the *sine qua non* of successful crop production under irrigation on soils from granite in this area. Should it be necessary to conduct water in canals, those canals should be lined, and great care should be taken over the construction of storage dams.

Middle Ecca sediments

No cane is at present grown on these sediments, which seem to consist mainly of micaceous and felspathic sandstones. The Estcourt series, a solonetz, was observed in a road cutting a short distance east of ML3.

This series has a permeable sandy clay loam topsoil about 30 cm thick, with an available moisture capacity of about 1,2 mm/cm. This abruptly overlies a dark brown, slowly permeable clay about 20 cm thick. The latter passes via a slowly permeable, yellow clay of variable thickness to weathered sediments. The subsoil clay is calcareous, often saline and usually alkali in the virgin state; the salinity and alkali hazards are very high. The soil is rich in Ca and Mg, contains a fair amount of K, and is dominated by 2:1 lattice clays.

Cave Sandstone

About 0,28 per cent of the area under cane has been mapped as Cave Sandstone (ML9, ML10). The soil is typically a slightly acid, grey fine sand of variable depth (Mispah fine sand) with an available moisture capacity of about 1,0 mm/cm.

Red soils varying from Shorrocks (loams) to Glendale (clays) series have been found developed in mixed drift from Cave Sandstone and basic igneous rocks.

*Not defined by Van der Eyk *et al* (1969).

Basalt and diabase

Karroo basalt in the Komatipoort area has produced the Shortlands series (more than 55% clay), the depth of which seems to vary from 40-120 cm. The porosity of the underlying weathered basalt is variable. The soil is rich in Ca and Mg and is unlikely to fix phosphate strongly. Infiltration rate appears to be in the range 3-7 mm/hr, and its available moisture capacity is about 1.5 mm/cm. It is thought to have a fairly large capacity for mineralizing nitrogen. The hazard of salinity is moderate, but high on level ground or in depressions. The exchange capacity of the clay varies from 35-60 me %, indicating the presence of illite and montmorillonite. The latter mineral would cause a marked reduction in permeability after the onset of alkali conditions. Arcadia and Bonheim series (see diabase) are occasionally found on basalt. In the vicinity of rock outcrops a shallow brown loam is sometimes found on basalt; this has been called Somerling series in Swaziland (Murdoch[6]).

Drift from rhyolite has probably been mixed into basaltic material along the western footslopes of the Lebombo range (ML129, ML 130, ML131, ML-M3). Dark coloured slowly permeable, montmorillonitic clays, with a high salinity hazard, a low infiltration rate, an available moisture capacity of about 1,2 mm/cm, and probably belonging to the Arcadia series, were found in some of these footslope situations.

Diabase has produced three main kinds of soil, namely Shortlands (see basalt), Arcadia and Bonheim (occasionally Rensburg) series. The upland soils are red (Shortlands) and black (Arcadia) clays, while the vlei soils are black (Bonheim) clays. Examples of these can be seen on ML19 and ML67.

The Arcadia and Bonheim series are slowly permeable, black montmorillonitic clays, rich in Ca and Mg. Infiltration rate is low (3 mm/hr) except when dry, and available moisture capacity is about 1,2 mm/cm. The Arcadia varies from 30-100 cm in thickness, while the Bonheim is deeper because, instead of the black clay lying directly on weathered rock as is the case in Arcadia series, its black clay horizon is underlain by a deep, slowly permeable brown clay. The latter material is very slowly permeable and requires artificial drainage prior to commencement of irrigation. The hazards of salinity and alkali are high in Arcadia and very high in Bonheim.

Basalt and diabase comprise about 27,88 per cent of the area under cane.

Alluvium

Recent stratified alluvium (types of the Dundee form) is of very limited occurrence, and is found as narrow, discontinuous strips along river banks (ML142). The soils of this young alluvium are grey, medium or fine sands to sandy loams. Infiltration is rapid and available moisture capacity varies from 0,8 mm/cm in sands to about 1,4 mm/cm in loams.

The majority of soils developed on the older, subrecent terraces are red loams. Here, the most common soil is the Shorrocks series, a deep, permeable sandy clay loam, well supplied with Ca and Mg. Infiltration rate is of the order of 7 mm/hr or higher, and its available moisture capacity is about 1,7 mm/cm. Examples of it can be found on the farms ML17, ML45, ML111, ML131 and ML138. A variant of the Shorrocks contains free lime at about 80 cm. Occasionally the clay content is high enough for the soil to be Makatini series. Heavy clays of Glendale and Shortlands series are occasionally found in alluvium (ML111); these are much deeper than their upland counterparts that overlie weathered rock.

The alluvial land bordering on the Lomati river between the farms ML59 and ML61 is a good example of a toposequence on an alluvial reverse slope. The highest part of this land is the levee occupied by the red loams described above. Proceeding downslope away from the river, grey hydromorphic soils of the Albany (grey loam with a subsoil layer of iron concretions) and Killarney (grey topsoil loam on heavy gleyed clay) series are encountered. These in turn are followed by the Rensburg series (black clay on heavy gleyed clay), which occupies the lowest portions of this alluvial land, namely along the boundary between the hill land and the alluvium. There are few other occurrences (ML111) of these hydromorphic (subject to watertables) soils in alluvium in the area surveyed. A member of the Uitvlugt series (see the discussion of solonetz soils on granite) was found in the alluvium of the Nweti stream south-east of Hectorspruit.

The hazard of salinity is high in solonetz and hydromorphic alluvial soils, and low in red loams and in the recent terrace grey sands. Land mapped as alluvium covers about 12,61 per cent of the area under cane.

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TABLE I
Summary of soil data

Parent material	%— age of [2] the area under cane	Soil series	Description	Wetness hazard	Salinity hazard
Swaziland basic rocks	38,52	Glendale	Red blocky clay (35-55% clay)	low	moderate
		Sunvalley	Red blocky clay (35-55% clay), calcareous	low	high
		(Shortlands)[3]	Red blocky clay (55%+clay)	low	moderate
		Argent	Leached red blocky clay (35-55% clay)	low	low
		(Richmond)	Leached red blocky clay (55%+clay)	low	low
		Shorrocks	Red structureless sandy clay loam (15-35% clay)	low	low
		Msinga	Leached red structureless sandy clay loam (15-35% clay)	low	low
		(Rydalvale)	Black blocky clay on rock	moderate	high
Swaziland shales and limestone	0,55	Mispah	Very shallow, brown sandy clay loam — clay loam	moderate	moderate
		Muden	Very shallow, brown sandy clay loam, calcareous	moderate	moderate
Swaziland quartzite and quartz-sericite schist	0,07	Mispah	Grey brown sandy clay loam, 30-60 cm deep	low	low
Granite	20,09	Shorrocks	Red gritty structureless sandy clay loam (15-35% clay)	low	low
		Msinga	Leached red gritty structureless sandy clay loam (15-35% clay)	low	low
		Mispah	Shallow grey sand 15-40 cm thick on rock	low	low
		Kusasa	Grey sand (6-15% clay) 40-160 cm thick on rock	low	low
		Grovedale	Grey sand (0-6% clay) 40-160 cm thick on rock	low	low
		Uitvlugt	Grey sand (6-15% clay) 15-45 cm thick on heavy calcareous clay	high	high
		Elim	Grey sand (0-6% clay) 15-45 cm thick on heavy calcareous clay	high	high
		Katarra	Grey sand (6-15% clay) 45-160 cm thick on mottled heavy clay	moderate	moderate
		Longlands	Grey medium sand (6-15% clay) 30-100 cm thick on iron concretions	moderate	moderate
		Vaalsand	Grey coarse sand (6-15% clay) 30-100 cm thick on iron concretions	moderate	moderate
		Killarney	Grey sand or loam 20-45 cm thick on mottled heavy clay	high	high
		(Glenrosa)	Grey sand or loam 25-45 cm thick over a thin permeable clayey layer, over rock	low	moderate
Middle Ecca sediments	0,00	Estcourt	Grey loam (15-35% clay) 15-45 cm thick on heavy calcareous clay	high	high
Cave Sandstone	0,28	Mispah	Grey fine sand (6-15% clay) 15-60 cm thick on rock	low	low
			Red structureless sandy clay loam (15-35% clay)	low	low
		(Glendale)	Red blocky clay (35-55% clay)	low	moderate
Basalt and Diabase	27,88	Shortlands	Red blocky clay (55%+clay)	low	moderate
		Arcadia	Black blocky clay on rock, calcareous	moderate	high
		Bonheim	Black blocky clay on brown clay, calcareous	high	high
Allumium	12,61	Dundee types	Grey stratified sands and loams	low	low
		Shorrocks	Red structureless sandy clay loam (15-35% clay), occasionally calcareous	low	low
		Makatini	Red structureless clay (35-55% clay)	low	low
		(Glendale)	Red blocky clay (35-55% clay)	low	moderate
		(Shortlands)	Red blocky clay (55%+clay)	low	moderate
		Albany	Grey loam (15-35% clay) 30-100 cm thick on iron concretions	moderate	moderate
		Killarney	Grey sand or loam 20-45 cm thick on mottled heavy clay	high	high
		Rensburg	Black blocky clay on mottled heavy clay, calcareous	high	high
		(Uitvlugt)	Grey sand (6-15% clay) 15-45 cm thick on heavy clay, on calcareous alluvium	high	high

[2]The total area under sugarcane is 9 811 hectares
[3]Bracketed series occur rarely