

SOIL MAPPING AND ADVISORY SERVICES
BOTSWANA

SOILS OF THE TSAU AREA



FOOD & AGRICULTURE
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REPUBLIC OF
BOTSWANA



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Soil Mapping and Advisory Services

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The conclusions given in this report are those considered appropriate at the time of its preparation. They may be modified in the light of further knowledge gained at subsequent stages of this project.

The definitions employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal or constitutional status of any country, territory or sea area or concerning the delimitation of frontiers.

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INTRODUCTION

The standard 1:250 000 map sheet code is known as Tsau. The report which covers the soils and physiography of the area, is part of an ongoing systematic mapping of the country at a reconnaissance scale of 1:250 000. Survey work was started in July 1989 and was completed in April 1990. Accompanying the report is a soil map.

1 GENERAL DESCRIPTION OF THE AREA

1.1 Location, Population, Communications and Land Use

1.1.1 Location

The surveyed area occupies the south western corner of the Ngamiland District (Botswana Tribal Territory). It is located between coordinates 20°00'00"S - 21°00'00"S and 21°00'00"E - 22°30'00"E. The area is approximately 17316 km². The western boundary of the sheet is delineated by the international boundary between Botswana and Namibia and the southern boundary by the Kuke veterinary fence. (see figure 1)

1.1.2 Population

The area is thinly populated, mainly concentrated in the eastern part of the sheet.

Tsau, the only major village and enumeration area (village with 500 or more people), has a population of 747 people after assuming a growth rate of 3.8% from the 1981 population census. Other smaller settlements with a population of less than 500 are Kareng, Mapororo, Simbayo and Makakung.

1.1.3 Communications

The area is isolated with hardly any infrastructure. Access to the west is almost non-existent. Roads are limited only to the periphery of the sheet by way of one major tarred road from Sehithwa to Tsau, a secondary road from Maun to Ghanzi, a track which follows the Namibian border and the veterinary cordon fence along the southern boundary of the sheet. The rest is in the form of tracks connecting the smaller settlements and cattle posts.

1.2 Climate

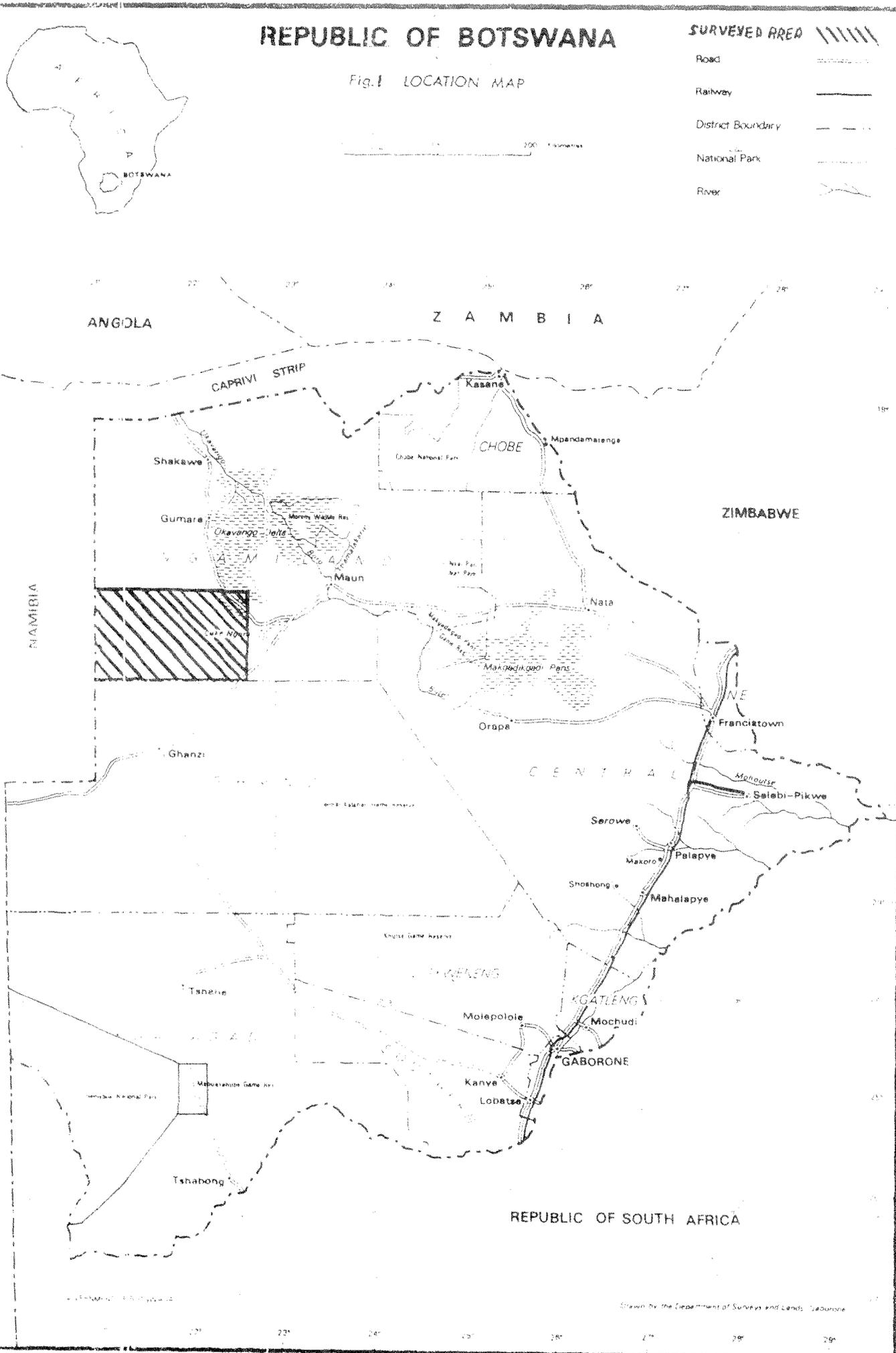
1.2.1 Rainfall

The climate is semi-arid. Mean annual rainfall which is in the region of 400 - 450 mm with a coefficient of variation of 40-45% (Y.P.R. Bhalotra 1987) is mainly accounted for by low pressure which develops over the interior of the sub-continent, leading to incursions of moist air from the Atlantic and Indian Ocean. The rainy season occurs between mid December and March with a maximum in January. The driest months are from June to August. Potential evapotranspiration is very high (2000mm per annum).

REPUBLIC OF BOTSWANA

Fig. 1 LOCATION MAP

- SURVEYED AREA** 
- Road 
 - Railway 
 - District Boundary 
 - National Park 
 - River 



Drawn by the Department of Surveys and Lands, Gaborone

1.2.2 Air Temperature

Temperature as recorded from Ghanzi presents a mean monthly maximum of 29.4°C with an extreme maximum of 41.3 in November. Mean monthly minimum temperature is 13.0°C with an extreme minimum of -8.5°C in July.

The average annual number of days of frost is 3.7 and it is likely to occur between May and September. In soil classification soil temperature regime and soil moisture regime are considered to be important parameters.

1.2.3 Soil Temperature Regime

The soil temperature regime is hyperthermic, implying that mean annual soil temperature is 22°C or higher and the difference between mean summer and mean winter soil temperature is more than 5°C at a depth of 50cm or at a lithic or paralithic contact, whichever is shallower (Soil Survey Staff 1987).

In Ghanzi the mean annual soil temperature is 28.3°C and the difference between the mean summer and winter soil temperature is 8.6°C.

1.2.4 Soil Moisture regime

The dominant soil moisture regime of the area representing about 95% is transitional from ustic to aridic and the rest (south eastern corner) is transitional from aridic to ustic. The definition of the soil moisture regimes as they occur in Botswana is as follows:

Ustic : If the mean annual soil temperature is 22°C or higher, the soil moisture control section is dry in some or all parts for 90 or more cumulative days in most years. But the moisture control section is moist in some parts for more than 180 cumulative days, or it is continuously moist in some part for at least 90 consecutive days.

Aridic : The soil moisture control section in most years is (1). Dry in all parts more than half the time (Cumulative) that the soil temperature at a depth of 50cm is above 5°C; and (2) never moist in some or all parts for as long as 90 consecutive days when the soil temperature at a depth of 50cm is above 8°C.

1.2.5 Agroclimatic Zone

Agro-climatic zoning for the entire country was determined by the Meteorological Service Department in Gaborone. The surveyed area falls into two zones, namely 2C3 covering 95% of the area and 3C3 covering the rest (South eastern corner). See figure 4.

Table 1
Monthly annual values of precipitation in
climatic Stations surrounding the survey area

Climatic Station	Month (mm)												Annual	Nr of Years	
	J	F	M	A	M	J	J	A	S	O	N	D			
Ghanzi	100.5	84.4	70.2	35.7	8.7	0.8	0.5	0.5	2.8	20.3	47.3	66.1	66.1	437.7	63
Nokaneng	85.9	97.5	70.2	25.8	2.7	0.7	0.0	0.0	8.1	13.8	44.4	66.3	66.3	453.9	10
Sehithwa	95.6	69.5	62.6	32.4	5.4	1.3	0.2	0.0	5.2	13.5	37.1	70.5	70.5	397.8	26

Table 2
Mean monthly rainfall and Potential
Evapotranspiration in Ghanzi

Climatic Station	Month (mm)												Annual	Nr of Years
	J	A	S	O	N	D	J	F	M	A	M	J		
Ghanzi(P)	0.5	0.5	2.8	20.3	47.3	66.1	100.5	84.4	70.2	35.7	8.7	0.8	437.7	63
Ghanzi PEF penman	72	102	145	186	179	187	162	136	140	101	80	60	1550	63
Ghanzi 1/2 PEF penman	36	51	72.5	93	89.5	93.5	81	68	70	50.5	40	30		

Table 3
Maximum and Minimum Temperatures (°C)
for Ghanzi

	Month (°C)												Annual	Nr of Years
	J	A	S	O	N	D	J	F	M	A	M	J		
Mean Maximum	24.0	26.8	30.8	33.2	32.8	32.9	31.6	31.3	30.9	28.7	26.2	23.3	29.4	1959-80
Minimum	4.1	7.0	11.5	15.5	17.8	18.5	19.0	18.3	16.8	14.0	8.2	4.7	13.0	
Extreme Maximum	29.8	34.5	37.2	40.6	41.3	40.0	40.3	39.6	38.8	36.4	34.5	29.8	41.3	1959-80
Minimum	-8.5	-5.4	-1.1	3.5	5.0	6.2	6.5	5.5	3.5	0.3	-2.2	-8.1	-8.5	

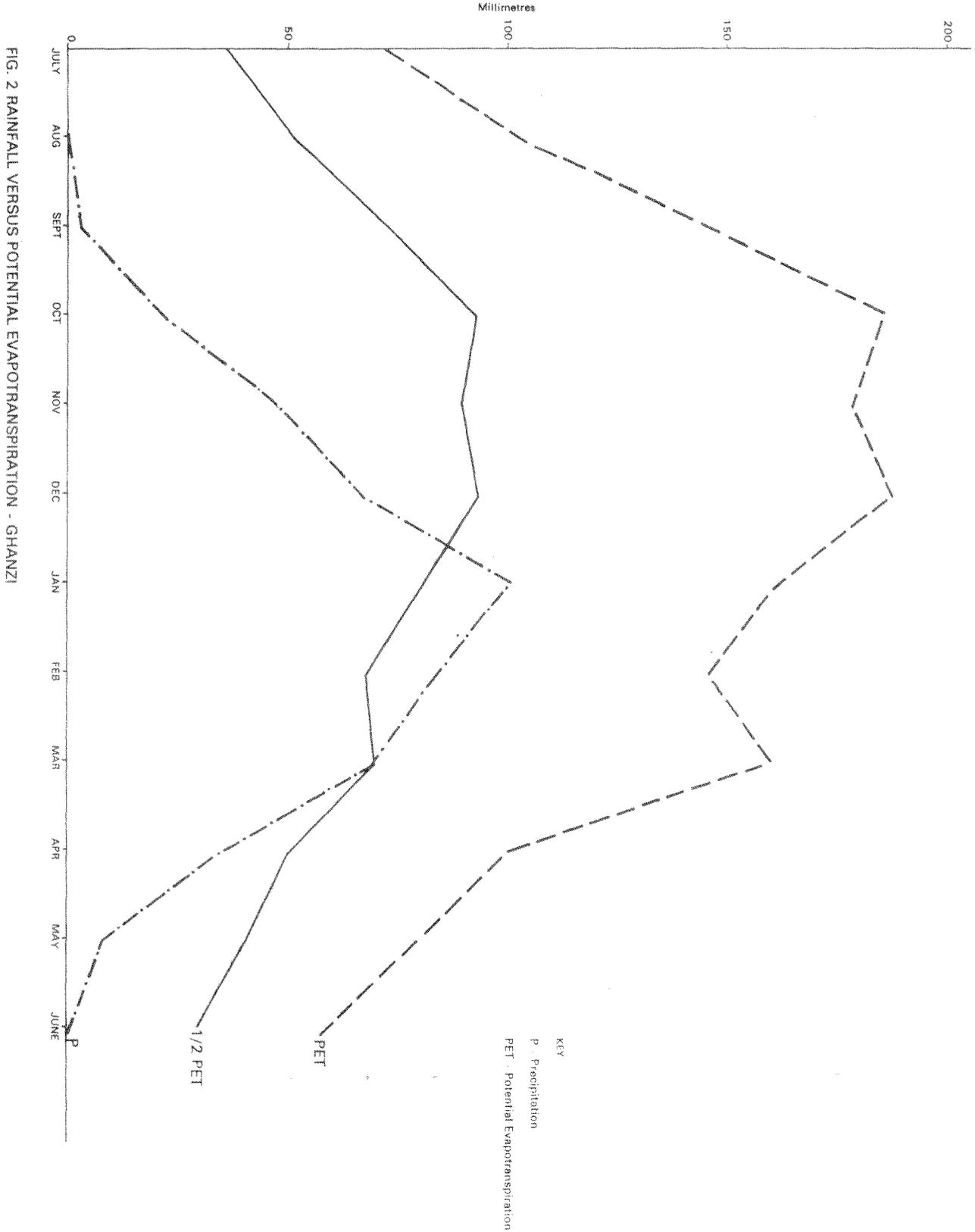
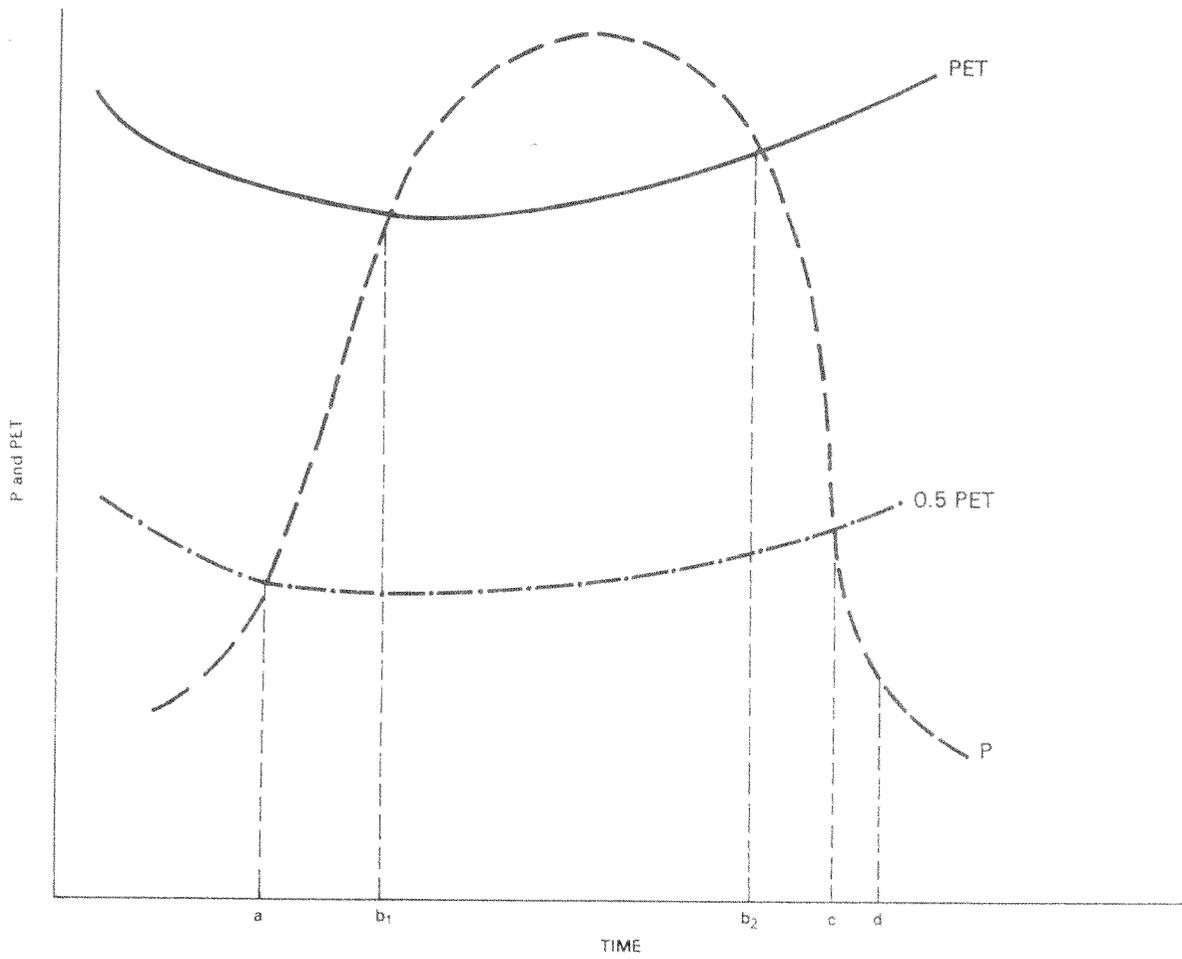


FIG. 2 RAINFALL VERSUS POTENTIAL EVAPOTRANSPIRATION - GHANZI

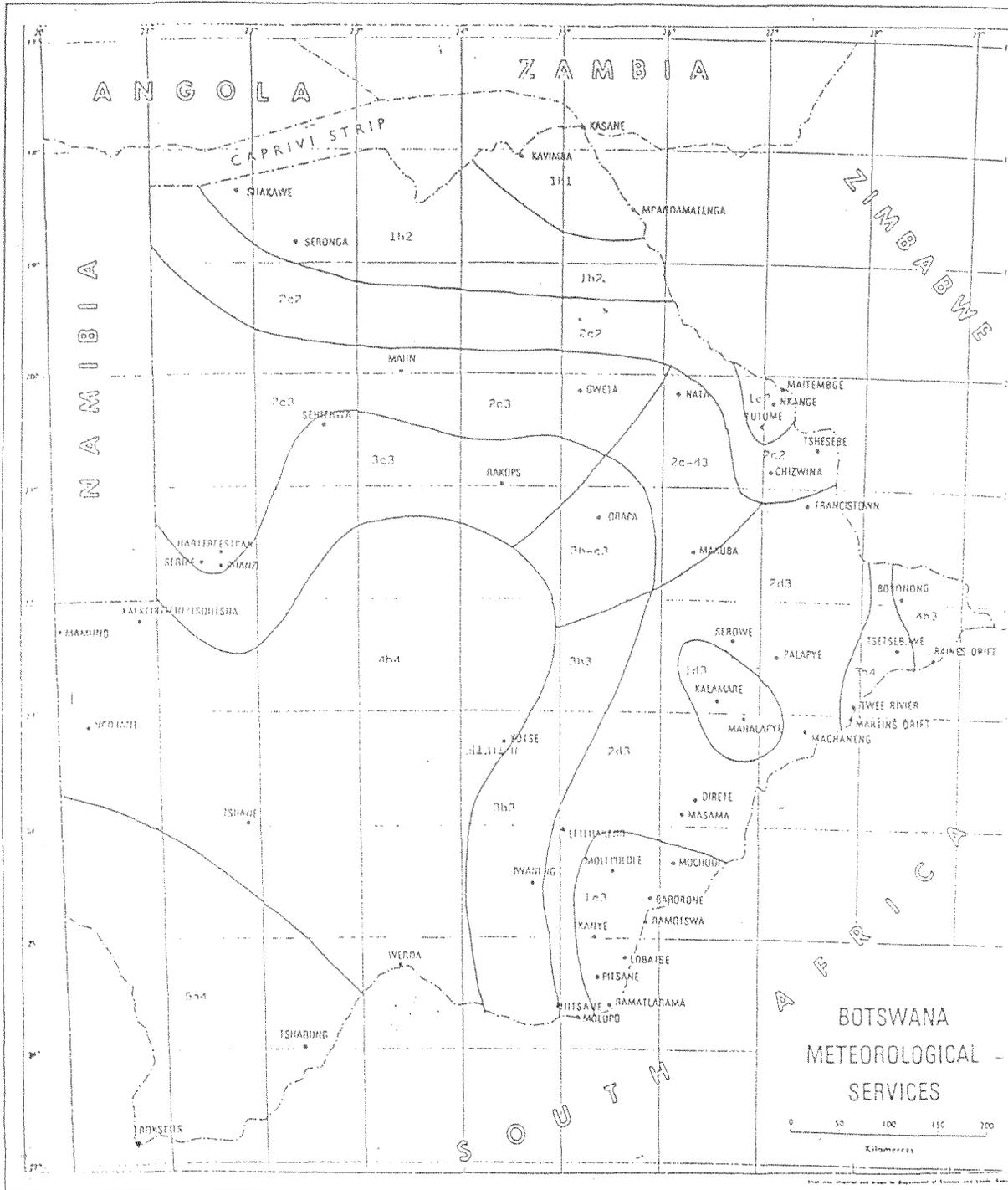
FIG. 3 AN EXAMPLE OF GROWING PERIOD



REFERENCE

- a Beginning of rains and Growing Period
- b₁ and b₂ Start and end of humid period respectively
- c End of rains and rainy season
- d End of Growing Period
- P Precipitation
- PET Potential Evapotranspiration

FIGURE 4. AGRO-CLIMATIC ZONES OF BOTSWANA.



length of season		number of dry days within the season	length of humid period	
duration (days)	frequency (%)		duration (days)	frequency (%)
1. 101-120	75-100	a. 0-10	1. 41-60	75-100
2. 81-100	75-100	b. 11-20	2. 20-40	50-74
3. 61-80	75-100	c. 21-30	3. 20-40	25-49
4. 41-60	75-100	d. 31-40	4. 20-40	< 25
5. 41-60	50-74	e. 41-50		

The methodology used in determining zones basically follows the concept of the growing period. Definitions are as follows (Rhebergen 1988):

Growing period: The start of the growing period is assumed when precipitation exceeds half the potential evapotranspiration. The end of the growing is assumed when precipitation falls below half potential evapotranspiration, plus a number of days required to evapotranspire an assumed 100mm of soil moisture reserve when available.

Growing season: The length of the growing season is equal to the length of the growing period if one growing period occurs or equals the total length of the growing periods, when two or more growing periods occur plus the number of dry days in between.

Humid period: This is a period during a growing season when precipitation exceeds full potential evapotranspiration.

Dry days: Days during the growing season when no soil moisture is available and rainfall is less than half the potential evapotranspiration.

Using the Ghanzi meteorological station data (figure 2), only one growing period occurs starting mid December and ending in March. There is no humid period occurring. From figure 4 it can be noted that agro-climatic zone 2C3 has a longer growing season of 81-100 days occurring at a frequency of 75-100% than zone 3C3 with 61-80 days also occurring with the same frequency.

1.3 Geology

Though a large part of the surveyed area is buried under deep sand, effects of the African Rift valley formation have left its mark. The subsequent faulting which occurred pushed the Ghanzi group rocks above the sand surface and also diverted the course of the Okavango which formerly fed Lake Ngami and the adjacent alluvial plains.

The only solid geology of mention is the Ghanzi group, consisting of basalt and clastic sediments.

The Ghanzi group is a mixture of sandstone, shales and limestone. Basalt and clastic sediments consist of a mixture of fragments of organic structures that have been moved individually from their place of origin.

1.4 Geomorphology

The present geomorphology of the area surveyed is believed to have been formed as a result of the overflow of the Okavango Delta combined with erosion which truncated and eroded a formally vast area of transverse dunes. Distinct physiographic units occurring in the area are described below. (See figure 5 and 6).

1.4.1 The Sandveld

The sandveld can be divided into two geomorphological sub-units of transverse sand dunes and almost flat to flat sandplains.

Transverse Dunes: These are west-north-west to east-south-east trending alab-dunes occupying an area west from the Namibian international boundary up to the Gumare fault line. Orientation of dunes is due to easterly winds. The dunes are well stabilized in the form of a cover of coarse grasses and low shrubs.

Sandplains

These are flat to almost flat plains which originally were transverse dunes but are now no more than relict eroded remnants. They are found south east of a steep scarp (the Gumare fault line) extending south beyond the Ghanzi Ridge.

1.4.2 Alluvial Plains

This is an area of alluvial deposition which was formed as a result of the overflow of the Okavango Delta. It lies between the delta in the north and the sandplain in the south, the Gumare fault line in the north west and Dautsa flats in the west. Arid conditions combined with lower and less frequent input from the Angola Highlands restricted outflow through the Okavango western fringe with consequent infilling of drainage channels with windblown sand and the formation of calcrete due to falling water levels. The landscape consists of a dense network of fossil channels and sand banks.

1.4.3 Lacustrine flats

Although Lake Ngami is not included in the surveyed area, the surrounding geomorphology can not be described without referring to it.

In the north the lake is defined by sand ridges separating the lake basin from the fossil channel of the Thaoge.

In the west the Dautsa Ridge, a complex of sand ridges and strandlines, bisects the western part of the Lake Ngami basin leaving the Magowegowe and Dautsa flats in the form of series of large pans connected by channels. (Paul Shaw, 1985).

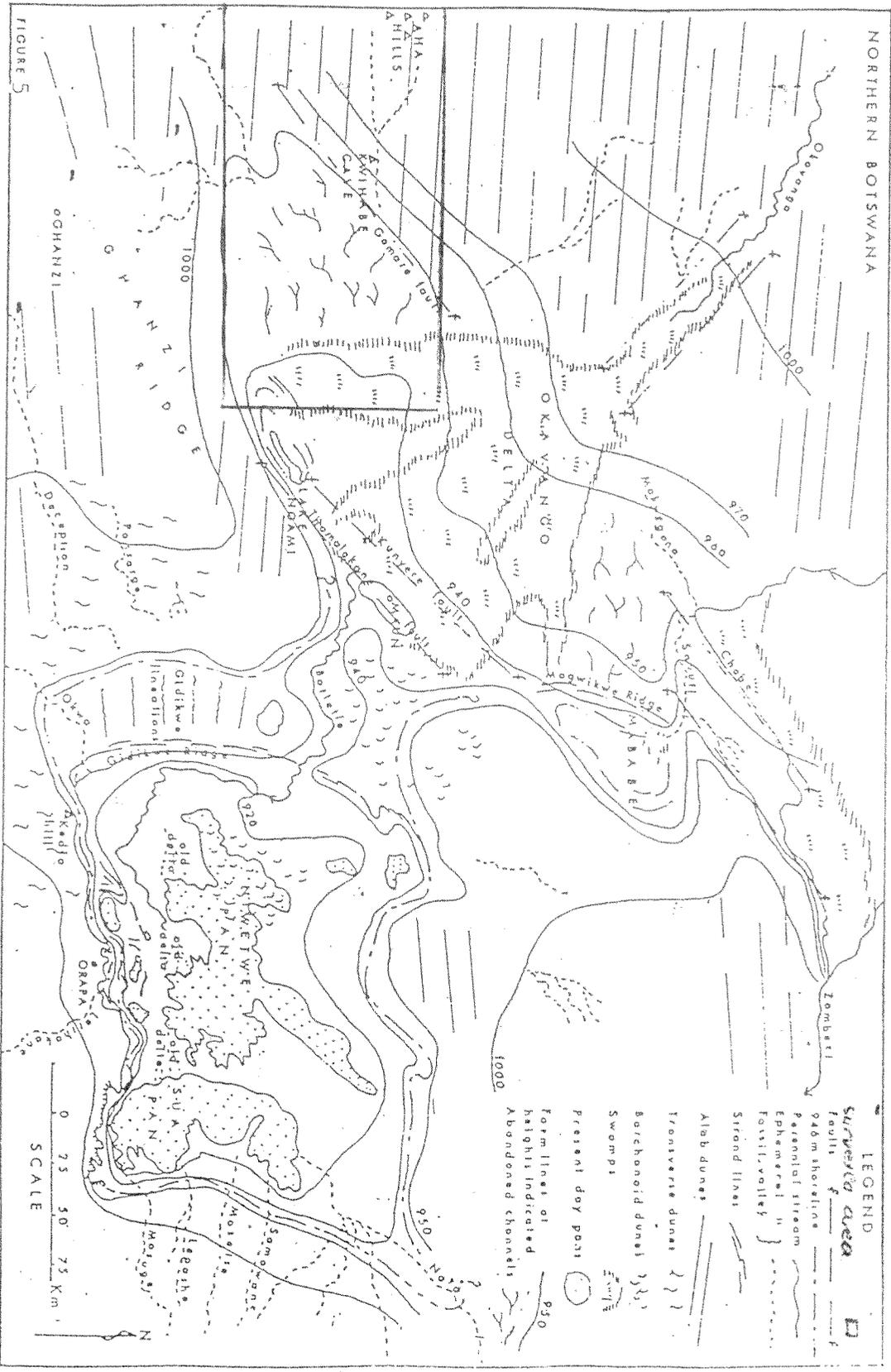


Figure 5. Landforms of Northern Botswana (From D.R.C. Grey and H.J. Cooke)

□ - surveyed area

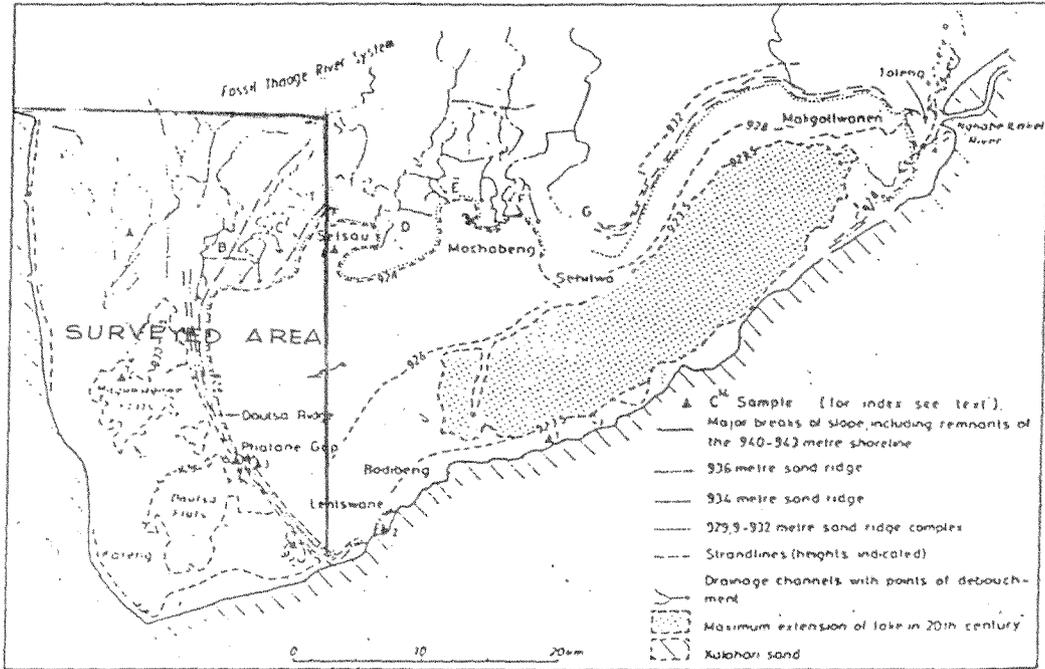


FIGURE 6 Geomorphology of Lake Ngami

(From Paul Shaw: 1985)

The flats are believed to have been formed through an overflow stream from lake Ngami.

1.4.4 Faults

Two faults are found in the area, the north-east to south-west trending Thamalakane fault which defines the base of the Okavango Delta and the Gumare fault dividing the area representing the former extent of the delta from the area marked by a sharp truncation of west-north-west to east-south-east trending dunes.

1.4.5 Hardveld

The Hardveld consists of outcrops of the Ghanzi formation and sediments in the south east of the surveyed area.

1.4.6 Hydrology

The swamp system of the Okavango Delta responds to inflow from the Angolan Highlands which reached the upper Okavango as a flood surge in March and reached a peak in the lower delta in July and August.

The change in climate, the instability of the present hydrological network as a product of low gradients, varying inflows, natural or man-made blockages and possible tectonic activity have affected the flow of water in the Thaoge river, the fossil dense channel network west and south of the Delta and sand filled Eisen and Groot Laagte rivers. The Thaoge river used to feed Lake Ngami but now it flows only as far as Tsau after recent channel retrenching and realignment.

Pan formations frequently occurring in the Kalahari beds and around the Dautsa flats have not been inundated during historical time.

1.5 Vegetation

A revised vegetation map of the country including the surveyed area was compiled by Weare and Yalala from various source of information in 1970.

In this report, a general overview of vegetation types has been presented. For detailed information the reader is referred to the above mentioned authors.

Vegetation has been described according to physiographic units because in this region they tend to correlate. The following groups have been identified.

Sandveld:

Open to dense shrub savanna of Terminalia sericea, Croton gratissimus and Combretum apiculatum. Some units have Acacia erubescens as the dominant species. Tall trees of Acacia erioloba are mainly confined to sand ridges.

Alluvial plains:

Open to dense savanna of Acacia mellifera and Acacia erioloba. In the fossil channels, shrubs of Acacia mellifera tend to dominate whilst on the banks trees of Acacia erioloba dominate.

Lacustrine plains:

Occurs in the Dautsa flats and surrounding pans. Vegetation is an open grassland in the center of the flats and pans while in the periphery it is an open shrub savanna of Acacia mellifera and Acacia tortilis.

Hardveld:

Vegetation in this area coincides approximately with the Ghanzi beds outcrops, having been modified by fire and severe grazing (Weare and Yalala 1971). Combretum apiculatum is the dominant species forming an open savanna with Terminalia sericea as the dominant shrub.

1.6 Land Use

The present day communities are engaged in pastoral farming. The soils are poor for any dryland arable farming.

2 SOILS

2.1 General

Mapping of this area was done mainly with the aid of 1:250 000 landsat imagery (enhanced colour composites). Although black and white 1:50 000 aerial photographs of May 1983 cover only half of the sheet (eastern half), they proved useful for orientation in the field.

In all 20 soil profiles were described and analyzed. In addition a substantial amount of data from soil profiles of completed adjacent sheets were used because a lot of soil units occurring on the common boundaries of these sheets extend well into the Tsau sheet. These additional profiles are described in the reports on South East Ngamiland (Verbeek, 1989), and North West Ngamiland (Jamagne, 1990). This data combined with augerings, reduced the number of soil pits which would otherwise have been needed to characterize these soils.

Overview of soils

In this area a strong relationship exists between soils and geomorphology. The following groupings were identified:

Soils of the Sandveld

Soils are poor for agriculture (see chapter on soil properties). Major soils occurring in this physiographic unit are Arenosols. These are coarse textured sandy soils. A distinction has been made between three types of Arenosols on the basis of their position on the landscape and these are as follows:

- (i) Arenosols on flat to gently undulating sandplains (KS3, KS17)
- (ii) Arenosols on undulating to rolling dunes (KS6)
- (iii) Arenosols on sand ridges (LS13 and LS17d). These are mainly of lacustrine origin.

Soils on Alluvial Plains

This is an area of older alluvial deposition characterized by a dense fossil drainage network with deep clayey soils in the channels, coarse sandy textured soils on the banks and highly calcareous soils on hummocks. Soils along channels are frequently used by subsistence farmers because their position on the landscape enables them to store more moisture.

Soils on the Hardveld

In the hardveld the solid geology is closer to the surface and hence the soils are in most cases shallower. They occur south of the Dautsa flats. Differences in soils are mainly attributed to parent material. They are clayey soils formed on basic igneous rocks (basalt) and coarse sandy soils formed on coarse - grained sedimentary rocks (sandstone).

Although soils on basic igneous rocks occupy a small area and have poor accessibility, they are rated as the best agricultural soils.

Soils on Lacustrine Deposits

These encompass the following:

i) Deep highly calcareous soils in pans. These occur mainly in the west where they form a series of pans connected by channels and are collectively known as the Dautsa flats. The flats are separated from the lake Ngami basin by a series of sand ridges known as the Dautsa ridge.

ii) Sands to sandy loams over a calcic or petrocalcic horizon on the western lake Ngami terrace.

iii) Deep sands in interdunal depressions. The material is mainly windblown sand from adjacent dunes. These are classified in the L-unit (of lacustrine origin) because they are formed within a closed depression which is environmentally similar to lacustrine conditions.

2.2 Soil Classification

Soils are classified according to the General Soil Legend of Botswana (Rommelzwaal 1988). This system is based on the Legend of the Soil Map of the World (FAO/UNESCO, 1974) with modifications to suit Botswana Soils. Reference is made to previous reports and publications for changes introduced to the FAO Legend. Correlation has been made with the 1988 revised Legend of the soil map of the World (FAO/UNESCO, 1988).

The Soil Taxonomy classification (Soil Survey staff, 1987) is used as a second classification system up to sub-group level.

2.3 Soil Mapping Units

A Soils on Alluvial Deposits

- A7b** FAO: Calcic Gleyic Luvisols (1974)
Calcic Gleyic Luvisols/Calcic Stagnic Luvisols (1988)
ST : Mollic Ochraqualfs
Area: 3900ha
Description: Deep to very deep poorly to imperfectly drained dark gray to grayish brown sandy loams to sandy clay.
Topography: Flat
Site: Water receiving
Profile: MA 78
Occurrence: On the fossil Thaoge depositional areas in association with A40
Vegetation: Open tree savanna of Acacia tortilis, Acacia erioloba, Acacia erubescens and Acacia mellifera.
- A9** FAO: Calcic Luvisols (1974)
Luvic Calcisols (1988)
ST : Typic Haplustalf
Area: 49600ha
Description: Deep to very deep imperfectly to moderately well drained dark grayish brown to yellowish brown sandy clay loam to clay.
Topography: Flat
Site: Water receiving
Profile: TA 16 and TA 18
Occurrence: On older Okavango alluvium south of the delta. Occurs in association with A40, A21 and A9a.
Characteristics: Strong sealing and strong sheet erosion. On broad flat hummocks east of the fossil Thaoge, the soils are strongly calcareous from the top.
Vegetation: Dense shrub savanna of Acacia mellifera and Acacia tortilis. In some areas its an open tree savanna of acacia erioloba.
- A9a** FAO: Arenic calcic Luvisols (1974)
Areni-calcic Luvisol / Areni-luvic Calcisols (1988)
ST : Arenic Haplustalf
Area: 57000ha
Description: Moderately deep to very deep imperfectly to moderately well dark grayish brown to strong brown sandy loam to sandy clayloam
Topography: undulating
Site: Slightly receiving
Profile: TO 367
Occurrence: On the edge of broad flat hummocks found on older Okavango allium east of the fossil Thaoge river
Characteristics: Mottled at 70cm
Vegetation: Dense savanna of Acacia tortilis and Acacia erioloba

- A14a** FAO: Orthic Luvisols (1974)
 Haplic Luvisol (1988)
ST : Typic Haplustalfs
Area: < 100ha
Description: Moderately deep to very deep imperfectly to moderately well drained very dark gray to grayish brown
Topography: Gently undulating
Site: Water receiving
Profile: TO 783
Occurrence: Along interdunal depressions in association with A9a
Vegetation: Dense savanna of Acacia erioloba, Acacia mellifera, Grewia Flava and Boscia albitrunca.
- A15a** FAO: Arenic Orthic Luvisols (1974)
 Areni-haplic Luvisols (1988)
ST : Arenic Haplustalf
Area: 222000ha
Description: Moderately well to very deep well but imperfectly to moderately well drained very dark gray to grayish brown
Topography: Flat to gently undulating
Site: Water receiving
Profile: TO 621
Occurrence: Along channels of old alluvial plains - in association with Eutric Arenosols which occur on the banks.
Vegetation: Dense shrub savanna of Acacia mellifera, Grewia flava and Boscia albitrunca
- A20** FAO: Calcaric Arenosols (1974)
 Calcaric Arenosols (1988)
ST : Ustic Quartzipsamment
Area: < 100ha
Description: Moderately deep to very deep moderately well to well drained dark grayish brown to yellowish brown sands to loamy sands
Topography: Gently undulating
Site: Water shedding
Profile:
Occurrence: On higher islands between fossil channels in association with calcic Arenosols
Vegetation: Savanna of Acacia mellifera, Grewia flava and Boscia albitrunca
- A21** FAO: Calcic Arenosols (1974)
 Haplic Calcisols (1988)
ST : Arenic Ustochrepts
Area: 49600ha
Description: Moderately deep to very deep moderately well to well drained dark grayish brown to yellowish brown sands to loamy sands
Topography: Flat to gently undulating

- Site:** Water shedding
Profile: TA 19
Occurrence: On old alluvial material of the Okavango delta west along the Thaoge river. Occurs in association with A9, A40 and A9a
Characteristics: Strongly calcareous from 50cm. Bleached sand found on the surface
Vegetation: Dense shrub savanna of Acacia mellifera
- A24d** **FAO:** Eutric Fluvisols
 Eutric Gleysols / Eutric Fluvisols (1988)
ST : Aeric Haplaquents / Fluvaquents
Area: 41400ha
Description: Very deep poorly to imperfectly drained black to dark grayish brown silty loam to silty clay, often overlying sands to loamy sands
Topography: Flat
Site: Receiving
Profile: TO 112
Occurrence: Along the Thaoge channel
Characteristics: Massive to very weak coarse prismatic structure. Silty top layer always overlying white fine to medium sand
Vegetation: Grassland
- A40** **FAO:** Eutric Arenosols (1974)
 Eutri-Haplic Arenosols (1988)
ST : Ustic Quartzipsamment
Area: 423200ha
Description: Deep to very deep moderately well to well drained brown to white sands to loamy sands
Topography: Gently undulating
Site: Shedding
Profile: TA 17
Occurrence: On older Okavango alluvium south of the delta. Mainly on higher areas
Characteristics: Dark brown sand lies over yellowish sand
Vegetation: Dense savanna of Acacia erioloba, Acacia mellifera and Acacia tortilis
- A40b** **FAO:** Eutric Arenosols (1974)
 Eutri-Haplic / Luvic Arenosols (1988)
ST : Ustic Quartzipsamments
Area: < 100ha
Description: Deep to very deep moderately well to well drained brown to white sands to loamy sands, but on ridges
Topography: Undulating
Site: Normal
Profile: TO 379
Occurrence: Along banks of fossil channel on alluvial plains
Characteristics: Structureless fine to medium sand
Vegetation: Trees savanna of Acacia erioloba

B - Soils on Basic Igneous Rocks

B6 **FAO:** Calcic Luvisol (1974)
 Calcic Luvisol (1988)
ST : Typic Haplustalf
Area: 7400ha
Description: Deep moderately well to well drained dark brown to reddish brown sand clayloam to clay (basalt)
Topography: Flat
Site: Water receiving
Profile: TA 5
Occurrence: On Basalt
Characteristics: Soils are flooded during heavy rains
Vegetation: Open tree savanna of Acacia erioloba and Boscia albitrunca

B6b **FAO:** Calcic Cambisols (1974)
 Haplic Calcisols (1988)
ST : Typic ustochrepts
Area: 400ha
Description: Shallow to moderately deep well drained dark brown to reddish brown clayloam to clay (basalt), but with cambic horizon
Topography: Gently undulating
Site: Water receiving
Profile: TA 4
Occurrence: On the Ghanzi formation
Characteristics: Rock outcrops and surface stones are a common feature. Soils are shallow to moderately deep. There is strong soil erosion.
Vegetation: Open tree savanna of Terminalia sericea, Boscia albitrunca and Acacia erioloba

LC- Highly calcareous soils developed on lacustrine deposits.

LC1 **FAO:** Lithosols (1974)
 Calci-Lithic Leptosols (1988)
ST : Lithic ustorthents
Area: < 100ha
Description: Very shallow (less than 10 cm) moderately well to well drained dark grayish brown to brown loamy sands to clayloam
Topography: flat to almost flat
Site: Water receiving
Profile:
Occurrence: In between the two Ghanzi formations and on calcrete pan formations
Characteristics: Sandy loam on top of calcrete
Vegetation: Open low shrub savanna

- LC3** FAO: Petrocalcic Arenosols shallow Petrocalcic (1974)
Epi- Petric Calcisols (1988)
ST : Typic ustochrept
Area: 25700ha
Description: Very shallow to shallow imperfectly to moderately well drained dark grayish brown to reddish brown sands to loamy sands
Topography: Almost flat
Site: normal to water receiving
Profile: TA 10
Occurrence: On shallow calcrete formations on the Ghanzi ridge
Characteristics: thin sand cover over calcrete
Vegetation: Open low shrub savanna of Acacia mellifera to a dense savanna of Terminalia prunoides and Acacia mellifera
- LC3b** FAO: Calcic Arenosol partly Petrocalcic (1974)
Haplic Calcisols (1988)
ST : Typic Ustorthrepts
Area: 33200ha
Description: Moderately deep moderately well to well drained light grayish brown to dark yellowish brown sands to loamy sands
Topography: undulating
Site: water receiving
Profile: TA 13
Occurrence: On terraces of the Dautsa flats in association with S13
Vegetation: Open savanna of Acacia mellifera and Acacia erioloba
- LC4** FAO: Calcic Cambisols partly Petrocalcic (1974)
Epi-Hypercalci-Haplic Calcisols (1988)
ST : Typic Ustochrept
Area: 33200ha
Description: Shallow to moderately deep imperfectly to well drained very dark gray to reddish brown sandy loams to clayloam
Topography: flat
Site: water receiving
Profile: TA 2, TA 7
Occurrence: In the pans west of the Dautsa ridge and in scattered pans in the sandveld
Characteristics: A thin layer of sometimes strongly calcareous topsoil rests on deep weakly cemented calcareous material of lacustrine origin
Vegetation: grassland with patches of low shrubs of Acacia mellifera and Acacia tortilis

D-Soils on Fine Grained Sedimentary Rocks

D1b **FAO:** Calcaric Regosols shallow Petric (1974)
 Calcaric Regosol (1988)
ST : Typic/Lithic Ustorthents
Area: 14200ha
Description: Very shallow to moderately deep well drained yellowish brown to reddish brown sandy loams to clayloam
Topography: undulating
Site: shedding
Profile: TO 1030
Occurrence: On the Ghanzi outcrop
Vegetation: Shrub savanna of Acacia erubescens, Acacia mellifera, Boscia foetida and Terminalia prunoides

L-Soils on Lacustrine Deposits

L6a **FAO:** Calcic Gleysols partly Sodic (1974)
 Calcic Gleysols (1988)
ST: Typic Haplaquepts
Area: 3100ha
Description: Deep to very deep poorly to imperfectly drained very dark gray to gray loam to clay, overlying grayish brown to white fine sands within 100cm
Topography: flat
Site: normal
Profile: TO 302
Occurrence: On the western Lake Ngami terrace in association with Arenic Calcic Luvisols
Vegetation: grassland to dense shrub savanna of Acacia tortilis

L7 **FAO:** Eutric Gleysols partly Sodic (1974)
 Eutric Gleysols (1988)
ST : Typic Haplaquepts
Area: 800ha
Description: Very deep poorly to imperfectly drained very dark gray to gray sandy clay to clay
Topography: flat
Site: water receiving
Profile: TO 901
Occurrence: On fossil Thaoge depositional areas in association with A7b and A40b
Characteristics: Soils are clayey (up to 80% clay). Structure is moderate to strong prismatic breaking into moderate angular and subangular blocky
Vegetation: Open tree savanna of Acacia tortilis, Acacia erioloba, Acacia erubescens and Acacia mellifera

- L11a** FAO: Calcic Arenosols (1974)
 Haplic Calcisols (1988)
ST : Grossarenic Ustochrept
Area: 2200ha
Description: Deep to very deep moderately well to well drained dark gray to pale brown fine sand to loamy fine sand. Having a calcic horizon
Topography: flat
Site: normal
Profile: TO 714
Occurrence: On lacustrine sands around Lake Ngami. Occur in association with L24c and LC4
Characteristics: Structureless loose sand
Vegetation: tree savanna of Acacia erioloba, Acacia tortilis and Acacia mellifera
- L16** FAO: Eutric Arenosols (1974)
 Haplic Arenosols (1988)
ST : Ustic Quartzipsamments
Area: 4400ha
Descriptions: Very deep well to somewhat excessively drained dark gray to pale brown fine sand to loamy fine sand, non calcareous between 0-100cm
Topography:
Site: water receiving
Profile: GO 333
Occurrence: In interdunal depressions in association with Arenic Orthic Luvisols (L22a)
- L22a** FAO: Arenic Orthic Luvisols (1974)
 Areni-Haplic Luvisols (1988)
ST : Arenic Haplustalf
Area: 54600ha
Description: Deep to very deep imperfectly to moderately well drained dark grayish brown to brown loamy sands to sandy clayloam
Topography: undulating
Site: water receiving
Profile: TO 600
Occurrence: Along interdunal depressions in association with Eutric Arenosols (L16)
- L24** FAO: Calcic Luvisols (1974)
 Calcic Luvisols (1988)
ST : Typic Haplustalfs
Area: 300ha
Description: Moderately deep to very deep imperfectly drained very

dark grayish brown to brown sandy clayloam to clay

Topography: undulating

Site: water receiving

Profile:

Occurrence: Along fossil valleys in the sandveld. Found in association with LC3 (Petrocalcic Arenosol)

Vegetation: Open low shrub savanna of Acacia mellifera and Grewia flava

L24c FAO: Arenic Calcic Luvisols partly Petrocalcic, partly sodic (1974)
Areni-calcic Luvisol (1988)

ST : Arenic Paleustalf

Area: 5400ha

Description: Very deep imperfectly to moderately well drained dark grayish brown to brown sandy loam to sandy clayloam

Topography: Flat

Site: Normal to slightly receiving

Profile: TO 677

Occurrence: On the Western terrace of lake Ngami in complex with calcic gleysols (L6a) and calcic Arenosols (L11a)

Vegetation: Savanna of Acacia leuderitzii, Acacia erubescens, Acacia erioloba, Acacia tortilis and Acacia mellifera

S - Soils on coarse-grained Sedimentary Rocks

S1b FAO: Arenic Eutric Regosols shallow petric (1974)
Areni-Eutric Regosols (1988)

ST : Typic Ustorthent

Area: 10000ha

Description: Shallow to moderately deep somewhat excessively drained brownish yellow to yellowish red sands and loamy sands

Topography: Flat to almost flat

Site: Normal

Profile: TA 8, TA 9

Occurrence: On fine grained sandstone of the Ghanzi formation

Vegetation: Dense savanna of Combretum apiculatum, Acacia erubescens and Terminalia prunoides

S3 FAO: Ferralic Arenosol (1974)
Ferralic Arenosol (1988)

ST : Typic Quartzipsamment

Area: < 100ha

Description: Deep to very deep well to somewhat excessively drained yellowish brown (with chroma of 5 or more) to yellowish red fine and fine-medium sand

Topography: Flat

Site: Normal

Profile: TA 11
Occurrence: On sandstone of the Karroo supergroup
Vegetation: Dense shrub savanna of Combretum apiculatum
Remark: Similar to KS3. Difference being parent material

S13a FAO: Petrocalcic Arenosols (1974)
Petric Calcisols (1988)
ST : Typic Ustochrept
Area: 5300ha
Description: Moderately deep to very deep well to somewhat excessively drained grayish brown to yellowish red sands and loamy sands, but having a petrocalcic horizon
Occurrence: On sandstone of the Karroo supergroup
Remark: Similar to KS3. Difference being parent material.

KS - Soils Development from Kalahari Sand

KS3 FAO: Ferralic Arenosols (1974)
Ferralic Arenosols (1988)
ST : Ustic Quartzipsamments
Area: 375100ha
Description: Deep to very deep well to somewhat excessively drained yellowish brown (with chroma of 5 or more) to yellowish red fine and fine-medium sand
Topography: Flat to almost flat
Site: Normal to slightly water shedding
Profile: TA 3
Occurrence: Predominantly on the eroded Kalahari sand plains. They occur in association with other sandy soils like KS13 and KS17
Vegetation: Open tree savanna of Acacia erubescens and Acacia erioloba.
Terminalia sericea becomes dominant on the heavier loose sand

KS5a FAO: Luvic Arenosol (1974)
Lamelli-Luvic Arenosols (1988)
ST : Alfic Quartzipsamment
Area: 500ha
Description: Deep to very deep well to somewhat excessively drained yellowish brown to red fine and fine-medium sand to loamy fine sand, but showing lamellae of clay accumulation
Topography: Almost flat
Site: slightly receiving
Profile:
Occurrence: Low lying areas east of Kuke
Characteristics: Have a clay increase with lamellae of clay accumulation
Vegetation: Open shrub savanna of Acacia mellifera and Grewia flava

- KS6** FAO: Ferralic Arenosols (1974)
 Ferralic Arenosols (1978)
ST : Ustic Quartzipsamment
Area: 71300ha
Description: Deep to very deep somewhat excessively, to excessively drained yellowish brown to red fine and fine-medium sands to loamy fine sand
Topography: Undulating to rolling
Site: Shedding
Profile:
Occurrence: On dunes
Vegetation: Open low shrub savanna of *Terminalia sericea*, Croton gratissimus and Grewia flava
- KS13** FAO: Calcic Arenosols (1974)
 Haplic Calcisols (1988)
ST : Grossarenic Ustochrept
Area: 33200ha
Description: Moderately deep to very deep well to somewhat excessively drained grayish brown to yellowish red sands and loamy sands
Topography: Gently undulating
Site: Shedding
Profile: MA 13
Occurrence: On low lying area west of the Dautsa ridge
Vegetation: Open tree savanna
- KS13a** FAO: Petrocalcic Arenosols (1974)
 Petric Calcisols (1988)
ST : Grossarenic Petrocalcic Ustochrept
Area: < 100ha
Description: Moderately deep to very deep well to somewhat excessively drained grayish brown to yellowish red sands and loamy sands, but having a petrocalcic horizon
Topography: Flat to almost flat
Site: Normal to slightly receiving
Profile:
Occurrence: On the Ghanzi formation
Vegetation:
- KS17** FAO: Eutric Arenosols (1974)
 Eutri-Haplic Arenosols (1978)
ST : Ustic Quartzipsamment
Area: 181500ha
Description: Deep to very deep well to somewhat excessively drained dark grayish brown to light yellowish brown fine and fine-medium sand to loamy fine sand, non calcareous between 50 and 100cm

Topography: Flat to almost flat
Site: Normal to slightly water receiving
Profile: TA 6
Occurrence: On eroded Kalahari sand plains. Occurs as one of the dominant soil units in association with KS3
Vegetation: Dense free savanna of Terminalia prunoides and Acacia erubescens

LS - Soils developed from aeolian reworked lacustrine deposits

- LS13** FAO: Calcic Arenosols (1974)
Haplic Calcisol (1988)
ST : Grassarenic Ustochrept
Area: 6200ha
Description: Moderately deep to very deep well to somewhat excessively drained grayish brown to yellowish red sands and loamy sands
Topography: flat
Site: normal to water receiving
Profile: TA 1
Occurrence: On sand ridges west of Lake Ngami
Vegetation: Open tree savanna of Acacia erioloba and Acacia mellifera
- LS17** FAO: Eutric Arenosols (1974)
Eutri-Haplic Arenosols (1988)
ST : Typic Quartzipsamment
Area: < 100ha
Description: Deep to very deep well to somewhat excessively drained dark grayish brown to light yellowish brown fine and fine-medium sand to loamy fine sand, non calcareous between 50 and 100cm
Topography: undulating
Site: shedding
Profile:
Occurrence: between sand ridges west of Lake Ngami
Vegetation: Open tree savanna of Acacia erioloba and Acacia mellifera
- LS17d** FAO: Eutric Arenosols (1974)
Eutri-Haplic Arenosols (1988)
ST : Ustic-Quartzipsamment
Area: 15200ha
Description: Deep to very deep well to somewhat excessively drained dark grayish brown to light yellowish brown fine and fine-medium sand to loamy fine sand, non calcareous between 50 and 100cm, but fine and fine-medium sand
Topography: gentle to undulating
Site: water receiving
Profile: TA 12
Occurrence: On beach ridges west of Lake Ngami
Vegetation: Open tree savanna of Acacia erioloba and Acacia mellifera

2.4 Soil Properties

2.4.1 Soils on the Sandveld:

These are very deep coarse - textured sandy soils and as such have a low water-holding capacity and are more permeable. Natural fertility and CEC is lower than in other soils.

Arenosols in this area differ not only by their position on the landscape but also by some soil characteristics. They are as follows:

i) Petrocalcic Arenosol with a continuous layer cemented by calcium carbonate at some depth within 100cm of the surface.

ii) Calcic Arenosol with a layer of calcium carbonate accumulation in the sub-horizon.

iii) Ferralic Arenosol with a cation exchange capacity (CEC by NH₄OAC) of less than 24me per 100g clay in the sub-horizon.

iv) Eutric Arenosols with a base saturation of more than 50%.

2.4.2 Soils on Alluvial Plains:

Soil properties according to position on the landscape:

On Hummocks: They are similar to those on the sandveld, the difference being that they have a much higher calcium carbonate content and are strongly calcareous throughout the profile.

On Banks: They are deep coarse textured soils (Eutric Arenosols). These are also similar to those on the sandveld, but are paler, bearing signs of past heavy leaching. Base saturation is high.

Along channels: Deep moderately well drained sandy clay loams with a layer of calcium carbonate accumulation (calcic Horizon) at 80cm. Base saturation is high. Deeper soils which have been covered by a layer of sand (arenic) also commonly occur.

2.4.3 Soils on Lacustrine Deposits:

Soils are highly calcareous with a pH (H₂O) of more than 8. Textures range from sandy in the form of a thin layer of sand resting on very deep calcrete on the lake Ngami terrace, to sandy clay loams in the lacustrine pans. Crusting and a high silt content are characteristic of soils in pans. Crusting is caused by lime which is a cementing agent.

2.4.4 Soils on the Hardveld:

Luvisols are the dominant soil unit. They are heavy textured soils (sandy clay) with a layer of accumulated fine clay particles that have been translocated from above the soil profile (illuvial clay). This is diagnostic of older soils. Base saturation is high and pH is around 7 increasing with depth as the calcium carbonate content increases. The same goes for the cation exchange capacity. These soils occur together with younger shallower transitional soils (cambisols) with a lighter texture (loamy sands).

3.1 Distribution of Soil Mapping Units

A - Soils on Alluvial Deposits

Unit	Area ha	Ha %	FAO Classification (1978)
A7b	3900	0.23	Calcic Gley Luvisol
A9	49600	2.87	Calcic Luvisol
A9a	57000	3.30	Arenic Calcic Luvisol
A14a	<100	<0.01	Orthic Luvisol
A15a	222000	13.00	Arenic Orthic Luvisol
A20	<100	<0.01	Calcic Arenosol
A21	49600	2.90	Calcic Arenosol
A24d	41400	0.02	Eutric Luvisol
A40	423200	24.78	Eutric Arenosol
A40b	<100	<0.01	Eutric Arenosol

B - Soil on Basic Igneous Rocks

B6	7400	0.43	Calcic Luvisol
B6b	400	0.02	Calcic Cambisol

C - Soils on Highly Calcareous Material

LC1			Lithosol
LC3	25700	1.50	Petrocalcic Arenosol Shallow petrocalcic
LC3b	7300	0.43	Calcic Arenosol Partly petrocalcic
LC4	33200	1.94	Calcic Cambisol

D - Soils on Fine Grained Sedimentary Rocks

D1b	14200	0.83	Calcic Regosols Shallow Petric
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L - Soils on Lacustrine Deposits

L6a	3100	0.18	Calcic Gleysols partly Sodic
L7	800	0.05	Eutric Gleysols partly Sodic
L11a	2200	0.13	Calcic Arenosol
L16	4400	0.26	Eutric Arenosol
L22	3000	0.18	Orthic Luvisol
L22a	54600	3.20	Arenic Orthic Luvisol
L24	300	0.02	Calcic Luvisol
L24c	5400	0.32	Arenic Calcic Luvisol

S - Soils on Coarse - grained Sedimentary Rocks

S1b	10000	0.58	Arenic Eutric Regosl Shallow Petric
S3			Ferralic Arenosol
S13	1800	0.10	Calcic Arenosol
S13a	5300	0.31	Petrocalcic Arenosol

KS - Soils Development from Khalarari Sands

KS3	375100	21.96	Ferralic Arenosol
KS5a	500	0.03	Luvic Arenosol
KS6	70300	4.12	Ferralic Arenosol
KS13	33200	1.94	Calcic Arenosol
KS13a	<100	<0.01	Petrocalcic Arenosol
KS17	181500	10.63	Eutric Arenosol

LS - Soils Development from Aelian rework Lacustrine Deposits

LS13	6200	0.36	Calcic Arenosol
LS17			Eutric Arenosol
LS17d	15200	0.89	Eutric Arenosol

Dominant soils occurring in the area are those on alluvial plains consisting 47% of the surveyed area. These are followed by sandy soils of the sandveld which occupy approximately 39%. The rest are mainly highly calcareous soils on lacustrine deposits and interdunal depressions west of the surveyed area.

3.2 Catenary associations

The cross-section through geomorphological units extending from Lake Ngami in the east to the Namibian boarder in the west (figure 7), indicates the great influence that the past climate and the Okavango river had in processes of soil formation in the area. These are mainly in the form of Lake Ngami, the Dautsa flats, the older Okavango alluvial plains and the well defined shoreline ridges in the form of sand ridges. These are clearly signs of a past wetter climate.

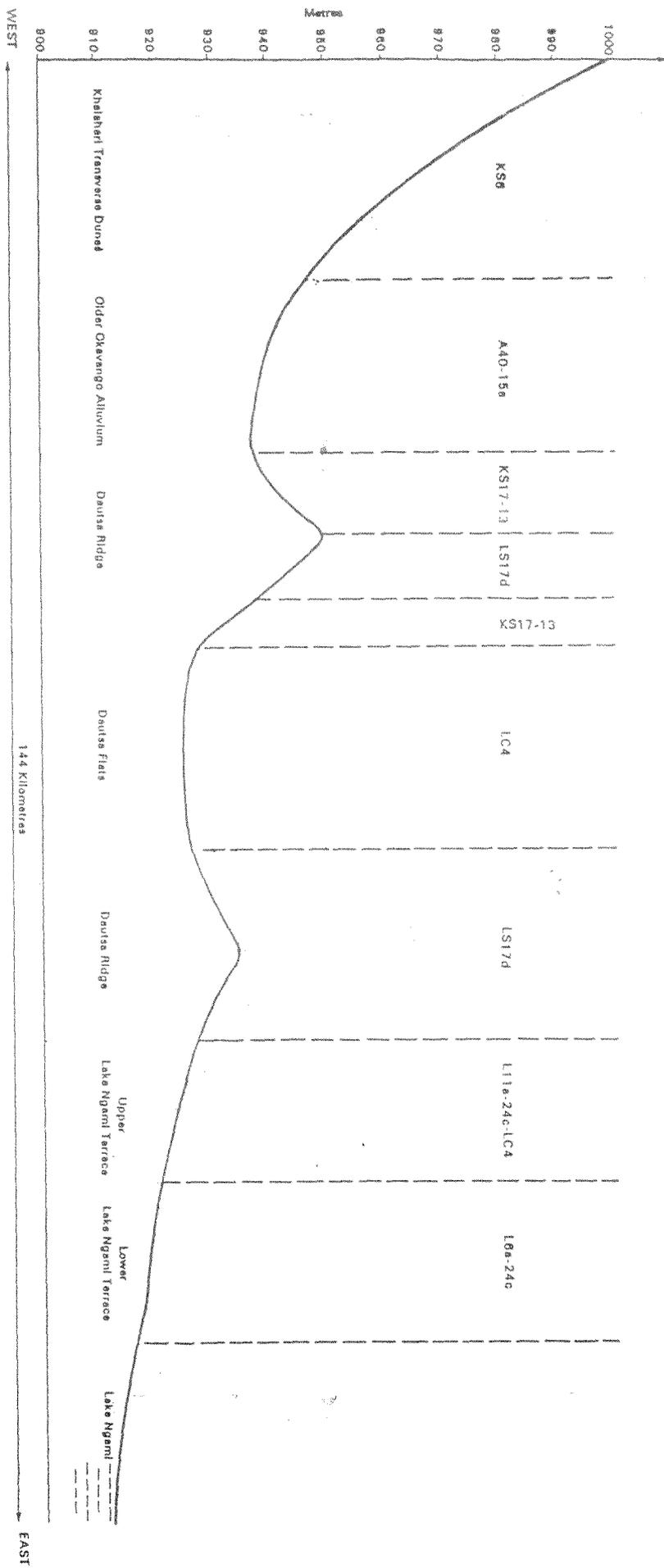
Flooding coupled with falling water levels which used to occur on the Lake Ngami terraces and the Dautsa flats is evidenced by highly calcareous and calcareous soils (LC4, LC24c and L11a) and on the other hand by hydromorphic properties (L6a).

The overflow of the Okavango delta in the south west of the delta is evidenced by broad alluvial plains with characteristic dark grey sandy clayloams (A15a) along channels and very deep coarse sands on the channel banks (A40).

In the west lies a system of transverse sand dunes with very coarse textured sandy soils on the crest (KS6). The formation of these dunes is believed to have occurred prior to the Okavango swamps in the North and the subsequent overflow of the delta (older Okavango alluvial plains) which now truncate it. In the interdunal depressions slightly more clayey soils ranging from loamy sands (L16) to sandy clay loams (L22a) occur.

On the sand ridges as the expression indicates, very deep fine sands occur both on the crest and on the slopes (LS17d). On the slopes, in addition one finds calcareous sands (LS13) due to influence from the lake and the flats.

FIG. 7. CROSS-SECTION THROUGH GEOMORPHOLOGICAL UNITS



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**Appendix 1. Selected Soil Profile Description
and Analytical Data**

A - Soils on Alluvial Deposits

Unit	Profile	FAO Classification (1978)
A7b	MA78	Calcic Gleyic Luvisol
A9	TA16,TA18	Calcic Luvisol
A9a	TO367	Arenic Calcic Luvisol
A14a	TO783	Orthic Luvisol
A15a	TO621	Arenic Orthic Luvisol
*A20		Calcic Arenosol
A21	TA19	Calcic Arenosol
A24d	TO112	Eutric Luvisol
A40	TA17	Eutric Arenosol
A40b	TO379	Eutric Arenosol

B - Soil on Basic Igneous Rocks

B6	TA5	Calcic Luvisol
B6b	TA4	Calcic Cambisol

C - Soils on Highly Calcareous Material

*LC1		Lithosol
LC3	TA10	Petrocalcic Arenosol Shallow petrocalcic
LC3b	TA13	Calcic Arenosol Partly petrocalcic
LC4	TA2/7	Calcic Cambisol

D - Soils on Fine Grained Sedimentary Rocks

D1b	TO1030	Calcaric Regosols Shallow Petric
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L - Soils on Lacustrine Deposits

L6a	TO302	Calcic Gleysols partly Sodic
L7	TO901	Eutric Gleysols partly Sodic
L11a	TO714	Calcic Arenosols
L16	G0333	Eutric Arenosols
L22		Orthic Luvisols
*L22a	TO600	Arenic Orthic Luvisols
*L24		Calcic Luvisols
L24c	TO677	Arenic Calcic Luvisols

S - Soils on Coarse - grained Sedimentary Rocks

S - Soils on Coarse - grained Sedimentary Rocks

S1b	TA8, TA9	Arenic Eutric Regosol Shallow Petric
S3	TA11	Ferralic Arenosol
*S13		Petrocalcic Arenosol

KS - Soils Developed from Khalahari Sands

KS3	TA3	Ferralic Arenosols
*KS5a		Luvic Arenosols
*KS6		Ferralic Arenosols
KS13	MA13	Calcic Arenosols
*KS13a		Petrocalcic Arenosols
KS17	TA6	Eutric Arenosols

**LS - Soils Developed from Aelian reworked
Lacustrine Deposits**

LS13	TA1	Calcic Arenosols
*LS17		Eutric Arenosols
LS17d	TA12	Eutric Arenosols

The following codes for profile are used:

GO - Gumare
MA - Maun
TA - Tsau
TO - Toteng
* - No representative profile

SOIL PROFILE DESCRIPTION

Profile: TA 0016 Unit: A-09 Status:

SHEET : 2002A2

LOCATION : 5.2km W of Tsau tarmac road/along Mapororo road.

AUTHOR(S) : T.D.Mafoko

CLASSIFICATION FAO: Luvis Calcisol(1988) Calcic Luvisol (1974)

ST : Typic Haplustalf

LANDFORM : alluvial plain

TOPOGRAPHY: almost flat

SURF. CHAR: strong sealing, no cracks, nil evidence of salt, bleached sand on surface

LAND USE: traditional grazing

SPECIES : Trees -

: Shrubs - Acacia mellifera (dom.) Acacia tortillis subs. heteroacantha

: Grasses/forbs-

PARENT MATERIAL: alluvium

MOIST. COND: dry 0 - 120 cm

SURF. STONES: none

EROSION : strong sheet erosion

REMARKS:

SAMPLES: A: 0 - 20 B: 20 - 40 C: 80 - 100

- A 0 - 20 cm Very dark gray (10YR 3/1) (moist) and dark gray (10YR 4.5/1) (dry), loamy sand to sandy loam, weak coarse to very coarse subangular blocky structure, hard, non calcareous, many fine to medium roots, clear smooth boundary.
- Btk1 20 - 40 cm Very dark gray (10YR 3/1) (moist) and dark grayish brown (10YR 4.5/1.5) (dry), sandy loam, weak coarse subangular blocky structure, slightly hard, patchy thin clay cutans on pedfaces, few medium irregular soft white calcareous soft segregations, strongly calcareous, many fine roots, gradual smooth boundary.
- Btk2 40 - 120 cm Dark gray (10YR 4/1) (moist) and light grayish brown (2.5Y 6/1) (dry), sandy clay loam, weak very coarse angular blocky structure, slightly hard, patchy thick clay cutans on pedfaces, frequent medium irregular soft white calcareous soft segregations, strongly calcareous, few fine roots.

Soil Survey of Botswana FAO/BOT/85/011

Last changed : 11/02/91

print date: 11/02/91

STANDARD SOIL ANALYSIS RESULTS

PROFILE: TA 0016

SAMPLE DEPTH	pH	H2O	CaCl2	mS/cm	EC	m	P	m	C	N	CEC	Ca	Mg	K	Na	EXAC	PBS	CARBO	Particle size (weight %)						CECclay	METH	PRETR	
																			weight %	<-----	meq/100gr soil	----->	%	%				vcS
A	0	20	6.7	6.5	0.1	B	0	A	0.5	0.5	6.2	8.6	0.9	0.0	0		0	2	22	49	7	2	7	11	40		H	N
B	20	40	7.8	7.4	0.3	B	0	A	0.4	0.4	8.2	25.6	2.1	0.1	>100		0	2	21	47	6	3	5	16	41		H	O
C	80	100	8.7	7.8	0.0	B	0	A	0.2	0.2	7.7	17.6	2.5	1.1	>100		0	2	22	48	7	3	2	16	44		H	N

Soil Survey of Botswana FAO/BOI/85/011

last changed : 14/08/90

Print date: 28/01/91

EC : Electrical Conductivity m : method ... A = saturated paste B = 1:2.5 in water

P : Available Phosphorus determination m : method ... O = Olsen B = Bray

C : Organic Carbon determination Walkley-Black method

N : Total Nitrogen determination Kjeldahl method

CEC and bases : Ammonium acetate method

EXAC : Exchangeable acidity extracted with KCl

CARBO : Free Carbonates by destruction with HCl

PART-SIZE DETERMINATION METHOD: H = Hydrometer Method, P = Pipette Method, * = Not Known
PRETREATMENT: O = Organic Matter, F = Free Iron Oxides, C = Carbonates, S = Soluble Salts N = None

SOIL PROFILE DESCRIPTION

Profile: TO 0367 Unit: A 09a Status: 2

SHEET : 2023A3
 LOCATION : 55.5km on Maun-Toteng, 4km southeast from road.
 AUTHOR(S): B.Kopelo R.Kelebembang
 CLASSIFICATION FAO: Arenic Calcic Luvisol (1988) Arenic Calcic Luvisol (1974)

GRID : GN-132-502
 COORD: 20-20-10-S 23-02-30-E
 DATE : 09/03/86

AGRO CLIM.ZONE: 2C3
 ELEVATION : 1350 m
 SMR: ustic to aridic

LANDFORM : alluvial plain
 TOPOGRAPHY: flat
 SURE. CHAR: no cracks, nil evidence of salt,
 LAND USE: traditional grazing
 SPECIES : Trees - Terminalia prunioides (dom.)
 : Shrubs - Dichrostachys cinerea (dom.)
 : Grasses/forbs -
 Acacia mellifera Acacia tortilis subs. heterocantha Grewia bicolor

LAND ELEMENT : not applicable
 MICRO TOPOGRAPHY: even
 VEGETATION: shrub savanna

POSITION: Lower part
 SLOPE : 0 - 0.5%

PARENT MATERIAL: alluvium
 MOIST. COND: dry 0 - 100 cm
 SURE.STONES: none
 EROSION : nil

ROCK TYPE:
 ROCK OUTCROP: none

GEOLOG. UNIT: Quaternary
 DRAINAGE : well drained
 HUMAN INT: nil

REMARKS: Petrocalcic may occur at depth.

SAMPLES: A: 0 - 20 B: 30 - 50 C: 60 - 80 D: 85 - 100

- A 0 - 25 cm Very dark grayish brown (10YR 3/2) (moist) and dark grayish brown (10YR 4/2) (dry), loamy fine sand, weak medium to coarse subangular blocky structure, slightly hard to hard, common fine pores, non calcareous, many fine to medium roots, gradual smooth boundary.
- Bt1 25 - 80 cm Very dark grayish brown (10YR 3/2) (moist) and dark grayish brown (10YR 4/2) (dry), loamy fine sand to fine sandy loam, weak medium to coarse subangular blocky structure, hard, common fine pores, non calcareous, many fine roots, clear smooth boundary.
- Bt2 80 - 100 cm Dark grayish brown (10YR 4/2) (moist) and grayish brown (10YR 5/1.5) (dry), fine sandy loam, weak fine to medium subangular blocky structure, slightly hard, few fine pores, non calcareous, few fine roots.
- Cck 100 cm + Light gray (10YR 7/2) (moist) and white (10YR 8/1) (dry), partly cemented, no pores, frequent medium irregular hard white calcareous nodules, strongly calcareous, no roots.

Soil Survey of Botswana FAO/BOT/85/011

last changed : 11/02/91

print date: 11/02/91

STANDARD SOIL ANALYSIS RESULTS

PROFILE: TO 0367

SAMPLE DEPTH	pH	H2O	CaCl2	EC	m	P	m	C	N	CEC	Ca	Mg	K	Na	EXAC	PBS	CARBO	Particle size (weight %)						CECclay	METH	PRETR			
																		ms/cm	ppm	weight %	<-----	meq/100gr soil	meq/100gr soil				meq/100gr soil	meq/100gr soil	meq/100gr soil
A	0	20	7.5	6.3	0.0	4	B	0.1	5.5	2.8	1.5	0.3	0.0	0.0	0.0	84	0.0	0.0	0	3	19	57	10	3	2	6	86	H	0
B	30	50	7.7	6.9	0.0	1	B	0.1	9.2	6.1	2.3	0.5	0.0	0.0	0.0	97	0.0	0.0	0	3	21	52	9	1	2	13	68	H	0
C	60	80	8.1	7.4	0.1	1	B	0.0	9.5	6.8	2.4	0.4	0.0	0.0	100	0.0	0.0	0	3	20	52	7	3	1	14	70	H	0	
D	85	100	8.5	7.9	0.1	1	B	0.1	10.0	9.7	2.6	0.3	0.1	0.0	100	0.0	0.0	0	3	17	53	11	3	2	13	75	H	0	

Soil Survey of Botswana FAO/BOI/85/011

Last changed : 01/06/89

Print date: 28/01/91

EC : Electrical Conductivity m : method ... A = saturated paste B = 1:2.5 in water

P : Available Phosphorus determination m : method ... O = Olsen B = Bray

C : Organic Carbon determination Walkley-Black method

N : Total Nitrogen determination Kjeldahl method

CEC and bases : Ammonium acetate method

EXAC : Exchangeable acidity extracted with KCl

CARBO : Free Carbonates by destruction with HCl

PART-SIZE DETERMINATION METHOD: H = Hydrometer Method, P = Pipette Method, * = Not Known
 PRETREATMENT: O = Organic Matter, F = Free Iron Oxides, C = Carbonates, S = Soluble Salts N = None

SOIL PROFILE DESCRIPTION

Profile: TO 0783 Unit: A 14a Status: 2

SHEET : 2023A1
 LOCATION : 10.2km from Toteng road to Moshu.
 AUTHOR(S): K.Verbeek B.Kopelo
 CLASSIFICATION FAO: Haplic Luvisol(1988) Orthic Luvisol (1974)
 ST : Typic Haplustalf
 LANDFORM : alluvial plain
 TOPOGRAPHY: almost flat
 SURF. CHAR: slight sealing, no cracks, nil evidence of salt, bleached sand on surface
 LAND USE: traditional grazing
 SPECIES : Trees
 : Shrubs - Colophospermum mopane (dom.) Acacia tortillis subs. heterocantha Acacia hebeclada
 : Grasses/forbs-
 PARENT MATERIAL: alluvium
 MOIST. COND: moist 0 - 20 , dry 20 - 90 cm
 SURF.STONES: none
 EROSION : moderate deposition by wind

REMARKS: Patch of white sand in Bt2. Samples were taken for thin sections:(1)30-40cm,(2)70-80cm,pit renumbered from MA344 to TO783

SAMPLES:

- A 0 - 10 cm Very dark grayish brown (10YR 3/1.5) (moist), fine sand, weak medium to coarse subangular blocky structure, very friable, common very fine to fine pores, non calcareous, common fine to medium roots, gradual smooth boundary.
- Bt1 10 - 50 cm Very dark grayish brown (10YR 3/2) (moist) and dark grayish brown (10YR 4.5/2) (dry), loamy fine sand to fine sandy loam, weak very coarse prismatic falling apart into very weak coarse to very coarse subangular blocky structure, slightly hard to hard, patchy thin clay cutans on pedfaces, few fine and few coarse pores, non calcareous, common medium to coarse roots, clear irregular boundary.
- Bt2 50 - 90 cm Grayish brown (10YR 5/1.5) (moist) and light brownish gray (10YR 6.5/1.5) (dry), fine sandy loam, very weak coarse subangular blocky structure, hard, patchy thin clay cutans on pedfaces, few very fine pores, non calcareous, few coarse roots, clear smooth boundary.
- Bt3 90 - 100 cm Grayish brown (10YR 5/1.5) (moist) and light brownish gray (10YR 6.5/1.5) (dry), sandy clay loam, strongly coherent massive structure, very hard, few very fine pores, non calcareous, very few roots.

Soil Survey of Botswana FAO/BOT/85/011

Last changed : 11/02/91

print date: 11/02/91

SOIL PROFILE DESCRIPTION

Profile: TO 0621 Unit: A 15a Status: 2

SHEET : 2023B1
 LOCATION : 22km from Maun - Nata.
 AUTHOR(S) : K.Verbeek
 CLASSIFICATION FAO: Areni-Haplic Luvisol (1988) Arenic Orthic Luvisol (1974) sodic phase
 ST : Arenic Haplustalf
 LANDFORM : alluvial plain
 TOPOGRAPHY: almost flat
 SURF. CHAR: no sealing, no cracks, nil evidence of salt, bleached sand on surface
 LAND USE: traditional grazing
 SPECIES : Trees - *Boscia albitrunca* (dom.) *Lonchocarpus nelsii*
 : Shrubs - *Dichrostachys cinerea* (dom.) *Acacia* sp. *Acacia erioloba*
 : Grasses/forbs-
 PARENT MATERIAL: alluvium
 MOIST. COND: dry 0 - 120 cm
 SURF. STONES: none
 ERUSION : nil

GRID : GN-719-736
 COORD: 20-07-05-S 23-36-00-E
 DATE : 22/09/86
 LAND ELEMENT : not applicable
 MICRO TOPOGRAPHY: uneven
 VEGETATION: dense shrub savanna
 VEGETATION COVER:

POSITION: lower part
 SLOPE : 0 - 1 % straight
 GRASSCOVER:

GEOL. UNIT: Quaternary
 DRAINAGE : moderately well to imperfectly drained
 HUMAN INF: nil

REMARKS: Alluvial plain of Botletle river

SAMPLES: A: 0 - 20 B: 35 - 60 C: 80 - 100

A 0 - 20 cm Very dark grayish brown (10YR 3.5/2) (moist) and grayish brown (10YR 5/2) (dry), fine sand, weak fine to coarse subangular blocky structure, soft to slightly hard, common very fine to fine pores, non calcareous, common very fine to fine roots, clear smooth boundary.

Bt1 20 - 65 cm Dark brown (10YR 3.5/2.5) (moist) and brown (10YR 5/2.5) (dry), loamy fine sand, very weak medium to coarse subangular blocky structure, slightly hard to hard, patchy thin clay cutans on pedfaces, common very fine to fine pores, non calcareous, few fine to medium roots, clear smooth boundary.

Bt2 65 - 120 cm Dark brown (10YR 3.5/2.5) (moist) and brown (10YR 5/2.5) (dry), sandy loam, very weak medium to coarse subangular blocky structure, hard, patchy thin clay cutans on pedfaces, common very fine to fine pores, non calcareous, infilled burrows, very few fine to medium roots.

Soil Survey of Botswana FAO/BOT/85/011

Last changed : 10/10/90

print date: 28/01/91

STANDARD SOIL ANALYSIS RESULTS

PROFILE: TO 0621

SAMPLE DEPTH	pH	EC m	P m	C N	Ca	Mg	K	Na	EXAC	PBS	CARBO	Particle size (weight %)					CECclay	METH	PRETR										
												H2O	CaCl2	mS/cm	ppm	weight %				<----->	%	veS	cS	mS	fS	vfs	cSi	fSi	Clay
A	0	20	7.4	6.6	0.1	* 12	B	0.3	3.5	6.4	3.4	0.5	0.5	0.0	100	0.0	0	1	16	62	12	3	3	3	3	72	H		
B	35	60	6.9	6.3	0.1	* 3	B	0.1	4.1	7.5	4.1	0.5	0.5	0.0	100	0.0	0	1	23	58	7	1	1	1	9	40	H		
C	80	100	7.3	6.6	0.1	* 2	B	0.1	5.0	9.1	4.3	0.6	0.5	0.0	100	0.0	0	1	21	52	7	2	0	17	27	H			0

Soil Survey of Botswana FAO/BOT/85/011

last changed : 01/06/89

Print date: 28/01/91

EC : Electrical Conductivity m : method ... A = saturated paste B = 1:2.5 in water

P : Available Phosphorus determination m : method ... O = Olsen B = Bray

C : Organic Carbon determination Walkley-Black method

N : Total Nitrogen determination Kjeldahl method

CEC and bases : Ammonium acetate method

EXAC : Exchangeable acidity extracted with KCl

CARBO : Free Carbonates by destruction with HCl

PART. SIZE DETERMINATION METHOD: H = Hydrometer Method, P = Pipette Method, * = Not Known
 PRETREATMENT: O = Organic Matter, F = Free Iron Oxides, C = Carbonates, S = Soluble Salts N = None

SOIL PROFILE DESCRIPTION

Profile: TA 0019 Unit: A 21 Status:

SHEET : 2022A3
 LOCATION : 22.2km West of Tsau tarmac road along Kgakge road.
 AUTHOR(S) : T.D.Mafoko
 CLASSIFICATION FAO: Haplic Calcisol(1988) Calcic Arenosol (1974)
 ST : Arenic Ustochrept
 LANDFORM : alluvial plain
 TOPOGRAPHY: flat
 SURF. CHAR: moderate sealing, no cracks, nil evidence of salt, bleached sand on surface
 LAND USE: traditional grazing
 SPECIES : Trees -
 : Shrubs - *Acacia mellifera* (dom.)
 : Grasses/forbs-
 PARENT MATERIAL: alluvium
 MOIST. COND: dry 0 - 120 cm
 SURF. STONES: none
 EROSION : slight wind erosion/deposition

REMARKS:

SAMPLES: A: 0 - 20 B: 30 - 50 C: 80 - 100

- A 0 - 25 cm Very dark grayish brown (10YR 3.5/1.5) (moist) and grayish brown (10YR 5/1.5) (dry), fine sand, very weak fine subangular blocky structure, soft, non calcareous, many fine to medium roots.
- B1 25 - 55 cm Grayish brown (10YR 5/2) (moist) and light gray (10YR 7/1) (dry), fine sand, single grain subangular blocky structure, soft, non calcareous, common fine to medium roots.
- B2 55 - 120 cm Brown (10YR 4.5/3) (moist) and pale brown (10YR 6/3) (dry), loamy sand to sandy loam, weak fine to medium subangular blocky structure, soft, frequent fine irregular soft white calcareous soft segregations, non calcareous, few fine to medium roots.

Soil Survey of Botswana FAO/BOT/85/011

Last changed : 11/02/91

print date: 11/02/91

GRID : " " " "
 COORD: 20-21-44-S 22-25-55-E
 DATE : 06/03/90
 LAND ELEMENT : not applicable
 MICRO TOPOGRAPHY: even
 VEGETATION: dense shrub savanna

ROCK TYPE: sandstone
 ROCK OUTCROP: none

AGRO CLIM.ZONE: 3C3
 ELEVATION : 1350 m
 SMR: ustic to aridic
 POSITION: intermediate part
 SLOPE : - 1 % straight
 GRASSCOVER: 10 - 30 %
 GEOL.UNIT: Quaternary
 DRAINAGE : somewhat excessively drained
 HUMAN INF: nil

STANDARD SOIL ANALYSIS RESULTS

PROFILE: TA 0019

SAMPLE DEPTH	pH	H2O CaCl2	EC mS/cm	P ppm	m ppm	C ppm	N weight %	CEC	Ca	Mg	K	Na	EXAC	PBS	CARBO	CECclay	METH	PRETR
																meq/100gr		
A	0	20	8.0	7.4	0.1	B	0.1	2.3	3.3	0.0	0.1	0.0	>100	>100	5.8	64	H	N
B	30	50	8.0	7.0	0.0	B	0.0	1.6	1.1	0.0	0.1	0.0	75	75	5.8	64	H	N
C	80	100	8.1	7.2	0.1	B	0.0	5.6	20.9	1.2	0.6	0.1	>100	>100	5.8	64	H	N

Soil Survey of Botswana FAO/BOT/85/011

Last changed: 10/08/90

Print date: 28/01/91

EC : Electrical Conductivity m : method ... A = saturated paste B = 1:2.5 in water

P : Available Phosphorus determination m : method ... O = Olsen B = Bray

C : Organic Carbon determination Walkley-Black method

N : Total Nitrogen determination Kjeldahl method

CEC and bases : Ammonium acetate method

EXAC : Exchangeable acidity extracted with KCl

CARBO : Free Carbonates by destruction with HCl

PART. SIZE DETERMINATION METHOD: H = Hydrometer Method, P = Pipette Method, * = Not Known
 PRETREATMENT: O = Organic Matter, F = Free Iron Oxides, C = Carbonates, S = Soluble Salts N = None

SOIL PROFILE DESCRIPTION

Profile: TA 0017 Unit: A 40 Status:

SHEET : 2022A2
 LOCATION : 7km W of Tsau tarmac road/along MNapororo road.
 AUTHOR(S):
 CLASSIFICATION FAO: Eutri-Haplic Arenosol(1988) Eutric Arenosol (1974)
 ST : Ustic Quartzipsamment
 LANDFORM : alluvial plain
 TOPOGRAPHY: gently undulating
 SURE. CHAR: slight sealing, no cracks, nil evidence of salt,
 LAND USE: traditional grazing
 SPECIES : Trees ~ Acacia erioloba (dom.)
 : Shrubs ~ Acacia tortilis subs. heterocantha (dom.) Acacia mellifera
 : Grasses/forbs-
 PARENT MATERIAL: alluvium
 MOIST. COND: dry 0 - 120 cm
 SURF.STONES: none
 EROSION : strong wind erosion/deposition

REMARKS:

SAMPLES: A: 0 - 20 B: 30 - 50 C: 60 - 80 D: 90 - 110

- A 0 - 20 cm Dark brown (10YR 3/3) (moist) and grayish brown (10YR 5/2) (dry), fine sand, single grain structure, soft, non calcareous, many fine roots, clear smooth boundary.
- B1 20 - 50 cm Very dark grayish brown (10YR 3/2) (moist) and dark grayish brown (10YR 4,5/2) (dry), fine sand, very weak fine to medium structure, soft, non calcareous, common fine roots, abrupt smooth boundary.
- B2 50 - 90 cm Dark brown (10YR 3/3) (moist) and dark brown (10YR 4/3) (dry), fine sand, very weak coarse structure, slightly hard, non calcareous, common very fine roots, abrupt smooth boundary.
- B2B 90 - 120 cm Brown (10YR 5/3) (moist) and light brownish gray (10YR 6/2) (dry), fine sand, single grain structure, loose, non calcareous, common very fine roots.

Soil Survey of Botswana FAO/BOT/85/011

last changed : 11/02/91

print date: 11/02/91

GRID : - -
 COORD: 22-15-00-S 22-28-31-E
 DATE : 06/03/90

AGRO CLIM.ZONE: 2C3
 ELEVATION : 1350 m

SMR: ustic to aridic

LAND ELEMENT : ridge
 MICRO TOPOGRAPHY: % convex

POSITION: upper slope
 SLOPE : % convex

GRASSCOVER: 30 - 70 %

VEGETATION: dense savanna

ROCK TYPE: sandstone

GEOLOGICAL UNIT: Quaternary
 DRAINAGE : somewhat excessively drained

ROCK OUTCROP: none

HUMAN INF: nil

STANDARD SOIL ANALYSIS RESULTS

PROFILE: TA 0017

SAMPLE DEPTH	pH	H2O CaCl2	EC	mS/cm	ppm	P	m	C	N	CEC	Ca	Mg	K	Na	EXAC	PBS	CARBO	Particle size (weight %)				CECclay	METH	PREFIR				
																		vcS	cS	mS	fS				vFS	cSI	fSI	Clay
A	0	20	7.4	6.9	0.0	B	0.0	A	0.2	1.7	11.2	0.1	0.0	0.1	>100			0	1	20	64	9	1	2	3		H	N
B	30	50	7.0	6.1	0.0	B	0.0	A	0.0	2.5	1.8	0.0	0.1	0.1	80			0	1	20	64	9	1	3	2		H	N
C	60	80	7.8	6.2	0.0	B	0.0	A	0.0	3.0	3.1	0.3	0.1	0.1	>100	0.0		0	1	23	62	7	1	2	4		H	N
D	90	110	8.2	7.1	0.1	B	1	A	0.0	0.6	2.0	0.0	0.0	0.1	>100			0	1	18	68	9	1	1	1		H	N

Soil Survey of Botswana FAO/BOT/85/011

last changed : 10/08/90

Print date: 28/01/91

EC : Electrical Conductivity m : method ... A = saturated paste B = 1:2.5 in water

P : Available Phosphorus determination m : method ... O = Olsen B = Bray

C : Organic Carbon determination Walkley-Black method

N : Total Nitrogen determination Kjeldahl method

CEC and bases : Ammonium acetate method

EXAC : Exchangeable acidity extracted with KCl

CARBO : Free Carbonates by destruction with HCl

PART. SIZE DETERMINATION METHOD: H = Hydrometer Method, P = Pipette Method, * = Not Known

PRETREATMENT: O = Organic Matter, F = Free Iron Oxides, C = Carbonates, S = Soluble Salts N = None

SOIL PROFILE DESCRIPTION

Profile: TA 0010 Unit: C 03 Status:

SHEET : 2022C4
 LOCATION : 3.4km East of Roman junction.
 AUTHOR(S) : T.D.Mafoko
 CLASSIFICATION FAO: Epi-Petric Calcisol(1988) Petrocalcic Arenosol (1974)
 ST : Typic Ustochrept
 LANDFORM : plain
 TOPOGRAPHY: almost flat
 SURF. CHAR: moderate sealing, no cracks, nil evidence of salt,
 LAND USE: traditional grazing
 SPECIES : Trees - Terminalia prunioides (dom.)
 : Shrubs - Combretum apiculatum (dom.)
 : Grasses/forbs-
 PARENT MATERIAL: in situ weathered
 MOIST. COND: moist 0 - 35 cm
 SURF.STONES:
 EROSION : slight sheet erosion

REMARKS:

SAMPLES: A: 0 - 20 B: 0 - 0 C: 0 - 0

A 0 - 20 cm Dark brown (7.5YR 3/4) (moist), loamy sand, single grain structure, loose, non calcareous, common fine roots, clear broken boundary.

Ck 20 - 35 cm Dark brown (7.5YR 3/4) (moist), loamy sand, single grain structure, loose, very frequent coarse rounded strongly weathered quartzite fragments, very frequent coarse irregular hard white calcareous nodules, moderately calcareous, common fine roots.

Soil Survey of Botswana FAO/BOT/85/011

Last changed : 11/02/91

print date: 11/02/91

GRID : - -
 COORD: 21-00-00-S 22-15-42-E
 DATE : 02/02/90

LAND ELEMENT : not applicable
 MICRO TOPOGRAPHY: even

VEGETATION: open savanna

SMR: aridic to ustic

POSITION: lower slope
 SLOPE : 0 - 2 % concave

GRASSCOVER: 30 - 70 %

ROCK TYPE: limestone

GEOLOG. UNIT: Olifantshoek Ganszi grp
 DRAINAGE : well drained

ROCK OUTCROP: none

HUMAN INF: nil

STANDARD SOIL ANALYSIS RESULTS

PROFILE: TA 0010

SAMPLE DEPTH	pH	H2O CaCL2	EC m	P m	C	N	CEC	Ca	Mg	K	Na	EXAC	PBS	CARBO	Particle size (weight %)				CECclay	METH	PRETR							
															wtS	cS	mS	fS				vfs	cSi	fSi	Clay	meq/100gr		
A	0	20	6.1	5.7	0.0	B	1	A	0.2	4.3	2.6	0.5	0.3	0.0	79	1.9	2	3	14	63	11	3	1	4			H	
B	0	0																										
C	0	0																										

Soil Survey of Botswana FAO/BOT/85/011

Last changed : 20/07/90

Print date: 28/01/91

EC : Electrical Conductivity m : method ... A = saturated paste B = 1:2.5 in water

P : Available Phosphorus determination m : method ... O = Olsen b = Bray

C : Organic Carbon determination Walkley-Black method

N : Total Nitrogen determination Kjeldahl method

CEC and bases : Ammonium acetate method

EXAC : Exchangeable acidity extracted with KCl

CARBO : Free Carbonates by destruction with HCl

PART. SIZE DETERMINATION METHOD: H = Hydrometer Method, P = Pipette Method, * = Not Known
 PRETREATMENT: O = Organic Matter, F = Free Iron Oxides, C = Carbonates, S = Soluble Salts N = None

SOIL PROFILE DESCRIPTION

Profile: TA 0002 Unit: LC04 Status:

SHEET : 2022C2
 LOCATION : 34.5km West of Tsau junction along Kare road.
 AUTHOR(S): T.D.Mafoko
 CLASSIFICATION FAO: Epi-Hypercalci-Stagni-Haplic Calcisol(1988) Calcic Cambisol (1974)
 ST : Typic Ustorthent
 LANDFORM : plain
 TOPOGRAPHY: flat
 SURF. CHAR: strong sealing, no cracks, nil evidence of salt,
 LAND USE: traditional grazing
 SPECIES : Trees -
 : Shrubs -
 : Grasses/forbs-
 PARENT MATERIAL: lacustrine
 MOIST. COND: moist 0 - 20 , slightly moist 20 - 50 cm
 SURF.STONES: none
 EROSION : strong sheet erosion and strong rill erosion

REMARKS:

SAMPLES: A: 0 - 15 B: 30 - 50

A 0 - 18 cm Very dark grayish brown (10YR 3/1.5) (moist), sandy loam, moderate fine subangular blocky structure, friable, non calcareous, many fine roots, abrupt wavy boundary.
 Ck1 18 - 50 cm Brown (10YR 5/3) (moist), sandy loam, moderate fine to medium subangular blocky structure, soft, very frequent fine irregular hard calcareous nodules, strongly calcareous, many fine roots, clear wavy boundary.
 Ck2 50 - 70 cm weakly cemented, dominant coarse spherical hard white calcareous nodules, strongly calcareous, many fine roots.

Soil Survey of Botswana FAO/BOT/85/011

last changed : 11/02/91

print date: 11/02/91

GRID : - -
 COORD: 20-31-05-S 22-23-37-E
 DATE : 27/10/80

LAND ELEMENT : pan
 MICRO TOPOGRAPHY: even
 VEGETATION: grassland

AGRO CLIM.ZONE: 3C3
 ELEVATION : 1350 m
 SMR: aridic to ustic

POSITION: intermediate part
 SLOPE : - 1 % straight
 GRASSCOVER: < 10 %

ROCK TYPE:
 ROCK OUTCROP: none
 GEOL. UNIT:
 DRAINAGE : well drained
 HUMAN INF: nil

STANDARD SOIL ANALYSIS RESULTS

PROFILE: TA 0002

SAMPLE DEPTH	pH	H2O CaCl2	EC	m	P	m	C	N	CEC	Ca	Mg	K	Na	EXAC	PBS	CARBO	CECclay	METH	PRETR	
		ms/cm	ppm	weight %	<	meq/100gr soil														
A	0	15	7.8	7.1	0.2	B	8	A	1.6	17.9	16.0	1.4	1.2	0.1	>100					
B	30	50	8.7	7.9	0.2	B	3	A	0.3	6.9	41.0	1.4	0.7	0.2	>100	13.2				

Soil Survey of Botswana FAO/BOT/85/011

last changed : 29/06/90

Print date: 28/01/91

EC : Electrical Conductivity m : method ... A = saturated paste B = 1:2.5 in water

P : Available Phosphorus determination m : method ... O = Olsen B = Bray

C : Organic Carbon determination Walkley-Black method

N : Total Nitrogen determination Kjeldahl method

CEC and bases : Ammonium acetate method

EXAC : Exchangeable acidity extracted with KCl

CARBO : Free Carbonates by destruction with HCl

PART-SIZE DETERMINATION METHOD: H = Hydrometer Method, P = Pipette Method, * = Not Known
 PRETREATMENT: O = Organic Matter, F = Free Iron Oxides, C = Carbonates, S = Soluble Salts N = None

SOIL PROFILE DESCRIPTION

Profile: GO 0333 Unit: L 16 Status: 1

SHEET : 1921B
 LOCATION : Gomare-Nxauxau road; 50.7km from Gomare airfield.
 AUTHOR(S) : P. Jamagne E. Telekelo
 CLASSIFICATION FAO: Eutri-Luvic Arenosol (1988) Eutric Arenosol (1974)
 ST : Ustic Quartzipsamment
 LANDFORM : dune field
 TOPOGRAPHY: flat
 SURF. CHAR: slight sealing, no cracks, nil evidence of salt,
 LAND USE: traditional grazing
 SPECIES : Trees - *Boscia albitrunca* (dom.)
 : Shrubs - *Grèwia flava* (dom.) *Lonchocarpus nelsii* *Dichrostachys cinerea* *Boscia albitrunca*
 : Grasses/forbs-

PARENT MATERIAL: colluvium
 MOIST. COND: moist 0 - 100 cm
 SURF. STONES: none
 EROSION : nil

REMARKS:

SAMPLES: A: 10 - 30 B: 50 - 70 C: 80 - 100

A 0 - 40 cm Dark brown (10YR 4/2.5) (moist), fine sand (7% clay), weak coarse subangular blocky falling apart into weak fine to medium subangular blocky structure, very friable, common very fine to fine pores, non calcareous, common very fine to fine roots, gradual wavy boundary.

Bt1 40 - 75 cm Brown (10YR 4.5/3) (moist), fine sand (8% clay), massive structure, friable to firm, few very fine to fine pores, non calcareous, few very fine to fine roots, gradual wavy boundary.

Bt2 75 - 100 cm Brown (10YR 5/3) (moist), fine sand (8% clay), weakly coherent massive structure, friable, few very fine to fine pores, non calcareous, few very fine to fine roots.

Soil Survey of Botswana FAO/BOT/85/011

Last changed : 11/02/91

print date: 11/02/91

GRID : EP-949-827
 COORD: 19-08-50-S 21-54-10-E
 DATE : 08/04/89
 LAND ELEMENT : interdunal depression
 MICRO TOPOGRAPHY: even
 VEGETATION: shrub savanna
 AGRO CLIM. ZONE: 2C2
 ELEVATION : 1350 m
 SMR: ustic
 POSITION: intermediate part
 SLOPE : 0 - 0.5% concave
 GRASSCOVER: > 70 %
 GEOL. UNIT: Kalahari beds
 DRAINAGE : well drained
 HUMAN INF: nil

STANDARD SOIL ANALYSIS RESULTS

PROFILE: GO 0333

SAMPLE DEPTH	pH	EC m	P m	C	N	CEC	Ca	Mg	K	Na	EXAC	PBS	CARBO	Particle size (weight %)	vcS	cS	mS	FS	vFS	cSi	fSi	Clay	CECclay	METH	PRETR	
	H2O CaCl2	mS/cm	ppm	weight %	<-----	<-----	meq/100gr soil	meq/100gr soil	meq/100gr soil	meq/100gr soil	----->	%	%										meq/100gr			
A	10 30	6.3	5.4	0.0	B	1 B	0.2	0.00	3.8	3.9	1.1	0.1	0.0	0.0	0.0	0	4	33	46	6	2	3	6	47	H	O
B	50 70	5.9	4.9	0.0	B	2 B	0.2	0.00	4.2	4.0	1.5	0.1	0.1	0.2	0	4	30	49	7	2	1	9	37	H	O	
C	80 100	5.0	3.9	0.0	B	1 B	0.1	0.00	4.4	3.7	1.2	0.1	0.1	0.8	0	4	31	46	8	0	2	10	42	H	N	

Soil Survey of Botswana FAO/BOY/85/011

last changed : 28/09/89

Print date: 28/01/91

EC : Electrical Conductivity m : method ... A = saturated paste B = 1:2.5 in water

P : Available Phosphorus determination m : method ... O = Olsen B = Bray

C : Organic Carbon determination Walkley-Black method

N : Total Nitrogen determination Kjeldahl method

CEC and bases : Ammonium acetate method

EXAC : Exchangeable acidity extracted with KCl

CARBO : Free Carbonates by destruction with HCl

PART-SIZE DETERMINATION METHOD: H = Hydrometer Method, P = Pipette Method, * = Not Known
 PRETREATMENT: O = Organic Matter, F = Free Iron Oxides, C = Carbonates, S = Soluble Salts N = None

SOIL PROFILE DESCRIPTION

Profile: TO 0600 Unit: L 22a Status: 2

SHEET : 2023B1
 LOCATION : 8km SE from Samedupi bridge.
 AUTHOR(S) : K.Verbeek R.Kelebemang
 CLASSIFICATION FAO: Areni-Haplic Luvisol(1988) Arenic Orthic Luvisol (1974)
 ST : Arenic Haplustalf
 LANDFORM : Lacustrine plain
 TOPOGRAPHY: almost flat
 SURF. CHAR: no sealing, no cracks, nil evidence of salt, bleached sand on surface
 LAND USE: traditional grazing
 SPECIES : Trees - Terminalia prunioides (dom.) Acacia tortillis subs. heteroacantha Acacia erioloba
 : Shrubs -
 : Grasses/forbs-
 PARENT MATERIAL: lacustrine
 MOIST. COND: dry 0 - 120 cm
 SURF.STONES: none
 EROSION : nil

REMARKS: Outer rim pan

SAMPLES: A: 0 - 30 B: 40 - 60 C: 70 - 90

- A 0 - 25 cm Very dark grayish brown (10YR 3.5/2) (moist) and dark grayish brown (10YR 4.5/2) (dry), fine sand, weak medium to coarse subangular blocky structure, slightly hard, few very fine pores, non calcareous, common very fine roots, clear smooth boundary.
- B 25 - 70 cm Very dark grayish brown (10YR 3/2) (moist) and dark brown (10YR 4/2.5) (dry), fine sand, massive and very weak structure, slightly hard, few very fine pores, non calcareous, common very fine roots, clear smooth boundary.
- Bt 70 - 120 cm Dark brown (10YR 3.5/3) (moist) and dark brown (10YR 4/3) (dry), loamy fine sand to fine sandy loam, massive structure, hard, patchy thin clay cutans on pedfaces, few fine to medium pores, non calcareous, burrows, few fine to medium roots.

Soil Survey of Botswana FAO/BOT/85/011

Last changed : 10/10/90

print date: 28/01/91

STANDARD SOIL ANALYSIS RESULTS

PROFILE: TO 0600

SAMPLE DEPTH	pH	EC m	P m	C	N	CEC	Ca	Mg	K	Na	EXAC	PBS	CARBO	Particle size (weight %)						CECclay	METH	PRETR						
					weight %	<-----	meq/100gr soil	%	%	vcS	cS	mS	fS	vfS	cSi	fSi	Clay	meq/100gr										
A	0	30	6.7	6.1	0.0	*	6 B	0.2	3.5	2.6	0.7	0.4	0.0	0.0	100	0.0	0.0	0	2	23	60	8	1	0	6	45		H
E	40	60	6.2	5.2	0.0		2 B	0.1	3.4	1.3	1.1	0.5	0.0	0.0	85	0.0	0.0	0	4	27	49	7	3	1	10	31		H
C	70	90	6.7	5.9	0.0		3 B	0.1	4.8	5.1	2.2	0.6	0.0	0.0	100	0.0	0.0	0	3	27	45	7	2	2	15	30		H

Soil Survey of Botswana FAO/BOI/85/011

last changed : 01/06/89

Print date: 28/01/91

EC : Electrical Conductivity m : method ... A = saturated paste B = 1:2.5 in water

P : Available Phosphorus determination m : method ... O = Olsen B = Bray

C : Organic Carbon determination Walkley-Black method

N : Total Nitrogen determination Kjeldahl method

CEC and bases : Ammonium acetate method

EXAC : Exchangeable acidity extracted with KCl

CARBO : Free Carbonates by destruction with HCl

PART-SIZE DETERMINATION METHOD: H = Hydrometer Method, P = Pipette Method, * = Not Known
 PRETREATMENT: O = Organic Matter, F = Free Iron Oxides, C = Carbonates, S = Soluble Salts N = None

SOIL PROFILE DESCRIPTION

Profile: TA 0003 Unit: KS03 Status: 2

SHEET : 2022C4
 LOCATION : 3.8km South West of Kgabaganyane pan.
 AUTHOR(S) : T.D.Mafoko
 CLASSIFICATION FAO: Ferralic Arenosol (1988) Ferralic Arenosol (1974)
 ST : Typic Quartzipsamment
 LANDFORM : sand plain
 TOPOGRAPHY: almost flat
 SURF. CHAR: moderate sealing, no cracks, nil evidence of salt,
 LAND USE: traditional grazing
 SPECIES : Trees - Acacia erubescens (dom.)
 : Shrubs - Acacia erubescens (dom.) Acacia erioloba
 : Grasses/forbs-
 PARENT MATERIAL: aeolian sand
 MOIST. COND: moist 0 - 120 cm
 SURF. STONES: none
 EROSION : moderate wind erosion/deposition

REMARKS:

SAMPLES: A: 0 - 20 B: 30 - 50 C: 80 - 100

A 0 - 20 cm Dark brown (7.5YR 3/4) (moist), fine sand, single grain structure, very friable, non calcareous, many fine roots, diffuse smooth boundary.

C 20 - 120 cm Dark reddish brown (5YR 3/4) (moist), fine sand, massive structure, soft, non calcareous, common fine to medium roots.

Soil Survey of Botswana FAO/BOT/85/011

last changed : 11/02/91

print date: 11/02/91

GRID : - - -
 COORD: 20-49-43-S 22-17-26-E
 DATE : 27/10/89

SMR: aridic to ustic

LAND ELEMENT : not applicable
 MICRO TOPOGRAPHY: low hummocks

VEGETATION: open tree savanna

ROCK TYPE: sandstone

ROCK OUTCROP: none

GEOL. UNIT: Karoo Lebung group
 DRAINAGE : somewhat excessively drained

HUMAN INF: nil

STANDARD SOIL ANALYSIS RESULTS

PROFILE: TA 0003

SAMPLE DEPTH	pH	H2O	CaCl2	EC	m	P	m	C	N	CEC	Ca	Mg	K	Na	EXAC	PBS	CARBO	Particle size (weight %)				CECclay	METH	PRETR					
									weight %	<			meq/100gr soil			%	%	vcS	cS	mS	fS	vfs	csi	fSi	Clay	meq/100gr			
A	0	20	5.7	4.9	0.1	B	3	A	0.2	3.0	1.5	0.4	0.1	0.1		70		1	3	25	55	9	3	1	4			H	N
B	30	50	5.4	4.6	0.1	B	1	B	0.1	3.7	0.0	0.8	0.8	0.1		46		1	3	21	53	12	1	1	9	37		H	N
C	80	100	5.2	4.5	0.1	B	0	B	0.1	3.8	1.3	0.9	0.2	0.1		66		1	3	20	50	12	2	1	11	31		H	N

Soil Survey of Botswana FAO/BOT/85/011

last changed : 08/08/90

Print date: 28/01/91

EC : Electrical Conductivity m : method ... A = saturated paste B = 1:2.5 in water

P : Available Phosphorus determination m : method ... O = Olsen B = Bray

C : Organic Carbon determination Walkley-Black method

N : Total Nitrogen determination Kjeldahl method

CEC and bases : Ammonium acetate method

EXAC : Exchangeable acidity extracted with KCl

CARBO : Free Carbonates by destruction with HCl

PART-SIZE DETERMINATION METHOD: H = Hydrometer Method, P = Pipette Method, * = Not Known
 PRETREATMENT: O = Organic Matter, F = Free Iron Oxides, C = Carbonates, S = Soluble Salts N = None

SOIL PROFILE DESCRIPTION

Profile: TA 0006 Unit: KS17 Status: 2

SHEET : 2022C3
 LOCATION : 7.2km North of borehole.
 AUTHOR(S) : T.D.Mafoko
 CLASSIFICATION FAO: Eutri-Haplic Arenosol(1988) Eutric Arenosol (1974)
 ST : Ustic Quartzipsamment
 LANDFORM : sand plain
 TOPOGRAPHY: almost flat
 SURF. CHAR: no sealing, no cracks, nil evidence of salt, bleached sand on surface
 LAND USE: traditional grazing
 SPECIES : Trees - Acacia erubescens (dom.) Terminalia sericea
 : Shrubs - Acacia erubescens (dom.) Terminalia sericea
 : Grasses/forbs-
 PARENT MATERIAL: aeolian sand
 MOIST. COND: moist 0 - 120 cm
 SURF.STONES: none
 EROSION : moderate wind erosion/deposition

REMARKS:

SAMPLES: A: 0 - 20 B: 30 ~ 50 C: 80 - 100

A 0 - 20 cm Dark brown (10YR 3/3) (moist), fine sand, single grain structure, loose, non calcareous, common fine roots, clear smooth boundary.

E 20 - 120 cm Dark brown (10YR 4/3) (moist), fine sand, single grain structure, loose, non calcareous, common fine and few fine roots.

GRID : - -
 COORD: 20-42-32-S 22-18-00-E
 DATE : 01/02/90

AGRO CLIM.ZONE: 3C3
 ELEVATION : 1350 m
 SMR: aridic to ustic

LAND ELEMENT : not applicable
 MICRO TOPOGRAPHY: even
 VEGETATION: open savanna
 POSITION: middle slope
 SLOPE : 0 - 2 % convex
 GRASSCOVER: 30 - 70 %

ROCK TYPE: sandstone

GEOLOGICAL UNIT: Karoo Lebung group
 DRAINAGE : somewhat excessively drained

ROCK OUTCROP: none

HUMAN INT: nil

Soil Survey of Botswana FAO/BOT/85/011

Last changed : 11/02/91

print date: 11/02/91

STANDARD SOIL ANALYSIS RESULTS

PROFILE: TA 0006

SAMPLE DEPTH	pH	H2O CaCl2	EC m	P ppm	m	C	N	CEC	Ca	Mg	K	Na	EXAC	PBS	CARBO	Particle size (weight %)				CECclay	METH	PRETR						
																vcS	cS	mS	fS				vfS	cSI	fSI	Clay	meq/100gr	
A	0	20	6.0	5.9	0.0	B	2	A	0.1	2.0	1.6	0.3	0.1	0.2	>100			0	1	23	68	7	1	0	1			H
F	30	50	5.6	5.4	0.0	B	0	A	0.1	2.1	1.0	0.4	0.2	0.1	81			0	1	28	65	5	0	1	1			H
C	80	100	5.9	5.3	0.0	B	0	A	0.0	2.0	0.9	0.3	0.1	0.1	70			0	1	24	64	7	1	0	4			H

Soil Survey of Botswana FAO/BOT/85/011

last changed : 31/07/90

Print date: 28/01/91

EC : Electrical Conductivity m : method ... A = saturated paste B = 1:2.5 in water

P : Available Phosphorus determination m : method ... O = Olsen B = Bray

C : Organic Carbon determination Walkley-Black method

N : Total Nitrogen determination Kjeldahl method

CEC and bases : Ammonium acetate method

EXAC : Exchangeable acidity extracted with KCl

CARBO : Free Carbonates by destruction with HCl

PART-SIZE DETERMINATION METHOD: H = Hydrometer Method, P = Pipette Method, * = Not Known
 PRETREATMENT: O = Organic Matter, F = Free Iron Oxides, C = Carbonates, S = Soluble Salts N = None

SOIL PROFILE DESCRIPTION

Profile: TA 0012 Unit: LS17d Status: 2

SHEET : 2022A4
 LOCATION : Dautso beach ridge.
 AUTHOR(S) : T.D.Mafoko
 CLASSIFICATION FAO: Entri-Haplic Arenosol(1988) Entric Arenosol (1974)
 ST : Ustic Quartzipsamment
 LANDFORM : plain
 TOPOGRAPHY: gently undulating
 SURF. CHAR: slight sealing, no cracks, nil evidence of salt, bleached sand on surface
 LAND USE: traditional grazing
 SPECIES : Trees - Acacia erioloba (dom.) Terminalia sericea Acacia erubescens
 : Shrubs -
 : Grasses/forbs-
 PARENT MATERIAL: littoral
 MOIST. COND: moist 0 - 120 cm
 SURF.STONES: none
 EROSION : slight wind erosion/deposition

REMARKS:

SAMPLES: A: 0 - 20 B: 30 - 50 C: 80 - 100

A 0 - 20 cm Dark grayish brown (10YR 4/2) (moist), fine sand, single grain structure, loose, non calcareous, common fine roots, gradual smooth boundary.
 B1 20 - 70 cm Brown (10YR 5/3) (moist), fine sand, single grain structure, loose, non calcareous, very few fine roots, clear smooth boundary.
 B2 70 - 120 cm Light brownish gray (10YR 6/2) (moist), fine sand, single grain structure, loose, non calcareous, very few fine roots.

GRID : - -
 COORD: 20-30-00-S 22-24-20-E
 DATE : 03/02/90

LAND ELEMENT : beach ridge
 MICRO TOPOGRAPHY: low hummocks
 VEGETATION: open tree savanna

AGRO CLIM.ZONE: 3C3
 ELEVATION : 1350 m
 SMR: aridic to ustic
 POSITION: intermediate part
 SLOPE : - 2 % straight
 GRASSCOVER: 10 - 30 %

ROCK TYPE:

GEOL.UNIT: Quaternary
 DRAINAGE : somewhat excessively drained

ROCK OUTCROP: none

HUMAN INF: nil

STANDARD SOIL ANALYSIS RESULTS

PROFILE: TA 0012

SAMPLE DEPTH	pH	EC m	P m	C	N	CEC	Ca	Mg	K	Na	EXAC	PBS	CARBO	Particle size (weight %)	CECclay	METH	PRETR								
		mS/cm	ppm	weight %	<----->	meq/100gr soil		meq/100gr soil				%	%	vcS	cS	mS	fS	vFS	cSi	fSi	Clay	meq/100gr			
A	0	20	6.2	6.0	0.0	B	2	A	0.2	1.4	0.7	0.1	0.2	0.0	71	0.0	0	0	11	78	8	2	2	0	H
B	30	50	6.0	5.6	0.0	B	1	A	0.0	1.2	0.6	0.0	0.0	0.0	50	2.9	0	1	9	78	9	1	0	2	H
C	80	100	6.3	5.9	0.0	B	0	A	0.0	2.1	0.7	0.0	0.2	0.0	43	2.9	2	1	5	79	9	1	2	1	H

Soil Survey of Botswana EAO/BOT/85/011

Last changed: 02/08/90

Print date: 28/01/91

EC : Electrical Conductivity m : method ... A = saturated paste B = 1:2.5 in water

P : Available Phosphorus determination m : method ... O = Olsen B = Bray

C : Organic Carbon determination Walkley-Black method

N : Total Nitrogen determination Kjeldahl method

CEC and bases : Ammonium acetate method

EXAC : Exchangeable acidity extracted with KCl

CARBO : Free Carbonates by destruction with HCl

PART-SIZE DETERMINATION METHOD: H = Hydrometer Method, P = Pipette Method, * = Not Known
 PRETREATMENT: O = Organic Matter, F = Free Iron Oxides, C = Carbonates, S = Soluble Salts N = None

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