1. Introduction

The Agro-ecological zoning (AEZ) is a procedure of small scale land suitability assessment. It was developed by the Food and Agriculture Organization of the United Nations with the objective of assessing the potential agricultural use of the worlds resources (FAO, 1978).

In the past, several technical co-operation projects have been performed to assist the Government of Namibia, through the AEZ programme office of the Ministry of Agriculture, Water and Rural Development (MAWRD), with building comprehensive inventories of agricultural resources, with managing these data through geographical information systems (GIS), with defining agro-ecological zones as a basis for land use planning and with conducting land evaluation studies for specific agricultural uses.

One of the main conclusions extracted from these projects has been the lack of appropriate information on soils and soil properties; this deficiency has made difficult to assess the land use potentials for specific areas, specially in the fragile environment of the natural resources of Namibia.

The project to support the agro-ecological zoning project in Namibia was designed to overcome this lack of information. The planned outputs from the project were:

- land mapping of the whole country with the following scales and coverages:
    - Soil map (E=1:1.000.000) of Namibia
    - Soil map (E=1:250.000) of the areas with a growing period 1, 2 and 3
    - Soil map (E=1:100.000) of the Kavango river area
    - Soil map (E=1:100.000) of the northern Central Namibia area
- Improvement of the GIS named "National Agricultural Resources Information System" (NARIS) and possible connection with other national agro-ecological databases in Namibia
- Training of local staff responsible for undertaking the project, in terms of the methodology and practical uses of the AEZ procedures

This report contains the results of the project. It is accompanied by a set of 79 maps and 68 CD-rooms.

The report dedicates the main part to the soil information gathered during the project. This information is divided in four chapters that correspond to the four soil surveys planned for the project. These chapters present the typical structure of the soil reports, where the legend and the description of the map units stand up.

Furthermore, information about the satellite map production and the design of the Geographical Information System developed during the project can be find in two chapters specially dedicated.

The map sheets allow the display of the soil maps on mosaics of the satellite images adjusted to the official topographical maps of Namibia and printed at the same scale of the surveys to facilitate their use and their connection with other information.

The CD-rooms contain the following information:

- 50 satellite images corrected according to the technical specifications.

- 54 images (bands 5-4-3) that represent the different mosaics of satellite images adjusted to the official topographical maps (E=1:250.000) of Namibia.

- 3 images (bands 5-4-3) that represent the different mosaics of satellite images adjusted to the official topographical maps (E=1:1.000.000) of Namibia.

- The shapes of the four soil maps.

- The databases that contain the whole information collected during the four soil surveys.

- An application, based on the AEZ, that shows the possibilities of the GIS designed with the information (soil maps and databases) available.

- The files that form the present report.

The following people have contributed to the project to support the agro-ecological zoning project in Namibia and to this publication:

MAWRD staff:

Mrs. Marina Coetzee	Head of the AEZ programme in Namibia
Mr. Albert Calitz	Co-ordinator of the project in the MAWRD
Mr. Heleon Beukes	Principal Agricultural Research Technician
Mr. Heiner Mouton	Agricultural Research Technician. Fieldwork
Mr. Josephat Kutuahupira	Agricultural Research Technician. Fieldwork
Mrs. Seraphia Ashipala	Agricultural Research Technician

ICC staff – AEZ Project:

Mr. Antoni Roca i Adrover	Head of the project
Mr. Pere Oller i Figueras	Co-ordinator of the project in Barcelona
Mr. Emilio Ascaso Sastrón	Long-term expert
Mr. Juan Francisco García Ruíz	Team leader
Mr. Gustavo Carrillo Mahiques	Team leader

Mr. Jordi Marturià Alavedra	Short-term expert
Mr. Paulus Amukwaya Festus	Agricultural Research Technician. Fieldwork
Mr. Gabriel Ngungaa Hangara	Agricultural Research Technician. Fieldwork
Ms. Eulàlia Pujal i Arbués	Administrative
Ms. Georgina Arnó i Pons	Operator

ICC staff - Remote Sensing:

Mr. Roman Arbiol Bertran	Head of the unit
Mr. Fernando Perez Aragues	Research and Development Technician
Ms. Matilde Vinya Lobo	Remote sensing operator

ICC staff – Automatic Cartography:

Ms. Maria Pla Toldrà	Head of the Unit
Ms. Blanca Baella Borderas	Automatic Cartography Responsible
Ms. Anna Bayona Huguet	Automatic Cartography
Ms. Margarita Sanchez Fernandez	Automatic Design Responsible
Mr. Joan Mulero Pruna	Automatic Design

ICC staff – Geodesy:

Ms. Assumpció Termens Perarnau	Geodesic Development Responsible

ICC staff – Data Base Information and Development:

Ms. Anna Lleopart Grau	Head of the unit
Ms. Inma Menacho Morales	Elevations Data Bases Responsible

ICC staff – Data Management:

Mr. Joaquim Oller Villagrasa	Data Management Responsible
Ms. Nuria Rodriguez Budia	Data Management Technician

Universitat de Lleida – Scientific support:

Mr. Jaume Boixadera i Llobet	Professor

Foreword

The Project to support the Agro-ecological Zoning in Namibia has been possible because of the agreement established during the 1st Commission between the Governments of the Republic of Namibia through the National Planning Commission (NPC) and the Kingdom of Spain through the Spanish Agency for International Co-operation (AECI).

The project has been performed by technicians of the Cartographic Institute of Catalonia supported by members of the staff of the Agro-ecological Zoning Programme within the Directorate of Agricultural Research and Training of the Ministry of Agriculture, Water and Rural Development.

The project describes the principal characteristics of the soil that can explain the soil behaviour for selected land uses and is designed for many different users. Farmers, foresters and agronomists can use it to evaluate the potential of the soil and the management practices needed for maximum production. Planners, engineers and developers can use this study to plan land use and identify special practices needed to ensure proper performance.

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Annexes

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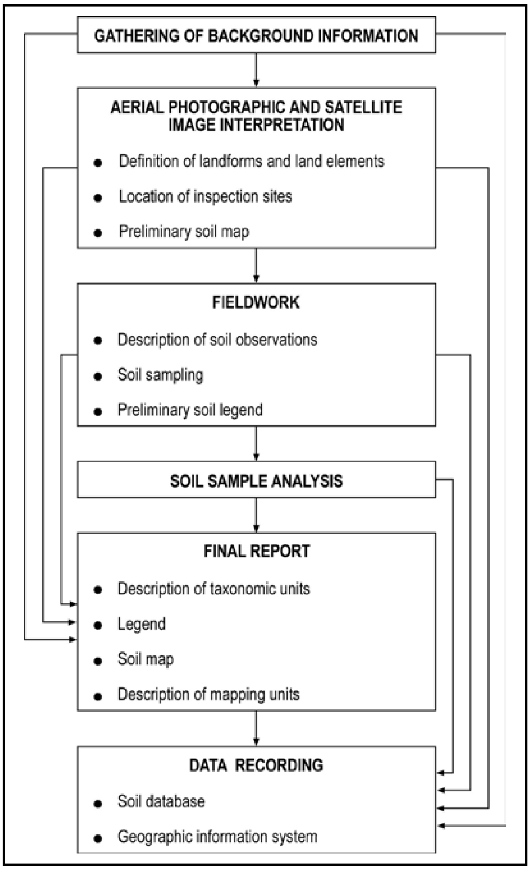
A.1.1. Soil survey methodology

These surveys were made to provide information about the soils of Namibia. The information includes a description of the soils and their location together with some discussion about the suitability and limitations of the soil for agronomic uses estimated from their characteristics.

The production of a soil map always starts with the collection of all available background information such as geology, topography, vegetation, land use, soils, etc.

In the methodology of soil surveying the soil-landscape model has been applied. According to this model the properties of the soils vary from place to place, but this variation is not random. Natural soil bodies are the result of climate and living organisms acting on parent material, with topography or local relief exerting a modifying influence and with time required for soil-forming processes to act. For the most part, soils are the same wherever all elements of the five factors are the same. This regularity permits prediction of the location of many different kinds of soils by assuming that there is a pattern or order in the spatial distribution of soil characteristics. Figure A.1.1 shows the flow-diagram of the methodology applied during this soil survey.

Figure A.1.1. Flow-diagram of the methodology applied during this soil survey



This is why the surveys have started with a systematic interpretation of the aerial photographs in the case of the maps at scale E=1:100.000, and of the satellite images in the case of the maps at scales E=1:250.000 and E=1:1.000.000, to infer the soil boundaries and to locate the setting of the different observations.

Fieldwork has been performed by means of 1655 pits and 645 auguerings (Table A.1.1.). These observations have been dug to study the soil profile, to characterize the different kind of soil and to determine their properties.

Table A.1.1. Summary of the fieldwork observations

Soil survey	Profiles	Auguerings
Kavango river area	73	645
Northern Central Namibia area	319	-
Areas with a growing period 2 and 3	435	-
Soil survey of Namibia	828	-

The soils have been described according to the Guidelines for soil description (FAO, 1997).

The soil profiles and the augers have been classified according to the World Reference Base for Soil Resources System (ISSS, 1998). Furthermore, the correlation with the revised legend of FAO (FAO, 1988) and the Soil Taxonomy System (SSS, 1996) has been given.

While fieldwork has been in progress, samples of the soils have been collected and sent for laboratory analyses. The analyses have been performed at the soil laboratory of the Ministry of Agriculture, Water and Rural Development of Namibia.

The taxonomic units has been the soil units of the World Reference Base. The map units consist of consociations, associations and complexes of the taxonomic units. Furthermore, in the more detailed maps, phases (slope, texture of the superficial horizon, salinity and sodicity) have been used in order to give more relevant information to evaluate the agriculture potential of the units.

The final map are presented on mosaics of the satellite images, previously corrected, at the Institut Cartogràfic de Catalunya in Barcelona (Spain).

Finally, it must be mentioned that all the information has been recorded on digital format by digitizing the soil map and introducing the attribute data in databases specially designed, in the case of the more detailed maps, and following the SOTER structure (ISSS, ISRIC, 1990) in the case of the surveys at scale E=1:250.000 and 1:1.000.000. In this way, the continuous updating of the information and the management of the information, by means of a Geographical Information System (GIS) can be facilitated.

A.1.2. Analytic methodology

The analyses have been performed at the agriculture laboratory of the Ministry of Agriculture, Water and Rural Development of Namibia. The methods used have been the ones described in "Soil survey laboratory methods and procedures for collecting soil samples" (USDA, 1984), complemented by the ones from ISRIC (ISRIC, 1987).

a) **pH**

Measured in a 1:2.5 soil:water suspension on a mass to volume basis.

b) **Electrical conductivity**

Measured in the supernatant of the 1:2.5 soil:water suspension prior to measurement of pH. Units of measurement are mS/cm. High results indicating possible salinity hazard are repeated on the extract of a saturated soil paste.

c) **Texture and particle size analysis**

Dispersion of the soil with sodium hexametaphosphate/sodium carbonate. Determination of silt and clay by pipette method. Sand fraction determined by sieving to retain >53 micron fraction.

d) **Carbonate (as Calcium carbonate)**

Reaction of soil with hydrochloric acid and estimation of acid consumed by titration with sodium hydroxide.

e) **organic carbon**

Walkley-Black method (sulphuric acid-potassium dichromate oxidation). A factor is included in calculations to take account of incomplete oxidation. Organic matter content calculated as organic-C x 1.74.

f) **Cation exchange capacity**

Extraction with 50:50 ammonium acetate (1M) and ethanol at pH 7 if pH(H2O)>6.8 & EC>0.4 mS/cm.
Extraction with 1M ammonium acetate at pH 7 if pH(H2O)<6.8 & EC<0.4 mS/cm

A.1.3. Guidelines for map units and soil description

Table A.1.2. Guidelines for evaluating drainage class (FAO, 1990)

DRAINAGE CLASS	DESCRIPTION
Excessively drained	Water is removed from de soil very rapidly. The soils are commonly very coarse textured or rocky, shallow or on steep slopes. If not irrigated, fine textured soils in arid regions also belong to this class
Somewhat excessively drained	Water is removed from the soil rapidly. The soils are commonly sandy and very pervious. Not irrigated soils in semi-arid regions also belong to this class
Well drained	Water is removed from the soil readily. The soils commonly retain optimal amounts of moisture, but wetness does not inhibit growth of roots for significant periods
Moderately well drained	Water is removed from the soil somewhat slowly during some periods of the year. The soils are wet for short periods within the rooting depth. They commonly have an almost impervious layer or periodically receive heavy rainfall
Imperfectly drained	Water is removed slowly so that the soil is wet at a shallow depth for significant periods. The soils have an almost impervious layer, a high water table, additions of water by seepage, or very frequent rainfall
Poorly drained	Water is removed so slowly that the soils are commonly wet at shallow depth for considerable periods. The soils have a shallow water table which is usually the result of an almost impervious layer, seepage, or very frequent rainfall
Very poorly drained	Water is removed so slowly that the soils are wet at shallow depths for long periods. The soils have a very shallow water table and are commonly in level or depressed sites or have very high amounts of rainfall almost every day.

Table A.1.3. Soil texture classes (USDA, 1975)

TEXTURAL CLASS	BASIC TEXTURE
Coarse	Sand Loamy sand
Moderately coarse-textured soils	Sandy loam
Medium-textured soils	Loam Silt loam Silt
Moderately fine-textured soils	Clay loam Sandy clay loam Silty clay loam
Fine-textured soils	Sandy clay Silty clay Silty

Table A.1.4. Rating of hydraulic conductivity values (FAO, 1963)

HYDRAULIC CONDUCTIVITY (m/day)	CONDUCTIVITY CLASS
< 0.2	Very slow
0.2 - 0.5	Slow
0.5- 1.4	Moderate
1.4 - 1.9	Moderately rapid
1.5 - 3.0	Rapid
> 3.0	Very rapid

Table A.1.5. Rating of infiltration rates (BAI, 1979)

INFILTRATION RATE (cm/h)	INFILTRATION CATEGORIES
< 0.1	Very slow
0.1- 0.5	Slow
0.5- 2.0	Moderately slow
2.0 - 6.0	Moderate
6.0 - 12.5	Moderately rapid
12.5 – 25.0	Rapid
> 25.0	Very rapid

Table A.1.6. Rating of water holding capacity

AVAILABLE WATER CAPACITY ($mm.m^{-1}$)	**AWA CATEGORIES**
< 120	Low
120 – 180	Medium
> 180	High

Table A.1.7. Rating of organic carbon contents (Metson, 1961)

ORGANIC CARBON CONTENT (%)	RATING
> 20	Very high
10 – 20	High
4 – 10	Medium
2 – 4	Low
< 2	Very low

Table A.1.8. Rating of calcium carbonate contents

CALCIUM CARBONATE CONTENT (%)	RATING
> 40	Very high
30 – 40	High
20 – 30	Moderately high
10 – 20	Medium
< 10	Low

Table A.1.9. Rating of gypsum contents

GYPSUM CONTENT (%)	RATING
> 60	Very high
30 – 60	High
15 – 30	Medium
2 – 15	Low
< 2	Very low

Table A.1.10. Rating of Cation Exchange Capacity

CATION EXCHANGE CAPACITY (cmol(+)/kg)	RATING
> 40	Very high
25 – 40	High
15 – 25	Medium
5 – 15	Low
< 5	Very low

Table A.1.11. Rating of Soil Reaction (pH)

PH	RATING
> 8.5	Very high
7.0 – 8.5	High
5.5 – 7.0	Medium
< 5.5	Low

Table A.1.12. Description of soil depth

EFECTIVE SOIL DEPTH (cm)	DESCRIPTION
> 120	Very deep
80 – 120	Deep
40 – 80	Moderately deep
< 40	Shallow

Table A.1.13. Description of slope (FAO)

SLOPE (%)	DESCRIPTION
< 0.5	Flat
0.5 – 2	Almost flat
2 – 5	Gently ondulating
5 – 10	Undulating
10 – 15	Rolling
15 – 30	Hilling
> 30 (< 3000 meters)	Steeply dissected
> 30 (> 3000 meters)	Mountanious

Table A.1.14. General interpretation of ECe values (FAO-UNESCO, 1976)

ECe (dS/m)	DESIGNATION
< 4	Salt free
4 – 8	Slightly saline
8 – 15	Moderately saline
> 15	Strongly saline

Table A.1.15. General interpretation of SAR values

SAR	DESIGNATION
< 13	No sodic
> 13	Sodic

A.2.1. arenic Fluvisols

Arenic Fluvisols are very deep, moderately well to well drained and coarse textured without rock fragments.

The profile presents fluvic soil materials. The typical sequence of layers in the soil is Ap-B.

These soils are classified as arenic Fluvisols (WRB, 1998); eutric Fluvisols (FAO, 1988) and Typic Ustifluvent (Soil Taxonomy, 1996).

1. Range of characteristics

The Ap horizon is 15 to 25 cm thick. Its colour (wet) is brown (10YR 4/3) to very dark grey (10YR 3/1). The texture is sand to loamy sand. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is very low.

The B horizons present a very weak structure and reach down to more than 150 cm. It has a colour (wet) brown (10YR 4/3) to light yellowish brown (10YR 6/2). The texture is sand to sandy loam. The pH is medium to high and the equivalent calcium carbonate is low.

2. Representative profile

The representative profile is **OKA-815**

Profile: OKA-815
Description date: 15/04/99
Authors: E. Ascaso, J.F. Garcí and G. Carrillo

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1720
Zone: 34K, Clark 1880 Spheroid
Coordinates: Longitude = 21º04'13''
Latitude = 17º57'31''

Landform/Land element: Kalahari region/Omurambas and river valleys
Parent material: Alluvial deposits
Erosion: no evidence

Groundwater table: -

Drainage class: Well drained

Land use and vegetation: Millet and sorghum

Classification (WRB, 1998): arenic Fluvisol

Observations:

Description (FAO Guidelines for Soil Description)

000-018 cm **Ap**
COLOUR: Matrix colour (wet): 10YR 3/2. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Very weak, sub-angular blocky, fine. CONSISTENCE: Soft. SOIL REACTION: Carbonates: Normal. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

018-086 cm **B1**
COLOUR: Matrix colour (wet): 10YR 4/2. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Very weak, sub-angular blocky, medium. CONSISTENCE: Very friable. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear.

086-110 cm **B2**
COLOUR: Matrix colour (wet): 10YR 4/3. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Very weak, sub-angular blocky, medium. CONSISTENCE: Very friable. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal.

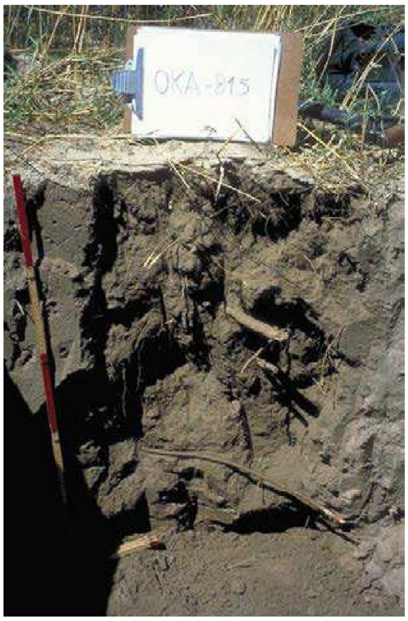


Photo 1: Arenic Fluvisol

A.2.2. arenic-leptic Regosols

Arenic-leptic Regosols are moderately deep, somewhat excessively drained and coarse textured without rock fragments.

The profile has hardly developed. The typical sequence of layers in the soil is A-C(sand)-R.

These soils are classified as arenic-leptic Regosol (WRB, 1998); dystric Regosol (FAO, 1988) and Lithic Ustipsamment (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is dark greyish brown (10YR 4/2) to dark reddish brown (5YR 3/4). The texture is sand. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is very low.

The C horizon is less than 50 cm thick. It has a colour (wet) dark brown (10YR 3/3) to yellowish red (5YR 4/6). The texture is sand. The pH is medium to high and the equivalent calcium carbonate is low.

The R horizon consists of a bedrock of basalt, limestone or quartzite.

2. Representative profile

The representative profile is **OKA-829**

Profile: OKA-829
Description date: 15/04/99
Authors: E. Ascaso, J.F. García and G. Carrillo

<u>Cartography</u>
Scale: 1:50.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1720
UTM Grid Zone: 34K, Clarke 1880 Spheroid
Coordinates: Longitude 21º15'18''E
Latitude 17º58'18''S

Landform/Land element: Kalahari region/Omurambas and river valleys
Parent material: Aeolian sand
Erosion: No evidence

Groundwater table: -

Drainage class: Well drained

Land use and vegetation: Grazing

Classification (WRB, 1998): arenic-leptic Regosol

Observations:

Description (FAO Guidelines for Soil Description)

000-024 cm **A**
COLOUR: Matrix colour (wet): 7.5YR 4/4. MOTTLES: None. TEXTURE: Loamy sand. ROCK FRAGMENTS: None. STRUCTURE: Weak, medium, sub-angular blocky. CONSISTENCE: Soft. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual. DIAGNOSTIC HORIZON: **Ochric**.

024-80/95 cm **Bw**
COLOUR: Matrix colour (wet): 2.5Y 3/6. MOTTLES: None. TEXTURE: Loamy sand. ROCK FRAGMENTS: None. STRUCTURE: Weak, medium, sub-angular blocky. CONSISTENCE: Soft. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal.

80/95-999 Cm **R**

Bedrock of quartzite.

Photo 2: arenic-leptic Regosol

A.2.3. calcic Solonetzs

Calcic Solonetzs are very deep, imperfectly to moderately well drained, and coarse to moderately fine textured without rock fragments.

The profile has developed natric and calcic horizons. The typical sequence of layers in the soil is A-Bwt-Bwck.

These soils are classified as calcic Solonetzs (WRB, 1998), calcic Solonetzs (FAO, 1988) and Typic Natrustalfs (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is about 20 cm thick. Its colour (wet) is black (10YR 2/1) to greyish brown (2.5Y 5/2). The texture is sand to sandy loam. The pH is high, the equivalent calcium carbonate is low and the organic matter content is very low.

The Bwt horizon is 30 to 50 cm thick and presents a moderate to very strong angular blocky or prismatic structure and, most of the times, cutans in the form of shiny faces and/or slickensides. It has a colour (wet) dark grey (10YR 4/1) to light yellowish brown (2.5Y 6/3). The texture is sandy loam to sandy clay loam showing a clear textural differentiation with the overlying horizon. The pH is very high and the equivalent calcium carbonate is low to medium.

The Bwck horizon reaches down more than 100 cm and presents accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon. It has a colour (wet) greyinsh brown (2.5Y 5/2) to pale yellow (5Y 7/4). The texture is sandy loam to sandy clay loam. The pH is high to very high and the calcium carbonate is moderately high to high.

2. Representative profile

The representative profile is **OWA-22**

Profile: OWA-22
Description date: 9/07/99
Authors: E. Ascaso, G. Hangara and J. Kutuahupira,

<u>Cartography</u>
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1714
UTM Grid Zone: 34K, Clarke 1880 Spheroid
Coordinates: Longitude 15º38'02''E

Latitude	17°47’15’’S
Landform/Land element:	Kalahari region/Flooded and over-flooded areas/ moderately dense inflowing stream pattern
Parent material:	Alluvial sand
Erosion:	No evidence
Groundwater table:	-
Drainage class:	Poorly drained
Land use and vegetation:	Extensive grazing
Classification (WRB, 1998):	calcic Solonetz

Observations:

Description (FAO Guidelines for Soil Description)

000-019 cm **A**
COLOUR: Matrix colour (wet): 2.5Y 5/2. MOTTLES: Many, medium, prominent, orange. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Very strong, coarse, columnar. CONSISTENCE: Extremely hard. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Without roots. HORIZON BOUNDARY: Abrupt. DIAGNOSTIC HORIZON: **Ochric**.

019-052 cm **Bwt**
COLOUR: Matrix colour (wet): 2.5Y 6/3. MOTTLES: None. TEXTURE: Sandy clay loam. ROCK FRAGMENTS: None. STRUCTURE: Strong, coarse, prismatic. CONSISTENCE: Friable. CUTANS: Many, faint, shiny faces, on ped faces. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Without roots. DIAGNOSTIC HORIZON: **Natric**.

052-093 cm **Bwck1**

COLOUR: Matrix colour (wet): 2.5Y 8/4. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, coarse, subangular blocky. CONSISTENCE: Friable. CONCENTRATIONS: Common, nodules, coarse, rounded, hard, carbonate. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Without roots. DIAGNOSTIC HORIZON: **Calcic**.

093-140 cm **Bwck2**

COLOUR: Matrix colour (wet): 2.5Y 7/4. MOTTLES: Very few, fine, prominent, orange. TEXTURE: Sandy clay loam. ROCK FRAGMENTS: None. STRUCTURE: Strong, coarse, angular blocky. CONSISTENCE: Slightly sticky, slightly plastic. CONCENTRATIONS: Very few, nodules, coarse, rounded, hard, carbonate. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Without roots. DIAGNOSTIC HORIZON: **Calcic**.

A.2.4. chromic Cambisols

Chromic Cambisols are very deep, coarse to moderately coarse textured and well drained.

The profile has developed a moderate to strong structure. The typical sequence of layers in the soil is A-Bw.

These soils are classified as chromic Cambisols (WRB, 1998), chromic Cambisols (FAO, 1988) and Typic Haplustept (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is about 20 cm thick. Its colour (wet) is very dark greyish brown (10Y 3/2) to dusky red (2.5YR 3/4). The texture is sand to sandy loam. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is very low.

The Bw horizons reach down more than 100 cm and presents a moderate structure. It has a colour brown (7.5YR 4/4) to red (2.5YR 5/8). The texture is loamy sand to sandy clay loam. The pH is medium to high and the equivalent calcium carbonate is low.

2. Representative profile

The representative profile is **TWO-463**

Profile: TWO-463
Description date: 30/02/00
Authors: G. Carrillo and J. Kutuahupira

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 2016
UTM Grid Zone: 34K, Clarke 1880 Spheroid
Coordinates: Longitude 16º27'14''E
Latitude 20º05'38''S

Landform/Land element: Central Plateau/Plateau with ridges in the plateau country/level lowlands
Parent material: Weathered in situ
Erosion: No evidence

Groundwater table: -

Drainage class: Well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): chromic Cambisol

Observations:

Description (FAO Guidelines for Soil Description)

000-018 cm **A**
COLOUR: Matrix colour (wet): 5YR 3/3. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Weak, medium, sub-angular blocky. CONSISTENCE: Friable. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual. DIAGNOSTIC HORIZON: **Ochric**.

018-049 cm **Bw1**
COLOUR: Matrix colour (wet): 5YR 3/4. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, medium, sub-angular blocky. CONSISTENCE: Friable. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal.

049-100 cm **Bw2**
COLOUR: Matrix colour (wet): 5YR 3/6. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Few, fine, sub-rounded, quartz. STRUCTURE: Moderate, medium, sub-angular blocky. CONSISTENCE: Slightly hard. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. DIAGNOSTIC HORIZON: **Cambic**.

A.2.5. chromic Luvisols

Chromic Luvisols are very deep, well drained and moderately coarse to moderately fine textured and without rock fragments.

The profile has developed an argic horizon. The typical sequence of layers in the soil is A-Bw-Bwt.

These soils are classified as haplic Luvisols (WRB, 1998); haplic Luvisols (FAO, 1988) and Typic Rhodustalf (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is very dark greyish brown (10YR 3/2) to yellowish red (5YR 4/6). The texture is loamy sand to sandy clay loam. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is low.

The Bw horizon is around 40 cm thick. It has a colour (wet) brown (7.5YR 4/4) to dark red (2.5YR 4/6). The texture is sandy loam to sandy clay loam. The pH is medium to high and the equivalent calcium carbonate is low.

The Bwt horizon reaches down to more than 100 cm and presents a moderate to strong structure and, most of the times, cutans in the form of shiny faces or slickensides . It has a colour (wet) brown (7.5YR 4/4) to dark red (2.5YR 4/6). The texture is sandy clay loam to sandy clay showing a textural differentiation with the overlying horizon. The pH is medium to high and the equivalent calcium carbonate is low.

2. Representative profile

The representative profile is **TWO-275**

Profile:	TWO-275	
Description date:	26/01/00	
Authors:	G. Carrillo and G. Hangara	

<u>*Cartography*</u>

Scale:	1:250.000	
Projection:	Gauss Conformal Projection (Bessel's Spheroid)	
Sheet number:	1916	
UTM Grid Zone:	34K, Clark 1880 Spheroid	
Coordinates:	Longitude	17º36'41'' E
	Latitude	19º40'37'' S

Landform/Land element:	Central Plateau/Karst on hard Damara limestone/ Mountain valley
Parent material:	Colluvial deposits
Erosion:	no evidence
Groundwater table:	-
Drainage class:	Well drained
Land use and vegetation:	Extensive grazing
Classification (WRB, 1998):	chromic Luvisol

Observations:

Description (FAO Guidelines for Soil Description)

000-024 cm **A**
COLOUR: Matrix colour (wet): 10YR 4/3. MOTTLES: None. TEXTURE: Sandy clay loam. ROCK FRAGMENTS: None. STRUCTURE: Weak, medium, sub-angular blocky. CONSISTENCE: Very friable. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual. DIAGNOSTIC HORIZON: **Ochric**.

024-053 cm **Bw**
COLOUR: Matrix colour (wet): 10YR 3/4. MOTTLES: None. TEXTURE: Clay loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, medium, sub-angular blocky. CONSISTENCE: Very friable. CUTANS: Few, Faint, shiny faces on pedfaces. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Moderately calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual.

053-100 cm **Bwt**
COLOUR: Matrix colour (wet): 7.5YR 4/6. MOTTLES: None. TEXTURE: Clay Loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, fine, sub-angular blocky. CONSISTENCE: Hard. CUTANS: Common, distinct, shiny faces on Pedfaces. CONCENTRATIONS: Few, nodules, fine, rounded, hard iron-manganese. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. DIAGNOSTIC HORIZON: **Argic**

A.2.6. ferralic Arenosols

Ferralic Arenosols are very deep, somewhat excessively drained and coarse textured without rock fragments.

The profile has hardly developed. The typical sequence of layers in the soil is A-C (sand) or Ap-C (sand).

These soils are classified as ferralic Arenosols (WRB, 1998); ferralic Arenosols (FAO, 1988) and Typic Ustipsamments (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is reddish brown (5YR 4/4) to very dark grey (2.5Y 3/1). The texture is sand. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is very low.

The C horizon is more than 100 cm thick. It has a colour (wet) yellowish red (5YR 5/8) to brown (10YR 4/3). The texture is sand. The pH is medium to high and the equivalent calcium carbonate is low.

2. Representative profile

The representative profile is **OKA-810**

Profile: OKA-810
Description date: 15/4/99
Authors: E. Ascaso, J.F. Garcia and G. Carrillo

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1820
UTM Grid Zone: 34K, Clark
Coordinates: Longitude 18º03'32''E
Latitude 20º53'32''S

Landform/Land element: Kalahari region/Fossil sand dunes
Parent material: Aeolian sand
Erosion: No evidence

Groundwater table: -
Drainage class: Somewhat excessively drained

Land use and vegetation: Savanna

Classification (WRB, 1998): ferralic Arenosol

Observations:

Description (FAO Guidelines for Soil Description)

000-025 cm, **A**

COLOUR: Matrix colour (wet): 10YR 4/3. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Very Weak; Very Coarse; Sub-angular Blocky. CONSISTENCE: Soft. SOIL REACTION: Carbonates: Non Calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual. DIAGNOSTIC HORIZON: **Ochric**.

025-100 cm **C (sand)**
COLOUR: Matrix colour (wet): 7.5 YR 5/6. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Very Weak; Very Coarse; Sub-angular Blocky. CONSISTENCE: soft. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non Calcareous. BIOLOGICAL ACTIVITY: Roots: Normal.

A.2.7. ferralic Cambisols

Ferralic Cambisols are very deep, moderately well to well drained and coarse to moderately coarse textured without rock fragments.

The profile has hardly developed. The typical sequence of layers in the soil is A-C-Bw.

These soils are classified as ferralic Cambisols (WRB, 1998), ferralic Cambisols (FAO, 1988) and Typic Ustipsamment (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is about 20 cm thick. Its colour (wet) is very dark brown (2.5Y 3/1) to brown (10YR 5/3). The texture is sand. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is very low.

The C horizon is 40 to 80 cm thick. It has a colour dark grey (5Y 4/1) to yellowish brown (10YR 5/3). The texture is sand. The pH is medium to high and the equivalent calcium carbonate is low.

The Bw horizon reaches down more than 120 cm. It has a colour greyish brown (2.5Y 5/2) to very pale brown (10YR 7/3). The texture is sandy loam. The pH is medium to high and the equivalent calcium carbonate is low. Occasionally presents few accumulations of calcium carbonate as discontinuous concentrations of hard and/or soft nodules.

2. Representative profile

The representative profile is **OWA-131**

Profile:	OWA-131
Description date:	1/08/99
Authors:	J.F. García, E. Ascaso and P. Festus

Cartography

Scale:	1:250.000
Projection:	Gauss Conformal Projection (Bessel's Spheroid)
Sheet number:	1714
UTM Grid Zone:	34K, Clarke 1880 Spheroid
Coordinates:	Longitude 16º00'43''E
	Latitude 17º31'03''S

Landform/Land element:	Kalahari region/Flooded and over-flooded areas/ Very dense inflowing stream pattern
Parent material:	Aeolian sand
Erosion:	No evidence
Groundwater table:	-
Drainage class:	Moderately well drained
Land use and vegetation:	Annual field cropping: Millet
Classification (WRB, 1998):	ferralic Cambisol

Observations:

Description (FAO Guidelines for Soil Description)

000-020 cm **Ap**
COLOUR: Matrix colour (wet): 10YR 4/1. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Very weak, coarse, sub-angular blocky. CONSISTENCE: Soft. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual. DIAGNOSTIC HORIZON: **Ochric**.

020-045 cm **C(sand)**
COLOUR: Matrix colour (wet): 2.5Y 5/1. MOTTLES: None. TEXTURE: Loamy sand. ROCK FRAGMENTS: None. STRUCTURE: Weak, coarse, sub-angular blocky. CONSISTENCE: Slightly hard. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal.

045-090 cm **Bw2**
COLOUR: Matrix colour (wet): 10YR 6/1. MOTTLES: Common, fine, distinct, orange. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, coarse, sub-angular blocky. CONSISTENCE: Firm. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal.

090-120 cm **Bw3**
COLOUR: Matrix colour (wet): 2.5Y 6/2. MOTTLES: Common, fine, distinct, orange and black. TEXTURE: Sandy loamy. ROCK FRAGMENTS: None. STRUCTURE: Moderate, coarse, sub-angular blocky. CONSISTENCE: Firm. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal.

A.2.8. ferralic-lamellic Arenosols

Ferralic-lamellic Arenosols are very deep, somewhat excessively drained and coarse textured without rock fragments.

The profile presents clay illuviation lamellae within 100 cm from the soils surface. The typical sequence of layers in the soil is A-C (sand)-Bw.

These soils are classified as ferralic-lamellic Arenosols (WRB, 1998); luvic Arenosols (FAO, 1988) and Lamellic Ustipsamments (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is reddish brown (5YR 4/4) to very dark grey (2.5Y 3/1). The texture is sand. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is very low.

The C horizon is about 40 cm thick. It has a colour (wet) yellowish red (5YR 5/8) to brown (10YR 4/3). The texture is sand. The pH is medium to high and the equivalent calcium carbonate is low.

The Bw horizon reaches down more than 100 cm and presents clay illuviation lamellae. It has a colour (wet) yellowish red (5YR 5/8) to brown (10YR 4/3). The texture is sand. The pH is medium to high and the equivalent calcium carbonate is low.

2. Representative profile

The representative profile is **TWO-26**

Profile: TWO-26
Description date: 25/08/99
Authors: E. Ascaso and G. Carrillo

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1716
UTM Grid Zone: 34K, Clark
Coordinates: Longitude 17º13'00''E
Latitude 17º33'13''S

Landform/Land element: Kalahari region/Sand deposits/Sand deposits with pans
Parent material: Aeolian sand
Erosion: No evidence

Groundwater table: -

Drainage class: Somewhat excessively drained

Land use and vegetation: Savanna

Classification (WRB, 1998): ferralic-lamellic Arenosol

Observations:

Description (FAO Guidelines for Soil Description)

000-012 cm, **A**

COLOUR: Matrix colour (wet): 7.5YR 4/4. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Very weak, coarse, sub-angular blocky. CONSISTENCE: Soft. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual. DIAGNOSTIC HORIZON: **Ochric**.

012-066 cm **C (sand)**
COLOUR: Matrix colour (wet): 7.5 YR 5/4. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Weak, coarse, sub-angular blocky. CONSISTENCE: Slightly hard. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Diffuse.

066-130 cm **Bw**
COLOUR: Matrix colour (wet): 7.5 YR 5/6. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Weak, coarse, sub-angular blocky. CONSISTENCE: Slightly hard. CUTANS: Few, distinct, clay, lamellae. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal.

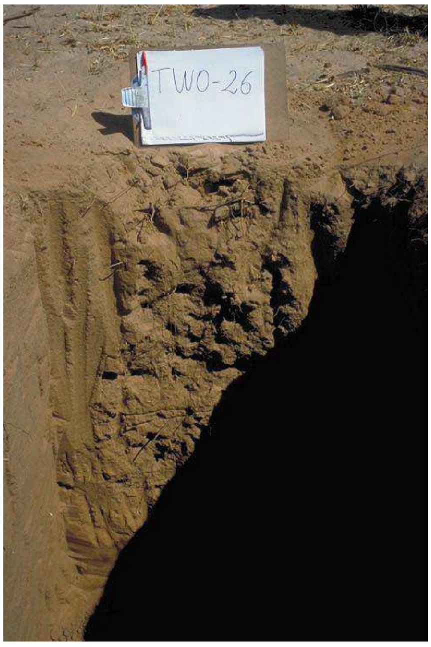


Photo 3: ferralic-lamellic Arenosol

A.2.9. fluvic Cambisols

Fluvic Cambisols are very deep, moderately well to well drained and coarse to moderately coarse to medium textured without rock fragments.

The profile presents fluvic soil materials that have developed a moderate structure. The typical sequence of layers in the soil is A-Bw.

These soils are classified as fluvic Cambisols (WRB, 1998), eutric Cambisols (FAO, 1988) and Fluventic Haplustepts (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is about 20 cm thick. Its colour (wet) is dark greyish brown (10YR 4/2) to yellowish brown (10YR 5/4). The texture is sand to sandy loam. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is very low.

The Bw horizons reach down more than 120 cm and present a moderate structure in spite of its fluviatile origin. It has a colour greyish brown (10YR 5/2) to yellowish red (5YR 4/6). The texture is loamy sand to sandy loam. The pH is medium to high and the equivalent calcium carbonate is low.

2. Representative profile

The representative profile is **TWO-397**

Profile: TWO-397
Description date: 1/02/00
Authors: G. Carrillo and G. Hangara

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 2016
UTM Grid Zone: 34K, Clarke 1880 Spheroid
Coordinates: Longitude 20º35'14''E
Latitude 17º40'02''S

Landform/Land element: Kalahari region/Flooded and over-flooded areas/ Omurambas and river valleys
Parent material: Alluvial sand
Erosion: No evidence

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): fluvic Cambisol

Observations:

Description (FAO Guidelines for Soil Description)

000-012 cm **A**
COLOUR: Matrix colour (wet): 10YR 5/4. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Very weak, medium, sub-angular blocky. CONSISTENCE: Very friable. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

012-052 cm **Bw1**
COLOUR: Matrix colour (wet): 7.5Y 5/4. MOTTLES: None. TEXTURE: Loamy sand. ROCK FRAGMENTS: None. STRUCTURE: Very weak, medium, sub-angular blocky. CONSISTENCE: Very friable. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear.

052-064 cm **Bw2**
COLOUR: Matrix colour (wet): 7.5YR 4/6. MOTTLES: None. TEXTURE: Loamy sand. ROCK FRAGMENTS: None. STRUCTURE: Very weak, medium, sub-angular blocky. CONSISTENCE: Very friable. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear.

064-100 cm **Bw3**
COLOUR: Matrix colour (wet): 7.5Y 5/6. MOTTLES: None. TEXTURE: Sandy loamy. ROCK FRAGMENTS: None. STRUCTURE: Moderate, fine, sub-angular blocky. CONSISTENCE: Hard. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal.

A.2.10. gypsic Solonetzs

Gypsic Solonetzs are very deep, poorly to imperfectly drained, and coarse to moderately fine textured without rock fragments. These soils are slightly to moderately saline and sodic.

The profile has developed natric and gypsic horizons. The typical horizons sequence of layers in the soil is A-Bwt-Bwcy.

These soils are classified as gypsic Solonetzs (WRB, 1998), gypsic Solonetzs (FAO, 1988) and Typic Natrustalfs (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is about 20 cm thick. Its colour (wet) is grey (2.5Y 5/1) to light brownish grey (10YR 6/2). The texture is sand to sandy loam. The pH is high, the equivalent calcium carbonate is low and the organic matter content is very low.

The Bwt horizon is 30 to 50 cm thick and presents a moderate to very strong angular blocky or prismatic structure and, most of the times, cutans in the form of shiny faces and/or slickensides. It has a colour (wet) very dark grey (2.5Y 3/1) to light grey (2.5Y 7/1). The texture is sandy loam to sandy clay loam showing a clear textural differentiation with the overlying horizon. The pH is very high and the equivalent calcium carbonate is low.

The Bwcy reaches down more than 100 cm and presents many accumulations of gypsum as discontinuous concentrations of soft crystals, resulting in a gypsic horizon, and sometimes discontinuous accumulations of calcium carbonate. It has a colour (wet) very dark grey (10YR 3/1) to pale yellow (2.5Y 7/3). The texture is sandy loam to sandy clay loam. The pH is high to very high, the calcium carbonate is low to moderate and the gypsum content is medium to high.

2. Representative profile

The representative profile is **OWA-152**

Profile:	OWA-152
Description date:	1/08/99
Authors:	G. Carrillo and G. Hangara

Cartography

Scale:	1:50.000
Projection:	Gauss Conformal Projection (Bessel's Spheroid)
Sheet number:	1714 CD

UTM Grid Zone: 34K, Clarke 1880 Spheroid
Coordinates: Longitude 15º21'04''E
Latitude 17º47'18''S

Landform/Land element: Kalahari sands plateau/ Oshana system
Parent material: Alluvial sand
Erosion: No evidence

Groundwater table: -
Drainage class: Poorly drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): gypsic Solonetz

Observations:

Description (FAO Guidelines for Soil Description)

000-010 cm **A**
COLOUR: Matrix colour (wet): 10YR 4/2. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Weak, medium sub-angular blocky. CONSISTENCE: Soft. SOIL REACTION: Carbonates: Non Calcareous. BIOLOGICAL ACTIVITY: Roots: Without roots. HORIZON BOUNDARY: Abrupt. DIAGNOSTIC HORIZON: **Ochric**.

010-080 cm **Bwt**
COLOUR: Matrix colour (wet): 10YR 7/1. MOTTLES: None. TEXTURE: Sandy clay loam. ROCK FRAGMENTS: None. STRUCTURE: Strong, medium, columnar. CONSISTENCE: Very hard. CUTANS: Many, distinct, slickensides, on pedfaces. CONCENTRATIONS: None. CEMENTATION: Non Cemented. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Without roots. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Natric**.

080-130 cm **Bwcyk**

COLOUR: Matrix colour (wet): 2.5Y 7/3. MOTTLES: Few, faint, distinct and orange. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Weak, medium, sub-angular blocky. CONSISTENCE: Friable. CONCENTRATIONS: Few, crystals, medium, elongated, soft, gypsum and common, nodules, fine to coarse, rounded, both, carbonate. CEMENTATION: Non Cemented. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Without roots. DIAGNOSTIC HORIZON:
Gypsic.

A.2.11. haplic Calcisols

Haplic Calcisols are very deep, coarse to moderately fine textured and moderately well to well drained.

The profile has developed a calcic horizon. The typical sequence of layers in the soil is A-Bw-Bwck.

These soils are classified as haplic Calcisol (WRB, 1998); haplic Calcisols (FAO, 1988) and Typic Calciustept (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is very dark grey (10YR 3/1) to olive brown (2.5Y 4/4). The texture is loamy sand to sandy clay loam. The pH is high, the equivalent calcium carbonate is low to medium and the organic matter content is very low.

The Bw horizon is about 50 cm thick. It has a colour (wet) dark grey (10YR 4/1) to light brownish grey (2.5Y 6/2). The texture is loamy sand to sandy clay loam. The pH is high and the equivalent calcium carbonate is medium to moderately high.

The Bwck horizon reaches down more than 100 cm and presents accumulations of calcium carbonate as discontinuous concentrations of hard or soft nodules, resulting in a calcic horizon. It has a colour (wet) dark grey (10YR 4/1) to light yellowish brown (2.5Y 6/3). The texture is loamy sand to sandy clay loam. The pH is high and the equivalent calcium carbonate is moderately high to high.

2. Representative profile

The representative profile on areas with soil materials of coarse texture is **TWO-92**

Profile:	TWO-92	
Description date:	9/11/99	
Authors:	G. Carrillo and G. Hangara	

Cartography

Scale:	1:250.000	
Projection:	Gauss Conformal Projection (Bessel's Spheroid)	
Sheet number:	1918	
UTM Grid Zone:	34K, Clark 1880 Spheroid	
Coordinates:	Longitude	18°31'14'' E
	Latitude	19°38'14'' S

Landform/Land element:	Kavango region/Flooded and over-flooded areas/ Omurambas and river banks
Parent material:	Alluvial deposits
Erosion:	No evidence
Groundwater table:	-
Drainage class:	Well drained
Land use and vegetation:	Extensive grazing
Classification (WRB, 1998):	haplic Calcisol

Observations:

Description (FAO Guidelines for Soil Description)

000-018 cm **A**
COLOUR: Matrix colour (wet): 10YR 3/1. MOTTLES: None. TEXTURE: Loamy sand. ROCK FRAGMENTS: None. STRUCTURE: Weak, medium, sub-angular blocky. CONSISTENCE: Soft. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

018-056 cm **Bw**
COLOUR: Matrix colour (wet): 10YR 4/2. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Weak, medium sub-angular blocky. CONSISTENCE: Hard. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear.

056-100 cm **Bwck1**
COLOUR: Matrix colour (wet): 10YR 5/2. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, coarse, sub-angular blocky. CONSISTENCE: Very hard. CONCENTRATIONS: Very few, nodules, very fine, irregular, soft, calcium carbonate. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual.

100-110 cm **Bwck2**
COLOUR: Matrix colour (wet): 10YR 7/1. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, medium, sub-angular blocky. CONSISTENCE: Hard. CONCENTRATIONS: Common, nodules, fedium, rounded, soft, calcium carbonate. SOIL REACTION: Carbonates: Extremely calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. DIAGNOSTIC HORIZON: **Calcic**.

The representative profile on areas with soil materials of medium texture is **NAM-73**

Profile:	NAM-73
Description date:	31/03/2000

Authors: E. Ascaso and and G. Hangara

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 2014
UTM Grid Zone: 34K, Clark 1880 Spheroid
Coordinates: Longitude 15º53'33'' E
Latitude 20º16'31'' S

Landform/Land element: Central plateaux/Plateaux with karst on hard Damara limestone/River terraces
Parent material: Alluvial deposits
Erosion: No evidence

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): haplic Calcisol

Observations:

Description (FAO Guidelines for Soil Description)

000-023 cm **A**
COLOUR: Matrix colour (wet): 10YR 4/4. MOTTLES: None. TEXTURE: Silty loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, medium, sub-angular blocky. CONSISTENCE: Friable. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual. DIAGNOSTIC HORIZON: **Ochric**.

023-052 cm **Bwck1**
COLOUR: Matrix colour (wet): 10YR 4/4. MOTTLES: None. TEXTURE: Silty loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, medium sub-angular blocky. CONSISTENCE: Friable. CONCENTRATIONS: Very few, nodules, fine, rounded, soft, calcium carbonate. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Diffuse. DIAGNOSTIC HORIZON: **Cambic**.

052-110 cm **Bwck2**
COLOUR: Matrix colour (wet): 10YR 5/4. MOTTLES: None. TEXTURE: Silty loam. ROCK FRAGMENTS: None. STRUCTURE: Strong, medium, sub-angular blocky. CONSISTENCE: Slightly hard. CONCENTRATIONS: Few, nodules, fine, rounded,

soft, calcium carbonate. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. DIAGNOSTIC HORIZON: **Calcic**.

A.2.12. haplic Cambisols

Haplic Cambisols are very deep, coarse to moderately coarse textured and well drained.

The profile has developed a moderate to strong structure. The typical sequence of layers in the soil is A-Bw.

These soils are classified as haplic Cambisols (WRB, 1998), eutric Cambisols (FAO, 1988) and Typic Haplustept (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is about 20 cm thick. Its colour (wet) is very dark brown (7.5Y 3/2) to olive brown (2.5YR 4/4). The texture is sand to sandy loam. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is very low.

The Bw horizon reaches down more than 100 cm and presents a moderate structure. It has a colour dark brown (7.5YR 3/3) to dark greyish brown (2.5YR 4/3). The texture is loamy sand to sandy clay loam. The pH is medium to high and the equivalent calcium carbonate is low.

2. Representative profile

The representative profile is **NAM-162**

Profile: NAM-162
Description date: 03/04/00
Authors: E. Ascaso and P. Festus

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 2116
UTM Grid Zone: 34K, Clarke 1880 Spheroid
Coordinates: Longitude 16º32'02''E
Latitude 21º28'27''S

Landform/Land element: Lowlands in the Central plateaux/nearly level lowlands
Parent material: Weathered in situ
Erosion: No evidence

Groundwater table: -

Drainage class: Well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): haplic Cambisol

Observations:

Description (FAO Guidelines for Soil Description)

000-025 cm **A**
COLOUR: Matrix colour (wet): 10YR 4/4. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, coarse, sub-angular blocky. CONSISTENCE: Friable. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual. DIAGNOSTIC HORIZON: **Ochric**.

025-100 cm **Bw**
COLOUR: Matrix colour (wet): 10YR 4/3. MOTTLES: None. TEXTURE: Loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, medium, sub-angular blocky. CONSISTENCE: Friable. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. DIAGNOSTIC HORIZON: **Cambic**.

A.2.13. haplic Fluvisols

Haplic Fluvisols are very deep, moderately well to well drained and moderately coarse textured without rock fragments.

The profile presents fluvic soil materials. The typical sequence of layers in the soil is A-B.

These soils are classified as haplic Fluvisols (WRB, 1998); eutric Fluvisols (FAO, 1988) and Typic Ustifluvent (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is brown (10YR 4/3) to very dark grey (2.5Y 3/1). The texture is sandy loam to loam. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is very low.

The B horizons present a weak to very weak structure and reach down to more than 150 cm. It has a colour (wet) pale yellow (2.5Y 7/4) to very dark grey (10YR 3/1). The texture is sandy loam to loam. The pH is medium to high and the equivalent calcium carbonate is low.

2. Representative profile

The representative profile is **OKA-826**

Profile: OKA-826
Description date: 15/04/99
Authors: E. Ascaso, J.F. García and G. Carrillo

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1820
UTM Grid Zone: 34K, Clark 1880 Spheroid
Coordinates: Longitude 18º01'01''
Latitude 21º21'22''

Landform/Land element: Kalahari region/Flooded and over-flooded areas/ Omurambas and river valleys
Parent material: Alluvial deposits
Erosion: no evidence

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: -

Classification (WRB, 1998): haplic Fluvisol

Observations:

Description (FAO Guidelines for Soil Description)

000-023 cm **A**
COLOUR: Matrix colour (wet): 7.5YR 3/3. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Weak; coarse, sub-angular blocky. CONSISTENCE: Slightly hard. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

023-040 cm **B1**
COLOUR: Matrix colour (wet): 7.5YR 3/4. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Weak, coarse, sub-angular blocky. CONSISTENCE: Slightly hard. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual.

040-064 cm **B2**
COLOUR: Matrix colour (wet): 7.5YR 4/2. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Weak, medium, sub-angular blocky. CONSISTENCE: Soft. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear.

064-105 cm **B3**
COLOUR: Matrix colour (wet): 5YR 4/4. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Weak, medium, sub-angular blocky. CONSISTENCE: Soft. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual.

105-125 cm **B4**
COLOUR: Matrix colour (wet): 5YR 4/4. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, medium, sub-angular blocky. CONSISTENCE: Hard. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal.

A.2.14. haplic Gypsisols

Haplic Gypsisols are very deep, well drained and coarse to moderately coarse textured with common to many coarse fragments.

The profile has developed a gypsic horizon. The typical sequence of layers in the soil is A-Bwcy.

These soils are classified as haplic Gypsisols (WRB, 1998); haplic Gypsisols (FAO, 1988) and Typic Haplogypsids (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is very dark brown (7.5YR 3/3) to yellowish red (5YR 4/8). The texture is loamy sand to sandy loam with common to many coarse fragments of quartz. The pH is medium to high, the equivalent calcium carbonate is low to medium and the organic matter content is very low.

The Bwcy horizons reach down more than 120 cm and presents accumulations of crystals of gypsum. It has a colour (wet) brown (7.5YR 4/4) to yellowish red (5YR 4/8). The texture is loamy sand to sandy loam with common to many coarse fragments of quartz. The pH is medium to high and the equivalent calcium carbonate is medium to moderately high.

2. Representative profile

The representative profile is **NAM-219**

Profile: NAM-219
Description date: 4/04/2000
Authors: E. Ascaso and G. Hangara

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 2214
UTM Grid Zone: 34K, Clark 1880 Spheroid
Coordinates: Longitude 14º23'19'' E
Latitude 22º04'13'' S

Landform/Land element: Namib desert pavements/gravel pavements
Parent material: Colluvial deposits
Erosion: Aeolian erosion and sedimentation

Groundwater table: -

Drainage class: Well drained

Land use and vegetation: -

Classification (WRB, 1998): haplic Gypsisol

Observations:

Description (FAO Guidelines for Soil Description)

000-019 cm **A**
COLOUR: Matrix colour (wet): MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: Few, medium gravel, rounded, quartz. STRUCTURE: Weak, medium, sub-angular blocky. CONSISTENCE: Very friable. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual. DIAGNOSTIC HORIZON: **Ochric**.

019-072 cm **Bwcy1**

COLOUR: Matrix colour (wet): MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: Common, fine gravel, rounded, polygenic. STRUCTURE: Very weak, fine, sub-angular blocky. CONSISTENCE: Friable. CONCENTRATIONS: Common, crystals, very fine, irregular, soft, gypsum. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual.

056-100 cm **Bwcy2**
COLOUR: Matrix colour (wet): MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: Common, stones, rounded, polygenic. STRUCTURE: Very weak, fine, sub-angular blocky. CONSISTENCE: Friable. CONCENTRATIONS: Few, crystals, very fine, irregular, soft, gypsum. SOIL REACTION: Carbonates: Moderately calcareous. BIOLOGICAL ACTIVITY: Roots: Normal.

A.2.15. haplic Leptosols

Haplic Leptosols are very shallow, well drained and coarse to moderately coarse textured with common to many rock fragments.

The typical sequence of layers in the soil is A-R.

These soils are classified as haplic Leptosols (WRB, 1998); eutric Leptosols (FAO, 1988) and Lithic Ustorthent (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is dark greyish brown (10YR 4/2) to dark reddish brown (5YR 3/4). The texture is loamy sand to loam. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is very low.

Below we find the R horizon that consists of a bedrock of limestone, quartzite, schist, shale, gneiss, granite, etc.

2. Representative profiles

The representative profile on limestone is **TWO-101**

Profile: TWO-101
Description date: 10/11/99
Authors: G. Carrillo and G. Hangara

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1916
UTM Grid Zone: 34K, Clarke 1880 Spheroid
Coordinates: Longitude 17º49'23''E
Latitude 19º52'34''S

Landform/Land element: Central Plateau/Karst on hard Damara limestone/ Level lowlands
Parent material: Weathered in situ
Erosion: No evidence

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): haplic Leptosol

Observations:

Description (FAO Guidelines for Soil Description)

000-020 cm **A**
COLOUR: Matrix colour (wet): 7.5YR 4/4. MOTTLES: None. TEXTURE: Loamy Sand. ROCK FRAGMENTS: None. STRUCTURE: Weak, coarse, sub-angular blocky. CONSISTENCE: Soft. SOIL REACTION: Carbonates: Non Calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact. HORIZON BOUNDARY: Abrupt. DIAGNOSTIC HORIZON: **Ochric**.

020-999 cm **R**

Bedrock of limestone.

The representative profile on gneiss is **NAM-479**

Profile: NAM-479
Description date: 9/06/2000
Authors: J.F. García and G. Hangara

<u>Cartography</u>
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1916
UTM Grid Zone: 34K, Clarke 1880 Spheroid
Coordinates: Longitude 13º14'07''E
Latitude 17º50'24''S

Landform/Land element: Central Plateau/Kaokoland/plain pediments
Parent material: Weathered in situ
Erosion: No evidence

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): haplic Leptosol

Observations:

Description (FAO Guidelines for Soil Description)

000-019 cm **A**
COLOUR: Matrix colour (wet): 7.5YR 4/4. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Abundant, fine, sub-rounded, quartz. STRUCTURE: Weak, fine, sub-angular blocky. CONSISTENCE: Slightly hard. SOIL REACTION: Carbonates: Non Calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact. HORIZON BOUNDARY: Abrupt. DIAGNOSTIC HORIZON: **Ochric**.

020-999 cm **R**

Bedrock of gneiss.

The representative profile on granite is **NAM-536**

Profile:	NAM-536
Description date:	20/06/2000
Authors:	G. Carrillo, P. Festus and P. Oller

Cartography

Scale:	1:250.000	
Projection:	Gauss Conformal Projection (Bessel's Spheroid)	
Sheet number:	1916	
UTM Grid Zone:	34K, Clarke 1880 Spheroid	
Coordinates:	Longitude	14º56'39''E
	Latitude	23º01'54''S

Landform/Land element:	Namib/Namib pavements/ gravel pavements
Parent material:	Weathered in situ
Erosion:	No evidence
Groundwater table:	**-**
Drainage class:	Well drained
Land use and vegetation:	Extensive grazing
Classification (WRB, 1998):	haplic Leptosol

Observations:

Description (FAO Guidelines for Soil Description)

000-012 cm **A**
COLOUR: Matrix colour (wet): 10YR 4/4. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: Common, fine gravel, sub-rounded, quartz. STRUCTURE: Very weak, medium, sub-angular blocky. CONSISTENCE: Soft. SOIL REACTION: Carbonates: Moderately Calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact. HORIZON BOUNDARY: Abrupt. DIAGNOSTIC HORIZON: **Ochric**.

020-999 cm **R**

Bedrock of granite.

The representative profile on quartzite is **NAM-663**

Profile:	NAM-663
Description date:	13/07/2000
Authors:	H. Mouton and E. Ascaso

Cartography

Scale:	1:250.000	
Projection:	Gauss Conformal Projection (Bessel's Spheroid)	
Sheet number:	2416	
UTM Grid Zone:	34K, Clarke 1880 Spheroid	
Coordinates:	Longitude	16°54'08''E
	Latitude	24°30'47''S

Landform/Land element:	Central Plateau/Plateaux/Plateaux
Parent material:	Weathered in situ
Erosion:	No evidence
Groundwater table:	**-**
Drainage class:	Well drained
Land use and vegetation:	Extensive grazing
Classification (WRB, 1998):	haplic Leptosol

Observations:

Description (FAO Guidelines for Soil Description)

000-014 cm **A**
COLOUR: Matrix colour (wet): 5YR 3/4. MOTTLES: None. TEXTURE: Clay loam. ROCK FRAGMENTS: Few to common, coarse gravel, angular, quartzite. STRUCTURE: Moderate, medium, sub-angular blocky. CONSISTENCE: Slightly hard. SOIL REACTION: Carbonates: Non Calcareous. BIOLOGICAL ACTIVITY: Roots:

Limited by lithic contact. HORIZON BOUNDARY: Abrupt. DIAGNOSTIC HORIZON: **Ochric**.

020-999 cm **R**

Bedrock of quartzite.

The representative profile on schist is **NAM-915**

Profile:	NAM-915
Description date:	11/08/2000
Authors:	H. Mouton and E. Ascaso

Cartography

Scale:	1:250.000	
Projection:	Gauss Conformal Projection (Bessel's Spheroid)	
Sheet number:	2316	
UTM Grid Zone:	34K, Clarke 1880 Spheroid	
Coordinates:	Longitude	16º33'59''E
	Latitude	23º29'38''S

Landform/Land element:	Central Plateaux/Highlands in the central plateaux/Undulating highlands
Parent material:	Weathered in situ
Erosion:	No evidence
Groundwater table:	-
Drainage class:	Well drained
Land use and vegetation:	Extensive grazing
Classification (WRB, 1998):	haplic Leptosol

Observations:

Description (FAO Guidelines for Soil Description)

000-012 cm **A**
COLOUR: Matrix colour (wet): 7.5YR 3/2. MOTTLES: None. TEXTURE: Loamy Sand. ROCK FRAGMENTS: Abundant, medium gravel, platy, schist. STRUCTURE: Without structure. CONSISTENCE: Looset. SOIL REACTION: Carbonates: Slightly Calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact. HORIZON BOUNDARY: Abrupt. DIAGNOSTIC HORIZON: **Ochric**.

020-999 cm **R**

Bedrock of schist.

The representative profile on shale is **NAM-968**

Profile:	NAM-968
Description date:	8/09/2000
Authors:	J.F. García and G. Hangara

<u>Cartography</u>

Scale:	1:250.000	
Projection:	Gauss Conformal Projection (Bessel's Spheroid)	
Sheet number:	2316	
UTM Grid Zone:	34K, Clarke 1880 Spheroid	
Coordinates:	Longitude	16º17'55''E
	Latitude	23º14'50''S

Landform/Land element:	Central Plateau/Highlands in the Central plateaux/gently undulating highlands
Parent material:	Weathered in situ
Erosion:	No evidence
Groundwater table:	-
Drainage class:	Well drained
Land use and vegetation:	Extensive grazing
Classification (WRB, 1998):	haplic Leptosol

Observations:

Description (FAO Guidelines for Soil Description)

000-020 cm **A**
COLOUR: Matrix colour (wet): 7.5YR 2.5/2. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: Many, stones, rounded, quartzite. STRUCTURE: Without structure. CONSISTENCE: Loose. SOIL REACTION: Carbonates: Slightly Calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact. HORIZON BOUNDARY: Abrupt. DIAGNOSTIC HORIZON: **Ochric**.

020-999 cm **R**

Bedrock of shale.

A.2.16. haplic Luvisols

Haplic Luvisols are very deep, imperfectly to moderately well drained and moderately coarse to moderately fine textured without rock fragments.

The profile has developed an argic horizon. The typical sequence of layers in the soils is A-Bw-Bwt.

These soils are classified as haplic Luvisols (WRB, 1998); haplic Luvisols (FAO, 1988) and Typic Haplustalf (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is brown (10YR 4/3) to very dark grey (10YR 3/1). The texture is sand to loamy sand. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is low.

The Bw horizon is around 40 cm thick. It has a colour (wet) yellowish brown (10YR 5/4) to dark brown (10YR 3/3). The texture is sandy loam to loam. The pH is medium to high and the equivalent calcium carbonate is low.

The Bwt horizon reaches down to more than 100 cm and presents a moderate to strong structure and, most of the times, cutans in the form of shiny faces or slickensides . It has a colour (wet) yellowish brown (10YR 5/4) to dark brown (10YR 3/3). The texture is sandy loam to sandy clay loam showing a textural differentiation with the overlying horizon. The pH is medium to high and the equivalent calcium carbonate is low.

2. Representative profile

The representative profile is **OKA-876**

Profile:	OKA-876
Description date:	01/10/99
Authors:	E. Ascaso, J.F. Garcia and G. Carrillo

Cartography

Scale:	1:250.000	
Projection:	Gauss Conformal Projection (Bessel's Spheroid)	
Sheet number:	1820	
UTM Grid Zone:	34K, Clark 1880 Spheroid	
Coordinates:	Longitude	21º22'27'' E
	Latitude	18º03'15'' S

Landform/Land element:	Kalahari region/Flooded and over-flooded area/ Omurambas and river valleys
Parent material:	Alluvial deposits
Erosion:	no evidence
Groundwater table:	-
Drainage class:	Imperfectly well drained
Land use and vegetation:	Extensive grazing
Classification (WRB, 1998):	haplic Luvisol

Observations:

Description (FAO Guidelines for Soil Description)

000-020 cm **A**
COLOUR: Matrix colour (wet): 10YR 3/2. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Moderate, coarse, sub-angular blocky. CONSISTENCE: Slightly hard. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual. DIAGNOSTIC HORIZON: **Ochric**.

020-060 cm **Bw**
COLOUR: Matrix colour (wet): 10YR 4/2. MOTTLES: Common, medium, distinct, orange. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Strong, very coarse, prismatic. CONSISTENCE: Extremely firm. CUTANS: Common, faint, clay, pedfaces. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual.

060-110 cm **Bwt**
COLOUR: Matrix colour (wet): 10YR 5/2. MOTTLES: Many, medium, prominent, orange. TEXTURE: Sandy clay loam. ROCK FRAGMENTS: None. STRUCTURE: Strong, very coarse, prismatic. CONSISTENCE: Extremely firm. CUTANS: Many, distinct, shiny faces, pedfaces. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. DIAGNOSTIC HORIZON: **Argic**

A.2.17. haplic Regosols

Haplic Regosols are very deep, well drained and coarse to moderately coarse textured with few to many rock fragments.

The profile has hardly developed. The typical sequence of layers in the soil is A-Bw.

These soils are classified as haplic Regosols (WRB, 1998), eutric Regosols (FAO, 1988) and Typic Ustorthent (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is about 20 cm thick. Its colour (wet) is very dark brown (7.5YR 3/3) to yellowish red (5YR 4/8). The texture is sand to sandy loam with few to many coarse fragments of quartz. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is very low.

The Bw horizons reach down more than 120 cm. It has a colour brown (7.5Y 4/4) to yellowish red (2.5YR 4/6). The texture is loamy sand to sandy loam with few to many coarse fragments of quartz. The pH is medium to high and the equivalent calcium carbonate is low.

2. Representative profile

The representative profile is **NAM-674**

Profile: NAM-674
Description date: 14/07/00
Authors: H. Mouton and E. Ascaso

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 2416
UTM Grid Zone: 34K, Clarke 1880 Spheroid
Coordinates: Longitude 16º12'57''E
Latitude 24º53'49''S

Landform/Land element: Namib/Namib desert pavements/ gravel pavements
Parent material: Colluvial + aeolian sand
Erosion: Aeolian erosion and sedimentation

Groundwater table: -

Drainage class: Well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): haplic Regosol

Observations:

Description (FAO Guidelines for Soil Description)

000-013 cm **A**
COLOUR: Matrix colour (wet): 5YR 3/4. MOTTLES: None. TEXTURE: Loamy sand. ROCK FRAGMENTS: Common to many, fine to medium gravel, rounded, quartz. STRUCTURE: Weak, medium, sub-angular blocky. CONSISTENCE: Soft. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual. DIAGNOSTIC HORIZON: **Ochric**.

013-060 cm **Bw1**
COLOUR: Matrix colour (wet): 5YR 3/6. MOTTLES: None. TEXTURE: Loamy sand. ROCK FRAGMENTS: Common to many, fine to medium gravel, rounded, quartz . STRUCTURE: Weak, medium, sub-angular blocky. CONSISTENCE: Slightly hard. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual.

060-120 cm **Bw2**
COLOUR: Matrix colour (wet): 5YR 3/4. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Common to many, fine to medium gravel, rounded, quarts. STRUCTURE: Weak, medium, sub-angular blocky. CONSISTENCE: Slightly hard. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal.

A.2.18. hypercalcic Calcisols

Hypercalcic Calcisols are very deep, coarse to moderately fine textured and moderately well to well drained.

The profile has developed a hypercalcic horizon. The typical horizons sequence is A-Bwck.

These soils are classified as hypercalcic Calcisol (WRB, 1998); haplic Calcisols (FAO, 1988) and Typic Calciustept (Soil Taxonomy, 1996).

1. *Range of characteristics*

The A horizon is 15 to 25 cm thick. Its colour (wet) is black (10YR 2/1) to brown (10YR 4/3). The texture is loamy sand to sandy clay loam. The pH is high, the equivalent calcium carbonate is low to medium and the organic matter content is very low.

The Bwck horizons reach down more than 100 cm and presents abundant accumulations of calcium carbonate as continuous concentrations that make disappear most of the soil structure, resulting in a hypercalcic horizon. It has a colour (wet) grey (2.5Y 5/1) to very pale brown (10YR 7/3). The texture is sandy loam to clay loam. The pH is high and the equivalent calcium carbonate is very high.

2. *Representative profile*

The representative profile is **TWO-149**

Profile: TWO-149
Description date: 25/11/99
Authors: G. Carrillo and G. Hangara

<u>Cartography</u>
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1916
UTM Grid Zone: 34K, Clark 1880 Spheroid
Coordinates: Longitude 17°57'02'' E
Latitude 19°37'30'' S

Landform/Land element: Central Plateau/Karst on hard Damara limestone/ Mountain valley
Parent material: Alluvial deposits
Erosion: No evidence

Groundwater table: -

Drainage class: Well drained

Land use and vegetation: Annual field cropping: Maize

Classification (WRB, 1998): hypercalcic Calcisol

Observations:

Description (FAO Guidelines for Soil Description)

000-025 cm **Ap**
COLOUR: Matrix colour (wet): 10YR 4/1. MOTTLES: None. TEXTURE: Sandy clay loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, medium, sub-angular blocky. CONSISTENCE: Hard. SOIL REACTION: Carbonates: Extremely calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

025-074 cm **Bwck1**

COLOUR: Matrix colour (wet): 2.5Y 7/2. MOTTLES: None. TEXTURE: Sandy clay loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, medium sub-angular blocky. CONSISTENCE: Very friable. CONCENTRATIONS: Abundant, concentrations, soft, calcium carbonate. SOIL REACTION: Carbonates: Extremely calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Abrupt.

074-120 cm **Bwck2**
COLOUR: Matrix colour (wet): 2.5Y 8/2. MOTTLES: None. TEXTURE: Silty loam. ROCK FRAGMENTS: None. STRUCTURE: Very weak, fine, sub-angular blocky. CONSISTENCE: Friable. CONCENTRATIONS: Dominant, concentrations, soft, calcium carbonate. SOIL REACTION: Carbonates: Extremely calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual. DIAGNOSTIC HORIZON: **Hypercalcic**.

A.2.19. hyposalic Arenosols

Hyposalic Arenosols are very deep, imperfectly to moderately well drained and coarse textured without rock fragments. These soils are slight to moderately saline and sodic.

The typical sequence of layers in the soil is A-Bw1-Bw2 or A-E-Bw1-Bw2.

These soils are classified as hyposalic Arenosol (WRB, 1998), cambic Arenosols (FAO, 1988), Typic Halaquept (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is dark grey (10YR 4/1) to pale brown (10YR 6/3). The texture is sand to loamy sand. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is very low.

The E horizon, that appears occasionally, is 2 to 10 cm thick. Its colour (wet) is greyish brown (10YR 5/2) to light grey (2.5 Y 7/2). The texture is sand.

The Bw1 horizon is 20 to 40 cm thick. It presents a massive or very coarse columnar structure and an extremely hard consistence when dry, probably associated with temporally floodings during the rainy season and the presence of sodium as dominating cation in the soil. The texture is sand to loamy sand. It has a colour (wet) greyish brown (10 YR 5/2) to light grey (10YR 7/2). The pH is high to very high and the equivalent calcium carbonate is low.

The Bw2 reaches down more than 120 cm. It has a colour (wet) greyish brown (10YR 5/2) to very pale brown (10YR 7/4). The texture is sand to loamy sand. The pH is high to very high and the equivalent calcium carbonate is low.

2. Representative profile

The representative profile is **OWA-27**

Profile:	OWA-27
Description date:	89/07/99
Authors:	E. Ascaso, H. Mouton and G. Hangara

Cartography

Scale:	1:250.000
Projection:	Gauss Conformal Projection (Bessel's Spheroid)
Sheet number:	1714
UTM Grid Zone:	34K, Clarke 1880 Spheroid

Coordinates:	Longitude	15°28'40''E
	Latitude	17°47'30''S

Landform/Land element: Kalahari region/Flooded and over-flooded areas/ Flat plains with pans
Parent material: Alluvial sand
Erosion: No evidence

Groundwater table: -
Drainage class: Moderately well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): hyposalic Arenosol

Observations:

Description (FAO Guidelines for Soil Description)

000-008 cm **A**
COLOUR: Matrix colour (wet): 2.5Y 6/2. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Loose. CONSISTENCE: Loose. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Abrupt. DIAGNOSTIC HORIZON: **Ochric**.

008-027 cm **Bw1**
COLOUR: Matrix colour (wet): 2.5Y 5/2. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Weak, very coarse, columnar. CONSISTENCE: Very hard. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear.

027-062 cm **Bw2**
COLOUR: Matrix colour (wet): 2.5Y 6/3. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Very weak, coarse, sub-angular blocky. CONSISTENCE: Friable. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual.

062-079 cm **Bw3**
COLOUR: Matrix colour (wet): 2.5Y 6/4. MOTTLES: Few, fine, distinct and orange. TEXTURE: Loamy sand. ROCK FRAGMENTS: None. STRUCTURE: Very weak, coarse, sub-angular blocky. CONSISTENCE: Friable. CONCENTRATIONS: Few, nodules, fine rounded, both, iron-manganese. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual.

079-120 cm **Bw4**
COLOUR: Matrix colour (wet): 2.5Y 6/4. MOTTLES: Many, common, prominent and orange. TEXTURE: Loamy sand. ROCK FRAGMENTS: None. STRUCTURE: Weak, coarse, sub-angular blocky. CONSISTENCE: Friable. CONCENTRATIONS: Common, nodules, medium, rounded, both, iron-manganese. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal.

A.2.20. leptic Calcisols

Leptic Calcisols are shallow, well drained and moderately coarse textured with common to many rock fragments.

The profile has developed a calcic horizon. The typical sequence of layers in the soil is A-Rck.

These soils are classified as leptic Calcisols (WRB, 1998); haplic Calcisols (FAO, 1988) and Lithic Calciustept (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is dark reddish brown (5YR 3/4) to brown (7.5YR 4/4). The texture is sand to loamy sand. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is very low.

Below we find the R horizon that consists of narrow layers of quartzite that present hard and continuous concentrations of calcium carbonate in between.

2. Representative profile

The representative profile is **NAM-585**

Profile:	NAM-585
Description date:	17/07/2000
Authors:	H. Mouton and E. Ascaso

<u>Cartography</u>

Scale:	1:250.000	
Projection:	Gauss Conformal Projection (Bessel's Spheroid)	
Sheet number:	2416	
UTM Grid Zone:	34K, Clarke 1880 Spheroid	
Coordinates:	Longitude	17.8099 E
	Latitude	24.2857 S

Landform/Land element:	Central Plateau/Erosion form on Karoo rocks/ Rolling hills
Parent material:	Weathered in situ
Erosion:	No evidence

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): leptic Calcisol

Observations:

Description (FAO Guidelines for Soil Description)

000-014 cm **A**
COLOUR: Matrix colour (wet): 7.5YR 3/3. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Many, stones, irregular, quartzite. STRUCTURE: Weak, fine, sub-angular blocky. CONSISTENCE: Very friable. SOIL REACTION: Carbonates: Extremely Calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

014-999 cm **Rck**

Thin layers of quartzite with bands of geopetal cement of calcium carbonate in between.

A.2.21. leptic Regosols

Leptic Regosols are shallow to moderately deep, well drained and coarse to moderately coarse textured with few rock fragments.

The profile has hardly developed. The typical sequence of layers in the soil is A-Bw-R.

These soils are classified as leptic Regosols (WRB, 1998); eutric Regosols (FAO, 1988) and Lithic Ustorthents (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is dark greyish brown (10YR 4/2) to dark reddish brown (5YR 3/4). The texture is sand to sandy loam. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is very low.

The Bw horizon is 20 to 40 cm thick. It has a colour very dark greyish brown (10YR 3/2) to dark red (2.5YR 4/6). The texture is loamy sand to sandy loam. The pH is medium to high and the equivalent calcium carbonate is low.

Below we find the R horizon that consists of a bedrock of limestone, quartzite, shale, schist, gneiss, granite, etc.

2. Representative profile

The representative profile on limestone is **TWO-474**

Profile: TWO-474
Description date: 31/06/00
Authors: G. Carrillo and J. Kutuahupira

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1916
UTM Grid Zone: 34K, Clarke 1880 Spheroid
Coordinates: Longitude 16º26'07''E
Latitude 19º56'51''S

Landform/Land element:	Central Plateau/Karst on hard Damara limestone/ Gently undulating lowlands
Parent material:	Weathered in situ
Erosion:	No evidence
Groundwater table:	-
Drainage class:	Well drained
Land use and vegetation:	Extensive grazing
Classification (WRB, 1998):	leptic Regosol

Observations:

Description (FAO Guidelines for Soil Description)

000-019 cm **A**
COLOUR: Matrix colour (wet): 7.5YR 3/3. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Very few, medium gravel, sub-rounded, limestone. STRUCTURE: Weak, medium, sub-angular blocky. CONSISTENCE: Very friable. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual. DIAGNOSTIC HORIZON: **Ochric**.

019-045 cm **Bw**
COLOUR: Matrix colour (wet): 7.5YR 4/4. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Very few, medium gravel, sub-rounded, limestone STRUCTURE: Weak, medium, sub-angular blocky. CONSISTENCE: Very friable. ACCUMULATION: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact.

045-999 cm **R**

Bedrock of limestone.

The representative profile on quartzite is **NAM-31**

Profile: NAM-31
Description date: 16/02/2000
Authors: E. Ascaso and J. Kutuahupira

<u>Cartography</u>
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 2118
UTM Grid Zone: 34K, Clarke 1880 Spheroid

Coordinates: Longitude 18º19'25''E
Latitude 21º48'54''S

Landform/Land element: Central plateaux/lowlands in the Central plateaux/level lowlands
Parent material: Weathered in situ
Erosion: No evidence

Groundwater table: -
Drainage class: Moderately well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): leptic Regosol

Observations:

Description (FAO Guidelines for Soil Description)

000-017 cm **A**
COLOUR: Matrix colour (wet): 7.5YR 4/4. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Weak, coarse, sub-angular blocky. CONSISTENCE: Very friable. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual. DIAGNOSTIC HORIZON: **Ochric**.

017-042 cm **Bw1**
COLOUR: Matrix colour (wet): 5YR 4/4. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None STRUCTURE: Very weak, coarse, sub-angular blocky. CONSISTENCE: Very friable. ACCUMULATION: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal.

042-060 cm **Bw2**
COLOUR: Matrix colour (wet): 5YR 4/6. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Few, fine, irregular, quartz STRUCTURE: Weak, coarse, sub-angular blocky. CONSISTENCE: Friable. ACCUMULATION: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact.

060-999 cm **R**

Bedrock of Quartzite.

The representative profile on granite is **NAM-157**

Profile: NAM-157
Description date: 03/04/2000
Authors: E. Ascaso and G. Hangara

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 2116
UTM Grid Zone: 34K, Clarke 1880 Spheroid
Coordinates: Longitude 16º02'53''E
Latitude 21º21'57''S

Landform/Land element: Central Plateau/Lowland in the Central plateaux/gently undulating lowlands
Parent material: Weathered in situ
Erosion: No evidence

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): leptic Regosol

Observations:

Description (FAO Guidelines for Soil Description)

000-019 cm **A**
COLOUR: Matrix colour (wet): 10YR 5/4. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: Very few, boulders, rounded, granite. STRUCTURE: Very weak, medium, sub-angular blocky. CONSISTENCE: Very friable. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

019-042 cm **Bw**
COLOUR: Matrix colour (wet): 10YR 4/4. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: Very few, boulders, rounded, granite STRUCTURE: Very weak, medium, sub-angular blocky. CONSISTENCE: Very friable. ACCUMULATION: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact.

042-999 cm **R**

Bedrock of granite.

The representative profile on schist is **NAM-421**

Profile: NAM-421
Description date: 8/05/2000
Authors: J. F. García and G. Hangara

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1714
UTM Grid Zone: 34K, Clarke 1880 Spheroid
Coordinates: Longitude 13º28'54''E
Latitude 17º38'19''S

Landform/Land element: Escarpment/High mountains of the escarpment/high mountains
Parent material: Weathered in situ
Erosion: No evidence

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): leptic Regosol

Observations:

Description (FAO Guidelines for Soil Description)

000-007 cm **A**
COLOUR: Matrix colour (wet): 5YR 4/6. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Many, coarse gravel, sub-angular, quartz. STRUCTURE: Moderate, coarse, sub-angular blocky. CONSISTENCE: Slightly hard. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

007-030 cm **Bw**
COLOUR: Matrix colour (wet): 5YR 4/6. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Many, coarse gravel, sub-angular, schist STRUCTURE: Weak, fine, sub-angular blocky. CONSISTENCE: Soft. ACCUMULATION: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact.

030-999 cm **R**

Bedrock of schist.

The representative profile on shale is **NAM-841**

Profile:	NAM-841
Description date:	28/07/2000
Authors:	P. Festus and E. Ascaso

Cartography

Scale:	1:250.000	
Projection:	Gauss Conformal Projection (Bessel's Spheroid)	
Sheet number:	2618	
UTM Grid Zone:	34K, Clarke 1880 Spheroid	
Coordinates:	Longitude	18º19'36''E
	Latitude	26º27'04''S

Landform/Land element:	Central Plateaux/Foothills and slopes in the Central plateaux/gently undulating hills
Parent material:	Weathered in situ
Erosion:	No evidence
Groundwater table:	-
Drainage class:	Well drained
Land use and vegetation:	Extensive grazing
Classification (WRB, 1998):	leptic Regosol

Observations:

Description (FAO Guidelines for Soil Description)

000-013 cm **A**
COLOUR: Matrix colour (wet): 10YR 4/4. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: Few, fine, platy, shale. STRUCTURE: Weak, medium, sub-angular. CONSISTENCE: Slightly hard. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual. DIAGNOSTIC HORIZON: **Ochric**.

013-033 cm **Bw**
COLOUR: Matrix colour (wet): 10YR 3/4. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: Few, coarse gravel, platy, shale STRUCTURE: Very weak, fine,

sub-angular blocky. CONSISTENCE: Soft. ACCUMULATION: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact.

033-999 cm **R**
Bedrock of shale.

A.2.22. leptic-chromic Cambisols

Leptic-chromic Cambisols are moderately deep to deep, well drained and moderately coarse to moderately fine textured with few rock fragments.

The profile has developed a moderate to strong structure. The typical horizons sequence is A-Bw-R.

These soils are classified as leptic-chromic Cambisols (WRB, 1998); chromic Cambisols (FAO, 1988) and Lithic Haplustept (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is very dark greyish brown (10 YR 3/2) to dusky red (2.5 YR 3/4). The texture is loamy sand to sandy clay loam. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is very low.

The Bw horizon is about 50 cm thick and present a moderate to strong structure. It has a colour (wet) brown (7.5YR 4/4) to red (2.5YR 5/8). The texture is sandy loam to sandy clay loam. The pH is medium to high and the equivalent calcium carbonate is low.

The R horizon consists of a bedrock of quartzite or limestone that underlies the soil.

2. Representative profile

The representative profile is **TWO-221**

Profile: TWO-221
Description date: 25/11/99
Authors: G. Carrillo and G. Hangara

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1918
UTM Grid Zone: 34K, Clark 1880 Spheroid
Coordinates: Longitude 18º02'08''
Latitude 19º29'04''

Landform/Land element: Central Plateau/Karst on hard Damara limestone/ Footslope
Parent material: colluvial deposits
Erosion: no evidence

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): leptic-chromic Cambisol

Observations:

Description (FAO Guidelines for Soil Description)

000-013 cm **A**
COLOUR: Matrix colour (wet): 7.5YR 3/3. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, coarse, sub-angular blocky. CONSISTENCE: Slightly hard. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

013-034 cm **Bw1**
COLOUR: Matrix colour (wet): 5YR 3/4. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, coarse, sub-angular blocky. CONSISTENCE: Slightly hard. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear.

034-053 cm **Bw2**
COLOUR: Matrix colour (wet): 5YR 3/4. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Common, fine gravel, irregular, limestone. STRUCTURE: Moderate, coarse, sub-angular blocky. CONSISTENCE: Slightly hard. CONCENTRATIONS: Very few, nodules, fine, irregular, soft, calcium carbonate. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact. DIAGNOSTIC HORIZON: **Cambic**.

070-999 cm **R**

Bedrock of dolomite.

A.2.23. leptic-mollic Cambisols

Leptic-mollic Cambisols are moderately deep to deep, well drained and moderately coarse to moderately fine textured with few rock fragments.

The profile has developed a moderate to strong structure and presents a mollic horizon. The typical sequence of layers of soil is A-Bw-R.

These soils are classified as leptic-chromic Cambisols (WRB, 1998); eutric Cambisols (FAO, 1988) and Lithic Haplustolls (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick and present a moderate structure. Its colour (wet) is very dark grey (2.5Y 3/1) to very dark greyish brown (10YR 3/2). The texture is sand to sandy loam. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is low.

The Bw horizon is about 50 cm thick and present a moderate to strong structure. It has a colour (wet) very dark grey (10YR 3/1) to brown (10YR 5/3). The texture is loamy sand to sandy clay loam. The pH is medium to high and the equivalent calcium carbonate is low.

The R horizon consists of a bedrock of limestone that underlies the soil.

2. Representative profile

The representative profile is **TWO-161**

Profile: TWO-161
Description date: 25/11/99
Authors: J.F. Garcia and P. Festus

<u>***Cartography***</u>
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1916
UTM Grid Zone: 34K, Clark 1880 Spheroid
Coordinates: Longitude 17°56'27''
Latitude 19°37'29''

Landform/Land element: Central Plateau/Karst on hard Damara limestone/ Level lowland
Parent material: Weathered in situ
Erosion: no evidence

Groundwater table: -

Drainage class: Well drained

Land use and vegetation: Annual field cropping: maize

Classification (WRB, 1998): leptic-mollic Cambisol

Observations:

Description (FAO Guidelines for Soil Description)

000-020 cm **Ap**
COLOUR: Matrix colour (wet): 10YR 2/1. MOTTLES: None. TEXTURE: Sandy clay loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, coarse, sub-angular blocky. CONSISTENCE: Very hard. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Mollic**.

020-060 cm **Bw1**
COLOUR: Matrix colour (wet): 10YR 3/1. MOTTLES: None. TEXTURE: Sandy clay loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, fine, sub-angular blocky. CONSISTENCE: Friable. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Moderately calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact. HORIZON BOUNDARY: Abrupt.

060-999 cm **R**
Bedrock of limestone.

A.2.24. leptic-skeletic Regosols

Leptic-skeletic Regosols are shallow to moderately deep, well drained and coarse to moderately coarse textured with abundant coarse fragments.

The profile has hardly developed. The typical sequence of layers in the soil is A-C(gravels)-R.

These soils are classified as leptic-skeletic Regosols (WRB, 1998); eutric Regosols (FAO, 1988) and Lithic Ustorthents (Soil Taxonomy, 1996).

1. *Range of characteristics*

The A horizon is 15 to 25 cm thick. Its colour (wet) is dark greyish brown (10YR 4/2) to yellowish red (5YR 4/6). The texture is sand to sandy loam, with many coarse fragments. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is very low.

The C horizon is 20 to 40 cm thick. It has a colour brown (10YR 4/3) to yellowish red (5YR 4/6). The texture is loamy sand to sandy loam with abundant coarse fragments. The pH is medium to high and the equivalent calcium carbonate is low.

Below we find the R horizon that consists of a bedrock of limestone, quartzite, shale, schist, gneiss, granite, etc.

2. *Representative profile*

The representative profile on limestone is **NAM-372**

Profile: NAM-372
Description date: 3/05/00
Authors: G. Carrillo and J. Kutuahupira

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 2014
UTM Grid Zone: 34K, Clarke 1880 Spheroid
Coordinates: Longitude 15º07'13''E
Latitude 20º20'42''S

Landform/Land element:	Escarpment/Erosion surfaces of the degraded escarpment/Eroded rolling hills
Parent material:	Weathered in situ
Erosion:	No evidence
Groundwater table:	-
Drainage class:	Well drained
Land use and vegetation:	Extensive grazing
Classification (WRB, 1998):	leptic-skeletic Regosol

Observations:

Description (FAO Guidelines for Soil Description)

000-023 cm **A**
COLOUR: Matrix colour (wet): 10YR 4/4. MOTTLES: None. TEXTURE: Loam. ROCK FRAGMENTS: Few, medium gravel, angular, limestone. STRUCTURE: Moderate, medium, sub-angular blocky. CONSISTENCE: Friable. SOIL REACTION: Carbonates: Moderately calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

023-050 cm **C (Gravels)**
COLOUR: Matrix colour (wet): 10YR 4/6. MOTTLES: None. TEXTURE: loam. ROCK FRAGMENTS: Abundant, stones, angular, limestone. STRUCTURE: Without structure . ACCUMULATION: None. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact.

050-999 cm **R**

Bedrock of limestone.

The representative profile on granite is **NAM-119**

Profile:	NAM-119
Description date:	2/04/00
Authors:	G. Carrillo and J. Kutuahupira

<u>Cartography</u>

Scale:	1:250.000	
Projection:	Gauss Conformal Projection (Bessel's Spheroid)	
Sheet number:	2114	
UTM Grid Zone:	34K, Clarke 1880 Spheroid	
Coordinates:	Longitude	15º37'05''E
	Latitude	21º18'27''S

Landform/Land element:	Central plateaux/Lowlands in the Central plateaux/ Gently undulating lowlands
Parent material:	Weathered in situ
Erosion:	No evidence
Groundwater table:	-
Drainage class:	Well drained
Land use and vegetation:	Extensive grazing
Classification (WRB, 1998):	leptic-skeletic Regosol

Observations:

Description (FAO Guidelines for Soil Description)

000-014 cm **A**
COLOUR: Matrix colour (wet): 10YR 4/4. MOTTLES: None. TEXTURE: Loam sand. ROCK FRAGMENTS: Many, coarse gravel, sub-rounded, granite. STRUCTURE: Very weak, medium sub-angular blocky. CONSISTENCE: Very friable. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

014-056 cm **C (Gravels)**
COLOUR: Matrix colour (wet): 10YR 4/6. MOTTLES: None. TEXTURE: loamy sand. ROCK FRAGMENTS: Abundant, stones, sub-rounded, granite. STRUCTURE: Very weak, medium, sub-angular blocky. CONSISTENCE: Very friable. ACCUMULATION: None. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact.

056-999 cm **R**

Bedrock of Granite.

The representative profile on shale is **NAM-842**

Profile:	NAM-842
Description date:	28/07/00
Authors:	E. Ascaso and P. Festus

<u>Cartography</u>

Scale:	1:250.000	
Projection:	Gauss Conformal Projection (Bessel's Spheroid)	
Sheet number:	2618	
UTM Grid Zone:	34K, Clarke 1880 Spheroid	
Coordinates:	Longitude	18º25'59''E
	Latitude	26º25'10''S

Landform/Land element:	Central plateaux/Erosion forms on Kaoo rocks/ Gently undulating hills
Parent material:	Weathered in situ
Erosion:	No evidence
Groundwater table:	-
Drainage class:	Well drained
Land use and vegetation:	Extensive grazing
Classification (WRB, 1998):	leptic-skeletic Regosol

Observations:

Description (FAO Guidelines for Soil Description)

000-020 cm **A**
COLOUR: Matrix colour (wet): 10YR 4/3. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Common, fine gravel, platy, shale. STRUCTURE: Very weak, medium sub-angular blocky. CONSISTENCE: Slightly hard. SOIL REACTION: Carbonates: Extremely calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

020-050 cm **Bwck**
COLOUR: Matrix colour (wet): 10YR 4/3. MOTTLES: None. TEXTURE: loamy sand. ROCK FRAGMENTS: Many, fine gravel, platy, shale. STRUCTURE: Very weak, coarse, sub-angular blocky. CONSISTENCE: Slightly hard. ACCUMULATION: Common, nodules, very fine, elongated, soft, calcium carbonate. SOIL REACTION: Carbonates: Extremely calcareous. BIOLOGICAL ACTIVITY: Roots: Normal.

050-070 cm **Cck (Gravels)**
COLOUR: Matrix colour (wet): 10YR 3/3. MOTTLES: None. TEXTURE: loamy sand. ROCK FRAGMENTS: Dominant, medium to coarse gravels, platy, shale. STRUCTURE: Without structure. ACCUMULATION: Few, coatings, fine, soft and hard, calcium carbonate. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact.

070-999 cm **R**

Bedrock of shale.

A.2.25. lithic Leptosols

Lithic Leptosols are very shallow, well drained and coarse to moderately coarse textured with common to many rock fragments.

The typical sequence of layers in the soil is A-R.

These soils are classified as lithic Leptosols (WRB, 1998); lithic Leptosols (FAO, 1988) and Lithic Ustorthent (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is dark greyish brown (10YR 4/2) to yellowish red (5YR 5/6). The texture is sand to sandy loam. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is very low.

Below we find the R horizon that consists of a bedrock of limestone, quartzite, schist, shale, gneiss, granite, etc.

2. Representative profile

The representative profile on quartzite is **NAM-684**

Profile:	NAM-684
Description date:	15/07/2000
Authors:	H. Mouton and E. Ascaso

Cartography

Scale:	1:250.000	
Projection:	Gauss Conformal Projection (Bessel's Spheroid)	
Sheet number:	2416	
UTM Grid Zone:	34K, Clarke 1880 Spheroid	
Coordinates:	Longitude	17º37'30''E
	Latitude	24º40'08''S

Landform/Land element:	Central Plateaux/Plateaux/Plateaux
Parent material:	Weathered in situ
Erosion:	No evidence
Groundwater table:	-
Drainage class:	Well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): lithic Leptosol

Observations:

Description (FAO Guidelines for Soil Description)

000-004 cm **A**
COLOUR: Matrix colour (wet): 5YR 3/4. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: Many, coarse to stones, platy, quartzite. STRUCTURE: Weak, fine, sub-angular blocky. CONSISTENCE: Slightly hard. SOIL REACTION: Carbonates: Non Calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact. HORIZON BOUNDARY: Abrupt. DIAGNOSTIC HORIZON: **Ochric**.

004-999 cm **R**

Bedrock of quatzite.

The representative profile on granite is **NAM-714**

Profile: NAM-714
Description date: 27/07/2000
Authors: J. F. García and G. Hangara

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 2718
UTM Grid Zone: 34K, Clarke 1880 Spheroid
Coordinates: Longitude 18º13'21''E
Latitude 27º40'18''S

Landform/Land element: Central Plateaux/Foothills and slopes in the Central Plateaux/Gently undulating hills
Parent material: Weathered in situ
Erosion: No evidence

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): lithic Leptosol

Observations:

Description (FAO Guidelines for Soil Description)

000-004 cm **A**
COLOUR: Matrix colour (wet): 5YR 4/6. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Abundant, fine, sub-rounded, quartz and feldspars. STRUCTURE: Weak, fine, sub-angular blocky. CONSISTENCE: Soft. SOIL REACTION: Carbonates: Moderately Calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact. HORIZON BOUNDARY: Abrupt. DIAGNOSTIC HORIZON: **Ochric**.

004-999 cm **R**

Bedrock of granite.

The representative profile on shale is **NAM-754**

Profile:	NAM-754
Description date:	27/07/2000
Authors:	E. Ascaso and P. Festus

Cartography

Scale:	1:250.000	
Projection:	Gauss Conformal Projection (Bessel's Spheroid)	
Sheet number:	2718	
UTM Grid Zone:	34K, Clarke 1880 Spheroid	
Coordinates:	Longitude	18º02'51''E
	Latitude	28º09'30''S

Landform/Land element:	Central Plateaux/Erosion forms on Karoo rocks/ Gently undulating hills
Parent material:	Weathered in situ
Erosion:	No evidence
Groundwater table:	-
Drainage class:	Well drained
Land use and vegetation:	Extensive grazing
Classification (WRB, 1998):	lithic Leptosol

Observations:

Description (FAO Guidelines for Soil Description)

000-009 cm **A**
COLOUR: Matrix colour (wet): 10YR 4/3. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Many, coarse gravel, platy, shale. STRUCTURE: Moderate, fine, sub-angular blocky. CONSISTENCE: Slightly hared. SOIL REACTION: Carbonates: Strongly Calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact. HORIZON BOUNDARY: Abrupt. DIAGNOSTIC HORIZON: **Ochric**.

009-999 cm **R**

Bedrock of shale.

The representative profile on schist is **NAM-807**

Profile: NAM-807
Description date: 30/07/2000
Authors: J. F. García and G. Hangara

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 2516
UTM Grid Zone: 34K, Clarke 1880 Spheroid
Coordinates: Longitude 17º46'40''E
Latitude 25º54'03''S

Landform/Land element: Central Plateaux/Plateaux/Dissected plateaux fringe
Parent material: Weathered in situ
Erosion: No evidence

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): lithic Leptosol

Observations:

Description (FAO Guidelines for Soil Description)

000-006 cm **A**

COLOUR: Matrix colour (wet): 5YR 4/5. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Many, coarse gravel, sub-rounded, schist. STRUCTURE: Weak, coarse, sub-angular blocky. CONSISTENCE: Slightly hared. SOIL REACTION: Carbonates: Non Calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact. HORIZON BOUNDARY: Abrupt. DIAGNOSTIC HORIZON: **Ochric**.

006-999 cm **R**

Bedrock of shale.

A.2.26. mollic Fluvisols

Mollic Fluvisols are very deep, imperfectly to moderately well drained and moderately coarse to medium textured without rock fragments.

The profile presents fluvic soil materials and has developed a mollic horizon. The typical sequence of layers in the soil is A-B.

These soils are classified as mollic Fluvisols (WRB, 1998); mollic Fluvisols (FAO, 1988) and mollic Ustifluvent (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick and present a strong structure. Its colour (wet) is dark brown (10YR 3/3) to very dark grey (10YR 3/1). The texture is sand to sandy loam. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is low.

Below the A horizon usually appear an horizon with a granular or platy structure, a low density and a content in organic carbon higher than that of the A horizon. This horizon reminds the histic horizon although the organic carbon content does not arrive to 4% in the samples analysed.

Below, the B horizons present a very weak structure and reach down to more than 150 cm. It has a colour (wet) pale yellow (2.5Y 7/4) to very dark grey (10YR 3/1). The texture is sandy loam to loam. The pH is medium to high and the equivalent calcium carbonate is low.

2. Representative profile

The representative profile is **OKA-831**

Profile: OKA-831
Description date: 29/09/99
Authors: E. Ascaso, J.F. Garcia and G. Carrillo

Cartography
Scale: 1:50.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1819 BB
UTM Grid Zone: 34K, Clark 1880 Spheroid
Coordinates: Longitude 19º45'43''
Latitude 18º11'23''

Landform/Land element: Kalahari Sands Plateau; Omuramba

Parent material: Alluvial deposits
Erosion: no evidence

Groundwater table: -
Drainage class: Imperfectly drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): mollic Fluvisol

Observations:

Description (FAO Guidelines for Soil Description)

000-021 cm **A1**
COLOUR: Matrix colour (wet): 10YR 3/2. MOTTLES: None. TEXTURE: Loam. ROCK FRAGMENTS: None. STRUCTURE: Strong, medium, sub-angular blocky. CONSISTENCE: Slightly hard. CONCENTRATIONS: Many, nodules, coarse, irregular, hard, iron-manganese. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Umbric**.

021-048 cm **Ab**
COLOUR: Matrix colour (wet): 10YR 2/1. MOTTLES: None. TEXTURE: Loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, very coarse, platy. CONSISTENCE: Hard. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear.

048-079 cm **B1**
COLOUR: Matrix colour (wet): 10YR 5/2. MOTTLES: None. TEXTURE: Loamy sand. ROCK FRAGMENTS: None. STRUCTURE: Weak, coarse, sub-angular blocky. CONSISTENCE: Firm. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual.

079-110 cm **B2**
COLOUR: Matrix colour (wet): 10YR 5/2. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Weak, Coarse, Subangular Blocky. CONSISTENCE: Friable. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal.

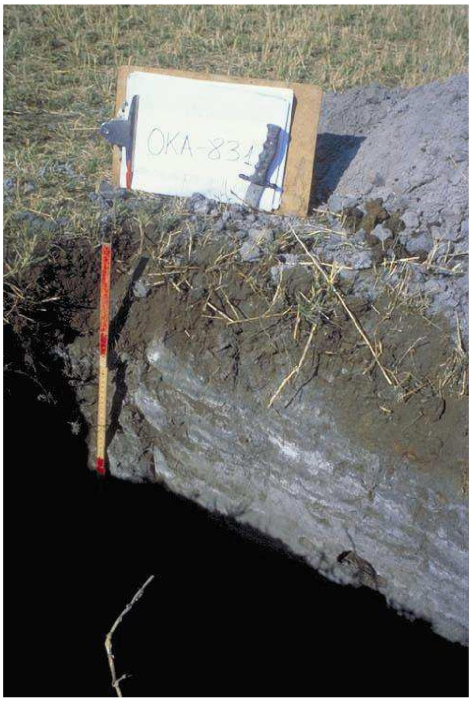


Photo 4: mollic Fluvisol

A.2.27. mollic Leptosols

Mollic Leptosols are very shallow, well drained and coarse to moderately coarse textured with few to common rock fragments.

The profile has developed a mollic horizon. The typical sequence of layers in the soil is A-R.

These soils are classified as mollic Leptosols (WRB, 1998); mollic Leptosols (FAO, 1988) and Lithic Haplustolls (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick and present a moderate to strong structure. Its colour (wet) is black (10YR 2/1) to very dark brown (7.5YR 2/2). The texture is loamy sand to loamy sand and can present few coarse fragments. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is low.

Below we find the R horizon that consists of a bedrock of limestone.

2. Representative profile

The representative profile is **TWO-89**

Profile: TWO-89
Description date: 11/11/99
Authors: E. Ascaso and H. Mouton

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1916
UTM Grid Zone: 34K, Clarke 1880 Spheroid
Coordinates: Longitude 17º51'58''E
Latitude 19º43'54''S

Landform/Land element: Central Plateau/Karst on hard Damara limestone/ Level lowlands
Parent material: Weathered in situ
Erosion: No evidence

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): mollic Leptosol

Observations:

Description (FAO Guidelines for Soil Description)

000-020 cm **A**
COLOUR: Matrix colour (wet): 7.5YR 3/1. MOTTLES: None. TEXTURE: Sand loam. ROCK FRAGMENTS: None. ROCK FRAGMENTS: Few, fine, sub-rounded, limestone. STRUCTURE: Moderate, coarse, sub-angular blocky. CONSISTENCE: Hard. SOIL REACTION: Carbonates: Strongly Calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by lithic contact. HORIZON BOUNDARY: Abrupt. DIAGNOSTIC HORIZON: **Mollic**.

020-999 cm **R**

Bedrock of limestone.

A.2.28. natric-calcic Vertisols

Natric-calcic Vertisols are very deep, poorly drained and moderately fine to fine textured without rock fragments. These soils are slight to moderately saline and sodic.

The profile has developed vertic and natric horizons. The typical sequence of layers in the soil is A-Bwt-Bwck.

These soils are classified as natric-calcic Vertisols (WRB, 1998), calcic Vertisols (FAO, 1988) and sodic Calciusterts (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is about 20 cm thick. Its colour (wet) is black (2.5Y 2.5/1) to dark grey (10YR 4/1). The texture is sandy clay loam to clay. The pH is high to very high, the equivalent calcium carbonate is low and the organic matter content is very low.

The Bwt horizon is 40 to 60 cm thick and presents a moderate to strong structure and cutans in the form of intersecting slickensides. The texture is sandy clay loam to clay, showing an increase in clay content with the overlying horizon. It has a colour (wet) very dark grey (10YR 3/1) to light brownish grey (10YR 6/2). The pH is high to very high and the equivalent calcium carbonate is medium.

The Bwck horizon reaches down to more than 120 cm and presents accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules and, most of the times, cutans in the form of intersecting slickensides. Texture is sandy clay loam to clay. It has a colour (wet) very dark grey (10YR 3/1) to pale yellow (2.5Y 7/4). The pH is high to very high, the equivalent calcium carbonate is medium to high.

2. Representative profile

The representative profile is **OWA-15**

Profile: OWA-15
Description date: 9/07/99
Authors: J. F. García, E. Ascaso and G. Hangara

Cartography
Scale: 1:50.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1715 DD
UTM Grid Zone: 34K, Clarke 1880 Spheroid
Coordinates: Longitude 15º58'01''E
Latitude 17º46'23''S

Landform/Land element: Kalahari Sands Plateau. Oshana
Parent material: Alluvial
Erosion: No evidence

Groundwater table: -
Drainage class: Poorly drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): natric-calcic Vertisol

Observations:

Description (FAO Guidelines for Soil Description)

000-020 cm **A**
COLOUR: Matrix colour (wet): 10YR 2/1. MOTTLES: None. TEXTURE: Clay loam. ROCK FRAGMENTS: None. STRUCTURE: Strong, medium, prismatic. CONSISTENCE: Extremely hard. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: No roots. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

020-080 cm **Bwt**
COLOUR: Matrix colour (wet): 10YR 3/1. MOTTLES: None. TEXTURE: Clay loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, medium, angular blocky. CONSISTENCE: Extremely hard. CUTANS: Common, distinct, slickensides on ped faces. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: No roots. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Vertic/natric**.

080-100 cm **Bwck**
COLOUR: Matrix colour (wet): 10YR 3/1. MOTTLES: None. TEXTURE: Clay loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, medium, angular blocky. CONSISTENCE: Extremely hard. CUTANS: Common, distinct, slickensides on ped faces. CONCENTRATIONS: Few, nodules, medium, rounded, soft of calcium carbonate. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: No roots. DIAGNOSTIC HORIZON: **Vertic**.

A.2.29. natric-gypsic Vertisols

Natric-gypsic Vertisols are very deep, poorly drained and moderately fine to fine textured without rock fragments. These soils are slight to moderately saline and sodic.

The profile has developed vertic and natric horizons. The typical sequence of layers in the soil is A-Bwt-Bwcyk.

These soils are classified as natric-gypsic Vertisols (WRB, 1998), gypsic Vertisols (FAO, 1988) and sodic Gypsiusterts (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is about 20 cm thick. Its colour (wet) is black (2.5Y 2.5/1) to very dark grey (10YR 3/2). The texture is sandy clay loam to clay. The pH is high to very high, the equivalent calcium carbonate is low and the organic matter content is very low.

The Bwt horizon is 40 to 60 cm thick and presents a moderate to strong structure and cutans in the form of intersecting slickensides. The texture is sandy clay loam to clay, showing an increase in clay content with the overlying horizon. It has a colour (wet) black (2.5Y 2.5/1) to very dark greyish brown (10YR 3/2). The pH is high to very high and the equivalent calcium carbonate is medium.

A Bwcyk horizon reaches down to more than 120 cm and presents accumulations of gypsum as discontinuous concentrations crystals and accumulations of calcium carbonate as discontinuous concentrations of hard nodules. Most of the times, the horizon presents cutans in the form of intersecting slickensides. Texture is sandy clay loam to clay. It has a colour (wet) very dark grey (2.5Y 3/1) to light olive grey (5Y 6/2). The pH is high to very high, the equivalent calcium carbonate is medium to high and the gypsum content is medium to high.

2. Representative profile

The representative profile is **OWA-169**

Profile: OWA-169
Description date: 31/07/99
Authors: H. Mouton, G. Carrillo and G. Hangara

<u>Cartography</u>
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1714
UTM Grid Zone: 34K, Clarke 1880 Spheroid

Coordinates:	Longitude	15º45’08’’E
	Latitude	17º37’10’’S

Landform/Land element: Kalahari Sands Plateau. Oshana
Parent material: Alluvial
Erosion: No evidence

Groundwater table: -
Drainage class: Poorly drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): natric-gypsic Vertisol

Observations:

Description (FAO Guidelines for Soil Description)

000-010 cm **A**
COLOUR: Matrix colour (wet): 10YR 4/1. MOTTLES: None. TEXTURE: Clay loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate to strong, fine, sub-angular. CONSISTENCE: Slightly hard. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: No roots. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

010-030 cm **Bwtck**
COLOUR: Matrix colour (wet): 10YR 4/1. MOTTLES: None. TEXTURE: Clay loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate to strong, fine, sub-angular blocky. CONSISTENCE: Slightly hard. CONCENTRATIONS: Common, nodules, fine, irregular, soft, calcium carbonate. SOIL REACTION: Carbonates: Moderately Calcareous. BIOLOGICAL ACTIVITY: Roots: No roots. HORIZON BOUNDARY: Clear.

030-050 cm **Bwcyk1**
COLOUR: Matrix colour (wet): 10YR 5/1. MOTTLES: None. TEXTURE: Clay loam. ROCK FRAGMENTS: None. STRUCTURE: Strong, fine, sub-angular blocky. CONSISTENCE: Hard. CUTANS: Common, distinct, slickensides on ped faces. CONCENTRATIONS: Few, nodules, fine, irregular, soft of calcium carbonate and very few, crystals, very fine, irregular, soft of gypsum. SOIL REACTION: Carbonates: Moderately calcareous. BIOLOGICAL ACTIVITY: Roots: No roots. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Vertic/Natric**.

050-100 cm **Bwcyk2**
COLOUR: Matrix colour (wet): 10YR 5/1. MOTTLES: None. TEXTURE: Clay loam. ROCK FRAGMENTS: None. STRUCTURE: Strong, fine, sub-angular blocky. CONSISTENCE: Very hard. CUTANS: Common, distinct, slickensides on ped faces. CONCENTRATIONS: Common, nodules, medium, irregular, both of calcium carbonate and very few, crystals, very fine, irregular, soft of gypsum. SOIL

REACTION: Carbonates: Moderately calcareous. BIOLOGICAL ACTIVITY: Roots: No roots. DIAGNOSTIC HORIZON: **Vertic**.

A.2.30. petric Calcisols

Petric Calcisols are shallow to moderately deep, moderately well to well drained and moderately coarse to medium textured without rock fragments.

The profile has developed a petrocalcic horizon and, sometimes, a calcic horizon. The typical sequence of layers in the soil is A-Bw-BmK or A-Bwk-Bmk.

These soils are classified as petric Calcisol (WRB, 1998); petric Calcisols (FAO, 1988) and petrocalcic Calciustept (Soil Taxonomy, 1996).

1. *Range of characteristics*

The A horizon is 15 to 25 cm thick. Its colour (wet) is dark brown (10 YR 3/3) to very dark grey (10 YR 3/1). The texture is loamy sand to sandy loam. The pH is medium to high, the equivalent calcium carbonate is low to medium and the organic matter content is very low.

The Bw horizon, that appear occasionally, is about 40 cm thick. It has a colour (wet) brown (7.5YR 4/4) to very dark greyish brown (10 YR 3/2). The texture is loamy sand to sandy loam. The pH is medium to high and the equivalent calcium carbonate is medium to moderately high. The profile can present accumulations of calcium carbonate as discontinuous or continuous concentrations of hard or soft nodules, resulting in a calcic or hypercalcic horizon.

The Bmk consist of a petrocalcic horizon moderately to strongly cemented

2. *Representative profiles*

The representative profile of the petric Calcisols formed on the omurambas and river valleys is **OKA-846**

Profile:	OKA-846	
Description date:	29/9/99	
Authors:	E. Ascaso, J.F. García and G. Carrillo	

Cartography

Scale:	1:250.000	
Projection:	Gauss Conformal Projection (Bessel's Spheroid)	
Sheet number:	1718	
Coordinates:	Longitude	19º03'27''
	Latitude	17º51'32''

Landform/Land element:	Kalahari Region/Flooded and over-flooded areas/ Omurambas and river valleys
Parent material:	Alluvial deposits
Erosion:	No evidence
Groundwater table:	-
Drainage class:	Well drained
Land use and vegetation:	-
Classification (WRB, 1998):	petric Calcisol

Observations:

Description (FAO Guidelines for Soil Description)

000-017 cm **A**
COLOUR: Matrix colour (wet): 10 YR 3/2. MOTTLES: None. TEXTURE: Loamy sand. ROCK FRAGMENTS: None. STRUCTURE: Weak, coarse, sub-angular blocky. CONSISTENCE: Slightly hard. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Abrupt. DIAGNOSTIC HORIZON: **Ochric**.

017-040 cm **Bw1**
COLOUR: Matrix colour (wet): 10YR 3/2. MOTTLES: None. TEXTURE: Loamy sand. ROCK FRAGMENTS: None. STRUCTURE: Moderate, medium, sub-angular blocky. CONSISTENCE: Friable. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear.

040-060 cm **Bw2**
COLOUR: Matrix colour (wet): 10 YR 4/2. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, medium, sub-angular blocky. CONSISTENCE: Friable. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Abrupt.

060-999 cm **Bmk**
DIAGNOSTIC HORIZON: Petrocalcic horizon

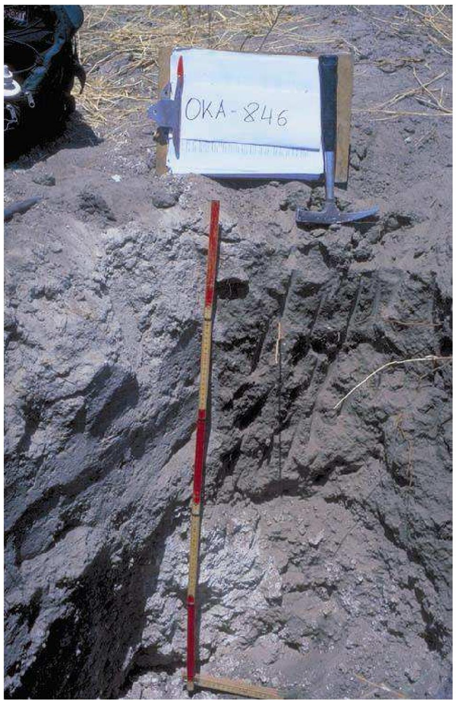


Photo 5: petric Calcisol

The representative profile for the petric Calcisols formed on the level lowlands of the plateaux with karst on hard Damara limestone is **TWO-291**

Profile: TWO-291
Description date: 29/9/99
Authors: G. Carrillo and G. Hangara

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1716
Coordinates: Longitude 17°15'09''
Latitude 19°39'17''

Landform/Land element: Central Plateaux/?Plateaux with karst on hard Damara limestone/Level lowlands
Parent material: Weathered in situ
Erosion: No evidence

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): petric Calcisol

Observations:

Description (FAO Guidelines for Soil Description)

000-014 cm **A**
COLOUR: Matrix colour (wet): 10 YR 4/1. MOTTLES: None. TEXTURE: Loam. ROCK FRAGMENTS: None. ROCK FRAGMENTS: Common, stones, sub-angular, petrocalcic fragments. STRUCTURE: Moderate, medium, sub-angular blocky. CONSISTENCE: Friable. SOIL REACTION: Carbonates: Extremely calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by cemented horizon. HORIZON BOUNDARY: Abrupt. DIAGNOSTIC HORIZON: **Ochric**.

014-999 cm **Bmk**
DIAGNOSTIC HORIZON: Petrocalcic horizon

The representative profile for the petric Calcisols formed on the pans all around the study area is **TWO-41**

Profile: TWO-41
Description date: 26/08/99
Authors: J.F. García, P. Festus and G. Hangara

Cartography

Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1716 CC
Coordinates: Longitude 17º31'54''
Latitude 17º27'32''

Landform/Land element: Kalahari Region/Sand deposits/ Sand deposits with pans
Parent material: Lagoonal deposits
Erosion: No evidence

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: -

Classification (WRB, 1998): petric Calcisol

Observations:

Description (FAO Guidelines for Soil Description)

000-022 cm **A**
COLOUR: Matrix colour (wet): 2.5Y 4/2. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, coarse, sub-angular blocky. CONSISTENCE: Slightly hard. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

022-038 cm **Bwck1**
COLOUR: Matrix colour (wet): 2.5Y 3/2. MOTTLES: None. TEXTURE: Loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, coarse, sub-angular blocky. CONSISTENCE: Slightly hard. CONCENTRATIONS: Common, nodules, medium, rounded, hard, calcium carbonate. SOIL REACTION: Carbonates: Extremely calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Calcic**.

038-059 cm **Bwck2**
COLOUR: Matrix colour (wet): 2.5Y 5/3. MOTTLES: None. TEXTURE: Loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, coarse, sub-angular blocky. CONSISTENCE: Slightly hard. CONCENTRATIONS: Abundant, nodules, medium, rounded, hard, calcium carbonate. SOIL REACTION: Carbonates: Extremely calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by cemented horizon. HORIZON BOUNDARY: Abrupt. DIAGNOSTIC HORIZON: **Hypercalcic**.

060-999 cm **Bmk**
DIAGNOSTIC HORIZON: Petrocalcic horizon

The representative profile for the petric Calcisols formed on the level lowlands of the Central plateaux is **NAM-20**

Profile: NAM-20
Description date: 16/02/2000
Authors: G. Carrillo, P. Festus and G. Hangara

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 2117
Coordinates: Longitude 18º24'44''
Latitude 21º20'32''

Landform/Land element: Central plateaux/level lowlands of the Central plateaux/level lowlands
Parent material: Weathered in situ
Erosion:

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): petric Calcisol

Observations:

Description (FAO Guidelines for Soil Description)

000-023 cm **A**
COLOUR: Matrix colour (wet): 10 YR 4/2. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, medium, sub-angular blocky. CONSISTENCE: Friable. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

023-060 cm **Bw**
COLOUR: Matrix colour (wet): 10YR 3/1. MOTTLES: None. TEXTURE: Sand loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, medium, prismatic. CONSISTENCE: Friable. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by cemented horizon. HORIZON BOUNDARY: Abrupt.

060-999 cm **Bmk**
DIAGNOSTIC HORIZON: Petrocalcic horizon

The representative profile for the petric Calcisols formed on the fossil sand dunes and the sand deposits is **TWO-4**

Profile: TWO-4
Description date: 25/08/99
Authors: E. Ascaso and G. Carrillo

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1716
Coordinates: Longitude 17º45'42''
Latitude 17º28'03''

Landform/Land element: Kalahari Region/Sand deposits/
Sand deposits with pans

Parent material: Lagoonal deposits
Erosion: No evidence

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: Extenive grazing

Classification (WRB, 1998): petric Calcisol

Observations:

Description (FAO Guidelines for Soil Description)

000-021 cm **A**
COLOUR: Matrix colour (wet): 5YR 3/3. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Weak, medium sub-angular blocky. CONSISTENCE: Soft. SOIL REACTION: Carbonates: Non Calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

021-050 cm **C (sand)**
COLOUR: Matrix colour (wet): 5YR 3/6. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Weak, medium, sub-angular blocky. CONSISTENCE: Soft. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by cemented horizon. HORIZON BOUNDARY: Abrupt.

050-999 cm **Bmk**
DIAGNOSTIC HORIZON: Petrocalcic horizon

The representative profile for the petric Calcisols formed on inter-mountain valleys **NAM-505**

Profile: NAM-505
Description date: 9/04/2000
Authors: E. Ascaso and J. Kutuahupira

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1714
Coordinates: Longitude 13º37'46''
Latitude 17º46'43''

Landform/Land element: Central plateaux/Kaokoland/intermountain valleys

Parent material:	Colluvial deposits
Erosion:	No evidence
Groundwater table:	-
Drainage class:	Well drained
Land use and vegetation:	Extenive grazing
Classification (WRB, 1998):	petric Calcisol

Observations:

Description (FAO Guidelines for Soil Description)

000-017 cm **A**
COLOUR: Matrix colour (wet): 5YR 4/6. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Weak, coarse sub-angular blocky. CONSISTENCE: Slightly hard. SOIL REACTION: Carbonates: Strongly Calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

017-037 cm **Bwck**
COLOUR: Matrix colour (wet): 5YR 4/4. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Few, fine, rounded, petrocalcic fragments and quartz. STRUCTURE: Moderate, medium, sub-angular blocky. CONSISTENCE: Friable. CONCENTRATIONS: Very few, soft segregations, fine, elongated, soft, calcium carbonate. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by cemented horizon. HORIZON BOUNDARY: Clear.

050-999 cm **Bmk**
DIAGNOSTIC HORIZON: Petrocalcic horizon

The representative profile for the petric Calcisols formed on plateaux and foothills is **NAM-884**

Profile:	NAM-884
Description date:	31/07/2000
Authors:	E. Ascaso and P. Festus

<u>Cartography</u>

Scale:	1:250.000	
Projection:	Gauss Conformal Projection (Bessel's Spheroid)	
Sheet number:	2616	
Coordinates:	Longitude	16º48'41''
	Latitude	26º14'50''

Landform/Land element: Central plateaux/plateaux/plateaux
Parent material: Weathered in situ
Erosion: No evidence

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: Extenive grazing

Classification (WRB, 1998): petric Calcisol

Observations:

Description (FAO Guidelines for Soil Description)

000-006 cm **A**
COLOUR: Matrix colour (wet): 2.5YR 4/6. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: Many, coarse gravel and stones, angular, quartzite and petrocalcic fragments. STRUCTURE: Weak, medium sub-angular blocky. CONSISTENCE: Very hard. SOIL REACTION: Carbonates: Non Calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by cemented horizon. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

050-999 cm **Bmk**
DIAGNOSTIC HORIZON: Petrocalcic horizon

A.2.31. petric Gypsisols

Petric Gypsisols are shallow to moderately deep, well drained and coarse to moderately coarse textured with many coarse fragments.

The profile has developed a petrogypsic horizon. The typical sequence of layers in the soil is A-Bwcy-Bmy.

These soils are classified as petric Gypsisols (WRB, 1998); petric Gypsisols (FAO, 1988) and Typic Petrogypsid (Soil Taxonomy, 1996).

1. *Range of characteristics*

The A horizon is 15 to 25 cm thick. Its colour (wet) is dark brown (10 YR 3/3) to reddish yellow (7.5 YR 6/8). The texture is loamy sand to sandy loam. The pH is medium to high, the equivalent calcium carbonate is low to medium and the organic matter content is very low.

The Bwcy is 20 to 40 cm thick and presents accumulations of gypsum as discontinuous concentrations of soft crystals. It has a colour (wet) dark brown (10YR 3/3) to reddish yellow (7.5YR 6/8). The texture is loamy sand to sandy loam. The pH is medium to high and the equivalent calcium carbonate is medium to moderately high.

The Bmy consist of a petrogypsic horizon, that most of the times, is broken or discontinuously cemented.

2. *Representative profiles*

The representative profile is **NAM-515**

Profile: NAM-515
Description date: 19/06/2000
Authors: J.F. García and G. Hangara

<u>Cartography</u>
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 2214
Coordinates: Longitude 14º59'49''
Latitude 22º50'35''

Landform/Land element: Namib/Namib desert pavements/ gravel pavements
Parent material: Colluvial deposits
Erosion: Aeolian erosion and sedimentation

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: -

Classification (WRB, 1998): petric Gypsisol

Observations:

Description (FAO Guidelines for Soil Description)

000-014 cm **A**
COLOUR: Matrix colour (wet): 10 YR 3/3. MOTTLES: None. TEXTURE: Loam. ROCK FRAGMENTS: Many, medium gravel, sub-rounded, quartz. STRUCTURE: Weak, medium, sub-angular blocky. CONSISTENCE: Slightly hard. SOIL REACTION: Carbonates: Extremely calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

014-030 cm **Bwcy**
COLOUR: Matrix colour (wet): 10YR 4/3. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Abundant, medium gravel, sub-rounded, quartz. STRUCTURE: Very weak, fine, sub-angular blocky. CONSISTENCE: Friable. CONCENTRATIONS: Common, crystals, medium, irregular, hard, gypsum. SOIL REACTION: Carbonates: Extremely calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by cemented horizon. HORIZON BOUNDARY: Abrupt.

030-999 cm Bmy
DIAGNOSTIC HORIZON: Petrogypsic horizon

The representative profile in case of broken or discontinuous petrogypsic horizon is **NAM-512**

Profile: NAM-512
Description date: 19/06/2000
Authors: J.F. García and G. Hangara

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1716
Coordinates: Longitude 14°41'07''
Latitude 22°44'50''

Landform/Land element: Namib/Namib pavements/gravel pavements
Parent material: Collvial
Erosion: Aeolian erosion and sedimentation

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: Extensive grazing

Classification (WRB, 1998): petric Gypsisol

Observations:

Description (FAO Guidelines for Soil Description)

000-019 cm **A**
COLOUR: Matrix colour (wet): 10 YR 4/2. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Abundant, medium to coarse gravel, sub-rounded poligenic. STRUCTURE: Weak, coarse, sub-angular blocky. CONSISTENCE: Friable. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

019-070 cm **Bmy1**
COLOUR: Matrix colour (wet): 10 YR 7/2. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Abundant, medium to coarse gravel, sub-rounded poligenic. STRUCTURE: Weak, coarse, sub-angular blocky. CONSISTENCE: Soft. ACCUMULATIONS: Abundant, crystals, fine, irregular, hard, gypsum. CEMENTATION: Broken, weak, gypsum. SOIL REACTION: Carbonates: Slightly calcareous. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Petrogypsic**.

070-999 cm **Bmy2**
COLOUR: Matrix colour (wet): 10 YR 7/2. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Abundant, medium to coarse gravel, sub-rounded poligenic. STRUCTURE: Weak, coarse, sub-angular blocky. CONSISTENCE: Soft. ACCUMULATIONS: Abundant, crystals, fine, irregular, hard, gypsum. CEMENTATION: Discontinuous, moderate, gypsum. SOIL REACTION: Carbonates: Non calcareous. DIAGNOSTIC HORIZON: **Petrogypsic**.

A.2.32. skeletic Fluvisols

Skeletic Fluvisols are very deep, moderately well to well drained and coarse textured with abundant rock fragments.

The profile presents coarse fluvic soil materials. The typical sequence of layers in the soil is A-B-C (gravels).

These soils are classified as skeletic Fluvisols (WRB, 1998); eutric Fluvisols (FAO, 1988) and Typic Ustifluvent (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is brown (10YR 4/3) to very dark grey (10YR 3/1). The texture is sand to sandy loam. The pH is medium, the equivalent calcium carbonate is low and the organic matter content is very low.

The B horizon is 10 to 30 cm thick and present a weak structure. It has a colour (wet) brown (10YR 4/3) to light yellowish brown (10YR 6/2). The texture is sand to sandy loam and present many to abundant rock fragments. The pH is medium and the equivalent calcium carbonate is low.

The C horizon consists of more than 40 percent of gravel or other coarse fragments to a depth of 100 cm from the soil surface.

2. Representative profile

The representative profile is **OKA-60**

Profile: OKA-60
Description date: 5/11/98
Authors: E. Ascaso, J.F: García and C. Carrillo

Cartography
Scale: 1:50.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 1821 AB & 1721 CD
UTM Grid Zone: 34K, Clark 1880 Spheroid
Coordinates: Longitude 21º26'20''
Latitude 18º03'20''

Landform/Land element: Kavango river; Terrace
Parent material: Alluvial deposits
Erosion: no evidence

Groundwater table: **-**
Drainage class: Well drained

Land use and vegetation: -

Classification (WRB, 1998): skeletic Fluvisol

Observations:

Description (FAO Guidelines for Soil Description)

000-022 cm **Ap**
COLOUR: Matrix colour (wet): 7.5YR 4/4. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Very weak, medium, sub-angular blocky. CONSISTENCE: Soft. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

022-050 cm **B**
COLOUR: Matrix colour (wet): 7.5YR 4/4. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Very weak, medium, sub-angular blocky. CONSISTENCE: Soft. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear.

050-999 cm **2C (gravels)**
ROCK FRAGMENTS: Abundance: Dominant (>90%), Nature: quartzite.

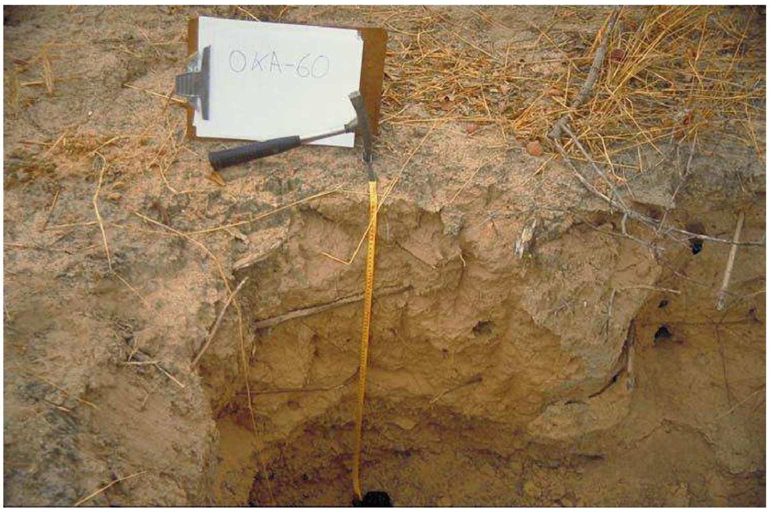


Photo 6: skeletic Fluvisol

A.2.33. skeletic Regosols

Skeletic Regosols are very deep, well drained and coarse to moderately coarse textured with abundant rock fragments.

The typical sequence of layers in the soil is A-C (gravels).

These soils are classified as skeletic Regosolss (WRB, 1998); eutric Regosols (FAO, 1988) and Typic Ustorthent (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is olive brown (2.5Y 3/4) to red (2.5YR 4/6). The texture is sand to sandy loam. The pH is medium to high, the equivalent calcium carbonate is low and the organic matter content is very low.

The C horizon reaches down more than 100 cm and presents more than 40 percent of gravel or other coarse fragments. Its colour (wet) is dark yellowish brown (10YR 4/3) to red (2.5YR 5/6). The pH is medium to high and the equivalent calcium carbonate is medium to high.

2. Representative profile

The representative profile is **NAM-669**

Profile: NAM-669
Description date: 13/07/2000
Authors: H. Mouton and E. Ascaso

Cartography
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 2416
UTM Grid Zone: 34K, Clark 1880 Spheroid
Coordinates: Longitude 16º17'27''
Latitude 24º06'34''

Landform/Land element: Escarpment/High mountains/High mountains
Parent material: Colluvial deposits
Erosion: Rills and gullies

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: -

Classification (WRB, 1998): skeletic Regosol

Observations:

Description (FAO Guidelines for Soil Description)

000-020 cm **A**
COLOUR: Matrix colour (wet): 7.5YR 3/3. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Abundant, medium gravel, platy, quartzite and limestone. STRUCTURE: Very weak, fine, sub-angular blocky. CONSISTENCE: Loose. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual. DIAGNOSTIC HORIZON: **Ochric**.

020-999 cm **C (gravels)**
COLOUR: Matrix colour (wet): 7.5YR 4/4. MOTTLES: None. TEXTURE: Sandy loam. ROCK FRAGMENTS: Dominant, stones and boulders, quartzite and limestone. STRUCTURE: Very weak, fine, sub-angular blocky. CONSISTENCE: Loose. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by skeletic material.

A.2.34. skeletic-calcaric Fluvisols

Skeletic-calcaric Fluvisols are very deep, moderately well to well drained and coarse to moderately coarse textured with abundant rock fragments.

The profile presents coarse fluvic soil materials. The typical sequence of layers in the soil is A-C (gravels).

These soils are classified as skeletic-calcaric Fluvisols (WRB, 1998); calcaric Fluvisols (FAO, 1988) and Typic Ustifluvent (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is brown (10YR 4/3) to very dark grey (10YR 3/1). The texture is sand to sandy loam. The pH is high, the equivalent calcium carbonate is medium to high and the organic matter content is very low.

The C horizons reach down more than 100 cm and consists of more than 40 percent of gravel or other coarse fragments. The texture is sand to sandy loam. The pH is high and the equivalent calcium carbonate is medium to high.

2. Representative profile

The representative profile is **NAM-676**

Profile: NAM-676
Description date: 14/07/2000
Authors: H. Mouton and E. Ascaso

<u>Cartography</u>
Scale: 1:250.000
Projection: Gauss Conformal Projection (Bessel's Spheroid)
Sheet number: 2414
UTM Grid Zone: 34K, Clark 1880 Spheroid
Coordinates: Longitude 15º59'05''
Latitude 24º39'27''

Landform/Land element: Central plateaux/Erosion forms on Karoo rocks/ River valleys
Parent material: Alluvial deposits
Erosion: no evidence

Groundwater table: -
Drainage class: Well drained

Land use and vegetation: -

Classification (WRB, 1998): skeletic-calcaric Fluvisol

Observations:

Description (FAO Guidelines for Soil Description)

000-020 cm **A**
COLOUR: Matrix colour (wet): 7.5YR 4/4. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: Few, medium gravel, rounded, limestone and quartzite. STRUCTURE: Weak, fine, sub-angular blocky. CONSISTENCE: Soft. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

020-999 cm **C (gravels)**
COLOUR: Matrix colour (wet): 7.5YR 4/4. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: Abundant, stones, rounded, limestone and quartzite. STRUCTURE: Very weak, fine, sub-angular blocky. CONSISTENCE: Soft. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Limited by skeletic horizon.

A.2.35. sodic Calcisols

Sodic Calcisols are very deep, imperfectly to moderately well drained and coarse to moderately coarse textured without rock fragments. These soils are slightly to moderately saline and sodic.

The profile has developed a calcic horizon. The typical sequence of layers in the soil is A-Bw-Bwck or A-E-Bw-Bwck.

These soils are classified as sodic Calcisols (WRB, 1998); haplic Calcisol (FAO, 1988) and Typic Halaquept (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is very dark grey (10YR 3/1) to olive grey (5Y 5/2). The texture is sand to sandy loam. The pH is high to very high, the equivalent calcium carbonate is low and the organic matter content is very low.

The E horizon, that appears occasionally, is 2 to 10 cm thick. Its colour (wet) is greyish brown (10YR 5/2) to light grey (2.5Y 7/2). The texture is sand.

The Bw horizon is around 30 cm thick and present a massive or very coarse columnar structure, and a extremely hard consistence when dry, probably associated with temporally floodings during the rainy season and the presence of sodium as dominating cation in the soil. They have a colour (wet) dark grey (10YR 4/1) to light brownish grey (10YR 6/2). The texture is sand to sandy loam. The pH is very high and the equivalent calcium carbonate is low. Occasionally, because of the loose consistence of the surface horizon, this horizon can be exposed at the surface.

The Bwck horizon reaches down more than 100 cm and presents accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon. It has a colour (wet) dark grey (10YR 4/1) to pale yellow (2.5Y 7/3). The texture is sand to sandy loam. The pH is very high and the equivalent calcium carbonate is medium to moderately high.

2. Representative profile

The representative profile is **OWA-97**

Profile: OWA-97
Description date: 28/07/99
Authors: H. Mouton, E. Ascaso and G. Hangara

Cartography

Scale:	1:250.000	
Projection:	Gauss Conformal Projection (Bessel's Spheroid)	
Sheet number:	1714	
UTM Grid Zone:	34K, Clark 1880 Spheroid	
Coordinates:	Longitude	15°38'12''
	Latitude	17°27'13''

Landform/Land element:	Kalahari Sands Plateau. Oshana system
Parent material:	alluvial deposits
Erosion:	no evidence
Groundwater table:	-
Drainage class:	Imperfectly drained
Land use and vegetation:	Extensive grazing
Classification (WRB, 1998):	sodic Calcisol

Observations:

Description (FAO Guidelines for Soil Description)

000-020 cm **A**
COLOUR: Matrix colour (wet): 2.5Y 4/3. MOTTLES: Few, fine, faint and orange. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Moderate, very coarse, columnar. CONSISTENCE: Very hard. SOIL REACTION: Carbonates: No calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

020-040 cm **Bwck1**
COLOUR: Matrix colour (wet): 2.5Y 5/2. MOTTLES: Few, fine, faint and orange. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Weak, medium, sub-angular blocky. CONSISTENCE: Very friable. CONCENTRATIONS: Few, nodules, fine, rounded, soft of calcium carbonate. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Calcic**.

040-110 cm **Bwck2**
COLOUR: Matrix colour (wet): 2.5Y 7/2. MOTTLES: Common, fine, prominent and black. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Weak, medium, sub-angular blocky. CONSISTENCE: Very friable. CONCENTRATIONS: Very few, nodules, medium, irregular, soft of calcium carbonate. SOIL REACTION: Carbonates: Moderately calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Cambic**.

110-130 cm **Bwck3**
COLOUR: Matrix colour (wet): 2.5Y 7/1. MOTTLES: Common, fine, prominent and black. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Weak,

medium, sub-angular blocky. CONSISTENCE: Very friable. CONCENTRATIONS: Very few, nodules, medium, rounded, soft of calcium carbonate. SOIL REACTION: Carbonates: Moderately calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. DIAGNOSTIC HORIZON: **Cambic**.

A.2.36. sodic Cambisols

Sodic Cambisols are very deep, imperfectly to moderately well drained and coarse to moderately coarse textured without rock fragments. These soils are slightly to moderately saline and sodic.

The typical sequence of layers in the soil is A-Bw1-Bw2 or A-E-Bw1-Bw2.

These soils are classified as sodic Cambisols (WRB, 1998); eutric Cambisols (FAO, 1988) and Typic Halaquept (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is very dark greyish brown (10YR 3/2) to light brownish grey (10YR 6/2). The texture is sand to sandy loam. The pH is high to very high, the equivalent calcium carbonate is low and the organic matter content is very low.

The E horizon, that appears occasionally, is 2 to 10 cm thick. Its colour (wet) is greyish brown (10YR 5/2) to light grey (2.5Y 7/2). The texture is sand.

The Bw1 horizon is around 30 cm thick and present a massive or very coarse columnar structure, and a extremely hard consistence when dry, probably associated with temporally floodings during the rainy season and the presence of sodium as dominating cation in the soil. They have a colour (wet) dark grey (10YR 4/1) to light brownish grey (10YR 6/2). The texture is sand to sandy loam. The pH is very high and the equivalent calcium carbonate is low.

The Bw2 horizon reaches down more than 100 cm. It has a colour (wet) greyish brown (10YR 5/2) to very pale brown (10YR 7/3). The texture is sand to sandy loam. The pH is very high and the equivalent calcium carbonate is low to moderate. Occasionally can present few accumulations of calcium carbonate (nodules) and/or gypsum (crystals).

2. Representative profile

The representative profile is **OWA-118**

Profile:	OWA-118
Description date:	31/07/99
Authors:	E. Ascaso, J. Kutuahupira and P. Festus

<u>Cartography</u>

Scale:	1:250.000
Projection:	Gauss Conformal Projection (Bessel’s Spheroid)
Sheet number:	1714

UTM Grid Zone: 34K, Clark 1880 Spheroid
Coordinates: Longitude 15°26'45''
Latitude 17°57'02''

Landform/Land element: Kalahari region/Flooded and over-flooded area/ Moderately dense inflowing stream pattern
Parent material: alluvial deposits
Erosion: no evidence

Groundwater table: -
Drainage class: Imperfectly drained

Land use and vegetation: Mopane savannah

Classification (WRB, 1998): sodic Cambisol

Observations:

Description (FAO Guidelines for Soil Description)

000-008 cm **A**
COLOUR: Matrix colour (wet): 10YR 5/2. MOTTLES: None. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Very weak, medium, sub-angular blocky. CONSISTENCE: Soft. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Abrupt. DIAGNOSTIC HORIZON: **Ochric**.

008-023 cm **Bw1**
COLOUR: Matrix colour (wet): 10YR 5/1. MOTTLES: Common, very fine, distinct and orange. TEXTURE: Sand. ROCK FRAGMENTS: None. STRUCTURE: Moderate, very coarse, columnar. CONSISTENCE: Extremely hard. CONCENTRATIONS: None. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear.

023-068 cm **Bwck**
COLOUR: Matrix colour (wet): 10YR 5/1. MOTTLES: Common, very fine, distinct and orange. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, medium, sub-angular blocky. CONSISTENCE: Friable. CONCENTRATIONS: Few, nodules, fine, irregular, soft of calcium carbonate and few, nodules, fine, rounded, hard and soft of iron-manganese. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual. DIAGNOSTIC HORIZON: **Cambic**.

068-120 cm **Bw2**
COLOUR: Matrix colour (wet): 10YR 5/1. MOTTLES: Many, medium, distinct and black. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Moderate, coarse, sub-angular blocky. CONSISTENCE: Firm. CONCENTRATIONS: Few, nodules, fine, round, hard and soft, iron-manganese. SOIL REACTION: Carbonates: Non calcareous. BIOLOGICAL ACTIVITY: Roots: Normal.

A.2.37. sodic Gypsisols

Sodic Gypsisols are very deep, imperfectly to moderately well drained and coarse to moderately coarse textured without rock fragments. These soils are slightly to moderately saline and sodic.

The profile has developed a gypsic horizon. The typical sequence of layers in the soil is A-Bw-Bwcy or A-E-Bw-Bwcyk.

These soils are classified as sodic Gypsisols (WRB, 1998); haplic Gypsisols (FAO, 1988) and Typic Halaquept (Soil Taxonomy, 1996).

1. Range of characteristics

The A horizon is 15 to 25 cm thick. Its colour (wet) is dark grey (5Y 4/1) to pale brown (10YR 6/3). The texture is sand to sandy loam. The pH is high to very high, the equivalent calcium carbonate is low and the organic matter content is very low.

The E horizon, that appears occasionally, is 2 to 10 cm thick. Its colour (wet) is greyish brown (10YR 5/2) to light grey (2.5Y 7/2). The texture is sand.

The Bw horizon is around 30 cm thick and present a massive or very coarse columnar structure, and a extremely hard consistence when dry, probably associated with temporally floodings during the rainy season and the presence of sodium as dominating cation in the soil. They have a colour (wet) grey (10YR 6/1) to very pale yellow (10YR 7/3). The texture is sand to sandy loam. The pH is very high and the equivalent calcium carbonate is low. Occasionally, because of the loose consistence of the surface horizon, this horizon can be exposed at the surface.

The Bwcyk horizon reaches down more than 100 cm and presents accumulations of gypsum as discontinuous concentrations of crystals and of calcium carbonate as discontinuous concentrations of hard and soft nodules, resulting in a gypsic horizon. It has a colour (wet) greyish brown (10YR 5/2) to pale yellow (5Y 7/3). The texture is sand to sandy loam. The pH is very high and the equivalent calcium carbonate is medium to moderately high.

1. Representative profile

The representative profile is **OWA-143**

Profile: OWA-143
Description date: 30/07/99
Authors: H. Mouton, E. Ascaso and G. Hangara

Cartography

Scale:	1:50.000	
Projection:	Gauss Conformal Projection (Bessel's Spheroid)	
Sheet number:	1715 DBC	
UTM Grid Zone:	34K, Clark 1880 Spheroid	
Coordinates:	Longitude	15°49'26''
	Latitude	17°30'08''

Landform/Land element: Kalahari Sands Plateau. Oshana system
Parent material: alluvial deposits
Erosion: no evidence

Groundwater table: -
Drainage class: Imperfectly drained

Land use and vegetation: Annual cropping system. Millet

Classification (WRB, 1998): sodic Gypsisol

Observations:

Description (FAO Guidelines for Soil Description)

000-014 cm **A**
COLOUR: Matrix colour (wet): 5Y 4/1. MOTTLES: Very few, very fine, faint and orange. TEXTURE: Loamy sand. ROCK FRAGMENTS: None. STRUCTURE: Moderate, very coarse, columnar. CONSISTENCE: Very hard. SOIL REACTION: Carbonates: Slightly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Ochric**.

014-031 cm **Bwcyk1**
COLOUR: Matrix colour (wet): 5Y 7/2. MOTTLES: Few, fine, distinct and orange. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Very weak, medium, sub-angular blocky. CONSISTENCE: Very friable. CONCENTRATIONS: Common, crystals, very fine, irregular, soft of gypsum and few, nodules, fine, rounded, soft of calcium carbonate. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Clear. DIAGNOSTIC HORIZON: **Gypsic**.

031-062 cm **Bwcyk2**
COLOUR: Matrix colour (wet): 5Y 7/3. MOTTLES: Common, fine, distinct and orange. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Weak, medium, sub-angular blocky. CONSISTENCE: Friable. CONCENTRATIONS: Few, crystals, very fine, irregular, soft of gypsum and few, nodules, fine, irregular, soft of calcium carbonate. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. HORIZON BOUNDARY: Gradual. DIAGNOSTIC HORIZON: **Cambic**.

062-120 cm **Bwck**

COLOUR: Matrix colour (wet): 5Y 7/2. MOTTLES: Common, fine, prominent and orange. TEXTURE: Sandy loam. ROCK FRAGMENTS: None. STRUCTURE: Weak, coarse, sub-angular blocky. CONSISTENCE: Friable. CONCENTRATIONS: Common, nodules, coarse, irregular, soft of calcium carbonate and common, nodules, fine, irregular, soft of iron-manganese. SOIL REACTION: Carbonates: Strongly calcareous. BIOLOGICAL ACTIVITY: Roots: Normal. DIAGNOSTIC HORIZON: **Calcic**.

Photo 7: sodic Gypsisol

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
NAM-1/1	8.4	93	0.3	87	7	6													
NAM-1/2	8.1	55	0.2	81	8	11													
NAM-3/1	6.4	13	0.3	84	9	8													
NAM-3/2	6.7	15	0.2	83	8	10													
NAM-3/3	6.3	10	0.2	78	9	13													
NAM-8/1	6.5	41	0.4	81	10	9													
NAM-8/2	7.3	30	0.3	66	11	24													
NAM-10/1	6.3	35	0.3	81	9	10													
NAM-10/2	6.3	40	0.2	82	6	12													
NAM-10/4	6.8	22	0.1	80	6	14													
NAM-11/1	7.0	16	0.2	88	7	6													
NAM-11/2	7.8	30	0.2	84	7	9													
NAM-12/1	8.4	90	0.6	90	6	3		0											
NAM-13/1	7.5	26	0.2	88	6	6													
NAM-13/2	7.9	22	0.1	82	5	13													
NAM-20/1	7.6	34	0.4	77	7	17													
NAM-20/2	8.0	60	0.3	77	6	18		0											
NAM-21/1	8.5	57	0.3	87	8	5		0											
NAM-21/2	8.6	74	0.2	88	5	8		0											
NAM-72/1	8.9	79	0.5	47	36	17		16											
NAM-72/2	8.6	229	0.4	44	32	25		20											
NAM-73/1	8.8	101	0.7	44	42	14		23											
NAM-73/2	8.9	108	0.5	38	39	23		29											
NAM-73/3	8.6	163	0.4	39	36	25		31											
NAM-75/1	8.4	93	0.6	70	26	4		9											
NAM-103/1	6.9	78	0.5	79	17	4		6											
NAM-263/1	7.5	30	0.2	95	3	2													
NAM-266/1	6.2	11	0.2	91	7	2													
NAM-266/2	6.1	10	0.1	89	7	4													
NAM-266/3	6.1	19	0.1	89	6	5													
NAM-270/1	6.8	10	0.1	88	8	4													
NAM-270/2	6.2	8	0.1	90	5	5													
NAM-270/3	6.6	6	0.1	91	4	6													
NAM-271/1	8.1	42	0.4	86	9	5													
NAM-271/2	8.0	38	0.3	87	9	4													
NAM-273/1	8.5	33	0.3	88	8	4													
NAM-276/1	7.4	18	0.1	91	5	4													
NAM-276/2	6.9	19	0.1	83	5	12													
NAM-276/3	7.0	38	0.0	85	6	10													
NAM-277/1	8.0	41	0.2	85	7	8													
NAM-277/2	7.9	36	0.2	77	9	15													
NAM-277/3	7.7	71	0.2	73	7	20													
NAM-280/1	8.8	70	0.4	75	7	18													
NAM-280/2	8.6	133	0.8	43	30	27		0											
NAM-280/3	9.2	91	0.4	49	31	20		51											
NAM-281/1	9.0	55	0.4	80	16	5		2											
NAM-282/1	8.8	995	0.5	31	17	53		11											
NAM-282/2	8.2	322	1.2	49	2	50		1											
NAM-282/3	8.9	200	0.7	18	25	57		1											
NAM-285/1	8.9	66	0.2	83	11	6		2											
NAM-285/2	9.1	70	0.2	82	8	10		2											
NAM-286/1	9.0	43	0.2	90	7	3		1											
NAM-289/1	9.0	83	0.4	40	37	23													
NAM-289/2	9.2	15	0.1	48	27	25													
NAM-289/3	10.3	617	0.1	42	34	24													
NAM-293/1	7.0	30	0.0	96	3	2													
NAM-293/2	6.9	51	0.0	92	6	2													
NAM-294/1	8.2	23	0.2	88	9	3													
NAM-294/2	9.1	39	0.1	90	6	4													
NAM-296/1	9.0	258	0.4	24	63	14		44											
NAM-296/2	8.9	858	0.3	20	74	5		44											
NAM-297/1	8.1	30	0.1	88	8	4													
NAM-297/2	7.7	13	0.1	89	8	3													
NAM-302/1	9.1	45	0.0	95	3	2													

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
NAM-302/2	8.7	26	0.0	94	4	2													
NAM-302/3	7.0	24	0.0	93	4	3													
NAM-304/1	8.6	16280	0.6	73	15	12		21											
NAM-304/2	8.9	11310	0.7	48	33	19		39											
NAM-304/3	9.0	9490	0.3	41	17	42		36											
NAM-305/1	9.1	59	0.3	84	12	4		2											
NAM-305/2	9.0	65	0.4	77	15	8		4											
NAM-307/1	8.8	62	0.1	94	4	2													
NAM-307/2	8.1	26	0.0	90	7	3													
NAM-307/3	7.8	113	0.5	92	7	1													
NAM-331/1	8.5	86	0.7	54	40	7		1											
NAM-331/2	8.9	67	0.1	50	4	46		4											
NAM-332/1	9.1	57	0.3	73	22	6		1											
NAM-332/2	10.0	101	0.1	66	22	12		7											
NAM-332/3	9.9	773	0.1	54	32	14		11											
NAM-332/4	10.2	1003	0.1	48	37	16		10											
NAM-336/1	9.6	66	0.5	75	20	5		2											
NAM-336/2	9.3	520	0.2	78	12	10		3											
NAM-336/3	8.9	2560	0.1	74	12	15		2											
NAM-337/1	9.8	156	0.1	59	37	4		7											
NAM-337/2	9.0	5480	0.1	55	36	9		18											
NAM-339/1	9.5	76	0.3	79	18	3		5											
NAM-339/2	9.6	68	0.2	80	16	5		2											
NAM-340/1	9.0	84	0.4	70	20	10		2											
NAM-340/2	8.6	44	0.2	63	15	23		2											
NAM-346/1	9.1	123	0.4	26	38	36		3											
NAM-346/2	9.3	165	0.3	23	22	55		4											
NAM-351/1	9.2	77	0.6	44	49	6		11											
NAM-354/1	9.2	73	0.3	66	26	8		1											
NAM-354/2	9.3	213	1.3	69	25	7		4											
NAM-357/1	9.3	48	0.1	88	9	3													
NAM-357/2	9.2	29	0.6	88	6	6													
NAM-360/1	9.1	37	0.3	73	24	4													
NAM-363/1	8.8	50	0.4	89	5	6													
NAM-364/1	8.7	31	0.3	88	8	4													
NAM-364/2	8.5	16	0.1	87	7	6													
NAM-365/1	8.7	29	0.3	91	5	4													
NAM-365/2	8.6	26	0.1	90	4	7													
NAM-371/1	9.0	99	0.5	25	64	11		14											
NAM-371/2	8.6	390	0.4	27	52	21		16											
NAM-371/3	8.8	235	0.3	28	49	22		13											
NAM-373/1	9.7	373	0.5	28	50	23		48											
NAM-373/2	8.8	2530	0.4	23	40	37		50											
NAM-373/3	9.2	1220	0.3	20	49	31		80											
NAM-377/1	9.0	64	0.5	56	34	10													
NAM-377/2	8.9	47	0.4	53	33	15													
NAM-382/1	9.0	71	0.4	70	25	5													
NAM-382/2	9.3	41	0.2	69	23	9													
NAM-382/3	9.3	83	0.1	69	25	6													
NAM-382/4	9.2	143	0.2	61	26	13													
NAM-383/1	7.2	88	0.2	78	14	8													
NAM-383/2	6.9	33	0.2	71	16	13													
NAM-385/1	8.5	146	0.2	76	16	8													
NAM-401/1	9.0	108	0.8	65	29	6		6											
NAM-401/2	8.9	78	0.5	62	27	12		8											
NAM-403/1	8.7	118	2.2	54	39	7		6											
NAM-403/2	8.9	66	1.2	52	37	11		8											
NAM-404/1	8.7	125	1.3	72	24	4		22											
NAM-404/2	9.3	131	0.9	65	27	8		24											
NAM-404/3	9.0	3960	0.5	60	28	13		50											
NAM-405/1	9.3	49	0.4	65	26	10		2											
NAM-408/1	9.6	75	0.2	78	18	4		11											
NAM-408/2	9.9	105	0.2	74	22	4		8											
NAM-408/3	9.8	367	0.0	79	17	4		6											

Horizon	pH	E.C. (1:2.5)	O.C.	Sand	Silt	Clay	C.E.C.	CaCO3	Gypsum	pH (paste)	E.C.(paste)	Ca	Mg	Na	K	Cl	SO4	HCO3	CO3
Reference	1:2.5	(microS/cm) 25ºC	(%)	(%)	(%)	(%)	(cmol+/kg)	(%)	(%)	1:2.5	(microS/cm) 25ºC	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)
NAM-413/1	9.1	92	0.8	67	30	3		9											
NAM-415/1	8.5	44	0.4	66	22	12		0											
NAM-415/2	9.1	116	0.9	60	23	16		2											
NAM-415/3	8.4	78	0.1	60	26	15		0											
NAM-421/1	8.9	32	0.0	69	25	6													
NAM-421/2	8.8	309	0.0	71	24	5													
NAM-424/1	8.1	18	0.1	75	21	4													
NAM-424/2	8.0	26	0.5	68	24	7													
NAM-425/1	9.3	39	0.3	56	28	16													
NAM-425/2	8.2	171	0.4	40	26	34													
NAM-425/3	7.5	227	0.4	76	20	4													
NAM-431/1	9.5	77	1.0	70	21	9		2											
NAM-431/2	8.5	82	0.2	65	21	14		2											
NAM-431/3	8.9	144	0.3	65	21	14		9											
NAM-431/4	9.2	224	0.1	58	26	16		6											
NAM-434/1	9.0	103	3.6	26	54	20		5											
NAM-434/2	8.9	174	1.0	25	45	30		13											
NAM-445/1	7.8	11	0.2	93	5	3													
NAM-445/2	7.9	7	0.1	92	5	3													
NAM-445/3	8.1	8	0.1	93	4	3													
NAM-448/1	7.0	20	0.2	93	5	2													
NAM-448/2	7.0	13	0.2	91	6	4													
NAM-448/3	7.1	14	0.1	93	5	2													
NAM-448/4	7.7	254	0.2	86	6	8													
NAM-449/1	7.1	19	0.1	87	7	6													
NAM-449/2	7.9	206	0.1	83	10	7													
NAM-449/3	8.5	25	0.0	91	7	2													
NAM-449/4	8.4	1100	0.3	79	5	16													
NAM-450/1	9.1	64	0.2	76	16	9		2											
NAM-450/2	9.2	63	0.3	70	12	18		5											
NAM-453/1	6.6	9	0.1	93	2	5													
NAM-453/2	7.9	17	0.1	94	1	7													
NAM-453/3	5.5	15	0.1	89	3	7													
NAM-455/1	8.0	214	0.3	83	6	11													
NAM-455/2	8.2	497	0.3	83	4	14													
NAM-455/3	8.7	248	0.1	81	9	10													
NAM-459/1	7.8	16	0.2	97	4	7													
NAM-459/2	8.3	13	0.1	89	3	8													
NAM-461/1	6.9	21	0.2	90	4	6													
NAM-461/2	7.8	18	0.1	90	4	7													
NAM-461/3	7.6	12	0.1	92	1	8													
NAM-463/1	7.8	1550	0.8	90	6	4			6										
NAM-463/2	8.2	2030	0.3	36	25	39			109										
NAM-475/1	7.1	78	0.1	75	22	3													
NAM-475/2	8.2	84	0.1	74	20	5													
NAM-475/3	8.4	239	0.1	72	21	8													
NAM-477/1	9.2	77	0.2	57	28	15		27											
NAM-477/2	9.5	582	0.2	52	26	22		9											
NAM-477/3	8.8	1810	0.1	54	25	21		12											
NAM-479/1	7.4	36	0.3	76	19	5													
NAM-480/1	9.0	93	0.1	45	39	16		6											
NAM-480/2	8.9	109	0.2	37	37	26		8											
NAM-484/1	8.6	50	0.4	70	18	13													
NAM-484/2	8.3	25	0.1	60	16	23													
NAM-484/3	7.9	245	0.2	64	12	25													
NAM-489/1	7.6	18	0.4	90	5	5													
NAM-489/2	7.9	15	0.5	91	3	6													
NAM-489/3	9.0	82	0.6	56	27	16													
NAM-492/1	8.2	60	0.5	61	18	20													
NAM-492/3	7.6	20	0.4	81	14	6													
NAM-494/1	7.6	12	1.3	72	17	11													
NAM-494/2	8.3	60	1.3	66	21	13													
NAM-494/3	8.4	66	0.8	60	27	12													
NAM-495/1	8.2	71	0.1	37	35	28													

Horizon	pH	E.C. (1:2.5)	O.C.	Sand	Silt	Clay	C.E.C.	CaCO3	Gypsum	pH (paste)	E.C.(paste)	Ca	Mg	Na	K	Cl	SO4	HCO3	CO3
Reference	1:2.5	(microS/cm) 25ºC	(%)	(%)	(%)	(%)	(cmol+/kg)	(%)	(%)	1:2.5	(microS/cm) 25ºC	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)
NAM-495/2	8.1	104	1.5	48	29	23													
NAM-495/3	8.3	89	1.5	41	31	28													
NAM-502/1	8.1	100	0.7	42	28	30		1											
NAM-502/3	9.3	87	0.5	77	17	7		4											
NAM-503/1	8.7	3280	0.6	63	25	13													
NAM-503/2	9.4	1730	0.1	66	23	12													
NAM-505/1	9.2	1800	0.2	53	30	17		17											
NAM-511/1	8.2	2800	0.4	81	15	5			33										
NAM-511/2	8.5	2160	0.0	95	2	3			62										
NAM-511/3	8.6	1780	0.0	97	0	2			30										
NAM-512/1	8.4	2940	0.3	77	17	6		5											
NAM-512/2	8.5	6680	0.1	90	5	5			63										
NAM-513/1	8.6	2600	0.1	89	9	2		12											
NAM-513/2	8.7	6240	0.1	91	9	0		18											
NAM-514/1	9.2	1400	0.1	89	10	2		5											
NAM-514/2	7.9	2780	0.1	83	11	6		13											
NAM-514/3	8.7	3000	0.4	89	6	5		7	11										
NAM-515/1	8.2	13620	0.1	70	26	5		3											
NAM-515/2	8.6	7580	0.2	80	16	4		9	5										
NAM-516/1	8.7	431	0.1	86	13	1		1											
NAM-516/2	8.6	1680	0.1	65	27	8		28											
NAM-516/3	9.1	3550	0.1	78	16	6		17											
NAM-516/4	8.6	4260	0.1	84	13	3		9											
NAM-517/1	8.5	1890	0.2	75	20	5		8											
NAM-518/1	8.8	193	0.2	79	19	2		9											
NAM-519/1	7.7	93	0.3	80	19	1		0											
NAM-519/2	8.2	3730	0.1	78	17	6		12											
NAM-520/1	8.1	3420	0.2	79	15	6													
NAM-521/1	9.1	145	0.1	91	8	1		4											
NAM-522/1	9.3	112	0.1	90	10	1		9											
NAM-523/1	7.8	14230	0.7	76	15	9		24											
NAM-523/2	8.1	37500	0.3	75	15	11		28	13										
NAM-523/3	8.0	12360	0.1	79	14	7		21	14										
NAM-524/1	7.8	7220	0.1	82	12	7		12											
NAM-524/2	7.9	6520	0.1	74	6	20		14	77										
NAM-525/1	8.6	4480	0.2	65	28	7		7											
NAM-525/2	8.3	3020	0.1	65	25	10		19											
NAM-526/1	8.4	5550	0.3	86	10	3													
NAM-526/2	8.1	2690	0.1	93	5	2			49										
NAM-527/1	8.5	662	0.4	93	7	1		1											
NAM-527/2	9.0	508	0.2	91	8	2		3											
NAM-527/3	8.4	2280	0.1	90	7	3		3											
NAM-527/4	8.4	2320	0.0	89	8	3		3	4										
NAM-528/1	8.5	2720	0.3	83	12	5		6											
NAM-528/2	9.1	2490	0.1	87	8	5		2	49										
NAM-529/1	9.0	2670	0.2	91	7	2													
NAM-529/2	9.1	1340	0.1	93	4	3													
NAM-530/1	9.1	8.33	0.1	85	11	4													
NAM-530/2	9.3	207	0.1	96	2	2													
NAM-530/3	9.1	469	0.0	96	1	3													
NAM-530/4	8.9	1710	0.0	96	0	4													
NAM-531/1	8.3	5600	0.2	70	20	9		14	8										
NAM-531/2	8.3	11330	0.2	90	-2	12			82										
NAM-532/1	8.7	5060	0.3	74	17	9		5	4										
NAM-532/2	8.4	6810	0.2	72	18	10		7	7										
NAM-533/1	8.8	451	0.3	87	11	2		1											
NAM-533/2	9.0	915	0.1	82	13	5		9											
NAM-533/3	8.8	2440	0.1	87	9	5		6											
NAM-534/1	8.1	4580	0.3	77	19	4													
NAM-534/2	8.4	3690	0.3	78	19	4			8										
NAM-534/3	8.6	2800	0.2	87	9	5			60										
NAM-535/1	8.6	5870	0.2	83	13	4													
NAM-535/2	8.4	5740	0.2	70	16	14													
NAM-535/3	8.2	13900	0.2	76	7	17			38										

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
NAM-536/1	9.0	578	0.1	93	6	1													
NAM-537/1	9.3	259	0.1	91	8	1		4											
NAM-537/2	8.4	2020	0.2	75	21	5		17	18										
NAM-538/1	8.4	1820	0.2	75	18	7		7											
NAM-538/2	8.6	9770	0.3	81	5	14		12	52										
NAM-542/1	9.1	171	0.2	73	16	11		8											
NAM-542/2	9.4	68	0.2	75	13	12		13											
NAM-544/1	10.2	207	0.2	76	13	11		3											
NAM-544/2	10.0	368	0.2	73	11	16		3											
NAM-544/3	8.6	2880	0.1	53	25	22		14											
NAM-547/1	9.7	122	0.2	86	9	5		6											
NAM-547/2	10.7	1880	0.2	60	17	23		21											
NAM-547/3	11.1	6720	0.2	47	29	24		28											
NAM-548/1	9.5	86	0.5	66	23	11		4											
NAM-548/2	9.5	86	0.4	60	24	16		11											
NAM-548/3	9.1	81	0.2	54	27	19		22											
NAM-549/1	9.5	77	0.2	50	27	24		2											
NAM-549/2	9.5	100	0.3	46	25	28		29											
NAM-549/3	8.7	492	0.2	44	27	29		5											
NAM-564/1	8.3	73	0.3	79	16	6													
NAM-569/1	8.4	45	0.2	66	25	9													
NAM-572/1	8.4	74	0.3	81	16	4													
NAM-573/1	8.8	79	0.4	72	19	9		3											
NAM-574/1	8.6	68	0.2	77	16	7		3											
NAM-574/2	8.7	70	0.2	51	22	27		8											
NAM-574/3	8.7	92	0.1	54	31	16		12											
NAM-575/1	7.8	547	0.4	52	28	20		1											
NAM-575/2	7.8	1308	0.4	48	37	15		4											
NAM-575/3	7.8	1353	0.6	44	40	16		5											
NAM-575/4	7.9	2080	0.3	47	43	10		2											
NAM-577/1	9.3	163	0.2	58	27	15		6											
NAM-577/2	9.5	662	0.2	60	22	18		7											
NAM-577/3	8.9	1834	0.2	64	19	17		11											
NAM-581/1	9.4	79	0.3	85	6	9		3											
NAM-581/2	9.6	102	0.0	97	1	2		3											
NAM-581/3	9.3	317	0.2	72	11	17		13											
NAM-582/1	11.2	1448	0.2	68	21	11		15											
NAM-586/1	9.9	68	0.2	88	3	9		13											
NAM-586/2	10.6	18	0.2	68	19	13		46											
NAM-590/1	9.7	92	0.2	70	21	9		8											
NAM-590/2	9.3	353	0.2	57	29	14		27											
NAM-621/1	9.2	215	0.3	62	20	18		4											
NAM-621/2	9.2	244	0.3	47	50	3		6											
NAM-624/1	9.1	52	0.5	51	31	19													
NAM-624/2	9.3	60	0.2	56	23	21													
NAM-626/1	8.5	10750	0.4	50	30	20		3											
NAM-626/2	8.3	8880	0.2	77	14	10		8											
NAM-626/3	8.1	10590	0.2	46	25	28		18											
NAM-627/1	8.9	1594	0.3	51	24	25		5											
NAM-627/2	8.4	5710	0.0	56	30	14		16											
NAM-552/1	9.3	88	0.2	79	10	11		3											
NAM-552/2	9.4	52	0.1	84	6	9		2											
NAM-552/3	8.4	63	0.2	77	14	9		6											
NAM-552/4	8.6	53	0.2	88	7	5		0											
NAM-552/5	8.4	65	0.1	85	7	8		0											
NAM-553/1	8.2	146	0.6	40	39	21		6											
NAM-553/2	8.7	117	0.2	39	32	29		7											
NAM-553/3	9.0	204	0.2	40	33	28		19											
NAM-554/1	8.6	96	0.4	34	48	18		7											
NAM-554/2	8.6	103	0.4	36	39	25		4											
NAM-555/1	6.6	1508	0.1	54	26	20													
NAM-557/1	8.4	1448	0.4	52	34	14		17											
NAM-557/2	8.1	180	1.0	65	12	23													
NAM-559/1	8.1	49	0.3	68	20	13													

Horizon	pH	E.C. (1:2.5)	O.C.	Sand	Silt	Clay	C.E.C.	CaCO3	Gypsum	pH (paste)	E.C.(paste)	Ca	Mg	Na	K	Cl	SO4	HCO3	CO3
Reference	1:2.5	(microS/cm) 25ºC	(%)	(%)	(%)	(%)	(cmol+/kg)	(%)	(%)	1:2.5	(microS/cm) 25ºC	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)
NAM-559/2	7.8	269	0.3	54	16	30													
NAM-601/1	9.7	69	0.1	72	19	9		9											
NAM-601/2	9.9	55	0.2	86	9	5		6											
NAM-604/1	6.9	555	0.5	71	20	10													
NAM-604/2	8.2	232	0.3	52	19	29													
NAM-606/1	9.2	71	0.6	40	21	39													
NAM-607/1	9.2	75	0.6	49	33	18		2											
NAM-607/2	9.4	70	0.8	42	32	27		1											
NAM-611/2	9.6	75	0.3	77	12	11		5											
NAM-631/1	9.0	38	0.1	46	34	21													
NAM-631/2	8.8	222	0.2	71	12	18													
NAM-631/3	9.0	142	0.1	71	12	17													
NAM-632/1	9.1	59	0.5	85	12	2													
NAM-632/2	9.3	40	0.2	81	12	7													
NAM-635/1	9.2	46	0.2	90	6	4		1											
NAM-635/2	9.4	56	0.2	81	9	10		2											
NAM-635/3	9.7	60	0.3	75	13	12		4											
NAM-636/1	9.6	48	0.2	94	5	1		2											
NAM-636/2	9.9	50	0.0	91	5	4		3											
NAM-641/1	8.2	43	0.3	72	17	11													
NAM-644/1	8.1	10	0.1	91	7	3													
NAM-644/2	7.7	49	0.1	66	27	7													
NAM-647/1	8.2	51	0.2	75	17	8													
NAM-647/2	9.0	45	0.1	67	8	25													
NAM-647/3	8.6	46	0.1	69	10	21													
NAM-647/4	8.7	123	0.1	67	9	24													
NAM-647/5	8.3	209	0.1	61	17	22													
NAM-656/1	8.7	68	0.2	72	24	4		5											
NAM-663/1	8.6	85	0.2	68	18	14													
NAM-668/1	9.0	44	0.1	52	36	12													
NAM-668/2	8.9	43	0.2	78	13	9													
NAM-668/3	8.4	173	0.2	67	13	22													
NAM-669/1	8.9	85	0.5	75	20	6		24											
NAM-671/1	9.2	100	0.3	32	37	32													
NAM-671/2	9.3	103	0.2	44	23	33													
NAM-671/3	9.4	97	0.2	33	42	25													
NAM-671/4	8.9	101	0.1	26	47	27													
NAM-674/1	8.9	62	0.2	76	17	7													
NAM-674/2	8.8	26	0.1	84	12	4													
NAM-674/3	9.0	34	0.1	74	20	6													
NAM-676/1	9.3	61	0.1	82	15	2		12											
NAM-676/2	9.2	83	0.1	83	14	3		16											
NAM-677/1	9.1	77	0.1	84	15	2													
NAM-678/1	9.1	111	0.1	79	15	6		15											
NAM-685/1			0.2	52	43	5		34											
NAM-685/2	9.1	85	0.2	61	30	9		25											
NAM-686/1	9.2	82	0.2	59	34	7		6											
NAM-686/2	9.2	85	0.2	53	33	14		18											
NAM-686/3	8.3	627	0.1	42	43	15		32											
NAM-687/1	8.2	1564	0.1	54	28	18		16											
NAM-687/2	8.5	617	0.2	63	32	5		10											
NAM-687/3	8.0	3740	0.2	46	32	23		30											
NAM-690/1	8.1	142	0.3	76	10	14		1											
NAM-690/2	8.8	71	0.6	66	33	2		8											
NAM-690/3	9.3	84	0.4	77	16	8		0											
NAM-694/1	7.8	13	0.2	85	12	3		2											
NAM-696/1	8.6	83	0.6	68	22	10		12											
NAM-698/1	8.2	37	0.2	98	0	1		0											
NAM-698/2	8.9	85	0.5	87	12	1		20											
NAM-698/3	9.4	40	0.1	88	14	25		0											
NAM-703/1	8.8	20	0.1	90	3	7													
NAM-703/2	8.6	16	0.1	92	6	2													
NAM-705/1	9.2	38	0.1	97	3	6													
NAM-705/2	9.2	57	0.2	84	27	43													

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
NAM-705/3	9.0	80	0.2	74	7	19													
NAM-710/1	9.1	56	0.2	91	7	2		3											
NAM-710/2	8.5	79	0.1	84	1	18		5											
NAM-711/1	8.8	34	0.1	97	9	13		0											
NAM-711/2	8.6	64	0.2	73	7	19		1											
NAM-711/3	8.7	95	0.2	70	11	20		5											
NAM-715/1	8.9	58	0.2	88	9	3		1											
NAM-715/2	9.2	162	0.2	71	22	8		0											
NAM-715/3	8.8	65	0.3	84	4	12		2											
NAM-717/1	8.6	45	0.2	82	13	5		3											
NAM-717/2	8.2	1670	0.2	79	9	12		6											
NAM-717/3	8.0	2350	0.2	77	2	25		1											
NAM-727/1	8.5	34	0.3	83	14	3													
NAM-727/2	9.1	63	0.2	81	13	7													
NAM-727/3	8.7	35	0.2	70	21	9													
NAM-731/1	8.8	224	0.2	66	29	6		7											
NAM-731/2	8.8	2450	0.3	72	22	6		10											
NAM-731/3	8.1	6520	0.2	72	25	3		20											
NAM-734/1	9.3	63	0.2	83	15	3		1											
NAM-734/2	8.7	64	0.2	79	11	10		1											
NAM-734/3	8.2	1660	0.1	91	5	5		1											
NAM-735/1	9.8	85	0.2	95	5	0													
NAM-735/2	9.5	82	0.2	94	3	3													
NAM-741/1	7.9	2580	0.4	55	32	14		2											
NAM-741/2	7.8	3020	0.3	42	35	23		4											
NAM-742/1	8.5	104	0.3	62	29	9													
NAM-742/2	8.4	66	0.4	81	14	6													
NAM-746/1	9.1	74	0.3	92	7	1		2											
NAM-746/2	9.5	616	0.1	62	31	8		38											
NAM-747/1	8.4	953	0.5	77	16	7		2											
NAM-747/2	8.8	1220	0.3	74	16	11		1											
NAM-747/3	8.7	2330	0.2	69	18	13		4											
NAM-750/1	8.9	51	0.2	90	4	5		1											
NAM-750/2	9.8	286	0.1	90	5	6		0											
NAM-751/1	9.6	51	0.3	94	5	2		1											
NAM-751/2	10.2	52	0.2	91	5	4		3											
NAM-754/1	10.4	70	0.2	83	11	6		2											
NAM-756/1	9.9	83	0.2	78	12	11													
NAM-756/2	9.6	112	0.2	76	13	11													
NAM-757/1	9.2	21	0.1	91	6	3													
NAM-757/2	9.5	34	0.1	84	8	8													
NAM-757/3	9.8	55	0.1	84	7	9													
NAM-759/1	9.6	125	0.2	76	14	10		2											
NAM-761/1	9.3	55	0.2	95	6	1													
NAM-764/1	9.7	66	0.2	88	10	2		3											
NAM-764/2	8.6	952	0.2	89	9	2		2											
NAM-764/3	8.6	587	0.1	80	15	4		8											
NAM-767/1	9.3	143	0.3	90	8	2		1											
NAM-767/2	9.2	155	0.3	95	4	1		1											
NAM-768/1	9.2	60	0.4	88	9	3		2											
NAM-768/2	9.5	233	0.2	75	14	12		17											
NAM-781/1	9.6	45	0.2	93	6	1		2											
NAM-781/2	9.9	43	0.1	96	3	1		2											
NAM-781/3	9.8	96	0.2	83	10	6		4											
NAM-781/4	9.9	140	0.2	85	9	6		5											
NAM-781/5	10.1	192	0.1	90	5	5		5											
NAM-782/1	9.0	107	0.3	76	21	4		6											
NAM-784/1	9.2	58	0.2	81	16	3		4											
NAM-784/2	9.4	63	0.2	77	18	5		8											
NAM-792/1	9.6	54	0.3	92	7	1		1											
NAM-792/2	9.9	786	0.4	77	11	12		3											
NAM-792/3	9.4	1897	0.2	51	36	12		13											
NAM-792/4	9.3	2930	0.2	53	41	7		13											
NAM-795/1	8.9	41	0.3	77	19	4		1											

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
NAM-795/2	9.2	30	0.3	73	19	7		1											
NAM-795/3	9.3	60	0.3	74	20	6		2											
NAM-799/1	9.2	49	0.3	85	12	3		3											
NAM-799/2	8.8	150	0.2	84	11	4		6											
NAM-800/1	9.3	40	0.3	91	8	2		2											
NAM-800/2	9.4	49	0.6	90	8	3		3											
NAM-800/3	9.3	60	0.2	82	13	5		6											
NAM-803/1	9.2	149	0.1	65	18	17		5											
NAM-803/2	9.6	100	0.1	68	18	14		5											
NAM-803/3	8.2	3340	0.2	61	41	2		4											
NAM-803/4	8.3	3560	0.0	63	36	2		3											
NAM-804/1	8.2	86	0.1	62	22	17		3											
NAM-806/1	8.3	2749	0.3	56	27	17		21											
NAM-806/2	7.8	4170	0.2	52	26	22		17											
NAM-811/1	9.2	63	0.3	86	12	2		3											
NAM-811/2	9.2	69	0.3	86	12	2		5											
NAM-817/1	9.1	143	0.1	60	29	11		14											
NAM-818/1	8.1	1159	0.3	72	19	10		5											
NAM-818/2	8.1	2050	0.2	61	35	4		1											
NAM-818/3	7.9	185	0.2	73	17	10		1											
NAM-820/0	8.7	184	0.2	53	37	10		2											
NAM-820/1	9.3	188	0.3	51	35	14		3											
NAM-820/2	9.8	579	0.1	67	25	8		7											
NAM-820/3	8.9	2570	0.1	70	28	3		8											
NAM-820/4	8.4	6340	0.1	71	1	29		8											
NAM-827/1	8.9	227	0.2	54	36	10		13											
NAM-827/2	8.2	1252	0.2	33	58	10		12											
NAM-827/3	8.0	2670	0.2	58	27	16		8											
NAM-828/1	8.6	2310	0.2	31	46	23		10											
NAM-828/2	8.5	3070	0.2	28	58	14		8											
NAM-828/3	8.2	3050	0.2	51	42	6		2											
NAM-829/1	9.4	52	0.1	92	6	3													
NAM-829/2	9.5	54	0.2	81	16	4													
NAM-829/3	9.5	42	0.1	94	4	3													
NAM-829/4	9.2	95	0.1	86	10	4													
NAM-830/1	9.5	148	0.1	89	8	3													
NAM-830/2	9.0	4130	0.1	75	14	11													
NAM-831/1	9.2	84	0.1	77	12	11		8											
NAM-831/2	8.9	218	0.1	70	18	12		8											
NAM-831/3	8.6	348	0.1	67	22	11		15											
NAM-834/1	8.7	53	0.2	82	13	6		1											
NAM-836/1	9.1	97	0.1	66	21	12		4											
NAM-837/1	9.0	79	0.1	66	24	10		7											
NAM-837/2	9.1	87	0.1	73	14	13		7											
NAM-844/1	9.4	57	0.1	90	7	3		5											
NAM-845/1	8.0	2050	0.1	69	29	2		9											
NAM-845/2	8.1	2040	0.1	67	12	21		2											
NAM-852/1	9.1	120	0.1	85	10	5													
NAM-852/2	9.3	51	0.0	94	4	2													
NAM-852/3	9.9	54	0.0	95	3	3													
NAM-853/1	9.2	58	0.1	89	9	3		8											
NAM-853/2	8.9	23	0.0	94	3	4		1											
NAM-854/1	8.9	105	0.1	66	30	5		13											
NAM-858/1	9.2	63	0.1	87	9	4		2											
NAM-860/1	8.8	233	0.1	71	16	13		3											
NAM-860/2	8.7	377	0.1	78	14	8		3											
NAM-861/1	8.8	266	0.1	91	5	4		0											
NAM-861/2	8.1	2710	0.2	71	6	23		2											
NAM-861/3	7.9	3500	0.1	74	5	21		3											
NAM-862/1	7.9	719	0.1	87	9	5													
NAM-871/1	8.1	21	0.1	87	9	4													
NAM-871/2	9.1	106	0.1	76	14	10													
NAM-871/3	8.5	596	0.1	71	8	22													
NAM-872/1	9.0	64	0.1	91	7	2													

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
NAM-872/2	8.8	57	0.1	92	6	3													
NAM-872/3	8.6	71	0.1	89	5	6													
NAM-875/1	9.0	95	0.1	83	13	4		1											
NAM-876/1	9.1	70	0.2	84	13	3		3											
NAM-876/2	9.1	112	0.1	90	6	4		5											
NAM-885/1	8.3	132	0.4	74	21	4		0											
NAM-885/2	9.2	62	0.1	92	5	3		1											
NAM-885/3	9.4	67	0.1	83	15	3		2											
NAM-886/1	9.1	76	0.1	90	8	2		1											
NAM-886/2	9.1	37	0.1	92	6	2		1											
NAM-893/1	8.8	70	0.1	85	10	5													
NAM-893/2	8.9	81	0.1	76	11	13													
NAM-894/1	7.9	131	0.2	81	13	7													
NAM-894/2	7.5	156	0.1	81	9	11													
NAM-895/1	7.6	53	0.4	77	18	5													
NAM-895/2	7.9	39	0.2	77	7	16													
NAM-896/1	8.8	85	0.1	88	7	5		2											
NAM-896/2	9.0	81	0.1	85	7	8		2											
NAM-896/3	9.1	478	0.1	83	8	9		4											
NAM-901/1	7.8	22	0.2	87	8	5													
NAM-901/2	7.8	13	0.1	81	13	7													
NAM-901/3	8.4	20	0.1	77	13	10													
NAM-903/1	7.9	40	0.3	67	24	9													
NAM-903/2	7.4	366	0.2	73	10	17													
NAM-904/1	9.1	77	0.2	83	11	6		4											
NAM-904/2	8.9	86	0.2	76	19	5		9											
NAM-906/1	9.0	66	0.1	85	12	4		5											
NAM-906/2	6.5	19	0.3	79	17	4		0											
NAM-908/1	8.4	31	0.1	90	8	3													
NAM-910/1	8.5	82	0.6	75	23	3		1											
NAM-911/1	8.7	77	0.3	71	28	2		2											
NAM-912/1	8.7	76	0.4	72	25	3		3											
NAM-912/2	8.9	115	0.2	73	18	9		36											
NAM-914/1	8.9	65	0.3	84	12	4													
NAM-915/1	8.6	85	0.7	70	27	3													
NAM-916/1	8.1	222	0.5	47	43	10		2											
NAM-916/2	8.7	245	0.4	37	57	5		2											
NAM-916/3	8.5	187	0.3	59	37	4		19											
NAM-917/1	8.1	51	0.3	76	18	7													
NAM-917/2	7.4	98	0.2	74	13	13													
NAM-931/1	8.5	73	0.4	83	11	6													
NAM-931/2	8.7	64	0.3	74	15	11													
NAM-931/3	8.5	40	0.2	78	12	10													
NAM-931/4	8.4	30	0.1	76	13	11													
NAM-932/1	8.2	51	0.3	82	12	6													
NAM-932/2	8.2	29	0.2	78	12	10													
NAM-932/3	8.2	27	0.2	71	9	20													
NAM-933/1	8.3	67	0.3	84	9	7													
NAM-933/2	7.8	19	0.1	83	7	10													
NAM-933/3	7.9	23	0.2	67	7	26													
NAM-934/1	8.2	57	0.3	78	13	10													
NAM-934/2	8.0	23	0.3	67	13	20													
NAM-934/3	8.5	50	0.1	87	11	2													
NAM-935/1	7.9	36	0.2	79	13	9													
NAM-935/2	7.5	13	0.2	77	9	14													
NAM-935/3	7.6	15	0.2	78	8	14													
NAM-937/1	6.7	44	0.2	95	4	2													
NAM-937/2	8.1	19	0.2	94	4	2													
NAM-938/1	8.5	79	0.3	82	10	8													
NAM-938/2	8.0	15	0.2	85	9	6													
NAM-938/3	7.9	22	0.1	74	8	19													
NAM-939/1	6.4	46	0.2	86	12	3													
NAM-939/2	7.5	18	0.2	73	16	11													
NAM-940/1	6.2	17	0.3	89	8	3													

Horizon	pH	E.C. (1:2.5)	O.C.	Sand	Silt	Clay	C.E.C.	CaCO3	Gypsum	pH (paste)	E.C.(paste)	Ca	Mg	Na	K	Cl	SO4	HCO3	CO3
Reference	1:2.5	(microS/cm) 25ºC	(%)	(%)	(%)	(%)	(cmol+/kg)	(%)	(%)	1:2.5	(microS/cm) 25ºC	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)
NAM-940/2	6.8	7	0.2	86	8	6													
NAM-940/3	7.1	8	0.1	87	7	6													
NAM-941/1	8.4	78	0.3	83	11	6		2											
NAM-941/2	8.7	80	0.3	76	13	11		3											
NAM-941/3	8.7	95	0.2	63	20	17		13											
NAM-942/1	6.7	17	0.2	92	4	4													
NAM-942/2	7.5	18	0.2	93	4	4													
NAM-943/1	6.7	56	0.2	81	7	13													
NAM-943/2	6.7	11	0.2	89	6	6													
NAM-943/3	6.8	12	0.1	88	5	7													
NAM-944/1	6.2	25	0.3	90	6	5													
NAM-944/2	7.3	15	0.1	85	6	9													
NAM-944/3	7.1	20	0.2	68	23	9													
NAM-946/1	8.5	67	0.4	77	19	4		2											
NAM-946/2	8.6	85	0.5	68	23	10		11											
NAM-946/3	9.0	72	0.3	46	37	17		56											
NAM-947/1	8.1	69	0.4	83	13	5													
NAM-947/2	7.7	13	0.1	84	8	9													
NAM-948/1	8.2	68	0.4	52	12	5													
NAM-948/2	8.1	52	0.3	62	17	22													
NAM-949/1	8.0	452	0.6	36	22	42		3											
NAM-949/2	8.4	17	0.3	30	10	60		4											
NAM-950/1	6.5	17	0.2	84	9	8													
NAM-950/2	6.4	16	0.1	76	14	10													
NAM-950/3	6.4	27	0.1	74	10	16													
NAM-952/1	7.1	43	0.5	54	16	30													
NAM-952/2	7.6	31	0.2	53	18	29													
NAM-953/1	7.1	31	0.5	50	22	29		3											
NAM-953/2			0.4	51	15	34		7											
NAM-953/3			0.3	45	10	45		7											
NAM-954/1	6.8	30	0.6	76	13	11													
NAM-954/2	7.3	18	0.3	69	7	24													
NAM-954/3	7.7	21	0.2	64	6	30													
NAM-955/1	7.6	32	0.3	85	7	8													
NAM-955/2	7.4	41	0.1	71	8	21													
NAM-956/1	8.1	49	0.4	79	11	10													
NAM-956/2	7.3	15	0.2	74	19	7													
NAM-962/1																			
NAM-963/1	8.6	65	0.3	80	17	4		11											
NAM-963/2	8.7	88	0.4	71	22	7		17											
NAM-963/3	8.2	238	0.3	71	23	6		20											
NAM-964/1	7.3	407	0.3	67	14	19													
NAM-964/2	7.5	760	0.3	66	13	21													
NAM-967/1	6.0	66	0.8	76	19	5													
NAM-967/2	7.5	16	0.3	76	16	9													
NAM-968/1	7.9	63	0.5	84	14	3													
NAM-969/1	8.5	83	0.4	73	22	5		13											
NAM-969/2	8.8	84	0.3	59	28	13		25											
NAM-970/1	6.9	42	0.5	81	12	7													
NAM-970/2	7.7	24	0.4	74	13	13													
NAM-974/1	8.7	72	0.3	84	12	4		5											
NAM-974/2	8.5	89	0.2	81	13	6		8											
NAM-974/3	8.5	92	0.1	77	15	8		12											
NAM-975/1	8.2	27	0.1	86	9	6													
NAM-975/2	7.7	11	0.1	84	5	11													
NAM-976/1	8.4	92	0.6	65	21	14		5											
NAM-976/2	8.7	83	0.3	59	19	22		9											
NAM-976/3	8.8	94	0.2	55	18	26		17											
NAM-977/1	8.8	56	0.2	88	8	4		1											
NAM-977/2	8.5	44	0.1	85	9	6		0											
NAM-979/1	7.1	19	0.3	86	10	3													
NAM-979/2	7.6	15	0.2	87	11	2													
NAM-979/3	7.9	12	0.1	85	10	5													
NAM-980/1	7.8	21	0.3	87	10	3													

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
NAM-980/2	8.5	24	0.1	84	14	3													
NAM-980/3	8.6	21	0.1	82	15	3													
NAM-981/1	8.4	31	0.2	88	3	9		0											
NAM-981/2	8.9	58	0.1	84	9	7		1											
NAM-981/3	8.9	83	0.6	81	13	6		8											
NAM-982/1	7.3	24	0.2	83	17	1													
NAM-982/2	7.6	210	0.1	77	21	2													
NAM-982/3	8.7	63	0.1	72	19	9													
NAM-985/1	6.3	22	0.5	84	15	1													
NAM-985/2	7.0	62	0.4	88	10	2													
NAM-986/1	6.3	20	0.3	83	16	1													
NAM-986/2	6.6	13	0.3	80	18	3													
NAM-987/2	6.5	27	0.3	74	18	8													
MAZ-1/1	5.1	56	0.3	90	5	5	1												
MAZ-1/2	5.1	27	0.2	87	7	6	1												
MAZ-2/1	5.3	54	0.4	92	3	5	2												
MAZ-2/2	5.1	30	0.2	89	4	7	1												
OKA-2/1	7.6	24	0.3	95	3	2	2												
OKA-2/2	7.2	12	0.2	97	2	2	1												
OKA-2/3	6.6	8	0.1	95	1	3	1												
OKA-3/1	7.0	21	0.2	96	2	3													
OKA-3/2	6.5	12	0.1	94	2	4													
OKA-3/3	6.6	13	0.3	95	2	3													
OKA-4/1	8.7	46	0.2	95	2	3													
OKA-4/2	7.7	12	0.1	95	1	4													
OKA-4/3	7.7	16	0.2	96	1	3													
OKA-5/1	7.0	14	0.2	96	1	3													
OKA-5/2	6.3	6	0.3	95	1	4													
OKA-5/3	6.1	12	0.2	96	1	4													
OKA-6/1	5.9	23	0.2	96	1	4													
OKA-6/2	6.1	18	0.1	96	1	3													
OKA-6/3	5.8	8	0.1	95	1	5													
OKA-7/1	7.4	36	0.2	92	2	6													
OKA-7/2	7.2	30	0.3	86	3	11													
OKA-8/1	8.4	69	0.4	92	2	5													
OKA-8/2	8.7	56	0.3	90	2	8													
OKA-8/3	8.6	82	0.3	74	16	10		20											
OKA-9/1	7.9	498	3.5	37	28	35													
OKA-9/2	7.6	515	2.2	29	22	50													
OKA-9/3	8.4	232	0.7	38	20	41													
OKA-10/1	7.8	61	0.4	92	2	5													
OKA-10/2	6.4	132	0.4	89	4	7													
OKA-10/3	6.3	91	0.3	89	4	7													
OKA-10/4	7.8	51	0.3	78	6	16													
OKA-11/1	6.7	27	0.6	96	2	2													
OKA-11/2	6.4	8	0.3	93	3	4													
OKA-11/3	6.4	6	0.2	93	2	4													
OKA-12/1	7.3	43	0.4	89	7	4		0											
OKA-12/2	7.7	20	0.3	88	7	6		0											
OKA-12/3	8.3	48	0.3	80	8	13		0											
OKA-12/4	8.6	165	0.3	68	11	21		3											
OKA-13/1	9.3	55	0.3	96	3	1		0		8.7	469	1					0		
OKA-13/2	10.5	1979	0.2	83	5	12		2		10.4	662						0		
OKA-13/3	10.4	1551	0.1	77	5	18		2		9.3	5								
OKA-13/4	10.1	1251	0.2	70	10	21		10		9.7	876	1	2	0	0		1		
OKA-14/1	8.8	88	1.0	75	18	7		1		8.5	886						0		
OKA-14/2	10.3	827	0.3	68	15	17		3		9.4	1571	2	3	4	1		0		
OKA-14/3	10.1	937	0.2	50	25	25		3		9.2	7950	2	3	4	1		1		
OKA-15/1	6.4	23	0.2	95	2	4													
OKA-15/2	6.2	11	0.4	93	3	4													
OKA-15/3	6.5	11	0.1	92	3	5													
OKA-16/1	6.4	20	0.2	96	2	3													
OKA-16/2	5.8	10	0.1	94	2	4													
OKA-16/3	5.6	11	0.1	92	4	4													

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OKA-17/1	5.9	19	0.3	95	5	0													
OKA-17/2	6.0	8	0.3	95	2	3													
OKA-18/1	6.4	30	0.1	97	2	1	2												
OKA-18/2	6.3	33	0.1	95	2	3	1												
OKA-18/3	6.7	11	0.1	94	3	3	0												
OKA-19/1	7.4	33	0.3	87	5	9													
OKA-19/2	7.6	24	0.2	82	8	10													
OKA-20/1	8.9	223	0.4	86	10	4				8.5	1257	3	1	6	0		0	0	30
OKA-20/2	9.9	315	0.2	85	7	9				8.6	647	3	0	7	1		1	0	30
OKA-20/3	9.0	82	0.1	74	16	10				8.8	495	3	1	4	1		0	0	20
OKA-21/1	7.3	34	0.8	85	9	7													
OKA-21/2	7.2	29	0.2	81	8	11													
OKA-21/3	7.5	25	0.0	81	12	7													
OKA-21/4	7.7	24	0.1	77	12	11													
OKA-22/1	6.6	46	0.5	92	4	4													
OKA-22/2	6.5	28	0.2	88	6	6													
OKA-22/3	5.8	21	0.2	90	3	7													
OKA-22/4	6.8	25	0.1	92	5	3													
OKA-23/1	7.0	63	0.3	90	3	7													
OKA-23/2	7.5	58	0.3	83	3	14													
OKA-25/1	6.8	99	0.6	90	7	3													
OKA-25/2	7.3	28	0.2	87	12	1													
OKA-25/3	7.4	198	0.1	86	14	1													
OKA-26/1	7.8	51	0.5	87	9	4				8.2	910	4	2	2	2		0	0	10
OKA-26/2	8.5	1924	0.2	80	7	13				8.3	355	1	1	1	0		0	0	5
OKA-30/1	7.8	1857	0.4	61	27	12				7.9	7510	9	3	5	0		10	0	10
OKA-30/2	7.7	3470	0.3	52	23	25				7.9	10290	31	5	4	0		18	0	10
OKA-30/3	8.2	3570	0.2	49	21	30				8.0	9590	36	4	4	0		21	25	0
OKA-30/4	9.0	2090	0.1	52	19	29				8.5	5430	4	3	5	0		13	4	5
OKA-31/1	7.7	108	0.4	87	9	5													
OKA-31/2	7.7	32	0.2	86	6	8													
OKA-31/3	8.5	99	0.2	86	6	8													
OKA-32/1	7.7	91	0.2	93	3	4													
OKA-32/2	7.5	39	0.1	89	2	9													
OKA-32/3	7.7	92	0.1	85	2	13													
OKA-33/1	8.4	98	0.2	90	4	7													
OKA-33/2	7.9	50	0.2	86	3	11													
OKA-33/3	8.5	54	0.1	78	3	19													
OKA-35/1	7.4	40	0.2	91	4	5													
OKA-35/2	6.2	16	0.1	90	4	6													
OKA-35/3	5.8	16	0.1	90	4	6													
OKA-36/1	8.5	79	0.4	82	12	6		1											
OKA-36/2	8.5	86	0.3	83	6	12		3											
OKA-36/3	8.6	94	0.2	77	9	14		8											
OKA-37/1	8.3	101	0.6	80	9	10				8.2	622	3	1	1	0		3	3	5
OKA-37/2	8.8	92	0.3	85	5	10				8.4	462	1	1	1	0		0	0	5
OKA-37/3	9.6	263	0.2	84	4	12		1		8.7	825	1	1	6	0		0	3	5
OKA-37/4	9.8	481	0.2	82	4	14		1		8.7	418	1	1	6	0		0	0	10
OKA-38/1	8.1	273	0.6	79	10	10		1											
OKA-38/2	8.2	235	0.4	77	11	13		2											
OKA-38/3	8.0	171	0.3	74	11	15		6											
OKA-38/4	8.2	352	0.2	62	18	20		3											
OKA-41/1	6.8	101	0.4	70	26	4													
OKA-43/1	8.4	130	0.5	91	5	4													
OKA-43/2	8.7	67	0.3	94	2	4													
OKA-43/3	8.8	44	0.1	94	3	4													
OKA-43/4	8.7	44	0.2	94	2	4													
OKA-44/1	8.5	144	0.4	71	18	11		0											
OKA-44/2	8.5	104	0.4	67	15	18		0											
OKA-44/3	8.5	97	0.2	60	19	21		3											
OKA-45/1	8.5	140	0.1	95	1	4				7.8	139	3	1	8	1		0	0	5
OKA-45/2	8.3	41	0.2	93	2	5				7.5	69	1	1	4	0		0	5	5
OKA-45/3	10.2	415	0.1	89	2	9				9.6	944	1	1	8	0		0	0	5
OKA-46/1	8.3	72	0.2	81	12	7													

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OKA-46/2	8.7	62	0.2	79	15	7													
OKA-46/3	8.7	89	0.2	71	17	12		2											
OKA-46/4	8.7	96	0.2	71	14	15		4											
OKA-47/1	6.6	116	0.3	77	16	7	1												
OKA-47/2	6.3	16	0.3	74	19	8	1												
OKA-48/1	6.7	56	0.3	92	6	2	1												
OKA-48/2	5.9	15	0.1	77	17	6	1												
OKA-49/1	8.6	102	0.5	74	18	9	3	0											
OKA-49/2	8.8	94	0.3	80	14	6	5	0											
OKA-49/3	8.8	100	0.2	73	18	10	3	0											
OKA-49/4			0.2	68	23	10	4	7											
OKA-53/1	8.4	110	0.4	80	14	6		0											
OKA-53/2	8.5	96	0.3	77	15	8		3											
OKA-57/1	8.3	202	0.4	83	13	5	3												
OKA-57/2	8.5	114	0.4	78	21	1	23												
OKA-57/3	8.4	119	0.3	69	15	16	1												
OKA-59/1	7.7	75	0.3	79	12	9	3												
OKA-59/2	7.5	22	0.3	71	13	16	37												
OKA-60/1	6.8	43	89.1	89	9	2		0											
OKA-60/2	5.9	15	88.5	89	9	3		0											
OKA-62/1	8.0	42	0.2	82	8	9													
OKA-62/2	8.3	85	0.2	81	8	12													
OKA-63/1	8.2	194	0.9	60	16	24		0		7.9	318	4	3	4	0		0	5	2
OKA-63/2	8.8	189	0.5	58	13	29		1		7.8	522	2	4	4	0		0	5	5
OKA-63/3	9.2	257	0.2	60	17	24		3		8.2	194	2	4	6	0			8	3
OKA-67/1	8.3	83	0.2	87	9	4	2												
OKA-67/2	7.1	27	0.2	87	7	6	2												
OKA-67/3	5.8	46	0.3	85	6	9	2												
OKA-82/1	6.4	96	1.3	64	15	20													
OKA-82/2	7.1	33	0.4	77	11	12													
OKA-82/3	6.6	84	0.2	78	9	13													
OKA-82/4	6.9	35	0.1	93	2	5													
OKA-83/1	7.5	66	0.5	87	8	5													
OKA-83/2	7.5	34	0.2	94	3	3													
OKA-83/3	7.9	25	0.1	96	2	2													
OKA-83/4	7.6	43	0.0	92	3	5													
OKA-84/1	8.3	4910	0.2	80	8	12	4			8.4	8650								
OKA-84/2	9.0	4420	0.1	76	9	15	4	0		9.2	15680	2	1	4	1			10	5
OKA-84/3	9.6	2890	0.1	72	12	16	2					19	3	3	2			8	5
OKA-88/1	7.2	72	0.4	84	5	11													
OKA-88/2	7.0	34	0.3	83	4	13													
OKA-88/3	7.3	43	0.2	84	4	12													
OKA-91/1	8.1	270	0.4	68	16	16		4											
OKA-91/2	8.2	223	0.4	64	16	20		4											
OKA-91/3	8.2	189	0.4	58	19	23		5											
OKA-91/4	8.1	369	0.4	56	17	27		8											
OKA-92/3	7.7	30	0.1	78	7	16													
OKA-93/1	8.3	71	0.3	83	7	10													
OKA-93/2	7.8	33	0.2	81	5	15													
OKA-95/1	7.1	50	0.4	82	10	8	4												
OKA-95/2	5.8	18	0.3	73	9	19	2												
OKA-96/1	7.3	27	0.2	88	10	1		0											
OKA-96/2	6.8	71	0.2	77	6	16		0											
OKA-96/3	7.3	67	0.2	73	8	19		0											
OKA-103/1	6.0	36	0.2	95	-1	6													
OKA-103/2	6.4	14	0.1	91	3	6													
OKA-106/1	8.1	135	0.8	77	13	10													
OKA-106/2	8.5	76	0.2	88	5	7													
OKA-106/3	8.9	42	0.0	97	2	2													
OKA-109/1	6.4	171	0.9	72	18	10				7.9	1026	1	1	6	1			10	0
OKA-109/2	9.0	8.08??	0.2	60	12	28				8.5	1780								
OKA-109/3	9.0	564	0.1	69	9	23				8.5	1520								
OKA-109/4	9.5	75	0.1	78	20	2				7.7	752								
OKA-112/1	6.1	23	0.4	88	1	10													

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OKA-112/2	6.7	39	0.3	68	15	17													
OKA-112/3	7.3	29	0.2	69	16	15													
OKA-112/4	7.3	22	0.1	78	12	10													
OKA-112/5	7.7	55	0.2	50	22	28													
OKA-114/1	4.6	192	1.0							7.2	352								
OKA-114/2	4.6	169	0.6	65	19	15				7.8	7670								
OKA-114/3	3.7	425	0.3							6.3	2350								
OKA-115/1	7.4	877	0.4							8.4	3790								
OKA-115/2	7.5	1883	0.2							8.3	4320								
OKA-115/3	8.2	423	0.1							8.5	2170								
OKA-116/1	6.4	87	0.2	96	2	3	1												
OKA-116/2	5.1	17	0.1	95	1	4	0												
OKA-116/3	5.1	92	0.1	96	1	4	0												
OKA-117/1	8.4	99	0.2	84	4	13													
OKA-121/1	6.0	86	0.7	81	10	8													
OKA-121/2	6.7	63	0.4	78	10	12													
OKA-121/3	6.4	38	0.3	79	8	13													
OKA-122/1	6.2	127	0.3	94	3	3	0												
OKA-122/2	6.9	30	0.2	92	3	4	0												
OKA-122/3	7.2	24	0.1	93	3	5	0												
OKA-123/1	6.5	59	0.2	85	12	3													
OKA-123/2	5.9	13	0.1	95	1	4													
OKA-123/3	6.2	26	0.1	95	1	4													
OKA-123/4			0.1	86	3	11													
OKA-126/1	6.0	62	0.2	86	8	6													
OKA-126/2	6.2	19	0.2	83	10	7													
OKA-126/3	6.3	34	0.2	77	10	14													
OKA-130/1	6.1	67	0.6	84	11	5													
OKA-130/2	8.7	151	0.3	77	6	17		1											
OKA-130/3	8.9	199	0.2	80	3	17		0											
OKA-133/1	6.4	60	0.2	96	1	3				8.2	426								
OKA-133/2	7.4	46	0.3	97	0	4				7.7	82								
OKA-133/3	8.2	555	0.1	92	0	8				8.4	1320								
OKA-134/1	8.6	163	0.3	66	15	19		19											
OKA-134/2	7.9	142	0.4	77	9	14		9											
OKA-134/3	8.0	207	0.6	81	9	11		6											
OKA-138/1																			
OKA-138/2	6.3	46	0.3	79	14	7													
OKA-138/3	5.9	26	0.2	80	12	8													
OKA-138/4	6.1	27	0.2	76	11	13													
OKA-147/1	6.5	58	0.8	91	3	6	1												
OKA-147/2	5.1	12	0.3	92	1	7	1												
OKA-150/1	8.4	206	0.5	89	3	8	3												
OKA-150/2	8.6	106	0.4	87	2	11	4												
OKA-152/1	6.3	68	0.4	89	4	6													
OKA-152/2	6.0	11	0.2	86	6	8													
OKA-152/3	5.7	27	0.2	78	6	16													
OKA-156/1	8.4	96	0.2	71	15	14													
OKA-156/2	7.1	42	0.3	93	3	4													
OKA-156/3	6.5	23	0.2	93	2	5													
OKA-156/4	6.6	12	0.1	90	0	10													
OKA-156/5	6.7	15	0.2	91	8	1													
OKA-166/1	7.4	51	0.4	91	5	4													
OKA-166/2	7.8	53	0.3	90	0	10													
OKA-166/3	8.5	93	0.3																
OKA-171/1	9.2	351	0.3	92	3	5				8.3	760								
OKA-171/2	10.0	1432	0.1	85	7	8		18		9.1	2750								
OKA-171/3	10.2	2020	0.0	86	9	5		10		8.9	3310								
OKA-171/4	10.2	3010	0.1	76	23	1		4		9.4	7750								
OKA-172/1	6.4	4110								8.9	2070								
OKA-172/2	7.0	3020								7.1	6730								
OKA-172/3	7.2	2300								7.0	5500								
OKA-174/1	8.4	172						21		8.6	264								
OKA-174/2	9.5	330						21		9.0	43								

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OKA-174/3	10.2	1144						4		9.6	2280								
OKA-175/1	5.9	32	0.1	96	1	3													
OKA-175/2	6.7	13	0.1	94	2	3													
OKA-177/1	6.6	45	0.3	88	12	1													
OKA-177/2	6.1	26	0.3	82	17	2													
OKA-177/3	7.1	30	0.2	77	10	13													
OKA-181/1	6.2	90	0.6	83	11	6													
OKA-181/2	5.8	26	0.3	85	15	1													
OKA-181/3	5.3	22	0.2	83	9	8													
OKA-188/1	8.6	70																	
OKA-188/2	6.4	19																	
OKA-193/1	6.4	36	1.8	19	57	25													
OKA-193/2	6.9	47	0.6	40	34	26													
OKA-196/1	6.0	47	0.9	75	6	19													
OKA-196/2	6.9	48	0.5	59	22	19													
OKA-196/3	7.7	60	0.3	74	3	23													
OKA-201/1	8.7	94	0.4	80	20	0		1											
OKA-201/2	8.7	96	0.2	81	6	13		3											
OKA-205/1	6.4	103	0.5	94	6	0													
OKA-205/2	6.5	31	0.1	92	8	0													
OKA-208/1	5.7	15																	
OKA-208/2	5.4	102																	
OKA-208/3	5.6	12																	
OKA-214/1	6.7	100					1												
OKA-214/2	7.6	36					2												
OKA-214/3	7.7	29					2												
OKA-216/1	9.2	347	0.2	92	8	0	1			8.4	11								
OKA-216/2	7.2	21	0.1	92	5	3	3			8.2	76								
OKA-222/1	6.6	29																	
OKA-222/2	6.2	41																	
OKA-222/3	6.7	15																	
OKA-228/1	6.9	34																	
OKA-228/2	7.6	29																	
OKA-228/3	7.9	35	0.1	86	4	10													
OKA-233/1	5.6	33	0.9	2	43	52													
OKA-233/2	5.7	33	0.7	22	28	50													
OKA-238/1	7.0	47	0.2	96	2	2													
OKA-238/2	8.0	25	0.1	97	1	1													
OKA-238/3	6.6	25	0.1	95	1	3													
OKA-240/1	6.5	81																	
OKA-240/2	7.5	107																	
OKA-240/3	7.3	97																	
OKA-250/1	7.0	54	0.3	91	8	2	3			8.2	21								
OKA-250/2	9.3	532	0.3	73	9	19	2			8.4	1240								
OKA-250/3	9.5	1135	0.2	61	12	27	14	0		8.5	1980								
OKA-250/4	9.3	1087	0.1	49	13	38	30	2		8.7	1470								
OKA-250/5	9.7	335	0.1	90	1	9	6	0		8.4	60								
OKA-253/1	6.9	18	0.5	98	1	1	2												
OKA-253/2	6.4	11	0.1	98	1	1	6												
OKA-254/1	5.8	37	0.6	92	3	4													
OKA-254/2	5.3	44	0.2	94	2	4													
OKA-254/3	6.6	37	0.1	96	2	2													
OKA-255/1	8.4	150	1.4	78	16	6													
OKA-255/2	8.8	79	0.3	94	3	3													
OKA-256/1	5.4	151	1.5	59	24	17	14												
OKA-256/2	6.6	28	0.7	81	6	13	8												
OKA-256/3	6.9	15	0.1	98	0	2	1												
OKA-262/1	6.1	49	0.8	90	5	4													
OKA-262/2	6.9	19	0.1	96	1	3													
OKA-264/1	3.6	825	2.9	94	4	2				5.1	2590								
OKA-264/2	3.9	80	0.1	96	1	3				7.8	3150								
OKA-267/1	9.2	799	0.4	82	5	13				8.6	3320	29	9	1059	0	210	1		
OKA-267/2	9.9	5690	0.2	72	6	22		5		9.4	9280								
OKA-272/1	8.0	76	0.2	92	5	4													

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OKA-272/2	6.3	35	0.2	88	4	8													
OKA-277/1	6.9	76																	
OKA-277/2	7.6	88																	
OKA-277/3	8.9	69																	
OKA-278/1	8.3	185																	
OKA-278/2	8.8	100																	
OKA-278/3	8.8	99																	
OKA-280/1	8.6	65																	
OKA-280/2	8.6	82																	
OKA-280/3	8.6	130						12											
OKA-287/1	7.6	61	0.2	91	2	7													
OKA-287/2	7.7	43	0.1	88	3	9													
OKA-290/1	6.8	17	0.1	96	3	1	0												
OKA-290/2	6.7	12	0.1	98	1	1	0												
OKA-300/1	7.3	52	0.2	89	3	8	7												
OKA-300/2	7.7	66	0.2	90	1	9	10												
OKA-301/1	8.2	192	0.3	80	9	11	15												
OKA-301/2	8.3	93	0.3	78	11	12	10												
OKA-301/3	8.0	154	0.2	76	9	15	8												
OKA-301/4	8.2	286	0.2	76	8	16	6												
OKA-303/1	8.7	49	0.2	91	3	7													
OKA-303/2	7.1	23	0.1	90	4	6													
OKA-305/1	7.0	65	0.2	87	3	10	10												
OKA-305/2	7.6	53	0.1	84	4	12	6												
OKA-310/1	6.9	60	0.2	94	0	6													
OKA-310/2	7.3	31	0.1	85	1	14													
OKA-311/1	5.2	46	0.3	96	1	3													
OKA-311/2	5.5	17	0.1	96	0	4													
OKA-313/1	6.7	49	0.3	91	5	5													
OKA-313/2	7.2	30	0.2	82	6	12													
OKA-316/1	8.6	98	0.3	86	6	8													
OKA-316/2	8.4	113	0.3	79	7	14													
OKA-319/1	7.1	263	0.1	91	3	6													
OKA-319/2	8.5	75	0.3	93	3	4													
OKA-321/1	7.2	771								7.9	2060								
OKA-321/2	5.1	388								7.8	1063	40	11	19	74	30	6		
OKA-322/1	8.0	119	0.4	84	6	10		0											
OKA-322/2	8.2	77	0.4	75	8	17		1											
OKA-322/3	8.3	145	0.4	78	7	15		1											
OKA-323/1	6.1	100																	
OKA-323/2	4.9	45																	
OKA-323/3	5.3	23		89	2	9													
OKA-324/1	7.3	225	0.4	90	4	6													
OKA-324/2	7.8	38	0.2	87	3	11													
OKA-325/1A	8.5	60	0.3	93	4	3													
OKA-325/1B	7.2	99	0.3	87	4	9													
OKA-325/2A	7.8	62	0.1	94	3	3													
OKA-325/2B	5.8	199	0.2	81	5	14													
OKA-325/3A	7.9	20	0.1	94	3	3													
OKA-325/3B	6.3	25	0.5	80	7	13													
OKA-334/1	8.2	178	0.3	93	7	0													
OKA-334/2	8.1	54	0.3	93	3	4													
OKA-337/1	5.7	120	1.1	74	20	6													
OKA-337/2	6.1	19	0.2	71	21	8													
OKA-337/3	5.5	43	0.2	71	19	10													
OKA-338/1	5.7	59	1.0	67	20	13													
OKA-338/3?	7.4	124	0.3	61	9	30													
OKA-340/1	8.8	66	0.2	92	3	6	17												
OKA-340/2	8.9	56	0.1	95	1	5	6												
OKA-340/3	7.3	175	0.0	98	0	2	11												
OKA-342/1	7.4	30	0.3	91	3	6													
OKA-342/2	8.1	52	0.4	89	3	8													
OKA-343/1	7.0	39	0.3	92	3	5													
OKA-343/2	8.0	53	0.2	85	5	10													

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OKA-345/1	4.9	49	0.3	98	1	1	21												
OKA-345/2	5.6	14	0.1	98	1	2	0												
OKA-348/1	7.2	134	0.4	88	4	8													
OKA-348/2	7.3	93	0.4	79	5	16													
OKA-348/3	7.8	60	0.1	78	0	22													
OKA-349/1	7.5	49	0.2	91	1	8													
OKA-349/2	7.3	19	0.2	90	2	8													
OKA-349/3	7.3	26	0.2	77	6	17													
OKA-350/1	9.4	84	0.2	91	3	6		0		8.3	413								
OKA-350/2	9.9	1480	0.1	82	2	16		1		8.6	3030	13	6	431	6	185	171		
OKA-350/3	9.6	1473	0.1	77	2	22		1		8.8	4120								
OKA-352/1	6.8	18	0.3	93	3	4	2												
OKA-352/2	4.7	76	0.1	93	1	6	*	1											
OKA-353/1	6.5	32	0.5	91	3	6													
OKA-353/2	7.8	40	0.2	92	2	7													
OKA-355/1	7.9	631	0.4	77	12	12		2		8.7	923								
OKA-355/2	10.3	1036	0.2	80	6	14		3		9.2	1564								
OKA-355/3	10.1	1086	0.1	79	3	18		3		9.7	2070								
OKA-358/1	7.4	86	1.0	78	2	20		1		7.6	444	9	10	9	1	10	9	5	10
OKA-358/2	4.2	628	0.5	79	3	18		1		8.0	519	10	8	2	0	5	2	10	20
OKA-358/3	7.6	35	0.2	90	2	9		1		7.8	910	25	25	7	1	55	3	10	20
OKA-364/1	7.9	37	0.2	96	1	4													
OKA-364/2	7.7	20	0.1	92	2	6													
OKA-364/3	7.2	16	0.1	82	1	17													
OKA-365/1	7.0	36	0.4	91	1	8													
OKA-365/2	5.8	109	0.1	89	2	10													
OKA-365/3	5.2	371	0.2	85	3	13													
OKA-366/1	7.4	27	0.2	96	1	3													
OKA-366/2	7.5	20	0.2	85	1	14													
OKA-367/1	8.5	61	0.3	89	8	3													
OKA-367/2	8.2	49	0.2	88	4	9													
OKA-367/3	8.4	31	0.1	84	5	11													
OKA-369/1	5.5	21	0.2	88	0	13													
OKA-369/2	5.5	15	0.3	85	1	14													
OKA-369/3	5.4	15	0.3	84	1	16													
OKA-371/1	8.3	36	0.2	94	4	2													
OKA-371/1A	7.1	24	0.2																
OKA-375/1	5.8	32	0.3	97	3	1	1												
OKA-375/2	5.3	16	0.1	96	2	2	1												
OKA-381/1	7.3	89	0.6	73	15	13													
OKA-381/2	7.4	98	0.3	63	12	25													
OKA-381/3	8.0	245	0.3	59	14	27		10											
OKA-386/1	8.2	141	0.8	86	11	4		3											
OKA-386/2	8.3	195	0.6	78	4	18		7											
OKA-390/1	6.8	41	0.5	87	3	10													
OKA-390/2	6.0	94	0.6	80	7	13													
OKA-390/3	6.4	253	0.3	65	6	29													
OKA-390/4	8.1	296	0.2	60	6	34													
OKA-392/2	7.8	47	0.2	82	3	15													
OKA-398/1	8.2	79	0.4	91	4	5													
OKA-398/2	8.0	74	0.2	90	2	8													
OKA-398/3	8.0	38	0.1	88	2	11													
OKA-399/1	7.7	53	0.5	89	9	3													
OKA-399/2	8.2	45	0.3	85	4	11													
OKA-399/3	8.4	132	0.2	84	5	11													
OKA-403/1	6.5	40	0.4	95	3	2													
OKA-403/2	4.9	82	0.2	94	3	4													
OKA-407/1	9.3	60	0.1	99	2	0	*	0		8.7	105								
OKA-407/2	10.3	1407	0.2	82	6	12	6	4		10.5	2830								
OKA-407/3	10.5	2200	0.1	84	4	12	2	3		11.1	4420								
OKA-408/1	7.5	77	0.6	90	4	6	6												
OKA-408/2	8.4	65	0.4	88	3	9	13												
OKA-409/1	6.4	22	0.3	98	1	1	0												
OKA-409/2	6.4	18	0.2	98	1	1	1												

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OKA-409/3	6.9	21	0.1	96	2	2	1												
OKA-414/1	7.4	64	0.3	92	3	5	6												
OKA-414/2	8.3	90	0.4	89	3	8	10												
OKA-414/3	7.9	63	0.2	87	3	15	9												
OKA-416/1	9.3	60	0.3	94	5	1		0		9.6	186	8	5	41	4	10	7	10	20
OKA-416/2	10.6	2030	0.1	88	2	10		3		11.0	3250								
OKA-416/3	10.6	3230	0.1	79	6	15		5		11.3	6840								
OKA-420/1	8.6	115	0.4	88	3	9	13												
OKA-420/2	8.3	156	0.2	87	3	10	12	1											
OKA-420/3	8.7	89	0.2				27	2											
OKA-433/1	5.6	20	0.2	99	0	1													
OKA-433/2	5.6	16	0.1	98	1	1													
OKA-438/1	8.0	59	0.3	90	3	7													
OKA-438/2	8.4	61	0.2	89	2	9		1											
OKA-438/3	8.3	47	0.1	89	1	10													
OKA-445/1	8.3	148	1.1	59	24	17	26	23											
OKA-445/2	8.5	100	1.1	73	13	13	20	14											
OKA-445/3	8.9	66	0.2	95	3	2	2	2											
OKA-447/1	8.9	65	0.3	98	1	1													
OKA-447/2	9.1	45	0.1	98	1	1				9.1	73								
OKA-450/1	7.3	60	0.5	89	4	7	6												
OKA-450/2	7.5	64	0.2	83	5	12	10												
OKA-452/1	4.6	3060	1.6	65	33	3	33			6.7	4050	640	286	19	2	3	1432	0	3
OKA-452/2	7.9	96	0.2	93	3	4	6			7.6	2320	51	82	9	1	10	324	0	0
OKA-461/1	7.4	21	0.1	95	2	2													
OKA-461/2	7.4	34	0.1	95	0	4													
OKA-461/3	7.0	32	0.1	93	13	6													
OKA-462/1	5.3	32	0.2	96	1	4	1												
OKA-462/2	5.5	13	0.1	94	1	5	0												
OKA-463/1	7.6	31	0.2	93	3	4	4												
OKA-463/2	8.3	54	0.1	89	4	8	8												
OKA-471/1	7.1	27	0.1	92	4	4	3			8.3	256	1	3	2	0	5	7	0	0
OKA-471/2	6.4	22	0.1	88	5	7	5			7.4	745	0	4	7	0	7		0	0
OKA-472/1	8.4	86	0.4	84	9	7		3											
OKA-472/2	8.5	133	0.5	47	34	20		14											
OKA-474/1	7.2	69	0.2	90	5	4				7.9	224								
OKA-474/2	6.8	29	0.1	90	5	5				7.6	197	3	4	1	0	10	5	0	5
OKA-474/3	9.8	636	0.1	94	10	4				9.1	1820	19	7	1375	15	720	950	10	10
OKA-474/4	6.3	22	0.2	75	7	18				8.3	401	7	5	19	0	8	4	5	13
OKA-475/1	6.0	21	0.3	93	7	1													
OKA-475/2	6.7	18	0.1	95	2	4													
OKA-476/1	7.0	18	0.3	83	6	11													
OKA-476/2	7.7	21	0.3	72	9	19													
OKA-477/1	8.6	80	0.7	78	10	11		2											
OKA-477/2	8.4	135	1.1	43	31	26		6											
OKA-477/3	8.7	113	0.9	27	44	29		49											
OKA-488/1	8.7	87	0.4	75	13	12		6											
OKA-488/2	8.7	298	0.5	57	17	25		11											
OKA-488/3	9.0	128	0.3	57	14	30		5											
OKA-491/1	8.7	70	0.3	93	4	2	6												
OKA-491/2	7.6	33	0.1	94	1	5	1												
OKA-493/1	8.1	65	0.2	86	5	9													
OKA-493/2	8.6	84	0.2	80	6	14		2											
OKA-496/1	8.5	116	0.9	45	37	19		9											
OKA-496/2	8.6	98	0.6	63	19	18		9											
OKA-496/3	8.8	68	0.1	83	11	6		1											
OKA-497/1	7.2	24	0.1	95	3	3													
OKA-497/2	6.9	33	0.2	93	3	5													
OKA-497/3	6.7	63	0.3	81	3	16													
OKA-497/4	8.0	350	0.2	83	3	14													
OKA-498/1	7.1	31	0.3	91	4	6													
OKA-498/2	8.2	49	0.2	84	5	12													
OKA-501/1	5.8	13		94	3	4													
OKA-501/2	5.3	18		95	2	4													

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OKA-501/3	5.4	14		93	2	6													
OKA-502/1	6.4	13		88			3												
OKA-502/2	6.1	14		93	3	4	2												
OKA-502/3	5.9	20		91	3	6	*												
OKA-503/1	7.6	30		87	8	5	2												
OKA-504/1	8.3	73		88	3	9	11												
OKA-504/2	6.9	55					2												
OKA-504/3	6.8	28					2												
OKA-505/1	5.9	66																	
OKA-505/2	7.5	68																	
OKA-505/3	8.1	56																	
OKA-511/1	7.4	21																	
OKA-511/2	7.5	20																	
OKA-511/3	7.2	23						1											
OKA-512/1	7.3	37																	
OKA-512/2	7.6	38																	
OKA-512/3	7.3	61																	
OKA-512/4	7.6	57																	
OKA-514/1	5.8	22																	
OKA-514/2	6.0	13																	
OKA-514/3	6.1	15																	
OKA-516/1	6.4	16																	
OKA-516/2	6.1	14																	
OKA-516/3	6.2	9																	
OKA-516/4	6.0	11																	
OKA-517/1	5.7	10																	
OKA-517/2	6.3	47																	
OKA-517/3	7.0	61																	
OKA-518/1	8.6	49																	
OKA-518/2	8.2	26																	
OKA-519/1	8.7	39																	
OKA-519/2	8.6	30																	
OKA-522/1	6.9	51																	
OKA-522/2	7.8	156																	
OKA-522/3	8.6	58																	
OKA-525/1	7.1	88																	
OKA-525/2	7.5	40																	
OKA-525/3	7.8	23																	
OKA-525/4	7.7	33																	
OKA-526/1	6.0	27																	
OKA-526/2	5.9	16																	
OKA-527/1	8.3	271								8.1	380	10	7	8	0	10	46	5	5
OKA-527/2	8.1	1058								7.6	2170	659	37	48	2	5	620	0	0
OKA-527/3	8.2	666								7.9	1894	55	26	37	1	8	274	0	3
OKA-527/4	8.5	234								8.0	899	22	8	18	1	10	33	5	0
OKA-528/1	6.5	1898								7.4	3210	1069	38	26	1	5	808	0	0
OKA-528/2	5.0	2440								6.7	3610	131	56	38	1	5	817	0	5
OKA-528/3	5.3	330								7.3	1355	37	13	7	1	25	66	0	0
OKA-529/1	8.5	176					7	20											
OKA-529/2	8.7	111					15	25											
OKA-529/3	8.6	103					15	35											
OKA-529/4	9.0	90					9												
OKA-531/1	8.2	185						36											
OKA-531/2	8.4	142						34											
OKA-531/3	8.4	328						2											
OKA-535/1	6.7	22																	
OKA-535/2	6.6	9																	
OKA-535/3	6.4	15																	
OKA-535/4	6.5	14																	
OKA-536/1	7.9	53						0											
OKA-536/2	8.0	36						0											
OKA-536/3	8.6	85						12											
OKA-536/4	8.7	108						10											
OKA-537/1	7.3	31																	

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OKA-537/2	7.5	25																	
OKA-537/3	7.2	63																	
OKA-537/4	8.7	38																	
OKA-538/1	8.7	104																	
OKA-538/2	6.8	7																	
OKA-542/1	8.9	48																	
OKA-542/2	7.9	110																	
OKA-542/3	9.1	192																	
OKA-543/1	6.8	6.6																	
OKA-543/2	7.1	23																	
OKA-543/3	7.9	179						3											
OKA-543/4	8.5	65																	
OKA-544/1	8.0	19																	
OKA-544/2	7.6	15																	
OKA-545/1	8.7	118						25											
OKA-545/2	8.7	185						22											
OKA-545/3	8.6	101						4											
OKA-545/4	8.6	84						2											
OKA-546/1	8.2	98						7											
OKA-546/2	8.6	268																	
OKA-546/3	8.7	59																	
OKA-547/1	8.5	92						6											
OKA-547/2	8.7	164						8											
OKA-547/3	7.9	281						7											
OKA-548/1	8.1	51																	
OKA-548/2	8.8	182																	
OKA-548/3	9.6	44						11											
OKA-550/1	8.2	108						39		8.1	325	10	6	2	1	5	65	0	0
OKA-550/2	8.7	99						23		8.3	343	6	6	2	1	5		5	0
OKA-550/3	9.1	105						4		7.9	414	6	7	6	1	15		0	70
OKA-552/1	8.0	181						7											
OKA-552/2	8.4	212						8											
OKA-552/3	8.5	154						3											
OKA-553/1	8.2	245						32											
OKA-553/2	8.7	100						1											
OKA-553/3	8.5	194						8											
OKA-554/1	8.1	227																	
OKA-554/2	8.5	231																	
OKA-554/3	8.5	191																	
OKA-554/4	8.3	193																	
OKA-556/1	8.4	131																	
OKA-556/2	8.5	205																	
OKA-556/3	9.2	87																	
OKA-557/1	6.6	16					4												
OKA-557/2	7.3	21					5												
OKA-557/3	6.3	15					4												
OKA-560/1	8.4	91						7											
OKA-560/2	8.3	82						29											
OKA-560/3	8.3	70																	
OKA-563/1	6.0	19					2												
OKA-563/2	7.3	49					5												
OKA-563/3	8.3	80					9												
OKA-564/1	7.3	47																	
OKA-564/2	7.9	39																	
OKA-601/1	10.5	1333	0.1	95	1	4				10.9	2060	12	5	238	3	35		20	40
OKA-602/2	10.6	3360	0.1	94	0	7	*												
OKA-602/3	10.6	2910	0.1	86	0	14	35			10.2	6850	8	4	697	3	65		40	35
OKA-604/1	8.1	75	0.2	91	1	8													
OKA-604/2	8.6	91	0.1	85	6	9													
OKA-605/1	6.8	111	0.3	86	8	6													
OKA-605/2	8.0	88	0.2	82	10	8													
OKA-605/3	8.7	156	0.2	77	16	7		8											
OKA-606/1	8.6	110	0.2	89	6	5	24	4											
OKA-607/1	8.6	80	0.2	89	4	7	20	2											

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OKA-607/2	8.7	91	0.3	89	4	7	15	1											
OKA-607/3	8.7	115	0.2	89	5	7	24	3											
OKA-608/1	8.2	34	0.3	97	1	2	2												
OKA-608/2	7.5	18	0.1	97	1	2	1												
OKA-609/1	8.7	68	0.4	93	3	3													
OKA-609/2	8.7	87	0.4	84	9	7		11											
OKA-609/3	8.8	87	0.2	90	6	5		12											
OKA-609/4	9.0	51	0.1	96	2	2													
OKA-626/1	8.7	55	0.4	95	3	3		16											
OKA-626/2	8.9	59	0.3	86	8	6		15											
OKA-626/3	9.2	47	0.1	97	1	2		18											
OKA-629/1	8.3	64	0.3	95	3	2													
OKA-629/2	8.4	64	0.2	96	2	3													
OKA-629/3	7.4	69	0.1	96	2	2													
OKA-631/1	8.5	53	0.2	90	3	7		8											
OKA-631/2	8.4	42	0.2					4											
OKA-631/3	8.4	69	0.2	80	8	12		2											
OKA-633/1	8.6	76	0.4	80	11	10		5		9.0	192								
OKA-633/2	8.5	209	0.4	71	9	20		6		8.6	510								
OKA-633/3	8.6	476	0.3	60	16	24		13		8.4	970								
OKA-635/1	8.4	29	0.2	95	2	3													
OKA-635/2	8.4	39	0.1	92	4	5													
OKA-649/1	8.4	56	0.3	87	4	9	9												
OKA-649/2	8.8	46	0.2	87	3	11	1												
OKA-649/3	8.6	52	0.1	85	3	12	9												
OKA-650/1	7.7	48	0.1	94	2	4													
OKA-650/2	8.4	105	0.2	92	3	6													
OKA-650/3	8.6	125	0.3	88	5	7		4											
OKA-658/1	8.2	44	0.2	89	5	6													
OKA-658/2	8.1	28	0.2	85	3	12													
OKA-658/3	8.6	64	0.1	83	3	14													
OKA-659/1	5.4	8	0.1	96	0	4	2												
OKA-659/2	5.1	9	0.2	94	0	6	1												
OKA-659/3	5.2	8	0.1	93	0	7	1												
OKA-663/1	8.3	120	0.2	93	3	4													
OKA-663/2	7.8	28	0.1	91	4	5													
OKA-663/3	6.7	108	0.1	91	3	5													
OKA-664/1	5.9	25	0.1	95	2	3													
OKA-664/2	5.6	156	0.1	95	2	3													
OKA-665/1	8.1	33	0.1	92	2	6													
OKA-665/2	8.0	23	0.1	91	1	9													
OKA-665/3	8.0	50	0.1	88	4	9													
OKA-687/1	6.7	51																	
OKA-687/2	7.0	71																	
OKA-801/1	5.9	19	0.2	97	0	3													
OKA-801/2	5.3	13	0.1	97	-1	4													
OKA-801/3	5.5	13	0.1	94	3	3													
OKA-802/1	7.3	22	0.3	92	4	4													
OKA-802/2	6.5	23	0.1	93	3	4													
OKA-802/3	6.2	18	0.2	81	4	16													
OKA-803/1	6.1	31	0.5	90	3	7													
OKA-803/2	5.2	16	0.2	88	5	7													
OKA-803/3	5.4	11	0.1	89	3	9													
OKA-804/1	5.9	15	0.4	96	2	2	2												
OKA-804/2	5.4	16	0.1	97	-1	3	1												
OKA-804/3	6.2	15	0.1	98	-1	3	2												
OKA-805/1	7.6	20	0.2	91	2	7													
OKA-805/2	7.8	25	0.1	90	1	9													
OKA-806/1	6.7	22	0.2	74	7	19	4												
OKA-806/2	7.0	24	0.1	92	1	8	5												
OKA-806/3	6.7	20	0.0	91	4	4	4												
OKA-807/1	7.0	43	0.4	92	2	6													
OKA-807/2	8.4	61	0.2	90	2	8													
OKA-807/3	8.2	37	0.1	90	2	9													

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OKA-809/1	8.7	90	0.8	74	12	14	22	3											
OKA-809/2	8.7	108	0.6	76	15	10	6	4											
OKA-809/3	8.8	117	0.5	78	12	10	25	16											
OKA-809/4	8.9	100	0.3	65	26	9	25	20											
OKA-810/1	7.6	31	0.3	97	0	3	4												
OKA-810/2	6.2	10	0.1	89	7	4	1												
OKA-811/1	8.4	97	1.5	47	11	42	20												
OKA-811/2	8.3	25	0.5	52	29	20	2												
OKA-811/3	8.4	25	0.3	71	17	13	5												
OKA-811/4	8.9	25	0.0	92	7	1	1												
OKA-811/5	9.0	25	0.1	88	8	4	2												
OKA-815/1	8.3	65	0.3	94	2	4	4												
OKA-815/2	7.8	27	0.2	95	1	4	3												
OKA-815/3	6.6	14	0.1	95	2	4	2												
OKA-816/1	5.4	9	0.2	98	1	1													
OKA-816/2	5.4	17	0.1	98	1	1													
OKA-816/3	5.7	7	0.1	98	1	2													
OKA-817/1	6.7	21	0.3	94	2	4	3												
OKA-817/2	5.8	11	0.1	90	6	4	3												
OKA-817/3	6.8	134	0.2	85	1	14	6												
OKA-818/1	6.1	12	0.4	98	1	2													
OKA-818/2	5.4	5	0.1	97	1	2													
OKA-819/1	6.6	20	0.3	93	5	2													
OKA-819/2	6.1	7	0.2	94	5	2													
OKA-820/1	7.7	33	0.3	93	3	4													
OKA-820/2	7.6	17	0.3	88	4	7													
OKA-822/1	7.4	29	0.4	94	3	2	4												
OKA-822/2	7.4	25	0.1	93	2	4	3												
OKA-822/3	7.5	22	0.1	93	4	4	7												
OKA-823/1	8.4	87	0.6	70	14	16		1											
OKA-823/2	8.7	103	0.3	61	15	24		8											
OKA-823/3	8.4	235	0.2	57	17	26		10											
OKA-824/1	6.7	23	0.2	83	10	8	4												
OKA-824/2	6.8	52	0.2	81	11	8	5												
OKA-825/1	8.5	30	0.2	83	17	1				8.5	165								
OKA-825/2	9.4	113	0.2	88	11	2				9.1	360								
OKA-825/3	9.8	82	0.1	85	11	4				9.2	2070								
OKA-825/4	10.3	1490	0.1	80	8	12		2		9.9	1570								
OKA-825/5	10.4	2200	0.1	73	13	13		1		10.3	4340								
OKA-826/1	6.6	42	0.5	78	12	11													
OKA-826/2	6.8	37	0.5	79	13	9													
OKA-826/3	6.1	22	0.4	76	11	12													
OKA-826/4	5.3	85	0.3	72	12	16													
OKA-826/5	5.7	74	0.3	77	10	14													
OKA-827/1	8.9	74	0.5	75	16	9		7											
OKA-827/2	8.6	91	0.3	67	16	17		2											
OKA-827/3	8.8	89	0.3	63	23	14		16											
OKA-828/1	7.3	43	0.5	77	16	7	5												
OKA-828/2	6.9	52	1.3	60	24	17	7												
OKA-828/3	6.6	36	0.7	46	29	24	10												
OKA-829/1	8.6	64	0.3	86	10	4	4												
OKA-829/2	5.0	46	0.4	81	7	11	1												
OKA-831/1	6.9	105	1.1	41	18	42				9.4	197								
OKA-831/2	7.7	475	1.6	34	40	26				7.6	610								
OKA-831/3	8.5	424	0.1	94	4	2				7.9	1680								
OKA-831/4	8.6	244	0.1	92	4	3				8.2	345								
OKA-832/1	6.1	141	0.9	22	35	43				5.9	50								
OKA-832/2	4.4	1222	1.2	24	27	50				4.5	1100								
OKA-832/3	4.1	1509	3.1	55	3	42				4.3	1770								
OKA-832/4	4.6	211	0.2	96	3	1				3.9	543								
OKA-833/1	7.9	249																	
OKA-833/2	7.7	339																	
OKA-833/3	8.9	58																	
OKA-833/4	8.4	48																	

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OKA-834/1	7.5	56		93	2	5													
OKA-834/2	8.4	51		90	2	8													
OKA-834/3	8.7	64		88	4	9		1											
OKA-834/4	8.7	92		76	11	14		4											
OKA-835/1	7.1	64		93	4	3				5.8	112								
OKA-835/2	6.6	1303		76	8	16				6.0	2350								
OKA-835/3	7.4	4480		44	22	34			5	7.7	7								
OKA-835/4	7.9	4160		60	2	38			60	8.3	6260								
OKA-836/1	8.6	34		96	3	1				7.8	49								
OKA-836/2	10.1	438		91	2	7				9.2	782								
OKA-836/3	10.3	846		88	1	11				9.9	908								
OKA-836/4	10.7	671		91	2	7				10.0	1290								
OKA-837/1	7.8	14																	
OKA-837/2	8.1	18																	
OKA-838/1	8.8	52																	
OKA-838/2	8.5	22																	
OKA-838/3	8.6	45																	
OKA-839/1	7.9	27		89	4	6													
OKA-839/2	7.8	32		86	3	11													
OKA-839/3	8.8	88		83	5	12		4											
OKA-839/4	8.7	86		83	4	12		2											
OKA-840/1	7.6	18																	
OKA-840/2	5.5	9																	
OKA-840/3	5.2	8																	
OKA-841/1	7.6	34		86	4	10													
OKA-841/2	8.3	28		83	4	13		1											
OKA-841/3	8.6	78		80	4	16		2											
OKA-841/4	8.8	105		65	7	28		11											
OKA-842/1	7.8	108		61	12	28				7.6	514								
OKA-842/2	7.9	139		65	13	23				7.7	486								
OKA-842/3	8.0	10		94	3	3				7.8	29								
OKA-843/1	7.7	29																	
OKA-843/2	8.0	34																	
OKA-843/3	8.0	29																	
OKA-844/1	8.6	71		84	5	11		2											
OKA-845/1	8.6	55																	
OKA-846/1	8.3	58		84	9	7													
OKA-846/2	8.6	74		78	11	12		1											
OKA-846/3	8.6	97		71	12	17		6											
OKA-847/1	5.7	12																	
OKA-847/2	5.3	12																	
OKA-847/3	6.0	13																	
OKA-848/1	5.7	16																	
OKA-848/2	5.4	13																	
OKA-848/3	5.8	9																	
OKA-849/1	8.6	60																	
OKA-849/2	8.6	50																	
OKA-849/3	7.4	12																	
OKA-850/1	9.9	893		82	6	12				8.6	782								
OKA-850/2	10.2	2830		70	8	22		6		9.8	3020								
OKA-850/3	10.3	2760		67	6	27		8		10.0	3600								
OKA-850/4	10.5	1946		61	12	27		12		10.1	3120								
OKA-851/1	6.3	31		75	18	7				6.3	36								
OKA-851/2	7.7	55		51	14	36				8.0	253								
OKA-851/3	7.2	34		35	18	47				6.3	173								
OKA-851/4	7.2	10		94	5	1				7.8	10								
OKA-852/1	8.7	64		94	4	2		20											
OKA-852/2	8.2	70		93	4	3		18											
OKA-852/3	8.4	66		92	4	4		4											
OKA-852/4	8.3	54		95	3	3		1											
OKA-853/1	8.2	47																	
OKA-853/2	7.4	16																	
OKA-853/3	6.3	8																	
OKA-854/1	8.2	48																	

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OKA-854/2	7.9	24																	
OKA-855/1	5.2	9																	
OKA-855/2	5.3	6																	
OKA-856/1	7.0	12																	
OKA-856/2	6.6	13																	
OKA-856/3	6.4	12																	
OKA-856/4	6.3	27																	
OKA-857/1	7.2	22																	
OKA-857/2	6.7	13																	
OKA-857/3	6.4	11																	
OKA-858/1	7.1	20																	
OKA-858/2	7.2	35																	
OKA-859/1	8.2	69																	
OKA-859/2	8.3	26																	
OKA-859/3	8.6	35																	
OKA-860/1	8.3	29		55	29	17													
OKA-860/2	8.0	166		59	23	19		21											
OKA-860/3	8.2	123		50	23	27		22											
OKA-861/1	7.2	25																	
OKA-861/2	7.4	42																	
OKA-861/3	missing																		
OKA-862/1	8.3	73		84	10	7		10											
OKA-862/2	8.5	57		90	7	4		6											
OKA-862/3	8.7	43		96	3	1		1											
OKA-863/1	7.8	85		80	9	11													
OKA-863/2	7.8	63		78	9	13													
OKA-863/3	7.8	45		78	8	14													
OKA-864/1	7.6	50		96	3	2				7.9	107								
OKA-864/2	9.4	583		92	3	5		0		8.9	859								
OKA-864/3	8.9	1485		89	4	7		2		8.5	2260								
OKA-864/4	8.5	2320		90	3	8		0		8.5	3720								
OKA-865/1	6.0	26																	
OKA-865/2	5.4	24																	
OKA-865/3	8.5	54																	
OKA-866/1	6.7	304		93	5	2				7.3	307								
OKA-866/2	8.7	504		91	3	6		0		8.8	630								
OKA-866/3	8.9	2350		92	3	5		0		7.5	82								
OKA-867/1	7.9	133		74	15	10		3											
OKA-867/2	8.2	80		75	14	11		4											
OKA-867/3	8.3	87		67	17	16		9											
OKA-868/1	7.4	173		66	22	12													
OKA-868/2	7.0	112		69	21	10													
OKA-868/3	7.9	93		69	19	12		0											
OKA-868/4	8.8	112		61	24	15		10											
OKA-868/5	8.8	96		66	21	13		5											
OKA-869/1	8.9	119																	
OKA-869/2	8.8	208																	
OKA-870/1	7.5	52		88	9	3													
OKA-870/2	7.0	47		82	9	9													
OKA-870/3	5.5	36		75	8	17													
OKA-870/4	6.3	41		71	7	21													
OKA-871/1	7.8	66		79	16	5													
OKA-871/2	7.6	38		76	12	12													
OKA-872/1	8.3	130																	
OKA-872/2	8.3	36																	
OKA-873/1	9.0	43																	
OKA-873/2	8.5	19																	
OKA-873/3	8.3	17																	
OKA-874/1	8.0	21																	
OKA-874/2	7.7	34																	
OKA-874/3	8.1	47																	
OKA-875/1	8.6	69																	
OKA-875/2	7.9	36																	
OKA-875/3	7.8	36																	

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OKA-876/1	7.5	23		90	4	6				7.6	58								
OKA-876/2	6.0	9		79	5	17				5.9	52								
OKA-876/3	6.3	11		76	5	20				6.4	61								
OKA-877/1	8.0	26		94	3	2		0											
OKA-877/2	8.0	27		90	4	6		0											
OKA-877/3	8.3	20		90	3	7		0											
OWA-1/1	7.1	46	0.1	95	1	4													
OWA-1/2	6.7	51	0.3	82	8	10													
OWA-1/3	7.3	20	0.1	74	12	14													
OWA-2/1	8.2	37	0.3	90	5	6													
OWA-2/2	8.6	61	0.2	85	1	14													
OWA-2/3	8.8	110	0.2	75	2	23		11											
OWA-3/1	7.3	50	0.1	89	4	7													
OWA-3/2	7.2	33	0.1	75	5	21													
OWA-3/3	7.0	93	0.1	78	1	21													
OWA-4/1	8.4	95	0.3	91	2	79													
OWA-4/2	8.7	84	0.3	78	13	9		2											
OWA-4/3	8.9	169	0.2	65	22	13		18											
OWA-5/1	8.5	344	0.4	78	6	17													
OWA-5/2	8.4	458	0.1	74	1	25													
OWA-5/3	8.6	339	0.1	77	1	22													
OWA-6/1	8.3	33	0.1	95	3	2													
OWA-6/2	9.2	42	0.0	97	3	0													
OWA-6/3	9.8	575	0.0	93	3	4				8.6		1	1	40	1	5	45	5	0
OWA-6/4	10.2	976	0.0	92	3	6				9.0		5	2	36	1	12	49	5	0
OWA-7/1	9.8	552	0.0	93	2	5													
OWA-7/2	10.5	2540	0.0	67	28	5													
OWA-8/1	8.2	17	0.1	97	2	1													
OWA-8/2	6.2	12	0.2	97	2	1													
OWA-8/3	7.5	18	0.0	99	1	0													
OWA-9/1	8.3	26	0.1	96	3	1	1												
OWA-9/2	8.1	152	0.2	95	3	2	1												
OWA-9/3	7.5	17	0.6	98	1	1	1												
OWA-10/1	8.8	298	0.6	33	11	56													
OWA-10/2	8.7	119	0.1	70	27	4													
OWA-10/3	8.7	20	0.3	95	4	2													
OWA-11/1	8.6	59	0.2	86	4	10													
OWA-11/2	8.9	87	0.3	78	5	17													
OWA-11/3	7.8	24	0.2	61	20	19													
OWA-11/4	8.9	127	0.3	50	39	11													
OWA-12/1	7.9	26	0.2	91	8	1													
OWA-12/2	6.5	5	0.1	92	6	3													
OWA-13/1	6.6	20	0.1	96	1	3													
OWA-13/2	7.4	31	0.1	97	2	1													
OWA-13/3	8.6	271	0.1	90	2	8													
OWA-13/4	9.2	1040	0.1	87	2	12													
OWA-14/1	8.2	35	0.2	94	2	4													
OWA-14/2	8.3	23	0.1	97	1	2													
OWA-15/1	7.4	64	0.3	58	11	31													
OWA-15/2	7.7	36	0.4	63	3	33													
OWA-15/3	8.5	113	0.4	56	6	39		2											
OWA-16/1	9.7	65	0.2	90	2	8				8.4	2250	4	2	29	1	10	35	10	0
OWA-16/2	10.1	426	0.1	81	9	11		3		8.5	8790	2	1	159	1	25	288	15	0
OWA-16/3	10.2	4980	0.1	81	2	17		3		8.8	6570	2	1	220	2	45	359	0	2
OWA-17/1	8.6	85	0.3	97	1	3													
OWA-17/2	9.8	541	0.1	93	1	7													
OWA-17/3	9.5	1641	0.0	86	3	11													
OWA-17/4	10.1	2030	0.1	86	3	11													
OWA-18/1			0.3	70	10	20				7.8	5940	1	46	341	3	10	465	5	0
OWA-18/2			0.1	64	1	35			16	7.5	8970	225	76	852	4	5	714	5	0
OWA-18/3			0.1	68	3	42			9	7.5	3690	10	8	336	2	5	552	5	0
OWA-18/4			0.1	55	3	42		10	11	7.6	8870	8	7	202	2	45	10	3	0
OWA-19/1	6.4	4960	0.4	75	6	20													
OWA-19/2	8.1	7250	0.4	49	1	50			16										

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-19/3	8.7	5830	0.1	73	2	25			7										
OWA-19/4	9.2	4820	0.1	72	2	26		2	8	8.5	8290								
OWA-20/1	7.6	111	0.2	95	2	3													
OWA-20/2	8.2	100	0.1	97	1	1													
OWA-20/3	9.4	544	0.1	91	2	7													
OWA-20/4	10.2	990	0.1	92	2	7													
OWA-21/1	6.7	51	0.2	94	2	4													
OWA-21/2	6.7	47	0.1	91	1	8													
OWA-21/3	8.7	592	0.1	86	6	9													
OWA-22/1	8.0	1543	0.3	81	7	12				7.5	3230								
OWA-22/2	10.1	482	0.2	73	6	21				9.7	4250								
OWA-22/3	10.3	4860	0.1	72	10	18		10		9.8	7350								
OWA-22/4	10.2	5670	0.1	73	9	18		8		9.8	4320								
OWA-23/1	8.3	949	0.3	76	12	13				7.9	7360								
OWA-23/2	9.3	1929	0.2	70	8	23				8.8	2340								
OWA-23/3	9.2	4230	0.1	62	8	30		6		9.1	5090								
OWA-23/4	9.3	4170	0.1	63	9	28		7		9.1	3650								
OWA-24/1	7.2	39	0.1	97	2	1													
OWA-24/2	6.3	17	0.2	97	1	2													
OWA-24/3	6.2	20	0.0	96	3	1													
OWA-25/1	9.3	37	0.3	38	34	28													
OWA-25/2	9.6	1740	0.2	28	7	65													
OWA-25/3	9.9	3170	0.1	32	15	53													
OWA-26/1	6.7	54	0.4	81	3	17													
OWA-26/2	7.5	84	0.2	81	2	17													
OWA-26/3	9.1	3350	0.1	67	2	32				9.0	2190								
OWA-26/4	9.4	4300	0.1	64	8	27		22		9.0	3560								
OWA-27/1	7.6	28	0.1	96	2	1	1			7.4	31	6	1	24	1	12	1	5	0
OWA-27/2	7.9	2130	0.4	89	1	11	3			8.0	3270	2	2	118	1	40	214	3	0
OWA-27/3	8.7	6340	0.1	87	1	12	9			7.7	8570	18	7	400	2	10	426	5	0
OWA-27/4	9.4	7550	0.1	85	1	14	11			7.8	5470	7	7	440	3	23	0	5	0
OWA-27/5	9.1	7760	0.1	85	2	13	8			7.9	2770	49	7	362	2	12	467	5	0
OWA-28/1	6.9	10	0.1	96	2	1													
OWA-28/2	8.3	1270	0.1	89	2	9													
OWA-28/3	8.3	5330	0.0	83	3	14													
OWA-29/1	6.6	40	0.1	91	2	8	1			8.1	1978	8	1	40	1	15	10	3	0
OWA-29/2	8.2	64	0.1	91	1	8	2			8.0	2150	1	1	41	1	25	13	3	0
OWA-29/3	9.5	1380	0.1				2			7.8	3790	4	3	70	1	6	144	3	0
OWA-29/4	9.0	2030	0.0	91	2	8	1			6.6	2990	4	3	124	1	45	222	3	0
OWA-30/1	6.7	44	0.1	97	1	2													
OWA-30/2	7.8	2930	0.1	84	1	16				8.0	3380								
OWA-30/3	9.0	6670	0.0	80	2	18		4		9.1	8520								
OWA-31/1	6.3	34	0.1	96	0	4													
OWA-31/2	7.3	34	0.0	98	2	0													
OWA-31/3	9.3	3360	0.0	91	2	7				9.3	7370								
OWA-31/4	9.5	6990	0.0	88	5	7		2		9.2	92								
OWA-31/5	9.4	4780	0.0	88	4	8				9.5	76								
OWA-32/1	8.7	10060	0.3	47	1	52				8.9	9160								
OWA-32/2	9.4	906	0.1	61	3	37				9.4	9400								
OWA-32/3	8.9	1575	0.1	75	2	23		5		9.1	11940								
OWA-33/1	7.0	816	0.2	80	4	16													
OWA-33/2	8.0	910	0.1	66	3	32													
OWA-33/3	8.5	19	0.2	67	4	30													
OWA-34/1	6.2	18	0.2																
OWA-34/2	5.0	50	0.1																
OWA-34/3	9.1	235	0.0																
OWA-34/4	8.2	6560	0.0																
OWA-35/1	6.5	12570	0.3																
OWA-35/2	8.2	214	0.1																
OWA-35/3	8.8	12510	0.1																
OWA-35/4	9.4	2620	0.1																
OWA-35/5	9.2	3270	0.0																
OWA-36/1	6.7	230	0.2																
OWA-36/2	8.3	1829	0.1																

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-36/3	8.3	4750	0.1																
OWA-36/4	8.4	5640	0.0																
OWA-36/5	9.1	4510	0.0																
OWA-37/1	6.9	86	0.2																
OWA-37/2	8.1	1501	0.1																
OWA-37/3	8.8	4350	0.0																
OWA-37/4	9.0	4270	0.0																
OWA-38/1	7.8	69	0.1																
OWA-38/2	7.7	129	0.1																
OWA-38/3	8.4	196	0.1																
OWA-38/4	7.5	1378	0.1																
OWA-38/5	7.5	1913	0.1																
OWA-39/1	7.0	6130	0.3																
OWA-39/2	7.8	10840	0.1																
OWA-39/3	8.7	8130	0.1																
OWA-39/4	8.8	8760	0.1																
OWA-40/1	5.5	65	0.3																
OWA-40/2	5.1	28	0.1																
OWA-40/3	5.4	42	0.0																
OWA-41/1	5.4	91	0.3																
OWA-41/2	6.9	1717	0.1																
OWA-41/3	8.8	4050	0.1																
OWA-41/4	9.2	4790	0.0																
OWA-42/1	5.7	51	0.2	94	3	4	1			6.6	57	1	1	11	1	10	3	0	0
OWA-42/2	5.7	103	0.1	92	3	5	1			7.4	186	1	1	8	1	5	0	3	0
OWA-42/3	8.1	1233	0.1	89	3	9	2			8.0	2170	3	3	60	1	5	91	5	0
OWA-42/4	8.1	3210	0.0	85	4	12	4			7.8	2560	7	6	81	1	25	320	5	0
OWA-42/5	8.4	4330	0.0	97	1	2	8			7.9	2780	2	6	112	1	40	301	3	0
OWA-43/1	5.5	12	0.1																
OWA-43/2	5.1	11	0.1	77	5	18													
OWA-43/3	5.3	40	0.0	41	4	55													
OWA-44/1	7.3	465	0.8	63	0	37													
OWA-44/2	7.8	2190	0.3	76	4	20													
OWA-44/3	8.2	3260	0.1	74	4	22													
OWA-44/4	8.4	1810	0.1	41	2	58													
OWA-45/1	7.5	78	0.3	38	5	57													
OWA-45/2	9.3	337	0.1	88	4	8													
OWA-45/3	9.4	530	0.0	87	4	9													
OWA-45/4	9.9	1275	0.0	85	0	15													
OWA-45/5	9.9	1189	0.1	80	4	16													
OWA-46/1	6.6	31	0.1																
OWA-46/2	5.3	20	0.0																
OWA-46/3	5.2	34	0.2																
OWA-47/1	7.1	29	0.1	45	3	49													
OWA-47/2	7.5	75	0.1	35	2	63													
OWA-47/3	7.4	10	0.1	33	1	67													
OWA-48/1	7.8	581	0.2	36	2	63													
OWA-48/2	8.8	833	0.1																
OWA-48/3	9.8	672	0.1																
OWA-48/4	9.7	719	0.1																
OWA-49/1	8.5	1340	0.3	56	8	36				7.9	2290								
OWA-49/2	8.8	297	0.3	33	10	57				9.6	2350								
OWA-49/3	9.0	361	0.1	32	10	58		5		9.9	3870								
OWA-49/4	9.6	284	0.0	55	9	36		21		9.2	4250								
OWA-50/1	6.9	26	0.1																
OWA-50/2	7.2	38	0.1																
OWA-50/3	9.2	77	0.1																
OWA-50/4	9.8	171	0.1																
OWA-51/1	6.8	19	0.2																
OWA-51/2	9.0	206	0.1																
OWA-51/3	9.5	143	0.1																
OWA-52/1	8.3	831	0.3																
OWA-52/2	9.4	237	0.1					22											
OWA-52/3	9.6	243	0.1																

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-52/4	9.7	204	0.1																
OWA-53/1	6.8	20	0.2																
OWA-53/2	7.1	32	0.1																
OWA-53/3	7.6	13	0.1																
OWA-53/4																			
OWA-54/1	6.7	61	0.3																
OWA-54/2	7.8	328	0.2																
OWA-54/3	8.6	1550	0.1																
OWA-55/1	7.5	45	0.1	96	1	3	1												
OWA-55/2	6.9	14	0.1	96	2	2	1												
OWA-55/3	6.6	10	0.1	96	1	2	1												
OWA-55/4	6.9	8	0.0	96	2	1	8												
OWA-56/1	8.0	482	0.0	74	1	25													
OWA-56/2	7.6	245	0.3	85	3	12		0	3										
OWA-56/3	8.2	380	0.1	77	3	21		2	8										
OWA-57/1	7.8	160	0.4																
OWA-57/2	8.1	1098	0.8																
OWA-57/3	8.7	915	0.4																
OWA-57/4	8.8	925	0.1																
OWA-58/1	7.0	27	0.2																
OWA-58/2	7.8	51	0.1																
OWA-58/3	9.3	526	0.1																
OWA-58/4	8.6	189	0.1																
OWA-58/5	8.7	92	0.1																
OWA-59/1	7.7	63	0.3																
OWA-59/2	8.4	146	0.2																
OWA-59/3	8.4	306	0.2																
OWA-60/1	7.6	59	0.3																
OWA-60/2	9.5	527	0.1																
OWA-60/3	10.3	137	0.1																
OWA-60/4	10.2	110	0.0																
OWA-61/1	8.6	364	0.2																
OWA-61/2	9.3	143	0.2																
OWA-61/3	9.4	267	0.1																
OWA-61/4	9.7	175	0.1																
OWA-62/1	7.7	22	0.2																
OWA-62/2	7.0	12	0.1																
OWA-62/3	7.7	17	0.1																
OWA-63/1	7.4	17	0.1	96	2	2	1												
OWA-63/2	6.8	15	0.2	75	3	22	0												
OWA-63/3	6.6	39	0.1	79	3	19	10												
OWA-63/4	6.8	16	0.1	78	5	18	12												
OWA-64/1	6.7	12	0.2																
OWA-64/2	6.2	8	0.1																
OWA-64/3	8.0	16	0.1																
OWA-64/4	8.0	12	0.1																
OWA-65/1	7.0	26	0.3	93	3	4	2												
OWA-65/2	7.4	15	0.1	97	1	3	1												
OWA-65/3	7.0	16	0.2	84	0	16	8												
OWA-65/4	6.7	16	0.1	78	2	20	10												
OWA-66/1	8.5	96	0.3																
OWA-66/2	8.8	100	0.3																
OWA-66/3	8.9	139	0.3																
OWA-66/4	8.8	132	0.2																
OWA-67/1	6.7	40	0.2																
OWA-67/2	5.6	12	0.1																
OWA-67/3	6.2	11	0.0																
OWA-68/1	9.0	1320	0.3																
OWA-68/2	9.9	2580	0.2																
OWA-68/3	10.0	2360	0.1																
OWA-68/4	9.9	2160	0.1																
OWA-69/1	7.7	67	0.3	93	3	4													
OWA-69/2	9.5	625	0.3	85	4	11				8.9	1350								
OWA-69/3	9.1	1620	0.1	85	4	11				8.4	3300								

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-69/4	9.4	1290	0.0	83	5	12		1		8.7	2850								
OWA-70/1	8.1	41	0.2																
OWA-70/2	8.0	43	0.1																
OWA-70/3	8.9	1320	0.1																
OWA-70/4	8.7	1580	0.0																
OWA-70/5	8.6	1590	0.1																
OWA-71/1	6.9	12	0.2																
OWA-71/2	6.2	8	0.1																
OWA-71/3	6.4	14	0.1																
OWA-71/4	6.0	10	0.1																
OWA-71/5	6.6	14	0.0																
OWA-72/1	8.3	342	0.1																
OWA-72/2	9.7	508	0.1																
OWA-72/3	9.7	327	0.0																
OWA-73/1	7.7	14	0.1																
OWA-73/2	7.5	12	0.1																
OWA-73/3	6.7	17	0.1																
OWA-73/4	7.9	200	0.1																
OWA-73/5	8.5	45	0.1																
OWA-74/1	8.1	22	0.3																
OWA-74/2	9.4	179	0.1																
OWA-74/3	10.1	67	0.1																
OWA-74/4	10.1	81	0.1																
OWA-75/1	7.6	17	0.1																
OWA-75/2	7.6	18	0.1																
OWA-75/3	7.6	14	0.0																
OWA-76/1	6.3	48	0.5																
OWA-76/2	6.1	30	0.2																
OWA-76/3	6.2	47	0.2																
OWA-76/4	6.5	56	0.1																
OWA-77/1	7.3	121	0.1																
OWA-77/2	9.5	616	0.1																
OWA-77/3	10.2	1596	0.1																
OWA-77/4	9.6	213	0.0																
OWA-77/5	10.1	207	0.1																
OWA-78/1	7.1	14	0.2																
OWA-78/2	7.5	13	0.1																
OWA-79/1	7.4	12	0.2																
OWA-79/2	5.0	26	0.1																
OWA-79/3	5.2	9	0.0																
OWA-80/1	6.5	19	0.2	94	4	2				7.6	34	4	1	10	2		1		
OWA-80/2	8.0	29	0.1	95	2	3				6.2	55	2	2	14	2	12	0	5	0
OWA-80/3	9.2	81	0.0	90	3	7				8.4	280	2	1	16	2	55	0	0	5
OWA-80/4	9.6	231	0.0	90	9	1				8.4	620	2	1	19	2	40	0	0	5
OWA-80/5	9.5	317	0.1	85	3	12		0		9.0	9380	2	2	22	3	35	0	0	0
OWA-81/1	8.7	79	0.3	88	4	8													
OWA-81/2	8.7	102	0.4	78	8	14		9											
OWA-81/3	8.7	115	0.3	77	9	14		15											
OWA-81/4	8.8	131	0.2	76	10	14		20											
OWA-82/1	7.2	23	0.2																
OWA-82/2	9.4	121	0.1																
OWA-82/3	10.1	664	0.1																
OWA-82/4	6.5	378	0.0																
OWA-83/1	9.8	24	0.1																
OWA-83/2	9.8	218	0.0																
OWA-83/3	10.1	520	0.0																
OWA-83/4	10.1	442	0.0																
OWA-84/1	6.4	98	0.6	54	28	18													
OWA-84/2	6.2	57	0.2	53	21	27													
OWA-84/3	6.5	62	0.2																
OWA-85/1	7.2	35	0.4																
OWA-85/2	7.7	58	0.2																
OWA-85/3	8.5	42	0.1																
OWA-86/1	6.6	39	0.3	77	11	12													

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-86/2	6.7	17	0.2	70	5	25													
OWA-86/3	7.2	23	0.1	73	5	22													
OWA-86/4	8.3	110	0.1	72	8	21		7											
OWA-87/1	6.5	21	0.1																
OWA-87/2	7.2	11	0.1																
OWA-88/1	6.8	31	0.3																
OWA-88/2	6.8	19	0.1																
OWA-88/3	7.1	35	0.1																
OWA-89/1	8.1	40	0.2	95	3	2				8.3	115	1	1	9	2	30	0	0	5
OWA-89/2	8.6	313	0.2	89	3	9				8.4	6460	1	1	24	3		3		
OWA-89/3	9.3	1264	0.1	85	4	11		2		8.6	1760	2	2	30	2	40	1	0	10
OWA-90/1	7.5	27	0.1					0											
OWA-90/2	6.9	15	0.1																
OWA-90/3	7.3	37	0.1																
OWA-90/4	7.5	35	0.1																
OWA-91/1	7.4	24	0.2	91	4	6													
OWA-91/2	8.9	172	0.1	78	3	19		0	4										
OWA-91/3	7.5	1608	0.1	78	2	20		1	23										
OWA-92/1	7.9	14																	
OWA-92/2	7.1	19																	
OWA-92/3	7.6	15																	
OWA-93/1	7.0	120		69	7	24													
OWA-93/2	8.2	769		70	9	21													
OWA-93/3	7.8	2860		70	0	30			58										
OWA-94/1	7.7	15																	
OWA-94/2	7.9	16																	
OWA-94/3	8.1	13																	
OWA-94/4	7.3	14																	
OWA-94/4																			
OWA-95/1	6.6	1071	0.4	76	7	18													
OWA-95/2	7.8	6360	0.4	39	1	60													
OWA-95/3	8.2	5380	0.1	61	1	39		2	14										
OWA-96/1	6.4	1225	0.1	76	6	18		2											
OWA-96/2	8.0	3070	0.1	74	6	20		1	12										
OWA-96/3	9.0	6760	0.1	44	3	54		7	71	6.2	13								
OWA-96/4	8.7	7130	0.1	41	2	57			78	6.3	15								
OWA-97/1	9.9	2660	0.2	89	4	8				5.3	15								
OWA-97/2	9.9	4280	0.1	86	3	11		2		5.6	19								
OWA-97/3	9.7	3010	0.0	84	3	13		6		7.8	4880								
OWA-97/4	9.6	1945	0.0	83	3	15		0		9.2	8310								
OWA-98/1	6.5	12	0.2																
OWA-98/2	6.0	10	0.1																
OWA-98/3	6.1	9	0.0																
OWA-99/1	7.9	4520	0.2	48	7	45													
OWA-99/2	8.3	9730	0.2	30	11	59		5	50										
OWA-99/3	8.8	9740	0.1	34	2	65		17	61										
OWA-99/4	8.8	8640	0.1	39	2	59		7	52										
OWA-100/1	6.0	6	0.1																
OWA-100/2	5.5	9	0.1																
OWA-100/3	5.4	7	0.1																
OWA-101/1	8.7	368	0.2	75	0	25													
OWA-101/2	10.1	1498	0.1	75	3	22		3		8.2	5550								
OWA-101/3	10.4	1672	0.0	47	4	49		3		8.6	4180								
OWA-102/1	8.8	87	0.2																
OWA-102/2	8.9	544	0.3																
OWA-102/3	9.4	1485	0.2																
OWA-102/4	8.3	2470																	
OWA-102/5	8.1	2210																	
OWA-103/1	7.0	37																	
OWA-103/2	7.1	12																	
OWA-103/3	6.7	80																	
OWA-103/4	6.9	25																	
OWA-104/1	7.1	17																	
OWA-104/2	7.0	17																	

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-104/3	6.9	42																	
OWA-105/1	8.7	76																	
OWA-105/2	8.9	95																	
OWA-105/3	9.4	223																	
OWA-105/4	9.8	679																	
OWA-106/1	8.4	43																	
OWA-106/2	9.3	2140																	
OWA-106/3	9.9	1280																	
OWA-106/4	9.6	1118																	
OWA-107/1	6.9	21		94	3	3													
OWA-107/2	9.3	191		88	2	10													
OWA-107/3	9.8	876		86	3	12		0		8.6	990	2	1	32	2	35	1	0	10
OWA-107/4	8.7	1028		88	1	12				7.9	1290	1	1	32	2	35	1	3	0
OWA-108/1	7.2	83																	
OWA-108/2	7.7	36																	
OWA-108/3	8.2	33																	
OWA-109/1	8.7	62																	
OWA-109/2	8.8	82																	
OWA-110/1	7.4	67																	
OWA-110/2	8.7	65																	
OWA-110/3	9.0	96																	
OWA-111/1	8.9	921																	
OWA-111/2	9.9	4180																	
OWA-111/3	9.8	3710																	
OWA-112/1	7.1	17																	
OWA-112/2	8.2	28																	
OWA-112/3	10.2	714																	
OWA-112/4	10.1	772																	
OWA-113/1	8.9	224																	
OWA-113/2	10.4	2590																	
OWA-113/3	10.3	2250																	
OWA-114/1	7.2	79		70	7	23													
OWA-114/2	7.3	94		63	8	30													
OWA-114/3	7.4	128		67	6	28													
OWA-115/1	8.2	76																	
OWA-115/2	7.7	40																	
OWA-115/3	7.7	50																	
OWA-115/4	7.8	29																	
OWA-116/1	9.0	84		93	6	1													
OWA-116/2	9.1	46		96	1	3													
OWA-116/3	6.4	29		80	2	18													
OWA-117/1	8.8	65		87	5	9		0											
OWA-117/2	9.1	60		83	5	12		0											
OWA-117/3	8.9	78		69	16	15		2											
OWA-118/1	7.3	21		93	4	3													
OWA-118/2	8.7	111		88	5	8													
OWA-118/3	9.3	412		78	7	15													
OWA-118/4	8.2	398		80	6	14													
OWA-119/1	6.7	12		90	4	6													
OWA-119/2	6.0	11		88	4	8													
OWA-119/3	6.0	13		84	5	11													
OWA-120/1	8.3	29		92	3	5	3												
OWA-120/2	7.6	16		89	4	8	5												
OWA-120/3	7.8	23		85	4	11	7												
OWA-121/1	6.0	13																	
OWA-121/2	5.2	10																	
OWA-121/3	4.9	13																	
OWA-122/1	7.4	17																	
OWA-122/2	6.8	29																	
OWA-122/3	7.0	21																	
OWA-122/4	5.7	23																	
OWA-123/1	6.4	16																	
OWA-123/2	5.7	8																	
OWA-123/3	5.8	13																	

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-124/1	8.5	52																	
OWA-124/2	8.7	62																	
OWA-124/3	9.0	61																	
OWA-125/1	7.8	26																	
OWA-125/2	7.7	22																	
OWA-125/3	7.5	24																	
OWA-125/4	8.0	42																	
OWA-126/1	7.8	23																	
OWA-126/2	6.7	19																	
OWA-126/3	6.6	10																	
OWA-127/1	7.8	53		88	7	4		0											
OWA-127/2	7.8	15		91	1	8		1											
OWA-127/3	7.4	19		87	3	10		1											
OWA-128/1	7.6	18																	
OWA-128/2	9.1	440																	
OWA-128/3	10.2	708																	
OWA-128/4	10.3	18																	
OWA-129/1	7.8	21																	
OWA-129/2	6.3	7																	
OWA-129/3	5.5	3																	
OWA-130/1	7.6	19																	
OWA-130/2	7.2	10																	
OWA-130/3	7.5	20																	
OWA-130/4	7.8	26																	
OWA-131/1	7.2	12		94	4	3	7												
OWA-131/2	6.5	12		92	2	12	1												
OWA-131/3	6.5	19		86	2	12	12												
OWA-131/4	7.4	21		81	5	14	7												
OWA-132/1	6.9	36																	
OWA-132/2	5.6	8																	
OWA-132/3	5.2	9																	
OWA-133/1	7.6	58																	
OWA-133/2	9.2	522																	
OWA-133/3	8.7	2690																	
OWA-133/4	8.8	1978																	
OWA-134/1	6.7	23																	
OWA-134/2	8.5	825																	
OWA-134/3	10.0	1210																	
OWA-134/4	9.7	1393																	
OWA-135/1	8.3	80		89	3	8													
OWA-135/2	9.1	751		75	4	22		3		8.4	1480	1	1	23	2	40	1	3	10
OWA-135/3	9.2	659		73	6	21		2		8.5	539	1	1	25	3	35	35	0	5
OWA-136/1	7.0	16		92	5	4	2												
OWA-136/2	6.8	14		89	5	6	3												
OWA-136/3	7.5	18		83	5	12	6												
OWA-137/1	5.1	39																	
OWA-137/2	9.5	585																	
OWA-137/3	9.2	1754																	
OWA-138/1	6.8	37																	
OWA-138/2	6.9	21																	
OWA-138/3	7.4	19																	
OWA-139/1	6.7	15																	
OWA-139/2	6.7	12																	
OWA-139/3	6.8	36																	
OWA-140/1	9.3	371		92	2	6				8.5	721								
OWA-140/2	10.2	3050		86	6	8		1		10.0	6330								
OWA-140/3	10.4	2980		81	8	11		0		10.4	5590								
OWA-141/1	7.0	61		96	2	2													
OWA-141/2	9.2	505		88	3	10				8.4	1020								
OWA-141/3	9.5	1080		87	2	12		2		8.7	1998								
OWA-141/4	9.8	85		86	2	12		6		9.0	1940								
OWA-141/5	9.7	83		86	1	13		2		8.8	2110								
OWA-142/1	9.6	24		93	3	4				8.9	670	1	0	21	2	35	0	0	5
OWA-142/2	8.1	3330		77	8	15		1	9	7.8	2830	4	3	98	3	30	7	0	10

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-142/3	9.8	1860		77	8	15		8	10	8.1	760	2	1	43	2	40	5	0	0
OWA-143/1	9.9	1310		85	3	11				8.6	430	1	0	45	3	30	3	0	0
OWA-143/2	10.7	3910		81	3	16		2	24	10.1	6290	1	0	121	3	45	8	5	15
OWA-143/3	10.5	2930		78	5	17		4	10	10.1	4310	2	2	103	4	35	5	5	20
OWA-143/4	10.6	2280		79	3	18		4	2	10.1	2190	1	1	51	3	35	4	0	20
OWA-144/1	7.8	98																	
OWA-144/2	10.6	1160																	
OWA-144/3	10.6	1358																	
OWA-144/4	6.6	80																	
OWA-145/1	8.0	3		89	5	6													
OWA-145/2	8.8	6		79	1	21		1											
OWA-145/3	7.3	48		77	8	15		1											
OWA-146/1	7.1	6																	
OWA-146/2	9.8	64																	
OWA-146/3	9.8	1446																	
OWA-147/1	8.9	6																	
OWA-147/2	10.1	63																	
OWA-147/3	10.3	1240																	
OWA-147/4	10.4	1030																	
OWA-148/1	9.6	620		95	3	3		0		8.2	480	1	2	29	3	40	2	0	5
OWA-148/2	9.0	4630		82	7	11		0		8.0	9790	13	7	196	6	25	9	0	0
OWA-148/3	10.0	2570		82	6	13		2		8.3	2570	3	3	51	4	40	4	0	5
OWA-148/4	10.1	1930		85	3	12		2		8.8	3970	3	3	52	4	40	3	0	10
OWA-149/1	7.5	1540		69	7	23				7.9	7150	2	3	40	3	10	0	0	0
OWA-149/2	7.7	4330		71	4	25		1	19	8.2	5410	7	5	39	4	65	3	0	0
OWA-149/3	8.3	3450		67	4	28		1	11	7.5	940	11	5	108	3	65	8	0	0
OWA-150/1	7.7	185																	
OWA-150/2	8.4	1440																	
OWA-150/3	8.9	3290																	
OWA-151/1	7.1	19																	
OWA-151/2	8.1	815																	
OWA-151/3	9.5	1420																	
OWA-151/4	9.1	935																	
OWA-152/1	7.5	32		95	4	2													
OWA-152/2	8.9	2780		75	2	24				8.5	5539								
OWA-152/3	9.6	3860		82	2	17		2	15	8.6	3760								
OWA-153/1	7.4	4		94	2	4													
OWA-153/2	8.2	1980		82	5	13													
OWA-153/3	9.2	3240		82	13	5		4											
OWA-153/4	8.3	2870		82	4	14													
OWA-154/1	6.6	7410																	
OWA-154/2	9.1	9260																	
OWA-155/1	6.3	45																	
OWA-155/2	6.1	51																	
OWA-155/3	7.5	61																	
OWA-155/4	8.2	469																	
OWA-155/5	9.1	909																	
OWA-156/1	6.1	38		95	4	1	1												
OWA-156/2	7.8	453		86	5	10	3												
OWA-156/3	8.7	1950		83	1	16	11			7.6	2870	2	2	51	2	60	3	5	0
OWA-157/1	6.4	12		94	3	2													
OWA-157/2	8.9	30		96	3	1													
OWA-157/3	8.9	185		90	5	6													
OWA-157/4	9.5	573		85	1	14													
OWA-158/1	6.9	57		95	1	4	1												
OWA-158/2	8.3	1280		72	18	11	9			8.1	3670	4	6	121	2	65	68	5	0
OWA-158/3	9.4	5600		78	9	13	22			8.0	6470	4	2	184	2	100	4	5	0
OWA-158/4	9.4	6710		78	8	14	25			8.1	6270	3	2	240	3	150	6	5	0
OWA-159/1	8.9	2330		72	15	13				8.6	3760								
OWA-159/2	9.7	3270		45	7	48		3		9.6	6370								
OWA-159/3	9.4	2820		38	1	61		2		9.3	4980								
OWA-159/4	9.4	2060		70	16	15		20		9.1	3470								
OWA-160/1	8.8	4830		79	4	17				8.1	2470	6	3	150	2	35	6	5	0
OWA-160/2	9.0	9940		77	3	21		1	15	7.7	4570	17	1	458	3	120	10	5	0

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-160/3	8.6	9150		75	2	23		1	16	7.6	9470	3	2	265	3	115	10	5	0
OWA-160/4	9.3	5720		77	3	21		1	15	8.4	5950	3	1	196	2	125	4	3	0
OWA-161/1	6.6	62																	
OWA-161/2	7.3	32																	
OWA-161/3	7.0	24																	
OWA-162/1	8.4	663		93	3	4					xxx								
OWA-162/2	9.8	2470		86	3	12				8.6	7380	3	1	125	2	90	2	5	0
OWA-162/3	9.7	3360		83	2	15		1		8.3	4930	3	1	139	2	85	3	5	0
OWA-162/4	9.6	3220		76	9	15		2		8.5	xxx	6	5	91	2	90	4	10	0
OWA-163/1	7.4	22																	
OWA-163/2	7.9	18																	
OWA-163/3	8.7	80																	
OWA-164/1	7.9	33																	
OWA-164/2	9.7	291																	
OWA-164/3	9.8	834																	
OWA-164/4	10.0	933																	
OWA-164/5	6.4	38																	
OWA-165/1	7.1	15																	
OWA-165/2	6.8	12																	
OWA-165/3	8.0	18																	
OWA-165/4	9.1	77																	
OWA-166/1	6.6	13																	
OWA-166/2	7.4	42																	
OWA-166/3	9.2	166																	
OWA-167/1	8.6	106		95	4	2				7.9	221								
OWA-167/2	10.1	427		91	4	6				9.3	741								
OWA-167/3	10.4	1746		88	1	11				9.9	3140								
OWA-167/4	10.2	3370		84	1	15				10.0	5490								
OWA-168/1	7.4	9		81	8	11													
OWA-168/2	7.9	2		96	1	3													
OWA-168/3	7.9	2		43	25	32													
OWA-168/4	6.6	4		81	2	17													
OWA-169/1	8.3	1300		62	9	29				8.2	4290	3	1	116	2	70	1	5	0
OWA-169/2	8.6	315		57	4	39		5	10	8.0	5960	5	7	108	2	90	2	5	0
OWA-169/3	8.9	2860		61	4	36		3	15	8.2	5870	3	5	62	2	70	4	5	0
OWA-169/4	8.3	3190		65	3	32		2	16	7.9	3580	10	8	60	3	65	3	5	0
OWA-170/1	7.6	281		82	2	16				8.5	xxx	2	1	89	2	35	0	5	0
OWA-170/2	9.1	1267		80	2	18		1	7	8.4	890	2	2	8	2	40	1	5	0
OWA-170/3	8.5	1825		79	2	19		1	12	8.1	6430	7	16	55	2	55	3	5	0
OWA-171/1	6.5	40		95	0	5													
OWA-171/2	6.3	36		87	9	3													
OWA-171/3	7.4	18		78	16	6													
OWA-172/1	6.0	2200		74	2	24													
OWA-172/2	8.1	8430		48	2	50		2	40										
OWA-172/3	8.4	4720		60	1	39		1	29										
OWA-173/1	7.5	1182																	
OWA-173/2	9.0	4440																	
OWA-173/3	9.9	2470																	
OWA-174/1	8.7	2																	
OWA-174/2	7.9	23																	
OWA-175/1	8.3	1819		54	9	37			28	8.0	4090								
OWA-175/2	10.0	5560		91	0	9		1	61	10.0	9780								
OWA-175/3	10.2	2860		74	2	24		0		10.1	4890								
OWA-176/1	7.4	19																	
OWA-176/2	6.0	11																	
OWA-177/1	7.2	25		94	3	3				7.4	53								
OWA-177/2	9.0	486		90	2	8				8.4	1244								
OWA-177/3	9.4	1231		86	4	11		0		9.1	2110								
OWA-178/1	8.9	506																	
OWA-178/2	10.2	5360																	
OWA-179/1	6.2	109																	
OWA-179/2	6.7	587																	
OWA-179/3	9.4	1290																	
OWA-180/1	6.9	12																	

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-180/2	7.3	15																	
OWA-180/3	7.7	70																	
OWA-181/1	6.4	64																	
OWA-181/2	8.4	851																	
OWA-181/3	9.7	2090																	
OWA-182/1	6.5	17																	
OWA-182/2	6.3	578																	
OWA-182/3	8.5	1820																	
OWA-183/1	6.2	52																	
OWA-183/2	7.8	434																	
OWA-183/3	8.1	891																	
OWA-183/4	9.3	1920																	
OWA-184/1	8.5	997																	
OWA-184/2	9.6	3310																	
OWA-184/3	8.7	4020																	
OWA-184/4	9.4	2050																	
OWA-184/5	8.4	1530																	
OWA-185/1	7.4	1450																	
OWA-185/2	8.5	3760																	
OWA-185/3	8.3	6330																	
OWA-186/1	6.3	433																	
OWA-186/2	8.4	3850																	
OWA-186/3	9.1	3680																	
OWA-187/1	6.1	70																	
OWA-187/2	8.7	907																	
OWA-187/3	9.0	2890																	
OWA-187/4	9.1	1560																	
OWA-188/1	7.9	2170		72	3	25													
OWA-188/2	8.6	5700		82	7	12													
OWA-188/3	9.1	5870		71	8	21		6											
OWA-189/1	7.6	1173																	
OWA-189/2	8.8	3130																	
OWA-189/3	8.3	7070																	
OWA-189/4	8.8	4290																	
OWA-189/5	9.5	5180																	
OWA-190/1	6.4	34																	
OWA-190/2	8.9	1006																	
OWA-190/3	7.5	49																	
OWA-190/4	9.2	1862																	
OWA-191/1	8.2	35																	
OWA-191/2	7.6	212																	
OWA-191/3	8.2	1595																	
OWA-191/4	7.5	3850																	
OWA-191/5	7.5	2210																	
OWA-192/1	6.1	46																	
OWA-192/2	6.4	264																	
OWA-192/3	8.4	1010																	
OWA-192/4	9.3	2240																	
OWA-193/1	7.1	113																	
OWA-193/2	8.2	2990																	
OWA-193/3	9.0	6240																	
OWA-194/1	8.1	4270																	
OWA-194/2	8.7	6510																	
OWA-195/1	9.0	1902																	
OWA-195/2	8.6	5580																	
OWA-195/3	8.6	4540																	
OWA-196/1	5.2	16	0.1	94	3	3													
OWA-196/2	4.7	21	0.1	92	4	4													
OWA-197/1	5.9	29	0.3	94	3	3													
OWA-197/2	5.3	15	0.1	93	4	3													
OWA-197/3	5.0	16	0.1	93	4	3													
OWA-197/4	7.3	41	0.0	95	5	1													
OWA-198/1	6.6	64	0.3	84	7	9													
OWA-198/2	8.1	210	0.4	77	8	16													

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-198/3	7.4	107	0.2	73	6	21													
OWA-198/4	6.8	89	0.2	75	5	19													
OWA-199/1	6.5	86	0.1	91	4	5													
OWA-199/2	7.0	15	0.0	88	3	9													
OWA-199/3	7.5	25	0.1	86	5	9													
OWA-200/1	7.2	14																	
OWA-200/2	7.3	16																	
OWA-200/3	9.0	54																	
OWA-200/4	9.4	230																	
OWA-201/1	6.5	226																	
OWA-201/2	7.5	132																	
OWA-201/3	8.5	461																	
OWA-202/1	6.4	21																	
OWA-202/2	7.2	875																	
OWA-202/3	8.1	2670																	
OWA-202/4	8.7	4000																	
OWA-203/1	6.6	21																	
OWA-203/2	6.9	26																	
OWA-203/3	7.4	69																	
OWA-203/4	8.6	630																	
OWA-203/5	9.3	1566																	
OWA-204/1	7.5	347		42	15	43													
OWA-204/2	7.8	3090		41	6	52		2	49										
OWA-204/3	8.0	4090		39	4	57		0	51										
OWA-205/1	8.0	69																	
OWA-205/2	9.8	1135																	
OWA-206/1	8.2	53																	
OWA-206/2	7.9	265																	
OWA-206/3	9.2	611																	
OWA-206/4	9.7	1024																	
OWA-207/1	8.9	89																	
OWA-207/2	8.4	257																	
OWA-207/3	8.7	1411																	
OWA-208/1	6.9	19																	
OWA-208/2	6.8	14																	
OWA-208/3	7.1	21																	
OWA-209/1	9.1	3380																	
OWA-209/2	9.9	5120																	
OWA-210/1	7.7	28																	
OWA-210/2	7.0	15																	
OWA-210/3	6.8	49																	
OWA-211/1	7.3	19																	
OWA-211/2	6.6	29																	
OWA-211/3	7.7	634																	
OWA-212/1	6.7	6160		55	4	40													
OWA-212/2	8.5	13860		34	5	62		3											
OWA-212/3	8.5	10130		51	3	46		2											
OWA-213/1	6.9	28																	
OWA-213/2	7.0	22																	
OWA-214/1	7.1	76		92	5	4													
OWA-214/2	8.2	2020		84	5	10													
OWA-214/3	8.9	2510		82	5	13		1											
OWA-215/1	7.4	25																	
OWA-215/2	6.8	8																	
OWA-215/3	6.6	16																	
OWA-216/1	6.7	608		86	3	11				6.6	2170								
OWA-216/2	8.9	2510		75	2	24		0		8.4	5930								
OWA-216/3	9.4	2680		72	1	27		0		8.8	3790								
OWA-217/1	6.4	19																	
OWA-217/2	6.4	34																	
OWA-217/3	8.8	15																	
OWA-218/1	6.9	21		92	4	4													
OWA-218/2	6.9	46		89	6	5													
OWA-218/3	8.9	507		82	7	11		0	7										

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-218/4	9.2	1427		63	4	33		0	10										
OWA-219/1	7.9	1172																	
OWA-219/2	8.6	620																	
OWA-219/3	7.7	29																	
OWA-219/4	9.5	250																	
OWA-220/1	9.5	2250																	
OWA-220/2	8.2	3870																	
OWA-220/3	8.5	1620																	
OWA-221/1	7.6	84		92	5	4													
OWA-221/2	8.8	414		85	7	8													
OWA-221/3	9.2	871		85	5	11		3		8.4	3230								
OWA-221/4	9.2	1085		84	6	10		0		8.4	4250								
OWA-222/1	7.5	81																	
OWA-222/2	7.7	76																	
OWA-222/3	7.9	181																	
OWA-222/4	9.9	393																	
OWA-223/1	5.9	59																	
OWA-223/2	7.7	593																	
OWA-223/3	8.2	2610																	
OWA-223/4	8.3	3680																	
OWA-223/5	8.8	3670																	
OWA-224/1	6.9	20																	
OWA-224/2	7.3	11																	
OWA-224/3	6.6	542																	
OWA-224/4	7.2	2430																	
OWA-225/1	6.5	35																	
OWA-225/2	8.6	387																	
OWA-225/3	8.6	964																	
OWA-225/4	9.4	1820																	
OWA-226/1	7.1	46																	
OWA-226/2	8.6	529																	
OWA-226/3	8.8	2620																	
OWA-226/4	9.1	1820																	
OWA-227/1	8.2	4230																	
OWA-227/2	8.2	8440																	
OWA-227/3	9.4	5300																	
OWA-228/1	7.4	44																	
OWA-228/2	8.4	779																	
OWA-228/3	8.4	2690																	
OWA-228/4	8.5	3210																	
OWA-228/5	9.5	2290																	
OWA-229/1	7.0	53																	
OWA-229/2	6.7	54																	
OWA-229/3	7.3	19																	
OWA-229/4	8.8	206																	
OWA-229/5	8.5	323																	
OWA-230/1	6.9	12																	
OWA-230/2	7.5	1569																	
OWA-230/3	8.6	3380																	
OWA-230/4	8.7	2200																	
OWA-231/1	9.0	2440																	
OWA-231/2	10.2	5060																	
OWA-231/3	10.3	5410																	
OWA-232/1	9.5	1491																	
OWA-232/2	10.3	3940																	
OWA-232/3	10.2	3520																	
OWA-233/1	8.3	33																	
OWA-233/2	8.9	1163																	
OWA-233/3	8.8	3700																	
OWA-233/4	8.8	2300																	
OWA-234/1	7.1	54																	
OWA-234/2	7.2	1400																	
OWA-234/3	9.0	3010																	
OWA-234/4	8.7	5160																	

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-234/5	9.2	3490																	
OWA-235/1	7.7	88																	
OWA-235/2	7.7	1380																	
OWA-235/3	8.3	2570																	
OWA-235/4	8.2	3370																	
OWA-235/5																			
OWA-236/1	9.0	1490																	
OWA-236/2	8.3	3580																	
OWA-236/3	9.1	2370																	
OWA-237/1	7.4	4910																	
OWA-237/2	8.6	8090																	
OWA-237/3	9.0	5590																	
OWA-238/1	7.8	56																	
OWA-238/2	8.3	1455																	
OWA-238/3	8.2	3470																	
OWA-238/4	8.3	4120																	
OWA-239/1	7.9	43																	
OWA-239/2	8.7	425																	
OWA-239/3	8.9	1410																	
OWA-239/4	8.5	2180																	
OWA-240/1	6.4	44																	
OWA-240/2	6.6	276																	
OWA-240/3	8.4	133																	
OWA-240/4	9.0	2530																	
OWA-241/1	6.4	32																	
OWA-241/2	7.4	1340																	
OWA-241/3	8.1	2150																	
OWA-242/1	6.7	47																	
OWA-242/2	7.9	512																	
OWA-242/3	9.4	1400																	
OWA-242/4	8.6	3380																	
OWA-242/5	8.3	1930																	
OWA-243/1	7.3	23		92	5	3													
OWA-243/2	7.4	23		83	7	10													
OWA-243/3	9.1	169		78	5	17		0		8.3	5600								
OWA-243/4	9.7	328		75	7	18		1		8.8	863								
OWA-244/1	7.2	55		91	6	3													
OWA-244/2	8.2	337		82	6	11													
OWA-244/3	8.7	2970		75	8	17		0											
OWA-245/1	6.6	47																	
OWA-245/2	7.9	495																	
OWA-245/3	8.6	3320																	
OWA-245/4	8.8	2780																	
OWA-246/1	7.3	154		70	9	22													
OWA-246/2	8.1	2440		56	5	40		0	3										
OWA-246/3	7.9	3370		52	1	48		0	22										
OWA-246/4	8.3	3480		55	8	37		1	78										
OWA-247/1	6.5	124																	
OWA-247/2	7.6	383																	
OWA-247/3	8.1	3460																	
OWA-248/1	6.8	49																	
OWA-248/2	8.2	119																	
OWA-248/3	7.7	576																	
OWA-249/1	7.0	425																	
OWA-249/2	8.8	2250																	
OWA-249/3	8.4	2890																	
OWA-250/1	8.2	56																	
OWA-250/2	7.4	25																	
OWA-250/3	8.1	38																	
OWA-251/1	6.3	83																	
OWA-251/2	6.9	171																	
OWA-251/3	8.9	1980																	
OWA-251/4	9.7	2520																	
OWA-251/5	9.5	2630																	

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-252/1	7.1	23																	
OWA-252/2	8.2	1600																	
OWA-253/1	7.2	57																	
OWA-253/2	7.4	674																	
OWA-253/3	7.8	4350																	
OWA-253/4	8.3	5020																	
OWA-254/1	6.9	108																	
OWA-254/2	7.4	1721																	
OWA-254/3	7.9	4030																	
OWA-254/4	9.0	3500																	
OWA-255/1	8.2	1610																	
OWA-255/2	7.9	8200																	
OWA-255/3	9.0	9710																	
OWA-256/1	8.7	173																	
OWA-256/2	7.8	1756																	
OWA-256/3	7.7	5640																	
OWA-256/4	8.0	4860																	
OWA-257/1	8.6	38																	
OWA-257/2	8.8	40																	
OWA-257/3	9.9	407																	
OWA-258/1	7.7	542																	
OWA-258/2	7.7	2280																	
OWA-258/3	8.7	2550																	
OWA-259/1	8.6	97																	
OWA-259/2	9.7	2020																	
OWA-259/3	9.5	5570																	
OWA-260/1	7.2	2290																	
OWA-260/2	8.1	8610																	
OWA-260/3	9.0	5250																	
OWA-261/1	7.9	1031																	
OWA-261/2	8.4	2450																	
OWA-261/3	8.3	3080																	
OWA-262/1	7.2	60																	
OWA-262/2	8.1	1907																	
OWA-262/3	8.0	5280																	
OWA-262/4	8.3	5050																	
OWA-263/1	7.7	33																	
OWA-263/2	6.9	19																	
OWA-263/3	7.1	22																	
OWA-264/1	6.6	14																	
OWA-264/2	6.8	17																	
OWA-264/3	8.2	70																	
OWA-265/1	7.5	51																	
OWA-265/2	7.6	585																	
OWA-265/3	8.6	3810																	
OWA-265/4	7.1	16																	
OWA-266/1	6.8	23		85	9	6													
OWA-266/2	7.7	513		78	6	16													
OWA-266/3	9.2	1650		71	6	23		3	18	8.7	4340								
OWA-266/4	9.1	1695		79	4	17		0	12	8.4	5470								
OWA-267/1	7.3	127																	
OWA-267/2	8.8	104																	
OWA-267/3	9.5	427																	
OWA-267/4	9.2	1106																	
OWA-267/5	8.8	1139																	
OWA-268/1	8.7	138																	
OWA-268/2	8.4	2560																	
OWA-269/1	7.6	23																	
OWA-269/2	9.3	114																	
OWA-269/3	9.8	159																	
OWA-270/1	6.4	99																	
OWA-270/2	8.3	3790																	
OWA-270/3	8.8	4870																	
OWA-270/4	9.2	4370																	

Horizon	pH	E.C. (1:2.5)	O.C.	Sand	Silt	Clay	C.E.C.	CaCO3	Gypsum	pH (paste)	E.C.(paste)	Ca	Mg	Na	K	Cl	SO4	HCO3	CO3
Reference	1:2.5	(microS/cm) 25ºC	(%)	(%)	(%)	(%)	(cmol+/kg)	(%)	(%)	1:2.5	(microS/cm) 25ºC	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)
OWA-271/1	6.1	22		88	3	8													
OWA-271/2	8.9	723		80	5	15													
OWA-271/3	8.3	1652		78	16	7		0	14										
OWA-271/4	8.6	2500		77	6	17		0	12										
OWA-272/1	6.9	28																	
OWA-272/2	8.2	1087																	
OWA-272/3	8.2	3600																	
OWA-273/1	6.5	30																	
OWA-273/2	8.2	340																	
OWA-273/3	7.9	1274																	
OWA-274/1	6.8	34																	
OWA-274/2	6.6	18																	
OWA-274/3	7.0	12																	
OWA-274/4	7.7	111																	
OWA-275/1	7.0	26																	
OWA-275/2	6.5	19																	
OWA-275/3	7.4	47																	
OWA-275/4	7.7	108																	
OWA-276/1	7.9	57																	
OWA-276/2	7.5	988																	
OWA-276/3	9.8	2810																	
OWA-276/4	9.5	3960																	
OWA-277/1	7.7	93																	
OWA-277/2	9.1	3100																	
OWA-277/3	10.0	3980																	
OWA-277/4	10.0	4710																	
OWA-278/1	7.8	68																	
OWA-278/2	7.3	49																	
OWA-278/3	9.7	447																	
OWA-279/1	7.0	1872																	
OWA-279/2	8.8	2710																	
OWA-279/3	9.2	3380																	
OWA-280/1	7.6	106																	
OWA-280/2	8.2	352																	
OWA-280/3	9.5	554																	
OWA-281/1	7.4	52																	
OWA-281/2	9.0	1484																	
OWA-281/3	9.7	1608																	
OWA-282/1	7.8	46																	
OWA-282/2	7.5	27																	
OWA-282/3	7.5	39																	
OWA-282/4	8.0	43																	
OWA-283/1	8.1	100																	
OWA-283/2	8.9	1045																	
OWA-283/3	9.0	3250																	
OWA-283/4	9.4	1968																	
OWA-284/1	6.7	192																	
OWA-284/2	7.9	1378																	
OWA-284/3	9.2	3000																	
OWA-284/4	8.5	4180																	
OWA-285/1	7.1	1195																	
OWA-285/2	8.0	7690																	
OWA-285/3	8.5	7000																	
OWA-285/4	8.8	4990																	
OWA-286/1	7.1	132																	
OWA-286/2	8.1	165																	
OWA-286/3	8.8	165																	
OWA-286/4	9.2	577																	
OWA-286/5	9.0	1498																	
OWA-287/1	7.7	447		72	4	24													
OWA-287/2	8.3	3030		49	6	46		1	42										
OWA-287/3	8.0	5920		49	1	50		1	95										
OWA-287/4	8.4	3780		55	2	44		1	55										
OWA-288/1	7.2	36																	

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-288/2	8.5	2160																	
OWA-288/3	9.1	3820																	
OWA-288/4	9.6	2860																	
OWA-289/1	8.6	87																	
OWA-289/2	9.7	34																	
OWA-289/3	9.0	1281																	
OWA-289/4	9.0	1261																	
OWA-290/1	7.2	54																	
OWA-290/2	9.0	4120																	
OWA-290/3	8.3	301																	
OWA-291/1	6.1	13																	
OWA-291/2	6.2	11																	
OWA-291/3	6.2	8																	
OWA-292/1	7.2	93																	
OWA-292/2	7.7	25																	
OWA-292/3	8.7	125																	
OWA-293/1	7.2	53																	
OWA-293/2	9.1	1437																	
OWA-293/3	8.6	275																	
OWA-293/4	9.3	1610																	
OWA-294/1	6.0	12																	
OWA-294/2	5.6	13																	
OWA-294/3	5.2	13																	
OWA-295/1	7.2	36																	
OWA-295/2	8.8	943																	
OWA-295/3	8.8	1922																	
OWA-295/4	8.3	3560																	
OWA-296/1	6.8	21		98	1	2													
OWA-296/2	9.1	1308		82	5	13				8.7	3580								
OWA-296/3	9.7	1419		82	5	13				9.2	3010								
OWA-297/1	7.4	35																	
OWA-297/2	8.2	1716																	
OWA-297/3	9.5	1948																	
OWA-298/1	7.0	23																	
OWA-298/2	7.1	230																	
OWA-298/3	8.2	516																	
OWA-298/4	9.6	566																	
OWA-299/1	8.5	53		71	5	24		0											
OWA-299/2	9.4	352		70	4	26		1		8.6	1060								
OWA-300/1	7.3	20																	
OWA-300/2	7.2	22																	
OWA-300/3	8.7	84																	
OWA-300/4	8.3	92																	
OWA-301/1	8.7	52																	
OWA-301/2	9.6	128																	
OWA-301/3	9.3	584																	
OWA-301/4	8.1	1879																	
OWA-302/1	8.2	652		36	32	32				7.4	2660								
OWA-302/2	8.3	6710		57	13	30		2		8.0	13140								
OWA-302/3	8.5	6130		45	4	51		3		8.2	13340								
OWA-302/4	8.7	4620		50	15	35		14		8.5	12420								
OWA-303/1	8.6	58																	
OWA-303/2	8.8	145																	
OWA-303/3	8.7	674																	
OWA-304/1	7.4	29																	
OWA-304/2	9.3	608																	
OWA-304/3	9.4	1027																	
OWA-305/1	7.2	39																	
OWA-305/2	6.7	17																	
OWA-305/3	7.7	68																	
OWA-305/4	8.8	221																	
OWA-306/1	8.0	34																	
OWA-306/2	9.4	115																	
OWA-306/3	9.4	2880																	

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-306/4	8.9	3570																	
OWA-306/5	9.5	1920																	
OWA-307/1	8.0	118																	
OWA-307/2	9.0	1074																	
OWA-307/3	8.9	3160																	
OWA-307/4	9.0	2070																	
OWA-308/1	9.2	19040		60	8	33				8.4	675								
OWA-308/2	9.1	2220		62	9	29		10		8.7	6570								
OWA-308/3	9.0	1920		70	4	26		3		8.5	3820								
OWA-309/1	7.8	43																	
OWA-309/2	8.3	47																	
OWA-309/3	8.5	57																	
OWA-311/1	8.1	198																	
OWA-311/2	9.3	655																	
OWA-311/3	9.3	2360																	
OWA-312/1	8.7	58																	
OWA-312/2	8.6	35																	
OWA-312/3	9.1	54																	
OWA-312/4	9.3	200																	
OWA-313/1	8.8	2070																	
OWA-313/2	9.2	8900																	
OWA-314/1	7.1	67																	
OWA-314/2	8.2	37																	
OWA-315/1	6.4	25																	
OWA-315/2	5.6	8																	
OWA-315/3	5.7	12																	
OWA-316/1	6.8	26																	
OWA-316/2	5.6	82																	
OWA-316/3	6.4	21																	
OWA-317/1	7.1	36																	
OWA-317/2	9.6	380																	
OWA-317/3	10.1	1447																	
OWA-317/4	10.2	1918																	
OWA-318/1	9.4	372																	
OWA-318/2	7.5	38																	
OWA-318/3	10.4	1716																	
OWA-318/4	10.5	2600																	
OWA-319/1	7.6	60																	
OWA-319/2	8.7	97																	
OWA-319/3	9.8	2280																	
OWA-319/4	9.7	2040																	
OWA-320/1	8.3	1420		52	10	39													
OWA-320/2	8.3	8130		51	5	44		3	57										
OWA-320/3	8.7	6310		49	7	44		4	85										
TWO-1/1	6.0	10	0.4	96	3	13	1												
TWO-1/2	5.1	12	0.1	94	4	2	1												
TWO-1/3	5.3	10	0.1	93	4	3	2												
TWO-2/1	5.7	11	0.3	96	3	1	1												
TWO-2/2	5.0	13	0.1	97	2	1	0												
TWO-2/3	5.5	13	0.1	96	4	0	1												
TWO-3/1	5.7	14	0.3	97	2	2	1												
TWO-3/2	5.0	9	0.1	97	3	1	0												
TWO-3/3	4.9	9	0.0	96	3	1	0												
TWO-4/1	6.8	20	0.3	93	5	3	0+												
TWO-4/2	7.2	16	0.2	92	5	3	0+												
TWO-5/1	7.1	53	0.3	90	5	5	6												
TWO-5/2	7.4	24	0.2	89	5	6	5												
TWO-5/3	8.0	39	0.2	89	5	7	6												
TWO-6/1	6.2	10	0.4	96	3	1	2												
TWO-6/2	5.5	10	0.2	94	4	2	1												
TWO-6/3	5.6	8	0.1	93	4	3	2												
TWO-7/1	5.9	16	0.2	95	3	2	1												
TWO-7/2	5.0	12	0.3	93	4	3	1												
TWO-7/3	4.8	13	0.1	92	4	5	1												

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
TWO-8/1	6.0	18	0.2	94	3	2	1												
TWO-8/2	4.8	15	0.1	95	3	3	1												
TWO-8/3	5.0	14	0.1	93	4	3	1												
TWO-9/1	4.9	19	0.4	95	3	2	1												
TWO-9/2	4.6	21	0.2	94	2	4	1												
TWO-10/1	5.5	15	0.3	94	3	3	1												
TWO-10/2	4.8	16	0.2	93	3	4	1												
TWO-10/3	4.9	14	0.1	93	2	5	1												
TWO-11/1	7.1	21	0.3	93	4	3	0+												
TWO-11/2	7.2	22	0.2	90	4	6	0+												
TWO-12/1	7.8	190	0.9	83	8	9	9.8+												
TWO-12/2	7.9	170	0.9	24	31	44	0+												
TWO-12/3	8.0	160	1.1	36	21	43	0+												
TWO-13/1	6.4	17	0.3	95	2	3	2												
TWO-13/2	5.9	16	0.1	96	2	3	1												
TWO-13/3	5.4	12	0.1	94	2	4	1												
TWO-14/1	6.0	14	0.3	94	2	4	2												
TWO-14/2	6.4	24	0.1	95	3	3	2												
TWO-14/3	6.3	20	0.1	94	2	4	4												
TWO-14/4	7.3	67	0.1	91	3	6													
TWO-15/1	7.8	400	0.6	72	13	15	0+												
TWO-15/2	8.4	130	0.5	65	10	26	13.2+												
TWO-15/3	8.8	110	0.4	43	17	40	88.2+												
TWO-15/4	8.9	120	3.4	36	15	49	88+												
TWO-16/1	7.0	32	0.2	95	2	2	1												
TWO-16/2	6.5	22	0.2	95	3	2	2												
TWO-16/3	6.2	20	0.1	96	3	2	2												
TWO-16/4	6.3	17	0.1	95	3	2	2												
TWO-17/1	6.5	26	0.4	94	3	3	2												
TWO-17/2	5.6	16	0.2	94	3	4	1												
TWO-17/3	5.4	11	0.1	94	3	3	1												
TWO-18/1	5.3	9	0.1	93	2	6	1												
TWO-18/2	5.9	8	0.3	93	3	4	1												
TWO-19/1	6.1	10	0.2	98	1	1	0												
TWO-19/2	5.8	8	0.1	98	1	1	0												
TWO-19/3	6.0	7	0.0	97	1	2	0												
TWO-20/1	6.7	15	0.2	91	3	5	3												
TWO-20/2	6.5	13	0.3	89	4	8	4												
TWO-20/3	6.5	17	0.2	87	3	10	7												
TWO-21/1	6.5	17	0.2	93	3	4	2												
TWO-21/2	6.6	19	0.2	93	2	4	2												
TWO-21/3	6.7	26	0.1	92	2	6	2												
TWO-22/1	5.6	11	0.2	97	1	2	1												
TWO-22/2	5.4	8	0.1	97	1	2	0												
TWO-22/3	5.2	10	0.1	96	2	2	0												
TWO-23/1	6.5	86	0.5	86	5	8	0+												
TWO-23/2	6.6	150	0.2	82	3	15	0+												
TWO-24/1	5.3	16	0.3	98	1	1	0												
TWO-24/2	5.4	9	0.1	97	2	1	0												
TWO-24/3	5.6	7	0.1	98	1	1	0												
TWO-25/1	5.2	14	0.3	97	1	2	0												
TWO-25/2	5.1	14	0.1	96	2	2	0												
TWO-25/3	5.3	8	0.1	97	1	2	0												
TWO-26/1	5.7	10	0.3	94	2	4	1												
TWO-26/2	5.5	12	0.1	94	2	4	1												
TWO-26/3	5.9	11	0.1	93	2	5	1												
TWO-27/1	6.0	11	0.3	96	1	2	1												
TWO-27/2	5.8	10	0.1	95	2	3	1												
TWO-27/3	5.6	11	0.1	94	3	3	1												
TWO-28/1	5.6	11	0.3	94	3	4	1												
TWO-28/2	5.4	10	0.2	92	3	5	2												
TWO-28/3	5.8	10	0.1	92	3	5	2												
TWO-29/1	7.5	30	0.4	90	6	4	0+												
TWO-29/2	8.0	53	0.3	87	7	6	0+												

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
TWO-30/1	6.4	13	0.2	91	3	6	11												
TWO-30/2	6.0	8	0.1	92	3	5	9												
TWO-30/3	5.5	12	0.1	90	4	6	5												
TWO-31/1	5.6	9	0.2	96	2	2	1												
TWO-31/2	5.4	10	0.1	95	2	3	0												
TWO-31/3	6.1	10	0.1	97	2	1	1												
TWO-32/1	6.8	110	1.3	54	10	36	0+												
TWO-32/2	7.0	61	1.0	60	20	20	0+												
TWO-32/3	8.4	92	3.5	43	36	21	87.8+												
TWO-33/1	7.7	29	0.2	95	3	3	1												
TWO-33/2	6.8	40	0.1	90	3	7	2												
TWO-33/3	6.8	31	0.2	81	2	18	7												
TWO-33/4	7.4	33	0.1	81	2	17	6												
TWO-34/1	6.7	29	0.2	91	3	6	2												
TWO-34/2	5.2	23	0.1	89	3	8	3												
TWO-34/3	6.4	31	0.1	87	2	10	3												
TWO-35/1	5.6	24	0.2	95	2	3	3												
TWO-35/2	5.0	17	0.2	95	3	3	4												
TWO-36/1	6.7	52	0.1	92	4	5	2												
TWO-36/2	5.8	24	0.2	92	2	7	2												
TWO-36/3	5.8	15	0.1	91	3	7	2												
TWO-37/1	6.4	20	0.3	94	2	4	3												
TWO-37/2	8.1	87	0.2	95	2	4	4												
TWO-37/3	8.8	83	0.1	95	2	3	4												
TWO-38/1	5.9	19	0.3	96	3	1	1												
TWO-38/2	4.9	15	0.1	95	2	3	1												
TWO-38/3	5.3	15	0.1	96	2	3	1												
TWO-39/1	6.5	30	0.3	94	3	3	0+												
TWO-39/2	6.9	31	0.2	92	3	5	0+												
TWO-39/3	7.2	22	0.1	92	2	6													
TWO-40/1	6.6	21	0.3	97	1	3	1												
TWO-40/2	5.2	15	0.2	95	2	3	1												
TWO-40/3	5.3	18	0.1	95	3	3	1												
TWO-41/1	7.9	116	0.6	76	5	19													
TWO-41/2	8.3	118	0.7	67	11	23													
TWO-41/3	8.5	101	0.5	68	2	30													
TWO-42/1	6.9	27	0.3	97	1	2	0												
TWO-42/2	5.6	16	0.1	97	1	2	0												
TWO-42/3	5.4	17	0.1	97	1	2	0												
TWO-43/1	5.6	19	0.2	95	2	3	0												
TWO-43/2	5.4	18	0.1	94	2	4	1												
TWO-44/1	6.7	30	0.3	94	4	3	0+												
TWO-44/2	6.9	20	0.1	94	2	4	0+												
TWO-45/1	5.2	15	0.2	96	2	2	0												
TWO-45/2	5.5	16	0.1	96	2	2	0												
TWO-45/3	5.1	15	0.1	96	2	2	0												
TWO-48/1	8.1	78	0.2	89	7	4		0											
TWO-48/2	9.4	222	0.2	83	4	13		0											
TWO-48/3	9.8	1287	0.1	76	5	19		4											
TWO-55/1	8.8	114	0.4	76	12	12		9											
TWO-56/1	8.4	131	0.5	60	11	30		3											
TWO-60/1	8.6	41	0.1	94	4	3		0											
TWO-60/2	8.9	123	0.5	37	43	21		21											
TWO-60/3	8.7	109	0.4	68	20	12		3											
TWO-60/4	10.7	2190	0.1	86	5	10		1											
TWO-64/1	9.1	54	0.2	90	5	5													
TWO-64/2	8.7	37	0.2	82	4	14													
TWO-64/3	8.3	28	0.1	81	4	15													
TWO-73/1	10.5	577	0.1	90	5	6		2											
TWO-73/3	10.8	1310	0.0	90	4	7		1											
TWO-73/4	10.9	1830	0.0	89	3	8		2											
TWO-73/5	10.9	1890	0.0	88	4	9		1											
TWO-80/1	9.1	108	0.5	69	17	14		21											
TWO-80/2	8.9	113	0.7	61	29	10		2											

Horizon	pH	E.C. (1:2.5)	O.C.	Sand	Silt	Clay	C.E.C.	CaCO3	Gypsum	pH (paste)	E.C.(paste)	Ca	Mg	Na	K	Cl	SO4	HCO3	CO3
Reference	1:2.5	(microS/cm) 25ºC	(%)	(%)	(%)	(%)	(cmol+/kg)	(%)	(%)	1:2.5	(microS/cm) 25ºC	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)
TWO-80/3	10.6	1660	0.0	87	5	9		0											
TWO-86/1	7.7	44	0.2	83	7	10													
TWO-86/2	7.7	48	0.3	76	6	18													
TWO-87/1	10.4	642	0.1	92	3	5		1											
TWO-88/1	9.0	110	0.6	61	23	16		21											
TWO-88/2	8.1	315	0.5	54	30	16		11											
TWO-89/1	8.4	121	0.5	59	30	11		10											
TWO-91/1	8.7	85	0.5	80	9	12		7											
TWO-91/2	8.8	117	0.5	81	5	14		6											
TWO-92/1	8.7	44	0.2	89	4	8		0											
TWO-92/2	8.8	66	0.2	85	6	9		0											
TWO-92/3	9.0	86	0.1	82	6	13		5											
TWO-92/4	9.1	96	0.1	75	8	17		13											
TWO-96/1	8.5	111	0.3	65	8	27		0											
TWO-96/2	7.9	446	0.5	35	26	39		0											
TWO-98/1	8.1	93	0.5	37	31	32		0											
TWO-98/2	8.6	114	0.7	84	2	14		2											
TWO-98/3	7.7	113	0.3	75	12	13		0											
TWO-98/4	8.5	124	0.5	63	19	18		2											
TWO-99/1	8.6	144	0.4	57	25	19		2											
TWO-99/2	8.5	187	0.3	62	16	22		1											
TWO-100/1	8.5	207	0.3	63	18	20													
TWO-100/2	8.2	56	0.2	58	1	41													
TWO-100/3	7.7	188	0.6	37	25	38													
TWO-100/4	7.7	135	0.5	38	16	46													
TWO-101/1	8.5	40	0.3	88	7	5													
TWO-102/1	8.9	85	0.2	89	7	5													
TWO-102/2	7.9	29	0.1	82	7	11													
TWO-102/3	8.3	175	0.5	48	16	37													
TWO-102/4	8.2	32	0.1	85	7	8													
TWO-103/1	7.2	23	0.2	83	7	10		0											
TWO-103/2	8.8	108	0.4	77	14	9		21											
TWO-103/3	7.4	25	0.1	82	6	12		0											
TWO-104/1	9.3	52	0.0	93	3	3		4											
TWO-104/2	8.5	141	0.7	48	13	39		0											
TWO-104/3	8.5	154	0.7	49	12	39		4											
TWO-104/4	8.7	109	0.3	71	8	21		1											
TWO-106/1	5.7	13	0.1	94	3	4													
TWO-106/2	8.1	14	0.1	93	3	4													
TWO-106/3	5.4	11	0.1	94	3	3													
TWO-113/1	7.5	27	0.1	91	1	9													
TWO-113/2	7.9	25	0.1	86	9	5													
TWO-115/1	7.4	304	0.5	41	29	30													
TWO-115/2	7.6	163	0.4	50	16	34													
TWO-115/3	8.5	93	0.4	81	12	7													
TWO-115/4	8.2	56	0.1	68	11	21													
TWO-136/1	8.4	108	0.7	66	24	10		7											
TWO-136/2	8.6	125	0.5	60	26	14		20											
TWO-137/1	8.0	71	0.7	56	35	9		10											
TWO-137/2	8.1	106	0.5	54	35	11		0											
TWO-138/1	8.5	129	0.6	52	28	20													
TWO-139/1	6.9	44	0.7	78	11	12													
TWO-139/2	6.7	31	0.4	53	19	28													
TWO-139/3	7.0	19	0.3	48	22	30													
TWO-140/1	6.6	30	0.2	82	12	6													
TWO-140/2	6.6	33	0.2	69	11	21													
TWO-140/3	6.4	17	0.4	55	13	32													
TWO-141/1	5.9	46	0.3	81	10	9		0											
TWO-141/2	6.2	28	0.2	65	9	26		0											
TWO-141/3	6.4	80	0.3	53	10	37		0											
TWO-142/1	5.7	63	0.4	75	17	8		0											
TWO-142/2	6.2	209	0.3	57	18	25		0											
TWO-142/3	8.2	143	0.2	59	15	26		3											
TWO-143/1	5.8	25	0.2	87	7	6													

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
TWO-143/2	5.2	23	0.1	83	7	10													
TWO-143/3	6.3	40	0.1	78	7	16													
TWO-144/1	8.3	148	0.5	40	30	30		10											
TWO-144/2	8.5	125	0.4	39	25	36		6											
TWO-145/1	6.5	32	0.2	80	12	9													
TWO-145/2	6.6	31	0.2	72	9	19													
TWO-145/3	6.4	32	0.2	58	9	32													
TWO-146/1	7.0	80	0.4	71	13	16		0											
TWO-146/2	6.2	80	0.4	66	11	23		0											
TWO-146/3	6.7	89	0.3	48	10	42		0											
TWO-146/4	7.5	85	0.2	52	12	36		0											
TWO-147/1	7.0	26	0.2	81	11	8													
TWO-147/2	6.9	23	0.1	75	13	13													
TWO-148/1	8.3	159	1.1	33	27	39		21											
TWO-148/2	8.6	118	1.2	45	27	28		21											
TWO-148/3	5.6	149	0.4	28	14	58		21											
TWO-149/1	8.5	144	0.6	45	24	30													
TWO-149/2	8.7	122	0.3	36	30	34													
TWO-149/3	8.9	106	0.2	16	63	20													
TWO-160/1	8.6	80	0.3	79	8	14		1											
TWO-160/2	8.6	103	0.2	75	8	17		2											
TWO-160/3	8.6	117	0.2	65	15	20		13											
TWO-161/1	8.3	96	0.3	70	9	21		5											
TWO-161/2	8.6	93	0.3	67	10	23		5											
TWO-161/3	8.4	138	0.3	49	29	22		21											
TWO-162/1	7.2	55	0.3	81	10	9		0											
TWO-162/2	7.1	118	0.3	64	11	25		0											
TWO-162/3	7.0	174	0.2	64	10	26		0											
TWO-163/1	8.1	206	0.2	79	9	12		0											
TWO-163/2	7.9	107	0.3	63	9	28		0											
TWO-163/3	8.0	149	0.2	59	10	31		0											
TWO-164/1	8.0	70	0.5	61	26	13													
TWO-164/2	7.4	13	1.8	48	25	27													
TWO-166/1	8.6	79	0.4	75	12	13		2											
TWO-166/2	8.4	131	0.3	61	20	19		16											
TWO-166/3	8.3	122	0.5	48	28	25		21											
TWO-169/1	8.2	79	0.3	65	11	25													
TWO-169/2	8.3	74	0.3	77	10	13													
TWO-200/1	8.6	243	0.3	71	10	19		1											
TWO-200/2	8.3	2580	0.4	57	-37	80		3											
TWO-206/1	8.7	107	0.5	50	19	31		16											
TWO-206/2	8.7	101	0.6	48	19	33		19											
TWO-206/3	8.7	110	0.3	44	24	32		21											
TWO-208/1	6.9	72	0.5	64	16	19													
TWO-208/2	7.1	116	0.4	58	16	26													
TWO-208/3	7.3	80	0.3	55	16	29													
TWO-209/1	8.3	122	0.3	67	18	15													
TWO-213/1	8.3	68	0.6	72	21	7		0											
TWO-214/1	8.7	64	0.3	81	9	10													
TWO-214/2	8.3	45	0.2	78	9	13													
TWO-214/3	8.0	50	0.2	70	6	24													
TWO-221/1	8.5	88	0.6	73	14	13		1											
TWO-221/2	8.4	64	0.4	64	14	22		0											
TWO-221/3	8.3	151	0.4	65	11	25		0											
TWO-243/1	8.1	123	0.2	92	3	5		0											
TWO-243/2	8.4	55	0.2	87	3	10		0											
TWO-243/3	8.5	62	0.1	87	3	10		0											
TWO-246/1	6.9	63	0.3	96	2	2													
TWO-246/2	8.8	25	0.1	95	2	3													
TWO-246/3	8.5	22	0.1	98	0	2													
TWO-267/1	7.9	32	0.2	91	5	4													
TWO-267/2	7.5	18	0.2	90	4	6													
TWO-267/3	6.8	45	0.1	92	4	5													
TWO-269/1	8.2	28	0.2	93	5	3		0											

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
TWO-269/2	8.0	35	0.2	90	4	6		0											
TWO-274/1	6.0	205	0.7	54	32	14													
TWO-274/2	6.7	157	0.6	47	27	26													
TWO-274/3	6.8	64	0.4	39	23	38													
TWO-275/1	7.2	46	0.4	53	26	22		0											
TWO-275/2	8.3	110	0.4	38	30	32		1											
TWO-275/3	8.0	234	0.3	34	26	40		3											
TWO-276/1	6.4	47	0.6	38	39	23													
TWO-276/2	6.6	23	0.5	33	53	15													
TWO-276/3	6.0	32	0.3	33	25	42													
TWO-279/1	6.3	251	1.1	34	39	27													
TWO-279/2	6.6	255	0.9	31	31	38													
TWO-279/3	6.2	78	0.5	27	25	48													
TWO-282/1	8.3	119	1.4																
TWO-282/2	8.4	131	0.6	62	6	32													
TWO-282/3	8.4	58	0.5	54	24	22		2											
TWO-283/0	8.4	69	0.6	63	21	17		6											
TWO-284/1	8.3	56	0.6	48	27	25													
TWO-284/2	6.0	29	0.5	43	25	33													
TWO-284/3	5.8	35	0.4	31	14	55													
TWO-285/1	5.6	21	0.4	77	12	11													
TWO-285/2	5.6	14	0.2	71	13	17													
TWO-285/3	8.2	14	0.2	70	12	18													
TWO-291/1	8.5	113	1.4	46	39	15		32											
TWO-292/1	8.5	55	1.5	79	14	8													
TWO-292/2	8.3	33	0.3	73	19	9													
TWO-293/1	8.6	66	0.2	76	14	10													
TWO-293/2	8.5	43	0.2	75	12	14													
TWO-293/3	8.3	24	0.1	75	12	13													
TWO-301/1	8.2	143	0.6	35	29	36		4											
TWO-301/2	8.2	165	0.4	34	27	39		0											
TWO-302/1	6.1	120	0.3	60	25	15		0											
TWO-302/2	5.3	296	0.3	49	26	25		0											
TWO-302/3	6.5	22	0.3	36	18	46		0											
TWO-348/1	8.1	37	0.4	82	11	7													
TWO-348/2	7.3	12	0.2	77	12	12													
TWO-348/3	7.5	20	0.1	81	4	15													
TWO-351/1	8.5	54	0.4	80	14	7													
TWO-351/2	8.4	20	0.1	78	13	8													
TWO-355/1	7.8	44	0.5	76	12	12													
TWO-355/2	7.5	21	0.4	73	11	17													
TWO-356/1	8.0	70	0.6	71	13	16		0											
TWO-356/2	8.2	47	0.4	82	9	9		0											
TWO-356/3	8.2	52	0.3	63	11	26		0											
TWO-356/4	8.4	122	0.4	50	19	30		15											
TWO-358/1	6.8	11	0.2	50	19	30													
TWO-358/2	8.0	63	0.1	74	9	18													
TWO-358/3	8.3	52	0.2	71	17	12													
TWO-359/1	6.8	48	0.2	85	5	10													
TWO-359/2	6.9	14	0.1	82	5	13													
TWO-359/3	7.5	10	0.1	79	8	13													
TWO-362/1	8.0	71	0.3	85	9	6													
TWO-362/2	8.1	60	0.3	80	9	11													
TWO-374/1	8.4	21	0.4	79	14	7													
TWO-374/2	7.7	13	0.2	79	11	10													
TWO-378/1	8.3	67	0.5	68	21	11													
TWO-378/2	7.0	75	0.4	65	14	22													
TWO-379/1	8.0	29	0.2	79	11	11													
TWO-379/2	8.2	34	0.2	76	11	13													
TWO-379/3	8.5	49	0.2	74	9	17													
TWO-379/4	8.7	93	0.2	67	11	23													
TWO-380/1	7.3	28	0.3	84	12	5													
TWO-380/2	8.4	77	0.4	46	21	33													
TWO-380/3	8.2	113	0.4	41	20	40													

Horizon Reference	pH 1:2.5	E.C. (1:2.5) (microS/cm) 25ºC	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste) 1:2.5	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
TWO-380/4	8.4	155	0.3	35	26	40		21											
TWO-382/1	7.9	27	0.4	81	9	10													
TWO-382/2	8.2	34	0.1	76	8	15													
TWO-382/3	8.3	36	0.0	82	7	11													
TWO-385/1	7.9	23	0.1	89	5	6													
TWO-385/2	6.7	14	0.1	87	5	8													
TWO-386/1	7.2	18	0.1	90	4	6													
TWO-386/2	7.8	37	0.1	84	4	12													
TWO-390/1	8.0	31	0.3	85	6	10		0											
TWO-390/2	8.2	54	0.5	83	3	14		0											
TWO-390/3	8.5	90	0.1	80	4	16		3											
TWO-391/1	7.4	10	0.1	93	2	4													
TWO-392/1	6.7	8	0.1	92	4	4													
TWO-392/2	6.3	8	0.1	91	3	6													
TWO-392/3	6.0	10	0.1	90	3	7													
TWO-395/1	7.1	22	0.2	89	5	6													
TWO-395/2	6.9	14	0.1	87	4	10													
TWO-395/3	7.7	96	0.1	76	5	20													
TWO-396/1	7.8	12	0.1	92	2	6													
TWO-396/2	6.5	7	0.1	94	0	6													
TWO-396/3	5.9	8	0.0	91	2	7													
TWO-397/1	7.1	26	0.2	90	3	7													
TWO-397/2	6.7	21	0.1	90	3	8													
TWO-397/3	6.7	19	0.1	89	2	10													
TWO-397/4	7.0	54	0.1	82	3	15													
TWO-399/1	7.2	25	0.2	83	5	12													
TWO-399/2	8.1	104	0.2	78	7	15													
TWO-399/3	8.2	241	0.1	77	7	17													
TWO-403/1	6.5	291	0.4	60	19	22		0											
TWO-403/2	6.4	470	0.3	50	14	36		0											
TWO-403/3	7.3	159	0.2	50	15	35		0											
TWO-426/1	8.4	29	0.3	80	9	1		0											
TWO-426/2	8.4	20	0.3	80	5	15		3											
TWO-433/1	6.7	105	0.6	78	13	10													
TWO-449/1	6.5	11	0.2	91	3	6													
TWO-449/2	6.2	14	0.1	89	3	8													
TWO-451/1	7.5	18	0.2	87	6	7													
TWO-451/2	6.4	11	0.1	85	5	10													
TWO-451/3	6.7	16	0.1	80	5	16													
TWO-452/1	8.3	28	0.1	87	6	7													
TWO-452/2	7.7	16	0.1	88	4	9													
TWO-452/3	6.6	13	0.0	84	3	12													
TWO-453/1	7.2	11	0.2	88	5	7													
TWO-453/2	6.8	10	0.1	87	5	9													
TWO-453/3	6.8	9	0.1	86	5	9													
TWO-454/1	8.1	62	0.1	62	3	35													
TWO-454/2	8.0	23	0.2	83	5	12													
TWO-454/3	7.9	26	0.1	82	3	15													
TWO-455/1	6.1	8	0.2	89	5	6													
TWO-455/2	5.9	8	0.1	91	3	6													
TWO-455/3	5.6	14	0.1	91	3	6													
TWO-459/1	8.6	126	0.8	59	20	22		10											
TWO-459/2	8.7	92	0.3	54	27	19		22											
TWO-460/1	8.5	118	0.6	66	18	16		1											
TWO-460/2	8.5	75	0.5	65	23	12		3											
TWO-462/1	7.7	79	0.3																
TWO-462/2	7.6	39	0.2	71	12	17													
TWO-462/3	7.7	69	0.1	69	13	17													
TWO-463/1	7.1	19	0.2	80	10	10													
TWO-463/2	7.3	26	0.8	76	9	15													
TWO-463/3	7.7	40	0.1	73	8	19													
TWO-465/1	8.2	105	0.4	80	15	5													
TWO-465/2	8.2	23	0.1	73	21	7													
TWO-465/3	8.0	19	0.1	82	10	8													

Horizon	pH	E.C. (1:2.5)	O.C.	Sand	Silt	Clay	C.E.C.	CaCO3	Gypsum	pH (paste)	E.C.(paste)	Ca	Mg	Na	K	Cl	SO4	HCO3	CO3
Reference	1:2.5	(microS/cm) 25ºC	(%)	(%)	(%)	(%)	(cmol+/kg)	(%)	(%)	1:2.5	(microS/cm) 25ºC	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)
TWO-467/1	8.6	114	0.7	42	40	17		17											
TWO-467/2	8.4	304	0.4	23	27	50		23											
TWO-468/1	8.7	218	0.3	23	16	61		26											
TWO-468/2	8.5	35	1.0	67	15	18		0											
TWO-470/1	8.7	66	0.0	61	23	15													
TWO-470/2	7.8	29	0.2	87	7	6													
TWO-471/1	7.5	24	0.2	85	5	10													
TWO-471/2	7.6	49	0.8	52	21	27													
TWO-472/1	7.9	30	0.4	36	20	44													
TWO-472/2	7.7	28	0.6	48	30	22													
TWO-473/1	7.2	131	0.4	34	20	46													
TWO-473/2	8.9	33	0.3	71	16	13													
TWO-473/3	8.3	695	0.7	71	21	8													
TWO-474/1	8.5	63	0.3	64	16	21													
TWO-474/2	8.7	92	0.5	65	27	8													

A.4.1. SOTER Database

This chapter shows a description of the SOTER Database: tables and attribute coding, for a fully description see the SOTER procedures manual FAO (1993).

A.4.1.1. SOTER Tables

For each table have:

- ATTRIBUTE FIELD : the name of each field in the database
- ATTRIBUTE DESCRIPTION, a brief note about the kind of information of the field.

Each table has the field, or combination of fields used as "key fields" marked in *cursive* (normally one, but maybe a combination of fields), and marked in **black** the fields, or combination of fields, used to establish the relations with the other tables.

TERRAIN: TERRAIN TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
ISO	Country code
SUID	SOTER unid_ID
DATE	year of date collection
MAPI	map_id
MINE	minimum elevation
MAXE	maximum elevation
GSLP	slope gradient
RELF	relief intensity
LNDF	major landform
RSLO	regional slope
HYPS	hypsometry
DISS	dissection
LITH	general lithology
PWAT	permanent water surface

TERRAIN COMPONENT: TERRCOMP TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
SUID	*SOTER unid_ID*
TCID	*terrain component number*
PROP	proportion of SOTER unid
TCDC	terrain component data_id

TERRAIN COMPONENT DATA: TCDATA TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
TCDC	terrain component data_id
SCGR	dominant slope
SCDL	length of slope
SCFM	form of slope
MRSF	local surface form
MRAH	average height
MRPR	coverage
LITH	Surface lithology
TEXT	Texture group non-consolidated parent material
BEDR	depth to bedrock
SDRA	surface drainage
GWAT	depth of groundwater
FLFR	frequency of flooding
FLDU	duration of flooding
FLST	start of flooding

SOIL COMPONENT: SOILCOMP TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
ISO	
SUID	SOTER unit_id
TCID	terrain component number
SCID	soil component number
PROP	proportion of SOTER unit
PRID	Representative Profile Name
PRRF	number of reference
POSI	position in terrain component
RKSC	surface rockiness
STSC	surface stoniness
ERTY	types of erosion/deposition
ERAA	area affected
ERDE	degree of erosion
SCAP	sensitivity to capping
RDEP	rootable depth
OTHS	relation with other soil components

PROFILE: PROFILE TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
PRID	*Representative Profile Name*
PDID	profile database_id
LATI	latitude
LONG	longitude
ELEV	elevation
DATE	sampling date
LABO	lab_ID
DRAI	drainage
INFR	infiltration rate
ORGA	surface organic matter
CLAF	classification
CLAV	classification version
STAX	Soil Taxonomy
PHAS	phase
CLAN	national classification

HORIZON: REPHORIZ TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
PRID	Representative Profile Name
HONU	horizon number
DIAH	diagnostic horizon
DIAP	diagnostic property
HODE	horizon designation
HBLO	lower depth
HBDI	disticness of transition
SCMO	moist colour
SCDR	dry colour
STGR	grade of structure
STSI	size of structure elements
STTY	type of structure
MINA	abundance of coarse fragments
MINS	size of coarse fragments
SDVC	very coarse sand
SDCO	coarse sand
SDME	medium sand
SDFI	fine sand
SDVF	very fine sand
SDTO	total sand
STPC	silt
CLPC	clay
PSCL	particle size class
BULK	bulk density
TEN1	tension 1
MCT1	moisture at tension 1
TEN2	tension 2
MCT2	moisture at tension 2
TEN3	tension 3
MCT3	moisture at tension 3
TEN4	tension 4

MCT4	moisture at tension 4
TEN5	tension 5
MCT5	moisture at tension 5
HYDC	hydraulic conductivity
INFI	infiltration rate
PHAQ	ph H20
PHKC	ph KCl
ELCO	electrical conductivity
SONA	Soluble Na
SOCA	Soluble Ca
SOMG	Soluble Mg
SOLK	Soluble K
SOCL	Soluble Cl
SSO4	Soluble SO4
HCO3	Soluble carbonat
SCO3	Soluble bicarbonat
EXCA	exchangeable Calcium
EXMG	exchangeable Magnesium
EXNA	exchangeable Sodium
EXCK	exchangeable Potassium
EXAL	exchangeable Aluminium
EXAC	exchangeable acidity
CECS	CEC soil
TOTC	total carbon
TOTN	total nitrogen
TCEQ	total carbonates equivalent
GYPS	gypsum
P2O5	P205
PRET	phosphate retention
FEDE	Fe dithionite
FEPE	Fe pyrophosphate
ALDE	Al dithionite
ALPE	Al pyrophosphate
CLAY	clay mineralogy

LAND USE: LANDUSE TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
REID	register_ID
SUID	SOTER unid_ID
DATE	date of observation
LUSE	Land use
PROP	Proportion of SOTER unit

VEGETATION: VEGETAT TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
REID	*register_ID*
SUID	SOTER unid_ID
DATE	date of observation
LUSE	vegetation
PROP	Proportion of SOTER unit

CLIMATE STATION : CLIMSTAT TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
STID	*climate station_ID*
STNA	climate station_name
LATI	latitude
LONG	longitude
ALTI	altitude

CLIMATE DATA: CLIMDAT TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
STID	climate station_id
KIND	kind of data: rainfall, temperature ...
SOID	source_id
FTYR	First year
LTYR	last year
NYRS	years
JANU	January
FEBR	February
MARC	March
APRI	April
MAY	May
JUNE	June
JULY	July
AUGU	August
SEPT	September
OCTO	October
NOVE	November
DECE	December
ANNU	Annual value

CLIMATE DATA SOURCES

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
SOID	Source_id
NAME	Source name

LABORATORY: LABNAME TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
LABO	Laboratory_ID
LNAM	Laboratory name

LABORATORY METHODS: LABMETH

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
LABO	Laboratory_ID
DATE	date of analysis
ATTR	attribute
AMID	method of analisys_id

ANALITYCAL METHOD

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
AMID	method of analysis
AMET	description of method

A.4.1.2. SOTER Codification

In order to construct the entry form and facility the database implementation, a dictionary tables are created with this structure:

- FIELDNAME: the name of the field on the table
- CODE: the code used in the database
- DESCRIPTION: the significance of the code used

The codes used (in a excel file soter_codes.xls), ordered by SOTER tables are:

TERRAIN TABLE

FIELDNAME	CODE	DESCRIPTION
LNDF	L	Level land
LNDF	S	Sloping land
LNDF	T	Steep land
LNDF	C	Land with composite landforms
LNDF	LP	Plain
LNDF	LL	Plateau
LNDF	LD	Depression
LNDF	LF	Low-gradient foot slope
LNDF	LV	Valley floor
LNDF	SM	Medium gradient mountain
LNDF	SH	Medium gradient hill
LNDF	SE	Medium-gradient escarpment zone
LNDF	SR	Ridges
LNDF	SU	Mountainous highland
LNDF	SP	Dissected plain
LNDF	TM	High-gradient mountain
LNDF	TH	High-gradient hill
LNDF	TE	High-gradient escarpment zone
LNDF	TV	High-gradient valleys
LNDF	CV	Valley
LNDF	CL	Narrow plateau
LNDF	CD	Major depression
RSLO		Not described
RSLO	W	0-2% flat, wet
RSLO	F	0-2% flat
RSLO	G	2-5% gently undulating
RSLO	U	5-8% undulating
RSLO	R	8-15% rolling
RSLO	S	15-30% moderately steep
RSLO	T	30-60% steep
RSLO	V	> 60% very steep
RSLO	CU	Cuesta-shaped
RSLO	DO	Dome-shaped
RSLO	RI	Ridged
RSLO	TE	Terraced
RSLO	IN	Inselberg covered (at least 1% of level land)
RSLO	DU	Dune-shaped
RSLO	IM	With intermontane plains (coverage at least 15%)
RSLO	WE	With wetlands (occupying at least 15%)

RSLO	KA	Strong karst
RSLO		Not described
HYPS	1	< 300 m
HYPS	2	300-600 m
HYPS	3	600-1500 m
HYPS	4	1500-300 m
HYPS	5	> 3000 m
HYPS	6	< 200 m
HYPS	7	200-400 m
HYPS	8	> 400 m
HYPS	9	600-1500 m
HYPS	10	1500-3000 m
HYPS	11	3000-5000 m
HYPS	12	> 5000 m
HYPS		Not described
DISS	1	Slightly dissected
DISS	2	Dissected
DISS	3	Strongly dissected
DISS		Not described
LITH	I	Igneous rock
LITH	IA	Acid igneous rock
LITH	IA1	Granite
LITH	IA2	Grano-diorite
LITH	IA3	Quartz-diorite
LITH	IA4	Rhyiolite
LITH	II	Intermediate igneous rock
LITH	II1	Andesite, trachyte, phonolite
LITH	II2	Diorite-syenite
LITH	IB	Basic igneous rock
LITH	IB1	Gabbro
LITH	IB2	Basalt
LITH	IB3	Dolerite
LITH	IU	Ultrabasic igneous rock
LITH	IU1	Peridotite
LITH	IU2	Pyroxenite
LITH	IU3	Ilmenite, magnetite, ironstone, serpentine
LITH	M	Metamorphic rock
LITH	MA	Acid metamorphic rock
LITH	MA1	Quartzite
LITH	MA2	Gneiss, migmatite
LITH	MB	Basic metamorphic rock
LITH	MB1	Slate, phyllite (pelitic rocks)
LITH	MB2	Schist
LITH	MB3	Gneiss rich in ferro-magnesian minerals
LITH	MB4	Metamorphic limestone (marble)
LITH	SC	Clastic sediments
LITH	SC1	Conglomerate, breccia
LITH	SC2	Sandstone, greywacke, arkose
LITH	SC3	Siltstone, mudstone, claystone
LITH	SC4	Shale
LITH	SO	Organic (sedimentary rock)
LITH	SO1	Limestone, other carbonate rocks
LITH	SO2	Marl and other mixtures
LITH	SO3	Coals, bitumen & related rocks
LITH	SE	Evaporites
LITH	SE1	Anhydrite. gypsum
LITH	SE2	Halite
LITH	U	Unconsolidated

LITH	UF	Fluvial
LITH	UL	Lacustrine unconsolidated rock
LITH	UM	Marine unconsolidated rock
LITH	UC	Colluvial unconsolidated rock
LITH	UE	Eolian unconsolidated rock
LITH	UG	Glacial unconsolidated rock
LITH	UP	Pyroclastic unconsolidated rock
LITH	UO	Organic unconsolidated rock
LITH		Not described

PROFILE TABLE

FIELDNAME	CODE	DESCRIPTION
DRAI	E	Excessively well drained
DRAI	S	Somewhat excessively well drained
DRAI	W	Well drained
DRAI	M	Moderately well drained
DRAI	I	Imperfectly drained
DRAI	P	Poorly drained
DRAI	V	Very poorly drained
DRAI		Not described
INFR	V	Very slow (<0.1 cm/h)
INFR	S	Slow (0.1-0.5 cm/h)
INFR	D	Moderately slow (0.5-2.0 cm/h)
INFR	M	Moderate (2.0-6.0 cm/h)
INFR	R	Rapid (6.0-12.5 cm/h)
INFR	Y	Very rapid (12.5-25.0 cm/h)
INFR	E	Extremely rapid (=> 25.0 cm/h)
INFR		Not described
ORGA	F	Fibric; weakly decomposed
ORGA	H	Hemic; moderately decomposed
ORGA	S	Sapric; highly decomposed
ORGA		Not described
ORGA	U	Uniform slope
ORGA	C	Concave
ORGA	V	Convex

TERRAIN COMPONENT TABLE

FIELDNAME	CODE	DESCRIPTION
SCFM	I	Irregular slope
SCFM		Not described
MRSF	H	Hummocky
MRSF	M	Mounded coverage by isolated mounds (> 2.5 m high)
MRSF	K	Towered
MRSF	R	Ridged
MRSF	T	Terraced
MRSF	G	Gullied
MRSF	S	Strongly dissected (drainage density > 25 km/km2)
MRSF	D	Dissected areas with drainage density > 10 km/km2)
MRSF	L	Slightly dissected (drainage density < 10 km/km2)
MRSF		Not described
TEXT	Y	Very clayey
TEXT	C	Clayey

TEXT	L	Loamy
TEXT	S	Sandy
TEXT	X	Extremely sandy
TEXT		Not described
FLFR	N	None
FLFR	D	Daily
FLFR	W	Weekly
FLFR	M	Monthly
FLFR	A	Annually
FLFR	B	Biennually
FLFR	F	Once every 2-5 years
FLFR	T	Once every 5-10 years
FLFR	R	Rare (less than once in every 10 years)
FLFR	U	Unknown
FLFR		Not described
FLDU	1	Less than 1 day
FLDU	2	1-15 days
FLDU	3	15-30 days
FLDU	4	30-90 days
FLDU	5	90-180 days
FLDU	6	180-360 days
FLDU	7	Continuously
FLDU		Not described
SDRA	E	Extremely slow
SDRA	S	Slow
SDRA	W	Well
SDRA	R	Rapid
SDRA	V	Very rapid
SDRA		Not described

SOIL COMPONENT TABLE

FIELDNAME	CODE	DESCRIPTION
POSI	H	High
POSI	M	Middle
POSI	L	Low
POSI	D	Lowest
POSI	A	All
POSI		Not described
RKSC	N	None (0%)
RKSC	V	Very few (0-2%)
RKSC	F	Few (2-5%)
RKSC	C	Common (5-15%)
RKSC	M	Many (15-40%)
RKSC	A	Abundant (40-80%)
RKSC	D	Dominant (> 80%)
RKSC		Not described
STSC	N	None (0%)
STSC	V	Very few (0-2%)
STSC	F	Few (2-5%)
STSC	C	Common (5-15%)
STSC	M	Many (15-40%)
STSC	A	Abundant (40-80%)
STSC	D	Dominant (> 80%)
STSC		Not described
ERTY	N	No visible evidence of erosion

ERTY	S	Sheet erosion
ERTY	R	Rill erosion
ERTY	G	Gully erosion
ERTY	T	Tunnel erosion
ERTY	P	Deposition by water
ERTY	W	Water and wind erosion
ERTY	L	Wind deposition
ERTY	A	Wind erosion and deposition
ERTY	D	Shifting sand
ERTY	Z	Salt deposition
ERTY	U	Type of erosion unknown
ERTY		Not described
ERAA	1	0-5%
ERAA	2	5-10%
ERAA	3	10-25%
ERAA	4	25-50%
ERAA	5	> 50%
ERAA		Not described
ERDE	S	Slight
ERDE	M	Moderate
ERDE	V	Severe
ERDE	E	Extreme
ERDE		Not described
SCAP	N	None
SCAP	W	Weak
SCAP	M	Moderate
SCAP	S	Strong
SCAP		Not described
RDEP	V	Very shallow (< 30 cm)
RDEP	S	Shallow (30-50 cm)
RDEP	M	Moderately deep (50-100 cm)
RDEP	D	Deep (100-150 cm)
RDEP	X	Very deep (> 150 cm)
RDEP		Not described

REPHORIZ TABLE

FIELDNAME	CODE	DESCRIPTION
DIAP	TC	Abrupt textural change
DIAP	AD	Andic properties
DIAP	CO	Calcareous
DIAP	CA	Calcaric
DIAP	RO	Continuous hard rock
DIAP	FA	Ferralic properties
DIAP	FI	Ferric properties
DIAP	FL	Fluvic properties
DIAP	GE	Geric properties
DIAP	GL	Gleyic and stagnic properties
DIAP	GY	Gypsiferous
DIAP	IN	Interfingering
DIAP	NI	Nitric properties
DIAP	OR	Organic soil materials
DIAP	PE	Permafrost
DIAP	PL	Plinthite
DIAP	SA	Salic properties
DIAP	SI	Slickensides

DIAP	SM	Smeary consistence
DIAP	SO	Sodic properties
DIAP	SL	Soft powdery lime
DIAP	HU	Strongly humic
DIAP	SU	Sulphidic materials
DIAP	TO	Tonguing
DIAP	VE	Vertic properties
DIAP	WM	Weatherable minerals
DIAP		Not described
HBDI	A	Abrupt: 0-2 cm
HBDI	C	Clear: 2-5 cm
HBDI	G	Gradual: 5-15 cm
HBDI	D	Diffuse: =15 cm
HBDI		Not described
STGR	N	Structureless
STGR	W	Weak
STGR	M	Moderate
STGR	S	Strong
STGR		Not described
STSI	V	Very fine
STSI	F	Fine
STSI	M	Medium
STSI	C	Coarse
STSI	X	Very coarse
STSI		Not described
STTY	P	Platy
STTY	R	Prismatic
STTY	C	Columnar
STTY	A	Angular blocky
STTY	S	Subangular blocky
STTY	G	Granular
STTY	B	Crumb
STTY	M	Massive
STTY	N	Single grain
STTY	W	Wedge shaped
STTY		Not described
MINA	N	None: 0%
MINA	V	Very few: 0-2%
MINA	F	Few: 2-5%
MINA	C	Common: 5-15%
MINA	M	Many: 15-40%
MINA	A	Abundant: 40-80%
MINA	D	Dominant:> 80%
MINA		Not described
MINS	V	Very fine: <2 mm
MINS	F	Fine: 2-6 mm
MINS	M	Medium: 6-20 mm
MINS	C	Coarse: > 20 mm
MINS		Not described
PSCL	S	Sand
PSCL	LS	Loamy sand
PSCL	SL	Sandy loam
PSCL	SIL	Silty loam
PSCL	SI	Silt
PSCL	L	Loam
PSCL	SCL	Sandy clay loam
PSCL	CL	Clay loam
PSCL	SICL	Silty clay loam

PSCL	SC	Sandy clay
PSCL	SIC	Silty clay
PSCL	C	Clay
PSCL		Not described
CLAY	AL	Allophane
CLAY	CH	Chloritic
CLAY	IL	Illitic
CLAY	IN	Interstratified or mixed
CLAY	KA	Kaolinitic
CLAY	MO	Montmorilonitic
CLAY	SE	Sesquioxidic
CLAY	VE	Vermiculitic
CLAY		Not described

A.4.1.3. SOTER Database modifications in GIS

The modifications in the tables database are: changes in the structure and adding new fields

ATTRIBUTES OF SOILMAP TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
AREA	Area in m2
PERIMETER	perimeter of the polygon
SUID	SOTER unid_ID
EPISOIL	Epigraph of SOTER unit
ISO	
DATE	year of date collection
MAPI	map_id
MINE	minimum elevation
MAXE	maximum elevation
GSLP	slope gradient
RELF	relief intensity
LNDF	major landform
RSLO	regional slope
HYPS	hypsometry
DISS	dissection
LITH	general lithology
PWAT	permanent water surface
SOIL1	first soil component
PROP1	proportion of the first soil component
SOIL2	second soil component
PROP2	proportion of the second soil component
SOIL3	third soil component
PROP3	proportion of the third soil component
SOIL4	fourth soil component
PROP4	proportion of the fourth soil component
SOIL5	fifth soil component
PROP5	proportion of the fifth soil component
SOIL6	sixth soil component
PROP6	proportion of the sixth soil component
SOIL7	seventh soil component
PROP7	proportion of the seventh soil component
QUALITY	Evaluation of the aptidude soil vs crop

SOIL COMPONENT: SOILCOMP TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
ISO	
SUID	SOTER unit_id
TCID	terrain component number
SCID	soil component number
PROP	proportion of SOTER unit
PRID	Representative Profile Name
PRRF	number of reference
POSI	position in terrain component
RKSC	surface rockiness

STSC	surface stoniness
ERTY	types of erosion/deposition
ERAA	area affected
ERDE	degree of erosion
SCAP	sensitivity to capping
RDEP	rootable depth
OTHS	relation with other soil components
TCDC	terrain component data ID
SOILNUM	SCID number inside SOTER unid

A.4.2. ICC100 Database

This annex chapter shows a description of the ICC100 Database: tables and attribute coding

A.4.2.1. ICC100 Tables

For each table have:

- ATTRIBUTE FIELD : the name of the field in the database
- ATTRIBUTE DESCRIPTION, a brief note about the kind of the information of the field.

Each table has the field, or combination of fields used as "key fields" marked in *cursive* (normally one, but maybe a combination of fields), and marked in **black** the fields, or combination of fields, used to establish the relations with the other tables

MAP UNITS: MAPUNITS TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
UNID (4,4,I)	Map unit_ID
EPIG (6,6,C)	Epigraph

MAP COMPONENT: MAPCOMPO TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
EPIG (6,6,C)	Epigraph
GEO1 (50,50,C)	Geomorphology: Major landform
GEO2 (50,50,C)	Geomorphology: Landform (second level)
GEO3 (50,50,C)	Geomorphology: Land element
TYPE (3,3,C)	Kind of map unit
NAME (50,50,C)	Name of the map unit
TEXT (4,4,C)	Surface texture
SLOP (2,2,C)	Slop
FRAG (2,2,C)	Surface coarse fragments
SALC (3,3,C)	Salinity class
SODI (3,3,C)	Sodicity class
EPCO1 (10,10C)	Map unit component 1
PROP1 (3,3,I)	Proportion of Map unit component 1
EPCO2 (10,10,C)	Map unit component 2
PROP2 (3,3,I)	Proportion of Map unit component 2
EPCO3 (10,10,C)	Map unit component 3
PROP3 (3,3I)	Proportion of Map unit component 3
EPCO4 (10,10C)	Map unit component 4
PROP4 (3,3,I)	Proportion of Map unit component 4

PROFILE: PROFILE TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
PRID (10,10C)	Representative profile name
PDID (7,7,C)	Profile_ID
UNID (4,4,I)	Map unit where the profile is located
SAPL (Y/N)	Sample (yes/no)
DATE (DATE)	Date of sampling
AUT (50,50,C)	Authors of the description
LATI (6,6,N,4)	Latitude
LONG (6,6,N,4)	Longitude
ELEV (4,4,I)	Elevation
WRB8 (50,50,C)	Classification (World Resource Base, 1998)
CLAF (40,40,C)	Classification (FAO, 1988)
STAX (20,20,C)	Classification (Soil taxonomy)
SOAF (50,50,C)	Classification (South African)
TOPO (1,1,C)	Topography
LNDF (2,2,C)	Major landform
LNDS (2,2,C)	Landform: second element
LNDE (2,2,C)	Land element
POSI (2,2,C)	Position
LNDU (3,3,C)	Land use
CROP (2,2,C)	Crops
HUMI (2,2,C)	Human influence
VEGE (2,2,C)	Vegetation
PAMA (2,2,C)	Parent material
DEPT (1,1,C)	Soil depth
RKSC (1,1,C)	Rock outcrops: abundance
RKAV (1,1,C)	Rock outcrops: average distance
RKST (2,2,C)	Rock outcrops: nature
STTY (2,2,C)	Surface coarse fragments: nature
STSC (1,1,C)	Surface coarse fragments: abundance
STSI (1,1,C)	Surface coarse fragments: greatest dimension
ERCA (2,2,C)	Erosion: category
ERTY (2,2,C)	Erosion: type
ERAF (1,1,C)	Erosion: area affected
ERDG (1,1,C)	Erosion: degree
SEAT (1,1,C)	Surface sealing: thickness
SEAC (1,1,C)	Surface sealing: consistence
SCWH (1,1,C)	Surface cracks: width
SCAV (2,2,C)	Surface cracks: average distance
SALC (2,2,C)	Salinity: class
SALN (50,50,C)	Salinity: nature
OTHE (100,100,C)	Other surface characteristics
DRCL (1,1,C)	Drainage class
GWAT (6,6,N,2)	Depth to groundwater
DRQU (2,2,C)	Groundwater quality
MOIS (1,1,C)	Moisture conditions

HORIZON: HORIZ TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
PDID (7,7,C)	Profile_ID
HONU (1,1,N)	Horizon number
HBDE (4,4,N,1)	Lower depth of the horizon
DIAP (1,1,C)	Horizon boundary

HODE (5,5,C)	Genetic horizon
SCMO (10,10,C)	Moist colour
MOAB (1,1,C)	Mottles: abundance
MOSI (1,1,C)	Mottles: size
MOCT (1,1,C)	Mottles: contrast
MOCO (2,2,C)	Mottles: colour
TEXT (4,4,C)	Texture
MINA (1,1,C)	Rock fragments: abundance
MINS (1,1,C)	Rock fragments: size
MISH (1,1,C)	Rock fragments: shape
MINT (2,2,C)	Rock fragments: nature
STGR (2,2,C)	Structure: grade
STSI (2,2,C)	Structure: size
STTY (2,2,C)	Structure: type
CODY (3,3,C)	Consistence: dry
COMO (3,3,C)	Consistence: moist
COWS (3,3,C)	Consistence: wet (stickness)
COWP (3,3,C)	Consistence: wet (plasticity)
CUAB (1,1,C)	Cutans: abundance
CUTH (1,1,C)	Cutans: contrast
CUTY (3,3,C)	Cutans: nature
CULO (2,2,C)	Cutans: location
CECO (1,1,C)	Cementation: continuity
CENA (3,3,C)	Cementation: nature
CEDE (1,1,C)	Cementation: degree
COAB (1,1,C)	Mineral nodules: abundance
COTY (1,1,C)	Mineral nodules: kind
COSI (1,1,C)	Mineral nodules: size
COSH (1,1,C)	Mineral nodules: shape
COHD (1,1,C)	Mineral nodules: hardness
CONA (2,2,C)	Mineral nodules: nature
ROOT (2,2,C)	Roots
BIAB (1,1,C)	Biological features: abundance
BIKI (2,2,C)	Biological features: kind
HCL (2,2,C)	HCl reaction
DIAH (20,20,C)	Diagnostic horizons
SAMP (9,9,C)	Sample references

HORIZON ANALISYS: HOR_ANA TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
PDID (7,7,C)	Profile_ID
HONU (1,1,N)	horizon number
SDTO (20,20,N,5)	Total sand
STPC (20,20,N,5)	Total silt
CLPC (20,20,N,5)	Total clay
PSCL (4,4,C)	Texture class
BULK (20,20,N,5)	Bulk density
TEN1 (20,20,N,5)	Tension 1
MCT1 (20,20,N,5)	Moisture at tension 1
TEN2 (20,20,N,5)	Tension 2
MCT2 (20,20,N,5)	Moisture at tension 2
TEN3 (20,20,N,5)	Tension 3
MCT3 (20,20,N,5)	Moisture at tension 3
TEN4 (20,20,N,5)	Tension 4
MCT4 (20,20,N,5)	Moisture at tension 4

TEN5 (20,20,N,5)	Tension 5
MCT5 (20,20,N,5)	Moisture at tension 5
HYDC (20,20,N,5)	Hydraulic conductivity
INFI (20,20,N,5)	Infiltration rate
PHAQ (20,20,N,5)	pH (water)
PHKC (20,20,N,5)	pH (KCl)
EL15 (20,20,N,5)	Electrical conductivity (extract 1:5)
ELCO (20,20,N,5)	Electrical conductivity (saturated extract)
SONA (20,20,N,5)	Soluble Na
SOCA (20,20,N,5)	Soluble Ca
SOMG (20,20,N,5)	Soluble Mg
SOLK (20,20,N,5)	Soluble K
SOCL (20,20,N,5)	Soluble Cl
SSO4 (20,20,N,5)	Soluble SO4
HCO3 (20,20,N,5)	Soluble HCO3
SCO3 (20,20,N,5)	Soluble CO3
EXCA (20,20,N,5)	Exchangeable Ca
EXMG (20,20,N,5)	Exchangeable Mg
EXNA (20,20,N,5)	Exchangeable Na
EXCK (20,20,N,5)	Exchangeable K
EXAL (20,20,N,5)	Exchangeable Al
EXAC (20,20,N,5)	Exchangeable acidity
CECS (20,20,N,5)	CEC
TOTC (20,20,N,5)	Total carbon
TOTN (20,20,N,5)	Total Nitrogen
TCEQ (20,20,N,5)	Total carbonate equivalent
GYPS (20,20,N,5)	Gypsum
P2O5 (20,20,N,5)	P2O5
PRET (20,20,N,5)	Phosphate retention
FEDE (20,20,N,5)	Fe Dithionite
FEPE (20,20,N,5)	Fe Pyrophosphate
ALDE (20,20,N,5)	Al Dithionite
ALPE (20,20,N,5)	Al Pyrophosphate
CLAY (20,20,C)	Clay mineralogy
SAMP (9,9,C)	Sample reference

A.4.2.2. ICC100 Codification

In order to construct the entry form and facility the database implementation, a dictionary tables are created with this structure:

- FIELDNAME: the name of the field on the table
- CODE: the code used in the database
- DESCRIPTION: the significance of the code used

The codes used (from original EXCEL files: profile_code.xls, hz_code.xls, mapa_code.xls) codes, ordered by ICC100 tables are:

MAPCOMPO TABLE

FIELDNAME	CODE	DESCRIPTION
TYPE	CN	Consociation
TYPE	CM	Complex
TYPE	AS	Association
TYPE	UA	Unassociated soils
TYPE	UD	Undifferenciated group
TEXT	C	Clay
TEXT	L	Loam
TEXT	CL	Clay loam
TEXT	Si	Silt
TEXT	SiC	Silty clay
TEXT	SiCL	Silty clay loam
TEXT	SiL	Silt loam
TEXT	SC	Sandy clay
TEXT	SCL	Sandy clay loam
TEXT	SL	Sandy loam
TEXT	LS	
TEXT	S	Sand
TEXT		Not described
SLOP	W	0-2% flat, wet
SLOP	F	0-2% flat
SLOP	G	Loamy sand
SLOP	U	5-8% undulating
SLOP	R	8-15% rolling
SLOP	S	15-30% moderately steep
SLOP	T	30-60% steep
SLOP	V	> 60% very steep
SLOP		Not described
FRAG	N	None 0 %
FRAG	V	Very few 0-2 %
FRAG	F	Few 2-5 %
FRAG	C	Common 5-15 %
FRAG	M	Many 15-40 %
FRAG	A	Abundant 40 -80 %
FRAG	D	Dominant > 80 %
FRAG		Not described
SALC	N	No saline < 2 dS/m
SALC	V	Very slightly saline 2 - 4 dS/m
SALC	SL	Slightly saline 4 - 8 dS/m

SALC	MO	Moderatly saline 8 - 16 dS/m
SALC	ST	Strongly saline > 16 dS/m
SALC		Not described
SODI	N	No sodic SAR < 8
SODI	SS	Slightly sodic SAR 8 -16
SODI	S	Sodic SAR > 16
SODI		Not described

PROFILE TABLE

FIELDNAME	CODE	DESCRIPTIO
TOPO	F	Flat
TOPO	A	Almost flat
TOPO	G	Gently undualing
TOPO	U	Undualating
TOPO	R	Rolling
TOPO	H	Hilling
TOPO	S	Stepply dissected
TOPO	M	Mountanious
TOPO		Not described
LNDF	MO	Mountain
LNDF	HI	Hill
LNDF	UP	Upland
LNDF	PL	Plain
LNDF	PT	Plateau
LNDF	BA	Basin
LNDF	VA	Valley
LNDF		Not described
LNDS	AP	Alluvial Plain
LNDS	CP	Coastall Plain
LNDS	LP	Lacustrine Plain
LNDS	GP	Glacial Plain
LNDS	PN	Peneplane
LNDS	PE	Pediment
LNDS	VO	Volcano
LNDS	DU	Dunefield
LNDS	DT	Delta
LNDS	TF	Tidal Flat
LNDS	PY	Playa
LNDS		Not described
LNDE	IF	Interfluve
LNDE	VA	Valley
LNDE	VF	Valley floor
LNDE	CH	Channel
LNDE	LE	Levee
LNDE	TE	Terrace
LNDE	FP	Floodplain
LNDE	LA	Lagoon
LNDE	PA	Pan
LNDE	CO	Coral Reef
LNDE	CA	Caldera
LNDE	DE	Depression
LNDE	DU	Dune
LNDE	LD	longuitudinal dune
LNDE	ID	Interdunal depression
LNDE	SL	Slope
LNDE	IR	Ridge

LNDE	BR	Beachridge
LNDE		Not described
LNDU	S	Industrial use
LNDU	SR	Residential use, cities
LNDU	SI	Industrial use
LNDU	ST	Transport (roads, railways etc.)
LNDU	SC	Recreation
LNDU	SX	Excavations, quarries
LNDU	A	Land used for cultivation of crops
LNDU	AA	Annual field cropping
LNDU	AA1	Shifting cultivation
LNDU	AA2	Fallow system cultivation
LNDU	AA3	Ley system cultivation
LNDU	AA4	Rainfed arable cultivation
LNDU	AA5	Wet rice cultivation
LNDU	AA6	Irrigated cultivation
LNDU	AP	Perennial field cropping
LNDU	AP1	Non-irrigated perennial field cropping
LNDU	AP2	Irrigated perennial field cropping
LNDU	AT	Tree and shrub cropping
LNDU	AT1	Non-irrigated tree crop cultivation
LNDU	AT2	Irrigated tree crop cultivation
LNDU	AT3	Non-irrigated shrub crop cultivation
LNDU	AT4	Irrigated shrub crop cultivation
LNDU	H	Animal husbandry
LNDU	HE	Extensive grazing
LNDU	HE1	Nomadism
LNDU	HE2	Semi-nomadism
LNDU	HI	Intensive grazing
LNDU	HI1	Animal production
LNDU	HI2	Dairying
LNDU	HI3	Ranching
LNDU	F	Forestry
LNDU	FN	Exploitation of natural forest and woodland
LNDU	FN1	Selective felling
LNDU	FN2	Clear felling
LNDU	FP	Plantation forestry
LNDU	M	Mixed farming
LNDU	MF	Agro-forestry
LNDU	MP	Agro-pastoralism
LNDU	E	Extraction of products from the environment
LNDU	EV	Exploitation of natural vegetation
LNDU	EH	Hunting and fishing
LNDU	P	Nature protection
LNDU	PN	Nature and game preservation
LNDU	PN1	Reserves
LNDU	PN2	Parks
LNDU	PN3	Wildlife management
LNDU	PD	Degradation control
LNDU	PD1	Degradation control - non-interference
LNDU	PD2	Degradation control - interference
LNDU	U	Not used and not managed
LNDU		Not described
POSI	CR	Crest
POSI	UP	Upper slope
POSI	MS	Middle slope
POSI	LS	lower slope

POSI	BO	Bottom (flat)
POSI	HI	Higher part
POSI	IN	Intermediate part
POSI	LO	Lower part
POSI	BO	Bottom (drainage line)
POSI		Not described
CROP	BA	Barley
CROP	BE	Beans
CROP	CH	Cashew
CROP	CA	Cassava
CROP	CO	Cocoa
CROP	CC	Coconut
CROP	CF	Coffee
CROP	CT	Cotton
CROP	CP	Cowpea
CROP	FR	Fruit trees
CROP	GR	Groundnut
CROP	MA	Maize
CROP	MI	Millet
CROP	OP	Oilpalm
CROP	PE	Peas
CROP	PO	Potato
CROP	IR	Rice
CROP	RB	Rice (flooded)
CROP	RU	Rice (upland)
CROP	RR	Rubber
CROP	SO	Sorghum
CROP	SB	Soyabean
CROP	SC	Sugar cane
CROP	SF	Sun flower
CROP	SP	Sweet potato
CROP	TE	Tea
CROP	TB	Tobacco
CROP	VE	Vegetables
CROP	WH	Wheat
CROP	YA	Yams
CROP		Not described
HUMI	N	No influence
HUMI	NK	Not Know
HUMI	VS	Vegetation slightly disturbed
HUMI	VM	Vegetation moderatly disturbed
HUMI	VE	Vegetation disturbed (unspec.)
HUMI	VU	Vegetation strongly disturbed
HUMI	IS	Sprinker irrigation
HUMI	IF	Furrow irrigation
HUMI	IP	Flood irrigation
HUMI	IB	Border irrigation
HUMI	IU	Irrigation (unspec.)
HUMI	AD	Artificial drainage
HUMI	FE	Application of fertilizers
HUMI	BU	Bunding
HUMI	BR	Burning
HUMI	TE	Terracing
HUMI	PL	Ploughing
HUMI	MP	Plaggen
HUMI	MR	Raised beds
HUMI	MS	Sand additions
HUMI	MU	Mineral additions unspec.

HUMI	PO	Pollution
HUMI	CL	Clearing
HUMI	SC	Surface compaction
HUMI	BP	Borrow pit
HUMI		Not described
VEGE	N	No vegetation
VEGE	G	Grassland:Grasses, subordinate forbs,no woody species
VEGE	FO	Forland:Hebaceous plants predominant
VEGE	F	Forest: Continuous tree layer, crowns ovelaping
VEGE	W	Woodaland: Continuous tree layer, crowns usually not touching
VEGE	S	Shruland: Continuous layer of shrub, crowns touching
VEGE	SA	Savanna: Grasses with discontinuous layer of trees or shrubs
VEGE		Not described
PAMA	AU	Aeolian deposits
PAMA	AS	Aeolian sand
PAMA	LI	Littoral deposits
PAMA	LG	Lagoonal deposits
PAMA	MA	Marine deposits
PAMA	LA	Lacustrine deposits
PAMA	FL	Fluvial deposits
PAMA	AL	Alluvial deposits
PAMA	UU	Uncomsolidated
PAMA	VA	Volcanic ash
PAMA	LO	Loess
PAMA	PY	Pyroclastic deposits
PAMA	GL	Glacial deposits
PAMA	OR	Organic deposits
PAMA	CO	Colluvial deposits
PAMA	WE	in situ weathered
PAMA		Not described
DEPT	V	Very shallow < 30 cm
DEPT	S	Shallow 30 - 50 cm
DEPT	M	Moderately 50 - 100 cm
DEPT	D	Deep 100 - 150 cm
DEPT	E	Very deep > 150 cm
RKSC	N	None 0 %
RKSC	V	Very few 0-2 %
RKSC	F	Few 2-5 %
RKSC	C	Common 5-15 %
RKSC	M	Many 15-40 %
RKSC	A	Abundant 40 -80 %
RKSC	D	Dominant > 80 %
RKSC		Not described
RKAV		> 50 m
RKAV		20-50 m
RKAV		5-20 m
RKAV		2-5 m
RKAV		< 2 m
RKAV		Not described
RKST	AC	Acid igneous/metamorfic rock
RKST	GR	Granite
RKST	GN	Gneiss
RKST	GG	Granite/gneiss
RKST	QZ	Quarzite
RKST	SC	Schist
RKST	AN	Andesite
RKST	DI	Diorite

RKST	BA	Basic igneous/metamorphic rock
RKST	UB	Ultra basic rock
RKST	GA	Gabro
RKST	BT	Basalt
RKST	DO	Dolerite
RKST	VO	Volcanic rock
RKST	SE	Sedimentary rock
RKST	LI	Limestone
RKST	DM	Dolomite
RKST	SA	Sandstone
RKST	QS	Quartzitic sandstone
RKST	SH	Shale
RKST	MA	Marl
RKST	TR	Travertine
RKST	CO	Conglomerate
RKST	SI	Silistone
RKST	TU	Tuff
RKST	PY	Pyroclastic roock
RKST	EV	Evaporite
RKST	GY	Gypsum rock
RKST	NK	not know
RKST		Not described
STSC	N	None 0 %
STSC	V	Very few 0-2 %
STSC	F	Few 2-5 %
STSC	C	Common 5-15 %
STSC	M	Many 15-40 %
STSC	A	Abundant 40 -80 %
STSC	D	Dominant > 80 %
STSC		Not described
STSI	F	Fine gravel 0.2-0.6 cm
STSI	M	Medium gravel 0.6-2 cm
STSI	C	Coarse gravel 2-6 cm
STSI	S	Stones 6-20 cm
STSI	B	Boulders 20-60 cm
STSI	L	Large boulders > 60 cm
STSI		Not described
ERCA	N	No evidence of erosion
ERCA	W	Water erosion or deposition
ERCA	A	Wind (aeolian) erosion or deposition
ERCA	M	Mass movement
ERCA	NK	Not know
ERCA		Not described
ERTY	WS	Sheet erosion
ERTY	WR	Rill erosion
ERTY	WG	Gully erosion
ERTY	WT	Tunnel erosion
ERTY	WD	Deposition by water
ERTY	WA	Water and wind erosion
ERTY	AD	Wind deposition
ERTY	AM	Wind erosion and deposition
ERTY	AS	Shifting sands
ERTY	AZ	Salt deposition
ERTY		Not described
ERAF		Not
ERAF		0 - 5 %
ERAF		5 - 10 %
ERAF		10 - 25 %

ERAF		25 - 50 %
ERAF		> 50 %
ERDG	S	Slight: some evidence of damage to surface horizons
ERDG	M	Moderate: clear evidence of removal of surface horizons
ERDG	V	Severe: surface horizons completely removed and subsurface horizons exposed
ERDG	E	Extreme: substancial removal of deeper subsurface horizons (badlands)
ERDG		Not described
SEAT	N	None
SEAT	F	Thin < 2 mm
SEAT	M	Medium 2 - 5 mm
SEAT	T	Thick 5 - 20 mm
SEAT	V	Very Thick > 20 mm
SEAT		Not described
SEAC	S	Slightly hard
SEAC	H	Hard
SEAC	V	Very hard
SEAC	E	Extremely hard
SEAC		Not described
SCWH	F	Fine < 1 cm
SCWH	M	Medium 1 - 2 cm
SCWH	W	Wide 2 - 5 cm
SCWH	V	Very wide 5 - 10 cm
SCWH	E	Extremely wide > 10 cm
SCWH		Not described
SCAV	C	Very closely spaced < 0.2 m
SCAV	D	Closely spaced 0..2 - 0.5 m
SCAV	MW	Moderatly widely spaced 0.5 - 2.0 m
SCAV	W	Widely spaced
SCAV	V	Very widely spaced
SCAV		Not described
SALC	N	No saline < 2 dS/m
SALC	V	Very slightly saline 2 - 4
SALC	SL	Slightly saline 4 - 8
SALC	MO	Moderatly saline 8 - 16
SALC	ST	Strongly saline > 16
SALC		Not described
DRCL	E	Excessively drained
DRCL	S	Somewhat excessively drained
DRCL	W	Well drained
DRCL	M	Moderatly well drained
DRCL	I	Somewhat poorly (imperfected) drained
DRCL	P	Poorly drained
DRCL	V	Very poorly drained
DRCL		Not described
DRQU	SA	Saline
DRQU	BR	Brackish
DRQU	FR	Fresh
DRQU	PO	Polluted
DRQU	OX	Oxigenated
DRQU	SG	Stagnating
DRQU		Not described
MOIS	D	Dry
MOIS	S	Slightlly moist
MOIS	M	Moist
MOIS	W	Wet

MOIS		Not described

HORIZ TABLE

FIELDNAME	CODE	DESCRIPTIO
DIAP	A	Abrupt 0 -2 cm
DIAP	C	Clearv 2 -5 cm
DIAP	G	Gradual 5 -15 cm
DIAP	D	Diffuse > 15 cm
DIAP		Not described
MOAB	N	None
MOAB	V	Very few 0-2 %
MOAB	F	Few 2-5 %
MOAB	C	Common 5-15 %
MOAB	M	Many 15-40 %
MOAB	A	Abundant > 40 %
MOAB		Not described
MOSI	V	Very fine < 2mm
MOSI	F	Fine 2 - 6 mm
MOSI	M	Medium 6-20 mm
MOSI	C	Coarse > 20 mm
MOSI		Not described
MOCT	F	Faint: Evidence onnly on close examination
MOCT	D	Distinct: Readly seen
MOCT	P	Prominent : Mottliing is one of the outstanding features
MOCT		Not described
MOCO	WH	White
MOCO	RE	Red
MOCO	RS	Reddish
MOCO	YR	Yellowish red
MOCO	BR	Brown
MOCO	BS	Brownish
MOCO	RB	Reddish Brown
MOCO	YB	Yellowish brown
MOCO	YE	Yellow
MOCO	RY	Reddish yellow
MOCO	GE	Greenish, green
MOCO	GR	Grey
MOCO	GS	Greyish
MOCO	BU	Blue
MOCO	BB	Bluish-black
MOCO	BL	Black
MOCO		Not described
TEXT	C	Clay
TEXT	L	Loam
TEXT	CL	Clay loam
TEXT	Si	Silt
TEXT	SiC	Silty clay
TEXT	SiCL	Silty clay loam
TEXT	SiL	Silt loam
TEXT	SC	Sandy clay
TEXT	SCL	Sandy clay loam
TEXT	SL	Sandy loam
TEXT	LS	Loamy sand
TEXT	S	Sand
TEXT		Not described
MINA	N	None

MINA	V	Very few: 0-2%
MINA	F	Few: 2-5%
MINA	C	Common: 5-15%
MINA	M	Many: 15-40%
MINA	A	Abundant: 40-80%
MINA	D	Dominant: > 80%
MINA		Not described
MINS	V	Very fine: <2 mm
MINS	F	Fine: 2-6 mm
MINS	M	Medium: 6-20 mm
MINS	C	Coarse: > 20 mm
MINS		Not described
MISH	F	Flat
MISH	A	Angular
MISH	S	Subrounded
MISH	R	Rounded
MISH		Not described
MINT	AC	Acid igneous/metamorfic rock
MINT	GR	Granite
MINT	GN	Gneiss
MINT	GG	Granite/gneiss
MINT	QZ	Quarzite
MINT	SC	Schist
MINT	AN	Andesite
MINT	DI	Diorite
MINT	BA	Basic igneous/metamorphic rock
MINT	UB	Ultra basic rock
MINT	GA	Gabro
MINT	BT	Basalt
MINT	DO	Dolerite
MINT	VO	Volcanic rock
MINT	SE	Sedimentary rock
MINT	LI	Limestone
MINT	DM	Dolomite
MINT	SA	Sandstone
MINT	QS	Quartzitic sandstone
MINT	SH	Shale
MINT	MA	Marl
MINT	TR	Travertine
MINT	CO	Conglomerate
MINT	SI	Silistone
MINT	TU	Tuff
MINT	PY	Pyroclastic roock
MINT	EV	Evaporite
MINT	GY	Gypsum rock
MINT	NK	not know
MINT		Not described
STGR	VW	Loose: non-coherent
STGR	WE	Weak
STGR	MO	Moderate
STGR	ST	Strong
STGR	VS	Very strong
STGR		Not described
STSI	VF	Very fine
STSI	FI	Fine
STSI	ME	Medium
STSI	CO	Coarse

STSI	VC	Very coarse
STSI		Not described
STTY	SG	Singel grain
STTY	MA	Massive
STTY	GR	Granular
STTY	PR	Prismatic
STTY	PS	Subangular prismatic
STTY	CO	Columnar
STTY	AB	Angular blocky
STTY	SB	Subangular blocky
STTY	AS	Angular and subangular blocky
STTY	SA	Subangular and Angular blocky
STTY	SN	Nutty subangular blocky
STTY	AW	Angular blocky wedge-shaped
STTY	AP	Angular blocky pparallelepiped
STTY	PL	Platy
STTY	RS	Rock structure
STTY	SS	Stratiffied structure
STTY		Not described
CODY	LO	None: 0%
CODY	SO	Soft: breaks under very slight pressure
CODY	SHA	Slighty hard: easily broken between thumb and forefinger
CODY	HA	hard: can be broken in the hands, not between thumb and forefinger
CODY	VHA	Very hard: can be brokenin the hands with dificult
CODY	EHA	Extremely hard: cannot be broken in the hands
CODY		Not described
COMO	LO	Loose: non-coherent
COMO	VFR	Very friable.
COMO	FI	Friable
COMO	VFI	Very firm
COMO	EFI	Extremely firm
COMO		Not described
COWS	NST	Non sticky
COWS	SST	Slighty sticky
COWS	ST	Sticky
COWS	VST	Very sticky
COWS		Not described
COWP	NPL	Non plastic
COWP	SPL	lightly plastic
COWP	PL	Plastic
COWP	VPL	Very plastic
COWP		Not described
CUAB	N	None
CUAB	V	Very few 0-2 %
CUAB	F	Few 2 - 5 %
CUAB	C	Common 5-15 %
CUAB	M	Many 15-40 %
CUAB	A	Abundant 40 -80 %
CUAB	D	Dominant > 80 %
CUAB		Not described
CUTH	F	Faint
CUTH	D	Distinct
CUTH	P	Prominent
CUTH		Not described
CUTY	C	Clay
CUTY	CSL	Clay and sesquioxides
CUTY	CH	Clay and humus

CUTY	PF	Pressure faces
CUTY	S	Slickensides, non--intersecting
CUTY	SPL	Slickensides, partly intersecting
CUTY	SI	Slickensides, predominantly intersecting
CUTY	SF	Shiny faces
CUTY		Not described
CULO	P	Pedfaces
CULO	PV	Vertical pedfaces
CULO	PH	Horitzontal pedfaces
CULO	CF	Coarse fragments
CULO	LA	Lamellae
CULO	V	Voids
CULO	NS	No specific location
CULO		Not described
CECO	B	Broken
CECO	D	Discontinuous
CECO	C	Continuous
CECO		Not described
CENA	K	Carbonates
CENA	Q	Silica
CENA	KQ	Carbonates-silica
CENA	F	Iron
CENA	FM	Iron-manganese
CENA	FO	Iron-organic matter
CENA	GY	Gypsum
CENA	C	Clay
CENA	CSL	Clay-sesquioxides
CENA	M	Mechanical
CENA	P	Ploughing
CENA	NK	not know
CENA		Not described
CEDE	N	Non cemented and non compacted
CEDE	Y	Compacted but non cemeted
CEDE	W	Weakly cemented
CEDE	M	Moderately cemented
CEDE	C	Cemented
CEDE		Not described
COAB	V	Very few 0-2 %
COAB	F	Few 2 - 5 %
COAB	C	Common 5-15 %
COAB	M	Many 15-40 %
COAB	A	Abundant 40 -80 %
COAB	D	Dominant > 80 %
COAB		Not described
COSI	V	Very fine < 2 mm
COSI	F	Fine 2-6 mm
COSI	M	Medium 6-20 mm
COSI	C	Coarse > 20 mm
COSI		Not described
COSH	R	Rounded
COSH	E	Elongate
COSH	F	Flat
COSH	I	Irregular
COSH	A	Angular
COSH		Not described
COHD	H	Hardness
COHD	S	Soft

COHD	B	Both
COHD		Not described
COTY	T	Crystal
COTY	C	Concretion
COTY	S	ft segregation
COTY	N	Nodule
COTY	R	Residual rock
COTY		Not described
CONA	K	Carbonates
CONA	KQ	Carbonates-silica
CONA	C	Clay (argilaceous)
CONA	CS	Clay-sesquioxides
CONA	GY	Gypsum
CONA	SA	Salt
CONA	S	Sulphur
CONA	Q	Silica
CONA	F	Iron
CONA	FM	Iron-manganese
CONA	M	Manganese
CONA	NK	Not know
CONA		Not described
ROOT	N	Normal
ROOT	LL	Limited by lithic layers
ROOT	PL	Limited by paralithic layers
ROOT	SL	Limited by skeletic layers
ROOT	CM	Limited by cemented horizons
ROOT	DL	Limited by dense layers
ROOT	WT	Limited by water table
ROOT	SA	Limited by saline layer
ROOT	RE	Limited by soil reaction
ROOT		Not described
BIAB	N	None
BIAB	F	Few
BIAB	C	Common
BIAB	M	Many
BIAB		Not described
BIKI	A	Artefacts
BIKI	B	Burrows
BIKI	BO	Open large burrows
BIKI	BI	Infilled large burrows
BIKI	C	charcoal
BIKI	E	Earthworm channels
BIKI	P	Pedotubules
BIKI	T	Termite or ant channels and nest
BIKI	I	Other insect activity
BIKI		Not described
HCL	N	Non calcareous
HCL	SL	Slightly calcareous
HCL	MO	Moderately calcareous
HCL	ST	Strongly calcareous
HCL	EX	Estremely calcareous
HCL		Not described

A.4.2.3. ICC100 Database modifications in GIS

MAP UNITS: MAPUNITS TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
UNID (4,4,I)	Map unit_ID
EPIG (6,6,C)	Epigraph

MAP COMPONENT: MAPCOMPO TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
EPIG (6,6,C)	Epigraph
GEO1 (50,50,C)	Geomorphology: Major landform
GEO2 (50,50,C)	Geomorphology: Landform (second level)
GEO3 (50,50,C)	Geomorphology: Land element
TYPE (3,3,C)	Kind of map unit
NAME (50,50,C)	Name of the map unit
TEXT (4,4,C)	Surface texture
SLOP (2,2,C)	Slop
FRAG (2,2,C)	Surface coarse fragments
SALC (3,3,C)	Salinity class
SODI (3,3,C)	Sodicity class
EPCO1 (10,10C)	Map unit component 1
PROP1 (3,3,I)	Proportion of Map unit component 1
EPCO2 (10,10,C)	Map unit component 2
PROP2 (3,3,I)	Proportion of Map unit component 2
EPCO3 (10,10,C)	Map unit component 3
PROP3 (3,3I)	Proportion of Map unit component 3
EPCO4 (10,10C)	Map unit component 4
PROP4 (3,3,I)	Proportion of Map unit component 4

PROFILE: PROFILE TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
PRID (10,10C)	Representative profile name
PDID (7,7,C)	Profile_ID
UNID (4,4,I)	Map unit where the profile is located
SAPL (Y/N)	Sample (yes/no)
DATE (DATE)	Date of sampling
AUT (50,50,C)	Authors of the description
LATI (6,6,N,4)	Latitude
LONG (6,6,N,4)	Longitude
ELEV (4,4,I)	Elevation
WRB8 (50,50,C)	Classification (World Resource Base, 1998)
CLAF (40,40,C)	Classification (FAO, 1988)
STAX (20,20,C)	Classification (Soil taxonomy)
SOAF (50,50,C)	Classification (South African)
TOPO (1,1,C)	Topography
LNDF (2,2,C)	Major landform
LNDS (2,2,C)	Landform: second element
LNDE (2,2,C)	Land element

POSI (2,2,C)	Position
LNDU (3,3,C)	Land use
CROP (2,2,C)	Crops
HUMI (2,2,C)	Human influence
VEGE (2,2,C)	Vegetation
PAMA (2,2,C)	Parent material
DEPT (1,1,C)	Soil depth
RKSC (1,1,C)	Rock outcrops: abundance
RKAV (1,1,C)	Rock outcrops: average distance
RKST (2,2,C)	Rock outcrops: nature
STTY (2,2,C)	Surface coarse fragments: nature
STSC (1,1,C)	Surface coarse fragments: abundance
STSI (1,1,C)	Surface coarse fragments: greatest dimension
ERCA (2,2,C)	Erosion: category
ERTY (2,2,C)	Erosion: type
ERAF (1,1,C)	Erosion: area affected
ERDG (1,1,C)	Erosion: degree
SEAT (1,1,C)	Surface sealing: thickness
SEAC (1,1,C)	Surface sealing: consistence
SCWH (1,1,C)	Surface cracks: width
SCAV (2,2,C)	Surface cracks: average distance
SALC (2,2,C)	Salinity: class
SALN (50,50,C)	Salinity: nature
OTHE (100,100,C)	Other surface characteristics
DRCL (1,1,C)	Drainage class
GWAT (6,6,N,2)	Depth to groundwater
DRQU (2,2,C)	Groundwater quality
MOIS (1,1,C)	Moisture conditions

HORIZON : HORIZ TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
PDID (7,7,C)	Profile_ID
HONU (1,1,N)	Horizon number
HBDE (4,4,N,1)	Lower depth of the horizon
DIAP (1,1,C)	Horizon boundary
HODE (5,5,C)	Genetic horizon
SCMO (10,10,C)	Moist colour
MOAB (1,1,C)	Mottles: abundance
MOSI (1,1,C)	Mottles: size
MOCT (1,1,C)	Mottles: contrast
MOCO (2,2,C)	Mottles: colour
TEXT (4,4,C)	Texture
MINA (1,1,C)	Rock fragments: abundance
MINS (1,1,C)	Rock fragments: size
MISH (1,1,C)	Rock fragments: shape
MINT (2,2,C)	Rock fragments: nature
STGR (2,2,C)	Structure: grade
STSI (2,2,C)	Structure: size
STTY (2,2,C)	Structure: type
CODY (3,3,C)	Consistence: dry
COMO (3,3,C)	Consistence: moist
COWS (3,3,C)	Consistence: wet (stickness)
COWP (3,3,C)	Consistence: wet (plasticity)
CUAB (1,1,C)	Cutans: abundance
CUTH (1,1,C)	Cutans: contrast
CUTY (3,3,C)	Cutans: nature

CULO (2,2,C)	Cutans: location
CECO (1,1,C)	Cementation: continuity
CENA (3,3,C)	Cementation: nature
CEDE (1,1,C)	Cementation: degree
COAB (1,1,C)	Mineral nodules: abundance
COTY (1,1,C)	Mineral nodules: kind
COSI (1,1,C)	Mineral nodules: size
COSH (1,1,C)	Mineral nodules: shape
COHD (1,1,C)	Mineral nodules: hardness
CONA (2,2,C)	Mineral nodules: nature
ROOT (2,2,C)	Roots
BIAB (1,1,C)	Biological features: abundance
BIKI (2,2,C)	Biological features: kind
HCL (2,2,C)	HCl reaction
DIAH (20,20,C)	Diagnostic horizons
SAMP (9,9,C)	Sample references

HORIZON ANALISYS : HOR_ANA TABLE

ATTRIBUTE FIELD	ATTRIBUTE DESCRIPTION
PDID (7,7,C)	Profile_ID
HONU (1,1,N)	horizon number
SDTO (20,20,N,5)	Total sand
STPC (20,20,N,5)	Total silt
CLPC (20,20,N,5)	Total clay
PSCL (4,4,C)	Texture class
BULK (20,20,N,5)	Bulk density
TEN1 (20,20,N,5)	Tension 1
MCT1 (20,20,N,5)	Moisture at tension 1
TEN2 (20,20,N,5)	Tension 2
MCT2 (20,20,N,5)	Moisture at tension 2
TEN3 (20,20,N,5)	Tension 3
MCT3 (20,20,N,5)	Moisture at tension 3
TEN4 (20,20,N,5)	Tension 4
MCT4 (20,20,N,5)	Moisture at tension 4
TEN5 (20,20,N,5)	Tension 5
MCT5 (20,20,N,5)	Moisture at tension 5
HYDC (20,20,N,5)	Hydraulic conductivity
INFI (20,20,N,5)	Infiltration rate
PHAQ (20,20,N,5)	pH (water)
PHKC (20,20,N,5)	pH (KCl)
EL15 (20,20,N,5)	Electrical conductivity (extract 1:5)
ELCO (20,20,N,5)	Electrical conductivity (saturated extract)
SONA (20,20,N,5)	Soluble Na
SOCA (20,20,N,5)	Soluble Ca
SOMG (20,20,N,5)	Soluble Mg
SOLK (20,20,N,5)	Soluble K
SOCL (20,20,N,5)	Soluble Cl
SSO4 (20,20,N,5)	Soluble SO4
HCO3 (20,20,N,5)	Soluble HCO3
SCO3 (20,20,N,5)	Soluble CO3
EXCA (20,20,N,5)	Exchangeable Ca
EXMG (20,20,N,5)	Exchangeable Mg
EXNA (20,20,N,5)	Exchangeable Na
EXCK (20,20,N,5)	Exchangeable K
EXAL (20,20,N,5)	Exchangeable Al

EXAC (20,20,N,5)	Exchangeable acidity
CECS (20,20,N,5)	CEC
TOTC (20,20,N,5)	Total carbon
TOTN (20,20,N,5)	Total Nitrogen
TCEQ (20,20,N,5)	Total carbonate equivalent
GYPS (20,20,N,5)	Gypsum
P2O5 (20,20,N,5)	P2O5
PRET (20,20,N,5)	Phosphate retention
FEDE (20,20,N,5)	Fe Dithionite
FEPE (20,20,N,5)	Fe Pyrophosphate
ALDE (20,20,N,5)	Al Dithionite
ALPE (20,20,N,5)	Al Pyrophosphate
CLAY (20,20,C)	Clay mineralogy
SAMP (9,9,C)	Sample reference

A.4.3. Evaluation Tables

For the evaluation process, we need to know the suitability relationships between crops and soil type. This data are loaded like news tables in DBF format in the GIS environment.

A.4.3.1. Crops.dbf

This matrix calculate the suitability between soil type and crop.

CLASSIFICA	EPIGRAPH	WHEAT	MAIZE	MILLET	SORGHUM	COTTON	W._POTATO	S._POTATO	SOYA	BEANS
ARENIC FLUVISOL	arFL	S3	S2	S2	S2	S2	S2	S2	S2	S2
ARENIC-LEPTIC REGOSOL	arleRE	N	N	N	N	N	N	N	N	N
BASALT OUTCROPS	ROCK	N	N	N	N	N	N	N	N	N
CALCIC SOLONETZ	caSN	N	N	S3	S3	N	N	N	N	N
CHROMIC CAMBISOL	crCM	S1	S1	S1	S1	S1	S1	S1	S1	S1
CHROMIC LUVISOL	crLV	S1	S1	S1	S1	S1	S1	S1	S1	S1
FERRALIC ARENOSOL	feAR	N	N	N	N	N	N	N	N	N
FLUVIC CAMBISOL	flCM	S3	S3	S2	S2	S2	S2	S2	S2	S2
HAPLIC CALCISOL	haCL	S3	S2	S2	S2	S2	S2	S2	S2	S2
HAPLIC FLUVISOL	haFL	S2	S2	S2	S2	S2	S2	S2	S2	S2
HAPLIC LEPTOSOL	haLE	N	N	N	N	N	N	N	N	N
HAPLIC LUVISOL	haLV	S1	S1	S1	S1	S1	S1	S1	S1	S1
HAPLIC REGOSOL	haRE	S3	S3	S3	S3	S3	S3	S3	S3	S3
HYPERCALCIC CALCISOL	hcCL	S3	S3	S2	S2	S3	S3	S3	S3	S3
HYPOSALIC ARENOSOL	hsAR	N	N	N	N	N	N	N	N	N
LEPTIC REGOSOL	leRE	N	N	S3	S3	S3	N	N	S3	S3
LEPTIC-CHROMIC CAMBISOL	lecrCM	S3	S3	S2	S2	S2	S3	S3	S2	S3
MOLLIC LEPTOSOL	moLE	N	N	S3	S3	S3	N	N	S3	S3
NATRIC-CALCIC VERTISOL	nacaVR	N	N	N	N	N	N	N	N	N
NATRIC-GYPSIC VERTISOL	nagyVR	N	N	N	N	N	N	N	N	N
PETRIC CALCISOL	peCL	N	N	S3	S3	S3	N	N	S3	S3
QUARTZITE OUTCROPS	ROCK	X	X	X	X	X	X	X	X	X
ROCK	ROCK	X	X	X	X	X	X	X	X	N
SKELETIC FLUVISOL	skFL	S3	S2	S2	S2	S2	N	N	S2	S2
SODIC CALCISOL	soCL	N	N	S3	S3	S3	N	N	N	N
SODIC CAMBISOL	soCM	N	N	S3	S3	S3	N	N	N	N

A.4.3.2. Lgpcrops.dbf

This table establish the reduction value (convert from Table 8.2) in function of the Growing Period Zones for each crop

MILLET	SORGHUM	MAIZE	SOYA	COTTON	SW_POTATO	WHEAT	POTATO	BEANS	LGP
0,375	0,281	0,188	0,250	0,500	0,375	0,375	0,375	0,2500	3
0,750	0,375	0,281	0,375	0,281	0,375	0,375	0,375	0,3750	2

A.4.3.3. Ranksoil.dbf

Convert the Suitability parameters to numeric ranks in order to calculate the suitability

SUSTA	PERCENT
S1	87,5
S2	62,5
S3	37,5
N	12,5
X	0,0

A.4.4. Avenue scripts

The scripts are the ArcView programs method, do it in Avenue programme language. This scripts are write and compiled inside the GIS.
Some of the scrips has local paths, that is necessary to modify if the application is installed with another structure.

A.4.4.1. Central_M

This script allows to choice the Central Meridian in the Gauss Conformal projection in the "Soilmap" View , and it is executed by new button : "C" situated in the buttons menu area of the View.

```
theView = av.getproject.Finddoc("Soilmap")
flist = {13,15,17,19,21}
CenMer = msgbox.choiceasstring(flist,"Choice Central Meridian","Projection Gauss Conformal")
r = rect.Make(13@"-21".Asnumber,21@"-17".asnumber)
p = TransverseMercator.Make(r)
p.setspheroid(#SPHEROID_BESSEL)
p.setCentralMeridian(CenMer)
p.SetreferenceLatitude(-22)
p.setScale(1)
p.SetfalseEasting(0)
p.SetFalseNorthing(0)
theview.setunits(#UNITS_LINEAR_METERS)
theView.GetDisplay.SetdistanceUnits(#UNITS_LINEAR_METERS)
theView.Setprojection(p)
Theview.Getwin.Open
```

A.4.4.2. Addfieldsoil

This script modify the soilmap.dbf (a copy of terrain table), adding the fields necessaries to add the soil information (type of soil and proportion)

```
' Add the fields to pass the soil information

theTable = av.getproject.findDoc("soilmap.dbf")
theVTab = theTable.GetVTab
theVTab.StartEditingWithRecovery
f1 = Field.Make("Episoil",#field_char,10,0)
f3 = Field.Make("Soil1",#field_char,6,0)
f4 = Field.Make("Prop1",#field_short,3,0)
f5 = Field.Make("Soil2",#field_char,6,0)
f6 = Field.Make("Prop2",#field_short,3,0)
f7 = Field.Make("Soil3",#field_char,6,0)
f8 = Field.Make("Prop3",#field_short,3,0)
f9 = Field.Make("Soil4",#field_char,6,0)
f10 = Field.Make("Prop4",#field_short,3,0)
f11 = Field.Make("Soil5",#field_char,6,0)
f12 = Field.Make("Prop5",#field_short,3,0)
f14 = Field.Make("Soil6",#field_char,6,0)
```

```
f15 = Field.Make("Prop6",#field_short,3,0)
f16 = Field.Make("Soil7",#field_char,6,0)
f17 = Field.Make("Prop7",#field_short,3,0)

f13 = Field.Make("Quality",#field_short,3,0)

mylist = {f1,f3,f4,f5,f6,f7,f8,f9,f10,f11,f12,f14,f15,f16,f17,f13}
theTable.GetVTab.addfields(mylist)

saveEdits = TRUE
ThevTab.StopeditingWithRecovery(saveEdits)
```

A.4.4.3. Addfre

This script modify the **soilcomp** table, adding a news fields called “tcdc” and “ soilnum” : calculating the number of soil components for each SOTER unid, and hierarchy it.

```
'Calculate the number of soil components for each SOTER unid
' and enumerate it.
thesoil = av.getproject.findDoc("soilcomp.dbf")
thesoilVTab = thesoil.GetVTab
thesoilVTab.StartEditingWithRecovery
thebitmap = thesoilvtab.Getselection

thefn = thesoilvtab.FindField("tcdc")
if (thefn = nil) then
  nwf = Field.Make("tcdc",#field_char,4,0)
  mylist = {nwf}
  thesoil.GetVTab.addfields(mylist)
end
   num = "([tcdc] = [SUID].asstring+""/""+[TCID].asstring)"

  for each rec in thesoilvtab.clone
  thesoilvtab.calculate(num, thefn)

  end


thefn = thesoilvtab.FindField("soilnum")
if (thefn = nil) then
  nwf = Field.Make("soilnum",#field_short,3,0)
  mylist = {nwf}
  thesoil.GetVTab.addfields(mylist)
end
for each i in thesoilvtab
 expre = "([SUID] = "+i.asstring+")"
 thesoilvtab.Query( expre, thebitmap, #vtab_seltype_NEW)
 thesoilvtab.UpdateSelection
 thecount = thebitmap.count
 num = 0
  for each rec in thesoilvtab.Getselection.clone
  num = 1 + num
  thesoilvtab.setvalue(thefn,rec,num)
  end
end
```

A.4.4.4. Soilprop

Add for each SOTER unid all the soil components and their proportions (after use the addfieldsoils and the addfre)

```
thetable = av.getproject.Finddoc("soilmap.dbf")
thevtab = thetable.Getvtab
theVTab.StartEditingWithRecovery
theterrain = av.getproject.Finddoc("soilcomp.dbf")
thevtabterr = theterrain.Getvtab
thevtabprof = av.getproject.Finddoc("profile.dbf").Getvtab
tofield = thevtabterr.Findfield("Prid")
fromfield = thevtabprof.Findfield("prid")
thevtabterr.join(tofield,thevtabprof,fromfield)

thecrop = av.getproject.Finddoc("epigrafs.dbf")
thevtabcrop = thecrop.Getvtab
thecropfield = thevtabcrop.FindField("Claf")
theclaffield = thevtabterr.FindField("Claf")
thevtabterr.join(theclaffield,thevtabcrop,thecropfield)

  'intentem pasar el valor de les variables de sol i prop
  'selecionem primer sol1, despres 2  fins numero total de sols
  thebitmap = thevtab.Getselection

  For each rec in thevtabterr.clone
    thesuid = thevtabterr.returnvalue(thevtabterr.Findfield("Suid"), rec)
    thescid = thevtabterr.returnvalue(thevtabterr.Findfield("Epigraph"), rec)
    theprop = thevtabterr.returnvalue(thevtabterr.Findfield("Prop"), rec)
    thefre = thevtabterr.returnvalue(thevtabterr.Findfield("soilnum"), rec)

    expre = "([SUID] = "+Thesuid.asstring+")"
       thevtab.Query(expre, thebitmap, #VTAB_SELTYPE_NEW)
    'thetable.Promoteselection
    ss = thevtab.Findfield("Soil"+thefre.asstring)
    pp = thevtab.Findfield("Prop"+thefre.asstring)
      for each r in  thebitmap
        thevtab.setvalue( ss, r,thescid.asstring)
        thevtab.setvalue( pp, r,theprop)
      end
    end
thevtabterr.Unjoinall

saveEdits = TRUE
thevTab.StopeditingWithRecovery(saveEdits)
```

A.4.4.5. Soil_qua

Using each one of the soil components of the SOTER unid, with and the parameters of the crops.dbf table, and the conversion table ranksoil.dbf this script obtain the soil suitability (and put it in the field “Quality” with the alias of the crop evaluate) for the SOTER unid by each crop.

```
ºtheview = av.GetactiveDoc
flist = {"Sorghum", "Millet", "Maize", "Soya","Beans", "Cotton", "S._potato", "Wheat", "W._potato" }
fieldcrop = msgbox.choiceasstring(flist, "Choice crop", "Quality soil")
_thefield = fieldcrop
'mytablelist = av.getproject.gettables
thetable  = av.getproject.FindDoc("Attributes of soilsusta.shp")
'theVTabs = theTable.Getvtab
'mytable = Table.Make(thevtabs)
theVTab = theTable.GetvTab
theVTab.StartEditingWithRecovery
thecfcalc =  theVtab.FindField("Quality")
thecfcalc.Setalias("")
thefields = thevtab.FindField("S1")
if ( thefields = nil ) then
  f1 = Field.Make("S1",#field_short,5,0)
  f2 = Field.Make("S2",#field_short,5,0)
  f3 = Field.Make("S3",#field_short,5,0)
  f4 = Field.Make("S4",#field_short,5,0)
  f5 = Field.Make("S5",#field_short,5,0)
  f6 = Field.Make("S6",#field_short,5,0)
  f7 = Field.Make("S7",#field_short,5,0)
  mylist = {f1,f2,f3,f4,f5,f6,f7}
  theTable.GetVTab.addfields(mylist)
end


for each i in 1..7 by 1
theTable.GetVTab.GetSelection.ClearAll
theTable.GetVTab.UpdateSelection
 thecrop = av.getproject.FindDoc("crops.dbf")
 thejoVtab = thecrop.GetvTab
 tofield = thevtab.FindField("soil"+i.asstring)
 fromfield = thejoVtab.FindField("Epigraph")
 thevtab.join(tofield,thejoVtab,fromfield)
 thecropS = av.getproject.FindDoc("ranksoil.dbf")
 thejoVtabS = thecropS.GetvTab
  tofield = thevtab.FindField(fieldcrop.asstring)
 fromfield = thejoVtabS.FindField("susta")
 thevtab.join(tofield,thejoVtabS,fromfield)
  thefcalc = thevtab.Findfield("s"+i.asstring)
  expre =
"("++"("++"("++"["++"Prop"+i.asstring++"]"++")"++"*"++"("++"["++"percent"++"]"++")"++")"+"/"+"1
00"++")"
  thevTab.Calculate(expre,thefcalc)
  thebitmap = thevtab.Getselection
    expres = "("++"["++"Soil"+i.asstring++"]"++"="++"""""")"
  thevtab.Query(expres, thebitmap, #VTAB_SELTYPE_NEW)
   n = thebitmap.count
   if ( n > 0 ) then thevtab.updateselection
              expre0 = "0"
```

```
              thevTab.Calculate(expre0,thefcalc)
   end
 saveEdits = TRUE
 thevTab.StopeditingWithRecovery(saveEdits)
 theVtab.UnjoinAll
end
'calcula qualitat del sol
theTable.GetVTab.GetSelection.ClearAll

theVTab.StartEditingWithRecovery

thecfcalc =  theVtab.FindField("Quality")
expre = "( [S1] + [S2] + [S3] + [S4] + [S5] + [S6] + [S7] )"

thevTab.Calculate(expre,thecfcalc)
saveEdits = TRUE
thevTab.StopeditingWithRecovery(saveEdits)
' if (fieldcrop <> thefcalc.Getalias)
  ' then thecfcalc.SetAlias(Fieldcrop.asstring)
 'end


f1 = Field.Make("S1",#field_short,5,0)
f2 = Field.Make("S2",#field_short,5,0)
f3 = Field.Make("S3",#field_short,5,0)
f4 = Field.Make("S4",#field_short,5,0)
f5 = Field.Make("S5",#field_short,5,0)
f6 = Field.Make("S6",#field_short,5,0)
f7 = Field.Make("S7",#field_short,5,0)

theVTab.StartEditingWithRecovery
mylist = {f1,f2,f3,f4,f5,f6,f7}
for each t in mylist
  thefield = thevtab.FindField(t.asstring)
'if (MsgBox.YesNo("Are you sure you want to delete the field "+
    'theField.GetAlias.AsString + "?","Delete Field",true)) then
  theTable.StopEditing
  theTable.GetVTab.RemoveFields({theField})
end
saveEdits = TRUE
 thevTab.StopeditingWithRecovery(saveEdits)
 thevtab.GetSelection.ClearAll
if (fieldcrop <> thefcalc.Getalias)
 then thecfcalc.SetAlias(Fieldcrop.asstring)
end
thetheme = theview.Findtheme("Soilsusta.shp")
thelegend = thetheme.Getlegend
a = Classification.make(0,25)
b = Classification.make(25,50)
c = Classification.make(50,75)
d = Classification.make(75,100)
e = Classification.make(999,999)
classlist = {a, b, c, d,e}
thelegend.setlegendtype(#Legend_type_color)
thelegend.Quantile(thetheme, fieldcrop.asstring, 4)
theclasslist = thelegend.Getclassifications
cnt = 0
for each i in theclasslist
  theclasslist.set(cnt,classlist.Get(cnt))
    cnt = cnt + 1
end
```

```
 thesymbol = thelegend.Getsymbols.Get(0)
 thesymbol.Setcolor(color.Getred)
thesymbol = thelegend.Getsymbols.Get(1)
 thesymbol.Setcolor(color.getyellow)
thesymbol = thelegend.Getsymbols.Get(2)
 thesymbol.Setcolor(color.getgreen)
thesymbol = thelegend.Getsymbols.Get(3)
 thesymbol.Setcolor(color.getblue)
thelegend.load("e:\users\jmarturia\namibia/aplicacio/suitable.avl".Asfilename,#Legend_loadtype_classes)
thetheme.Updatelegend
```

A.4.4.6. ConvertGrid

This script allows to define the analysis environment to convert vector data (the crop soil suitability and the Growing Period Zone map) to raster data and then calculate the GPZ suitability using the gpz.dbf .

```
'Setting analysis environment
mes = Msgbox.Info(_thefield,"Crop to evaluate")
theview = av.GetActiveDOC
theAE = AnalysisPropertiesDialog.Show(theView,FALSE,"Analysis Properties")
if ( theAE = NIL) then
  return NIL
 end
TheAE.Activate
'Find the themes, join tables and convert to grid

mylist = theView.Getthemes
 thelgp = msgbox.List(mylist, "", "Choice Grown Period Map")
 thesoil = msgbox.List(mylist, "", "Choice Soil Map")
 thelgptab = thelgp.Getftab
tofield = thelgptab.FindField("gpz")
fromfield = av.getproject.Finddoc("lgpcrops.dbf").Getvtab.FindField("lgp")
thelgptab.join(tofield,av.getproject.Finddoc("lgpcrops.dbf").Getvtab,fromfield)
 for each t in mylist
 t.setactive(false)
 end
mylist2 = {thelgp,thesoil}


' Spatial.ConvertToGrid



' loop through each active theme
firstTime = TRUE
for each t in mylist2
  if (firstTime) then
    def = av.GetProject.MakeFileName("l"+_thefield.asstring, "")
    thefield = t.Getftab.FindField(_thefield.asstring)
  else
    def = FileName.GetCWD.MakeTmp("s"+_thefield.asstring ,"")
    thefield = t.Getftab.FindField(_thefield.asstring)
  end

  ' call proper script to convert theme to grid
```

```
  if (t.GetClass.GetClassName = "FTheme") then
    av.Run("Surface.GridAEZ",{t,def,theView,thefield})
   else
    continue
  end
  firstTime = FALSE
end
theView.GetWin.Activate

thelgptab.unjoinall

'griD SOIL LEGEND

soillist = theview.GEtActiveThemes
theG = soillist.Get(1)
TheG.SetLegendVisible(not (theG.IsLegendVisible))
theG = soillist.Get(0)
thename =  _thefield.Asstring+":"+" "+"Soil Suitability"
kk = theG.SetName(thename)
thelegend = theG.Getlegend
a = Classification.make(0,25)
b = Classification.make(25,50)
c = Classification.make(50,75)
d = Classification.make(75,100)
e = Classification.make(999,999)
classlist = {a, b, c, d,e}
thelegend.setlegendtype(#Legend_type_color)
thelegend.Interval(theG,"value", 4)
theclasslist = thelegend.Getclassifications
cnt = 0
for each i in theclasslist
  theclasslist.set(cnt,classlist.Get(cnt))
    cnt = cnt + 1
end
 thesymbol = thelegend.Getsymbols.Get(0)
 thesymbol.Setcolor(color.Getred)
thesymbol = thelegend.Getsymbols.Get(1)
 thesymbol.Setcolor(color.getyellow)
thesymbol = thelegend.Getsymbols.Get(2)
 thesymbol.Setcolor(color.getgreen)
thesymbol = thelegend.Getsymbols.Get(3)
 thesymbol.Setcolor(color.getblue)
thelegend.load("e:\users\jmarturia\namibia/aplicacio/suitable.avl".Asfilename,#Legend_loadtype_classes)
theg.Updatelegend

' Spatial.Calculator
listgrid = Theview.GetActivethemes
theg1 = listgrid.Get(0).GetGrid
Theg2 = listgrid.Get(1).GetGrid
theGG = theG1 * theG2
thegtheme = Gtheme.Make(theGG)
theView.AddTheme(thegtheme)
thegtheme.Setvisible(true)
thegtheme.SetActive(true)
listgrid2 = Theview.GetActiveThemes
theG = thegtheme
thename =  _thefield.Asstring+":"+" "+"GPZ Suitability"
kk = theG.SetName(thename)
thelegend = theG.Getlegend
a = Classification.make(0,25)
b = Classification.make(25,50)
```

```
c = Classification.make(50,75)
d = Classification.make(75,100)
e = Classification.make(999,999)
classlist = {a, b, c, d,e}
thelegend.setlegendtype(#Legend_type_color)
thelegend.Interval(theG,"value", 4)
theclasslist = thelegend.Getclassifications
cnt = 0
for each i in theclasslist
  theclasslist.set(cnt,classlist.Get(cnt))
    cnt = cnt + 1
end
 thesymbol = thelegend.Getsymbols.Get(0)
 thesymbol.Setcolor(color.Getred)
thesymbol = thelegend.Getsymbols.Get(1)
 thesymbol.Setcolor(color.getyellow)
thesymbol = thelegend.Getsymbols.Get(2)
 thesymbol.Setcolor(color.getgreen)
thesymbol = thelegend.Getsymbols.Get(3)
 thesymbol.Setcolor(color.getblue)
thelegend.load("e:\users\jmarturia\namibia/aplicacio/suitable.avl".Asfilename,#Legend_loadtype_classes)
theg.Updatelegend
```

A.4.4.7. SurfaceGrid Aez

This script convert vector data to raster data (is executed by ConverGrid script)

```
' Surface.GridAEZ

t = SELF.Get(0)
def = SELF.Get(1)
theView = SELF.Get(2)
afield = Self.Get(3)

' convert selected features of a FTheme to Grid
anFTab = t.GetFTab

' make a list of fields
fl = { }
for each f in anFTab.GetFields
  if (f.IsVisible and (f.IsTypeNumber or f.IsTypeString)) then
    fl.Add(f)
  end
end

' check if valid conversion field exists
if (fl.Count = 0) then
  return NIL
end

' get class name of doc to see if script is running from a view or scene
theDocName = theView.GetClass.GetClassName

' obtain output grid name
aFN = SourceManager.PutDataSet(GRID,"Convert " + t.getName,def,TRUE)
if (aFN = NIL) then
```

```
  return NIL
end

'set extent and cell size for conversion if not already set
ae = theView.GetExtension(AnalysisEnvironment)
box = Rect.Make(0@0,1@1)
cellSize = 1
if ((ae.GetExtent(box) <> #ANALYSISENV_VALUE) or (ae.GetCellSize(cellSize) <>
#ANALYSISENV_VALUE)) then
  ce = AnalysisPropertiesDialog.Show(theView,TRUE,"Conversion Extent:" ++ t.GetName)
  if (ce = NIL) then
    return NIL
  end
  ce.GetCellSize(cellSize)
  ce.GetExtent(box)
end

' obtain field to convert with
'aField = MsgBox.List(fl,"Pick field for cell values:","Conversion Field :" ++ t.GetName)
'if (aField = NIL) then
 ' return NIL
'end

' actually do conversion
aPrj = theView.GetProjection
aGrid = Grid.MakeFromFTab(anFTab,aPrj,aField,{cellSize, box})

if (aGrid.HasError) then
  MsgBox.Error(t.GetName ++ "could not be converted to a grid","Conversion Error")
  return NIL
end
status = Grid.GetVerify
Grid.SetVerify(#GRID_VERIFY_OFF)
if (aGrid.SaveDataSet(aFN).Not) then
  Grid.SetVerify(status)
  return NIL
end
Grid.SetVerify(status)
gthm = GTheme.Make(aGrid)
if (aGrid.GetVTab <> NIL) then
  theVTab = aGrid.GetVTab
  if (aField.IsTypeNumber) then
    toField = theVTab.FindField("Value")
  else
    toField = theVTab.FindField("S_Value")
    theLegend = gthm.GetLegend
    theLegend.Unique(gthm,"S_Value")
    gthm.UpdateLegend
  end
  'if (anFTab.IsBase and anFTab.IsBeingEditedWithRecovery.Not) then
    'if (MsgBox.YesNo("Join feature attributes to grid?","Attribute Join :" ++ t.GetName,FALSE)) then
     'theVTab.Join(toField,anFTab,aField)
   'end
  'end
end
'if (MsgBox.YesNo("Add grid as theme to the" ++ theDocName + "?","Convert to Grid
:"++t.GetName,TRUE).Not) then
 ' return NIL
'end
theView.AddTheme(gthm)
gthm.setactive(true)
```

2. How to use these soils surveys

The project to support the Agro-ecological zoning project in Namibia mainly provides information about the soils of Namibia that can be used in agricultural practices and land planning. The information includes a description of the soils and their location, and a discussion of the suitability and limitations.

Furthermore, information about the production of the satellite cartography and the geographical information system specially designed for this project can be find in chapters 3 and 8 respectively.

The soil surveys consist of the soil map and the reports.

The soil maps envisage boundaries that enclose areas called soil delineations. Each delineation represents an area dominated by one or more kinds of soils and is identified by a unique symbol. All delineations which are identified with the same symbol constitute a map unit. The map units are identified and named according to the taxonomic classification of the dominant soil or soils. The organized list of map units is called the legend of the soil map. In all cases a physiographic approach has been used.

If you want to know the soil type that appears in an area, you must locate your area of interest on the appropriate map sheet and list the map unit symbols that are included there. With the list of map units you can look at the legend of the appropriate survey to know the name or the names of each map unit.

With the symbols and the names of the map units you have to turn to the chapter on description of the map units. This chapter is aimed primarily at the non specialized land resources assessor and gives a brief description of the map units.

If you want a more specialized soil information, concerning soil morphology and soil chemical data, you have to turn to Annex 2: description of the taxonomic units. Furthermore, in all chapters you can find information about the soil classification, and in the chapters of the more detailed surveys you can find a brief description of the study areas and the factors and processes involved in the soil formation.

On the other hand, Annex 1 gives information about how the surveys were performed and establishes the different criteria used along this report and Annex 3 includes the test results determined during laboratory analyses.

Finally, it must be mentioned that all the information gathered during the soil surveys is also available on a digital format. The information has been recorded by digitising the maps and implementing the databases specially designed to this effect. In this way, the continuous updating of the information and the management for different applications, by means of the so called Geographical Information Systems (GIS), is facilitated.

3. Satellite map production from Landsat images

3.1. Introduction

Remote sensing image data of the earth's surface acquired from either aircraft or spacecraft platforms is ready available in digital format; spatially the data is composed of discrete picture elements, or pixels, and radiometrically it is quantized into discrete brightness levels.

Together with the frame size of an image, in equivalent ground kilometers, the number of spectral bands and spatial resolution determine the data volume provided by a particular sensor

3.2. Characteristics of the Landsat satellite

The series of the Earth observation satellites Landsat provides high resolution multispectral images since 1972. The satellite Landsat-5 payload includes the sensor Thematic Mapper (TM). This sensor has these characteristics:

Channel	Wavelength	Resolution
Ch1	0.45-0.52 μ	30 m
Ch2	0.52-0.60 μ	30 m
Ch3	0.63-0.69 μ	30 m
Ch4	0.76-0.90 μ	30 m
Ch5	1.55-1.75 μ	30 m
Ch6	10.4-12.5 μ	120 m
Ch7	2.08-2.35 μ	30 m

The Landsat scenes cover an area of 185 Km x 185 Km.

3.3. Geometric correction

There are potentially many sources of geometric distortion of image data than radiometric distortion and their effects are more severe. They can be related to a number of factors, including:

- The rotation of the earth during image acquisition
- The finite scan rate of some sensors
- The curvature of the earth
- Variations in platform altitude, attitude and velocity

The technique to correct these geometric distortions depends upon establishing mathematical relationships between the address of pixels in an image and the corresponding coordinates of those points on the ground (via a map). Since it can often be assumed that the bands are well registered to each other, steps taken to correct one band in an image, can be used on all remaining bands.

We can define two cartesian coordinate systems. One describes the location of points in the map (x,y) and the other defines the location of pixels in the image (u,v). Now suppose that the two coordinate systems can be related via a pair of mapping functions f and g so that, as a first approximation:

$$u = f(x,y)$$
$$v = g(x,y)$$

If these functions are known then we could locate a point in the image knowing its position on the map. With this ability we could build up a geometrically correct version of the image. First, we define a grid over the map to act as the grid of pixel centers in the corrected image. This grid is parallel to the map coordinate grid itself. We then move over the grid on a pixel-by-pixel basis and use the mapping functions above to find the corresponding pixel in the image for each grid position. Those pixels are then placed on the grid. At the end of the process, we have a geometrically correct image built up on the display grid utilizing the original image as a source of pixels.

There are some practical difficulties that must be addressed. First we do not know the explicit form of the mapping function. Secondly, they may not point to a pixel in the image corresponding to a grid location; instead, some form of interpolation my be required.

The objects on the ground have a different height over the reference level. This information is included in a Digital Terrain Model file where we can extract the elevation associated to a (x,y) position. Depending on the relief the geometrical distortion will be different. This difference suggests that we should include the z component in the mapping function.

The mapping function finally used has been:

$$u = a_0+a_1x+a_2y+a_3z+a_4xz+a_5yz$$
$$v = b_0+b_1x+b_2y+b_3z+b_4xz+b_5yz$$

At present the coefficients a_i and b_i are unknown. Values can be estimated by identifying sets of features on the map that can also be identified on the image. These features, often referred to as ground control points (GCP) are well defined and spatially small and could be road intersections, airport runway intersections, prominent coastline features and the like. Enough of these are chosen so that the polynomial coefficients can be estimated by substitution into the mapping polynomials to yield sets of equations in those unknowns. A minimum of six is required for first order mapping. In practice however significantly more than these are chosen and the coefficients are evaluated using least squares estimation. In this manner any control points that contain significant positional errors either on the map or in the image will not have an undue influence on the polynomial coefficients.

Contiguous images have a significant overlap and we can also use common points identified on both images can also be used to improve the geometric model. Each one of those common points introduces two new unknowns to be adjusted (the position on the map) but provides four new equations to link the image unknowns. The unknowns determination will then be done for a set of images using the bundle adjustment procedure.

Concerning the interpolation issue we have selected the cubic convolution interpolation. This approach uses sixteen pixels around the desired point. Cubic polynomials are fitted along the four lines of four pixels surrounding the point in the image. A fifth cubic polynomial is then fitted through these to synthesize a brightness value for the corresponding location in the display grid.

3.4. Radiometric correction

Satellite images suffer from some radiometric quality degradation due to different reasons: atmospheric effects, sensor noise, etc. The restoration is a process which attempts to reconstruct or recover an image that has been degraded by using some a priori knowledge of the degradation phenomenon. Thus, restoration techniques are oriented towards modeling the degradation and applying the inverse process in order to recover the original image.

We proceed to build this degradation model using a maximum likelihood estimator adapted to each sensor and each earth environment. The result is a convolution kernel that will be applied to the original image in order to enhance the edges and reduce image blurring.

3.5. DTM

Before the geometric correction of the Landsat images a DTM data base has been built. The information comes from the US Geological Survey GTOPO30. This is a global DTM using a 30 seconds (about 1 Km) regular grid size. Different data sources have been used to fill the GTOPO30 data base. In Africa, the Digital Terrain Elevation Data (DTED) and the Digital Chart of the World (DCW) have been used.

This DTM data base has been transformed in order to adapt to the reference system used during the project. From the WGS84 original coordinates a reference system change has been applied to obtain a new regular grid in the Schwarzeck reference system (ellipsoid Bessel 1841).

3.6. Map production

Three different products have been obtained:

1. A whole country 1:1000000 mosaic image map
2. A set of 1:250000 map sheets
3. A geometric correction of the individual Landsat images

1. Whole country 1:1000000 mosaic image map

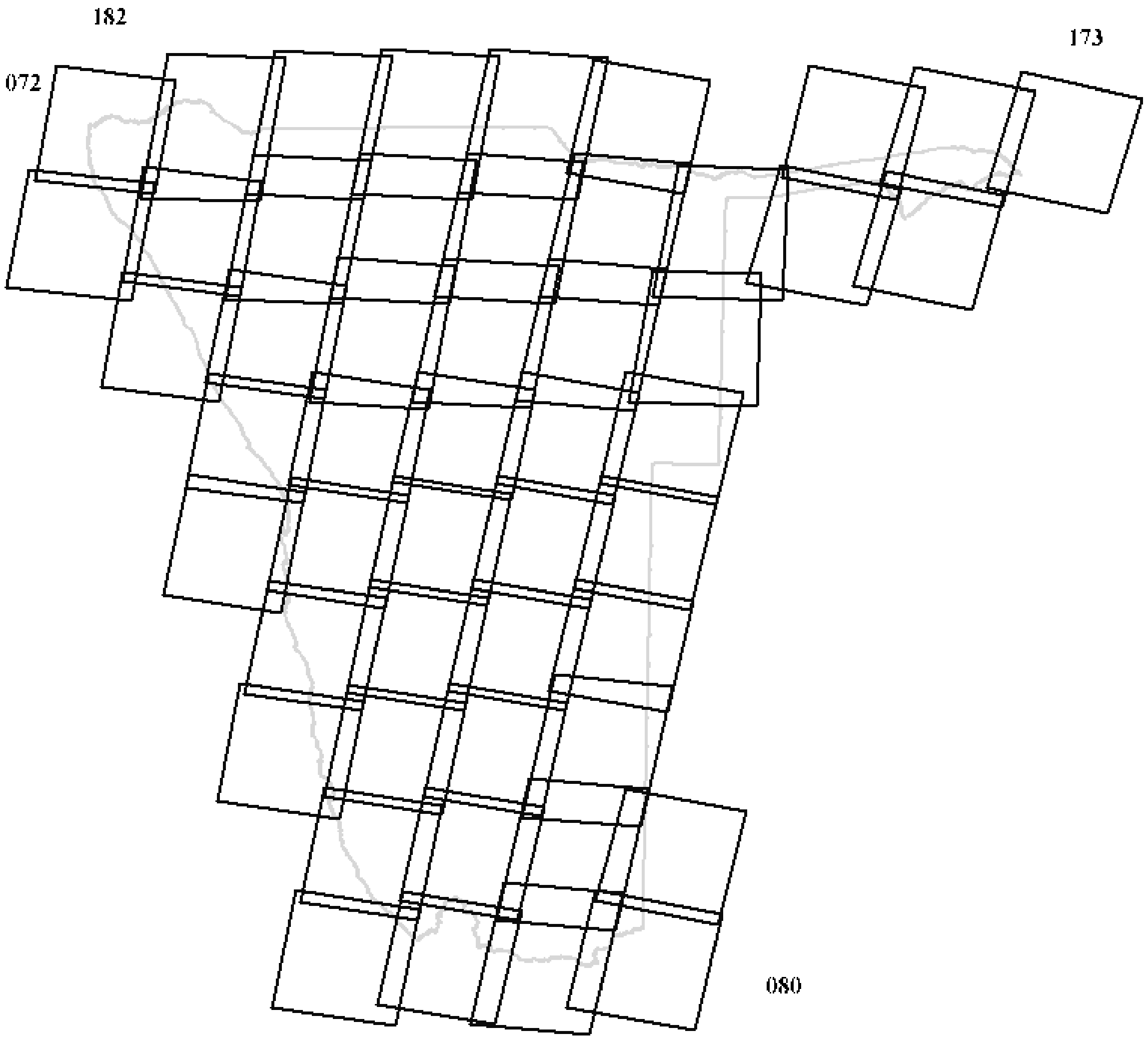
The goal was to produce an image map covering the whole country. So, a common map projection should be selected and the most convenient seemed to be the Albers projection and the Schwarzeck reference system. The parameters of this projection are:

Map projeccion parameters:
Origin longitude [d,m,s]: 18,30,0
Origin latitude [d,m,s]: -22,0,0
First standard parallel [d,m,s]: -20,0,0
Second standard parallel [d,m,s]: -26,0,0
Scale factor: 1.0
X false origin [m]: 0.0
Y false origin [m]: 0.0

Adjusted images:

182072	181072	180072	179072	178072	177072		175072	174072	173072
182073	181073	180073	179073	178073	177073	176073	175073	174073	
	181074	180074	179074	178074	177074	176074			
		180075	179075	178075	177075	176075			
		180076	179076	178076	177076	176076			
			179077	178077	177077	176077			
			179078	178078	177078	176078			
				178079	177079	176079	175079		
				178080	177080	176080	175080		

Global RMS error after bundle adjustment:
X (pix) 0.52
Y (pix) 0.45



2. 1:250000 map sheets

Combining pieces of information from different satellite images an image map covering each map sheet has been produced. The map projection selected for this series was the Gauss Conformal and the Schwarzeck reference system. The whole country has been divided in 5 grid zones. The images covering one zone have been adjusted using the ground control points present in the images. The result of these adjustments has been:

GC zone 13

Map projeccion parameters:
GAUSS CONFORMAL

Origin Longitude CENTRAL [d,m,s]:	13,0,0
Origin Latitude [d,m,s]:	-22,0,0
Scale factor:	1.0
X false origin [m]:	0.0
Y false origin [m]:	0.0

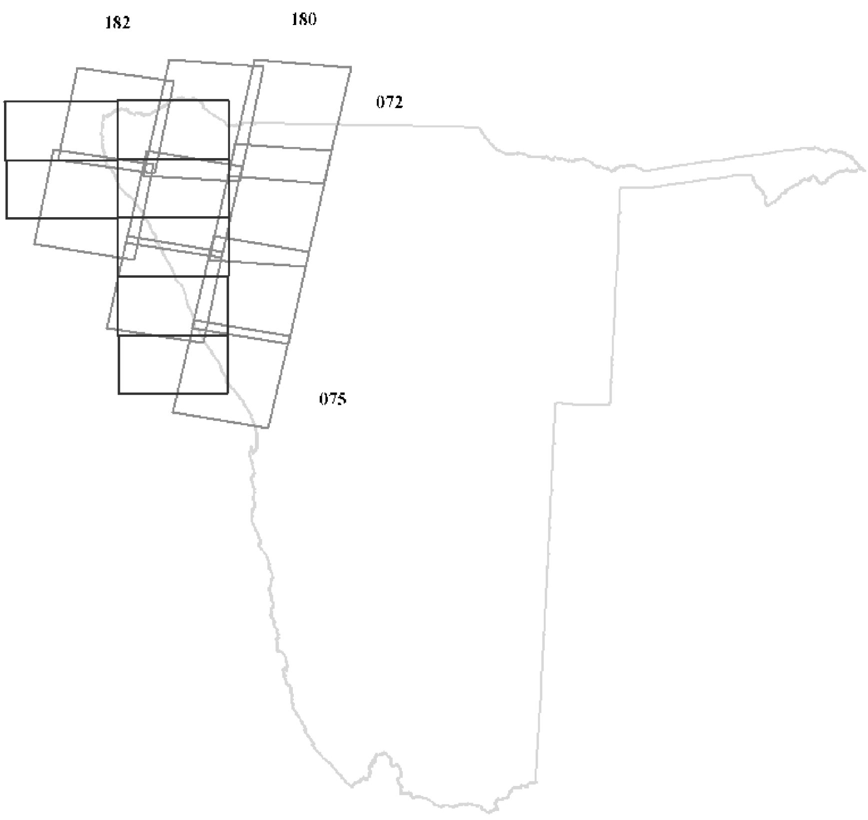
Map sheets produced:
1710 1810
1712 1812 1912 2012 2112

Adjusted images:

182072	181072	180072
182073	181073	180073
	181074	180074
		180075

Global RMS error after bundle adjustment:

X (pix)	0.52
Y (pix)	0.45



GC zone 15

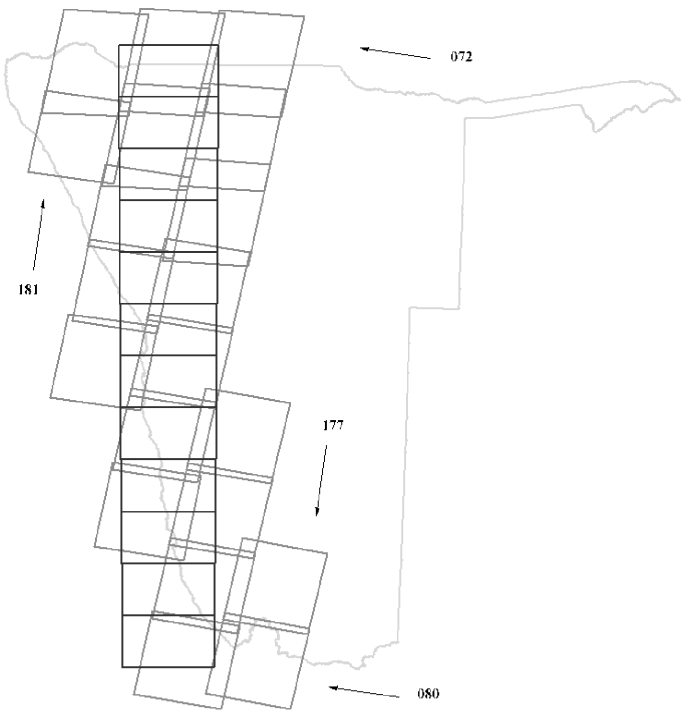
Map projeccion parameters:
GAUSS CONFORMAL
Origin Longitude CENTRAL [d,m,s]: 15,0,0
Origin Latitude [d,m,s]: -22,0,0
Scale factor: 1.0
X false origin [m]: 0.0
Y false origin [m]: 0.0

Map sheets produced:
1714 1814 1914 2014 2114 2214 2314 2414 2514 2614 2714 2814

Adjusted images:

181072	180072	179072		
181073	180073	179073		
	180074	179074		
	180075	179075		
	180076	179076		
		179077	178077	
		179078	178078	
			178079	177079
			178080	177080

Global RMS error after bundle adjustment:
X (pix) 0.45
Y (pix) 0.53



GC zone 17

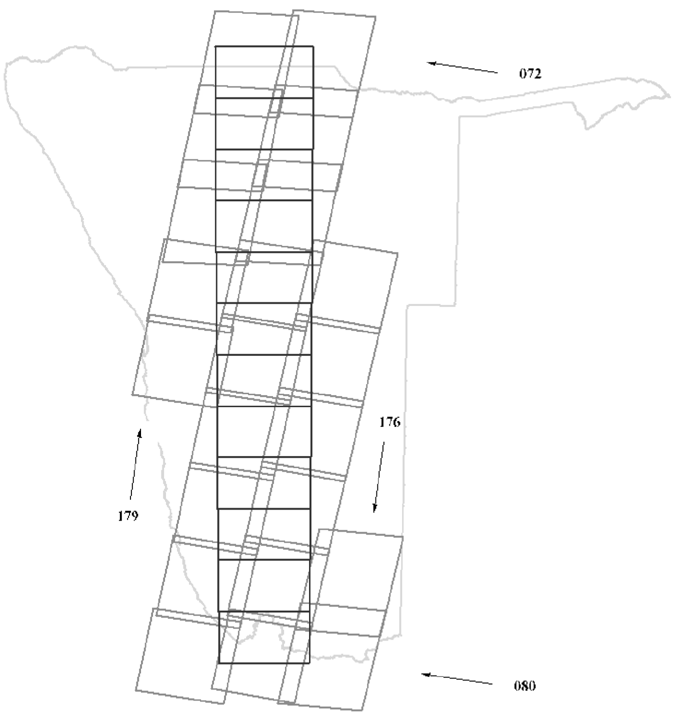
Map projeccion parameters:
GAUSS CONFORMAL
Origin Longitude CENTRAL [d,m,s]: 17,0,0
Origin Latitude [d,m,s]: -22,0,0
Scale factor: 1.0
X false origin [m]: 0.0
Y false origin [m]: 0.0

Map sheets produced:
1716 1816 1916 2016 2116 2216 2316 2416 2516 2616 2716 2816

Adjusted images:

179072	178072		
179073	178073		
179074	178074		
179075	178075	177075	
179076	178076	177076	
	178077	177077	
	178078	177078	
	178079	177079	176079
	178080	177080	176080

Global RMS error after bundle adjustment:
X (pix) 0.72
Y (pix) 0.73



GC zone 19

Map projection parameters:
GAUSS CONFORMAL

Origin Longitude CENTRAL [d,m,s]:	19,0,0
Origin Latitude [d,m,s]:	-22,0,0
Scale factor:	1.0
X false origin [m]:	0.0
Y false origin [m]:	0.0

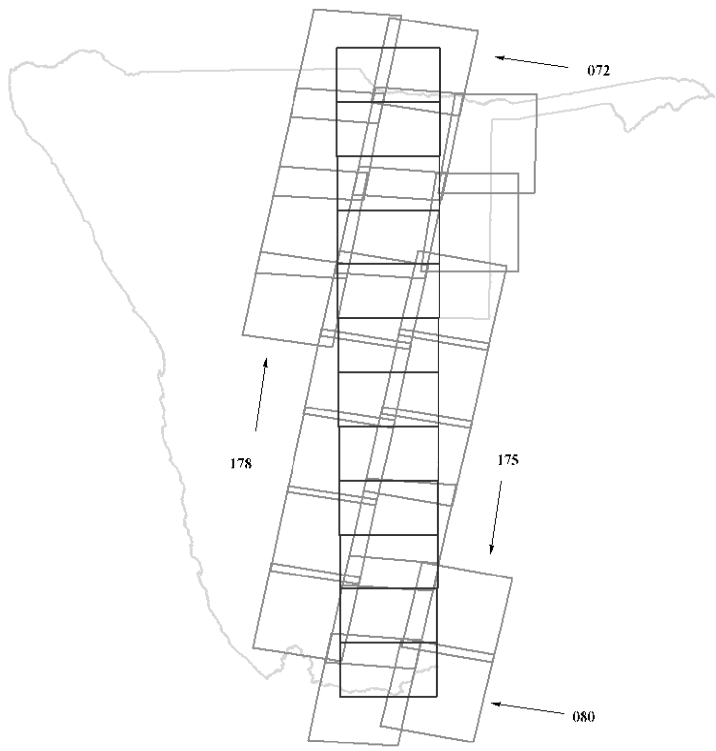
Map sheets produced:
1718 1818 1918 2018 2118 2218 2318 2418 2518 2618 2718 2818

Adjusted images:

178072	177072		
178073	177073	176073	
178074	177074	176074	
178075	177075	176075	
	177076	176076	
	177077	176077	
	177078	176078	
	177079	176079	175079
		176080	175080

Global RMS error after bundle adjustment:

X (pix)	0.59
Y (pix)	0.69



GC zone 21

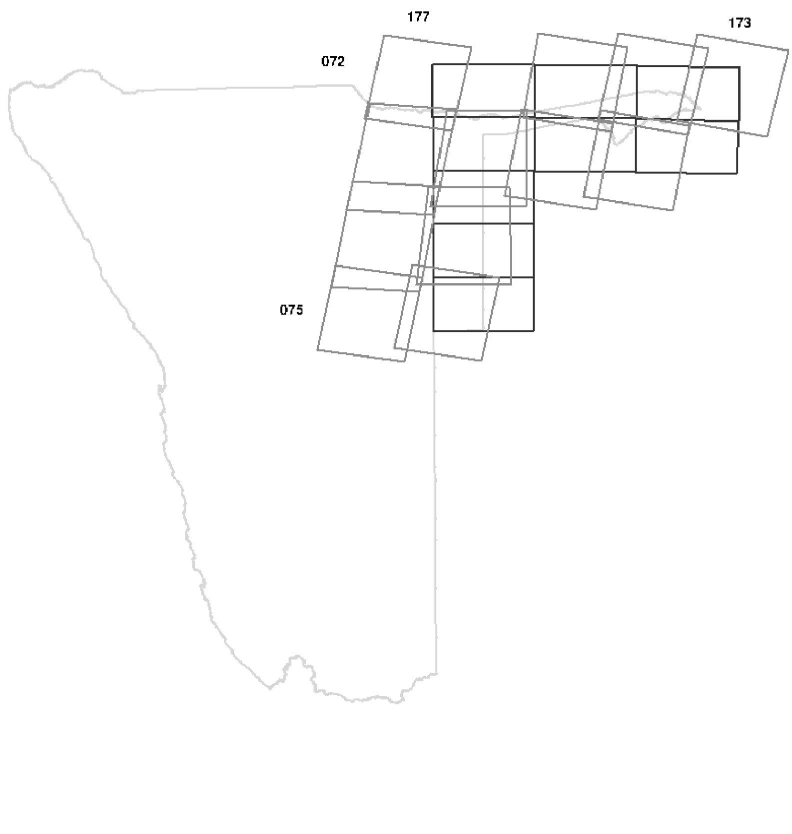
Map projection parameters:
GAUSS CONFORMAL
Origin Longitude CENTRAL [d,m,s]: 21,0,0
Origin Latitude [d,m,s]: -22,0,0
Scale factor: 1.0
X false origin [m]: 0.0
Y false origin [m]: 0.0

Map sheets produced:
1720 1820 1920 2020 2120
1722 1822
1724 1824

Adjusted images:

177072		175072	174072	173072
177073	176073	175073	174073	
177074	176074			
177075	176075			

Global RMS error after bundle adjustment:
X (pix) 0.88
Y (pix) 0.83



3.7. Geometric correction

The final digital product has been the geometric correction. The 6 high resolution channels of each image have been corrected using the Gauss Conformal map projection and a new image file has been produced on the local zone coordinates with a uniform pixel size of 30 m.

3.7.1. Ground Control Points

The geometric accuracy obtained after a block adjustment depends basically on the quantity and the quality of the ground control points used. The 242 GCP used in this project have been extracted from the existing 1:50 000 scale national map now under responsibility of the Surveyor General's Department.

Next there is the list of ground control points used. An identification, the longitude and latitude geographical coordinates and the orthometric height are provided for each point:

POINT	LON (G)	LAT (G)	H (M)
A001	16.858038	-26.677692	1403.40
A002	16.893937	-26.667233	1319.60
A005	16.711583	-26.882178	1350.50
A007	16.704934	-26.621393	1459.43
A008	19.632370	-27.854940	883.95
A009	19.670991	-27.849383	884.58
A013	18.152714	-26.536310	987.76
A015	18.231821	-26.915313	1056.02
A016	18.236716	-26.953119	997.15
A017	15.163708	-26.584061	1.00
A018	15.152298	-26.617963	1.00
A030	17.903147	-27.907902	882.06
A031	17.954973	-27.899005	917.71
A032	17.034028	-24.825132	1398.12
A033	17.107637	-24.826036	1340.99
A034	17.184739	-24.533481	1341.29
A035	17.104192	-25.302234	1575.47
A036	17.070411	-25.406463	1687.69
A037	17.475404	-25.340803	1135.73
A038	17.465659	-25.362382	1152.18
A041	19.692012	-25.353860	1053.70
A042	19.740509	-25.326292	1054.06
A043	19.691013	-25.020430	1079.34
A044	19.693212	-25.014712	1078.74
A045	19.616092	-26.653913	988.29
A046	19.632105	-26.623941	972.49

A048	15.954818	-25.239479	1141.13
A050	15.964686	-25.366713	1090.81
A053	19.889217	-26.658368	953.83
A054	16.532434	-23.302527	1790.96
A055	16.845100	-23.360462	1573.60
A056	17.603398	-23.409263	1331.83
A057	17.658426	-23.412490	1322.06
A058	17.516936	-23.934174	1238.64
A059	17.521958	-23.980017	1252.63
A060	17.971646	-23.695625	1303.56
A061	17.981353	-23.732478	1298.73
A067	19.050737	-23.745868	1241.83
A068	19.147399	-23.716759	1237.77
A070	19.052035	-23.317733	1314.33
A071	19.236293	-23.075931	1388.38
A072	19.241323	-23.005554	1404.35
A073	19.337718	-24.363093	1123.16
A075	19.056699	-24.420755	1164.82
A076	19.063697	-24.437452	1163.71
A079	17.394003	-24.827841	1184.26
A080	17.306780	-24.817793	1221.99
A092	15.851421	-23.979256	935.43
A093	15.876404	-23.953659	923.01
A096	15.664830	-23.507585	715.16
A097	15.624513	-23.504597	721.89
A098	14.483528	-22.971992	1.00
A099	14.499181	-22.967903	1.00
A100	14.557247	-22.670385	53.08
A101	14.586321	-22.700823	58.67
A106	15.934179	-22.904700	1121.37
A109	15.982200	-22.666041	1258.52
A110	16.375470	-22.760654	1664.05
A116	16.428726	-22.263054	1063.14
A117	16.465161	-22.260240	1081.09
A118	17.472879	-22.480243	1694.10
A119	17.495404	-22.487140	1675.74
A120	17.083025	-22.360182	1504.46
A121	17.079814	-22.341806	1572.79
A122	17.644273	-22.473686	1609.28
A123	17.688745	-22.466099	1611.05
A124	17.830649	-22.290980	1600.07
A125	17.771596	-22.290595	1606.79
A127	18.497313	-22.416946	1471.92
A128	18.495809	-22.386546	1481.79
A129	17.935761	-23.058619	1425.23
A130	17.914881	-23.051326	1428.32
A151	16.287801	-28.316442	180.00

A152	16.665542	-28.166363	250.00
A157	19.411550	-22.076284	1478.24
A158	19.400710	-22.058635	1478.88
A160	19.052035	-23.317733	1314.33
A161	19.794944	-23.093514	1315.58
B101	19.438602	-21.672955	1437.04
B104	20.745976	-21.176255	1141.30
B105	20.999660	-21.469648	1200.09
B106	20.904285	-21.461489	1209.70
B107	19.342828	-21.358563	1418.77
B108	19.334091	-21.352903	1409.56
B110	19.308650	-21.136784	1381.36
B111	19.196344	-21.901060	1501.43
B112	19.172403	-21.967877	1507.70
B113	18.232756	-21.477857	1611.11
B115	18.182404	-21.022418	1434.62
B116	18.212146	-21.166446	1492.27
B117	18.340870	-21.080658	1448.89
B118	18.355740	-21.101652	1453.86
B119	18.086317	-21.175305	1492.13
B120	18.144195	-21.193800	1513.12
B121	18.068493	-21.495493	1606.58
B122	18.064617	-21.478415	1599.39
B124	17.811069	-21.116062	1399.37
B126	17.556811	-21.003260	1342.62
B128	17.868534	-22.209804	1622.11
B129	16.651407	-21.161509	1428.63
B130	16.673845	-21.169816	1424.29
B131	16.503419	-21.444939	1565.48
B132	16.532425	-21.422256	1556.18
B134	16.515528	-22.171940	1156.00
B135	17.806009	-20.058664	1310.32
B136	17.797384	-20.022324	1343.70
B137	17.545033	-20.052710	1445.76
B138	17.539806	-20.038645	1443.14
B139	17.222298	-20.058750	1546.30
B140	17.238395	-20.144906	1493.80
B145	19.455961	-20.188347	1227.78
B156	19.897361	-20.000418	1204.77
B157	19.890633	-20.071845	1197.42
B158	20.695085	-20.210631	1105.49
B161	19.117147	-19.422815	1210.35
B162	18.145982	-19.434599	1391.59
B163	18.164677	-19.390127	1364.34
B164	17.358707	-19.266624	1227.33
B166	17.049888	-19.320293	1223.94

B167	17.032954	-19.299831	1264.58
B168	16.808659	-20.012906	1416.35
B169	16.800671	-20.039423	1425.96
B170	16.600392	-19.435905	1180.69
B171	16.708028	-19.483380	1241.71
B172	20.489109	-18.041829	1065.76
B173	20.465665	-18.041882	1066.04
B174	19.451342	-18.230481	1162.56
B175	19.417228	-18.200765	1158.63
B176	19.110329	-18.055067	1134.94
B177	19.139232	-18.079648	1121.20
B178	17.790824	-18.368351	1139.20
B180	18.392879	-17.794292	1100.17
B181	18.432403	-17.804428	1107.46
B182	19.187712	-17.824310	1063.73
B183	19.194193	-17.865619	1073.30
B184	19.428531	-17.859557	1058.25
B200	15.875886	-18.148068	1074.56
B201	15.903643	-18.187527	1072.28
B203	16.772749	-18.524089	1087.50
B204	15.169631	-18.975691	1119.10
B205	15.141557	-18.975410	1120.54
B214	20.397444	-18.011465	1043.71
B215	20.363107	-18.046787	1057.05
B216	14.075239	-19.039684	947.25
B217	14.050712	-19.022123	986.33
B219	14.033652	-19.017408	1062.04
B221	14.147371	-19.437282	902.04
B222	14.190834	-19.436609	910.42
B224	14.271422	-19.662879	1162.74
B225	14.035811	-19.546268	996.39
B226	14.034699	-19.562483	991.05
B227	14.737454	-19.640035	1157.31
B228	14.686894	-19.609267	1220.92
B229	14.990122	-19.646477	1260.67
B233	14.001129	-18.188465	1357.74
B235	15.933463	-19.287566	1104.98
B236	15.940848	-19.329700	1122.82
B237	15.514536	-19.306586	1160.78
B239	15.540002	-20.410627	938.54
B240	15.543589	-20.406511	950.91
B241	16.477498	-20.404184	1350.64
B242	16.457515	-20.420512	1357.51
B243	14.195892	-17.412619	858.55
B244	14.212017	-17.418179	790.63
B245	14.402427	-17.425075	1147.63
B246	14.373349	-17.410583	1158.52

B247	14.718222	-17.930675	1110.81
B248	14.698497	-17.895641	1121.82
B253	15.724071	-18.006856	1075.95
B254	15.569253	-18.105473	1075.62
B260	17.999400	-17.388818	1141.96
B262	16.995726	-17.482958	1145.47
B263	16.948410	-17.437685	1141.90
B264	16.747164	-17.461366	1150.13
B301	11.807049	-17.267748	22.24
B302	11.815112	-17.264068	25.61
B305	11.820359	-17.864921	85.13
B306	11.822323	-17.863243	88.65
C001	14.427424	-22.934995	1472.31
C002	14.429065	-22.950503	1435.76
C003	14.495583	-22.472772	1622.53
C006	14.821440	-22.478354	1716.33
C007	14.630439	-22.976988	1644.80
C008	14.643599	-22.979501	1640.00
C009	14.487424	-23.395595	1724.05
C010	14.495710	-23.382001	1778.75
C013	14.602771	-23.099511	1838.56
C301	13.432246	-20.870415	1.00
C302	13.444881	-20.868347	18.77
C320	12.386842	-18.833206	1.00
C321	12.420934	-18.872078	1.00
C323	12.595580	-19.061171	55.81
C324	12.704825	-19.377381	1.00
C337	13.034836	-19.987420	24.73
C338	13.342052	-19.969165	392.04
C339	13.352322	-19.954913	412.86
C340	13.430378	-19.549836	744.44
C341	13.404946	-19.544634	752.89
C342	13.030787	-19.524850	397.44
C345	13.452805	-20.897418	1.21
C346	13.458057	-17.634544	1226.38
C347	13.442429	-17.639318	1233.69
C348	13.048230	-17.538474	1328.72
C349	13.023494	-17.516953	1341.98
M104	23.468033	-17.631383	981.16
M105	23.375556	-17.700833	954.41
M111	25.033333	-17.586389	814.77
M115	25.171389	-17.745000	736.62
M117	24.388333	-17.948889	924.13
M119	23.397778	-17.675000	954.00
M132	21.557137	-19.337958	1022.56
N0011	12.416078	-18.773878	99.79

N0018	12.013286	-18.095507	192.46
Q002	14.822028	-25.244416	1.00
Q005	15.465227	-25.811173	764.95
Q006	15.485159	-25.807497	774.60
Q010	15.111285	-26.648033	1.00
V127	24.876111	-18.822500	989.09
W002	14.800875	-23.726691	351.14
W003	14.920018	-23.773754	416.89
W004	14.922950	-23.793170	431.15
W005	14.921956	-23.815292	417.31
W007	15.344130	-23.864140	709.16
W008	15.477948	-23.875069	798.00
W009	15.501750	-23.872736	810.05
W011	15.930080	-23.973222	963.10
W013	15.931713	-23.961249	955.71
W014	15.856011	-24.402534	915.12
W015	15.853354	-24.373884	931.34
W023	15.546033	-25.266761	964.03
W024	15.522546	-25.288512	922.07
W025	15.533276	-25.301113	947.86
W026	14.874552	-25.087380	1.00
W027	14.871101	-25.069320	1.00
W028	14.860900	-25.105650	1.00
W033	14.694651	-24.660840	1.00
W034	14.698562	-24.678228	1.00
Z001	16.024007	-28.142176	1014.34
Z003	16.026748	-28.176711	970.05
Z007	16.255651	-28.441941	1041.41
Z008	16.283653	-28.465478	1066.24
Z103	19.560972	-28.024932	839.35

3.7.2. Landsat images

This is the list of the input Landsat images that were used in this project. The **Path/Row** is a pair of numbers in the Landsat World Reference System to identify the image geographical position. **Date** give the information about when the image was captured. **Oriented** informs how the image has been pre-processed: along the orbit or along the map coordinates. **Pixel size** is the pre-processed ground resolution. **File format** give details of the file organization in input media.

PATH/ROW	DATE	ORIENTED	PIXEL SIZE	FILE FORMAT
182/072	17/06/98	ORBIT	30	RAW
182/073	19/11/99	MAP	30	TIFF
181/072	08/09/96	MAP	25	TIFF

181/073	11/09/97	ORBIT	30	RAW
181/074	08/09/96	ORBIT	30	RAW
180/072	15/07/96	MAP	25	TIFF
180/073	15/07/96	MAP	25	TIFF
180/074	02/07/97	ORBIT	30	RAW
180/075	02/07/97	ORBIT	30	RAW
180/076	30/06/99	MAP	30	TIFF
179/072	08/09/95	MAP	25	TIFF
179/073	08/09/95	MAP	25	TIFF
179/074	08/09/95	MAP	25	TIFF
179/075	25/06/97	ORBIT	30	RAW
179/076	11/07/97	ORBIT	30	RAW
179/077	25/06/97	ORBIT	30	RAW
179/078	26/08/99	MAP	30	TIFF
178/072	03/09/96	MAP	25	TIFF
178/073	03/09/96	MAP	25	TIFF
178/074	03/09/96	MAP	25	TIFF
178/075	21/08/97	ORBIT	30	RAW
178/076	21/08/97	ORBIT	30	RAW
178/077	21/08/97	ORBIT	30	RAW
178/078	21/08/97	ORBIT	30	RAW
178/079	21/08/97	ORBIT	30	RAW
178/080	02/07/99	MAP	30	TIFF
177/072	29/07/97	ORBIT	30	RAW
177/073	11/08/96	ORBIT	25	RAW
177/074	11/08/96	ORBIT	25	RAW
177/075	10/08/97	ORBIT	30	RAW
177/076	14/08/97	ORBIT	30	RAW
177/077	06/02/98	ORBIT	30	RAW
177/078	30/08/97	ORBIT	30	RAW
177/079	29/07/97	ORBIT	30	RAW
177/080	17/10/97	ORBIT	30	RAW
176/073	22/07/97	MAP	25	RAW
176/074	22/07/97	MAP	25	RAW
176/075	07/08/97	ORBIT	30	RAW
176/076	07/08/97	ORBIT	30	RAW
176/077	07/08/97	ORBIT	30	RAW
176/078	03/05/97	MAP	25	RAW
176/079	03/05/97	MAP	25	RAW
176/080	03/05/97	MAP	25	RAW

175/072	16/08/97	ORBIT	30	RAW
175/073	31/07/99	MAP	25	RAW
175/079	16/08/97	ORBIT	30	RAW
175/080	30/08/99	MAP	30	TIFF
174/072	24/09/99	MAP	30	TIFF
174/073	10/10/99	MAP	30	TIFF
173/072	01/09/99	MAP	30	TIFF

4.2. Soil Classification

Formal taxonomic classifications are sometimes of limited use as mapping tools because of the following reasons:

- They are difficult to apply in the field when they are based on detailed laboratory results.

- Their criteria for differentiating between soils may not allow immediate adaptation to specific development objectives.

- They are often not suitable for practical use at the needed level

However, the decision to fit the soils described in the field into a recognized classification system is important and presents some advantages:

- It gives, to the people that are not familiar with the study area, a first idea about the main characteristics of the soils and prevent misunderstandings.

- The map becomes a transmitter of soil information and allows correlation with previous works and technology transfer between similar soils.

The system of soil classification used in the soil surveys of the project to support the agro-ecological zoning project in Namibia has been the World Reference Base (WRB) for Soil Resources System (ISSS, 1998).

Classification has been performed to the level of soil subunits (WRB, 1998).

In order to facilitate correlations with previous works, the taxonomic units have been also classified according to the Revised Legend of FAO (FAO, 1988) and the Soil Taxonomy System (SSS, 1996).

Table 4.1 shows the different taxonomic units (WRB, 1998) that have been recognized during the soil surveys, and their correlation with other classification systems.

Table 4.1. Classification of the taxonomic units

World Reference Base (1998) Soil Subunits	Revised Legend of FAO (1988) Soil Units	Soil Taxonomy (1999) Subgroups
Arenic Fluvisol	Eutric Fluvisol	Typic Ustifluvent
Arenic-leptic Regosol	Dystric Regosol	Lithic Ustipsamment
Calcic Solonetz	Calcic Solonetz	Typic Natrustalf
Chromic Cambisol	Chromic Cambisol	Typic Haplustept
Chromic Luvisol	Chromic Luvisol	Typic Rhodustalf
Ferralic Arenosol	Ferralic Arenosol	Typic Ustipsamment
Ferralic Cambisol	Ferralic Cambisol	Typic Ustipsamment
Ferralic-lamellic Arenosol	Luvic Arenosol	Lamellic Ustipsamment
Fluvic Cambisol	Eutric Cambisol	Fluventic Haplustept
Haplic Calcisol	Haplic Calcisol	Typic Calciustept
Haplic Cambisol	Eutric Cambisol	Typic Haplustept
Haplic Fluvisol	Eutric Fluvisol	Typic Ustifluvent
Haplic Gypsisol	Haplic Gypsisol	Typic Haplogypsid
Haplic Leptosol	Eutric Leptosol	Lithic Ustorthent
Haplic Luvisol	Haplic Luvisol	Typic Haplustalf
Haplic Regosol	Eutric Regosol	Typic Ustorthent
Hypercalcic Calcisol	Haplic Calcisol	Typic Calciustept
Hyposalic Arenosol	Cambic Arenosol	Typic Halaquept
Leptic Calcisol	Haplic Calcisol	Lithic Calciustept
Leptic Regosol	Eutric Regosol	Lithic Usthortent
Leptic-chromic Cambisol	Chromic Cambisol	Lithic Haplustept
Leptic-mollic Cambisol	Eutric Cambisol	Lithic Haplustoll
Leptic-Skeletic Regosol	Eutric Regosol	Lithic Ustorthent
Lithic Leptosol	Lithic Leptosol	Lithic Ustorthent
Mollic Fluvisol	Mollic Fluvisol	Mollic Ustifluvent
Mollic Leptosol	Mollic Leptosol	Lithic Haplustoll
Natric-calcic Vertisol	Calcic Vertisol	Sodic Calciustert
Natric-gypsic Vertisol	Gypsic Vertisol	Sodic Gypsiustert
Petric Calcisol	Petric Calcisol	Petrocalcic Calciustept
Petric Gypsisol	Petric Gypsisol	Typic Petrogypsid
Skeletic Fluvisol	Eutric Fluvisol	Typic Ustifluvent
Skeletic Regosol	Eutric Regosol	Typic Ustorthent
Skeletic-calcaric Fluvisol	Calcaric Fluvisol	Typic Ustifluvent
Sodic Calcisol	Haplic Calcisol	Typic Halaquept
Sodic Cambisol	Eutric Cambisol	Typic Halaquept
Sodic Gypsisol	Haplic Gypsisol	Typic Halaquept

Annex 2 presents a detailed description of the taxonomical series and their representative profile.

4.1.1. Structure of the legend

The legend of the soil survey (1:1.000.000) follows a physiographic approach. In this way, four distinct physiographic regions, or land divisions denoting areas within a continental structure and a climatic zone, have been defined (FAO, 1984): the Namib desert, the Great Escarpment, the Central Plateaux and the Kalahari basin.

Each of these land divisions is made up of a number of land provinces which are areas adjacent or in close proximity in the same large lithological association. In this way, the Namib desert consist of Namib sand dunes and Namib desert pavement. The Great Escarpment contains the high mountains of the Escarpment, and the erosion surfaces of the degraded Escarpment. In the Central Plateaux have been defined Kaokoland, plateaux with karst on hard Damara limestone, lowlands of the Central Plateaux, highlands of the Central Plateaux, plateaux, foothills and slopes of the Central Plateaux, erosion forms on Karoo rocks, area with active sand drifts and structural hills in the Central Plateaux. The Kalahari basin has been divided in hills in the Kalahari basin, sand deposits, fossil sand dunes and flooded and overflooding areas.

Finally, each land province has been divided into land regions, which are areas having similar lithology and surface form. The legend of the soil survey indicates the land regions where the different soil consociations, associations and complex occur.

4.1.2. Legend of the soil map (1:1.000.000) of Namibia

N. Namib

ND. Namib sand dunes

NDh. Rock hills

NDh1. rock outcrops & active sand Complex

NDa. Active sand dunes

NDa1. Active sand

NP. Namib desert pavement

NPh. Inselbergs and hills

NPh1. granite outcrops

NPh2. rock outcrops & lithic Leptosols Complex

NPc. River canyons

NPc1. rock outcrops & lithic Leptosols Complex

NPc2. rock outcrops & haplic Leptosols & petric Calcisols Association

NPp. Gravel pavements

NPp1. petric Calcisols & haplic Leptosols Association

NPp2. petric Gypsisols & haplic Gypsisols Association

NPp3. haplic Regosols & petric Calcisols & leptic Regosols Association

NPt. River terrace

NPt1. haplic Gypsisols & petric Gypsisols Association

E. Escarpment

EH. High mountains of the escarpment

EHm. High mountains

EHm1. High mountains (Brandberg and Erongo mountains)

EHm2. rock outcrops & lithic Leptosols Complex

EHp. Plateau remnant of the escarpment

EHp1. haplic Leptosols & leptic-skeletic Regosols & petric Calsisols Association

EHt. Tableau mountains

EHt1. petric Calcisols & lithic Leptosols Association

EHv. Mountain valleys

EHv1. petric Calcisols & skeletic Regosols & haplic Calcisols Association

EHv2. haplic Regosols & petric Calcisols & leptic-skeletic Regosols Association

EHv3. leptic-chromic Cambisols & petric Calcisols & haplic Calcisols Association

ED. Erosion surfaces of the degraded escarpment

EDr. Eroded rolling hills

EDr1. lithic Leptosols & petric Calcisols Association

EDs. Eroded surface with hills

EDs1. rock outcrops & leptic Regosols & haplic Regosols Complex

EDp. Erosion surface with remanat palteau

EDp1. haplic Leptosols & leptic-skeletic Regosols & petric Calcisols Complex

EDp2. haplic Leptosols & petric Calcisols & haplic Calcisols Complex

EDl. Level lowlands

EDl1. leptic Regosols & petric Calcisols Association

C. Central Plateaux

CA. Kaokoland

CAh. Mountain and hills

CAh1. rock outcrops & lithic Leptosols Complex

CAh2. rock outcrops & active sand Complex

CAv. Intermountain valleys

CAv1. petric Calcisols & ferralic Arenosols & leptic-skeletic Regosols Association

CAp. Plain pediments

CAp1. leptic-chromic Cambisols & haplic Calcisols & petric Calcisols Association

CK. Plateaux wiht karst on hard damara limestone

CKh. Hills and ridges

CKh1. rock outcrops & lithic Leptosols Complex

CKv. Mountain valleys

CKv1. chromic Luvisols & leptic-chromic Cambisols Association

CKv2. leptic Regosols

CKf. Footslope

CKf1. chromic Cambisols & leptic-chromic Cambisols Association

CKf2. leptic Regosols

CKg. Gently undulating lowlands

CKg1. chromic Cambisols & leptic Regosols & petric Calcisols Complex

CKl. Level lowlands

CKl1. mollic Leptosols & petric Calcisols Complex

CKl2. ferralic Arenosols & petric Calcisols Association

CKp. Level lowlands with pans

CKp1. mollic Leptosols & petric Calcisols & haplic Calcisols Association

CKt. River terrace

CKt1. petric Calcisols & haplic Calcisols Association

CKt2. petric Calcisols

CL. Lowlands in the Central Plateaux

CLh. Hills and ridges

CLh1. rock outcrops & lithic Leptosols Complex

CLg. Gently undulating lowlands

CLg1. leptic Regosols & haplic Regosols & petric Calcisols Complex

CLl. Nearly level lowlands

CLl1. chromic Cambisols

CLl2. chromic Cambisols & leptic-chromic Cambisols Association

CLl3. petric Calcisols & leptic-chromic Cambisols Complex

CH. Highlands in the Central Plateaux

CHh. Hills and ridges

CHh1. rock outcrops & lithic Leptosols Complex

CHu. Undulating highlands

CHu1. haplic Leptosols & leptic-skeletic Regosols Complex

CHg. Gently undulating highlands

CHg1. haplic Leptosols & leptic Regosols Complex

CHl. Nearly level highlands

CHl1. leptic Regosols & haplic Leptosols Association

CP. Plateaux

CPp. Plateaux

CPp1. haplic Leptosols

CPk. Flat plains of the Kalkrand

CPk1. petric Calcisols

CPd. Dissected plateaux fringes

CPd1. haplic Leptosols & leptic-skeletic Regosols Complex

CF. Foothills and slopes in the Central Plateaux

CFh. Hills and ridges

CFh1. haplic Leptosols & rock outcrops & leptic-skeletic Regosols Association

CFh2. haplic Regosols & haplic Leptosols & rock outcrops Association

CFr. Rolling uplands

CFr1. haplic Leptosols & leptic Regosols Complex

CFg. Gently undulating hills

CFg1. haplic Leptosols & petric Calcisols Complex

CFs. Scarp slopes

CFs1. haplic Calcisols & calcaric-skeletic Regosols Association

CFf. Footslopes

CFf1. haplic Regosols & haplic Calcisols & haplic Leptosols Association

CFf2. leptic Regosols & petric Calcisols Complex

CE. Erosion forms on Karoo rocks

CEo. Hills

CEo1. Dolerite outcrops

CEr. Rolling hills

CEr1. haplic Leptosols & leptic Calcisols Complex

CEg. Gently undulating hills

CEg1. haplic Leptosols & leptic Regosols Complex

CEv. River valleys

CEv1. haplic Calcisols & skeletic-calcaric Fluvisols Complex

CEv2. Haplic Leptosols & leptic Regosols & petric Calcisols Complex

CS. Area with active sand drifts

CSh. Hills

CSh1. rock outcrops & lithic Leptosol Complex

CSd. Dunefield

CSd1. ferralic Arenosols

CSp. Flat plains with dunes

CSp1. arenic-leptic Regosols & haplic Leptosols & ferralic Arenosols Association

CT. Structural hills in the Central Plateaux

CTb. Brukkaros

CTb1. haplic Leptosols & rock outcrops Complex

K. Kalahari

KH. Hills in the Kalahari basin

KHh. North-eastern hills in the Kalahari basin

KHh1. rock outcrops & arenic-leptic Regosols & ferralic Arenosols Association

KHp. Hummocky plain

KHp1. rock outcrops & petric Calcisols & arenic-leptic Regosols & leptic-chromic Cambisols & ferralic Arenosols Complex

KHm. Area of relict meanders

KHm1. ferralic Arenosols

KHm2. Arenic-leptic Regosols

KS. Sand deposits

KSd. Sand deposits

KSd1. ferralic Arenosols

KSd2. petric Calcisols & ferralic Arenosols Association

KSd3. ferralic Arenosols & sodic Calcisols & sodic Cambisols Association

KSa. Sand deposits with aligned dunes

KSa1. ferralic Arenosols

KSa2. petric Calcisols & ferralic Arenosols Association

KSp. Sand deposits with pans

KSp1. ferralic Arenosols & petric Calcisols Association

KSp2. petric Calcisols

KSp3. sodic Calcisols & ferralic Arenosols & petric Calcisols Association

KD. Fossil sand dunes

KDf. Aligned sand dunes

KDf1. ferralic Arenosols & arenic Fluvisols & haplic Calcisols Association

KDf2. ferralic Arenosols & petric Calcisols Association

KF. Flooded and overflooding areas

KFv. Omuramba and river valleys

KFv1. arenic Fluvisols & haplic Calcisols Association

KFv2. arenic Fluvisols & ferralic Arenosols Association

KFv3. mollic Leptosols & petric Calcisols & arenic Fluvisols Association

KFv4. petric Calcisols & haplic Calcisols Association

KFv5. fluvic Cambisols & haplic Fluvisols & ferralic Arenosols Complex

KFv6. arenic Fluvisols & fluvic Cambisols Complex

KFd. Very dense inflowing stream pattern

KFd1. haplic Calcisols & sodic Cambisols & haplic Luvisols & ferralic Arenosols Association

KFm. Moderately dense inflowing stream pattern

KFm1. sodic Cambisols & calcic Solonetzs &sodic Calcisols & ferralic Arenosols & natric-calcic Vertisols & natric-gypsic Vertisols Association

KFp. Flat plains with pans

KFp1. hyposalic Arenosols & sodic Cambisols & natric-calcic Vertisols & natric-gypsic Vertisols Association

KFp2. mollic Leptosols & petric Calcisols & hyposalic Arenosols Complex

4.1.3. Description of the map units

CAh1. rock outcrops & lithic Leptosols Complex

This complex consists of soils formed on the high mountains and hills of Kaokoland in the Central plateaux. It presents lithic Leptosols as dominating soils, furthermore abundant outcrops of limestone, quartzite and schist are present throughout the map unit.

Lithic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments, and well drained.

Typically the surface layer is about 10 cm thick, sandy loam to loam with common to many coarse fragments of limestone, quartzite and/or schist, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of limestone, quartzite or schist, that can also appear exposed on the soil surface.

Leptic-skeletic Regosols can appear as inclusions in these map units.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the steep slopes of this map unit and the presence of rock outcrops that strongly affect the workability of these soils. Moreover, the shallow depth of these soils limits the effective rooting depth and low water holding capacity restricts the water in the soil that can be readily absorbed by plants. On the other hand, the steep slopes of this map unit and the low water holding capacity favour the formation of rills and gullies in the soil.

CAh2. rock outcrops & active sand Complex

CAp1. leptic-chromic Cambisols & haplic Calcisols & petric Calcisols Association

This association consists of soils formed on the plain pediments of Kaokoland in the Central plateaux. It presents leptic-chromic Cambisols, haplic Calcisol and petric Calcisols as dominating soils.

Leptic-chromic Cambisols are moderately deep to deep, moderately coarse to medium textured with few to common coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy clay loam with few to common coarse fragments of quartz, and very dark greyish brown to dusky red in colour. Underneath, to a depth of 60 to 80 cm, we find brown to red, sandy loam to sandy clay loam material that presents few to common coarse fragments of quartz and a moderate structure. Below we find the bedrock of quartzite or limestone.

Leptic and skeletic Regosols can appear as inclusions in this map units.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate water holding capacity.

The main constraints for agriculture are the moderate depth than can limit the effective rotting depth of the plants and the moderate water holding capacity that restricts the water in the soils that can be readily absorbed by plants.

Haplic Calcisols are very deep, moderately coarse to medium textured and well drained.

Typically the surface layer is 15 to 25 cm thick, sandy loam to loam, and very dark grey to dark yellowish brown in colour. Underneath, to a depth of more than 100 cm, we find dark grey to yellowish red, loamy sand to sandy loam material that presents common to many accumulations of discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon.

These soils have a moderate hydraulic conductivity and present a moderate infiltration rate. They have a moderate water holding capacity.

They present few constraints for agriculture.

Petric Calcisols, in the intermountain valleys of Kaokoland in the Central plateaux, are very shallow, moderately coarse to medium textured with common to many coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with common to many coarse fragments of quartz, schist and limestone, and very dark grey to brown in colour. Underneath it appears a petrocalcic horizon formed by cementation of the coarse fragments by calcium carbonate.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CAv1. petric Calcisols & ferralic Arenosols & leptic-skeletic Regosols Association

This association consists of soils formed on the intermountain valleys of Kaokoland in the Central plateaux. It presents petric Calcisols, ferralic Arenosols and leptic-skeletic Regosols as dominating soils.

Petric Calcisols, in the intermountain valleys of Kaokoland in the Central plateaux, are very shallow, moderately coarse to medium textured with many coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with many coarse fragments of quartz, schist and/or limestone, and very dark grey to brown in colour. Underneath it appears a petrocalcic horizon formed by cementation of the coarse fragments by calcium carbonate.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth of the plants and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and brown to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find a brown to yellowish red, sand material showing a very weak structure development.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

Leptic-skeletic Regosols are shallow to moderately deep, moderately coarse to medium textured with abundant coarse fragments, and well drained.

Typically the surface layer is 15 to 25 cm thick, loamy sand to loam with abundant coarse fragments of quartz, schist and/or limestone, and dark grey to dark red in colour. Underneath, it appears an horizon 20 to 50 cm thick, very dark greyish brown to dark red in colour, sandy loam to sandy clay loam with abundant coarse fragments of quartz, schist and/or limestone, and a weak structure. Below underlies the bedrock of quartzite, schist or limestone.

Skeletic Regosols can appear as inclusions in this positions

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. Moreover, the presence of abundant coarse fragments strongly affects the workability of these soils.

CEg1. haplic Leptosols & leptic Regosols Complex

This complex consists of soils formed on the gently undulating hills of the eroded Karoo rocks in the Central plateaux. It presents haplic Leptosols and leptic Regosols as dominating soils.

Haplic Leptosols are very shallow, moderately coarse to medium textured with few to common coarse fragments, and well drained.

Typically the surface layer is 10 to 20 cm thick, sandy loam to loam with few to common coarse fragments of shale and quartz, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of shale, that can occasionally appear exposed on the soil surface.

These soils have a moderate hydraulic conductivity and present a moderate infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Leptic Regosols are shallow to moderately deep, coarse to moderately coarse textured with common rock fragments, and well drained.

Typically the surface layer is about 20 cm thick, sandy loam to loam with common coarse fragments of shale and quartz, and dark brown to dark red in colour. Underneath, to a depth of 40 to 60 cm, we find brown to yellowish red loamy sand to sandy loam material that presents common coarse fragments of shale and quartz and a weak structure. Below it appears the bedrock of shale.

Leptic-skeletic Regosols, petric Calcisols and gypsiric Leptosols can appear as inclusions in this map unit.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the moderate depth that limits the effective rooting depth and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CEo1. Dolerite outcrops

CEr1. haplic Leptosols & leptic Calcisols Complex

This complex consists of soils formed on the rolling hills of the eroded Karoo rocks in the Central plateaux. It presents haplic Leptosols and leptic Calcisols as dominating soils.

Haplic Leptosols are very shallow, moderately coarse to medium textured with few to common coarse fragments, and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy clay loam with few to common coarse fragments of quartz and quartzite, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of quartzite, that can occasionally appear exposed on the soil surface.

Leptic Regosols can appear as inclusions in this map unit.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. Moreover, the presence of rock outcrops and the moderate slope of this map unit strongly affect the workability of these soils. On the other hand, the moderate slope of this map unit and the low water holding capacity favour soil erosion and the formation of rills and gullies.

Leptic Calcisols are moderately deep, moderately coarse to medium textured with few to common coarse fragments, and well drained.

Typically the surface layer is 15 to 25 cm thick, sandy loam to sandy clay loam with few to common coarse fragments of quartz, and very dark grey to dark yellowish brown in colour. Underneath, to a depth of 40 to 60 cm, we find dark grey to light yellowish brown, sandy loam to sandy clay loam material that presents few to common coarse fragments of quartz, and common to many accumulations of hard and continuous concentrations of calcium carbonate, resulting in a calcic horizon. Below, we find the bedrock, consisting of narrow layers of quartzite that present hard and continuous concentrations of calcium carbonate, like lamellas, in between.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. On the other hand, the moderate slope of this map unit and the low water holding capacity favour soil erosion and the formation of rills and gullies.

CEv1. petric Calcisols & skeletic-calcaric Fluvisols Complex

This complex consists of soils formed on the river valleys of the eroded Karoo rocks in the Central plateaux. It presents petric Calcisols and skeletic-calcaric Fluvisols as dominating soils.

Petric Calcisols, in the river valleys of the eroded Karoo rocks in the Central plateau, are very shallow, coarse to moderately coarse textured with many to abundant coarse fragments, and well drained.

Typically the surface layer is about 15 cm thick, loamy sand to sandy loam with many to abundant coarse fragments of quartzite and limestone, and very dark grey to brown in colour. Underneath it appears a petrocalcic horizon formed by cementation of the coarse fragments by calcium carbonate.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. Furthermore, the presence of abundant coarse fragments reduces the effective volume explored by the plants and the workability of these soils.

Skeletic-calcaric Fluvisols are very deep, coarse to moderately coarse textured with abundant coarse fragments, and moderately well to well drained.

Typically the soil surface is about 20 cm thick, sand to sandy loam with abundant coarse fragments of quartzite and limestone, and very dark grey to dark reddish brown in colour. Underneath, to a depth of more than 100 cm, we find very dark greyish brown to dusky red, loamy sand to sandy loam material than presents abundant coarse fragments of quartzite and limestone, and a weak structure. The whole profile shows an extreme effervescence with 10% HCl in most of the fine earth.

Haplic Calcisols can appear as inclusions in this positions.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make some parts of the map unit prone to flooding during the rainy season and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. Furthermore, the presence of abundant coarse fragments affects the volume of soil effectively explored by plants and the workability of these soils.

CEv2. haplic Leptosols & leptic Regosols & petric Calcisols Complex

This complex consists of soils formed on the river valleys of the eroded Karoo rocks in the Central plateaux. It presents haplic Leptosols, leptic Regosols and petric Calcisols as dominating soils. Salinity is present in vast areas of this map unit.

Haplic Leptosols are very shallow, moderately coarse to medium textured with few to common coarse fragments, and well drained.

Typically the surface layer is 10 to 20 cm thick, sandy loam to loam with few to common coarse fragments of shale and quartz, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of quartzite or shale, that can occasionally appear exposed on the soil surface.

These soils have a moderate hydraulic conductivity and present a moderate infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. On the other hand, the slight to moderate salinity, that can be present in this soils, reduces water holding capacity and can cause specific toxicity for certain crops.

Leptic Regosols are shallow to moderately deep, coarse to moderately coarse textured with few to common rock fragments, and well drained.

Typically the surface layer is about 20 cm thick, sandy loam to loam with common coarse fragments of shale and quartz, and dark brown to dark red in colour. Underneath, to a depth of 40 to 60 cm, we find brown to yellowish red loamy sand to sandy loam material that presents common coarse fragments of shale and quartz and a weak structure. Below it appears the bedrock of quartzite or shale.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the moderate depth that limits the effective rooting depth and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants. On the other hand, the slight to moderate salinity, that can present this soils, reduces water holding capacity and can cause specific toxicity for certain crops.

Petric Calcisols, in the river valleys of the eroded Karoo rocks in the Central plateaux, are shallow to moderately deep, coarse to moderately coarse textured with many coarse fragments, and well drained.

Typically the surface layer is about 15 cm thick, loamy sand to sandy loam with many to abundant coarse fragments of quartzite and limestone, and very dark grey to brown in colour. Underneath, to a depth of 40 to 60 cm, we find very dark greyish brown to reddish brown, loamy sand to sandy loam material than presents many coarse fragments of quartzite and limestone. Below it appears a petrocalcic horizon cemented by calcium carbonate.

Skeletic-calcaric Fluvisols and hypercalcic Calcisols can appear as inclusions in these map units.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. On the other hand, the presence of many coarse fragments reduces the effective volume explored by the plants and the workability of these soils.

CFf1. haplic Regosols & haplic Calcisols & haplic Leptosols Association

This association consists of soils formed on the footslopes of the foothills and slopes in the Central plateaux. It presents haplic Regosols, haplic Calcisols and haplic Leptosols as dominating soils.

Haplic Regosols are very deep, coarse to moderately coarse textured with common to many coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with common to many coarse fragments of quartz, and dark brown to yellowish red in colour. Underneath, to a depth of more than 120 cm, we find brown to yellowish red, loamy sand to sandy loam material that presents common to many coarse fragments of quartz, and a weak structure.

Leptic Regosols can appear as inclusions in this map unit.

These soils present a moderate to moderately rapid hydraulic conductivity and a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Haplic Calcisols are very deep, coarse to moderately coarse textured with common to many coarse fragments, and well drained.

Typically the surface layer is 15 to 25 cm thick, loamy sand to sandy loam with common to many coarse fragments of quartz, and dark brown to yellowish red in colour. Underneath, to a depth of more than 100 cm, we find brown to yellowish red, loamy sand to sandy loam material that presents common to many coarse fragments of quartz and common to many accumulations of discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon.

Petric Calcisols can appear as inclusions in this positions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Haplic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments, and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy loam with common to many coarse fragments of quartz, and dark brown to yellowish red in colour. Below underlies the bedrock of quartzite, gneiss or granite.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. On the other hand, the steep slope favours the formation of rills and gullies on the higher parts of the map unit.

CFf2. leptic Regosols & petric Calcisols Complex

This complex consists of soils formed on the footslopes of the foothills and slopes in the Central plateaux. It presents leptic Regosols and petric Calcisols as dominating soils. Salinity is present in vast areas of this map unit.

Leptic Regosols are shallow to moderately deep, moderately coarse to moderately fine textured and imperfectly to moderately well drained.

Typically the surface layer is 15 to 25 cm thick, sandy loam to sandy clay loam, and dark grey to dark red in colour. Underneath, to a depth of 40 to 60 cm, we find a very dark greyish brown to dark red in colour, sandy loam to sandy clay loam material that presents a weak structure. Below underlies the bedrock of shale.

These soils have a slow to moderate hydraulic conductivity and present a moderately slow infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. Moreover, the low position where they are located in the landscape make these soils prone to flooding during the rainy season. On the other hand, the slight to moderate salinity, that can be present in this soils, reduces water holding capacity and can cause specific toxicity for certain crops.

Petric Calcisols, in the footslopes of the foothills and slopes in the Central plateaux are shallow, moderately coarse to moderately fine textured and imperfectly to moderately well drained.

Typically the surface layer is about 20 cm thick, sandy loam to sandy clay loam with few coarse fragments and very dark grey to brown in colour. Underneath, to a depth of 40 to 60 cm, we find very dark greyish brown to dark red in colour, sandy loam to loam material that presents few to common accumulations of discontinuous concentrations of soft nodules. Below, it appears a petrocalcic horizon cemented by calcium carbonate

Hypercalcic Calcisols can appear as inclusions in these map units.

These soils have a moderate hydraulic conductivity and present a moderate infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. Furthermore, the low positions where they are located in the landscape make these soils prone to flooding during the rainy season. On the other hand, the slight to moderate salinity, that can be present in this soils, reduces water holding capacity and can cause specific toxicity for certain crops.

CFg1. haplic Leptosols & petric Calcisols Complex

This complex consists of soils formed on the gently undulating hills of the foothills and slopes in the Central plateaux. It presents haplic Leptosols and petric Calcisols as dominating soils.

Haplic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments, and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy loam with common to many coarse fragments of quartz, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of granite, gneiss or schist.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Petric Calcisols, in the gently undulating hills of the foothills and slopes in the Central plateaux, are very shallow, moderately coarse to medium textured and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with common to many coarse fragments of quartz, and very dark grey to brown in colour. Underneath it appears a petrocalcic horizon, cemented by calcium carbonate.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the very low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CFh1. haplic Leptosols & rock outcrops & leptic-skeletic Regosols Association

This association consists of soils formed on the hills and ridges of the foothills and slopes in the Central plateaux. It presents haplic Leptosols and leptic-skeletic Regosols as dominating soils.

Haplic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments, and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy loam with common to many coarse fragments of quartz and shale, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of quartzite or shale, that can also appear exposed on the soil surface.

These soils have a moderate hydraulic conductivity and present a moderate infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. Moreover, the presence of rock outcrops affects the workability of these soils. On the other hand, the steep slope and the low water holding capacity favour the formation of rills and gullies in the soil, on the higher parts of the map unit.

Leptic-skeletic Regosols are shallow to moderately deep, coarse to moderately coarse textured with abundant rock fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with abundant rock fragments of quartz and shale, and dark brown to dark red in colour. Underneath, to a depth of 40 to 60 cm, we find brown to yellowish red loamy sand to sandy loam material that presents abundant rock fragments of quartz and shale and a weak structure. Below it appears the bedrock of quartzite, gneiss or shele.

Skeletic Regosols appear as inclusions in this map unit.

These soils present a moderate to moderately rapid hydraulic conductivity and a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth, the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants, and the presence of abundant rock fragments that affects the volume of soil effectively explored by the plants and the workability of theses soils. On the other hand, the steep slope favours the formation of rills and gullies in the soil on the higher parts of the map.

CFh2. haplic Regosols & haplic Leptosols & rock outcrops Association

This association consists of soils formed on the hills and ridges of the foothills and slopes in the Central plateaux. It presents haplic Regosols and haplic Leptosols as dominating soils.

Haplic Regosols are very deep, coarse to moderately coarse textured with common to many coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with common to many coarse fragments of quartz, and dark brown to yellowish red in colour. Underneath, to a depth of more than 120 cm, we find brown to yellowish red, loamy sand to sandy loam material that presents common to many coarse fragments of quartz, and a weak structure.

Leptic Regosols can appear as inclusions in this map unit.

These soils present a moderate to moderately rapid hydraulic conductivity and a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Haplic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments, and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy loam with common to many coarse fragments of quartz, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of quartzite or gneiss.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CFr1. haplic Leptosols & leptic-skeletic Regosols Complex

This complex consists of soils formed on the rolling hills of the foothills and slopes in the Central plateaux. It presents haplic Leptosols and leptic-skeletic Regosols as dominating soils.

Haplic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments, and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy loam with common to many coarse fragments of quartz and shale, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of quartzite or shale, that can also appear exposed on the soil surface.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. Moreover, the presence of rock outcrops affects the workability of these soils. On the other hand, the steep slopes of the area and the low water holding capacity favour the formation of rills and gullies in the soil.

Leptic-skeletic Regosols are shallow to moderately deep, coarse to moderately coarse textured with abundant rock fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with abundant rock fragments of quartz and shale, and dark brown to dark red in colour. Underneath, to a depth of 40 to 60 cm, we find brown to yellowish red loamy sand to sandy loam material that presents abundant rock fragments of quartz and shale and a weak structure. Below it appears the bedrock of quartzite, gneiss or shale.

Skeletic Regosols and petric Calcisols appear as inclusions in this map unit.

These soils present a moderate to moderately rapid hydraulic conductivity and a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture is the shallow to moderate depth that limits the effective rooting depth, the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the presence of abundant rock fragments that affects the volume of soil effectively explored by the plants and the workability of theses soils.

CFs1. haplic Calcisols & leptic-skeletic Regosols Association

This association consists of soils formed on the scarp slopes of the foothills and slopes in the Central plateaux. It presents haplic Calcisols and calcaric-skeletic Regosols as dominating soils. Salinity is present in vast areas of this map unit.

Haplic Calcisols are very deep, moderately coarse to moderately fine textured and well drained.

Typically the surface layer is 15 to 25 cm thick, loamy sand to sandy clay loam and very dark grey to dark yellowish brown in colour. Underneath, to a depth of more than 100 cm, we find dark grey to light yellowish brown, sandy loam to sandy clay loam material that presents common to many accumulations of discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon.

Petric Calcisols can appear as inclusions in this positions.

These soils have a moderate hydraulic conductivity and present a moderate infiltration rate. They have a moderate water holding capacity.

The main constraints for agriculture is the moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants. On the other hand, the slight to moderate salinity, that can be present in this soils, reduces water holding capacity and can cause specific toxicity for certain crops.

Leptic-skeletic Regosols are shallow to moderately deep, coarse to moderately coarse textured with abundant rock fragments, and well drained.

Typically the surface layer is about 20 cm thick, sand loam to sandy clay loam with abundant rock fragments of quartz, quartzite and shale, and dark brown to dark red in colour. Underneath, to a depth of 60 to 80 cm, we find brown to yellowish red sandy loam to sandy clay loam material that presents abundant rock fragments of quartz, quartzite and shale and a weak structure. Below it appears the bedrock of quartzite or shale.

Haplic Leptosols and skeletic Regosols can appear as inclusions in this map units.

These soils present a moderate to moderately rapid hydraulic conductivity and a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth, the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the presence of abundant rock fragments that affects the volume of soil effectively explored by the plants and the workability of these soils. Moreover, the steep slope favours the formation of rills and gullies on the higher parts of this map unit. On the other hand, the slight to moderate salinity, that can be present in this soils, reduces water holding capacity and can cause specific toxicity for certain crops.

CHg1. haplic Leptosols & leptic Regosols Complex

This complex consists of soils formed on the gently undulating highlands of the Central plateaux. It presents haplic Leptosols and leptic Regosols as dominating soils.

Haplic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments, and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy clay loam with common coarse fragments of quartz, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of quartzite or schist.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Leptic Regosols are shallow to moderately deep, coarse to moderately coarse textured with few to common rock fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with few to common coarse fragments of quartz, and dark brown to dark red in colour. Underneath, to a depth of 40 to 60 cm, we find brown to yellowish red loamy sand to sandy loam material that presents few to common rock fragments of quartz and/or schist and a weak structure. Below it appears the bedrock of quartzite or schist.

Petric Calcisols can appear as inclusions in this map unit.

These soils present a moderate to moderately rapid hydraulic conductivity and a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CHh1. rock outcrops & lithic Leptosols Complex

This complex consists of soils formed on the hills and ridges of the highlands of the Central plateaux. It presents lithic Leptosols as dominating soils, furthermore abundant outcrops of quartzite are present throughout the map unit.

Lithic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments, and well drained.

Typically the surface layer is about 10 cm thick, sandy loam to loam with common to many coarse fragments of quartz, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of quartzite, schist or gneiss, that can also appear exposed on the soil surface.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the presence of rock outcrops and the steep slope of this map unit strongly affect the workability of these soils. Moreover, the shallow depth of these soils limits the effective rooting depth and the low water holding capacity restricts the water in the soil that can be readily absorbed by plants. On the other hand, the steep slope of this map unit and the low water holding capacity favour the formation of rills and gullies in the soil.

CHl1. leptic Regosols & haplic Leptosols Association

This association consists of soils formed on the nearly level highlands of the Central plateaux. It presents leptic Regosols and haplic Leptosols as dominating soils.

Leptic Regosols are shallow to moderately deep, coarse to moderately coarse textured with few rock fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam and dark brown to dark red in colour. Underneath, to a depth of 40 to 60 cm, we find brown to yellowish red loamy sand to sandy loam material that presents a weak structure. Below it appears the bedrock of quartzite or schist.

Petric Calcisols and haplic Calcisols appear as inclusions in this map unit.

These soils present a moderate to moderately rapid hydraulic conductivity and a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Haplic Leptosols are very shallow, moderately coarse to medium textured with few to common coarse fragments, and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy clay loam with few to common coarse fragments of quartz, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of quartzite or schist.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CHu1. haplic Leptosols & leptic-skeletic Regosols Complex

This complex consists of soils formed on the undulating highlands of the Central plateaux. It presents haplic Leptosols and leptic-skeletic Regosols as dominating soils.

Haplic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments, and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy clay loam with common to many coarse fragments of quartz, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of quartzite or schist, that can occasionally appear exposed on the soil surface.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. Moreover, the presence of rock outcrops affects the workability of these soils.

Leptic-skeletic Regosols are shallow to moderately deep, coarse to moderately coarse textured with abundant rock fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with abundant rock fragments of quartz, quartzite and/or schist, and dark brown to dark red in colour. Underneath, to a depth of 40 to 60 cm, we find brown to yellowish red loamy sand to sandy loam material that presents abundant rock fragments of quartz, quartzite and/or schist and a weak structure. Below it appears the bedrock of quartzite or schist.

petric Calcisols appear as inclusions in this map unit.

These soils present a moderate to moderately rapid hydraulic conductivity and a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth, the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the presence of abundant rock fragments that affects the volume of soil effectively explored by the plants and the workability of these soils.

CKf1. chromic Cambisols & leptic-chromic Cambisols Association

This association consists of soils formed on the footslopes of the hills and ridges of the plateau with karst on the hard Damara limestone in the Central plateaux. It presents chromic Cambisols and leptic-chromic Cambisols as dominating soils.

Chromic Cambisols are very deep, moderately coarse to moderately fine textured and well drained.

Typically the surface layer is 15 to 25 cm thick, loamy sand to sandy clay loam and very dark greyish brown to dusky red in colour. Underneath, to a depth of more than 120 cm, we find brown to red, sandy loam to sandy clay loam material that presents a moderate structure.

Haplic Cambisols and haplic Regosols can appear as inclusions in this map units.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate to high water holding capacity.

They present few constraints for agriculture.

Leptic-chromic Cambisols are moderately deep to deep, moderately coarse to medium textured and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy clay loam and very dark greyish brown to dusky red in colour. Underneath, to a depth of 60 to 80 cm, we find brown to red, sandy loam to sandy clay loam material that presents a moderate structure. Below we find the bedrock of limestone.

Leptic and leptic-skeletic Regosols can appear as inclusions in this map units.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate water holding capacity.

The main constraints for agriculture are the moderate depth than can limit the effective rotting depth of the plants and the moderate water holding capacity that restricts the water in the soils that can be readily absorbed by plants.

CKf2. leptic Regosol

Leptic Regosols, on the footslopes of the hills and ridges of the plateau with karst on the hard Damara limestone in the Central plateaux, are shallow to moderately deep, moderately coarse to medium textured with few to common coarse fragments and well drained.

Typically the surface layer is 15 to 25 cm thick, loamy sand to loam with few to common coarse fragments of limestone, and dark grey to dark red in colour. Underneath, it appears an horizon 20 to 40 cm thick, very dark greyish brown to dark red in colour, sandy loam to loam with few to common coarse fragements of limestone, and a weak structure. Below underlies the bedrock of limestone.

Leptic-skeletic Regosols and Leptic-chromic Cambisols can appear as inclusions in this positions

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CKg1. chromic Cambisols & leptic Regosols & petric Calcisols Complex

This complex consists of soils formed on the gently undulating lowlands of the plateau with karst on the hard Damara limestone in the Central plateaux. It presents chromic Cambisols, leptic Regosols and petric Calcisols as dominating soils.

Chromic Cambisols are very deep, moderately coarse to moderately fine textured and well drained.

Typically the surface layer is 15 to 25 cm thick, loamy sand to sandy clay loam and very dark greyish brown to dusky red in colour. Underneath, to a depth of more than 120 cm, we find brown to red, sandy loam to sandy clay loam material that presents a moderate structure.

Haplic Regosols and chromic Luvisols can appear as inclusions in this map units.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate to high water holding capacity.

They present few constraints for agriculture.

Leptic Regosols are shallow to moderately deep, moderately coarse to medium textured with few to common coarse fragments and well drained.

Typically the surface layer is 15 to 25 cm thick, loamy sand to loam with few to common coarse fragments of limestone, and dark grey to dark red in colour. Underneath, it appears an horizon 20 to 40 cm thick, very dark greyish brown to dark red in colour, sandy loam to loam with few to common coarse fragments of limestone, and a weak structure. Below underlies the bedrock of limestone.

Leptic-skeletic Regosols and leptic-chromic Cambisols and can appear as inclusions in this positions

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Petric Calcisols, in the gently undulating lowlands formed on the plateau with karst on the hard Damara limestone in the Central plateau, are very shallow, moderately coarse to medium textured with few coarse fragments and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with few coarse fragments of limestone, and very dark grey to brown in colour. Underneath it appears a petrocalcic horizon formed by dissolution and precipitation of the calcium carbonate present in the bedrock of limestone.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the very low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CKh1. rock outcrops & lithic Leptosols Complex

This complex consists of soils formed on the hills and ridges of the plateau with karst on the hard Damara limestone in the Central plateaux. It presents lithic Leptosols as dominating soils; on the other hand, many outcrops of limestone are present throughout the map unit.

Lithic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments, and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy clay loam with common to many coarse fragments of limestone, and dark greyish brown to dark reddish brown in colour. Below underlies the limestone bedrock, that can also appear exposed on the soil surface.

Leptic-skeletic Regosols can appear as inclusions in this positions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the steep slope of this map unit and the presence of rock outcrops that strongly affect the workability of these soils. Moreover, the shallow depth of these soils limits the effective rooting depth and the low water holding capacity restricts the water in the soil that can be readily absorbed by plants. On the other hand, the steep slope of this map unit and the low water holding capacity favour the formation of rills and gullies in the soil.

CKl1. mollic Leptosols & petric Calcisols Complex

This complex consists of soils formed on the level lowlands of the plateau with karst on the hard Damara limestone in the Central plateaux. It presents mollic Leptosols and petric Calcisols as dominating soils.

Mollic Leptosols are very shallow, moderately coarse and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy loam and black to very dark brown in colour. It presents a moderate to strong structure. Below it appears the bedrock of limestone.

Leptic-mollic Cambisols can appear as inclusions in this positions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Petric Calcisols, in the level lowlands of the plateau with karst on the hard Damara limestone in the Central plateaux, are very shallow, moderately coarse to medium textured with few coarse fragments and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with few coarse fragments of limestone, and black to very dark grey in colour. Underneath it appears a petrocalcic horizon formed by dissolution and precipitation of the calcium carbonate present in the bedrock of limestone.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CKl2. ferralic Arenosols & petric Calcisols Association

This association consists of soils formed on the level lowlands of the plateau with karst on the hard Damara limestone in the Central plateaux. It presents ferralic Arenosols and petric Calcisols as dominating soils.

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand material showing a very weak structure development.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

Petric Calcisols, in the level lowlands of the plateau with karst on the hard Damara limestone in the Central plateaux, are very shallow, coarse to moderately coarse textured with few coarse fragments and well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam, and brown to dark reddish brown in colour. Underneath, to a depth of 40 to 60 cm, we find dark brown to yellowish red, sand to sandy loam material showing a weak structure. Below, it appears a petrocalcic horizon formed by dissolution and precipitation of the calcium carbonate present in the bedrock of limestone.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CKp1. mollic Leptosols & petric Calcisols & hypercalcic Calcisols Association

This association consists of soils formed on the level lowlands with pans of the plateau with karst on the hard Damara limestone in the Central plateaux. It presents mollic Leptosols, petric Calcisols and hypercalcic Calcisols as dominating soils.

Mollic Leptosols are very shallow, moderately coarse and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy loam and black to very dark brown in colour. It presents a moderate to strong structure. Below it appears the bedrock of limestone.

Leptic-mollic Cambisols and haplic Leptosols can appear as inclusions in this positions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Petric Calcisols, in the level lowlands with pans of the plateaux with karst on the hard Damara limestone in the Central plateau, are very shallow, moderately coarse to medium textured with few coarse fragments and imperfectly to well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with few coarse fragments of limestone and black to very dark grey in colour. Underneath it appears a petrocalcic horizon formed by dissolution and precipitation of the calcium carbonate presented in the bedrock of limestone.

In the petric Calcisols that appear on the pans, below the petrocalcic horizon most of the times can appear an hypercalcic horizon.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. Moreover, in the pans, the low position where the soils are located in the landscape, make these soils prone to flooding during and after the rainy season.

Hypercalcic Calcisols are deep to very deep, moderately coarse to moderately fine textured and poorly to imperfectly drained. They formed on the pans of the level lowlands with pans of the areas with karst on hard Damara limestone in the Central plateau.

Typically the surface layer is 15 to 25 cm thick, loamy sand to loam and black to brown. Underneath, to a depth of more than 100 cm, we find grey to very pale brown, sandy loam to sandy clay loam material that presents abundant to dominant accumulations of continuous concentrations of calcium carbonate that make disappear most of the structure, resulting in a hypercalcic horizon.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate water holding capacity.

The main constraints for agriculture are the low positions where they are located that make them prone to flooding during the rainy season and the high contents of calcium carbonate that can cause nutritional deficiencies and/or toxicity for certain crops.

CKt1. petric Calcisols & haplic Calcisols Association

This association consists of soils formed on the terraces of the plateau with karst on the hard Damara limestone in the Central plateaux. It presents petric Calcisols and haplic Calcisols as dominating soils.

Petric Calcisols, formed in the terraces on the plateau with karst on the hard Damara limestone in the Central plateaux, are shallow, moderately coarse textured with common to many coarse fragments and well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam with many coarse fragments of limestone and schist, and very dark grey to dark brown. Underneath, it appears a petrocalcic horizon formed by cementation of coarse fragments by calcium carbonate.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Haplic Calcisols are very deep, moderately coarse to medium textured and well drained.

Typically the surface layer is 15 to 25 cm thick, sandy loam to silty loam and very dark grey to dark yellowish brown in colour. Underneath, to a depth of more than 100 cm, we find dark grey to light yellowish brown, sandy loam to silty sandy loam material that presents common to many accumulations of discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon.

These soils have a moderate hydraulic conductivity and present a moderate infiltration rate. They have a moderate water holding capacity.

These soils present few constraints form agriculture.

CKt2. petric Calcisols

Petric Calcisols, formed in the terraces on areas plateaux with karst on the hard Damara limestone in the Central plateau, are shallow to moderately deep, coarse to moderately coarse textured with common to many coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, sandy loam to loam with many coarse fragments of limestone and quartz, and very dark grey to dark brown. Underneath, to a depth of 40 to 80 cm, we find very dark greyish brown to brown, sandy loam to loam material that present common to many coarse fragments of limestone and quartz, and sometimes, accumulations of calcium carbonate as discontinuous concentrations of hard and/or soft nodules, resulting in a calcic horizon. Below it appears a petrocalcic horizon formed by cementation of coarse fragments by calcium carbonate.

Haplic Calcisols can appear as inclusions in this map units.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CKv1. chromic Luvisols & leptic-chromic Cambisols Association

This association consists of soils formed on the mountain valleys of the plateau with karst on the hard Damara limestone in the Central plateaux. It presents chromic Luvisols and leptic-chromic Cambisols as dominating soils.

Chromic Luvisols are very deep, moderately coarse to moderately fine textured and moderately well drained to well drained.

Typically the surface layer is about 20 cm thick, sandy loam to sandy clay loam and very dark greyish brown to yellowish red in colour. Underneath, to a depth of more than 100 cm, we find brown to dark red, sandy loam to sandy clay material that presents a moderate to strong prismatic or angular blocky structure and, most of the times, slickensides and/or shiny faces, resulting in an argic horizon.

These soils have a moderately slow to moderate hydraulic conductivity and present a moderate infiltration rate. They have a moderate to moderately high water holding capacity.

The hard consistence, when dry, of the argic horizon can be a minor constraintst for agriculture because can limit the root penetration and, therefore, the effective rooting depth.

Leptic-chromic Cambisols are moderately deep to deep, moderately coarse to medium textured and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy clay loam and very dark greyish brown to dusky red in colour. Underneath, to a depth of 60 to 80 cm, we find brown to red, sandy loam to sandy clay loam material that presents a moderate structure. Below we find the bedrock of limestone.

Leptic and leptic-skeletic Regosols can appear as inclusions in this map units.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate water holding capacity.

The main constraints for agriculture are the moderate depth than can limit the effective rotting depth of the plants and the moderate water holding capacity that restricts the water in the soils that can be readily absorbed by plants.

CKv2. leptic Regosols

Leptic Regosols, in the mountain valleys of the plateau with karst on the hard Damara limestone in the Central plateaux, are shallow to moderately deep, moderately coarse to medium textured with few to common coarse fragments and well drained.

Typically the surface layer is 15 to 25 cm thick, loamy sand to loam with few to common coarse fragments of limestone, and dark grey to dark red in colour. Underneath, it appears an horizon 20 to 40 cm thick, very dark greyish brown to dark red in colour, sandy loam to loam with few to common coarse fragments of limestone, and a weak structure. Below underlies the bedrock of limestone.

Leptic-skeletic Regosols and Leptic-chromic Cambisols can appear as inclusions in this positions

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CLg1. leptic Regosols & haplic Regosols & petric Calcisols Complex

This complex consists of soils formed on the gently undulating lowlands of the Central plateaux. It presents leptic Regosols, haplic Regosols and petric Calcisols as dominating soils.

Leptic Regosols are shallow to moderately deep, coarse to moderately coarse textured with many coarse fragments, and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy loam with many coarse fragments of quartz and granite, and dark grey to dark red in colour. Underneath, it appears an horizon 20 to 40 cm thick, very dark greyish brown to dark red in colour, loamy sand to sandy loam with many coarse fragments of quartz, and a weak structure. Below underlies the bedrock of granite.

Haplic Leptosols can appear as inclusions in this map unit.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Haplic Regosols are very deep, coarse to moderately coarse textured with common to many coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with common to many coarse fragments of quartz, and dark brown to yellowish red in colour. Underneath, to a depth of more than 120 cm, we find brown to yellowish red, loamy sand to sandy loam material that presents common to many coarse fragments of quartz, and a weak structure.

These soils present a moderate to moderately rapid hydraulic conductivity and a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Petric Calcisols, in the gently undulating lowlands of the Central plateau, are very shallow, coarse to moderately coarse textured with many coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with many coarse fragments of quartz, and very dark grey to brown in colour. Underneath it appears a petrocalcic horizon formed by cementation of the coarse fragments by calcium carbonate.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the very low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CLh1. rock outcrops & lithic Leptosols Complex

This complex consists of soils formed on the hills and ridges of the lowlands in the Central plateaux. It presents lithic Leptosols as dominating soils, furthermore abundant outcrops of quartzite are present throughout the map unit.

Lithic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments and well drained.

Typically the surface layer is about 10 cm thick, sandy loam to loam with common to many coarse fragments of quartz, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of quartzite, that can also appear exposed on the soil surface.

Leptic-skeletic Regosols can appear as inclusions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the presence of rock outcrops and the steep slopes of this map unit strongly affect the workability of these soils. Moreover, the shallow depth of these soils limits the effective rooting depth and the low water holding capacity restricts the water in the soil that can be readily absorbed by plants. On the other hand, the steep slope of this map unit and the low water holding capacity favour the formation of rills and gullies in the soil.

CLl1. chromic Cambisols

Chromic Cambisols, on the nearly level lowlands of the Central plateaux, are very deep, moderately coarse to moderately fine textured and well drained.

Typically the surface layer is 15 to 25 cm thick, sand loam to sandy clay loam and very dark greyish brown to dusky red in colour. Underneath, to a depth of more than 120 cm, we find brown to red, sandy loam to sandy clay loam material that presents a moderate structure.

Leptic-chromic Cambisols and petric Calcisols can appear as inclusions in this map unit.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate to high water holding capacity.

They present few constraints for agriculture.

CLl2. chromic Cambisols & leptic-chromic Cambisols Association

This association consists of soils formed on the nearly level lowlands of the Central plateaux. It presents chromic Cambisols and leptic-chromic Cambisols as dominating soils.

Chromic Cambisols are very deep, moderately coarse to moderately fine textured and well drained.

Typically the surface layer is 15 to 25 cm thick, sandy loam to sandy clay loam and very dark greyish brown to dusky red in colour. Underneath, to a depth of more than 120 cm, we find brown to red, sandy loam to sandy clay loam material that presents a moderate structure.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate to high water holding capacity.

They present few constraints for agriculture.

Leptic-chromic Cambisols are moderately deep to deep, moderately coarse to medium textured and well drained.

Typically the surface layer is about 20 cm thick, sandy loam to sandy clay loam and very dark greyish brown to dusky red in colour. Underneath, to a depth of 60 to 80 cm, we find brown to red, sandy loam to sandy clay loam material that presents a moderate structure. Below we find the bedrock of quartzite.

Petric Calcisols can appear as inclusions in this map units.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate water holding capacity.

The main constraints for agriculture are the moderate depth than can limit the effective rotting depth of the plants and the moderate water holding capacity that restricts the water in the soils that can be readily absorbed by plants.

CLl3. petric Calcisols & leptic-chromic Cambisols Complex

This complex consists of soils formed on the nearly level lowlands of the Central plateaux. It presents petric Calcisols and leptic-chromic Cambisols as dominating soils.

Petric Calcisols, in the nearly level lowlands of the Central plateaux, are very shallow, moderately coarse to medium textured and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy clay loam, and very dark grey to brown in colour. Underneath, to a depth of 40 to 60 cm we find grey to brown, sandy loam material that presents a moderate structure. Below, it appears a petrocalcic horizon.

These soils have a moderate hydraulic conductivity and present a moderate infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Leptic-chromic Cambisols are moderately deep to deep, moderately coarse to medium textured and well drained. They formed on the nearly level lowlands of the Central plateau.

Typically the surface layer is about 20 cm thick, sandy loam to sandy clay loam and very dark greyish brown to dusky red in colour. Underneath, to a depth of 60 to 80 cm, we find brown to red, sandy loam to sandy clay loam material that presents a moderate structure. Below we find the bedrock of quartzite.

Chromic Cambisols appear as inclusions in this map unit.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate water holding capacity.

The main constraints for agriculture are the moderate depth than can limit the effective rotting depth of the plants and the moderate water holding capacity that restricts the water in the soils that can be readily absorbed by plants.

CPd1. haplic Leptosols & leptic-skeletic Regosols Complex

This complex consists of soils formed on the dissected plateaux fringes of the Central plateaux. It presents haplic Leptosols and leptic-skeletic Regosols as dominating soils.

Haplic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments, and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy clay loam with common to many coarse fragments of quartz and shale, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of shale or quartzite, that can occasionally appear exposed on the soil surface.

These soils have a moderate hydraulic conductivity and present a moderate infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Leptic-skeletic Regosols are shallow to moderately deep, coarse to moderately coarse textured with abundant rock fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with abundant rock fragments of shale, quartz and/or schist, and dark brown to dark red in colour. Underneath, to a depth of 60 to 80 cm, we find brown to yellowish red loamy sand to sandy loam material that presents abundant rock fragments of shale, quartz and/or schist and a weak structure. Below it appears the bedrock of shale, quartzite or schist.

Skeletic Regosols and petric Calcisols appear as inclusions in this map unit.

These soils present a moderate to moderately rapid hydraulic conductivity and a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth, the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the presence of abundant rock fragments that affects the volume of soil effectively explored by the plants and the workability of these soils. On the other hand, the steep slope of the positions where they are located favours the formation of rills and gullies in the soil.

CPk1. petric Calcisols

Petric Calcisols, in the flat plains of the Kalkrand in the Central plateaux, are shallow, coarse to moderately coarse textured, and well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and brown to yellowish red in colour. Below, it appears a petrocalcic horizon.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CPp1. haplic Leptosols

Haplic Leptosols, on the Central plateaux, are very shallow, moderately coarse to medium textured with common to many coarse fragments, and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy loam with common to many coarse fragments of quartz and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of quartzite or shale, that can occasionally appear exposed on the soil surface.

Leptic Regosols can appear as inclusions in these map units.

These soils have a moderate hydraulic conductivity and present a moderate infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and very low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CSd1. ferralic Arenosols

Ferralic Arenosols, in the dunefields of the area with active sand drifts in the Central plateaux, are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and brown to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find a brown to red, sand material showing a very weak structure development.

Arenic-leptic Regosols can appear as inclusions in this map unit.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

CSh1. rock outcrops & lithic Leptosols Complex

This complex consists of soils formed on the hills of the area of active sand drift in the Central plateaux. It presents lithic Leptosols as dominating soils, furthermore abundant outcrops of quartzite, schist and shale are present throughout the map unit..

Lithic Leptosols are very shallow, coarse textured with common to many coarse fragments and well drained.

Typically the surface layer is abiut 10 cm thick, sand with common to many coarse fragments of quartzite, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of quartzite, schist or shale, that can also appear exposed on the soil surface.

Arenic-leptic Regosols can appear as inclusions in these map units.

These soils have a rapid hydraulic conductivity and present a rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the presence of rock outcrops and the steep slope of this map unit that strongly affect the workability of these soils. Moreover, the shallow depth of these soils limits the effective rooting depth and the low water holding capacity restricts the water in the soil that can be readily absorbed by plants. On the other hand, the steep slope of this map unit, the low water holding capacity and the intensity of rain favours the formation of rills and gullies in the soil.

CSp1. arenic-leptic Regosols & haplic Leptosols & ferralic Arenosols Association

This association consists of soils formed on the flat plains with dunes of the area with active sand drift in the Central plateaux. It presents arenic-leptic Regosols, haplic Leptosols and ferralic Arenosols as dominating soils.

Arenic-leptic Regosols are shallow to moderately deep, coarse textured and somewhat excessively drained.

Typically the surface layer is 15 to 25 cm thick, sand to loamy sand and brown to dark reddish brown in colour. Underneath, to a depth of 40 to 60 cm, we find dark brown to yellowish red, sand to loamy sand material showing very weak structure development. Below underlies the bedrock of quartzite, limestone or shale.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the moderately depth that limits the effective rooting depth, the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

Haplic Leptosols are very shallow, coarse textured and somewhat excessively drained.

Typically the surface layer is 10 to 20 cm thick, sand to loamy sand and brown to yellowish red in colour. Below underlies the bedrock of quartzite, limestone or shale.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the very shallow depth that limits the effective rooting depth, the very low water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and brown to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find a brown to red, sand material showing a very weak structure development.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

CTb1. haplic Leptosols & rock outcrops Association

This association consists of soils formed on the structural hills (Brukkaros) of the Central plateaux. It presents haplic Leptosols as dominating soils. Furthermore, many outcrops of shale and quartzite are present throughout the map unit.

Haplic Leptosols are very shallow, moderately coarse to medium textured with few to common coarse fragments, and well drained.

Typically the surface layer is 10 to 20 cm thick, sandy loam to loam with few to common coarse fragments of shale and quartz, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of shale and or quartzite, that can appear exposed on the soil surface.

Leptic Regosols and petric Calcisols can appear as inclusions in this map unit.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. On the other hand, the presence of rock outcrops in this map unit strongly affect the workability of these soils.

EDl1. leptic Regosols & petric Calcisols Association

This association consist of soils formed on the level lowlands of the erosion surface of the degraded escarpment. It presents leptic Regosols and petric Calcisols as dominating soils.

Leptic Regosols are moderately deep to deep, moderately coarse to medium textured with common to many coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy clay loam with common to many coarse fragments of quartz, and very dark greyish brown to yellowish red in colour. Underneath, to a depth of 60 to 80 cm, we find brown to red, loamy sand to sandy loam material that presents common to many coarse fragments of quartz, and a weak structure. Below we find the bedrock of limestone or quartzite.

Leptic-chromic Cambisols and haplic Regosols can appear as inclusions in this map units.

These soils present a moderate to moderately rapid hydraulic conductivity and a moderate to moderately rapid infiltration rate. They have a moderate water holding capacity.

The main constraints for agriculture are the moderate depth than can limit the effective rotting depth of the plants and the moderate water holding capacity that restricts the water in the soils that can be readily absorbed by plants.

Petric Calcisols, formed on the level lowlands of the erosion surfaces of the degraded escarpment are moderately deep, moderately coarse to medium textured with common coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with common coarse fragments of limestone and quartz, and very dark grey to brown in colour. Underneath, to a depth of 40 to 60 cm, we find brown to yellowish red loamy sand to sandy loam material that presents common coarse fragments of limestone and quartzite, and a weak structure. Below it appears a petrocalcic horizon formed the cementation of the coarse fragments by calcium carbonate.

Haplic Calcisols can appear as inclusions in these map units.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

EDp1. haplic Leptosols & leptic-skeletic Regosols & petric Calcisols Complex

This complex consists of soils formed on the erosion surface of the remnant plateau of the escarpment. It presents haplic Leptosol, leptic-skeletic Regosols and petric Calcisols as dominating soils.

Haplic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy clay loam with common to many coarse fragments of basalt and quartzite, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of basalt, gneiss or quartzite that can also appear exposed on the soil surface.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. Moreover, the presence of rock outcrops affects the workability of these soils. On the other hand, the steep slope of the area and the low water holding capacity favour the formation of rills and gullies on the higher parts of the map unit.

Leptic-skeletic Regosols are shallow to moderately deep, coarse to moderately coarse textured with abundant rock fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with abundant rock fragments of quartzite and basalt, and dark brown to dark red in colour. Underneath, to a depth of 40 to 60 cm, we find brown to yellowish red loamy sand to sandy loam material that presents abundant rock fragments of quartzite and basalt, and a weak structure. Below it appears the bedrock of quartzite, gneiss or schist.

Skeletic Regosols and leptic-chromic Cambisols can appear as inclusions in this map unit.

These soils present a moderate to moderately rapid hydraulic conductivity and a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth, the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the presence of abundant coarse fragments that affects the volume of soil effectively explored by the plants and the workability of theses soils.

Petric Calcisols, formed on the erosion surfaces of the remnant plateau of the escarpment, are shallow, moderately coarse to medium textured with common to many coarse fragments and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with common to many coarse fragments of quartzite and basalt and very dark grey to brown in colour. Underneath it appears a petrocalcic horizon formed the cementation of the coarse fragments by calcium carbonate.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the very shallow depth that limits the effective rooting depth and the very low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

EDp2. haplic Leptosols & petric Calcisols & haplic Calcisols Complex

This complex consists of soils formed on the erosion surface of the remnant plateau of the escarpment. It presents haplic Leptosol, petric Calcisols and haplic Calcisols as dominating soils.

Haplic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy clay loam with common to many coarse fragments of qurtzite, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of gneiss or quartzite that can also appear exposed on the soil surface.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. On the other hand, the steep slopes and the low water holding capacity favour the formation of rills and gullies on the higher parts of the map unit.

Petric Calcisols, formed on the erosion surfaces of the remnant plateau of the escarpment, are shallow, moderately coarse to medium textured with common to many coarse fragments and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with common to many coarse fragments of quartzite, and basalt and very dark grey to brown in colour. Underneath it appears a petrocalcic horizon formed the cementation of the coarse fragments by calcium carbonate.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the very shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Haplic Calcisols are very deep, coarse to moderately coarse textured and well drained. They appear on the lower parts of the mountain valleys in the escarpment.

Typically the surface layer is 15 to 25 cm thick, sandy loam to loam and very dark grey to dark yellowish brown in colour. Underneath, to a depth of more than 100 cm, we find dark grey to light yellowish brown, sand to sandy loam material that presents common to many accumulations of discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon.

Hypercalcic Calcisols appear as inclusions in these map units.

These soils have a moderate hydraulic conductivity and present a moderate infiltration rate. They have a moderate water holding capacity.

They present few constraints for agriculture.

EDr1. lithic Leptosols & petric Calcisols Association

This association consist of soils formed on the eroded rolling hills of the degraded escarpment. It presents lithic Leptosols and petric Calcisols as dominating soils.

Lithic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments and well drained.

Typically the surface layer is about 10 cm thick, sandy loam to loam with common to many coarse fragments quartz, quartzite and schist, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of quartzite, gneiss or schist, that can also appear exposed on the soil surface.

Haplic Leptosols can appear as inclusions in this map unit.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth of the plants, the very low water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the presence of rock outcrops that affects the workability of these soil.

Petric Calcisols, formed on the lower parts of the eroded rolling hills of the degraded escarpment, are shallow, moderately coarse to medium textured with abundant coarse fragments and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with abundant coarse fragments of quartzite and schist, and very dark grey to brown in colour. Below it appears a petrocalcic horizon formed the cementation of the coarse fragments by calcium carbonate.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the very shallow depth that limits the effective rooting depth, the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the presence of abundant coarse fragments that reduces the volume of soil that can be effectively explored by the plants and affects the workability of these soils.

EDs1. rock outcrops & leptic Regosols & haplic Regosols Association

This association consists of soils formed on the eroded surface with hills of the escarpment. It presents leptic Regosols and haplic Regosols as dominating soils; furthermore abundant outcrops of granite, gneiss and schist are present throughout the map unit.

Leptic Regosols are shallow to moderately deep, moderately coarse to medium textured with few to common coarse fragments and well drained.

Typically the surface layer is 15 to 25 cm thick, loamy sand to loam with few to common coarse fragments of quartz, and dark grey to dark red in colour. Underneath, we find an horizon 20 to 40 cm thick, very dark greyish brown to dark red in colour, sandy loam to sandy clay loam with few to common rock fragments of quartz, and a weak structure. Below underlies the bedrock of granite, gneiss or schist.

Skeletic Regosols can appear as inclusions in this positions

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. Moreover, the presence of rock outcrops can affect the workability of these soils.

Haplic Regosols are very deep, coarse to moderately coarse textured with common to many coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with common to many coarse fragments of quartz, and dark brown to yellowish red in colour. Underneath, to a depth of more than 120 cm, we find brown to yellowish red loamy sand to sandy loam material that presents common to many coarse fragments of quartz, and a weak structure.

These soils present a moderate to moderately rapid hydraulic conductivity and a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

EHm1. rock outcrops (Brandberg and Erongo mountains)

EHm2. rock outcrops & lithic Leptosols Complex

This complex consists of soils formed on the high mountains in the great escarpment of Namibia. It presents lithic Leptosols as dominating soils, furthermore abundant outcrops of limestone, quartzite and schist are present throughout the map unit.

Lithic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments, and well drained.

Typically the surface layer is about 10 cm thick, sandy loam to loam with common to many coarse fragments of limestone, quartz and/or schist, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of limestone, quartzite or schist, that can also appear exposed on the soil surface.

Leptic-skeletic Regosols and petric Calcisols can appear as inclusions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the presence of rock outcrops and the steep slope of this map unit that strongly affect the workability of these soils. Moreover, the shallow depth of these soils limits the effective rooting depth and the low water holding capacity restricts the water in the soil that can be readily absorbed by plants. On the other hand, the steep slope of this map unit and the low water holding capacity favour the formation of rills and gullies in the soil.

EHp1. haplic Leptosols & leptic-skeletic Regosols & petric Calsisols Association

This association consists of soils formed on the remnants of the plateau in the escarpment. It presents haplic Leptosols, leptic-skeletic Regosols and petric Calcisols as dominating soils.

Haplic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments, and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy clay loam with common to many coarse fragments of basalt and quart, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of basalt, that can also appear exposed on the soil surface.

Lithic Leptosols can appear as inclusions in this map unit.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. Moreover, the presence of rock outcrops affect the workability of these soils. On the other hand, the steep slopes and the low water holding capacity favour the formation of rills and gullies on the higher parts of the map unit.

Leptic-skeletic Regosols are shallow to moderately deep, coarse to moderately coarse textured with abundant rock fragments, and well drained. They formed on the slopes of the remnant plateau in the escarpment.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with abundant rock fragments of limestone, quartz and basalt, and dark brown to dark red in colour. Underneath, to a depth of 60 to 80 cm, we find brown to yellowish red loamy sand to sandy loam material that presents abundant rock fragments of limestone, quartz and basalt, and a weak structure. Below it appears the bedrock of quartzite, gneiss or schist.

Skeletic Regosols appear as inclusions in this map unit.

These soils present a moderate to moderately rapid hydraulic conductivity and a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth, the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the presence of abundant rock fragments that affect the volume of soil effectively explored by the plants and the workability of theses soils.

Petric Calcisols, formed in the gently to undulating lowlands of the remnant plateau in the escarpment, are very shallow, moderately coarse to medium textured with common to many coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with common to many coarse fragments of quartz and basalt, and very dark grey to brown in colour. Underneath it appears a petrocalcic horizon formed the cementation of the coarse fragments by calcium carbonate.

Chromic Luvisols can appear as inclusions on the lower areas of these positions.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the very shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

EHt1. petric Calcisols & lithic Leptosols Association

This association consists of soils formed on the table mountains in the escarpment. It presents petric Calcisols and haplic Leptosols as dominating soils.

Petric Calcisols, formed on the table mountains in the escarpment, are very shallow, moderately coarse to medium textured with abundant coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with abundant coarse fragments of quartz, and very dark grey to brown in colour. Underneath it appears a petrocalcic horizon formed the cementation of the coarse fragments by calcium carbonate.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the very shallow depth that limits the effective rooting depth, low water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the presence of abundant coarse fragments that reduces the volume of soil that can be effectively explored by the plants and affects the workability of these soils.

Lithic Leptosols are very shallow, moderately coarse to medium textured with abundant coarse fragments, and well drained.

Typically the surface layer is about 10 cm thick, sand to loamy sand with abundant coarse fragments of quartzite, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of quartzite, that can also appear exposed on the soil surface.

These soils have moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the very shallow depth that limits the effective rooting depth and the very low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. Moreover, the presence of abundant rock fragments reduces the volume of soil that can be effectively explored by the plants and affects the workability of these soils.

EHv1. petric Calcisols & skeletic Regosols & haplic Calcisols Association

This association consists of soils formed on the mountain valleys in the escarpment. It presents petric Calcisols, skeletic Regosols and haplic Calcisols as dominating soils.

Petric Calcisols, formed on the mountain valleys in the escarpment, are shallow, moderately coarse to medium textured with many to abundant coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with abundant coarse fragments of limestone and quartzite, and very dark grey to brown in colour. Underneath, to a depth of 40 to 60 cm, we find brown to yellowish red loamy sand to sandy loam material that presents abundant rock fragments of limestone and quartzite, and a weak structure. Below it appears a petrocalcic horizon formed the cementation of the coarse fragments by calcium carbonate.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth, the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the presence of abundant coarse fragments that reduces the volume of soil that can be effectively explored by the plants and affects the workability of these soils.

Skeletic Regosols are very deep, coarse to moderately coarse textured with abundant rock fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with abundant rock fragments of limestone, quartzite and/or schist, and dark brown to dark red in colour. Underneath, to a depth of more than 100 cm, we find brown to yellowish red loamy sand to sandy loam material that presents abundant rock fragments of limestone, quartzite and/or schist, and a weak structure.

Leptic-skelteic Regosols appear as inclusions in this map unit.

These soils present a moderately rapid hydraulic conductivity and a moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the presence of abundant rock fragments that reduces the volume of soil that can be effectively explored by the plants and affects the workability of theses soils.

Haplic Calcisols are very deep, coarse to moderately coarse textured with few to common coarse fragments, and moderately well to well drained.

Typically the surface layer is 15 to 25 cm thick, sand to sandy loam with few to common coarse fragments of quartz and limestone, and very dark grey to dark yellowish brown in colour. Underneath, to a depth of more than 100 cm, we find dark grey to light yellowish brown, sand to sandy loam material that presents few to common coarse fragments of quartz and limestone, and common to many accumulations of discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon.

These soils have a moderate hydraulic conductivity and present a moderate infiltration rate. They have a moderate water holding capacity.

They present few constraints for agriculture.

EHv2. haplic Regosols & petric Calcisols & leptic-skeletic Regosols Association

This association consists of soils formed on the mountain valleys in the escarpment. It presents haplic Regosols, petric Calcisols and leptic-skeletic Regosols as dominating soils.

Haplic Regosols are very deep, coarse to moderately coarse textured with common to many coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with common to many coarse fragments of quartz, and dark brown to yellowish red in colour. Underneath, to a depth of more than 120 cm, we find brown to yellowish red loamy sand to sandy loam material that presents common to many coarse fragments of quartz, and a weak structure.

These soils present a moderate to moderately rapid hydraulic conductivity and a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Petric Calcisols, formed on the mountain valleys in the escarpment, are shallow, moderately coarse to medium textured with few to common coarse fragments and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with common to many coarse fragments of limestone and/or quartzite, and very dark grey to brown in colour. Underneath, to a depth of 40 to 60 cm, we find brown to yellowish red loamy sand to sandy loam material that presents common to many coarse fragments of limestone and/or quartzite, and a weak structure. Below it appears a petrocalcic horizon formed the cementation of the coarse fragments by calcium carbonate.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Leptic-skeletic Regosols are shallow to moderately deep deep, coarse to moderately coarse textured with abundant rock fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with abundant rock fragments of limestone and/or quartzite, and dark brown to dark red in colour. Underneath, to a depth of 40 to 60 cm, we find brown to yellowish red loamy sand to sandy loam material that presents abundant rock fragments of limestone and/or quartzite, and a weak structure. Below it appears a bedrock of limestone or quartzite.

Skeletic Regosols appear as inclusions in this map unit.

These soils present a moderately rapid hydraulic conductivity and a moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are moderate depth that limits the effective rooting depth, the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants, and the presence of abundant rock fragments that reduces the volume of soil that can be effectively explored by the plants and affects the and the workability of these soils.

EHv3. leptic-chromic Cambisols & petric Calcisols & haplic Calcisols Association

This association consists of soils formed on the mountain valleys in the escarpment. It presents leptic-chromic Cambisols, petric Calcisols and haplic Calcisols as dominating soils.

Leptic-chromic Cambisols are moderately deep to deep, moderately coarse to medium textured and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy clay loam and very dark greyish brown to dusky red in colour. Underneath, to a depth of 60 to 80 cm, we find brown to red, sandy loam to sandy clay loam material that presents a moderate structure. Below we find the bedrock of limestone, dolomite or quartzite.

Leptic and skeletic Regosols can appear as inclusions in this map units.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate water holding capacity.

The main constraints for agriculture are the moderate depth than can limit the effective rotting depth of the plants and the moderate water holding capacity that restricts the water in the soils that can be readily absorbed by plants.

Petric Calcisols, formed on the mountain valleys in the escarpment, are shallow, moderately coarse to medium textured with few to common coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with few to common coarse fragments of limestone and quartzite, and very dark grey to brown in colour. Underneath, to a depth of 40 to 60 cm, we find brown to yellowish red loamy sand to sandy loam material that presents few to common coarse fragments of limestone and/or quartzite, and a weak structure. Below it appears a petrocalcic horizon formed the cementation of the coarse fragments by calcium carbonate.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Haplic Calcisols are very deep, coarse to moderately coarse textured and well drained.

Typically the surface layer is 15 to 25 cm thick, sandy loam to loam and very dark grey to dark yellowish brown in colour. Underneath, to a depth of more than 100 cm, we find dark grey to light yellowish brown, sand to sandy loam material that presents common to many accumulations of discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon.

Hypercalcic Calcisols appear as inclusions in these map units.

These soils have a moderate hydraulic conductivity and present a moderate infiltration rate. They have a moderate water holding capacity.

They present few constraints for agriculture.

KDf1. ferralic Arenosols & arenic Fluvisols & haplic Calcisols Association

This association consists of soils formed on the areas of fossil sand dunes that are located in the Kalahari region. It presents ferralic Arenosols as dominating soil on the crests and intermediate parts of the dunes, and arenic Fluvisols and haplic Calcisols on the "streets" formed between the longitudinal dunes.

Ferralic Arenosols soils are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand material showing a very weak structure development.

Petric Calcisols can appear as inclusions in this map unit.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

Arenic Fluvisols are very deep, coarse textured and moderately well to well drained.

Typically the soil surface is 15 to 25 cm thick, sandy to loamy sand and very dark grey to brown in colour. Underneath, to a depth of more than 100 cm, we find brown to light yellowish brown, sand to loamy sand material that presents a weak structure.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Haplic Calcisols are very deep, coarse to moderately coarse textured and moderately well to well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and dark grey to grey in colour. Underneath, to a depth of more than 100 cm, we find dark grey to light yellowish brown, sand to sandy loam material that presents a weak structure and common to many accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon.

Petric Calcisols can appear as inclusions in this map unit.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

KDf2. ferralic Arenosols & petric Calcisols Association

This association consists of soils formed on the areas of aligned sand dunes that are located in the Kalahari region. It presents ferralic Arenosols as dominating soil on the crests and intermediate parts of the dunes, and ferralic Arenosols and petric Calcisols on the “streets” formed between the longitudinal dunes.

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and brown to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find a brown to red, sand material showing a very weak structure development.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

Petric Calcisols are shallow to moderately deep, coarse to moderately coarse textured and well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and brown to dark reddish brown in colour. Underneath, to a depth of 30 to 50 cm, we find brown to red, sand to sandy loam material that, sometimes, can present accumulations of calcium carbonate as discontinuous concentrations of hard and/or soft nodules, resulting in a calcic horizon. Below it appears a petrocalcic horizon.

Hypercalcic Calcisols can appear as inclusions on the pans that, occasionally, appear on the area.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

KFd1. haplic Calcisols & sodic Cambisols & haplic Luvisols & ferralic Arenosols Association

This association consists of soils formed on the very dense inflowing stream pattern that constitutes the Cuvelai river in the Kalahari region. It presents haplic Calcisols, sodic Cambisols, haplic Luvisols and ferralic Arenosols as dominating soils.

Haplic Calcisols are very deep, coarse to moderately coarse textured and well drained. They formed on the higher parts of the inter-channels that are located in the very dense inflowing stream pattern that constitutes the Cuvelai river in the Kalahari region.

Typically the surface layer is 15 to 25 cm thick, sand to loamy sand and dark grey to brown in colour. Underneath, to a depth of more than 100 cm, we find very dark greyish brown to light yellowish brown loamy sand to sandy clay loam material that presents a weak structure and many to abundant accumulations of calcium carbonate in a diffuse form dispersed in the matrix or in discontinuous concentrations hard and soft nodules, both resulting in a calcic (occasionally, hypercalcic) horizon.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plant roots.

Sodic Cambisols are very deep, coarse to moderately coarse textured and moderately well to well drained. They formed on the intermediate parts of the inter-channels that are located in the very dense inflowing stream pattern that constitutes the Cuvelai river in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to loamy sand and very dark greyish brown to light brownish grey in colour, loose or with a very weak structure. Underneath, it appears an horizon 20 to 40 cm thick, dark grey to light brownish grey, sand to sandy loam, with a massive or very coarse subangular blocky structure and an extremely hard consistence when dry probably associated with temporarily floodings during the rainy season and the presence of sodium as dominant cation in the soil. Below we find a greyish brown to very pale brown, sandy loam material that presents a weak structure and, occasionally, very few to few accumulations of calcium carbonate and/or gypsum.

Most of the times, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

Calcic Solonetz can appear as inclusions in this positions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Haplic Luvisol are very deep, moderately coarse to moderately fine-textured and imperfectly to moderately well drained. They formed on the lower parts of the inter-channels that are located in the very dense inflowing stream pattern that constitutes the Cuvelai river in the Kalahari region.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam and very dark grey to brown in colour. Underneath, it appears an horizon 20 to 40 cm thick, loamy sand to sandy clay loam, very dark grey to pale brown in colour that presents a weak to moderate structure. Below, to a depth of more than 100 cm, we find very dark grey to light grey, sandy clay loam material that presents a moderate to strong prismatic or angular blocky structure and, most of the times, slickensides and/or shine faces, resulting in an argic horizon.

These soils have a moderately slow to moderate hydraulic conductivity and present a moderate infiltration rate. They have a moderate to moderately high water holding capacity.

The main constraints for agriculture is the position where they are located on the ladscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. Moreover, the hard consistence of the argic horizon, when dry, can limit the root penetration and, therefore, the effective rooting depth.

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained. They formed on the sand banks scattered along the very dense inflowing stream pattern that constitutes the Cuvelai river in the Kalahari region.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to yellowish red in colour. Underneath, to a depth of more than 100 cm, we find dark grey to reddish yellow, sand material showing very weak horizon differentiation.

Hyposalic Arenosols and sodic Cambisols can appear as inclusions at the borders of these positions.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

KFm1. sodic Cambisols & calcic Solonetzs & sodic Calcisols & ferralic Arenosols & natric-calcic Vertisols & natric-gypsic Vertisols Association

This association consists of soils formed on the moderately dense inflowing stream pattern that constitutes the oshana system in the Kalahari region. It presents sodic Cambisols, calcic Solonetzs, sodic Calcisols, ferralic Arenosols, natric-calcic Vertisols and natric-gypsic Vertisols as dominating soils.

Sodic Cambisols are very deep, coarse to moderately coarse textured and moderately well to well drained. They formed on the side slopes of the woodlands that constitutes the oshana system in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to loamy sand and very dark greyish brown to light brownish grey in colour, loose or with a very weak structure. Underneath, it appears an horizon 20 to 40 cm thick, dark grey to light brownish grey, sand to sandy loam, with a massive or very coarse subangular blocky structure and an extremely hard consistence when dry probably associated with temporarily floodings during the rainy season and the presence of sodium as dominant cation in the soil. Below we find a greyish brown to very pale brown, sandy loam material that presents a weak structure and, occasionally, very few to few accumulations of calcium carbonate and/or gypsum.

Most of the times, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Calcic Solonetzs are very deep, moderately coarse to moderately fine-textured and imperfectly to moderately well drained. They formed on the oshanas that constitute the moderately dense inflowing stream pattern in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to sandy loam and black to greyish brown in colour. Underneath, to a depth of more than 100 cm, we find pale yellow to dark grey, sandy clay loam to sandy clay material that presents a moderate to strong prismatic or angular blocky structure and, most of the times, shiny faces and/or slickensides, resulting in a natric horizon because of the sodium that dominates the soil solution and the exchangeable sites. Moreover, this material also presents accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules resulting in a calcic horizon.

These soils have a moderately slow to moderate hydraulic conductivity and present a moderate infiltration rate. They have a moderate to moderately high water holding capacity.

The main constraints for agriculture is the position where they are located on the landscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. On the other hand, the hard consistence of the natric horizon, when dry, can limit the root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity can reduce the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Sodic Calcisols are very deep, coarse to moderately coarse textured and moderately well to well drained. They formed on the woodlands that are located between the dense inflowing streams that constitutes the oshana system in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to loamy sand and very dark grey to olive grey in colour, loose or with a very weak structure. Underneath, it appears an horizon 20 to 40 cm thick, dark grey to brownish grey, sand to sandy loam, with a massive or very coarse subangular blocky structure and an extremely hard consistence when dry, probably associated with temporarily floodings during the rainy season and the presence of sodium as dominating cation in the soil. Below we find a greyish brown to pale yellow, sandy loam material that presents a weak structure and common to many accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules resulting in a calcic horizon.

Occasionally, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained. They formed on the higher parts of the woodlands that are located between the dense inflowing streams that constitutes the oshana system in the Kalahari region.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to yellowish red in colour. Underneath, to a depth of more than 100 cm, we find dark grey to reddish yellow, sand material showing very weak horizon differentiation.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

Natric-calcis Vertisols are very deep, fine textured and poorly to imperfectly drained. They formed on the pans scattered along the dense inflowing streams that constitutes the oshana system in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sandy clay loam to sandy clay and black to dark grey in colour. Underneath, to a depth of more than 100 cm, we find pale yellow to very dark grey, sandy clay material that presents a moderate to strong subangular or angular blocky structure and, in some horizons, intersecting slickensides resulting in a vertic horizon. Moreover, this material also presents accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules resulting in a calcic horizon.

These soils have a slow hydraulic conductivity and present a slow infiltration rate. They have a moderately high to high water holding capacity.

The main constraints for agriculture is the position where they are located on the landscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. On the other hand, the consistence of the soils (hard when dry and sticky when wet) and the expansible character of the clay minerals make them difficult to work. Moreover, the slight to moderate salinity can reduce the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Naric-gypsic Vertisols are very deep, fine textured and poorly to imperfectly drained. They formed on the pans scattered along the dense inflowing streams that constitutes the oshana system in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is between 15 and 25 cm thick, sandy clay loam to sandy clay and black to very dark grey in colour. Underneath, to a depth of more than 100 cm, we find light olive grey to very dark grey, sandy clay material that presents a moderate to strong subangular or angular blocky structure and, in some horizons, intersecting slickensides resulting in a vertic horizon. Moreover, this material also presents accumulations of crystals of gypsum resulting in a gypsic horizon.

These soils have a slow hydraulic conductivity and present a slow infiltration rate. They have a moderately high to high water holding capacity.

The main constraints for agriculture is the position where they are located on the landscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. On the other hand, the consistence of the soils (hard when dry and sticky when wet) and the expansible character of the clay minerals make them difficult to work. Moreover, the slight to moderate salinity can reduce the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

KFp1. hyposalic Arenosols & sodic Cambisols & natric-calcic Vertisols & natric-gypsic Vertisols Association

This association consists of soils formed on some of the flat plains with pans in the Kalahari region. It presents hyposalic Arenosols, sodic Cambisols, natric-calcic Vertisols and natric-gypsic Vertisols as dominating soils.

Hyposalic Arenosols are very deep, coarse textured and imperfectly to moderately well drained. They formed on the higher parts of the flat plains with pans in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is between 15 to 25 cm thick, sand and dark grey to pale brown in colour. Underneath, it appears an horizon 20 to 40 cm thick, sand and greyish brown to light brownish grey in colour, that presents a massive or very coarse subangular blocky structure and an extremely hard consistence when dry associated with temporarily floodings during the rainy season and the presence of sodium as dominating cation in the soil. Below we find a greyish brown to very pale brown sand material showing very weak horizon differentiation.

Most of the times, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

These soils have a rapid to very rapid hydraulic conductivity and present a rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Sodic Cambisols are very deep, coarse to moderately coarse textured and moderately well to well drained. They formed on the higher parts of the flat plains with pans in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to loamy sand and very dark greyish brown to light brownish grey in colour, loose or with a very weak structure. Underneath, it appears an horizon 20 to 40 cm thick, dark grey to light brownish grey, sand to sandy loam, with a massive or very coarse subangular blocky structure and an extremely hard consistence when dry probably associated with temporarily floodings during the rainy season and the presence of sodium as dominating cation in the soil. Below we find a greyish brown to very pale brown, sandy loam material that presents a weak structure and, occasionally, very few to few accumulations of calcium carbonate and/or gypsum.

Most of the times between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Natric-calcic Vertisols are very deep, fine textured and poorly to imperfectly drained. They formed on the on the pans scattered throughout the flat plains in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sandy clay loam to sandy clay and black to dark grey in colour. Underneath, to a depth of more than 100 cm, we find pale yellow to very dark grey, sandy clay material that presents a moderate to strong subangular or angular blocky structure and, in some horizons, intersecting slickensides resulting in a vertic horizon. Moreover, this material also presents accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules resulting in a calcic horizon.

Calcic Solonetz can appear as inclusions in this positions.

These soils have a slow hydraulic conductivity and present a slow infiltration rate. They have a moderately high to high water holding capacity.

The main constraints for agriculture is the position where they are located on the landscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. On the other hand, the consistence of the soils (hard when dry and sticky when wet) and the expansible character of the clay minerals make them difficult to work. Moreover, the slight to moderate salinity can reduce the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Natric-gypsic Vertisols are very deep, fine textured and poorly to imperfectly drained. They formed on the on the pans scattered throughout the flat plains in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is between 15 and 25 cm thick, sandy clay loam to sandy clay and black to very dark grey in colour. Underneath, to a depth of more than 100 cm, we find light olive grey to very dark grey, sandy clay material that presents a moderate to strong subangular or angular blocky structure and, in some horizons, intersecting slickensides resulting in a vertic horizon. Moreover, this material also presents accumulations of crystals of gypsum resulting in a gypsic horizon.

Calcic Solonetzs can appear as inclusions in these positions.

These soils have a slow hydraulic conductivity and present a slow infiltration rate. They have a moderately high to high water holding capacity.

The main constraints for agriculture is the position where they are located on the landscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. On the other hand, the consistence of the soils (hard when dry and sticky when wet) and the expansible character of the clay minerals make them difficult to work. Moreover, the slight to moderate salinity can reduce the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

KFp2. mollic Leptosols & petric Calcisols & hyposalic Arenosols Complex

This complex consists of soils formed on some of the flat plains with pans in the Kalahari region. It presents mollic Leptosols, petric Calcisols and hyposalic Arenosols as dominating soils.

Mollic Leptosols are very shallow, moderately coarse and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy loam and black to very dark brown in colour. It presents a moderate to strong structure. Below it appears the bedrock of limestone.

Leptic-mollic Cambisol can appear as inclusions in this map unit.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Petric Calcisols, in some flat plains with pans in the Kalahari region, are very shallow, moderately coarse to medium textured with few coarse fragments and imperfectly to moderately well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with few coarse fragments and black to very dark grey in colour. Underneath it appears a petrocalcic horizon formed by dissolution and precipitation of the limestone bedrock.

Hypercalcic Calcisols appear as inclusions on the pans

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Hyposalic Arenosols are very deep, coarse textured and imperfectly to moderately well drained.. These soils are slightly to moderately saline and sodic.

Typically the surface layer is between 15 to 25 cm thick, sand and dark grey to pale brown in colour. Underneath, it appears an horizon 20 to 40 cm thick, sand and greyish brown to light brownish grey in colour, that presents a massive or very coarse subangular blocky structure and an extremely hard consistence when dry associated with temporarily floodings during the rainy season and the presence of sodium as dominating cation in the soil. Below we find a greyish brown to very pale brown sand material showing very weak horizon differentiation.

Most of the times, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

These soils have a rapid to very rapid hydraulic conductivity and present a rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

KFv1. arenic Fluvisols & haplic Calcisols Association

This association consists of soils formed on some omurambas and river valleys in the Kalahari region. It presents arenic Fluvisols and haplic Calcisols as dominating soils.

Arenic Fluvisols are very deep, coarse textured and moderately well to well drained.

Typically the soil surface is 15 to 25 cm thick, sandy to loamy sand and very dark grey to brown in colour. Underneath, to a depth of more than 100 cm, we find brown to light yellowish brown, sand to loamy sand material that presents a weak structure.

Haplic Fluvisols can appear as inclusions in this positions.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make some parts of the map unit prone to flooding during the rainy season and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Haplic Calcisols are very deep, coarse to moderately coarse textured and moderately well to well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and dark grey to grey in colour. Underneath, to a depth of more than 100 cm, we find dark grey to light yellowish brown, sand to sandy loam material that presents a weak structure and common to many accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon.

Petric Calcisols can appear as inclusions in this map unit.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make some parts of the map unit prone to flooding during the rainy season and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

KFv2. arenic Fluvisols & ferralic Arenosols Association

This association consists of soils formed on some omurambas and river valleys in the Kalahari region. It presents arenic Fluvisols and ferralic Arenosols as dominating soils.

Arenic Fluvisols are very deep, coarse textured and moderately well to well drained. They formed on the lower parts of the omurambas and river valleys in the Kalahari region.

Typically the soil surface is 15 to 25 cm thick, sandy to loamy sand and very dark grey to brown in colour. Underneath, to a depth of more than 100 cm, we find brown to light yellowish brown, sand to loamy sand material that presents a weak structure.

Haplic Luvisols and haplic Fluvisols can appear as inclusions in this positions.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make some parts of the map unit prone to flooding during the rainy season and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained. They formed on the side slopes of the omurambas and river valleys in the Kalahari region.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand materials showing a very weak structure development.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

KFv3. mollic Leptosols & petric Calcisols & arenic Fluvisols Association

This association consists of soils formed on the omurambas and river valleys formed on the border of the Kalahari region and the plateaux with karst on hard Damara limestone in the Central Plateau. It presents mollic Leptosols and petric Calcisols as dominating soils on the higher parts of the omurambas, and arenic Fluvisols as dominating soils on the lower parts.

Mollic Leptosols are very shallow, moderately coarse and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy loam and black to very dark brown in colour. It presents a moderate to strong structure. Below it appears the bedrock of limestone.

Leptic-mollic Cambisols can appear as inclusions in this positions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Petric Calcisols are shallow to moderately deep, coarse to moderately coarse textured and well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and very dark brown to dark greyish brown. Underneath, to a depth of 30 to 50 cm, we find very dark greyish brown to light olive brown, sand to sandy loam material that, sometimes, can present accumulations of calcium carbonate as discontinuous concentrations of hard and/or soft nodules, resulting in a calcic horizon. Below it appears a petrocalcic horizon.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make them prone to flooding during the rainy season, the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Arenic Fluvisols are very deep, coarse textured and moderately well to well drained.

Typically the soil surface is 15 to 25 cm thick, sandy to loamy sand and very dark grey to brown in colour. Underneath, to a depth of more than 100 cm, we find brown to light yellowish brown, sand to loamy sand material that presents a weak structure.

Haplic Luvisols and haplic Fluvisols can appear as inclusions in this positions.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make some parts of the map unit prone to flooding during the rainy season and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

KFv4. petric Calcisols & haplic Calcisols Association

This association consists of soils formed on some omurambas and river valleys in the Kalahari region. It presents petric Calcisols and haplic Calcisols as dominating soils.

Petric Calcisols are shallow to moderately deep, coarse to moderately coarse textured and well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and very dark brown to dark greyish brown. Underneath, to a depth of 30 to 50 cm, we find very dark greyish brown to light olive brown, sand to sandy loam material that, sometimes, can present accumulations of calcium carbonate as discontinuous concentrations of hard and/or soft nodules, resulting in a calcic horizon. Below it appears a petrocalcic horizon.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make them prone to flooding during the rainy season, the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Haplic Calcisols are very deep, coarse to moderately coarse textured and moderately well to well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and dark grey to grey in colour. Underneath, to a depth of more than 100 cm, we find dark grey to light yellowish brown, sand to sandy loam material that presents a weak structure and common to many accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon.

Ferralic Arenosols can appear as inclusions in these map units.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make some parts of the map unit prone to flooding during the rainy season and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

KFv5. fluvic Cambisols & haplic Fluvisols & ferralic Arenosols Complex

This complex consists of soils formed on some river valleys in the Kalahari region. It presents fluvic Cambisols, haplic Fluvisols and ferralic Arenosols as dominating soils.

Fluvic Cambisols are very deep, coarse to moderately coarse textured and moderately well to well drained.

Typically the soil surface is about 20 cm thick, sand to sandy loam and dark greyish brown to yellowish brown in colour. Underneath, to a depth of more than 100 cm, we find greyish brown to yellowish red, loamy sand to sandy loam material than presents a moderate structure.

Haplic Calcisols and arenic Fluvisols can appear as inclusions in this positions.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make some parts of the map unit prone to flooding during the rainy season and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Haplic Fluvisols are very deep, coarse to moderately coarse textured and moderately well to well drained.

Typically the soil surface is about 20 cm thick, sand to sandy loam and very dark grey to dark reddish brown in colour. Underneath, to a depth of more than 100 cm, we find very dark greyish brown to dusky red, loamy sand to sandy loam material than presents a weak structure.

Arenic Fluvisols and haplic Calcisols can appear as inclusions in this positions.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make some parts of the map unit prone to flooding during the rainy season and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand materials showing a very weak structure development.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

KFv6. arenic Fluvisols & fluvic Cambisols Complex

This complex consists of soils formed on some river valleys in the Kalahari region. It presents arenic Fluvisols and fluvic Cambisols as dominating soils.

Arenic Fluvisols are very deep, coarse textured and moderately well to well drained.

Typically the soil surface is 15 to 25 cm thick, sandy to loamy sand and very dark grey to brown in colour. Underneath, to a depth of more than 100 cm, we find brown to light yellowish brown, sand to loamy sand material that presents a weak structure.

Haplic Calcisols can appear as inclusions in this positions.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make some parts of the map unit prone to flooding during the rainy season and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Fluvic Cambisols are very deep, coarse to moderately coarse textured and moderately well to well drained.

Typically the soil surface is about 20 cm thick, sand to sandy loam and dark greyish brown to yellowish brown in colour. Underneath, to a depth of more than 100 cm, we find greyish brown to yellowish red, loamy sand to sandy loam material than presents a moderate structure.

Haplic Calcisols and haplic Luvisols can appear as inclusions in this positions.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make some parts of the map unit prone to flooding during the rainy season and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

KHh1. rock outcrops & arenic-leptic Regosols & ferralic Arenosols Association

This association consists of soils formed on the north-eastern hills that are located in the Kalahari region. It presents arenic-leptic Regosols and ferralic Arenosols as dominating soils; on the other hand, many rock outcrops are present throughout the map unit.

Arenic-leptic Regosols are shallow to moderately deep, coarse textured and somewhat excessively drained. They formed on the side slopes of the north-eastern hills that are located in the Kalahari basin.

Typically the surface layer is 15 to 25 cm thick, sand to loamy sand and brown to dark reddish brown in colour. Underneath, to a depth of 40 to 60 cm, we find dark brown to yellowish red, sand to loamy sand material showing very weak structure development. Below underlies the bedrock.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the moderately depth that limits the effective rooting depth, the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients. Moreover, the presence of rock outcrops and the steep slopes of this map unit affect the workability of these soils.

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained. They formed on the lower parts or the north-eastern hills that are located in the Kalahari basin.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand material showing a very weak structure development.

Petric Calcisols can appear as inclusions in this map unit.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

KHm1. ferralic Arenosols

Ferralic Arenosols, in the area of relict meanders located in the Kalahari region, are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand material showing a very weak structure development.

Arenic-leptic Regosols can appear as inclusions in this map unit.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

KHm2. Arenic-leptic Regosols

Arenic-leptic Regosols, in the area of relict meanders located in the Kalahari basin, are shallow to moderately deep, coarse textured and somewhat excessively drained.

Typically the surface layer is 15 to 25 cm thick, sand to loamy sand and brown to dark reddish brown in colour. Underneath, to a depth of 40 to 60 cm, we find dark brown to yellowish red, sand to loamy sand material showing very weak structure development. Below underlies the bedrock of quartzite.

Ferralic arenosols can appear as inclusions in this map unit.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the moderately depth that limits the effective rooting depth, the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

KHp1. Rock outcrops & petric Calcisols & arenic-leptic Regosols & leptic-chromic Cambisols & ferralic Arenosols Complex

This complex consists of soils formed on the hummocky plains that are located in the Kalahari region. It presents petric Calcisol, arenic-leptic Regosols, leptic-chromic Cambisols and ferralic Arenosols as dominating soils; furthermore, common rock outcrops are present throughout the map unit.

Petric Calcisols, in the hummocky plains of the Kalahari basin, are shallow to moderately deep, coarse to moderately coarse textured and well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and very dark brown to dark reddish brown. Underneath, to a depth of 40 to 80 cm, we find very dark brown to yellowish red, sand to sandy loam material that, sometimes, can present accumulations of calcium carbonate as discontinuous concentrations of hard and/or soft nodules, resulting in a calcic horizon. Below it appears a petrocalcic horizon.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Arenic-leptic Regosols are shallow to moderately deep, coarse textured and somewhat excessively drained.

Typically the surface layer is 15 to 25 cm thick, sand to loamy sand and brown to dark reddish brown in colour. Underneath, to a depth of 40 to 60 cm, we find dark brown to yellowish red, sand to loamy sand material showing very weak structure development. Below underlies the bedrock.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the moderately depth that limits the effective rooting depth, the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients. Moreover, the presence of rock outcrops and the steep slopes of this map unit affect the workability of these soils.

Leptic-chromic Cambisols are moderately deep to deep, moderately coarse to medium textured and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy clay loam and very dark greyish brown to dusky red in colour. Underneath, to a depth of 60 to 80 cm, we find brown to red, sandy loam to sandy clay loam material that presents a moderate structure. Below we find the limestone bedrock.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate water holding capacity.

The main constraints for agriculture are the moderate depth than can limit the effective rotting depth of the plants and the moderate water holding capacity that restricts the water in the soils that can be readily absorbed by plants.

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand material showing a very weak structure development.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

KSa1. ferralic Arenosols

Ferralic Arenosols, in the sand deposits with aligned dunes located in the Kalahari region, are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and brown to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find a brown to red, sand material showing a very weak structure development.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

KSa2. ferralic Arenosols & petric Calcisols Association

This association consists of soils formed on the sand deposits with aligned dunes that are located in the Kalahari region. It presents ferralic Arenosols and petric Calcisols as dominating soils.

Ferralic Arenosols, in the dunes of the sand deposits with aligned dunes that are located in the Kalahari region, are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and brown to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find a brown to red, sand material showing a very weak structure development.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

Petric Calcisols, in the lower areas of the sand deposits with aligned dunes located in the Kalahari region, are shallow, coarse to moderately coarse textured and well drained.

Typically the surface layer is about 20 cm thick, sand to loamy sand and dark brown to reddish brown in colour. Underneath, to a depth of 40 to 60 cm, we find a brown to red, sand material showing a very weak structure development. Below, it appears a petrocalcic horizon.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the very low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

KSd1. ferralic Arenosols

Ferralic Arenosols, in the sand deposits that are located in the Kalahari region, are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand material showing a very weak structure development.

Petric Calcisols can appear as inclusions in this map unit.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

KSd2. petric Calcisols & ferralic Arenosols Association

This association consists of soils formed on the sand deposits that are located in the Kalahari region. It presents petric Calcisols and ferralic Arenosols as dominating soils.

Petric Calcisols, in the sand deposits located in the Kalahari region, are shallow to moderately deep, coarse to moderately coarse textured and well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and very dark brown to dark reddish brown. Underneath, to a depth of 40 to 80 cm, we find very dark brown to yellowish red, sand to sandy loam material that, sometimes, can present accumulations of calcium carbonate as discontinuous concentrations of hard and/or soft nodules, resulting in a calcic horizon. Below it appears a petrocalcic horizon.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Ferralic Arenosols, in the sand deposits that are located in the Kalahari region, are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand material showing a very weak structure development.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

KSd3. ferralic Arenosols & sodic Calcisols & sodic Cambisols Association

This association consists of soils formed on the sand deposits that are located in the Kalahari region. It presents ferralic Arenosols, sodic Calcisols and sodic Cambisols as dominating soils.

Ferralic Arenosols, in the sand deposits that are located in the Kalahari region, are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand material showing a very weak structure development.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

Sodic Cambisols are very deep, coarse to moderately coarse textured and moderately well to well drained. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to loamy sand and very dark greyish brown to light brownish grey in colour, loose or with a very weak structure. Underneath, it appears an horizon 20 to 40 cm thick, dark grey to light brownish grey, sand to sandy loam, with a massive or very coarse subangular blocky structure and an extremely hard consistence when dry probably associated with temporarily floodings during the rainy season and the presence of sodium as dominant cation in the soil. Below we find a greyish brown to very pale brown, sandy loam material that presents a weak structure and, occasionally, very few to few accumulations of calcium carbonate and/or gypsum.

Most of the times, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

Calcic Solonetz can appear as inclusions in this positions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Sodic Calcisols are very deep, coarse to moderately coarse textured and moderately well to well drained. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to loamy sand and very dark grey to olive grey in colour, loose or with a very weak structure. Underneath, it appears an horizon 20 to 40 cm thick, dark grey to brownish grey, sand to sandy loam, with a massive or very coarse subangular blocky structure and an extremely hard consistence when dry, probably associated with temporarily floodings during the rainy season and the presence of sodium as dominating cation in the soil. Below we find a greyish brown to pale yellow, sandy loam material that presents a weak structure and common to many accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules resulting in a calcic horizon.

Occasionally, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

KSp1. ferralic Arenosols & petric Calcisols Association

This association consists of soils formed on the sand deposits with pans that are located in the Kalahari region. It presents ferralic Arenosols and petric Calcisols as dominating soils.

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand material showing a very weak structure development.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

Petric Calcisols are shallow to moderately deep, coarse to moderately coarse textured and well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and very dark brown to dark greyish brown. Underneath, to a depth of 30 to 50 cm, we find very dark greyish brown to light olive brown, sand to sandy loam material that, sometimes, can present accumulations of calcium carbonate as discontinuous concentrations of hard and/or soft nodules, resulting in a calcic horizon. Below it appears a petrocalcic horizon.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make them prone to flooding during the rainy season, the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

KSp2. petric Calcisols

Petric Calcisols, on the sand deposits with pans in the Kalahrai basin, are shallow, coarse to moderately coarse textured and well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and very dark brown to dark greyish brown. Underneath, to a depth of 30 to 50 cm, we find very dark greyish brown to light olive brown, sand to sandy loam material that, sometimes, can present accumulations of calcium carbonate as discontinuous concentrations of hard and/or soft nodules, resulting in a calcic horizon. Below it appears a petrocalcic horizon.

Ferralic Arenosols can appear as inclusions in these map units.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. Moreover, the lower positions of this map unit are prone to flooding during the rainy season.

KSp3. sodic Calcisols & ferralic Arenosols & petric Calcisols Association

This association consists of soils formed on the sand deposits with pans that are located in the Kalahari region. It presents sodic Calcisols, ferralic Arenosols and petric Calcisols as dominating soil.

Sodic Calcisols are very deep, coarse to moderately coarse textured and moderately well to well drained. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to loamy sand and very dark grey to olive grey in colour, loose or with a very weak structure. Underneath, it appears an horizon 20 to 40 cm thick, dark grey to brownish grey, sand to sandy loam, with a massive or very coarse subangular blocky structure and an extremely hard consistence when dry, probably associated with temporarily floodings during the rainy season and the presence of sodium as dominating cation in the soil. Below we find a greyish brown to pale yellow, sandy loam material that presents a weak structure and common to many accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules resulting in a calcic horizon.

Occasionally, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Ferralic Arenosols soils are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand material showing a very weak structure development.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

Petric Calcisols, on the sand deposits with pans in the Kalahrai basin, are shallow, coarse to moderately coarse textured and well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and very dark brown to dark greyish brown. Underneath, to a depth of 30 to 50 cm, we find very dark greyish brown to light olive brown, sand to sandy loam material that, sometimes, can present accumulations of calcium carbonate as discontinuous concentrations of hard and/or soft nodules, resulting in a calcic horizon. Below it appears a petrocalcic horizon.

Hypercalcic Calcisols can appear as inclusions in these map units.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. Moreover, the lower positions of this map unit are prone to flooding during the rainy season.

NDa1. active sand

NDh1. rock outcrops-active sand Complex

NPc1. rock outcrops & lithic Leptosols Complex

This complex consists of soils formed on the river canyons of the Namib desert pavement. It presents lithic Leptosols as dominating soils; furthermore, abundant outcrops of gneiss, quartzite and schist are present throughout the map unit.

Lithic Leptosols are very shallow, moderately coarse to medium textured with abundant coarse fragments and well drained.

Typically the surface layer is about 10 cm thick, sandy loam to loam with abundant coarse fragments of quartz, quartzite and schist, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of gneiss, quartzite or schist, that can also appear exposed on the soil surface.

Leptic-skeletic Regosols can appear as inclusions in this map unit.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the presence of rock outcrops and the steep slope of this map unit that strongly affect the workability of these soils. Moreover, the shallow depth of these soils limits the effective rooting depth and the very low water holding capacity restricts the water in the soil that can be readily absorbed by plants. On the other hand, the steep slope of this map unit and the low water holding capacity favour the formation of rills and gullies in the soil.

NPc2. rock outcrops & haplic Leptosols & petric Calcisols Association

This association consists of soils formed on the river canyons of the Namib desert pavement. It presents haplic Leptosols and petric Calcisols as dominating soils, furthermore abundant outcrops of gneiss, quartzite and schist are present throughout the map unit.

Haplic Leptosols are shallow, moderately coarse to medium textured with common to many coarse fragments and well drained.

Typically the surface layer is 10 to 20 cm thick, sandy loam to loam with many to abundant coarse fragments and dark greyish brown to dark reddish brown in colour.

Below underlies the bedrock of gneiss, quartzite or schist, that can also appear exposed on the soil surface.

Leptic-skeletic Regosols can appear as inclusions in this pam unit.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow depth of these soils that limits the effective rooting depth and the very low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. Moreover, the presence of rock outcrops and the steep slope of this map unit strongly affect the workability of these soils.

Petric Calcisols, in the river canyons formed on the Namib desert pavements are very shallow, moderately coarse to medium textured with few coarse fragments and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with many to abundant coarse fragments of gneiss, quartzite and schist and very dark grey to brown in colour. Underneath it appears a petrocalcic horizon formed by cementation of the abundant coarse fragments by calcium carbonate.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

NPh1. granite outcrops

NPh2. rock outcrops & lithic Leptosols Complex

This complex consists of soils formed on the hills of the Namib desert pavement. It presents lithic Leptosols as dominating soils; furthermore, abundant outcrops of granite, quartzite and schist are present throughout the map unit.

Lithic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments and well drained.

Typically the surface layer is about 10 cm thick, sandy loam to loam with many to abundant coarse fragments of quartz, quartzite and schist, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of granite, quartzite or schist, that can also appear exposed on the soil surface.

Leptic-skeletic Regosols can appear as inclusions in this map unit.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the presence of rock outcrops and the steep slope of this map unit that strongly affect the workability of these soils. Moreover, the shallow depth of these soils limits the effective rooting depth and the very low water holding capacity restricts the water in the soil that can be readily absorbed by plants. On the other hand, the steep slope of this map unit and the low water holding capacity favour the formation of rills and gullies in the soil.

NPp1. petric Calcisols & haplic Leptosols Association

This association consists of soils formed on the gravel pavement of the Namib desert. It presents petric Calcisols and haplic Leptosols as dominating soils.

Petric Calcisols, in the gravel pavement formed on the Namib desert are very shallow, moderately coarse to medium textured with few coarse fragments and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with many to abundant coarse fragments of quartz, gneiss, quartzite and/or schist and very dark grey to brown in colour. Underneath it appears a petrocalcic horizon formed by cementation of the abundant coarse fragments by calcium carbonate.

Skeletic Regosols appear as inclusions in this map units.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Haplic Leptosols are shallow, moderately coarse to medium textured with common to many coarse fragments and well drained.

Typically the surface layer is 10 to 20 cm thick, sandy loam to loam with common to many coarse fragments of quartz, quartzite and/or schist, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of gneiss, quartzite or schist, that can also appear exposed on the soil surface.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

NPp2. petric Gypsisols & haplic Gypsisols Association

This association consists of soils formed on the gravel pavement of the Namib desert. It presents petric Gypsisols and haplic Gypsisols as dominating soils.

Petric Gypsisol are shallow to moderately deep, coarse to moderately coarse with common to many coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with many to abundant coarse fragments of quartz and very dark grey to brown in colour. Underneath, to a depth of 40 to 60 cm we find dark grey to brown, loamy sand to sandy loam material that presents many to abundant coarse fragments of quartz, gneiss and/or schist and common to many accumulations of crystals of gypsum, resulting in a gypsic horizon. Below, it appears a petrogypsic horizon formed by cementation of the abundant coarse fragments by gypsum.

Petrosalic and other lower categoric levels of Solonchaks appear as inclusions in the coastal salt plains comprised in these map units.

These soils have a moderately rapid to rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. On the other hand, the high contents of gypsum that present this soils can cause some adverse effect in crop growth, mainly, attributed to cation imbalance.

Haplic Gypsisols are very deep, coarse to moderately coarse textured with common to many coarse fragments of quartz, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with common to many coarse fragments of quartz, and dark brown to yellowish red in colour. Underneath, to a depth of more than 120 cm, we find brown to yellowish red loamy sand to sandy loam material that presents common to many coarse fragments of quartz and common to many accumulations of crystals of gypsum, resulting in a gypsic horizon.

These soils present a moderately rapid hydraulic conductivity and a moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

NPp3. haplic Regosols & petric Calcisols & leptic Regosols Association

This association consists of soils formed on the gravel pavement of the Namib desert. It presents haplic Regosols, petric Calcisols and leptic Regosols as dominating soils.

Haplic Regosols are very deep, coarse to moderately coarse textured with common to many coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with common to many coarse fragments of quartz, and dark brown to yellowish red in colour. Underneath, to a depth of more than 120 cm, we find brown to yellowish red loamy sand to sandy loam material that presents common to many coarse fragments of quartz, and a weak structure.

These soils present a moderately rapid hydraulic conductivity and a moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Petric Calcisols, in the gravel pavement formed on the Namib desert are shallow to moderately deep, coarse to moderately coarse textured with many coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with many to abundant coarse fragments of quartz, and very dark grey to brown in colour. Underneath, to a depth of 40 to 60 cm, we find dark grey to yellowish red material that presents many coarse fragments of quartz and, occasionally, few to common accumulations of discontinuous concentrations of soft nodules, resulting in a calcic horizon. Below, it appears a petrocalcic horizon formed by cementation of the abundant coarse fragments of quartz by calcium carbonate.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Leptic Regosols, in the gravel pavement formed on the Namib desert are shallow to moderately deep, coarse to moderately coarse textured with many coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with many coarse fragments of quartz, and very dark grey to brown in colour. Underneath, to a depth of 40 to 60 cm, we find dark grey to yellowish red material that presents many coarse fragments of quartz, and a weak structure. Below, it appears the bedrock of granite and/or gneiss.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

NPt1. haplic Gypsisols & petric Gypsisols Association

This association consists of soils formed on the river terraces of the Namib desert. It presents haplic Gypsisols and petric Gypsisols as dominating soils.

Haplic Gypsisols are very deep, coarse to moderately coarse textured with many to abundant coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with common to many coarse fragments of quartz, and dark brown to yellowish red in colour. Underneath, to a depth of more than 120 cm, we find brown to yellowish red loamy sand to sandy loam material that presents common to many coarse fragments of quartz and common to many accumulations of crystals of gypsum, resulting in a gypsic horizon.

Haplic Regosols can appear as inclusions in this map unit.

These soils present a moderately rapid hydraulic conductivity and a moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Petric Gypsisol are shallow to moderately deep, coarse to moderately coarse with common to many coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with many to abundant coarse fragments of quartz and very dark grey to brown in colour. Underneath, to a depth of 40 to 60 cm we find dark grey to brown, loamy sand to sandy loam material that presents many to abundant coarse fragments of quartz, gneiss and/or schist and common to many accumulations of crystals of gypsum, resulting in a gypsic horizon. Below, it appears a petrogypsic horizon formed by cementation of the abundant coarse fragments by gypsum.

These soils have a moderately rapid to rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. On the other hand, the high contents of gypsum that present this soils can cause some adverse effect in crop growth, mainly, attributed to cation imbalance.

5.1. Location of the study area

The study area roughly comprises the areas with a growing period 2 and 3 in Namibia (de Pauw, 1996) and covers, to a large extent, the regions of Kunene, Omusati, Oshana, Ohangwena, Oshikoto, Kavango, Otjozondjupa and Omaheke (Figure 5.1).

Two land divisions, defined as areas denoting a continental structure within a climate zone, can be distinguished: the Plateau and the Kalahari basin.

Each of these land divisions is made up of different land provinces that are areas adjacent or in close proximity in the same lithological association. In this way, the Plateau contains plateaux on hard limestone and plateaux with ridges, and the Kalahari basin presents hills and ridges, fossil sand dunes, sand deposits and flooded and overflowing areas.

Each land province is divided into land regions which are the areas having similar lithology and surface form. The legend of this soil survey identifies these provinces.

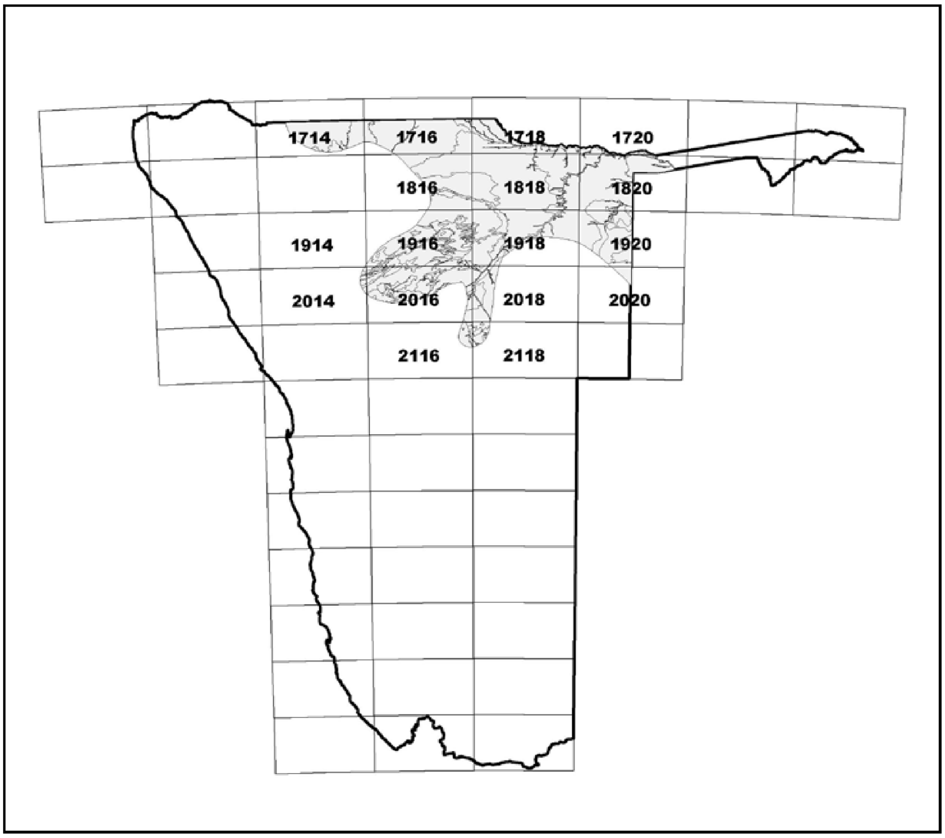


Figure 5.1. Location of the study area

5.2.1. Legend of the soil map (1:250.000) of the areas with a growing period 2 and 3.

C. Central Plateau

CK. Karst on hard Damara limestone

CKh. Hill and ridges

CKh1. rock outcrops & haplic Leptosols & leptic Regosols Complex

CKv. Mountain valleys

CKv1. chromic Luvisols & leptic-chromic Cambisols Association

CKv2. Leptic Regosols

CKf. Footslopes

CKf1. chromic Cambisols & haplic Regosols Association

CKf2. Leptic Regosols

CKg. Gently undulating lowlands

CKg1. chromic Cambisols & leptic Regosols & petric Calcisols Complex

CKl. Level lowlands

CKl1. mollic Leptosols & petric Calcisols Complex

CKl2. chromic Cambisols & leptic Regosols Complex

CKp. Level lowlands with pans

CKp1. mollic Leptosols & petric Calcisols & haplic Calcisols Association

CKt. Terraces

CKt1. petric Calcisols & haplic Calcisols Association

CKt2. Petric Calcisols

CP. Plateau with ridges in the plateau country

CPg. Gently undulating lowlands

CPg1. haplic Regosols & leptic Regosols Complex

CPl. Level lowlands

CPl1. chromic Cambisols & leptic-chromic Cambisols Complex

CPl2. arenic Regosols & petric Calcisols Complex

CPv. Valleys

CPv1. petric Calcisols

K. The Kalahari Region

KH. Hills in the Kalahari basin

KHh. North-eastern hills in the Kalahari basin

KHh1. Rock outcrops & arenic-leptic Regosols & ferralic Arenosols Complex

KHp. Hummocky plains

KHp1. Rock outcrops & arenic-leptic Regosols & leptic-chromic Cambisols
Complex

KD. Fossil sand dunes of the Kalahari Region

KDf. Fossil sand dunes

KDf1. ferralic Arenosols & arenic Fluvisols & haplic Calcisols Association

KS. Sand deposits

KSd. Sand deposits

KSd1. ferralic Arenosols

KSd2. petric Calcisols & ferralic Arenosols Association

KSp. Sand deposits with pans

KSp1. ferralic Arenosols & petric Calcisols Association

KF. Flooded and overflooded areas in the Kalahari Region

KFv. Omuramba and River valleys in the Kalahari sand

KFv1. arenic Fluvisols & haplic Calcisols Association

KFv2. petric Calcisols & haplic Calcisols Complex

KFv3. mollic Leptosols & petric Calcisol & arenic Fluvisols Association

KFv4. fluvic Cambisols & haplic Fluvisols & ferralic Arenosols Complex

KFv5. fluvic Cambiols & haplic Fluvisols Complex

KFv6. arenic Fluvisols & ferralic Arenosols Association

KFm. Moderately dense inflowing stream pattern

KFm1. Sodic Cambisols & Calcic Solonetzs & sodic Calcisols &ferralic Arenosols & natric-calcic Vertisols & natric-gypsic Vertisols Association

KFd. Very dense inflowing stream pattern

KFd1. haplic Calcisols & sodic Cambisols & haplic Luvisols & ferralic Arenosols Association

KFp. Flat plains with pans

KFp1. hyposalic Arenosols & sodic Cambisols & natric-calcic Vertisols & natric-gypsic Vertisols Association

KFp2. mollic Leptosols & petric Calcisols & hyposalic Arenosols Complex

5.2.2. Description of the map units

CKf1. chromic Cambisols & haplic Regosols Association

This association consists of soils formed on the footslopes of the hills and ridges of the plateau with karst on the hard Damara limestone in the Central plateaux. It presents chromic Cambisols and haplic Regosols as dominating soils.

Chromic Cambisols are very deep, moderately coarse to moderately fine textured and well drained.

Typically the surface layer is 15 to 25 cm thick, loamy sand to sandy clay loam and very dark greyish brown to dusky red in colour. Underneath, to a depth of more than 120 cm, we find brown to red, sandy loam to sandy clay loam material that presents a moderate structure.

Haplic Cambisols and haplic Regosols can appear as inclusions in this map units.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate to high water holding capacity.

They present few constraints for agriculture.

Haplic Regosols are very deep, coarse to moderately coarse textured with common to many coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with common to many coarse fragments of quartz, and dark brown to yellowish red in colour. Underneath, to a depth of more than 120 cm, we find brown to yellowish red, loamy sand to sandy loam material that presents common to many coarse fragments of quartz, and a weak structure.

These soils present a moderate to moderately rapid hydraulic conductivity and a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CKf2. leptic Regosol

Leptic Regosols, on the footslopes of the hills and ridges of the plateau with karst on the hard Damara limestone in the Central plateaux, are shallow to moderately deep, moderately coarse to medium textured with few to common coarse fragments and well drained.

Typically the surface layer is 15 to 25 cm thick, loamy sand to loam with few to common coarse fragments of limestone, and dark grey to dark red in colour. Underneath, it appears an horizon 20 to 40 cm thick, very dark greyish brown to dark red in colour, sandy loam to loam with few to common coarse fragements of limestone, and a weak structure. Below underlies the bedrock of limestone.

Leptic-skeletic Regosols and Leptic-chromic Cambisols can appear as inclusions in this positions

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CKg1. chromic Cambisols & leptic Regosols & petric Calcisols Complex

This complex consists of soils formed on the gently undulating lowlands of the plateau with karst on the hard Damara limestone in the Central plateaux. It presents chromic Cambisols, leptic Regosols and petric Calcisols as dominating soils.

Chromic Cambisols are very deep, moderately coarse to moderately fine textured and well drained.

Typically the surface layer is 15 to 25 cm thick, loamy sand to sandy clay loam and very dark greyish brown to dusky red in colour. Underneath, to a depth of more than 120 cm, we find brown to red, sandy loam to sandy clay loam material that presents a moderate structure.

Haplic Regosols and chromic Luvisols can appear as inclusions in this map units.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate to high water holding capacity.

They present few constraints for agriculture.

Leptic Regosols are shallow to moderately deep, moderately coarse to medium textured with few to common coarse fragments and well drained.

Typically the surface layer is 15 to 25 cm thick, loamy sand to loam with few to common coarse fragments of limestone, and dark grey to dark red in colour. Underneath, it appears an horizon 20 to 40 cm thick, very dark greyish brown to dark red in colour, sandy loam to loam with few to common coarse fragments of limestone, and a weak structure. Below underlies the bedrock of limestone.

Leptic-skeletic Regosols and leptic-chromic Cambisols and can appear as inclusions in this positions

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Petric Calcisols, in the gently undulating lowlands formed on the plateau with karst on the hard Damara limestone in the Central plateau, are very shallow, moderately coarse to medium textured with few coarse fragments and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with few coarse fragments of limestone, and very dark grey to brown in colour. Underneath it appears a petrocalcic horizon formed by dissolution and precipitation of the calcium carbonate present in the bedrock of limestone.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the very low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CKh1. rock outcrops & haplic Leptosols & leptic Regosols Complex

This complex consists of soils formed on the hills and ridges of the plateau with karst on the hard Damara limestone in the Central plateaux. It presents haplic Leptosols and leptic Regosols as dominating soils; on the other hand, many outcrops of limestone are present throughout the map unit.

Haplic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments, and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy clay loam with common to many coarse fragments of limestone, and dark greyish brown to dark reddish brown in colour. Below underlies the limestone bedrock, that can also appear exposed on the soil surface.

Leptic-skeletic Regosols can appear as inclusions in this positions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the steep slope of this map unit and the presence of rock outcrops that strongly affect the workability of these soils. Moreover, the shallow depth of these soils limits the effective rooting depth and the low water holding capacity restricts the water in the soil that can be readily absorbed by plants. On the other hand, the steep slope of this map unit and the low water holding capacity favour the formation of rills and gullies in the soil.

Leptic Regosols are shallow to moderately deep, moderately coarse to medium textured with few to common coarse fragments and well drained.

Typically the surface layer is 15 to 25 cm thick, loamy sand to loam with few to common coarse fragments of limestone, and dark grey to dark red in colour. Underneath, it appears an horizon 20 to 40 cm thick, very dark greyish brown to dark red in colour, sandy loam to loam with few to common coarse fragments of limestone, and a weak structure. Below underlies the bedrock of limestone.

Leptic-skeletic Regosols and leptic-chromic Cambisols and can appear as inclusions in this positions

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CKl1. mollic Leptosols & petric Calcisols Complex

This complex consists of soils formed on the level lowlands of the plateau with karst on the hard Damara limestone in the Central plateaux. It presents mollic Leptosols and petric Calcisols as dominating soils.

Mollic Leptosols are very shallow, moderately coarse and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy loam and black to very dark brown in colour. It presents a moderate to strong structure. Below it appears the bedrock of limestone.

Leptic-mollic Cambisols can appear as inclusions in this positions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Petric Calcisols, in the level lowlands of the plateau with karst on the hard Damara limestone in the Central plateaux, are very shallow, moderately coarse to medium textured with few coarse fragments and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with few coarse fragments of limestone, and black to very dark grey in colour. Underneath it appears a petrocalcic horizon formed by dissolution and precipitation of the calcium carbonate present in the bedrock of limestone.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CKl2. Chromic Cambisols & leptic Regosols Complex

This complex consists of soils formed on the level lowlands of the plateau with karst on the hard Damara limestone in the Central plateaux. It presents chromic Cambisols and leptic Regosols as dominating soils.

Chromic Cambisols are very deep, moderately coarse to moderately fine textured and well drained.

Typically the surface layer is 15 to 25 cm thick, loamy sand to sandy clay loam and very dark greyish brown to dusky red in colour. Underneath, to a depth of more than 120 cm, we find brown to red, sandy loam to sandy clay loam material that presents a moderate structure.

Ferralic Arenosols and leptic-chromic Cambisols can appear as inclusions in this map units.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate to high water holding capacity.

They present few constraints for agriculture.

Leptic Regosols are shallow to moderately deep, moderately coarse to medium textured with few to common coarse fragments and well drained.

Typically the surface layer is 15 to 25 cm thick, loamy sand to loam with few to common coarse fragments of limestone, and dark grey to dark red in colour. Underneath, it appears an horizon 20 to 40 cm thick, very dark greyish brown to dark red in colour, sandy loam to loam with few to common coarse fragments of limestone, and a weak structure. Below underlies the bedrock of limestone.

Leptic-chromic Cambisols and can appear as inclusions in this positions

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CKp1. mollic Leptosols & petric Calcisols & hypercalcic Calcisols Association

This association consists of soils formed on the level lowlands with pans of the plateau with karst on the hard Damara limestone in the Central plateaux. It presents mollic Leptosols, petric Calcisols and hypercalcic Calcisols as dominating soils.

Mollic Leptosols are very shallow, moderately coarse and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy loam and black to very dark brown in colour. It presents a moderate to strong structure. Below it appears the bedrock of limestone.

Leptic-mollic Cambisols and haplic Leptosols can appear as inclusions in this positions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Petric Calcisols, in the level lowlands with pans of the plateaux with karst on the hard Damara limestone in the Central plateau, are very shallow, moderately coarse to medium textured with few coarse fragments and imperfectly to well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with few coarse fragments of limestone and black to very dark grey in colour. Underneath it appears a petrocalcic horizon formed by dissolution and precipitation of the calcium carbonate presented in the bedrock of limestone.

In the petric Calcisols that appear on the pans, below the petrocalcic horizon most of the times can appear an hypercalcic horizon.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants. Moreover, in the pans, the low position where the soils are located in the landscape, make these soils prone to flooding during and after the rainy season.

Hypercalcic Calcisols are deep to very deep, moderately coarse to moderately fine textured and poorly to imperfectly drained. They formed on the pans of the level lowlands with pans of the areas with karst on hard Damara limestone in the Central plateau.

Typically the surface layer is 15 to 25 cm thick, loamy sand to loam and black to brown. Underneath, to a depth of more than 100 cm, we find grey to very pale brown, sandy loam to sandy clay loam material that presents abundant to dominant accumulations of continuous concentrations of calcium carbonate that make disappear most of the structure, resulting in a hypercalcic horizon.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate water holding capacity.

The main constraints for agriculture are the low positions where they are located that make them prone to flooding during the rainy season and the high contents of calcium carbonate that can cause nutritional deficiencies and/or toxicity for certain crops.

CKt1. petric Calcisols & haplic Calcisols Association

This association consists of soils formed on the terraces of the plateau with karst on the hard Damara limestone in the Central plateaux. It presents petric Calcisols and haplic Calcisols as dominating soils.

Petric Calcisols, formed in the terraces on the plateau with karst on the hard Damara limestone in the Central plateaux, are shallow, moderately coarse textured with common to many coarse fragments and well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam with many coarse fragments of limestone and schist, and very dark grey to dark brown. Underneath, it appears a petrocalcic horizon formed by cementation of coarse fragments by calcium carbonate.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a very low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Haplic Calcisols are very deep, moderately coarse to medium textured and well drained.

Typically the surface layer is 15 to 25 cm thick, sandy loam to silty loam and very dark grey to dark yellowish brown in colour. Underneath, to a depth of more than 100 cm, we find dark grey to light yellowish brown, sandy loam to silty sandy loam material that presents common to many accumulations of discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon.

These soils have a moderate hydraulic conductivity and present a moderate infiltration rate. They have a moderate water holding capacity.

These soils present few constraints form agriculture.

CKt2. petric Calcisols

Petric Calcisols, formed in the terraces on areas plateaux with karst on the hard Damara limestone in the Central plateau, are shallow to moderately deep, coarse to moderately coarse textured with common to many coarse fragments, and well drained.

Typically the surface layer is about 20 cm thick, sandy loam to loam with many coarse fragments of limestone and quartz, and very dark grey to dark brown. Underneath, to a depth of 40 to 80 cm, we find very dark greyish brown to brown, sandy loam to loam material that present common to many coarse fragments of limestone and quartz, and sometimes, accumulations of calcium carbonate as discontinuous concentrations of hard and/or soft nodules, resulting in a calcic horizon. Below it appears a petrocalcic horizon formed by cementation of coarse fragments by calcium carbonate.

Haplic Calcisols can appear as inclusions in this map units.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CKv1. chromic Luvisols & leptic-chromic Cambisols Association

This association consists of soils formed on the mountain valleys of the plateau with karst on the hard Damara limestone in the Central plateaux. It presents chromic Luvisols and leptic-chromic Cambisols as dominating soils.

Chromic Luvisols are very deep, moderately coarse to moderately fine textured and moderately well drained to well drained.

Typically the surface layer is about 20 cm thick, sandy loam to sandy clay loam and very dark greyish brown to yellowish red in colour. Underneath, to a depth of more than 100 cm, we find brown to dark red, sandy loam to sandy clay material that presents a moderate to strong prismatic or angular blocky structure and, most of the times, slickensides and/or shiny faces, resulting in an argic horizon.

These soils have a moderately slow to moderate hydraulic conductivity and present a moderate infiltration rate. They have a moderate to moderately high water holding capacity.

The hard consistence, when dry, of the argic horizon can be a minor constraintst for agriculture because can limit the root penetration and, therefore, the effective rooting depth.

Leptic-chromic Cambisols are moderately deep to deep, moderately coarse to medium textured and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy clay loam and very dark greyish brown to dusky red in colour. Underneath, to a depth of 60 to 80 cm, we find brown to red, sandy loam to sandy clay loam material that presents a moderate structure. Below we find the bedrock of limestone.

Leptic and leptic-skeletic Regosols can appear as inclusions in this map units.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate water holding capacity.

The main constraints for agriculture are the moderate depth than can limit the effective rotting depth of the plants and the moderate water holding capacity that restricts the water in the soils that can be readily absorbed by plants.

CKv2. leptic Regosols

Leptic Regosols, in the mountain valleys of the plateau with karst on the hard Damara limestone in the Central plateaux, are shallow to moderately deep, moderately coarse to medium textured with few to common coarse fragments and well drained.

Typically the surface layer is 15 to 25 cm thick, loamy sand to loam with few to common coarse fragments of limestone, and dark grey to dark red in colour. Underneath, it appears an horizon 20 to 40 cm thick, very dark greyish brown to dark red in colour, sandy loam to loam with few to common coarse fragments of limestone, and a weak structure. Below underlies the bedrock of limestone.

Leptic-skeletic Regosols and Leptic-chromic Cambisols can appear as inclusions in this positions

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CPg1. haplic Leptosols & leptic Regosols Complex

This complex consists of soils formed on the gently undulating lowlands of the plateau with ridges in the Central plateaux. It presents haplic Leptosols and leptic Regosols as dominating soils.

Haplic Leptosols are very shallow, moderately coarse to medium textured with common to many coarse fragments, and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy clay loam with common coarse fragments of quartz, and dark greyish brown to dark reddish brown in colour. Below underlies the bedrock of quartzite or schist.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Leptic Regosols are shallow to moderately deep, coarse to moderately coarse textured with few to common rock fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with few to common coarse fragments of quartz, and dark brown to dark red in colour. Underneath, to a depth of 40 to 60 cm, we find brown to yellowish red loamy sand to sandy loam material that presents few to common rock fragments of quartz and/or schist and a weak structure. Below it appears the bedrock of quartzite or schist.

Petric Calcisols can appear as inclusions in this map unit.

These soils present a moderate to moderately rapid hydraulic conductivity and a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CPl1. chromic Cambisols & leptic-chromic Cambisols Complex

This complex consists of soils formed on the nearly level lowlands of the plateau with ridges in the Central plateaux. It presents chromic Cambisols and leptic-chromic Cambisols as dominating soils.

Chromic Cambisols are very deep, moderately coarse to moderately fine textured and well drained.

Typically the surface layer is 15 to 25 cm thick, sandy loam to sandy clay loam and very dark greyish brown to dusky red in colour. Underneath, to a depth of more than 120 cm, we find brown to red, sandy loam to sandy clay loam material that presents a moderate structure.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate to high water holding capacity.

They present few constraints for agriculture.

Leptic-chromic Cambisols are moderately deep to deep, moderately coarse to medium textured and well drained.

Typically the surface layer is about 20 cm thick, sandy loam to sandy clay loam and very dark greyish brown to dusky red in colour. Underneath, to a depth of 60 to 80 cm, we find brown to red, sandy loam to sandy clay loam material that presents a moderate structure. Below we find the bedrock of quartzite.

Petric Calcisols can appear as inclusions in this map units.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate water holding capacity.

The main constraints for agriculture are the moderate depth than can limit the effective rotting depth of the plants and the moderate water holding capacity that restricts the water in the soils that can be readily absorbed by plants.

CPl2. leptic Regosols & petric Calcisols Complex

This complex consists of soils formed on the level lowlands of the plateau with ridges in the Central plateaux. It presents leptic Regosols and petric Calcisols as dominating soils.

Leptic Regosols are shallow to moderately deep, coarse to moderately coarse textured with few to common rock fragments, and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam with few to common coarse fragments of quartz, and dark brown to dark red in colour. Underneath, to a depth of 40 to 60 cm, we find brown to yellowish red loamy sand to sandy loam material that presents few to common rock fragments of quartz and/or schist and a weak structure. Below it appears the bedrock of quartzite or schist.

These soils present a moderate to moderately rapid hydraulic conductivity and a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Petric Calcisols, on the level lowlands of the plateau with ridges in the Central plateaux, are very shallow, moderately coarse to medium textured and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy clay loam, and very dark grey to brown in colour. Underneath, to a depth of 40 to 60 cm we find grey to brown, sandy loam material that presents a moderate structure. Below, it appears a petrocalcic horizon.

These soils have a moderate hydraulic conductivity and present a moderate infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

CLv1. petric Calcisols

Petric Calcisols, formed on the small valleys of the plateau with ridges in the Central plateaux, are very shallow, moderately coarse to medium textured and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy clay loam, and very dark grey to brown in colour. Underneath, to a depth of 40 to 60 cm we find grey to brown, sandy loam material that presents a moderate structure. Below, it appears a petrocalcic horizon.

These soils have a moderate hydraulic conductivity and present a moderate infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

KDf1. ferralic Arenosols & arenic Fluvisols & haplic Calcisols Association

This association consists of soils formed on the areas of fossil sand dunes that are located in the Kalahari region. It presents ferralic Arenosols as dominating soil on the crests and intermediate parts of the dunes, and arenic Fluvisols and haplic Calcisols on the “streets” formed between the longitudinal dunes.

Ferralic Arenosols soils are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand material showing a very weak structure development.

Petric Calcisols can appear as inclusions in this map unit.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

Arenic Fluvisols are very deep, coarse textured and moderately well to well drained.

Typically the soil surface is 15 to 25 cm thick, sandy to loamy sand and very dark grey to brown in colour. Underneath, to a depth of more than 100 cm, we find brown to light yellowish brown, sand to loamy sand material that presents a weak structure.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Haplic Calcisols are very deep, coarse to moderately coarse textured and moderately well to well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and dark grey to grey in colour. Underneath, to a depth of more than 100 cm, we find dark grey to light yellowish brown, sand to sandy loam material that presents a weak structure and common to many accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon.

Petric Calcisols can appear as inclusions in this map unit.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

KFd1. haplic Calcisols & sodic Cambisols & haplic Luvisols & ferralic Arenosols Association

This association consists of soils formed on the very dense inflowing stream pattern that constitutes the Cuvelai river in the Kalahari region. It presents haplic Calcisols, sodic Cambisols, haplic Luvisols and ferralic Arenosols as dominating soils.

Haplic Calcisols are very deep, coarse to moderately coarse textured and well drained. They formed on the higher parts of the inter-channels that are located in the very dense inflowing stream pattern that constitutes the Cuvelai river in the Kalahari region.

Typically the surface layer is 15 to 25 cm thick, sand to loamy sand and dark grey to brown in colour. Underneath, to a depth of more than 100 cm, we find very dark greyish brown to light yellowish brown loamy sand to sandy clay loam material that presents a weak structure and many to abundant accumulations of calcium carbonate in a diffuse form dispersed in the matrix or in discontinuous concentrations hard and soft nodules, both resulting in a calcic (occasionally, hypercalcic) horizon.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plant roots.

Sodic Cambisols are very deep, coarse to moderately coarse textured and moderately well to well drained. They formed on the intermediate parts of the inter-channels that are located in the very dense inflowing stream pattern that constitutes the Cuvelai river in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to loamy sand and very dark greyish brown to light brownish grey in colour, loose or with a very weak structure. Underneath, it appears an horizon 20 to 40 cm thick, dark grey to light brownish grey, sand to sandy loam, with a massive or very coarse subangular blocky structure and an extremely hard consistence when dry probably associated with temporarily floodings during the rainy season and the presence of sodium as dominant cation in the soil. Below we find a greyish brown to very pale brown, sandy loam material that presents a weak structure and, occasionally, very few to few accumulations of calcium carbonate and/or gypsum.

Most of the times, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

Calcic Solonetz can appear as inclusions in this positions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Haplic Luvisol are very deep, moderately coarse to moderately fine-textured and imperfectly to moderately well drained. They formed on the lower parts of the inter-channels that are located in the very dense inflowing stream pattern that constitutes the Cuvelai river in the Kalahari region.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam and very dark grey to brown in colour. Underneath, it appears an horizon 20 to 40 cm thick, loamy sand to sandy clay loam, very dark grey to pale brown in colour that presents a weak to moderate structure. Below, to a depth of more than 100 cm, we find very dark grey to light grey, sandy clay loam material that presents a moderate to strong prismatic or angular blocky structure and, most of the times, slickensides and/or shine faces, resulting in an argic horizon.

These soils have a moderately slow to moderate hydraulic conductivity and present a moderate infiltration rate. They have a moderate to moderately high water holding capacity.

The main constraints for agriculture is the position where they are located on the ladscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. Moreover, the hard consistence of the argic horizon, when dry, can limit the root penetration and, therefore, the effective rooting depth.

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained. They formed on the sand banks scattered along the very dense inflowing stream pattern that constitutes the Cuvelai river in the Kalahari region.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to yellowish red in colour. Underneath, to a depth of more than 100 cm, we find dark grey to reddish yellow, sand material showing very weak horizon differentiation.

Hyposalic Arenosols and sodic Cambisols can appear as inclusions at the borders of these positions.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

KFm1. sodic Cambisols & calcic Solonetzs & sodic Calcisols & ferralic Arenosols & natric-calcic Vertisols & natric-gypsic Vertisols Association

This association consists of soils formed on the moderately dense inflowing stream pattern that constitutes the oshana system in the Kalahari region. It presents sodic Cambisols, calcic Solonetzs, sodic Calcisols, ferralic Arenosols, natric-calcic Vertisols and natric-gypsic Vertisols as dominating soils.

Sodic Cambisols are very deep, coarse to moderately coarse textured and moderately well to well drained. They formed on the side slopes of the woodlands that constitutes the oshana system in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to loamy sand and very dark greyish brown to light brownish grey in colour, loose or with a very weak structure. Underneath, it appears an horizon 20 to 40 cm thick, dark grey to light brownish grey, sand to sandy loam, with a massive or very coarse subangular blocky structure and an extremely hard consistence when dry probably associated with temporarily floodings during the rainy season and the presence of sodium as dominant cation in the soil. Below we find a greyish brown to very pale brown, sandy loam material that presents a weak structure and, occasionally, very few to few accumulations of calcium carbonate and/or gypsum.

Most of the times, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Calcic Solonetzs are very deep, moderately coarse to moderately fine-textured and imperfectly to moderately well drained. They formed on the oshanas that constitute the moderately dense inflowing stream pattern in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to sandy loam and black to greyish brown in colour. Underneath, to a depth of more than 100 cm, we find pale yellow to dark grey, sandy clay loam to sandy clay material that presents a moderate to strong prismatic or angular blocky structure and, most of the times, shiny faces and/or slickensides, resulting in a natric horizon because of the sodium that dominates the soil solution and the exchangeable sites. Moreover, this material also presents accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules resulting in a calcic horizon.

These soils have a moderately slow to moderate hydraulic conductivity and present a moderate infiltration rate. They have a moderate to moderately high water holding capacity.

The main constraints for agriculture is the position where they are located on the landscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. On the other hand, the hard consistence of the natric horizon, when dry, can limit the root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity can reduce the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Sodic Calcisols are very deep, coarse to moderately coarse textured and moderately well to well drained. They formed on the woodlands that are located between the dense inflowing streams that constitutes the oshana system in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to loamy sand and very dark grey to olive grey in colour, loose or with a very weak structure. Underneath, it appears an horizon 20 to 40 cm thick, dark grey to brownish grey, sand to sandy loam, with a massive or very coarse subangular blocky structure and an extremely hard consistence when dry, probably associated with temporarily floodings during the rainy season and the presence of sodium as dominating cation in the soil. Below we find a greyish brown to pale yellow, sandy loam material that presents a weak structure and common to many accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules resulting in a calcic horizon.

Occasionally, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained. They formed on the higher parts of the woodlands that are located between the dense inflowing streams that constitutes the oshana system in the Kalahari region.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to yellowish red in colour. Underneath, to a depth of more than 100 cm, we find dark grey to reddish yellow, sand material showing very weak horizon differentiation.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

Natric-calcis Vertisols are very deep, fine textured and poorly to imperfectly drained. They formed on the pans scattered along the dense inflowing streams that constitutes the oshana system in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sandy clay loam to sandy clay and black to dark grey in colour. Underneath, to a depth of more than 100 cm, we find pale yellow to very dark grey, sandy clay material that presents a moderate to strong subangular or angular blocky structure and, in some horizons, intersecting slickensides resulting in a vertic horizon. Moreover, this material also presents accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules resulting in a calcic horizon.

These soils have a slow hydraulic conductivity and present a slow infiltration rate. They have a moderately high to high water holding capacity.

The main constraints for agriculture is the position where they are located on the landscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. On the other hand, the consistence of the soils (hard when dry and sticky when wet) and the expansible character of the clay minerals make them difficult to work. Moreover, the slight to moderate salinity can reduce the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Naric-gypsic Vertisols are very deep, fine textured and poorly to imperfectly drained. They formed on the pans scattered along the dense inflowing streams that constitutes the oshana system in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is between 15 and 25 cm thick, sandy clay loam to sandy clay and black to very dark grey in colour. Underneath, to a depth of more than 100 cm, we find light olive grey to very dark grey, sandy clay material that presents a moderate to strong subangular or angular blocky structure and, in some horizons, intersecting slickensides resulting in a vertic horizon. Moreover, this material also presents accumulations of crystals of gypsum resulting in a gypsic horizon.

These soils have a slow hydraulic conductivity and present a slow infiltration rate. They have a moderately high to high water holding capacity.

The main constraints for agriculture is the position where they are located on the landscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. On the other hand, the consistence of the soils (hard when dry and sticky when wet) and the expansible character of the clay minerals make them difficult to work. Moreover, the slight to moderate salinity can reduce the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

KFp1. hyposalic Arenosols & sodic Cambisols & natric-calcic Vertisols & natric-gypsic Vertisols Association

This association consists of soils formed on some of the flat plains with pans in the Kalahari region. It presents hyposalic Arenosols, sodic Cambisols, natric-calcic Vertisols and natric-gypsic Vertisols as dominating soils.

Hyposalic Arenosols are very deep, coarse textured and imperfectly to moderately well drained. They formed on the higher parts of the flat plains with pans in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is between 15 to 25 cm thick, sand and dark grey to pale brown in colour. Underneath, it appears an horizon 20 to 40 cm thick, sand and greyish brown to light brownish grey in colour, that presents a massive or very coarse subangular blocky structure and an extremely hard consistence when dry associated with temporarily floodings during the rainy season and the presence of sodium as dominating cation in the soil. Below we find a greyish brown to very pale brown sand material showing very weak horizon differentiation.

Most of the times, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

These soils have a rapid to very rapid hydraulic conductivity and present a rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Sodic Cambisols are very deep, coarse to moderately coarse textured and moderately well to well drained. They formed on the higher parts of the flat plains with pans in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to loamy sand and very dark greyish brown to light brownish grey in colour, loose or with a very weak structure. Underneath, it appears an horizon 20 to 40 cm thick, dark grey to light brownish grey, sand to sandy loam, with a massive or very coarse subangular blocky structure and an extremely hard consistence when dry probably associated with temporarily floodings during the rainy season and the presence of sodium as dominating cation in the soil. Below we find a greyish brown to very pale brown, sandy loam material that presents a weak structure and, occasionally, very few to few accumulations of calcium carbonate and/or gypsum.

Most of the times between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Natric-calcic Vertisols are very deep, fine textured and poorly to imperfectly drained. They formed on the on the pans scattered throughout the flat plains in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sandy clay loam to sandy clay and black to dark grey in colour. Underneath, to a depth of more than 100 cm, we find pale yellow to very dark grey, sandy clay material that presents a moderate to strong subangular or angular blocky structure and, in some horizons, intersecting slickensides resulting in a vertic horizon. Moreover, this material also presents accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules resulting in a calcic horizon.

Calcic Solonetz can appear as inclusions in this positions.

These soils have a slow hydraulic conductivity and present a slow infiltration rate. They have a moderately high to high water holding capacity.

The main constraints for agriculture is the position where they are located on the landscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. On the other hand, the consistence of the soils (hard when dry and sticky when wet) and the expansible character of the clay minerals make them difficult to work. Moreover, the slight to moderate salinity can reduce the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Natric-gypsic Vertisols are very deep, fine textured and poorly to imperfectly drained. They formed on the on the pans scattered throughout the flat plains in the Kalahari region. These soils are slightly to moderately saline and sodic.

Typically the surface layer is between 15 and 25 cm thick, sandy clay loam to sandy clay and black to very dark grey in colour. Underneath, to a depth of more than 100 cm, we find light olive grey to very dark grey, sandy clay material that presents a moderate to strong subangular or angular blocky structure and, in some horizons, intersecting slickensides resulting in a vertic horizon. Moreover, this material also presents accumulations of crystals of gypsum resulting in a gypsic horizon.

Calcic Solonetzs can appear as inclusions in these positions.

These soils have a slow hydraulic conductivity and present a slow infiltration rate. They have a moderately high to high water holding capacity.

The main constraints for agriculture is the position where they are located on the landscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. On the other hand, the consistence of the soils (hard when dry and sticky when wet) and the expansible character of the clay minerals make them difficult to work. Moreover, the slight to moderate salinity can reduce the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

KFp2. mollic Leptosols & petric Calcisols & hyposalic Arenosols Complex

This complex consists of soils formed on some of the flat plains with pans in the Kalahari region. It presents mollic Leptosols, petric Calcisols and hyposalic Arenosols as dominating soils.

Mollic Leptosols are very shallow, moderately coarse and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy loam and black to very dark brown in colour. It presents a moderate to strong structure. Below it appears the bedrock of limestone.

Leptic-mollic Cambisol can appear as inclusions in this map unit.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Petric Calcisols, in some flat plains with pans in the Kalahari region, are very shallow, moderately coarse to medium textured with few coarse fragments and imperfectly to moderately well drained.

Typically the surface layer is about 20 cm thick, loamy sand to loam with few coarse fragments and black to very dark grey in colour. Underneath it appears a petrocalcic horizon formed by dissolution and precipitation of the limestone bedrock.

Hypercalcic Calcisols appear as inclusions on the pans

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Hyposalic Arenosols are very deep, coarse textured and imperfectly to moderately well drained.. These soils are slightly to moderately saline and sodic.

Typically the surface layer is between 15 to 25 cm thick, sand and dark grey to pale brown in colour. Underneath, it appears an horizon 20 to 40 cm thick, sand and greyish brown to light brownish grey in colour, that presents a massive or very coarse subangular blocky structure and an extremely hard consistence when dry associated with temporarily floodings during the rainy season and the presence of sodium as dominating cation in the soil. Below we find a greyish brown to very pale brown sand material showing very weak horizon differentiation.

Most of the times, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

These soils have a rapid to very rapid hydraulic conductivity and present a rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

KFv1. arenic Fluvisols & haplic Calcisols Association

This association consists of soils formed on some omurambas and river valleys in the Kalahari region. It presents arenic Fluvisols and haplic Calcisols as dominating soils.

Arenic Fluvisols are very deep, coarse textured and moderately well to well drained.

Typically the soil surface is 15 to 25 cm thick, sandy to loamy sand and very dark grey to brown in colour. Underneath, to a depth of more than 100 cm, we find brown to light yellowish brown, sand to loamy sand material that presents a weak structure.

Haplic Fluvisols can appear as inclusions in this positions.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make some parts of the map unit prone to flooding during the rainy season and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Haplic Calcisols are very deep, coarse to moderately coarse textured and moderately well to well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and dark grey to grey in colour. Underneath, to a depth of more than 100 cm, we find dark grey to light yellowish brown, sand to sandy loam material that presents a weak structure and common to many accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon.

Petric Calcisols can appear as inclusions in this map unit.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make some parts of the map unit prone to flooding during the rainy season and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

KFv2. petric Calcisols & haplic Calcisols Complex

This complex consists of soils formed on some omurambas and river valleys in the Kalahari region. It presents petric Calcisols and haplic Calcisols as dominating soils.

Petric Calcisols are shallow to moderately deep, coarse to moderately coarse textured and well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and very dark brown to dark greyish brown. Underneath, to a depth of 30 to 50 cm, we find very dark greyish brown to light olive brown, sand to sandy loam material that, sometimes, can present accumulations of calcium carbonate as discontinuous concentrations of hard and/or soft nodules, resulting in a calcic horizon. Below it appears a petrocalcic horizon.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that makes them prone to flooding during the rainy season, the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Haplic Calcisols are very deep, coarse to moderately coarse textured and moderately well to well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and dark grey to grey in colour. Underneath, to a depth of more than 100 cm, we find dark grey to light yellowish brown, sand to sandy loam material that presents a weak structure and common to many accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon.

Ferralic Arenosols can appear as inclusions in these map units.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that makes some parts of the map unit prone to flooding during the rainy season and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

KFv3. mollic Leptosols & petric Calcisols & arenic Fluvisols Association

This association consists of soils formed on the omurambas and river valleys formed on the border of the Kalahari region and the plateaux with karst on hard Damara limestone in the Central Plateau. It presents mollic Leptosols and petric Calcisols as dominating soils on the higher parts of the omurambas, and arenic Fluvisols as dominating soils on the lower parts.

Mollic Leptosols are very shallow, moderately coarse and well drained.

Typically the surface layer is 10 to 20 cm thick, loamy sand to sandy loam and black to very dark brown in colour. It presents a moderate to strong structure. Below it appears the bedrock of limestone.

Leptic-mollic Cambisols can appear as inclusions in this positions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Petric Calcisols are shallow to moderately deep, coarse to moderately coarse textured and well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and very dark brown to dark greyish brown. Underneath, to a depth of 30 to 50 cm, we find very dark greyish brown to light olive brown, sand to sandy loam material that, sometimes, can present accumulations of calcium carbonate as discontinuous concentrations of hard and/or soft nodules, resulting in a calcic horizon. Below it appears a petrocalcic horizon.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make them prone to flooding during the rainy season, the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Arenic Fluvisols are very deep, coarse textured and moderately well to well drained.

Typically the soil surface is 15 to 25 cm thick, sandy to loamy sand and very dark grey to brown in colour. Underneath, to a depth of more than 100 cm, we find brown to light yellowish brown, sand to loamy sand material that presents a weak structure.

Haplic Luvisols and haplic Fluvisols can appear as inclusions in this positions.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make some parts of the map unit prone to flooding during the rainy season and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

KFv4. fluvic Cambisols & haplic Fluvisols & ferralic Arenosols Complex

This complex consists of soils formed on some river valleys in the Kalahari region. It presents fluvic Cambisols, haplic Fluvisols and ferralic Arenosols as dominating soils.

Fluvic Cambisols are very deep, coarse to moderately coarse textured and moderately well to well drained.

Typically the soil surface is about 20 cm thick, sand to sandy loam and dark greyish brown to yellowish brown in colour. Underneath, to a depth of more than 100 cm, we find greyish brown to yellowish red, loamy sand to sandy loam material than presents a moderate structure.

Haplic Calcisols and arenic Fluvisols can appear as inclusions in this positions.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make some parts of the map unit prone to flooding during the rainy season and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Haplic Fluvisols are very deep, coarse to moderately coarse textured and moderately well to well drained.

Typically the soil surface is about 20 cm thick, sand to sandy loam and very dark grey to dark reddish brown in colour. Underneath, to a depth of more than 100 cm, we find very dark greyish brown to dusky red, loamy sand to sandy loam material than presents a weak structure.

Arenic Fluvisols and haplic Calcisols can appear as inclusions in this positions.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make some parts of the map unit prone to flooding during the rainy season and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand materials showing a very weak structure development.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

KFv5. fluvic Cambisols & haplic Fluvisols Complex

This complex consists of soils formed on some river valleys in the Kalahari region. It presents fluvic Cambisols and haplic Fluvisols as dominating soils.

Fluvic Cambisols are very deep, coarse to moderately coarse textured and moderately well to well drained.

Typically the soil surface is about 20 cm thick, sand to sandy loam and dark greyish brown to yellowish brown in colour. Underneath, to a depth of more than 100 cm, we find greyish brown to yellowish red, loamy sand to sandy loam material than presents a moderate structure.

Haplic Calcisols and arenic Fluvisols can appear as inclusions in this positions.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make some parts of the map unit prone to flooding during the rainy season and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Haplic Fluvisols are very deep, coarse to moderately coarse textured and moderately well to well drained.

Typically the soil surface is about 20 cm thick, sand to sandy loam and very dark grey to dark reddish brown in colour. Underneath, to a depth of more than 100 cm, we find very dark greyish brown to dusky red, loamy sand to sandy loam material than presents a weak structure.

Arenic Fluvisols and haplic Calcisols can appear as inclusions in this positions.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make some parts of the map unit prone to flooding during the rainy season and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

KFv6. arenic Fluvisols & ferralic Arenosols Association

This association consists of soils formed on some omurambas and river valleys in the Kalahari region. It presents arenic Fluvisols and ferralic Arenosols as dominating soils.

Arenic Fluvisols are very deep, coarse textured and moderately well to well drained. They formed on the lower parts of the omurambas and river valleys in the Kalahari region.

Typically the soil surface is 15 to 25 cm thick, sandy to loamy sand and very dark grey to brown in colour. Underneath, to a depth of more than 100 cm, we find brown to light yellowish brown, sand to loamy sand material that presents a weak structure.

Haplic Luvisols and haplic Fluvisols can appear as inclusions in this positions.

These soils have a rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make some parts of the map unit prone to flooding during the rainy season and the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained. They formed on the side slopes of the omurambas and river valleys in the Kalahari region.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand materials showing a very weak structure development.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

KHh1. rock outcrops & arenic-leptic Regosols & ferralic Arenosols Complex

This complex consists of soils formed on the north-eastern hills that are located in the Kalahari region. It presents arenic-leptic Regosols and ferralic Arenosols as dominating soils; on the other hand, many rock outcrops are present throughout the map unit.

Arenic-leptic Regosols are shallow to moderately deep, coarse textured and somewhat excessively drained. They formed on the side slopes of the north-eastern hills that are located in the Kalahari basin.

Typically the surface layer is 15 to 25 cm thick, sand to loamy sand and brown to dark reddish brown in colour. Underneath, to a depth of 40 to 60 cm, we find dark brown to yellowish red, sand to loamy sand material showing very weak structure development. Below underlies the bedrock.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the moderately depth that limits the effective rooting depth, the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients. Moreover, the presence of rock outcrops and the steep slopes of this map unit affect the workability of these soils.

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained. They formed on the lower parts or the north-eastern hills that are located in the Kalahari basin.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand material showing a very weak structure development.

Petric Calcisols can appear as inclusions in this map unit.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

KHp1. Rock outcrops & petric Calcisols & arenic-leptic Regosols & leptic-chromic Cambisols & ferralic Arenosols Complex

This complex consists of soils formed on the hummocky plains that are located in the Kalahari region. It presents petric Calcisol, arenic-leptic Regosols, leptic-chromic Cambisols and ferralic Arenosols as dominating soils; furthermore, common rock outcrops are present throughout the map unit.

Petric Calcisols, in the hummocky plains of the Kalahari basin, are shallow to moderately deep, coarse to moderately coarse textured and well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and very dark brown to dark reddish brown. Underneath, to a depth of 40 to 80 cm, we find very dark brown to yellowish red, sand to sandy loam material that, sometimes, can present accumulations of calcium carbonate as discontinuous concentrations of hard and/or soft nodules, resulting in a calcic horizon. Below it appears a petrocalcic horizon.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Arenic-leptic Regosols are shallow to moderately deep, coarse textured and somewhat excessively drained.

Typically the surface layer is 15 to 25 cm thick, sand to loamy sand and brown to dark reddish brown in colour. Underneath, to a depth of 40 to 60 cm, we find dark brown to yellowish red, sand to loamy sand material showing very weak structure development. Below underlies the bedrock.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the moderately depth that limits the effective rooting depth, the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients. Moreover, the presence of rock outcrops and the steep slopes of this map unit affect the workability of these soils.

Leptic-chromic Cambisols are moderately deep to deep, moderately coarse to medium textured and well drained.

Typically the surface layer is about 20 cm thick, loamy sand to sandy clay loam and very dark greyish brown to dusky red in colour. Underneath, to a depth of 60 to 80 cm, we find brown to red, sandy loam to sandy clay loam material that presents a moderate structure. Below we find the limestone bedrock.

These soils present a moderate hydraulic conductivity and a moderate infiltration rate. They have a moderate water holding capacity.

The main constraints for agriculture are the moderate depth than can limit the effective rotting depth of the plants and the moderate water holding capacity that restricts the water in the soils that can be readily absorbed by plants.

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand material showing a very weak structure development.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

KSd1. ferralic Arenosols

Ferralic Arenosols, in the sand deposits that are located in the Kalahari region, are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand material showing a very weak structure development.

Petric Calcisols can appear as inclusions in this map unit.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

KSd2. petric Calcisols & ferralic Arenosols Association

This association consists of soils formed on the sand deposits that are located in the Kalahari region. It presents petric Calcisols and ferralic Arenosols as dominating soils.

Petric Calcisols, in the sand deposits located in the Kalahari region, are shallow to moderately deep, coarse to moderately coarse textured and well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and very dark brown to dark reddish brown. Underneath, to a depth of 40 to 80 cm, we find very dark brown to yellowish red, sand to sandy loam material that, sometimes, can present accumulations of calcium carbonate as discontinuous concentrations of hard and/or soft nodules, resulting in a calcic horizon. Below it appears a petrocalcic horizon.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Ferralic Arenosols, in the sand deposits that are located in the Kalahari region, are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand material showing a very weak structure development.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

KSp1. ferralic Arenosols & petric Calcisols Association

This association consists of soils formed on the sand deposits with pans that are located in the Kalahari region. It presents ferralic Arenosols and petric Calcisols as dominating soils.

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to reddish brown in colour. Underneath, to a depth of more than 100 cm, we find an olive brown to yellowish red, sand material showing a very weak structure development.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soils that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

Petric Calcisols are shallow to moderately deep, coarse to moderately coarse textured and well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and very dark brown to dark greyish brown. Underneath, to a depth of 30 to 50 cm, we find very dark greyish brown to light olive brown, sand to sandy loam material that, sometimes, can present accumulations of calcium carbonate as discontinuous concentrations of hard and/or soft nodules, resulting in a calcic horizon. Below it appears a petrocalcic horizon.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low position where they are located in the landscape that make them prone to flooding during the rainy season, the shallow to moderate depth that limits the effective rooting depth and low water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

5.3. Soil Classification

Formal taxonomic classifications are sometimes of limited use as mapping tools because of the following reasons:

- They are difficult to apply in the field when they are based on detailed laboratory results.

- Their criteria for differentiating between soils may not allow immediate adaptation to specific development objectives.

- They are often not suitable for practical use at the needed level

However, the decision to fit the soils described in the field into a recognized classification system is important and presents some advantages:

- It gives, to the people that are not familiar with the study area, a first idea about the main characteristics of the soils and prevent misunderstandings.

- The map becomes a transmitter of soil information and allows correlation with previous works and technology transfer between similar soils.

The system of soil classification used in the soil survey of the areas with a growing period 2 and 3 has been the World Reference Base (WRB) for Soil Resources System (ISSS, 1998).

Classification has been performed to the level of soil subunits (WRB, 1998).

In order to facilitate correlations with previous works, the taxonomic units have been also classified according to the Revised Legend of FAO (FAO, 1988) and the Soil Taxonomy System (SSS, 1996).

Table 5.1 shows the different taxonomic units (WRB, 1998) that have been recognized during the soil survey of the areas with a growing period 2 and 3, and their correlation with other classification systems.

Table 5.1. Classification of the map units

World Reference Base (1998) Soil Subunits	Revised Legend of FAO (1988) Soil Units	Soil Taxonomy (1999) Subgroups
Arenic Fluvisol	Eutric Fluvisol	Typic Ustifluvent
Arenic-leptic Regosol	Dystric Regosol	Lithic Ustipsamment
Calcic Solonetz	Calcic Solonetz	Typic Natrustalf
Chromic Cambisol	Chromic Cambisol	Typic Haplustept
Chromic Luvisol	Chromic Luvisol	Typic Rhodustalf
Ferralic Arenosol	Ferralic Arenosol	Typic Ustipsamment
Ferralic Cambisol	Ferralic Cambisol	Typic Ustipsamment
Ferralic-lamellic Arenosol	Luvic Arenosol	Lamllic Ustipsamment
Fluvic Cambisol	Eutric Cambisol	Fluventic Haplustept
Haplic Calcisol	Haplic Calcisol	Typic Calciustept
Haplic Fluvisol	Eutric Fluvisol	Typic Ustifluvent
Haplic Leptosol	Eutric Leptosol	Lithic Ustorthent
Haplic Luvisol	Haplic Luvisol	Typic Haplustalf
Haplic Regosol	Eutric Regosol	Typic Ustorthent
Hypercalcic Calcisol	Haplic Calcisol	Typic Calciustept
Hyposalic Arenosol	Cambic Arenosol	Typic Halaquept
Leptic Regosol	Eutric Regosol	Lithic Usthortent
Leptic-chromic Cambisol	Chromic Cambisol	Lithic Haplustept
Leptic-mollic Cambisol	Eutric Cambisol	Lithic Haplustoll
Mollic Leptosol	Mollic Leptosol	Lithic Haplustoll
Natric-gypsic Vertisol	Gypsic Vertisol	Sodic Gypsiustert
Natric-calcic Vertisol	Calcic Vertisol	Sodic Calciustert
Petric Calcisol	Petric Calcisol	Petrocalcic Calciustept
Sodic Calcisol	Haplic Calcisol	Typic Halaquept
Sodic Cambisol	Eutric Cambisol	Typic Halaquept

Annex 2 presents a detailed description of the taxonomical series and their representative profile.

6.1. Description of the kavango river area

6.1.1. Location

The survey area is located in north-eastern Namibia, in the Kavango region. It covers a area of 13.183 Km2, that includes a narrow 10 kilometres strip along the south bank of the Kavango river, from Katwitwi to Popa falls, plus part of the omurambas (Omatako, Fontein, Mpuku, Namungundo, Npungu and Dikweya) that form the drainage system (Figure 6.1.). This is the area where settle most of the population of the region.

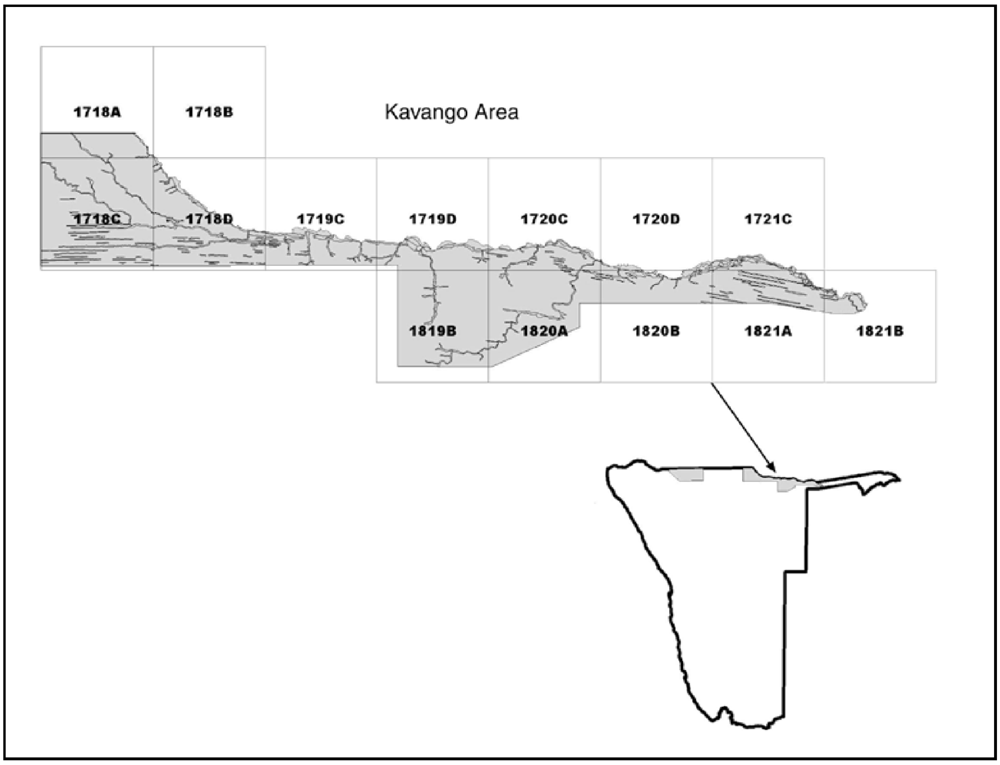


Figure 6.1. Location of the Kavango River area.

6.1.2. Climate

The Kavango river area presents a subtropical climate. Rainfall occurs mainly as summer thunderstorms during the period late November to mid March. Summers are extremely hot, temperatures can reach to 40ºC during the period October-February. Winters are mild, although temperatures below 0ºC can be achieved during the period May-August.

According to the data gathered in Rundu during the period 1937-1975, average rainfall is around 600 mm. The driest months range from May to September.

The average annual temperature in the study area is around 22.5ºC. Table 1 gives a general view of the thermometric regimen.

The average evapotranspiration, according to the class A evaporation pan, is around 1859 mm (Table 6.2).

The strongest winds come from the East and the North-East.

Table 6.1. Thermic characteristics (ºC) of the Okavango river area. (Rundu, 1937-1975)

Month	J	F	M	A	M	J	J	A	S	O	N	D
T max	30.9	30.0	30.3	30.3	28.7	26.2	26.7	29.7	33.4	35.1	32.8	33.2
t min	18.7	18.3	17.5	15.1	10.0	6.5	6.5	8.9	13.3	17.7	18.4	18.4
t mean	24.8	24.2	23.9	22.7	19.0	16.3	16.6	19.3	23.3	26.4	25.6	25.3
Abs. m	9.5	11.5	6.4	7.0	-0.7	-2.3	-4.2	0.0	3.4	8.5	9.8	12.0
Abs. M	39.0	39.5	37.5	36.6	33.3	31.6	32.9	35.7	38.2	40.8	40.0	39.3

Table 6.2. Hidric characteristics of the Okavango river area (Rundu, 1937-1975)

Month	J	F	M	A	M	J	J	A	S	O	N	D	Year
Rainf.	143.7	140.7	98.2	49.7	2.6	0.0	0.1	0.3	2.2	17.7	57.7	97.7	600.6
RH%	83	86	85	80	72	72	70	57	46	49	66	76	70
rh %	52	53	49	42	32	28	27	23	22	26	37	45	36
E.T.P.	149.7	121.1	134.0	118.9	119.4	94.7	120.2	150.3	189.5	211.7	222.9	226.6	1859.0

6.1.3. Geology and geomorphology

Geologically most of the Kavango comprises Cenozoic deposits of the Kalahari Group that overlays extensive basalt sheets of the Stormberg Series, together with some areas of the quarzites, phyllites and conglomerates of the Nosib Formation (Geological Survey, 1963) that are exposed only near Andara and Rundu.

The deposits of the Kalahari Group consist of light coloured sands, chalcedonic limestones, silicified sandstones and ochreous sands, the last mentioned forming the Kalahari Sandveld in Namibia (Hamilton and Cooke, 1960). The Kalahari sands appear to be primarily of Pliocene age that were subsequently redistributed during the Quaternary.

Petrocalcic materials occurs along the river bank, at shallow depths in the terraces associated with the Kavango river and in low-lying areas where surface water collects after rainfall, or where calcium carbonate has precipitated out of local ground water (Schneider, 1987).

Two physiographical regions have been distinguished in the Kavango River Area: the inland sand plateau and the terrace system of the Kavango river.

The sand covered plateau is flat to gently undulating and has inactive fossil dunes ridges. It presents some troughs very steeply incised, called omurambas, that drain the area. Among these, the Omatako Omuramba is the most outstanding and the largest tributary of the Kavango river.

The riverine landform consists of a flood plain, that is partly under water during the rainy season and shows evidence of a braided river system, and a terrace situated 6-7 m above the river bed. The width of this landform changes from a few meters to some kilometers.

The parent material of the soils in the inland sand plateau is composed predominantly of infertile aeolian sands of the Kalahari formation with a low organic matter content. Along the flood plain and the terraces, the sandy soils are enriched with interspersed clay and silt layers deposited by seasonal water floods (FAO, 1984).

6.1.4. Vegetation and land use

All of the study area was once a forest savanna, however the increasing population cut down trees for firewood and particularly for houses and transform the area into a mixed grazing and veld. Now there are large open overgrazing and intensively cultivated areas, mainly along the terraces of the Kavango river that, together with the omurambas, are the most suitable landforms for agricultural practices.

The natural vegetation of the Kavango is classifed as Kalahari woodland which is characterized by stands of dolfwood (Pterocarpus angolensis), rhodensian leak (Baikiaea plurijuga), mangetti (Schinziophyton rautanenii), yellowwood (Terminalia sericea) and various typus of acacia (Acacia spp.). Makalani palms occur along the omurambas and the flood plain. Herbs and grasses are spread intensively despite the overgrazing.

The main constraints of the Kavango river area for agriculture are its climate (availability of water), soil characteristics (organic matter contents, cation exchange capacity and water holding capacity) and the general needs for plant nutrients and soil improvement. Smut diseases are also very common.

Agricultural productions by the Kavango people is primarily at the subsistence level and arable cropping is supplemented by cattle farming.

Sorghum and pearl millet are traditionally the most important subsistence food crops in the communal areas; maize is also been grown, but only on a small scale. Some research stations (Musese, Mashare, Shitemo and Shadikongoro) and some small private gardening projects are the only examples of irrigated agriculture.

Cows, goats and hens are the most common domestic animals in the area. Animal husbandry based solely on natural grazing has always been the practice of the inhabitants of the area. Till now this practice has allow to achieve the balance of energy, products and carrying capacity of the country. However, the situation is changing with population growth; the forest is being cut down and common pastures between fields are overgrazed. That is why it will be necessary to develop new sustainable methods of cattle farming that are more pleasant, profitable and realistically planned.

6.2.1. Legend of the Soil Survey (1:100.000) of the Kavango River Area

P. Kalahari Sands Plateau

Pp. Plateau

Pp1. ferralic Arenosols, sandy, slope < 2%
Pp2. arenic-leptic Regosols & quarzite outcrops Association, sandy, slope < 2%
Pp3. Quarzite outcrops

Pi. Interdunal pans

Pi1. arenic Fluvisols & haplic Calcisols Complex, loamy sand, slope < 2%

Po. Omuramba

Po1. ferralic Arenosols, sandy, slope <2%
Po2. arenic Fluvisols, loamy sand, slolpe < 2%
Po3. arenic Fluvisols & haplic Calcisols Complex, loamy sand, slope < 2%

R. Kavango River System

Rt. Terraces

Rt1. arenic Fluvisols, sandy, slope < 2%
Rt2. Leptic-chromic Cambisols, sandy loam, slope < 2%
Rt3. arenic-leptic Regosols & basalt outcrops Association, sandy loam, slope < 2%
Rt4. skeletic Fluvisols & arenic Fluvisols Association, loamy sandy, slope < 2%
Rt5. arenic Fluvisols & haplic Calcisols Complex, loamy sand, slope < 2%
Rt6. arenic Fluvisols & petric Calcisols Association, loamy sand, slope < 2%
Rt7. arenic Fluvisols & sodic Cambisol Association, loamy sand, slope < 2%, slightly to moderately saline and sodic
Rt8. haplic Calcisols & petric Calcisols Complex, sandy loam, slope < 2%

Rf. Flood plains

Rf1. arenic Fluvisols & haplic Fluvisols Complex, loamy sand, slope <2%, slightly to moderately saline

Rd. Dunes on the river terrace

Rd1. ferralic Arenosols, sandy, slope < 2%

6.2.2. Description of the soil map units

Pi1. arenic Fluvisols & haplic Calcisols Complex, loamy sand, slope <2%

This complex consists of soils formed on the interdunal depressions ("streets") and pans that incise the Kalahari Sands Plateau. It presents arenic Fluvisols and haplic Calcisols as dominating soil

Arenic Fluvisols are very deep, coarse textured and moderately well to well drained.

Typically the surface layer is 15 to 25 cm thick, sandy to loamy sand and grey to brown in colour. Underneath, to a depth of more than 100 cm, we find brown to light brownish brown, sandy to sandy loam material that presents a very weak structure.

Haplic Luvisols can appear as inclusions in this map units.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plant roots.

Haplic Calcisols are very deep, coarse to moderately coarse textured and moderately well to well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and dark grey to grey in colour. Underneath, to a depth of more than 100 cm, we find dark grey to light yellowish brown, sand to sandy loam material that presents a weak structure and common to many accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon.

Petric Calcisols can appear as inclusions in this map unit.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plant roots.

Po1. ferralic Arenosols, sandy, slope <2%

Ferralic Arenosols, on the flat omurambas that incise the Kalahari Sands Plateau, are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sandy and reddish brown to dark brown in colour. Underneath, to a depth of more than 100 cm, we find yellowish red to strong brown sandy material showing very weak horizon differentiation.

Ferralic Arenosols have very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity

The main constraints for agriculture are the low water holding capacity that restricts the water in the soil that can be readily absorbed by plant roots and the low cation exchange capacity that restricts the availability of plant nutrients.

Po2. arenic Fluvisols, loamy sand, slope < 2%

Arenic Fluvisols, on the flat omurambas that incise the Kalahari Sands Plateau, are very deep, coarse textured and well to moderately well drained.

Typically the surface layer is 15 to 25 cm thick, sandy to loamy sand and grey to brown in colour. Underneath, to a depth of more than 100 cm, we find brown to light brownish brown, sandy to sandy loam material that presents a very weak structure.

Haplic Luvisols can appear as inclusions in this map units.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plant roots.

Po3. arenic Fluvisols & haplic Calcisols Complex, loamy sand, slope < 2%

This complex consists of soils formed on the flat omurambas that incise the Kalahari Sands Plateau. It presents arenic Fluvisols and haplic Calcisols as dominating soil

Arenic Fluvisols are very deep, coarse textured and moderately well to well drained.

Typically the surface layer is 15 to 25 cm thick, sandy to loamy sand and grey to brown in colour. Underneath, to a depth of more than 100 cm, we find brown to light brownish brown, sandy to sandy loam material that presents a very weak structure.

Haplic Luvisols can appear as inclusions in this map units.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plant roots.

Haplic Calcisols are very deep, coarse to moderately coarse textured and moderately well to well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and dark grey to grey in colour. Underneath, to a depth of more than 100 cm, we find dark grey to light yellowish brown, sand to sandy loam material that presents a weak structure and common to many accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon.

Petric Calcisols can appear as inclusions in this map unit.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plant roots.

Pp1. ferralic Arenosols, sandy, slope < 5%

Ferralic Arenososls, on the flat to gently undulated sand deposits of the Kalahari Sands Plateau, are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is between 15 to 25 cm thick, sandy and reddish brown to very dark grey in colour. Underneath, to a depth of more than 100 cm, we find a yellowish red to olive brown sandy material showing very weak horizon differentiation.

Petric Calcisol can appear as inclusions in this map unit.

Ferralic Arenosols have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity

The main constraints for agriculture are the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the low cation exchange capacity that restricts the availability of plant nutrients.

Pp2. arenic-leptic Regosol & Quarzite outcrops Association, sandy, slope <5%

This association consists of soils formed on the flat to gently undulated sand deposits of the Kalahari Sands Plateau. It presents arenic-leptic Regosols as dominating soil, Furthermore, many outcrops of quartzite are present throughout the map unit.

Arenic-leptic Regosols are moderately deep, coarse textured and somewhat excessively drained.

Typically the surface layer is about 20 cm thick, sandy and dark reddish brown to dark greyish brown in colour. Underneath, to a depth of 40 to 80 cm, we find yellowish red to dark brown sandy material showing very weak horizon differentiation. Below underlies the bedrock of quartzite, that can also appear exposed on the soil surface.

Shallower soils, classified as Leptosol, can appear as inclusions in this map units.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity

The main constraints for agriculture are the moderately depth that limits the effective rooting depth, the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants, the low cation exchange capacity that restricts the availability of plant nutrients and the presence of rock outcrops that affects the workability of these soils.

Pp3. Quarzite outcrops

Rd1. ferralic Arenosols, sandy, slope <2%

Ferralic Arenososls, on the dunes that remanin on the Kavango river terrace, are very deep, coarse textured and somewhat excessively drained.

Typically the surface layer is about 20 cm thick, sandy and reddish brown to dark brown in colour. Underneath, to a depth of more than 100 cm, we find yellowish red to strong brown, sandy material showing very weak horizon differentiation.

Arenic Fluvisols can appear as inclusions in this map units.

Ferralic Arenosols have very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity

The main constraints for agriculture are the low water holding capacity that restricts the water in the soil that can be readily absorbed by plant roots and the low cation exchange capacity that restricts the availability of plant nutrients.

Rf1. arenic Fluvisols & haplic Fluvisols Complex, loamy sand, slope <2%, slightly to moderately saline

This complex consists of soils formed on the flood plains of the Kavango river. It presents arenic Fluvisols and hapli Fluvisols as dominating soils. Salinity is present in some areas of this map unit.

Arenic Fluvisols are very deep, coarse textured and moderately well to well drained.

Typically the surface layer is 15 to 25 cm thick, sandy to loamy sand and grey to brown in colour. Underneath, to a depth of more than 100 cm, we find brown to light brownish brown, sandy to sandy loam material that presents a very weak structure.

Haplic Calcisols can appear as inclusions in this map units.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture is the low position where they are located in the landscape that make them prone to flooding during the rainy season. Moreover, they present during long periods of the year a high water table that can create an adverse environment for the root system. On the other hand their slight to moderate salinity reduces the water holding capacity of the soil and can cause specific toxicity for certain crops.

Haplic Fluvisols are very deep, coarse to moderately coarse textured and imperfectly to moderately well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and very dark grey to brown in colour. Underneath, to a depth of more than 100 cm, we find very dark grey to light olive brown, sandy to loam material that present a weak structure.

Haplic Calcisols, petric Calcisols and sodic Cambisols can appear as inclusions in this map unit.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderately rapid infiltration rate. They have a moderate to high water holding capacity.

The main constraints for agriculture is the low position where they are located in the landscape that make them prone to flooding during the rainy season. Moreover, they present during long periods of the year a high water table that can create an adverse environment for the root system. On the other hand their slight to moderate salinity reduces the water holding capacity of the soil and can cause specific toxicity for certain crops.

Rt1. arenic Fluvisols, loamy sand, slope <2%

Arenic Fluvisols, on the terraces of the Kavango river, are very deep, coarse textured and well to moderately well drained.

Typically the surface layer is 15 to 25 cm thick, sandy to loamy sand and grey to brown in colour. Underneath, to a depth of more than 100 cm, we find brown to light brownish brown, sandy to sandy loam material that presents a very weak structure.

Haplic and petric Calcisols can appear as inclusions in this map units.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plant roots.

Rt2. Leptic-chromic Cambisols, sandy loam, slope < 2%

Leptic-chromic Cambisols, on the terraces of the Kavango river where the bedrock of quartzite approaches the surface, are moderately deep, modertely coarse to medium textured and well to moderately well drained.

Typically the surface layer is about 20 cm thick, moderately coarse textured and brown to dark brown in colour. Underneath, to a depth of 60 to 80 cm, we find yellowish red to strong brown sandy loam to loam material that presents a moderate structure. Below underlies the bedrock of quartzite.

These soils have a moderate hydralic conductivity and present a moderate infiltration rate. They have a moderate water holding capacity

The main constraint for agriculture are the moderate depth that can limit the effective rotting of the plant and the moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plants.

Rt3. arenic-leptic Regosols & basalt outcrops Association, sandy loam, slope < 2%

This association consists of soils formed on the terraces of the Kavango river. It presents arenic-leptic Regosols as dominating soil, Furthermore, many outcrops of basalt are present throughout the map unit.

Arenic-leptic Regosols are moderately deep, coarse textured and somewhat excessively drained.

Typically the surface layer is 15 to 25 cm thick, loamy sand to sandy loam and brown to dark greyish brown in colour. Underneath, to a depth of 40 to 80 cm, we find strong brown to dark brown loamy sand to sandy loam material that present a weak structure. Below underlies the bedrock of basalt sheet, that can also appear exposed on the soil surface.

Arenic Fluvisols and haplic Leptosol can appear as inclusions in this soil units.

These soils have a rapid hydralic conductivity and present a moderately rapid to rapid infiltration rate. They have a low water holding capacity

The main constraints for agriculture are the moderately deep that can limit the effective rooting of the plants and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plans and the presence of rock outcrops that affects the workability.

Rt4. skeletic Fluvisol & arenic Fluvisol Association, loamy sandy, slope 2-5%

This association consists of soils formed on the terraces of the Kavango river. It presents skeletic Fluvisols and arenic Fluvisols as dominating soil.

Skeletic Fluvisols are very deep, coarse to moderately coarse textured with abundant coarse fragments, and moderately well to well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam with abundant coarse fragments of quartzite, and brown to very dark grey in colour. Underneath, to a depth of more than 100 cm, we find brown to light yellowish brown, loamy sand to sandy loam material that presents abundant coarse fragments of quartzite, and a weak structure.

The main constraints for agriculture are the low water holding capacity that restricts the water in the soil that can be readily absorbed by plants and the presence of abundant coarse fragments that affects the workability of these soils.

Arenic Fluvisols are very deep, coarse textured and well to moderately well drained.

Typically the surface layer is 15 to 25 cm thick, sandy to loamy sand and grey to brown in colour. Underneath, to a depth of more than 100 cm, we find brown to light brownish brown, sandy to sandy loam material that presents a very weak structure.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plant roots.

Rt5. arenic Fluvisols & haplic Calcisols Complex, loamy sand, slope < 2%

This complex consists of soils formed on the terraces of the Kavango river. It presents arenic Fluvisols and haplic Calcisols as dominating soil

Arenic Fluvisols are very deep, coarse textured and moderately well to well drained.

Typically the surface layer is 15 to 25 cm thick, sandy to loamy sand and grey to brown in colour. Underneath, to a depth of more than 100 cm, we find brown to light brownish brown, sandy to sandy loam material that presents a very weak structure.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plant roots.

Haplic Calcisols are very deep, coarse to moderately coarse textured and moderately well to well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and dark grey to grey in colour. Underneath, to a depth of more than 100 cm, we find dark grey to light yellowish brown, sand to sandy loam material that presents a weak structure and common to many accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon.

Petric Calcisols can appear as inclusions in this map unit.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plant roots.

Rt6. arenic Fluvisols & petric Calcisols Association, loamy sand, slope < 2%

This association consists of soils formed on the terraces of the Kavango river. It presents arenic Fluvisols and petric Calcisols as dominating soil

Arenic Fluvisols are very deep, coarse textured and moderately well to well drained.

Typically the surface layer is 15 to 25 cm thick, sandy to loamy sand and grey to brown in colour. Underneath, to a depth of more than 100 cm, we find brown to light brownish brown, sandy to sandy loam material that presents a very weak structure.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plant roots.

Petric Calcisols are shallow to moderately deep, coarse to moderately coarse textured and moderately well to well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam, and very dark grey to very dark brown in colour. Underneath, to a depth of 30 to 50 cm, we find very dark greyish brown to light olive brown, sand to sandy loam material that, sometimes, can present accumulations of calcium carbonate as discontinuous concentrations of hard and/or soft nodules, resulting in a calcic horizon. Below it appears the petrocalcic horizon.

Haplic Calcisols can appear as inclusions in this map unit.

These soils have a moderately rapid hydralic conductivity and present a moderately rapid to infiltration rate. They have a low water holding capacity

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth for the plants, and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plant.

Rt7. arenic Fluvisols & sodic Cambisols Association, sandy loam, slope < 2%, slightly to moderately saline and sodic

This association consists of soils formed on the terraces of the Kavango river. It presents arenic Fluvisols and sodic Cambisols as dominating soil

Arenic Fluvisols are very deep, coarse textured and moderately well to well drained.

Typically the surface layer is 15 to 25 cm thick, sandy to loamy sand and grey to brown in colour. Underneath, to a depth of more than 100 cm, we find brown to light brownish brown, sandy to sandy loam material that presents a very weak structure.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plant roots.

Sodic Cambisols are very deep, coarse to moderately coarse textured and moderately well to well drained. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to loamy sand and very dark greyish brown to light brownish grey in colour, loose or with a very weak structure. Underneath, it appears an horizon 20 to 40 cm thick, dark grey to light brownish grey, sand to sandy loam, with a massive or very coarse sub-angular blocky structure and an extremely hard consistence when dry probably associated temporarily floodings during the rainy season and the presence of sodium as dominant cation in the soil. Below we find a greyish brown to very pale brown, sandy loam material that presents a weak structure and, occasionally, few accumulations of calcium carbonate and/or gypsum.

Most of the times, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon 2 to 10 cm thick, that can be classified as albic horizon.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by the plants and the extemely hard consistence, when dry, of the subsurface horizon that can limit the root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, an the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Rt8. haplic Calcisols & petric Calcisols Complex, sandy loam, slope < 2%

This complex consists of soils formed on the terraces of the Kavango river. It presents haplic Calcisols and petric Calcisols as dominating soil

Haplic Calcisols are very deep, coarse to moderately coarse textured and moderately well to well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam and dark grey to grey in colour. Underneath, to a depth of more than 100 cm, we find dark grey to light yellowish brown, sand to sandy loam material that presents a weak structure and common to many accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules, resulting in a calcic horizon.

Arenic Fluvisols can appear as inclusions in this map unit.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraint for agriculture is the low to moderate water holding capacity that restricts the water in the soil that can be readily absorbed by plant roots.

Petric Calcisols are shallow to moderately deep, coarse to moderately coarse textured and moderately well to well drained.

Typically the surface layer is about 20 cm thick, sand to sandy loam, and very dark grey to very dark brown in colour. Underneath, to a depth of 30 to 50 cm, we find very dark greyish brown to light olive brown, sand to sandy loam material that, sometimes, can present accumulations of calcium carbonate as discontinuous concentrations of hard and/or soft nodules, resulting in a calcic horizon. Below it appears the petrocalcic horizon.

These soils have a moderately rapid hydralic conductivity and present a moderately rapid to infiltration rate. They have a low water holding capacity

The main constraints for agriculture are the shallow to moderate depth that limits the effective rooting depth for the plants, and the low water holding capacity that restricts the water in the soil that can be readily absorbed by plant.

6.3. Formation of the soils

6.3.1. Introduction

The classic factors of the soil formation are the parent material, the climate, the living organisms (including mankind), the geomorphology and the time (Jenny, 1941). Their actions determine the direction, speed and duration of the processes of the soil formation and the kind of soil that can be found on each spot. Therefore, we can say that the soil is a function of the different factors of the soil formation.

Soil = f(parent material, climate, living organisms, geomorphology, time)

This approach in the soil study is, from a conceptual point of view, very rich. However this equation has been solved very few times and, at best, just for one factor or soil characteristic.

In soil survey, however, this approach is very useful. It allows the soil scientist to develop a model of how the soils were formed and of how each kind of soil is associated with a particular kind of landscape. Thus, during mapping, this model enables the soil scientist to predict with considerable accuracy the kind of soil at a specific location.

6.3.2. Factors of the soil formation

Parent material

The parent material is the most important factor in the study area. On the inland sand plateau the parent material consists of Cenozoic deposits of sands of the Kalahari group. The soils show, to a great extent, the characteristics of the parent material.

On the terraces and floodplain the parent material consists also of sands of the Kalahari group even though enriched with organic matter, clay and silt deposited by seasonal flooding, showing in this way its fluvic character.

The soils on the omurambas usually show similar characteristics than the soils of the terraces and floodplain. That is, material of coarse, medium and fine textures deposited on poorly sorted strata.

Finally, it must be mentioned that petrocalcic horizons appear scattered in the study area. Most of them are believed to have formed on conditions very different to the present ones, showing therefore a “paleo” character.

Climate

The area of dune formation is delimited by the 150 mm/y isohyet. This is why, we can say that the present climate differs from that prevailing when the dunes, mostly of longitudinal type, were formed.

The subtropical nature of the climate in the Kavango river area where most of the rain occurs during the summer period and the coarse texture of most of the soils facilitates the leaching of carbonates and prevent salt accumulation in the soils of the plateau and in most of the soils of the terrace.

On the floodplain an the omurambas, the presence of high water tables and the hydraulic regime created by the nature of the climate favours the accumulation of calcium carbonate, resulting in calcic horizons. The same processes took place on the terraces time ago.

Finally, it must be mentioned that ponds and lakes can remain for long time on some areas of the floodplain and the lower terraces favouring the accumulation of salt and the degradation of the soil structure.

Living organisms

Although vegetation favoured fixation of the dunes and the accumulation of organic matter in the topsoil, we can say that living organisms have had few effects on soil properties in the study area.

In recent times, however, overgrazing and the increasing intensity of cultivation have significantly reactivated eolian and water erosion in the area.

Geomorphology

The evolution of the soils of the Kavango river area is also related to the geomorphology of the area.

The inland sand plateau is flat to gently undulating. Soils have developed on fixed dunes and show, to a great extent, the coarse textures of the parent material. The only process that can take place on this soils is the removal of calcium carbonate and other easily soluble salts by leaching caused by rainfall during the summer period.

On the floodplain and Omurambas, erosion and deposition processes take place giving to the soils some stratification. Moreover, the calcium carbonate that is translocated with water that percolates from higher areas and calcium bicarbonate that is transported by the river can precipitate and accumulate forming a calcic horizon and, ultimately, a petrocalcic horizon.

On the terraces, soils hardly present a weak stratification that would show their fluviatile origin. However, they still present calcic horizons that were formed in the same way than, at present, are formed on the floodplain and the omurambas.

Time

The Kavango river area presents soils of different age.

The boundary of the 150 mm/y isohyet, that delimites the area of dune formation, appears to have moved up and down in the recent past; between 20.000 and 13.000 BP. Processes that have resulted in the soils formed on the Kalahari dunes started to taking place by that time.

The youngest are those soils developed on the present floodplain. Soils formed on the terraces are of intermediate age.

6.3.3. Processes of the soil formation

The processes of the soil formation that have been identified on the Kavango river area are the following:

- Physical and chemical weathering of the older rocks (basalts, quarzites and phyllites) that are exposed near Rundu and Andara.
- Darkening of the topsoil by accumulation of organic matter
- Structure formation and degradation
- Oxidation and reduction processes
- Dissolution, transport and precipitation of carbonates
- Carbonates accumulation and cementation
- Erosion and sedimentation
- Salt accumulation
- Sodification
- Clay transport

6.4. Soil Classification

Formal taxonomic classifications are sometimes of limited use as mapping tools because of the following reasons:

- They are difficult to apply in the field when they are based on detailed laboratory results.

- Their criteria for differentiating between soils may not allow immediate adaptation to specific development objectives.

- They are often not suitable for practical use at the needed level

However, the decision to fit the soils described in the field into a recognized classification system is important and presents some advantages:

- It gives, to the people that are not familiar with the study area, a first idea about the main characteristics of the soils and prevent misunderstandings.

- The map becomes a transmitter of soil information and allows correlation with previous works and technology transfer between similar soils.

The system of soil classification used in the soil survey of the Kavango river area has been the World Reference Base (WRB) for Soil Resources System (ISSS, 1998).

Classification has been performed to the level of soil subunits (WRB, 1998). Furthermore, phases (slope, superficial texture and salinity) have been used to describe the map units in order to give more relevant information to evaluate the agricultural potential of the units.

In order to facilitate correlations with previous works, the taxonomic units have been also classified according to the Revised Legend of FAO (FAO, 1988) and the Soil Taxonomy System (SSS, 1996).

Most of the soils that appear on the study area show minimal profile development because of soil forming processes that are at a standstill during long periods of drought (Arenosols, Regosols, Cambisols) and because the parent material is of young age (Fluvisol). Moreover their parent materials, with an eolian or alluvial origin, present a certain homogeneity in themselves. This is why the taxonomic units have been defined within a relatively broad interval of characteristics.

Table 6.3 shows the different taxonomic units (WRB, 1998) that have been recognized during the soil survey of the Kavango river area and their correlation with other classification systems.

Table 6.3. Classification of the taxonomic units

World Reference Base (1998) Soil Subunits	**Revised Legend of FAO (1988) Soil Units**	**Soil Taxonomy (1999) Subgroups**
Mollic Fluvisol	Mollic Fluvisol	Mollic Ustifluvent
Arenic Fluvisol	Eutric Fluvisol	Typic Ustifluvent
Skeletic Fluvisol	Eutric Fluvisol	Typic Ustifluvent
Haplic Fluvisol	Eutric Fluvisol	Typic Ustifluvent
Petric Calcisol	Petric Calcisol	Petrocalcic Calciustept
Haplic Calcisol	Haplic Calcisol	Typic Calciustept
Haplic Luvisol	Haplic Luvisol	Typic Haplustalf
Chromic-leptic Cambisol	Chromic Cambisol	Typic Haplustept
Fluvic Cambisol	Eutric Cambisol	Fluventic Haplustept
Sodic Cambisol	Eutric Cambisol	Typic Halaquept
Ferralic Arenosol	Ferralic Arenosol	Typic Ustipsamment
Arenic-leptic Regosol	Dystric Regosol	Lithic Ustipsamment

Annex 2 presents a detailed description of the taxonomical series and their representative profile.

Auguering Reference	pH	E.C. (microS/cm) 25ºC	O.C (%)	P (ppm)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/Kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)
OKA-2/1	7.6	24	0.3	1.6	95.4	2.6	1.9	1.6											
OKA-2/2	7.2	12	0.2	8.8	96.5	1.6	1.9	0.8											
OKA-2/3	6.6	8	0.1	0.9	95.4	1.4	3.4	0.5											
OKA-3/1	7.0	21	0.2	2	95.6	1.5	2.9												
OKA-3/2	6.5	12	0.1	1.5	94.2	1.5	4.3												
OKA-3/3	6.6	13	0.3	2.1	94.9	2.1	3												
OKA-4/1	8.7	46	0.2	0.6	94.7	1.9	3.4												
OKA-4/2	7.7	12	0.1	0.1	95.4	0.6	4												
OKA-4/3	7.7	16	0.2	0.1	96.3	0.9	2.8												
OKA-5/1	7.0	14	0.2	0.5	96.1	0.9	3												
OKA-5/2	6.3	6	0.3	0	94.9	0.7	4.4												
OKA-5/3	6.1	12	0.2	0	95.7	0.5	3.8												
OKA-6/1	5.9	23	0.2	0.5	95.5	0.8	3.7												
OKA-6/2	6.1	18	0.1	0.4	96.1	0.5	3.4												
OKA-6/3	5.8	8	0.1	0.1	94.5	1	4.5												
OKA-7/1	7.4	36	0.2	1.2	91.7	1.9	6.4												
OKA-7/2	7.2	30	0.3	0.3	85.7	3	11.3												
OKA-8/1	8.4	69	0.4	2.2	92.4	2.2	5.4												
OKA-8/2	8.7	56	0.3	0.6	90.3	1.7	8												
OKA-8/3	8.6	82	0.3	0.1	74.4	16.2	9.5		20										
OKA-9/1	7.9	498	3.5	13	37.3	28.1	34.6												
OKA-9/2	7.6	515	2.2	4.4	29	21.5	49.5												
OKA-9/3	8.4	232	0.7	0.9	38.4	20.3	41.3												
OKA-10/1	7.8	61	0.4	1.9	92.3	2.4	5.4												
OKA-10/2	6.4	132	0.4	0.3	89.1	3.6	7.3												
OKA-10/3	6.3	91	0.3	0.2	89.4	3.7	6.9												
OKA-10/4	7.8	51	0.3	0.8	77.7	6.3	16												
OKA-11/1	6.7	27	0.6	2.6	96.1	1.5	2.4												
OKA-11/2	6.4	8	0.3	0.2	93.3	3.1	3.6												
OKA-11/3	6.4	6	0.2	0.2	93.4	2.2	4.4												
OKA-12/1	7.3	43	0.4	1.5	89.4	6.7	3.9		0										
OKA-12/2	7.7	20	0.3	0.3	87.5	6.7	5.8		0										
OKA-12/3	8.3	48	0.3	0.1	79.5	7.6	12.9		0										
OKA-12/4	8.6	165	0.3	0.6	68	10.7	21.3		3										
OKA-13/1	9.3	55	0.3	0.2	95.6	3.3	1.1		0		8.7	469	1					0	
OKA-13/2	10.5	1979	0.2	0.6	83.4	4.8	11.9		2		10.4	662						0	
OKA-13/3	10.4	1551	0.1	0.4	77.4	5.1	17.5		2		9.3	5							
OKA-13/4	10.1	1251	0.2	1	69.5	10.4	20.5		10		9.7	876	1	2	0	0		1	
OKA-14/1	8.8	88	1.0	1.5	74.6	18	7.4		1		8.5	886						0	
OKA-14/2	10.3	827	0.3	1.1	68.1	14.5	17.4		3		9.4	1571	2	3	4	1		0	
OKA-14/3	10.1	937	0.2	1.3	50.1	24.6	25.3		3		9.2	7950	2	3	4	1		1	
OKA-15/1	6.4	23	0.2	1.4	95	1.5	3.5												
OKA-15/2	6.2	11	0.4	1.5	93.1	3	3.9												
OKA-15/3	6.5	11	0.1	0.3	92.3	3.3	4.5												
OKA-16/1	6.4	20	0.2	0.1	95.6	2	2.5												
OKA-16/2	5.8	10	0.1	0.3	94.4	2	3.6												
OKA-16/3	5.6	11	0.1	0.6	91.8	3.8	4.4												
OKA-17/1	5.9	19	0.3	0.9	95.2	4.5	0.3												
OKA-17/2	6.0	8	0.3	0.6	94.9	2.4	2.7												
OKA-18/1	6.4	30	0.1	1.6	97.3	1.7	1	1.6											
OKA-18/2	6.3	33	0.1	0.3	95.4	1.7	2.9	0.6											
OKA-18/3	6.7	11	0.1	0.3	94.1	2.9	2.9	0.4											
OKA-19/1	7.4	33	0.3	1.6	87	4.5	8.5												
OKA-19/2	7.6	24	0.2	0.4	81.7	7.8	10.4												
OKA-20/1	8.9	223	0.4	1.8	86.2	9.7	4.1				8.5	1257	3	1	6	0		0	0
OKA-20/2	9.9	315	0.2	1.6	84.5	6.8	8.7				8.6	647	3	0	7	1		1	0
OKA-20/3	9.0	82	0.1	1.7	73.6	16.2	10.2				8.8	495	3	1	4	1		0	0
OKA-21/1	7.3	34	0.8	1.2	84.8	8.6	6.6												
OKA-21/2	7.2	29	0.2	1.2	80.9	8.2	10.9												
OKA-21/3	7.5	25	0.0	0.1	81.2	12.1	6.8												
OKA-21/4	7.7	24	0.1	0	76.7	12.2	11.1												

Augering Reference	pH	E.C. (microS/cm) 25ºC	O.C (%)	P (ppm)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/Kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)
OKA-22/1	6.6	46	0.5	4.7	91.6	4.1	4.4												
OKA-22/2	6.5	28	0.2	1	88	5.6	6.4												
OKA-22/3	5.8	21	0.2	0.8	89.8	2.9	7.3												
OKA-22/4	6.8	25	0.1	0.5	91.7	4.9	3.4												
OKA-23/1	7.0	63	0.3	6.6	89.6	3.2	7.2												
OKA-23/2	7.5	58	0.3	0.4	83.2	3.3	13.6												
OKA-25/1	6.8	99	0.6	2.4	89.7	6.9	3.4												
OKA-25/2	7.3	28	0.2	0.3	86.9	12.1	1												
OKA-25/3	7.4	198	0.1	0.1	85.7	13.5	0.9												
OKA-26/1	7.8	51	0.5	2.9	86.6	9	4.4				8.2	910	4	2	2	2		0	0
OKA-26/2	8.5	1924	0.2	0.1	79.7	7	13.3				8.3	355	1	1	1	0		0	0
OKA-30/1	7.8	1857	0.4	2.6	60.8	27.3	11.8				7.9	7510	9	3	5	0		10	0
OKA-30/2	7.7	3470	0.3	0.9	51.5	23.2	25.3				7.9	10290	31	5	4	0		18	0
OKA-30/3	8.2	3570	0.2	0.5	49.1	20.7	30.2				8.0	9590	36	4	4	0		21	25
OKA-30/4	9.0	2090	0.1	0.2	52.2	19.2	28.6				8.5	5430	4	3	5	0		13	4
OKA-31/1	7.7	108	0.4	4.1	86.6	8.7	4.7												
OKA-31/2	7.7	32	0.2	0.4	86.2	5.9	7.9												
OKA-31/3	8.5	99	0.2	0.5	86.2	5.9	7.9												
OKA-32/1	7.7	91	0.2	4.4	92.7	3.2	4.1												
OKA-32/2	7.5	39	0.1	0.8	88.9	1.9	9.2												
OKA-32/3	7.7	92	0.1	1.6	85.2	2.2	12.6												
OKA-33/1	8.4	98	0.2	4.1	89.5	3.5	7.1												
OKA-33/2	7.9	50	0.2	0.9	85.9	3	11.1												
OKA-33/3	8.5	54	0.1	-0.2	77.7	3.2	19.1												
OKA-35/1	7.4	40	0.2	2.6	90.6	4.4	5												
OKA-35/2	6.2	16	0.1	0.9	90.2	4.2	5.6												
OKA-35/3	5.8	16	0.1	1	90.1	3.9	6												
OKA-36/1	8.5	79	0.4	5.8	81.9	11.9	6.2		1										
OKA-36/2	8.5	86	0.3	1.5	82.7	5.5	11.7		3										
OKA-36/3	8.6	94	0.2	0.5	76.8	8.8	14.4		8										
OKA-37/1	8.3	101	0.6	5.1	80.2	9.3	10.4				8.2	622	3	1	1	0		3	3
OKA-37/2	8.8	92	0.3	1.1	85.4	4.6	10				8.4	462	1	1	1	0		0	0
OKA-37/3	9.6	263	0.2	0.4	83.5	4.3	12.3		1		8.7	825	1	1	6	0		0	3
OKA-37/4	9.8	481	0.2	0.4	82.2	4.3	13.6		1		8.7	418	1	1	6	0		0	0
OKA-38/1	8.1	273	0.6	14.8	79.4	10.2	10.4		1										
OKA-38/2	8.2	235	0.4	4.9	76.8	10.6	12.6		2										
OKA-38/3	8.0	171	0.3	2.8	74.4	11	14.6		6										
OKA-38/4	8.2	352	0.2	2	62.4	18	19.6		3										
OKA-41/1	6.8	101	0.4	0.8	69.8	25.7	4.4												
OKA-43/1	8.4	130	0.5	14.4	90.9	4.8	4.2												
OKA-43/2	8.7	67	0.3	3.4	93.6	2	4.4												
OKA-43/3	8.8	44	0.1	2	93.9	2.6	3.6												
OKA-43/4	8.7	44	0.2	2.8	93.8	2	4.2												
OKA-44/1	8.5	144	0.4	3.1	71.3	17.8	11		0										
OKA-44/2	8.5	104	0.4	1.3	66.7	15.1	18.1		0										
OKA-44/3	8.5	97	0.2	0.4	59.8	19	21.2		3										
OKA-45/1	8.5	140	0.1	3.6	94.5	1.2	4.2				7.8	139	3	1	8	1		0	0
OKA-45/2	8.3	41	0.2	0.3	93.3	1.8	4.9				7.5	69	1	1	4	0		0	5
OKA-45/3	10.2	415	0.1	1.5	88.5	2.3	9.2				9.6	944	1	1	8	0		0	0
OKA-46/1	8.3	72	0.2	1.5	80.8	12.3	6.9												
OKA-46/2	8.7	62	0.2	0.7	78.6	14.7	6.6												
OKA-46/3	8.7	89	0.2	0.9	71.1	17	12		2										
OKA-46/4	8.7	96	0.2	0.5	70.5	14.3	15.2		4										
OKA-47/1	6.6	116	0.3	1.6	77.4	15.9	6.7	1.1											
OKA-47/2	6.3	16	0.3	0.2	73.8	18.8	7.5	0.7											
OKA-48/1	6.7	56	0.3	1.2	92.2	5.5	2.3	1.3											
OKA-48/2	5.9	15	0.1	0.1	76.6	17.3	6.1	0.5											
OKA-49/1	8.6	102	0.5	1.2	73.8	17.5	8.7	2.8	0										
OKA-49/2	8.8	94	0.3	0.5	80.4	13.9	5.7	4.6	0										
OKA-49/3	8.8	100	0.2	0.7	72.5	17.8	9.6	2.6	0										
OKA-49/4			0.2	0.4	67.5	22.8	9.8	3.9	7										

Auguering Reference	pH	E.C. (microS/cm) 25ºC	O.C (%)	P (ppm)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/Kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)
OKA-53/1	8.4	110	0.4	4.1	80.4	13.9	5.7		0										
OKA-53/2	8.5	96	0.3	1.3	77	14.9	8.1		3										
OKA-57/1	8.3	202	0.4	15	82.7	12.8	4.5	2.7											
OKA-57/2	8.5	114	0.4	2.2	77.5	21.4	1.3	22.8											
OKA-57/3	8.4	119	0.3	1.1	69.3	14.9	15.8	1.2											
OKA-59/1	7.7	75	0.3	1.1	79	12.4	8.6	3.1											
OKA-59/2	7.5	22	0.3	0.5	70.6	13.2	16.2	36.6											
OKA-60/1	6.8	43	89.1	1	89.1	9.1	1.8		0										
OKA-60/2	5.9	15	88.5	0	88.5	8.6	2.9		0										
OKA-62/1	8.0	42	0.2	0.8	82.3	8.4	9.3												
OKA-62/2	8.3	85	0.2	0.4	80.5	8	11.6												
OKA-63/1	8.2	194	0.9	7.1	59.6	16.1	24.4		0		7.9	318	4	3	4	0		0	5
OKA-63/2	8.8	189	0.5	1.6	58	13.1	28.9		1		7.8	522	2	4	4	0		0	5
OKA-63/3	9.2	257	0.2	0.6	59.7	16.6	23.6		3		8.2	194	2	4	6	0			8
OKA-67/1	8.3	83	0.2	1.5	87.2	9.2	3.6	1.7											
OKA-67/2	7.1	27	0.2	0.4	87.1	6.9	6	2.0											
OKA-67/3	5.8	46	0.3	0.4	85.4	5.6	9	2.2											
OKA-82/1	6.4	96	1.3	5.1	64.4	15.3	20.3												
OKA-82/2	7.1	33	0.4	1.1	77	10.7	12.3												
OKA-82/3	6.6	84	0.2	0.5	78.3	8.7	13												
OKA-82/4	6.9	35	0.1	0.3	93	2.2	4.7												
OKA-83/1	7.5	66	0.5	0.8	87.2	8.1	4.7												
OKA-83/2	7.5	34	0.2	0.5	93.8	3.3	2.8												
OKA-83/3	7.9	25	0.1	0.2	96.2	2.4	1.5												
OKA-83/4	7.6	43	0.0	0.3	92.3	2.8	4.9												
OKA-84/1	8.3	4910	0.2	1.7	79.6	8.3	12.1	3.8			8.4	8650							
OKA-84/2	9.0	4420	0.1	2.3	76.4	9.1	14.5	4.1	0		9.2	15680	2	1	4	1			10
OKA-84/3	9.6	2890	0.1	1.4	71.6	12.1	16.4	2.1					19	3	3	2			8
OKA-88/1	7.2	72	0.4	1.4	84.4	4.8	10.7												
OKA-88/2	7.0	34	0.3	0.9	83.3	3.8	12.9												
OKA-88/3	7.3	43	0.2	0.5	84.1	4.2	11.7												
OKA-91/1	8.1	270	0.4	1.9	67.6	16.2	16.2		4										
OKA-91/2	8.2	223	0.4	1.6	64.1	15.7	20.2		4										
OKA-91/3	8.2	189	0.4	1.8	58.2	18.6	23.2		5										
OKA-91/4	8.1	369	0.4	3.1	56.4	17	26.6		8										
OKA-92/3	7.7	30	0.1	0.6	77.7	6.8	15.5												
OKA-93/1	8.3	71	0.3	2.1	83.1	6.9	9.9												
OKA-93/2	7.8	33	0.2	0.8	80.7	4.8	14.5												
OKA-95/1	7.1	50	0.4	1.2	82	10.2	7.7	3.6											
OKA-95/2	5.8	18	0.3	0.6	72.5	8.6	19	1.6											
OKA-96/1	7.3	27	0.2	1.2	88.4	10.3	1.3		0										
OKA-96/2	6.8	71	0.2	0.7	77.3	6.4	16.3		0										
OKA-96/3	7.3	67	0.2	0.8	72.8	7.9	19.3		0										
OKA-103/1	6.0	36	0.2	1.4	95.1	-1.3	6.2												
OKA-103/2	6.4	14	0.1	0.8	91.4	2.7	6												
OKA-106/1	8.1	135	0.8	3.6	77.1	12.7	10.2												
OKA-106/2	8.5	76	0.2	0.7	87.7	4.9	7.4												
OKA-106/3	8.9	42	0.0	0.5	97	1.5	1.5												
OKA-109/1	6.4	171	0.9	2.5	72.4	17.7	9.9				7.9	1026	1	1	6	1			10
OKA-109/2	9.0	8.08??	0.2	0.6	60	12.4	27.6				8.5	1780							
OKA-109/3	9.0	564	0.1	0.6	68.7	8.8	22.5				8.5	1520							
OKA-109/4	9.5	75	0.1		77.7	20.1	2.2				7.7	752							
OKA-112/1	6.1	23	0.4		88.4	1.2	10.4												
OKA-112/2	6.7	39	0.3		67.8	15.4	16.8												
OKA-112/3	7.3	29	0.2		68.6	16.4	15												
OKA-112/4	7.3	22	0.1		78	12	10												
OKA-112/5	7.7	55	0.2		49.7	22.4	27.9												
OKA-114/1	4.6	192	1.0	3.8							7.2	352							
OKA-114/2	4.6	169	0.6	0.1	65.3	19.4	15.3				7.8	7670							
OKA-114/3	3.7	425	0.3								6.3	2350							
OKA-115/1	7.4	877	0.4	3.4							8.4	3790							

Auguering Reference	pH	E.C. (microS/cm) 25ºC	O.C (%)	P (ppm)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/Kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)
OKA-115/2	7.5	1883	0.2	1.3							8.3	4320							
OKA-115/3	8.2	423	0.1								8.5	2170							
OKA-116/1	6.4	87	0.2	2.9	95.8	1.5	2.6	0.6											
OKA-116/2	5.1	17	0.1		94.9	1.2	3.8	0.3											
OKA-116/3	5.1	92	0.1		95.6	1.1	3.5	0.5											
OKA-117/1	8.4	99	0.2		83.8	3.7	12.5												
OKA-121/1	6.0	86	0.7	5.1	81.4	10.4	8.3												
OKA-121/2	6.7	63	0.4	4.9	77.9	10.2	11.8												
OKA-121/3	6.4	38	0.3	0.4	79.1	8.1	12.9												
OKA-122/1	6.2	127	0.3	3	93.9	2.7	3.4	0.5											
OKA-122/2	6.9	30	0.2	3.97	92.3	3.4	4.3	0.2											
OKA-122/3	7.2	24	0.1	0.63	92.6	2.8	4.6	0.2											
OKA-123/1	6.5	59	0.2	0.66	84.9	11.8	3.4												
OKA-123/2	5.9	13	0.1	0.98	95.4	0.7	3.9												
OKA-123/3	6.2	26	0.1	0.52	94.9	0.8	4.2												
OKA-123/4			0.1	0.53	86.3	3.1	10.6												
OKA-126/1	6.0	62	0.2	0.14	85.5	8.4	6.1												
OKA-126/2	6.2	19	0.2	0.04	83.2	9.6	7.2												
OKA-126/3	6.3	34	0.2	0.04	76.5	9.9	13.7												
OKA-130/1	6.1	67	0.6	1.09	84	10.8	5.2												
OKA-130/2	8.7	151	0.3		76.6	6.4	17		1										
OKA-130/3	8.9	199	0.2	0.04	79.6	3.1	17.3		0										
OKA-133/1	6.4	60	0.2	1.66	96.1	0.7	3.2				8.2	426							
OKA-133/2	7.4	46	0.3	0.18	96.5	0	3.5				7.7	82							
OKA-133/3	8.2	555	0.1	0	92	0.3	7.7				8.4	1320							
OKA-134/1	8.6	163	0.3	0.46	65.9	14.8	19.3		19										
OKA-134/2	7.9	142	0.4	1.45	77	8.7	14.3		9										
OKA-134/3	8.0	207	0.6	2.36	80.7	8.7	10.6		6										
OKA-138/1																			
OKA-138/2	6.3	46	0.3	0.08	79.4	13.5	7.1												
OKA-138/3	5.9	26	0.2	0.02	79.9	12.3	7.8												
OKA-138/4	6.1	27	0.2	0	76.2	10.6	13.2												
OKA-147/1	6.5	58	0.8	2.29	90.6	3.3	6.2	1.4											
OKA-147/2	5.1	12	0.3	0	92	0.8	7.2	1.1											
OKA-150/1	8.4	206	0.5	6.5	88.8	3.2	8	3.2											
OKA-150/2	8.6	106	0.4	6	86.8	2.2	11	3.8											
OKA-152/1	6.3	68	0.4	0.58	89.4	4.2	6.4												
OKA-152/2	6.0	11	0.2	0	85.9	5.9	8.2												
OKA-152/3	5.7	27	0.2	0.14	78.1	5.7	16.1												
OKA-156/1	8.4	96	0.2	0.17	70.9	15.4	13.7												
OKA-156/2	7.1	42	0.3	0.51	93	2.8	4												
OKA-156/3	6.5	23	0.2	0.1	92.8	2.4	4.8												
OKA-156/4	6.6	12	0.1	0.19	90.2	0	9.8												
OKA-156/5	6.7	15	0.2	0.39	90.8	8.1	1.1												
OKA-166/1	7.4	51	0.4	0.68	90.8	5.2	4												
OKA-166/2	7.8	53	0.3	0.36	90.2	0	9.8												
OKA-166/3	8.5	93	0.3																
OKA-171/1	9.2	351	0.3	-0.2	92.4	2.7	4.9				8.3	760							
OKA-171/2	10.0	1432	0.1	1.1	85.2	7	7.8		18		9.1	2750							
OKA-171/3	10.2	2020	0.0	0.1	86.3	8.5	5.3		10		8.9	3310							
OKA-171/4	10.2	3010	0.1	5.1	76.2	22.7	1		4		9.4	7750							
OKA-172/1	6.4	4110		0.9							8.9	2070							
OKA-172/2	7.0	3020		1.6							7.1	6730							
OKA-172/3	7.2	2300		0.4							7.0	5500							
OKA-174/1	8.4	172		5.4					21		8.6	264							
OKA-174/2	9.5	330		1.1					21		9.0	43							
OKA-174/3	10.2	1144		0.5					4		9.6	2280							
OKA-175/1	5.9	32	0.1	1.1	96.1	1	2.9												
OKA-175/2	6.7	13	0.1	0.1	94.3	2.3	3.4												
OKA-177/1	6.6	45	0.3	1.1	87.6	11.6	0.8												
OKA-177/2	6.1	26	0.3	0.5	81.7	16.5	1.8												

Auguering	pH	E.C.	O.C	P	Sand	Silt	Clay	C.E.C.	CaCO3	Gypsum	pH (paste)	E.C.(paste)	Ca	Mg	Na	K	Cl	SO4	HCO3
Reference		(microS/cm) 25ºC	(%)	(ppm)	(%)	(%)	(%)	(cmol+/Kg)	(%)	(%)		(microS/cm) 25ºC	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)
OKA-177/3	7.1	30	0.2	0.6	77.2	9.7	13.1												
OKA-181/1	6.2	90	0.6	2	83.2	10.5	6.3												
OKA-181/2	5.8	26	0.3	0.5	84.6	14.8	0.6												
OKA-181/3	5.3	22	0.2	1.6	82.8	9.4	7.8												
OKA-188/1	8.6	70		12.8															
OKA-188/2	6.4	19		1.3															
OKA-193/1	6.4	36	1.8	1.7	18.5	56.5	25												
OKA-193/2	6.9	47	0.6	0.8	39.9	34.1	26.4												
OKA-196/1	6.0	47	0.9	3.3	74.9	6.4	18.8												
OKA-196/2	6.9	48	0.5	1.9	59.2	21.5	19.3												
OKA-196/3	7.7	60	0.3	0.5	73.9	3.3	22.7												
OKA-201/1	8.7	94	0.4	5.2	80.3	19.7	0		1										
OKA-201/2	8.7	96	0.2	1.8	80.9	6	13.1		3										
OKA-205/1	6.4	103	0.5	3.1	93.6	6.1	0.3												
OKA-205/2	6.5	31	0.1	1.3	92.4	7.6	0												
OKA-208/1	5.7	15		1.9															
OKA-208/2	5.4	102		0.4															
OKA-208/3	5.6	12		0															
OKA-214/1	6.7	100		0.9				1.0											
OKA-214/2	7.6	36		0.5				1.8											
OKA-214/3	7.7	29		0				2.3											
OKA-216/1	9.2	347	0.2	3.1	92	8	0	1.2			8.4	11							
OKA-216/2	7.2	21	0.1	0.9	92.1	4.8	3.1	3.0			8.2	76							
OKA-222/1	6.6	29		0.7															
OKA-222/2	6.2	41		-0.1															
OKA-222/3	6.7	15		0.3															
OKA-228/1	6.9	34		3.6															
OKA-228/2	7.6	29		0															
OKA-228/3	7.9	35	0.1	0.8	86.1	3.7	10.2												
OKA-233/1	5.6	33	0.9	1	2.1	42.7	51.8												
OKA-233/2	5.7	33	0.7	1.1	22.1	27.5	50.4												
OKA-238/1	7.0	47	0.2	1.5	96.3	1.7	2												
OKA-238/2	8.0	25	0.1	0.3	97.2	1.4	1.4												
OKA-238/3	6.6	25	0.1	0.8	95.4	1.2	3.4												
OKA-240/1	6.5	81		2															
OKA-240/2	7.5	107		0.4															
OKA-240/3	7.3	97		0.2															
OKA-250/1	7.0	54	0.3	1.2	90.8	7.6	1.6	3.4			8.2	21							
OKA-250/2	9.3	532	0.3	0.8	72.8	8.6	18.6	2.4			8.4	1240							
OKA-250/3	9.5	1135	0.2	0.1	60.8	11.8	27.4	13.7	0		8.5	1980							
OKA-250/4	9.3	1087	0.1	0	49.4	13.1	37.5	30.2	2		8.7	1470							
OKA-250/5	9.7	335	0.1	0.8	90.1	1	8.9	6.4	0		8.4	60							
OKA-253/1	6.9	18	0.5	0.5	97.7	1.1	1.2	2.0											
OKA-253/2	6.4	11	0.1	-0.3	98.1	0.8	1.1	5.9											
OKA-254/1	5.8	37	0.6	0.7	92.3	3.4	4.3												
OKA-254/2	5.3	44	0.2	0.3	94.3	1.8	3.9												
OKA-254/3	6.6	37	0.1	0.4	95.9	2.1	2												
OKA-255/1	8.4	150	1.4	2.5	78	15.7	6.2												
OKA-255/2	8.8	79	0.3	0.3	94	3	3												
OKA-256/1	5.4	151	1.5	2.2	58.9	23.8	17.3	14.1											
OKA-256/2	6.6	28	0.7	0.3	81.1	5.8	13.1	7.7											
OKA-256/3	6.9	15	0.1	0.1	98	0.3	1.7	1.2											
OKA-262/1	6.1	49	0.8	0.5	90.4	5.4	4.2												
OKA-262/2	6.9	19	0.1	0.1	96.4	0.9	2.6												
OKA-264/1	3.6	825	2.9	2.9	94.3	4.1	1.6				5.1	2590							
OKA-264/2	3.9	80	0.1	-0.3	95.8	1.3	2.8				7.8	3150							
OKA-267/1	9.2	799	0.4	1	81.6	5.3	13.1				8.6	3320	29	9	1059	0	210	1	
OKA-267/2	9.9	5690	0.2	0.9	71.8	5.9	22.2		5		9.4	9280							
OKA-272/1	8.0	76	0.2	2.1	91.5	4.6	3.9												
OKA-272/2	6.3	35	0.2	-0.6	88.3	3.7	7.9												
OKA-277/1	6.9	76																	

Auguering Reference	pH	E.C. (microS/cm) 25ºC	O.C (%)	P (ppm)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/Kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)
OKA-277/2	7.6	88																	
OKA-277/3	8.9	69																	
OKA-278/1	8.3	185																	
OKA-278/2	8.8	100																	
OKA-278/3	8.8	99																	
OKA-280/1	8.6	65																	
OKA-280/2	8.6	82																	
OKA-280/3	8.6	130							12										
OKA-287/1	7.6	61	0.2	2.2	91.1	1.7	7.2												
OKA-287/2	7.7	43	0.1	0.6	88	2.9	9.1												
OKA-290/1	6.8	17	0.1	0.2	96.1	3.2	0.7	0.4											
OKA-290/2	6.7	12	0.1	0.2	98	1.1	0.9	0.4											
OKA-300/1	7.3	52	0.2	3	88.8	3.2	8	7.0											
OKA-300/2	7.7	66	0.2	1.6	90.4	0.6	9	10.3											
OKA-301/1	8.2	192	0.3	6.6	80.4	8.9	10.6	15.1											
OKA-301/2	8.3	93	0.3	0.5	77.6	10.6	11.8	10.5											
OKA-301/3	8.0	154	0.2	0.3	76.1	9.3	14.6	7.8											
OKA-301/4	8.2	286	0.2	0.6	75.7	7.9	16.4	5.8											
OKA-303/1	8.7	49	0.2	0.5	90.6	2.7	6.8												
OKA-303/2	7.1	23	0.1	0.5	89.5	4.4	6												
OKA-305/1	7.0	65	0.2	0.8	87.1	3.2	9.7	10.1											
OKA-305/2	7.6	53	0.1	-0.2	84.3	3.5	12.3	6.1											
OKA-310/1	6.9	60	0.2	2.3	93.9	0	6.1												
OKA-310/2	7.3	31	0.1	0	84.7	1	14.2												
OKA-311/1	5.2	46	0.3	1	95.5	1.4	3.1												
OKA-311/2	5.5	17	0.1	0.5	95.5	0.4	4.1												
OKA-313/1	6.7	49	0.3	0.9	90.5	4.5	5												
OKA-313/2	7.2	30	0.2	1.2	82.1	5.6	12.3												
OKA-316/1	8.6	98	0.3	12.7	86.2	5.6	8.2												
OKA-316/2	8.4	113	0.3	1.3	79.1	7.2	13.7												
OKA-319/1	7.1	263	0.1	0.7	90.8	3	6.2												
OKA-319/2	8.5	75	0.3	2.7	93.1	3.1	3.8												
OKA-321/1	7.2	771									7.9	2060							
OKA-321/2	5.1	388									7.8	1063	40	11	19	74	30	6	
OKA-322/1	8.0	119	0.4	0.9	84.1	5.8	10.1		0										
OKA-322/2	8.2	77	0.4	0.4	75.1	8	16.9		1										
OKA-322/3	8.3	145	0.4	0.3	77.9	7.2	14.9		1										
OKA-323/1	6.1	100																	
OKA-323/2	4.9	45																	
OKA-323/3	5.3	23			89.1	2.1	8.8												
OKA-324/1	7.3	225	0.4	13.5	90.1	3.6	6.3												
OKA-324/2	7.8	38	0.2	1.2	86.9	2.5	10.6												
OKA-325/1A	8.5	60	0.3	7.9	92.9	4.4	2.7												
OKA-325/1B	7.2	99	0.3	4.5	87.3	4.1	8.7												
OKA-325/2A	7.8	62	0.1	2.5	93.9	2.8	3.3												
OKA-325/2B	5.8	199	0.2	0.6	81.2	5.2	13.6												
OKA-325/3A	7.9	20	0.1	1.2	93.9	2.8	3.3												
OKA-325/3B	6.3	25	0.5	0.2	79.7	7	13.4												
OKA-334/1	8.2	178	0.3	10.6	92.6	7.2	0.2												
OKA-334/2	8.1	54	0.3	0.7	93	3.2	3.8												
OKA-337/1	5.7	120	1.1	2.5	74.1	19.8	6.1												
OKA-337/2	6.1	19	0.2	0.9	71.4	20.8	7.8												
OKA-337/3	5.5	43	0.2	0.8	71.4	18.6	10												
OKA-338/1	5.7	59	1.0	1.7	66.9	19.9	13.2												
OKA-338/3?	7.4	124	0.3	0.5	60.5	9.2	30.4												
OKA-340/1	8.8	66	0.2	0.5	91.6	2.5	5.9	16.8											
OKA-340/2	8.9	56	0.1	0.3	94.7	0.7	4.6	6.2											
OKA-340/3	7.3	175	0.0	0	97.9	0.4	1.7	11.2											
OKA-342/1	7.4	30	0.3	0.4	91	2.6	6.3												
OKA-342/2	8.1	52	0.4	1	88.5	3.2	8.3												
OKA-343/1	7.0	39	0.3	1.3	91.9	2.8	5.3												

Auguering Reference	pH	E.C. (microS/cm) 25ºC	O.C (%)	P (ppm)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/Kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)
OKA-343/2	8.0	53	0.2	0.6	85.1	4.5	10.3												
OKA-345/1	4.9	49	0.3	0.7	98.1	1.2	0.7	21.1											
OKA-345/2	5.6	14	0.1	0.4	97.9	0.8	1.5	0.3											
OKA-348/1	7.2	134	0.4	18.1	88	3.7	8.3												
OKA-348/2	7.3	93	0.4	2.7	79.4	4.6	16												
OKA-348/3	7.8	60	0.1	0.5	78	0.4	21.6												
OKA-349/1	7.5	49	0.2	8.4	90.9	0.8	8.3												
OKA-349/2	7.3	19	0.2	2.3	90.4	1.6	8												
OKA-349/3	7.3	26	0.2	0.7	77	5.8	17.2												
OKA-350/1	9.4	84	0.2	3.1	90.5	3.2	6.3		0		8.3	413							
OKA-350/2	9.9	1480	0.1	2.8	82.2	2.3	15.5		1		8.6	3030	13	6	431	6	185	171	
OKA-350/3	9.6	1473	0.1	0.4	76.6	1.7	21.6		1		8.8	4120							
OKA-352/1	6.8	18	0.3	12.9	92.7	3.1	4.2	1.8											
OKA-352/2	4.7	76	0.1	1.6	92.7	1.1	6.2	*	1										
OKA-353/1	6.5	32	0.5	2.2	91.3	3.1	5.7												
OKA-353/2	7.8	40	0.2	0.6	91.5	1.5	7												
OKA-355/1	7.9	631	0.4	1.3	76.5	11.8	11.6		2		8.7	923							
OKA-355/2	10.3	1036	0.2	1.6	80.1	5.6	14.3		3		9.2	1564							
OKA-355/3	10.1	1086	0.1	0.9	79.1	2.5	18.4		3		9.7	2070							
OKA-358/1	7.4	86	1.0	2.1	78.4	1.6	20		1		7.6	444	9	10	9	1	10	9	5
OKA-358/2	4.2	628	0.5	0.2	78.7	3.4	18		1		8.0	519	10	8	2	0	5	2	10
OKA-358/3	7.6	35	0.2	0.5	89.6	1.7	8.7		1		7.8	910	25	25	7	1	55	3	10
OKA-364/1	7.9	37	0.2	5.7	95.5	0.5	4.1												
OKA-364/2	7.7	20	0.1	0.7	91.6	2.4	6												
OKA-364/3	7.2	16	0.1	0.2	81.8	1.4	16.8												
OKA-365/1	7.0	36	0.4	0.7	91.1	0.9	8												
OKA-365/2	5.8	109	0.1	0.4	88.5	2	9.5												
OKA-365/3	5.2	371	0.2	0.5	84.5	2.7	12.7												
OKA-366/1	7.4	27	0.2	0.5	96.3	1.1	2.7												
OKA-366/2	7.5	20	0.2	0.8	84.8	1	14.2												
OKA-367/1	8.5	61	0.3	5.1	89.3	8	2.7												
OKA-367/2	8.2	49	0.2	0.9	88	3.5	8.5												
OKA-367/3	8.4	31	0.1	0.3	83.5	5.3	11.2												
OKA-369/1	5.5	21	0.2	1.1	87.5	0	12.5												
OKA-369/2	5.5	15	0.3	0.2	84.5	1.1	14.4												
OKA-369/3	5.4	15	0.3	0	84.3	1.1	15.8												
OKA-371/1	8.3	36	0.2	3.6	94.3	3.9	1.8												
OKA-371/1A	7.1	24	0.2	1.3															
OKA-375/1	5.8	32	0.3	0.7	96.7	2.6	0.7	1.0											
OKA-375/2	5.3	16	0.1	0.1	96.3	1.9	1.9	1.5											
OKA-381/1	7.3	89	0.6	3.1	72.7	14.7	12.6												
OKA-381/2	7.4	98	0.3	1.1	62.6	12.4	25												
OKA-381/3	8.0	245	0.3	1.5	59.3	14	26.7		10										
OKA-386/1	8.2	141	0.8	2.4	85.9	10.5	3.6		3										
OKA-386/2	8.3	195	0.6	1.5	77.9	4.1	17.9		7										
OKA-390/1	6.8	41	0.5	1.4	87.2	2.9	9.9												
OKA-390/2	6.0	94	0.6	0.7	80.4	6.9	12.7												
OKA-390/3	6.4	253	0.3	0.7	64.6	6.1	29.4												
OKA-390/4	8.1	296	0.2	0	59.9	6.2	33.9												
OKA-392/2?	7.8	47	0.2	0.4	82.3	2.8	15												
OKA-398/1	8.2	79	0.4	1.8	90.5	4.4	5.1												
OKA-398/2	8.0	74	0.2	0	90	2.4	7.6												
OKA-398/3	8.0	38	0.1	0.6	87.5	2	10.5												
OKA-399/1	7.7	53	0.5	2.4	88.7	8.9	2.5												
OKA-399/2	8.2	45	0.3	0.3	84.8	4.2	11												
OKA-399/3	8.4	132	0.2	0.5	84	5.4	10.6												
OKA-403/1	6.5	40	0.4	2.1	95.3	3.1	1.7												
OKA-403/2	4.9	82	0.2	1.3	93.8	2.5	3.8												
OKA-407/1	9.3	60	0.1	1.7	98.5	1.9	0.4	*	0		8.7	105							
OKA-407/2	10.3	1407	0.2	3.3	82	5.8	12.2	6.0	4		10.5	2830							
OKA-407/3	10.5	2200	0.1	4	83.9	4.2	11.9	2.3	3		11.1	4420							

Auguering Reference	pH	E.C. (microS/cm) 25ºC	O.C (%)	P (ppm)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/Kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)
OKA-408/1	7.5	77	0.6	0.6	89.9	4	6	5.9											
OKA-408/2	8.4	65	0.4	0.7	88	3.1	8.9	13.2											
OKA-409/1	6.4	22	0.3	2.2	97.7	0.9	1.4	0.4											
OKA-409/2	6.4	18	0.2	0.3	98.1	0.8	1.1	0.9											
OKA-409/3	6.9	21	0.1	0.1	96.2	1.6	2.2	0.8											
OKA-414/1	7.4	64	0.3	3.2	91.9	3	5.1	5.7											
OKA-414/2	8.3	90	0.4	0.2	88.6	3.2	8.3	9.7											
OKA-414/3	7.9	63	0.2	0.2	87.4	2.7	14.5	9.1											
OKA-416/1	9.3	60	0.3	0.9	94.3	5.2	0.5		0		9.6	186	8	5	41	4	10	7	10
OKA-416/2	10.6	2030	0.1	1.5	87.7	2.3	10		3		11.0	3250							
OKA-416/3	10.6	3230	0.1	1.2	79.4	5.6	14.9		5		11.3	6840							
OKA-420/1	8.6	115	0.4	1.2	88.1	3.2	8.7	12.5											
OKA-420/2	8.3	156	0.2	0.2	87.4	2.6	10	11.7	1										
OKA-420/3	8.7	89	0.2	0.3				27.3	2										
OKA-433/1	5.6	20	0.2	1.8	98.9	0.3	0.7												
OKA-433/2	5.6	16	0.1	0.9	98	0.9	1.1												
OKA-438/1	8.0	59	0.3	5.1	90.4	3	6.7												
OKA-438/2	8.4	61	0.2	0.6	89	2.3	8.7		1										
OKA-438/3	8.3	47	0.1	0.3	88.8	1.3	9.9												
OKA-445/1	8.3	148	1.1	1.5	59.4	23.6	17	25.9	23										
OKA-445/2	8.5	100	1.1	1.2	73.4	13.2	13.4	19.9	14										
OKA-445/3	8.9	66	0.2	0.8	95	3.2	1.8	2.2	2										
OKA-447/1	8.9	65	0.3	1.4	98.3	0.8	0.9												
OKA-447/2	9.1	45	0.1	0.4	98.3	0.8	0.9				9.1	73							
OKA-450/1	7.3	60	0.5	2.3	89.1	3.9	7	6.5											
OKA-450/2	7.5	64	0.2	0.8	82.8	5.2	12	10.0											
OKA-452/1	4.6	3060	1.6	0.1	64.7	32.7	2.5	33.2			6.7	4050	640	286	19	2	3	1432	0
OKA-452/2	7.9	96	0.2	0.6	92.7	3.1	4.2	5.9			7.6	2320	51	82	9	1	10	324	0
OKA-461/1	7.4	21	0.1	0.83	95.4	2.4	2.2												
OKA-461/2	7.4	34	0.1	0.55	95.4	0.3	4.3												
OKA-461/3	7.0	32	0.1	0.6	92.9	13	5.9												
OKA-462/1	5.3	32	0.2	0.89	95.6	1	3.5	0.5											
OKA-462/2	5.5	13	0.1	0.17	93.9	1.4	4.7	0.3											
OKA-463/1	7.6	31	0.2	0.1	92.7	3.2	4.1	4.4											
OKA-463/2	8.3	54	0.1	0.1	88.5	3.6	7.9	7.8											
OKA-471/1	7.1	27	0.1	0.38	91.8	4.3	3.9	3.1			8.3	256	1	3	2	0	5	7	0
OKA-471/2	6.4	22	0.1	0.07	87.5	5	7.4	4.6			7.4	745	0	4	7	0	7		0
OKA-472/1	8.4	86	0.4	0.56	84.2	8.9	6.8		3										
OKA-472/2	8.5	133	0.5	0.14	46.8	33.6	19.6		14										
OKA-474/1	7.2	69	0.2	0.13	90.4	5.4	4.3				7.9	224							
OKA-474/2	6.8	29	0.1	0.03	90	5	5				7.6	197	3	4	1	0	10	5	0
OKA-474/3	9.8	636	0.1	2.93	94.3	9.5	3.8				9.1	1820	19	7	1375	15	720	950	10
OKA-474/4	6.3	22	0.2	0.12	74.8	7.2	18				8.3	401	7	5	19	0	8	4	5
OKA-475/1	6.0	21	0.3	0.2	92.6	6.8	0.6												
OKA-475/2	6.7	18	0.1	0.08	94.8	1.7	3.5												
OKA-476/1	7.0	18	0.3	0.27	83.1	6.2	10.7												
OKA-476/2	7.7	21	0.3	0.31	72.2	9	18.8												
OKA-477/1	8.6	80	0.7	0.34	78.4	10.4	11.2		2										
OKA-477/2	8.4	135	1.1	0.13	42.6	31.2	26.2		6										
OKA-477/3	8.7	113	0.9	0.39	26.8	44.3	28.9		49										
OKA-488/1	8.7	87	0.4	0.44	74.6	13.2	12.2		6										
OKA-488/2	8.7	298	0.5	0.43	57.3	17.4	25.3		11										
OKA-488/3	9.0	128	0.3	0.18	56.6	13.5	29.8		5										
OKA-491/1	8.7	70	0.3	0.48	93.3	4.4	2.3	6.4											
OKA-491/2	7.6	33	0.1	0.26	94	1.3	4.7	1.5											
OKA-493/1	8.1	65	0.2	0.25	85.6	5.3	9.1												
OKA-493/2	8.6	84	0.2	0.12	80.3	5.9	13.8		2										
OKA-496/1	8.5	116	0.9	1.61	44.6	36.8	18.6		9										
OKA-496/2	8.6	98	0.6	0.56	63.3	19.1	17.6		9										
OKA-496/3	8.8	68	0.1	0.13	82.9	11.2	5.9		1										
OKA-497/1	7.2	24	0.1	0.3	94.6	2.7	2.8												

Auguering	pH	E.C.	O.C	P	Sand	Silt	Clay	C.E.C.	CaCO3	Gypsum	pH (paste)	E.C.(paste)	Ca	Mg	Na	K	Cl	SO4	HCO3
Reference		(microS/cm) 25ºC	(%)	(ppm)	(%)	(%)	(%)	(cmol+/Kg)	(%)	(%)		(microS/cm) 25ºC	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)
OKA-497/2	6.9	33	0.2	0.07	92.9	2.7	4.5												
OKA-497/3	6.7	63	0.3	0	81.4	2.6	16												
OKA-497/4	8.0	350	0.2	0.13	83.1	2.6	14.4												
OKA-498/1	7.1	31	0.3	1.13	90.5	3.6	5.9												
OKA-498/2	8.2	49	0.2	0.57	83.6	4.6	11.9												
OKA-501/1	5.8	13		0.34	93.6	2.6	3.7												
OKA-501/2	5.3	18		0.1	94.7	1.7	3.7												
OKA-501/3	5.4	14		0	92.9	1.5	5.6												
OKA-502/1	6.4	13		0.38	88			2.6											
OKA-502/2	6.1	14		0.22	92.8	3	4.3	1.6											
OKA-502/3	5.9	20		0.53	91.3	3	5.7	*											
OKA-503/1	7.6	30		0.99	87.3	7.7	4.9	1.6											
OKA-504/1	8.3	73		2.54	88.1	2.8	9	10.6											
OKA-504/2	6.9	55		1.09				2.1											
OKA-504/3	6.8	28		0.75				2.2											
OKA-505/1	5.9	66		0.69															
OKA-505/2	7.5	68		0.25															
OKA-505/3	8.1	56		0.07															
OKA-511/1	7.4	21		0.55															
OKA-511/2	7.5	20		1.07															
OKA-511/3	7.2	23		1.01					1										
OKA-512/1	7.3	37		0.93															
OKA-512/2	7.6	38		0.99															
OKA-512/3	7.3	61		0.14															
OKA-512/4	7.6	57		0.64															
OKA-514/1	5.8	22		0.82															
OKA-514/2	6.0	13		0.62															
OKA-514/3	6.1	15		0.71															
OKA-516/1	6.4	16		0.27															
OKA-516/2	6.1	14		0.28															
OKA-516/3	6.2	9		0.21															
OKA-516/4	6.0	11		0.24															
OKA-517/1	5.7	10		3.08															
OKA-517/2	6.3	47		1.02															
OKA-517/3	7.0	61		0.58															
OKA-518/1	8.6	49		0.48															
OKA-518/2	8.2	26		0.3															
OKA-519/1	8.7	39		0.66															
OKA-519/2	8.6	30		0.79															
OKA-522/1	6.9	51		0.5															
OKA-522/2	7.8	156		0.43															
OKA-522/3	8.6	58		0.07															
OKA-525/1	7.1	88		0.63															
OKA-525/2	7.5	40		0.91															
OKA-525/3	7.8	23		0.8															
OKA-525/4	7.7	33		0.38															
OKA-526/1	6.0	27		0.57															
OKA-526/2	5.9	16		0.28															
OKA-527/1	8.3	271		0							8.1	380	10	7	8	0	10	46	5
OKA-527/2	8.1	1058									7.6	2170	659	37	48	2	5	620	0
OKA-527/3	8.2	666									7.9	1894	55	26	37	1	8	274	0
OKA-527/4	8.5	234									8.0	899	22	8	18	1	10	33	5
OKA-528/1	6.5	1898									7.4	3210	1069	38	26	1	5	808	0
OKA-528/2	5.0	2440									6.7	3610	131	56	38	1	5	817	0
OKA-528/3	5.3	330									7.3	1355	37	13	7	1	25	66	0
OKA-529/1	8.5	176						6.7	20										
OKA-529/2	8.7	111						14.9	25										
OKA-529/3	8.6	103						15.2	35										
OKA-529/4	9.0	90						9.4											
OKA-531/1	8.2	185							36										
OKA-531/2	8.4	142							34										

Auguering Reference	pH	E.C. (microS/cm) 25ºC	O.C (%)	P (ppm)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/Kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)
OKA-531/3	8.4	328							2										
OKA-535/1	6.7	22																	
OKA-535/2	6.6	9																	
OKA-535/3	6.4	15																	
OKA-535/4	6.5	14																	
OKA-536/1	7.9	53							0										
OKA-536/2	8.0	36							0										
OKA-536/3	8.6	85							12										
OKA-536/4	8.7	108							10										
OKA-537/1	7.3	31																	
OKA-537/2	7.5	25																	
OKA-537/3	7.2	63																	
OKA-537/4	8.7	38																	
OKA-538/1	8.7	104																	
OKA-538/2	6.8	7																	
OKA-542/1	8.9	48																	
OKA-542/2	7.9	110																	
OKA-542/3	9.1	192																	
OKA-543/1	6.8	6.6																	
OKA-543/2	7.1	23																	
OKA-543/3	7.9	179							3										
OKA-543/4	8.5	65																	
OKA-544/1	8.0	19																	
OKA-544/2	7.6	15																	
OKA-545/1	8.7	118							25										
OKA-545/2	8.7	185							22										
OKA-545/3	8.6	101							4										
OKA-545/4	8.6	84							2										
OKA-546/1	8.2	98							7										
OKA-546/2	8.6	268																	
OKA-546/3	8.7	59																	
OKA-547/1	8.5	92							6										
OKA-547/2	8.7	164							8										
OKA-547/3	7.9	281							7										
OKA-548/1	8.1	51																	
OKA-548/2	8.8	182																	
OKA-548/3	9.6	44							11										
OKA-550/1	8.2	108							39		8.1	325	10	6	2	1	5	65	0
OKA-550/2	8.7	99							23		8.3	343	6	6	2	1	5		5
OKA-550/3	9.1	105							4		7.9	414	6	7	6	1	15		0
OKA-552/1	8.0	181							7										
OKA-552/2	8.4	212							8										
OKA-552/3	8.5	154							3										
OKA-553/1	8.2	245							32										
OKA-553/2	8.7	100							1										
OKA-553/3	8.5	194							8										
OKA-554/1	8.1	227																	
OKA-554/2	8.5	231																	
OKA-554/3	8.5	191																	
OKA-554/4	8.3	193																	
OKA-556/1	8.4	131																	
OKA-556/2	8.5	205																	
OKA-556/3	9.2	87																	
OKA-557/1	6.6	16						4.5											
OKA-557/2	7.3	21						5.3											
OKA-557/3	6.3	15						3.5											
OKA-560/1	8.4	91							7										
OKA-560/2	8.3	82							29										
OKA-560/3	8.3	70																	
OKA-563/1	6.0	19						1.8											
OKA-563/2	7.3	49						5.4											

Auguering Reference	pH	E.C. (microS/cm) 25ºC	O.C (%)	P (ppm)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/Kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)
OKA-563/3	8.3	80						9.4											
OKA-564/1	7.3	47																	
OKA-564/2	7.9	39																	
OKA-601/1	10.5	1333	0.1	0.91	95.2	1	3.7				10.9	2060	12	5	238	3	35		20
OKA-602/2	10.6	3360	0.1	0.91	93.5	0	6.5	*											
OKA-602/3	10.6	2910	0.1	1	86.1	0.3	13.5	34.7			10.2	6850	8	4	697	3	65		40
OKA-604/1	8.1	75	0.2	0.7	90.8	1.3	7.9												
OKA-604/2	8.6	91	0.1	0.82	84.8	5.9	9.3												
OKA-605/1	6.8	111	0.3	3.02	86.4	7.7	5.9												
OKA-605/2	8.0	88	0.2	1.24	82.4	9.7	7.8												
OKA-605/3	8.7	156	0.2	0.33	77.1	15.9	7		8										
OKA-606/1	8.6	110	0.2	0.36	88.5	6.1	5.4	23.7	4										
OKA-607/1	8.6	80	0.2	2.5	89.2	4	6.7	20.4	2										
OKA-607/2	8.7	91	0.3	1.1	89.2	4.2	6.7	15.4	1										
OKA-607/3	8.7	115	0.2	0.85	88.6	4.7	6.7	24.2	3										
OKA-608/1	8.2	34	0.3	0.9	97	1.3	1.6	2.4											
OKA-608/2	7.5	18	0.1	0.37	96.5	1.3	2.1	1.0											
OKA-609/1	8.7	68	0.4	0.81	93.4	3.4	3.2												
OKA-609/2	8.7	87	0.4	0.96	83.5	9.2	7.3		11										
OKA-609/3	8.8	87	0.2	0.36	89.7	5.7	4.6		12										
OKA-609/4	9.0	51	0.1	0.38	96.2	2	1.8												
OKA-626/1	8.7	55	0.4	3.11	94.5	2.7	2.7		16										
OKA-626/2	8.9	59	0.3	0.75	86.3	7.9	5.8		15										
OKA-626/3	9.2	47	0.1	0.27	97	1.1	1.9		18										
OKA-629/1	8.3	64	0.3	0.6	95.3	2.9	1.8												
OKA-629/2	8.4	64	0.2	1.29	95.8	1.7	2.5												
OKA-629/3	7.4	69	0.1	0.48	95.9	1.7	2.4												
OKA-631/1	8.5	53	0.2	1.08	90.2	3.2	6.5		8										
OKA-631/2	8.4	42	0.2	6.23					4										
OKA-631/3	8.4	69	0.2	7.93	80	7.8	12.2		2										
OKA-633/1	8.6	76	0.4	6.4	79.5	10.9	9.6		5		9.0	192							
OKA-633/2	8.5	209	0.4	5.8	70.6	9.2	20.2		6		8.6	510							
OKA-633/3	8.6	476	0.3	1.9	60.1	15.5	24.4		13		8.4	970							
OKA-635/1	8.4	29	0.2	0.6	94.9	2.4	2.7												
OKA-635/2	8.4	39	0.1	0.31	91.6	3.9	4.6												
OKA-649/1	8.4	56	0.3	0.24	86.9	3.7	9.4	8.8											
OKA-649/2	8.8	46	0.2	0.79	86.7	2.6	10.7	1.4											
OKA-649/3	8.6	52	0.1	0.14	85.2	2.5	12.3	9.5											
OKA-650/1	7.7	48	0.1	0.55	93.9	2.3	3.8												
OKA-650/2	8.4	105	0.2	1.1	91.5	2.7	5.8												
OKA-650/3	8.6	125	0.3	0.75	88.3	4.6	7.1		4										
OKA-658/1	8.2	44	0.2	1.93	89	5	6												
OKA-658/2	8.1	28	0.2	0.31	84.9	3.4	11.7												
OKA-658/3	8.6	64	0.1	0	82.7	3	14.3												
OKA-659/1	5.4	8	0.1	0.8	95.8	0.4	3.8	1.7											
OKA-659/2	5.1	9	0.2	0.05	93.9	0.2	5.9	1.3											
OKA-659/3	5.2	8	0.1	0.02	92.8	0.3	6.9	1.1											
OKA-663/1	8.3	120	0.2	1.18	93	3	4												
OKA-663/2	7.8	28	0.1	0.25	91.2	3.6	5.2												
OKA-663/3	6.7	108	0.1	0.08	91.1	3.4	5.4												
OKA-664/1	5.9	25	0.1	0.96	95.2	1.7	3.1												
OKA-664/2	5.6	156	0.1	0.8	94.7	2.1	3.2												
OKA-665/1	8.1	33	0.1	1.91	92.1	2	5.9												
OKA-665/2	8.0	23	0.1	0.19	90.6	0.5	8.9												
OKA-665/3	8.0	50	0.1	0.2	87.7	3.8	8.6												
OKA-687/1	6.7	51																	
OKA-687/2	7.0	71																	
OKA-801/1	5.9	19	0.2	0.24	97.3	-0.2	2.8												
OKA-801/2	5.3	13	0.1	0.03	97	-0.9	3.9												
OKA-801/3	5.5	13	0.1	0	94.3	2.6	3.1												
OKA-802/1	7.3	22	0.3	0.64	92.1	3.9	4												

Auguering	pH	E.C.	O.C	P	Sand	Silt	Clay	C.E.C.	CaCO3	Gypsum	pH (paste)	E.C.(paste)	Ca	Mg	Na	K	Cl	SO4	HCO3
Reference		(microS/cm) 25ºC	(%)	(ppm)	(%)	(%)	(%)	(cmol+/Kg)	(%)	(%)		(microS/cm) 25ºC	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)
OKA-802/2	6.5	23	0.1	0.09	93.3	2.6	3.8												
OKA-802/3	6.2	18	0.2	0.1	80.5	3.8	15.7												
OKA-803/1	6.1	31	0.5	0.73	90.1	3.1	6.9												
OKA-803/2	5.2	16	0.2	0.21	88.1	4.7	7.2												
OKA-803/3	5.4	11	0.1	0.21	88.6	2.9	8.5												
OKA-804/1	5.9	15	0.4	0.29	96.3	2.2	1.5	2.3											
OKA-804/2	5.4	16	0.1	0.07	97.4	-0.8	3.3	1.2											
OKA-804/3	6.2	15	0.1	0	97.7	-0.8	3.1	1.7											
OKA-805/1	7.6	20	0.2	0.2	91	1.9	7.1												
OKA-805/2	7.8	25	0.1	0.13	90.3	1.1	8.6												
OKA-806/1	6.7	22	0.2	0.87	74	7.3	18.7	3.7											
OKA-806/2	7.0	24	0.1	0	91.6	0.7	7.7	4.7											
OKA-806/3	6.7	20	0.0	0.31	91.4	4.2	4.4	4.4											
OKA-807/1	7.0	43	0.4	0.62	92.1	2.2	5.7												
OKA-807/2	8.4	61	0.2	0	90	2.4	7.6												
OKA-807/3	8.2	37	0.1	0	89.6	1.5	8.9												
OKA-809/1	8.7	90	0.8	0.34	74.1	11.6	14.3	21.7	3										
OKA-809/2	8.7	108	0.6	0.2	75.6	14.8	9.6	6.0	4										
OKA-809/3	8.8	117	0.5	0.4	77.9	11.9	10.3	24.8	16										
OKA-809/4	8.9	100	0.3	0.35	65.4	25.6	9	24.6	20										
OKA-810/1	7.6	31	0.3	0.32	96.5	0.3	3.2	4.1											
OKA-810/2	6.2	10	0.1	0.18	89.3	7.3	3.5	0.8											
OKA-811/1	8.4	97	1.5	1.08	47.2	11.3	41.5	19.7											
OKA-811/2	8.3	25	0.5	0.6	51.7	28.9	19.5	2.4											
OKA-811/3	8.4	25	0.3	0.45	70.8	16.5	12.7	5.1											
OKA-811/4	8.9	25	0.0	0	91.5	7	1.4	1.1											
OKA-811/5	9.0	25	0.1	0.03	87.7	8	4.3	2.4											
OKA-815/1	8.3	65	0.3	0.65	94.3	2.1	3.6	3.8											
OKA-815/2	7.8	27	0.2	0.35	94.8	1.3	4	3.0											
OKA-815/3	6.6	14	0.1	0.4	94.5	1.5	4.1	2.3											
OKA-816/1	5.4	9	0.2	0.37	98.2	1.3	0.5												
OKA-816/2	5.4	17	0.1	0.17	97.9	0.8	1.3												
OKA-816/3	5.7	7	0.1	0.27	97.8	0.7	1.5												
OKA-817/1	6.7	21	0.3	0.36	94.4	1.6	4	2.8											
OKA-817/2	5.8	11	0.1	0.41	90.2	5.5	4.4	2.7											
OKA-817/3	6.8	134	0.2	0.39	85.3	0.6	14.1	5.8											
OKA-818/1	6.1	12	0.4	3.91	97.6	0.8	1.6												
OKA-818/2	5.4	5	0.1	0.12	97.2	1.1	1.7												
OKA-819/1	6.6	20	0.3	0.74	93.4	4.5	2.1												
OKA-819/2	6.1	7	0.2	0.12	93.5	4.7	1.8												
OKA-820/1	7.7	33	0.3	0.6	92.9	3.2	3.9												
OKA-820/2	7.6	17	0.3	0.37	88.2	4.4	7.4												
OKA-822/1	7.4	29	0.4	9.74	94.3	3.2	2.4	3.6											
OKA-822/2	7.4	25	0.1	4.89	93.2	2.4	4.3	2.7											
OKA-822/3	7.5	22	0.1	0.33	92.7	3.8	3.5	7.0											
OKA-823/1	8.4	87	0.6	1	69.7	14.3	16		1										
OKA-823/2	8.7	103	0.3	0.38	60.6	15.1	24.2		8										
OKA-823/3	8.4	235	0.2	0.22	57.3	16.6	26.1		10										
OKA-824/1	6.7	23	0.2	0.64	82.8	9.7	7.5	4.1											
OKA-824/2	6.8	52	0.2	0.49	81	11	8	5.0											
OKA-825/1	8.5	30	0.2	0.27	82.5	16.7	0.7				8.5	165							
OKA-825/2	9.4	113	0.2	0	87.7	10.5	1.9				9.1	360							
OKA-825/3	9.8	82	0.1	0.34	85	11.4	3.6				9.2	2070							
OKA-825/4	10.3	1490	0.1	0.9	80	8	12		2		9.9	1570							
OKA-825/5	10.4	2200	0.1	3.54	73.2	13.4	13.4		1		10.3	4340							
OKA-826/1	6.6	42	0.5	1.31	77.5	11.8	10.7												
OKA-826/2	6.8	37	0.5	0.57	78.5	12.9	8.6												
OKA-826/3	6.1	22	0.4	0.59	76.4	11.2	12.3												
OKA-826/4	5.3	85	0.3	0.17	72.4	11.9	15.7												
OKA-826/5	5.7	74	0.3	0.61	76.5	9.6	13.9												
OKA-827/1	8.9	74	0.5	4.13	74.9	15.7	9.4		7										

Auguering Reference	pH	E.C. (microS/cm) 25ºC	O.C (%)	P (ppm)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/Kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)
OKA-827/2	8.6	91	0.3	0.66	67.1	15.6	17.3		2										
OKA-827/3	8.8	89	0.3	0.64	63.1	22.9	13.9		16										
OKA-828/1	7.3	43	0.5	1.52	77.2	15.6	7.3	5.4											
OKA-828/2	6.9	52	1.3	0.34	59.6	23.9	16.5	6.6											
OKA-828/3	6.6	36	0.7	0.15	46.1	29.4	24.4	9.5											
OKA-829/1	8.6	64	0.3	0.52	86.4	9.7	3.9	3.7											
OKA-829/2	5.0	46	0.4	0.04	81.2	7.4	11.4	1.2											
OKA-831/1	6.9	105	1.1		40.5	17.8	41.7				9.4	197							
OKA-831/2	7.7	475	1.6		33.6	40.3	26.2				7.6	610							
OKA-831/3	8.5	424	0.1		94.2	4.1	1.7				7.9	1680							
OKA-831/4	8.6	244	0.1		92.4	4.2	3.4				8.2	345							
OKA-832/1	6.1	141	0.9		21.9	35.1	43				5.9	50	xxx						
OKA-832/2	4.4	1222	1.2		23.7	26.6	49.7				4.5	1100	xxx						
OKA-832/3	4.1	1509	3.1		55.3	2.9	41.8				4.3	1770	xxx						
OKA-832/4	4.6	211	0.2		95.9	2.8	1.3				3.9	543	xxx						
OKA-833/1	7.9	249																	
OKA-833/2	7.7	339																	
OKA-833/3	8.9	58																	
OKA-833/4	8.4	48																	
OKA-834/1	7.5	56			93.1	2.2	4.7												
OKA-834/2	8.4	51			89.9	2.2	7.9												
OKA-834/3	8.7	64			87.6	3.5	8.9		1										
OKA-834/4	8.7	92			75.5	10.5	14		4										
OKA-835/1	7.1	64			92.7	4.3	3				5.8	112	xxx						
OKA-835/2	6.6	1303			75.9	7.7	16.3				6.0	2350	xxx						
OKA-835/3	7.4	4480			43.5	22.3	34.2			5	7.7	7	xxx						
OKA-835/4	7.9	4160			59.8	2.3	37.9			60	8.3	6260	xxx						
OKA-836/1	8.6	34			95.6	3.2	1.2				7.8	49	xxx						
OKA-836/2	10.1	438			90.8	2.2	7.1				9.2	782	xxx						
OKA-836/3	10.3	846			88.1	1.1	10.8				9.9	908	xxx						
OKA-836/4	10.7	671			90.9	1.9	7.2				10.0	1290	xxx						
OKA-837/1	7.8	14																	
OKA-837/2	8.1	18																	
OKA-838/1	8.8	52																	
OKA-838/2	8.5	22																	
OKA-838/3	8.6	45																	
OKA-839/1	7.9	27			89.4	4.2	6.4												
OKA-839/2	7.8	32			86.1	2.9	11												
OKA-839/3	8.8	88			83.1	4.7	12.2		4										
OKA-839/4	8.7	86			83.4	4.2	12.4		2										
OKA-840/1	7.6	18																	
OKA-840/2	5.5	9																	
OKA-840/3	5.2	8																	
OKA-841/1	7.6	34			86.2	4.2	9.6												
OKA-841/2	8.3	28			82.9	4.2	12.9		1										
OKA-841/3	8.6	78			79.7	4.1	16.2		2										
OKA-841/4	8.8	105			65	7	28		11										
OKA-842/1	7.8	108			60.6	11.5	27.8				7.6	514							
OKA-842/2	7.9	139			64.5	12.5	23				7.7	486							
OKA-842/3	8.0	10			94.1	3.2	2.7				7.8	29							
OKA-843/1	7.7	29																	
OKA-843/2	8.0	34																	
OKA-843/3	8.0	29																	
OKA-844/1	8.6	71			83.9	5	11.1		2										
OKA-845/1	8.6	55																	
OKA-846/1	8.3	58			84.2	8.7	7.1												
OKA-846/2	8.6	74			77.7	10.6	11.7		1										
OKA-846/3	8.6	97			71.3	12.2	16.5		6										
OKA-847/1	5.7	12																	
OKA-847/2	5.3	12																	
OKA-847/3	6.0	13																	

Auguering Reference	pH	E.C. (microS/cm) 25ºC	O.C (%)	P (ppm)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/Kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)
OKA-848/1	5.7	16																	
OKA-848/2	5.4	13																	
OKA-848/3	5.8	9																	
OKA-849/1	8.6	60																	
OKA-849/2	8.6	50																	
OKA-849/3	7.4	12																	
OKA-850/1	9.9	893			82	5.8	12.3				8.6	782	xxx						
OKA-850/2	10.2	2830			70.1	7.8	22.1		6		9.8	3020	xxx						
OKA-850/3	10.3	2760			66.5	6	27.4		8		10.0	3600	xxx						
OKA-850/4	10.5	1946			60.8	12.4	26.8		12		10.1	3120	xxx						
OKA-851/1	6.3	31			75.3	17.7	6.9				6.3	36							
OKA-851/2	7.7	55			50.9	13.6	35.5				8.0	253							
OKA-851/3	7.2	34			34.5	18.2	47.4				6.3	173							
OKA-851/4	7.2	10			93.6	5.4	1				7.8	10							
OKA-852/1	8.7	64			93.8	4.1	2.1		20										
OKA-852/2	8.2	70			92.6	4.4	3		18										
OKA-852/3	8.4	66			92.2	3.6	4.1		4										
OKA-852/4	8.3	54			94.5	2.8	2.7		1										
OKA-853/1	8.2	47																	
OKA-853/2	7.4	16																	
OKA-853/3	6.3	8																	
OKA-854/1	8.2	48																	
OKA-854/2	7.9	24																	
OKA-855/1	5.2	9																	
OKA-855/2	5.3	6																	
OKA-856/1	7.0	12																	
OKA-856/2	6.6	13																	
OKA-856/3	6.4	12																	
OKA-856/4	6.3	27																	
OKA-857/1	7.2	22																	
OKA-857/2	6.7	13																	
OKA-857/3	6.4	11																	
OKA-858/1	7.1	20																	
OKA-858/2	7.2	35																	
OKA-859/1	8.2	69																	
OKA-859/2	8.3	26																	
OKA-859/3	8.6	35																	
OKA-860/1	8.3	29			54.7	28.7	16.6												
OKA-860/2	8.0	166			58.7	22.5	18.9		21										
OKA-860/3	8.2	123			49.7	23.2	27.1		22										
OKA-861/1	7.2	25																	
OKA-861/2	7.4	42																	
OKA-861/3	missing																		
OKA-862/1	8.3	73			83.7	9.7	6.6		10										
OKA-862/2	8.5	57			89.5	6.8	3.7		6										
OKA-862/3	8.7	43			95.8	2.9	1.3		1										
OKA-863/1	7.8	85			80.3	9.1	10.7												
OKA-863/2	7.8	63			77.6	9.2	13.2												
OKA-863/3	7.8	45			77.6	8	14.4												
OKA-864/1	7.6	50			95.8	2.6	1.6				7.9	107							
OKA-864/2	9.4	583			91.9	3	5.1		0		8.9	859							
OKA-864/3	8.9	1485			89.4	3.8	6.8		2		8.5	2260							
OKA-864/4	8.5	2320			89.5	2.5	8		0		8.5	3720							
OKA-865/1	6.0	26																	
OKA-865/2	5.4	24																	
OKA-865/3	8.5	54																	
OKA-866/1	6.7	304			93.4	4.7	1.9				7.3	307							
OKA-866/2	8.7	504			90.8	3.3	5.9		0		8.8	630							
OKA-866/3	8.9	2350			91.9	2.8	5.2		0		7.5	82							
OKA-867/1	7.9	133			74.4	15.2	10.4		3										
OKA-867/2	8.2	80			75.3	14.1	10.6		4										

Auguering Reference	pH	E.C. (microS/cm) 25ºC	O.C (%)	P (ppm)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/Kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm) 25ºC	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)
OKA-867/3	8.3	87			67.3	16.7	16		9										
OKA-868/1	7.4	173			65.9	21.9	12												
OKA-868/2	7.0	112			69	21	10												
OKA-868/3	7.9	93			69.2	18.8	12		0										
OKA-868/4	8.8	112			60.7	23.9	15.4		10										
OKA-868/5	8.8	96			66.3	20.8	12.9		5										
OKA-869/1	8.9	119																	
OKA-869/2	8.8	208																	
OKA-870/1	7.5	52			88.3	8.6	3												
OKA-870/2	7.0	47			82.3	8.5	9.2												
OKA-870/3	5.5	36			75.2	7.5	17.3												
OKA-870/4	6.3	41			71.2	7.2	21.4												
OKA-871/1	7.8	66			78.8	15.9	5.4												
OKA-871/2	7.6	38			76.1	11.6	12.3												
OKA-872/1	8.3	130																	
OKA-872/2	8.3	36																	
OKA-873/1	9.0	43																	
OKA-873/2	8.5	19																	
OKA-873/3	8.3	17																	
OKA-874/1	8.0	21																	
OKA-874/2	7.7	34																	
OKA-874/3	8.1	47																	
OKA-875/1	8.6	69																	
OKA-875/2	7.9	36																	
OKA-875/3	7.8	36																	
OKA-876/1	7.5	23			90	4.2	5.8				7.6	58	xxx						
OKA-876/2	6.0	9			78.7	4.5	16.8				5.9	52	xxx						
OKA-876/3	6.3	11			75.8	4.6	19.5				6.4	61	xxx						
OKA-877/1	8.0	26			94.2	3.4	2.3		0										
OKA-877/2	8.0	27			90.1	3.6	6.3		0										
OKA-877/3	8.3	20			90.2	2.9	6.8		0										

CO3 (meq/l)
30
30
20

CO3
(meq/l)
10
5
10
10
0
5
5
5
5
10
5
5
5

CO3 (meq/l)
2
5
3
5
5
0

CO_3 (meq/l)

CO3
(meq/l)

CO3 (meq/l)

CO_3 (meq/l)
10
20
20

CO3
(meq/l)
20
3
0
0
0
5
10
13

CO3 (meq/l)
5
0
3
0
0
5
0

CO3 (meq/l)
0
0
70

CO3 (meq/l)
40
35

CO3 (meq/l)

CO3 (meq/l)

CO3
(meq/l)

CO3
(meq/l)

7.1.1. Location

The study area is located in the four northern central regions of Omusati-Oshikoto-Oshana and Ohangwena. The area, trapezoidal in shape, covers an area of 87.645 Km^2 and is included in the polygon formed by the border with Angola, the meridian 16º05', the line that would connect Ondangwa with Tsandi and the road Tsandi-Etunda.

The area is characterized by a flat plain, averaging 1100 meters above sea level, which forms part of the Etosha depression. The plain is traversed by shallow, ephemeral water courses, called oshanas, that originated in Angola and flow southwards through a flat plathe study area, to the Ethosa Pan; forming in this way the drainage system of the area.

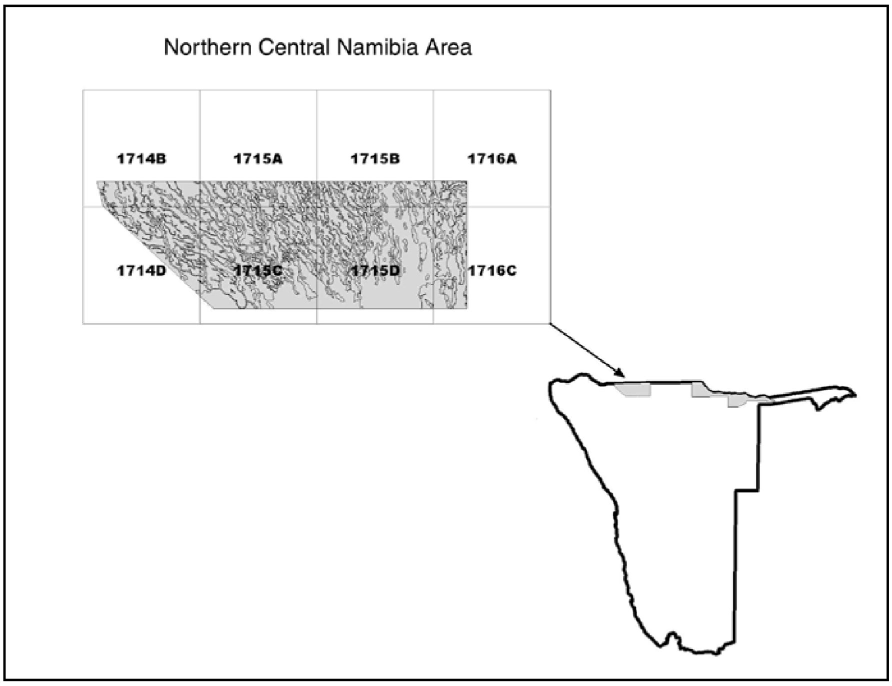


Figure 7.1. Location of the Northern Central Namibia area.

7.1.2 Climate

The study area presents a subtropical climate. Rainfall occurs mainly as summer thunderstorms during the period late November to early April. Summers are extremely hot, temperatures can arrive to 39ºC during the period October-February. Winters are mild, although temperatures below 0ºC can be achieved during the period June-August.

According to the data gathered in Ondangwa during the period 1961-1990, average rainfall is around 309 mm, but clearly decreases to the west of the area where the average rainfall in Uutapi hardly reaches 265 mm.

Rainfall in the survey area vary from year to year, and from place to place. Normally starts from mid October and continues until April. The driest months range from May to September.

The average annual temperature in the study area is around 22.9ºC. Table 1 gives a general view of the thermometric regime.

The reference crop evapotranspiration, according to Blaney-Criddle, is around 1990 mm (Table 7.1).

The strongest winds, from August to Novemver, come from the East and the North-East.

Table 7.1. Climatic characteristics of Ondangwa. (Ondangwa, 1961-1990)

Month	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
T max	31.7	30.6	30.4	30.6	28.9	26.5	26.8	29.6	33.2	34.5	33.3	32.7
t min	19.1	18.8	18.6	16.5	12.0	8.4	7.7	9.4	13.3	17.1	18.6	18.9
t mean	25.4	24.7	24.5	23.5	20.4	17.4	17.3	19.5	23.2	25.8	25.9	25.8
Abs. m	12.3	11.7	7.4	8.0	0.1	-3.0	-1.0	-0.6	2.5	6.1	10.8	9.5
Abs. M	39.4	39.1	37.5	36.6	35.4	31.0	32.0	35.0	38.5	39.4	40.2	38.5
Rainf.	113.4	99.0	97.2	28.8	2.0	0.7	0.0	0.0	2.0	12.5	44.5	41.3
E.T.o.	167.4	142.8	151.9	165.0	142.6	114.0	127.1	182.9	210.0	254.2	162.0	170.0

7.1.3. Geology and geomorphology

Geologically most of the study area comprises Cenozoic deposits of the Kalahari Group that overlays extensive sandstones sheets of the Karoo sequence (Geological Survey, 1963).

The successive layers of sands, clays, sandstones and conglomerate of the Kalahari Group are up to 500 m thick and of Tertiary to Quaternary age (30 to 40 million years). In the central part of the area the basal portion of the succession consists of the conglomeratic sandstone of the Beiseb Formation, between 15 m and 30 m thick. The basal unit is overlain by the poorly consolidated calcareous sandstone of the Olukonda Formation, reaching a thickness of more than 120 m. Above the reddish basal layers, a material change in the lithology of the remaining upper portion of the succession occurs in the Andoni Formation. The Formation comprises sandy clay and clayey sands which probably indicate a change in climatic conditions during the time of deposition.

The deposition of the windblown sand, that makes up the Kalahari sands, took place primarily during the Pliocene age and were subsequently redistributed during the Quaternary.

Three physiographical regions have been distinguished in the study area: the Cuvelai river system, the oshanas system and the flat plains with small pans.

The Cuvelai river system is a flat to gently ondulated network of low-lying interconecting ephemeral water courses that flows and overflows the sand deposits of the Kalahari plateau in a dense inflowing stream pattern. This confers to the area the aspect of a braided river with abandoned sand banks along the stream.

The oshanas system is also a flat to gently ondulated network of low-lying interconected ephemeral pans and shallow water courses that flow in a shouth-easterly direction the sand deposits of the Kalahari plateau in a moderately dense inflowing stream pattern.

The flat plains with small pans is a flat area formed where the watercourses of the Cuvelai river and the oshanas lose completely their transport capacity and shift constantly.

The parent material of the soils is remarkably uniform and composed predominantly of poor aeolian sand of the Kalahari formation with a low colloid (organic matter and clay) content that influences colour and structure. When dry, most of these soils develop a hard layer between five and fifty centimetres below the surface probably caused by sodicity. This layer is believed to act as a serious constraint to the yield of crops.

Along the ephimeral watercourses the sandy materials are enriched with silt and highly expandible clay deposited by seasonal flooding. In this way clayey soils occur in scattered locations associated with the beds of the oshanas and pans. These soils are generally too saline for crop production.

7.1.4. Vegetation and land use

The natural vegetation of the study area can be broadly classified into three groups:

An open woodland savannah with sparsely distributed high trees, such as zambezi teak (Baikiaea plurijuga), kalahari apple-leaf (Lonchocarpus nelsii) and copal wood (Giboutia coleoperma), is associated with aeolian sand located in the Cuvelay river system and in narrow lenses in the higher lying areas in the oshanas system.

The oshana system is dominated by mopane shrubland and some grasslands. Other vegetation such as acacias (Acacia spp.), Shepherd's tree (Boscia albitrunca), mangueti tree (Schinziophyton rautanenii), sickle bush (Dichrostachys cinerea), mustard tree (Salvadora persica), marula tree (Schlerocarya birrea), baobab (Adansonia digitat) and makalani palms are the most characteristics.

The palm savannah, associated with secondary growth of acacia and mopane shrub, also occurs around the whole area. Scattered stands of these plant communities are common on the perimeters of the oshanas and are a typical feature of the landscape.

Finally, open grassland occurs in the flat plains with small pans. Trees and shrubs are absent because the area is seasonally inundated. The grass utilization is restricted due to the seasonal inundation and moderate nutritional value.

The local land use system is an agrosilvipastoral one where crops, trees and livestock are used. The crops components consists primarily of millet (omahangu) with inter-cropping of various crops such as sorghum, beans, pumpkin and watermelons. The livestock component consists of cattle, goats and donkeys grazing in a extensive way. Finally, the tree component consists of a diverse mix of local, multipurpose species, including mopane, marula, palms, figs and baobabs.

The main constraints of the study area for agriculture are the climate (availability of water), soil characteristics (sodicity and salinity, low organic matter contents, low cation exchange capacity and low water holding capacity) and the general needs for plant nutrients (although livestock manure is used to fertilize the soil).

7.2.1. Legend of the Soil Survey (1:100.000) of the Northern Central Namibia Area

C. Cuvelai River System

Cs. Cuvelai Stream

Cs1. haplic Calcisols & sodic Cambisols & haplic Luvisols Association, loamy sand, slope < 2%

Cb. Sand Banks

Cb1. ferralic Arenosols, sandy, slope < 2%

O. Oshanas System

Oo. Oshanas

Oo1. sodic Cambisols & calcic Solonetzs & natric-calcic vertisols & natric-gypsic Vertisols Association, sandy loam, slope <2%

Oi. Isolated Oshanas

Oi1. sodic Cambisols & calcic Solonetzs & natric-calcic vertisols & natric-gypsic Vertisols Association, sandy loam, slope <2%

Ow. Woodlands

Ow1. ferralic Arenosols & sodic Cambisols Association, loamy sand, slope <2%
Ow2. sodic Calcisols & sodic Cambisols Association, loamy sand, slope <2%
Ow3. ferralic Arenosols, sandy, slope <2%

P. Flat plains with dense and small pans

Pf. Flat plains with small pans

Pf1. hyposalic Arenosols & sodic Cambisols & natric-calcic Vertisols & natric-gypsic Vertisols Association, sandy loam, slope <2%

7.2.2. Description of the map units

Cb1. ferralic Arenosols, sandy, slope < 2%

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained. They formed on the sand banks scattered along the Cuvelai stream.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to yellowish red in colour. Underneath, to a depth of more than 100 cm, we find dark grey to reddish yellow, sand material showing very weak horizon differentiation.

Hyposalic Arenosols, haplic Cambisols and sodic Cambisols can appear as inclusions at the borders of the map unit.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that controls the water in the soil that can be readily absorbed by plants and the low cation exchange capacity that controls the availability of plant nutrients.

Cs1. haplic Calcisols & sodic Cambisols & haplic Luvisols Association, loamy sand, slope < 2%

This association consists of soils formed on the flat to gently undulating network of low-lying interconnecting ephemeral water courses that form the Cuvelay stream. It presents haplic Calcisols, sodic Cambisols and haplic Luvisols as dominating soils.

Haplic Calcisols are very deep, coarse to moderately coarse textured and well drained. They formed on the higher parts of the inter-channels of the Cuvelai stream.

Typically the surface layer is 15 to 25 cm thick, sand to loamy sand and dark grey to brown in colour. Underneath, to a depth of more than 100 cm, we find very dark greyish brown to light yellowish brown loamy sand to sandy clay loam material that presents a weak structure and many to abundant accumulations of calcium carbonate in a diffuse form dispersed in the matrix or in discontinuous concentrations hard and soft nodules, both resulting in a calcic (occasionally, hypercalcic) horizon.

Ferralic Arenosols, haplic Cambisols and petric Calcisols can appear as inclusions in these positions.

These soils have a moderately rapid hydraulic conductivity and present a moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture is the low to moderate water holding capacity that controls the water in the soil that can be readily absorbed by plant roots.

Sodic Cambisols are very deep, coarse to moderately coarse textured and moderately well to well drained. They formed on the side slopes of the inter-channels of the Cuvelai stream. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to loamy sand and very dark greyish brown to light brownish grey in colour, loose or with a very weak structure. Underneath, it appears an horizon 20 to 40 cm thick, dark grey to light brownish grey, sand to sandy loam, with a massive or very coarse subangular blocky structure and an extremely hard consistence when dry probably associated with temporarily floodings during the rainy season and the presence of sodium as dominant cation in the soil. Below we find a greyish brown to very pale brown, sandy loam material that presents a weak structure and, occasionally, very few to few accumulations of calcium carbonate and/or gypsum.

Most of the times, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

Sodic Calcisols, sodic Gypsisols, calcic Solonetzs and gypsic Solonetzs can appear as inclusions in these positions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that controls the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Haplic Luvisols are very deep, moderately coarse to moderately fine-textured and imperfectly to moderately well drained. They formed on the lower parts of the ephemeral channels that form the Cuvelai stream.

Typically the surface layer is about 20 cm thick, loamy sand to sandy loam and very dark grey to brown in colour. Underneath, it appears an horizon 20 to 40 cm thick, loamy sand to sandy clay loam, very dark grey to pale brown in colour that presents a weak to moderate structure. Below, to a depth of more than 100 cm, we find very dark grey to light grey, sandy clay loam material that presents a moderate to strong prismatic or angular blocky structure and, most of the times, slickensides and/or shine faces, resulting in an argic horizon.

These soils have a moderately slow to moderate hydraulic conductivity and present a moderate infiltration rate. They have a moderate to moderately high water holding capacity.

The main constraints for agriculture is the position where they are located on the ladscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. Moreover, the hard consistence of the argic horizon, when dry, can limit the root penetration and, therefore, the effective rooting depth.

Oi1. sodic Cambisols & calcic Solonetzs & natric-calcic Vertisols & natric-gypsic Vertisols Association, sandy loam, slope <2%, slightly to moderately saline and sodic.

This association consists of soils formed on the isolated oshanas scattered around the study area. It presents sodic Cambisols and calcic Solonetzs as dominating soils on the narrow areas of the isolated oshanas, and natric-calcic Vertisols and natric-gypsic Vertiols as dominating soils on the wide areas and on the pans that can be present in the isolated oshanas.

Sodic Cambisols are very deep, coarse to moderately coarse textured and moderately well to well drained. They mainly formed on the narrow areas of the isolated oshanas. These soils are slightly saline and sodic.

Typically the surface layer is about 20 cm thick, sand to loamy sand and very dark greyish brown to light brownish grey in colour, loose or with a very weak structure. Underneath, it appears an horizon 20 to 40 cm thick, dark grey to light brownish grey, sand to sandy loam, with a massive or very coarse subangular blocky structure and an extremely hard consistence when dry, probably associated with temporarily floodings during the rainy season and the presence of sodium as dominated cation in the soil. Below we find a greyish brown to very pale brown, sandy loam material that presents a weak structure and, occasionally, very few to few accumulations of calcium carbonate and/or gypsum.

Most of the times, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

Sodic Calcisols, sodic Gypsisols, and gypsic Solonetzs can appear as inclusions in these positions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that controls the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Calcic Solonetzs are very deep, moderately coarse to moderately fine-textured and imperfectly to moderately well drained. They formed on the narrow areas of the isolated oshanas. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to sandy loam and black to greyish brown in colour. Underneath, to a depth of more than 100 cm, we find pale yellow to dark grey, sandy clay loam to sandy clay material that presents a moderate to strong prismatic or angular blocky structure and, most of the times, shiny faces and/or slickensides, resulting in a natric horizon because of the sodium that dominates the soil solution and the exchangeable sites. Moreover, this material also presents accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules resulting in a calcic horizon.

Sodic Calcisols, sodic Gypsisols and gypsic Solonetzs can appear as inclusions in these positions.

These soils have a moderately slow to moderate hydraulic conductivity and present a moderate infiltration rate. They have a moderate to moderately high water holding capacity.

The main constraints for agriculture is the position where they are located on the landscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. On the other hand, the hard consistence of the natric horizon, when dry, can limit the root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity can reduce the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Natric-calcic Vertisols are very deep, fine textured and poorly to imperfectly drained. They formed on the pans that can be present in the isolated the oshanas. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sandy clay loam to sandy clay and black to dark grey in colour. Underneath, to a depth of more than 100 cm, we find pale yellow to very dark grey, sandy clay material that presents a moderate to strong subangular or angular blocky structure and, in some horizons, intersecting slickensides resulting in a vertic horizon. Moreover, this material also presents accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules resulting in a calcic horizon.

These soils have a slow hydraulic conductivity and present a slow infiltration rate. They have a moderately high to high water holding capacity.

The main constraints for agriculture is the position where they are located on the landscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. On the other hand, the consistence of the soils (hard when dry and sticky when wet) and the expansible character of the clay minerals make them difficult to work. Moreover, the slight to moderate salinity can reduce the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Natric-gypsic Vertisols are very deep, fine textured and poorly to imperfectly drained. They formed on the pans that can be present in the isolated oshanas. These soils are slightly to moderately saline and sodic.

Typically the surface layer is between 15 and 25 cm thick, sandy clay loam to sandy clay and black to very dark grey in colour. Underneath, to a depth of more than 100 cm, we find light olive grey to very dark grey, sandy clay material that presents a moderate to strong subangular or angular blocky structure and, in some horizons, intersecting slickensides, resulting in a vertic horizon. Moreover, this material also presents accumulations of crystals of gypsum resulting in a gypsic horizon.

Gypsic Solonetzs can appear as inclusions in these positions.

These soils have a slow hydraulic conductivity and present a slow infiltration rate. They have a moderately high to high water holding capacity.

The main constraints for agriculture is the position where they are located on the landscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. On the other hand, the consistence of the soils (hard when dry and sticky when wet) and the expansible character of the clay minerals make them difficult to work. Moreover, the slight to moderate salinity can reduce the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Oo1. sodic Cambisols & calcic Solonetzs & natric-calcic Vertisols & natric-gypsic Vertisols Association, sandy loam, slope <2%, slightly to moderately saline and sodic

This association consists of the soils formed on the long, narrow and branching areas that form the oshanas. It presents sodic Cambisols and calcic Solonetzs as dominating soils on the narrower parts of the oshanas and natric-calcic Vertisols and natric-gypsic Vertiols as dominating soils on the wider parts of the oshanas and on the pans scattered along the map unit.

Sodic Cambisols are very deep, coarse to moderately coarse textured and moderately well to well drained. They mainly formed on the narrow parts of the oshanas. These soils are slightly saline and sodic.

Typically the surface layer is about 20 cm thick, sand to loamy sand and very dark greyish brown to light brownish grey in colour, loose or with a very weak structure. Underneath, it appears an horizon 20 to 40 cm thick, dark grey to light brownish grey, sand to sandy loam, with a massive or very coarse subangular blocky structure and an extremely hard consistence when dry, probably associated with temporarily floodings during the rainy season and the presence of sodium as dominating cation in the soil. Below we find a greyish brown to very pale brown, sandy loam material that presents a weak structure and, occasionally, very few to few accumulations of calcium carbonate and/or gypsum.

Most of the times, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

Sodic Calcisols, sodic Gypsisols and gypsic Solonetzs can appear as inclusions in these positions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that controls the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Calcic Solonetzs are very deep, moderately coarse to moderately fine-textured and imperfectly to moderately well drained. They formed on the narrower areas of the oshanas. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to sandy loam and black to greyish brown in colour. Underneath, to a depth of more than 100 cm, we find pale yellow to dark grey, sandy clay loam to sandy clay material that presents a moderate to strong prismatic or angular blocky structure and, most of the times, shiny faces and/or slickensides, resulting in a natric horizon because of the sodium that dominates the soil solution and the exchangeable sites. Moreover, this material also presents accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules resulting in a calcic horizon.

Sodic Calcisols, sodic Gypsisols and gypsic Solonetzs can appear as inclusions in these positions.

These soils have a moderately slow to moderate hydraulic conductivity and present a moderate infiltration rate. They have a moderate to moderately high water holding capacity.

The main constraints for agriculture is the position where they are located on the landscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. On the other hand, the hard consistence of the natric horizon, when dry, can limit the root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity can reduce the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Natric-calcic Vertisols are very deep, fine textured and poorly to imperfectly drained. They formed on the pans scattered along the oshanas. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sandy clay loam to sandy clay and black to dark grey in colour. Underneath, to a depth of more than 100 cm, we find pale yellow to very dark grey, sandy clay material that presents a moderate to strong subangular or angular blocky structure and, in some horizons, intersecting slickensides resulting in a vertic horizon. Moreover, this material also presents accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules resulting in a calcic horizon.

These soils have a slow hydraulic conductivity and present a slow infiltration rate. They have a moderately high to high water holding capacity.

The main constraints for agriculture is the position where they are located on the landscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. On the other hand, the consistence of the soils (hard when dry and sticky when wet) and the expansible character of the clay minerals make them difficult to work. Moreover, the slight to moderate salinity can reduce the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Natric-gypsic Vertisols are very deep, fine textured and poorly to imperfectly drained. They formed on the pans scattered along the oshanas. These soils are slightly to moderately saline and sodic.

Typically the surface layer is between 15 and 25 cm thick, sandy clay loam to sandy clay and black to very dark grey in colour. Underneath, to a depth of more than 100 cm, we find light olive grey to very dark grey, sandy clay material that presents a moderate to strong subangular or angular blocky structure and, in some horizons, intersecting slickensides resulting in a vertic horizon. Moreover, this material also presents accumulations of crystals of gypsum resulting in a gypsic horizon.

Gypsic Solonetzs can appear as inclusions in these positions.

These soils have a slow hydraulic conductivity and present a slow infiltration rate. They have a moderately high to high water holding capacity.

The main constraints for agriculture is the position where they are located on the landscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. On the other hand, the consistence of the soils (hard when dry and sticky when wet) and the expansible character of the clay minerals make them difficult to work. Moreover, the slight to moderate salinity can reduce the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Ow1. ferralic Arensols & sodic Cambisols Association, loamy sand, slope <2%

This association consists of soils formed on the flat to gently undulating woodlands that appear between the low-lying interconnecting ephemeral water courses that form the Oshanas. It presents ferralic Arenosols and sodic Cambisols as dominating soils.

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained. They formed on the higher parts of the woodlands that appear between the low-lying interconnecting ephemeral water courses that form the Oshanas.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to yellowish red in colour. Underneath, to a depth of more than 100 cm, we find dark grey to reddish yellow, sand material showing very weak horizon differentiation.

Haplic Calcisols and haplic Cambisols can appear as inclusions in these positions.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that controls the water in the soil that can be readily absorbed by plants and the low cation exchange capacity that controls the availability of plant nutrients.

Sodic Cambisols are very deep, coarse to moderately coarse textured and moderately well to well drained. They formed on the border of the woodlands that appear between the low-lying interconnecting ephemeral water courses that form the Oshanas. These soils are slight to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to loamy sand and very dark greyish brown to light brownish grey in colour, loose or with a very weak structure. Underneath, it appears an horizon 20 to 40 cm thick, dark grey to light brownish grey, sand to sandy loam, with a massive or very coarse subangular blocky structure and an extremely hard consistence when dry, probably associated with temporarily floodings during the rainy season and the presence of sodium as dominating cation in the soil. Below we find a greyish brown to very pale brown, sandy loam material that presents a weak structure and, occasionally, very few to few accumulations of calcium carbonate and/or gypsum.

Most of the times between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

Sodic Calcisols, calcic Solonetz, and gypsic Solonetzs can appear as inclusions in these positions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that controls the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Ow2. sodic Calcisols & sodic Cambisols Association, sandy loam, slope <2%, slightly to moderately saline and sodic.

This association consists of soils formed on the flat to gently undulating woodlands that appear between the low-lying interconnecting ephemeral water courses that form the Oshanas. It presents sodic Calcisols and sodic Cambisols as dominating soils.

Sodic Calcisols are very deep, coarse to moderately coarse textured and moderately well to well drained. They formed on the woodlands that appear between the low-lying interconnecting ephemeral water courses that form the Oshanas. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to loamy sand and very dark grey to olive grey in colour, loose or with a very weak structure. Underneath, it appears an horizon 20 to 40 cm thick, dark grey to brownish grey, sand to sandy loam, with a massive or very coarse subangular blocky structure and an extremely hard consistence when dry, probably associated with temporarily floodings during the rainy season and the presence of sodium as dominating cation in the soil. Below we find a greyish brown to pale yellow, sandy loam material that presents a weak structure and common to many accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules resulting in a calcic horizon.

Occasionally, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

Calcic Solonetzs and haplic Calcisols can appear as inclusions in these positions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid to rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that controls the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Sodic Cambisols are very deep, coarse to moderately coarse textured and moderately well to well drained. They formed on the border of the woodlands that appear between the low-lying interconnecting ephemeral water courses that form the Oshanas. These soils are slight to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to loamy sand and very dark greyish brown to light brownish grey in colour, loose or with a very weak structure. Underneath, it appears an horizon 20 to 40 cm thick, dark grey to light brownish grey, sand to sandy loam, with a massive or very coarse subangular blocky structure and an extremely hard consistence when dry, probably associated with temporarily floodings during the rainy season and the presence of sodium as dominating cation in the soil. Below we find a greyish brown to very pale brown, sandy loam material that presents a weak structure and, occasionally, very few to few accumulations of calcium carbonate and/or gypsum.

Most of the times, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

Calcic Solonets and ferralic Cambisols can appear as inclusions in these positions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that controls the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Ow3. Ferralic Arenosols, sandy, slope < 2%

Ferralic Arenosols are very deep, coarse textured and somewhat excessively drained. They formed on the woodlands that appear between the low-lying interconnecting ephemeral water courses that form the Oshanas.

Typically the surface layer is between 15 to 25 cm thick, sand and very dark grey to yellowish red in colour. Underneath, to a depth of more than 100 cm, we find dark grey to reddish yellow, sand material showing very weak horizon differentiation.

Ferralic Cambisols, hyposalic Arenosols and sodic Cambisols can appear as inclusions at the borders of the map unit.

These soils have a very rapid hydraulic conductivity and present a very rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that controls the water in the soil that can be readily absorbed by plants and the low cation exchange capacity that controls the availability of plant nutrients.

Pf1. hyposalic Arenosols & sodic Cambisols & natric-calcic Vertisols & natric-gypsic Vertisols Association, sandy loam, slope <2%, slightly to moderately saline and sodic.

This association consists of soils formed on the flat plains with dense and small pans that appear where the watercourses of the Cuvelai river and the oshanas lose completely their transport capacity. It presents hyposalic Arenosols and sodic Cambisols as dominating soils on the higher parts of the area and natric-calcic Vertisols and natric-gypsic Vertiols as dominating soils on the pans scattered along the map unit.

Hyposalic Arenosols are very deep, coarse textured, imperfectly to moderately well drained. They formed on the higher parts of the flat plains developed where the watercourses of the Cuvelai river and of the oshanas lose their transport capacity. These soils are slightly to moderately saline and sodic.

Typically the surface layer is between 15 to 25 cm thick, sand and dark grey to pale brown in colour. Underneath, it appears an horizon 20 to 40 cm thick, sand and greyish brown to light brownish grey in colour, that presents a massive or very coarse subangular blocky structure and an extremely hard consistence when dry associated with temporarily floodings during the rainy season and the presence of sodium as dominating cation in the soil. Below we find a greyish brown to very pale brown sand material showing very weak horizon differentiation.

Most of the times, between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

Calcic Solonetzs and gypsic Solonetzs appear as inclusions in these positions.

These soils have a rapid to very rapid hydraulic conductivity and present a rapid infiltration rate. They have a low water holding capacity.

The main constraints for agriculture are the low water holding capacity that controls the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Sodic Cambisols are very deep, coarse to moderately coarse textured and moderately well to well drained. They formed on the higher parts of the flat plains developed where the watercourses of the Cuvelai river and of the oshanas lose their transport capacity. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sand to loamy sand and very dark greyish brown to light brownish grey in colour, loose or with a very weak structure. Underneath, it appears an horizon 20 to 40 cm thick, dark grey to light brownish grey, sand to sandy loam, with a massive or very coarse subangular blocky structure and an extremely hard consistence when dry probably associated with temporarily floodings during the rainy season and the presence of sodium as dominating cation in the soil. Below we find a greyish brown to very pale brown, sandy loam material that presents a weak structure and, occasionally, very few to few accumulations of calcium carbonate and/or gypsum.

Most of the times between the surface layer and the extremely hard consistent horizon, appears a sand, loose and light coloured horizon, 2 to 10 cm thick, that can be classified as albic horizon.

Calcic Solonetzs and gypsic Solonetzs can appear as inclusions in these positions.

These soils have a moderate to moderately rapid hydraulic conductivity and present a moderate to moderately rapid infiltration rate. They have a low to moderate water holding capacity.

The main constraints for agriculture are the low to moderate water holding capacity that controls the water in the soil that can be readily absorbed by the plant roots and the extremely hard consistence when dry of the subsurface horizon than can limit root penetration and, therefore, the effective rooting depth. Moreover, the slight to moderate salinity reduces the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Natric-calcic Vertisols are very deep, fine textured and poorly to imperfectly drained. They formed on the on the pans scattered around the flat plains developed where the watercourses of the Cuvelai river and of the oshanas lose their transport capacity. These soils are slightly to moderately saline and sodic.

Typically the surface layer is about 20 cm thick, sandy clay loam to sandy clay and black to dark grey in colour. Underneath, to a depth of more than 100 cm, we find pale yellow to very dark grey, sandy clay material that presents a moderate to strong subangular or angular blocky structure and, in some horizons, intersecting slickensides resulting in a vertic horizon. Moreover, this material also presents accumulations of calcium carbonate as discontinuous concentrations of hard and soft nodules resulting in a calcic horizon.

Calcic Solonetzs and sodic Calcisols can appear as inclusions in these positions.

These soils have a slow hydraulic conductivity and present a slow infiltration rate. They have a moderately high to high water holding capacity.

The main constraints for agriculture is the position where they are located on the landscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. On the other hand, the consistence of the soils (hard when dry and sticky when wet) and the expansible character of the clay minerals make them difficult to work. Moreover, the slight to moderate salinity can reduce the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

Natric-gypsic Vertisols are very deep, fine textured and poorly to imperfectly drained. They formed on the on the pans scattered around the flat plains developed where the watercourses of the Cuvelai river and of the oshanas lose their transport capacity. These soils are slightly to moderately saline and sodic.

Typically the surface layer is between 15 and 25 cm thick, sandy clay loam to sandy clay and black to very dark grey in colour. Underneath, to a depth of more than 100 cm, we find light olive grey to very dark grey, sandy clay material that presents a moderate to strong subangular or angular blocky structure and, in some horizons, intersecting slickensides resulting in a vertic horizon. Moreover, this material also presents accumulations of crystals of gypsum resulting in a gypsic horizon.

Gypsic Solonetzs can appear as inclusions in these positions.

These soils have a slow hydraulic conductivity and present a slow infiltration rate. They have a moderately high to high water holding capacity.

The main constraints for agriculture is the position where they are located on the landscape that make them prone to flooding during the rainy season and to having, during long periods of the year, a high water table that can create an adverse environment for the root system. On the other hand, the consistence of the soils (hard when dry and sticky when wet) and the expansible character of the clay minerals make them difficult to work. Moreover, the slight to moderate salinity can reduce the water holding capacity and can cause specific toxicity for certain crops, and the sodicity affects the structure of the soil and can also cause specific toxicity for certain crops.

7.3.1. Introduction

The classic factors of the soil formation are the parent material, the climate, the living organisms (including mankind), the geomorphology and the time (Jenny, 1941). Their actions determine the direction, speed and duration of the processes of the soil formation and the kind of soil that can be found on each spot. Therefore, we can say that the soil is a function of the different factors of the soil formation.

Soil = f(parent material, climate, living organisms, geomorphology, time)

This approach in the soil study is, from a conceptual point of view, very rich. However this equation has been solved very few times and, at best, just for one factor or soil characteristic.

In soil survey, however, this approach is very useful. It allows the soil scientist to develop a model of how the soils were formed and of how each kind of soil is associated with a particular kind of landscape. Thus, during mapping, this model enables the soil scientist to predict with considerable accuracy the kind of soil at a specific location.

7.3.2. Factors of the soil formation

Parent material

The common parent material of the study area consists of Cenozoic deposits of medium-textured sand of the Kalahari group, that vary essentially only by virtue of their colloid content and their salinity.

Extensive sand mantles of aeolian origin also occur like sand banks along the Cuvelai valley and on the woodlands formed between the oshanas.

Along the oshanas the sandy materials are enriched with silt and highly expansible clay, reaching its greatest expression on the numerous pans scattered all over the area.

Soda ash occurs in a number of pans in the study area. The salts are mainly thenardite (Na_2SO_4) and trona ($Na_2CO_3.2H_2O$).

The presence of sodium as dominating cation in the soil solution and on the exchangeable sites seriously acts on the structure of the soils and causes the development of an extremely hard layer below the surface horizon in most of the soils of the area. This layer is believed to act as a serious constraint to the root system of the crops.

Climate

In spite of the fact that most of the rain concentrates during the summer period and the coarse texture of most of the soils, the high potential evaporation in the study area prevent the leaching of the soluble salts that are present in most of the soils.

Moreover, the hydraulic regime created by this climate favours the accumulation of calcium carbonate and gypsum at some depth of the soils, mainly along the beds of the drainage system and the pans scattered along.

On the other hand, after heavy downpours and especially when the Efundja occurs, vast areas of the study area are flooded. Although run-off is rather insignificant due to the nature of the soil and the flat geomorphology of the area, these periodical floods favours the degradation of the structure.

Living organisms

Although vegetation favoured fixation of the dunes and the accumulation of organic matter in the topsoil, we can say that living organisms have had few effects on soil properties in the study area.

In recent times, however, overgrazing and the increasing intensity of cultivation have significantly reactivated eolian and water erosion in the area.

Geomorphology

Influenced by the extremely flat plain that characterizes the topography in the area, the sandy nature of the soils and the ephemeral flow in the water courses, the drainage system is generally poorly developed. This fact together with the high potential evaporation in the area favours the accumulation of calcium carbonate, gypsum and soluble salts that play an important role in the morphology of the soils.

Only the sand mantles that form the sand banks along the Cuvelai river valley and on the higher parts of the woodlands can be considered salt free. Other soils formed on the woodlands and on the borders of the sand banks are affected by floodings and temporally high water tables that usually presents high salt contents.

Finally, the soils formed along the oshanas and on the flat plains with pans are affected by flood periods and high water tables. Although run-off is rather insignificant due to the flat geomorphology, these conditions and the chemical characteristics of the groundwater significantly influence the morphology of the soils.

Time

The Kavango river area presents soils of different age.

The boundary of the 150 mm/y isohyet, that delimites the area of dune formation, appears to have moved up and down in the recent past; between 20.000 and 13.000 BP. Processes that have resulted in the soils formed on the sand banks started to taking place by that time.

Soils formed on the woodlands and on the oshanas seems to be older and formed from materials transported and deposited by endorreic rivers and streams while the deposition of windblown sand was still taking place. These materials have subsequently been much altered by aeolian reworking of the surface deposits. All that remains of the ancient drainage system are some of the depressed oshanas.

7.3.3. Processes of the soil formation

The main processes of the soil formation that have been identified in the Northern Central Namibia area are:

- Darkening of the topsoil by accumulation of organic matter
- Structure formation and degradation
- Oxidation and reduction processes
- Dissolution, transport and precipitation of carbonates
- Carbonates accumulation and cementation
- Precipitation, transport and accumulation of gypsum
- Erosion and sedimentation
- Salt accumulation
- Sodification
- Clay transport and accumulation

7.4. Soil Classification

Formal taxonomic classifications are sometimes of limited use as mapping tools because of the following reasons:

- They are difficult to apply in the field when they are based on detailed laboratory results.
- Their criteria for differentiating between soils may not allow immediate adaptation to specific development objectives.
- They are often not suitable for practical use at the needed level

However, the decision to fit the soils described in the field into a recognized classification system is important and presents some advantages:

- It gives, to the people that are not familiar with the study area, a first idea about the main characteristics of the soils and prevent misunderstandings.
- The map becomes a transmitter of soil information and allows correlation with previous works and technology transfer between similar soils.

The system of soil classification used in the soil survey of the Kavango river area has been the World Reference Base (WRB) for Soil Resources System (ISSS, 1998).

Classification has been performed to the level of soil subunits (WRB, 1998). Furthermore, phases (slope, superficial texture and salinity) have been used to describe the map units in order to give more relevant information to evaluate the agricultural potential of the units.

In order to facilitate correlations with previous works, the taxonomic units have been also classified according to the Revised Legend of FAO (FAO, 1988) and the Soil Taxonomy System (SSS, 1996).

Most of the soils that appear on the study area show minimal profile development because of soil forming processes that are at a standstill during long periods of drought (Arenosols, Regosols, Cambisols) and because the parent material is of young age (Fluvisol). Moreover their parent materials, with an eolian or alluvial origin, present a certain homogeneity in themselves. This is why the taxonomic units have been defined within a relatively broad interval of characteristics.

Table 7.2 shows the different taxonomic units (WRB, 1998) that have been recognized during the soil survey of the Kavango river area and their correlation with other classification systems.

Table 7.2. Classification of the taxonomic units.

World Reference Base (1998) **Soil Subunits**	**Revised Legend of FAO (1988)** **Soil Units**	**Soil Taxonomy (1999)** **Subgroups**
Natric-gypsic Vertisol	Gypsic Vertisol	Sodic Gypsiustert
Natric-calcic Vertisol	Calcic Vertisol	Sodic Calciustert
Gypsic Solonetz	Gypsic Solonetz	Typic Natrustalf
Calcic Solonetz	Calcic Solonetz	Typic Natrustalf
Sodic Gypsisol	Haplic Gypsisol	Typic Halaquept
Petric Calcisol	Petric Calcisol	Petrocalcic Calciustept
Sodic Calcisol	Haplic Calcisol	Typic Halaquept
Haplic Calcisol	Haplic Calcisol	Typic Calciustept
Haplic Luvisol	Haplic Luvisol	Typic Haplustalf
Sodic Cambisol	Eutric Cambisol	Typic Halaquept
Ferralic Cambisol	Ferralic Cambisol	Typic Ustipsamment
Ferralic Arenosol	Ferralic Arenosol	Typic Ustipsamment
Hyposalic Arenosol	Cambic Arenosol	Typic Halaquept

Annex 2 presents a detailed description of the taxonomical series and their representative profile.

Horizon Reference	pH	E.C. (microS/cm)	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-1/1	7.1	46	0.1	94.9	1.1	4													
OWA-1/2	6.7	51	0.3	82.2	7.8	10													
OWA-1/3	7.3	20	0.1	73.5	12.4	14.2													
OWA-2/1	8.2	37	0.3	89.9	4.6	5.6													
OWA-2/2	8.6	61	0.2	85.2	1	13.8													
OWA-2/3	8.8	110	0.2	75.2	1.9	23		11											
OWA-3/1	7.3	50	0.1	88.5	4.3	7.3													
OWA-3/2	7.2	33	0.1	74.5	4.8	20.7													
OWA-3/3	7.0	93	0.1	77.6	1.2	21.3													
OWA-4/1	8.4	95	0.3	90.6	1.6	79													
OWA-4/2	8.7	84	0.3	77.8	13.1	9.2		2											
OWA-4/3	8.9	169	0.2	64.6	22.1	13.4		18											
OWA-5/1	8.5	344	0.4	77.8	5.5	16.7													
OWA-5/2	8.4	458	0.1	74	0.7	25.3													
OWA-5/3	8.6	339	0.1	77.3	0.8	22													
OWA-6/1	8.3	33	0.1	95.2	2.8	2													
OWA-6/2	9.2	42	0.0	97	3	0													
OWA-6/3	9.8	575	0.0	93	2.7	4.2				8.6		1	1	40	1	5	45	5	0
OWA-6/4	10.2	976	0.0	92.1	2.5	5.5				9.0		5	2	36	1	12	49	5	0
OWA-7/1	9.8	552	0.0	93.1	2.2	4.6													
OWA-7/2	10.5	2540	0.0	67.4	28.1	4.5													
OWA-8/1	8.2	17	0.1	96.9	2.3	0.8													
OWA-8/2	6.2	12	0.2	97.3	2.1	0.5													
OWA-8/3	7.5	18	0.0	98.9	1	0.1													
OWA-9/1	8.3	26	0.1	96	3.1	0.9	0.7												
OWA-9/2	8.1	152	0.2	95	3.1	1.9	1.4												
OWA-9/3	7.5	17	0.6	97.7	1.1	1.1	0.5												
OWA-10/1	8.8	298	0.6	33.3	10.7	56													
OWA-10/2	8.7	119	0.1	69.5	26.7	3.8													
OWA-10/3	8.7	20	0.3	94.5	3.6	2													
OWA-11/1	8.6	59	0.2	86.4	4.1	9.5													
OWA-11/2	8.9	87	0.3	78.1	4.7	17.2													
OWA-11/3	7.8	24	0.2	61	20	19													
OWA-11/4	8.9	127	0.3	50	39	11													
OWA-12/1	7.9	26	0.2	91.3	7.6	1.1													
OWA-12/2	6.5	5	0.1	91.5	5.6	2.8													
OWA-13/1	6.6	20	0.1	96.4	0.6	3													
OWA-13/2	7.4	31	0.1	97.1	2	0.9													
OWA-13/3	8.6	271	0.1	90.2	2.2	7.6													
OWA-13/4	9.2	1040	0.1	86.8	1.8	11.5													
OWA-14/1	8.2	35	0.2	93.9	1.9	4.2													
OWA-14/2	8.3	23	0.1	97	0.8	2.3													
OWA-15/1	7.4	64	0.3	57.8	11.3	31													
OWA-15/2	7.7	36	0.4	63.3	3.4	33.4													
OWA-15/3	8.5	113	0.4	55.6	5.8	38.7		2											
OWA-16/1	9.7	65	0.2	89.6	2.1	8.2				8.4	2250	4	2	29	1	10	35	10	0
OWA-16/2	10.1	426	0.1	80.5	8.8	10.7		3		8.5	8790	2	1	159	1	25	288	15	0
OWA-16/3	10.2	4980	0.1	81	2.2	16.8		3		8.8	6570	2	1	220	2	45	359	0	2
OWA-17/1	8.6	85	0.3	97	0.5	2.5													
OWA-17/2	9.8	541	0.1	92.6	0.7	6.7													
OWA-17/3	9.5	1641	0.0	86.2	2.9	10.9													
OWA-17/4	10.1	2030	0.1	86.2	2.9	10.9													
OWA-18/1			0.3	69.7	10	20.3				7.8	5940	1	46	341	3	10	465	5	0
OWA-18/2			0.1	63.7	1.2	35.1			16	7.5	8970	225	76	852	4	5	714	5	0

Horizon Reference	pH	E.C. (microS/cm)	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-18/3			0.1	68	2.8	42.3			9	7.5	3690	10	8	336	2	5	552	5	0
OWA-18/4			0.1	54.9	2.8	42.3		10	11	7.6	8870	8	7	202	2	45	10	2.5	0
OWA-19/1	6.4	4960	0.4	74.8	5.6	19.6													
OWA-19/2	8.1	7250	0.4	49.3	0.6	50.1			16										
OWA-19/3	8.7	5830	0.1	73.4	2.1	24.5			7										
OWA-19/4	9.2	4820	0.1	71.9	2.4	25.7		2	8	8.5	8290								
OWA-20/1	7.6	111	0.2	94.7	2.2	3.1													
OWA-20/2	8.2	100	0.1	97.4	1.4	1.3													
OWA-20/3	9.4	544	0.1	91	2.4	6.7													
OWA-20/4	10.2	990	0.1	91.9	1.5	6.7													
OWA-21/1	6.7	51	0.2	94	1.8	4.2													
OWA-21/2	6.7	47	0.1	91.4	0.7	7.9													
OWA-21/3	8.7	592	0.1	85.8	5.6	8.7													
OWA-22/1	8.0	1543	0.3	81	7.1	11.9				7.5	3230								
OWA-22/2	10.1	482	0.2	73.3	6.1	20.5				9.7	4250								
OWA-22/3	10.3	4860	0.1	72.3	9.6	18.1		10		9.8	7350								
OWA-22/4	10.2	5670	0.1	72.6	9.2	18.2		8		9.8	4320								
OWA-23/1	8.3	949	0.3	75.7	11.6	12.8				7.9	7360								
OWA-23/2	9.3	1929	0.2	69.8	7.5	22.7				8.8	2340								
OWA-23/3	9.2	4230	0.1	62.4	7.7	29.9		6		9.1	5090								
OWA-23/4	9.3	4170	0.1	63.1	8.6	28.3		7		9.1	3650								
OWA-24/1	7.2	39	0.1	96.5	2.2	1.4													
OWA-24/2	6.3	17	0.2	96.9	1	2.1													
OWA-24/3	6.2	20	0.0	96.1	2.7	1.1													
OWA-25/1	9.3	37	0.3	38.2	33.5	28.3													
OWA-25/2	9.6	1740	0.2	28	7.2	64.8													
OWA-25/3	9.9	3170	0.1	32.1	14.7	53.2													
OWA-26/1	6.7	54	0.4	80.6	2.6	16.8													
OWA-26/2	7.5	84	0.2	80.5	2.3	17.1													
OWA-26/3	9.1	3350	0.1	66.6	1.6	31.8				9.0	2190								
OWA-26/4	9.4	4300	0.1	64.4	8.2	27.4		22		9.0	3560								
OWA-27/1	7.6	28	0.1	96.4	2.3	1.3	0.6			7.4	31	6	1	24	1	12	1	5	0
OWA-27/2	7.9	2130	0.4	88.9	0.5	10.5	2.7			8.0	3270	2	2	118	1	40	214	2.5	0
OWA-27/3	8.7	6340	0.1	87.1	1.1	11.8	9			7.7	8570	18	7	400	2	10	426	5	0
OWA-27/4	9.4	7550	0.1	84.9	1.2	13.9	11			7.8	5470	7	7	440	3	23	0	5	0
OWA-27/5	9.1	7760	0.1	84.8	1.7	13.4	8.1			7.9	2770	49	7	362	2	12	467	5	0
OWA-28/1	6.9	10	0.1	96.2	2.3	1.4													
OWA-28/2	8.3	1270	0.1	89	2.3	8.6													
OWA-28/3	8.3	5330	0.0	83	3.4	13.5													
OWA-29/1	6.6	40	0.1	90.5	1.7	7.7	1.3			8.1	1978	8	1	40	1	15	10	2.5	0
OWA-29/2	8.2	64	0.1	91.1	1.1	7.8	1.6			8.0	2150	1	1	41	1	25	13	2.5	0
OWA-29/3	9.5	1380	0.1				2			7.8	3790	4	3	70	1	6	144	2.5	0
OWA-29/4	9.0	2030	0.0	90.7	1.8	7.6	0.6			6.6	2990	4	3	124	1	45	222	2.5	0
OWA-30/1	6.7	44	0.1	96.5	1.1	2.4													
OWA-30/2	7.8	2930	0.1	83.5	0.7	15.8				8.0	3380								
OWA-30/3	9.0	6670	0.0	80.3	2.2	17.5		4		9.1	8520								
OWA-31/1	6.3	34	0.1	95.9	0.1	4													
OWA-31/2	7.3	34	0.0	97.7	1.9	0.4													
OWA-31/3	9.3	3360	0.0	91.2	1.9	6.9				9.3	7370								
OWA-31/4	9.5	6990	0.0	88.1	4.5	7.4		2		9.2	92								
OWA-31/5	9.4	4780	0.0	88	3.9	8.2				9.5	76								
OWA-32/1	8.7	10060	0.3	47	1.2	51.9				8.9	9160								
OWA-32/2	9.4	906	0.1	60.5	2.6	36.9				9.4	9400								
OWA-32/3	8.9	1575	0.1	75.1	2	22.9		5		9.1	11940								

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OWA-33/1	7.0	816	0.2	80.2	4.3	15.5													
OWA-33/2	8.0	910	0.1	65.7	2.5	31.9													
OWA-33/3	8.5	19	0.2	66.8	3.6	29.6													
OWA-34/1	6.2	18	0.2																
OWA-34/2	5.0	50	0.1																
OWA-34/3	9.1	235	0.0																
OWA-34/4	8.2	6560	0.0																
OWA-35/1	6.5	12570	0.3																
OWA-35/2	8.2	214	0.1																
OWA-35/3	8.8	12510	0.1																
OWA-35/4	9.4	2620	0.1																
OWA-35/5	9.2	3270	0.0																
OWA-36/1	6.7	230	0.2																
OWA-36/2	8.3	1829	0.1																
OWA-36/3	8.3	4750	0.1																
OWA-36/4	8.4	5640	0.0																
OWA-36/5	9.1	4510	0.0																
OWA-37/1	6.9	86	0.2																
OWA-37/2	8.1	1501	0.1																
OWA-37/3	8.8	4350	0.0																
OWA-37/4	9.0	4270	0.0																
OWA-38/1	7.8	69	0.1																
OWA-38/2	7.7	129	0.1																
OWA-38/3	8.4	196	0.1																
OWA-38/4	7.5	1378	0.1																
OWA-38/5	7.5	1913	0.1																
OWA-39/1	7.0	6130	0.3																
OWA-39/2	7.8	10840	0.1																
OWA-39/3	8.7	8130	0.1																
OWA-39/4	8.8	8760	0.1																
OWA-40/1	5.5	65	0.3																
OWA-40/2	5.1	28	0.1																
OWA-40/3	5.4	42	0.0																
OWA-41/1	5.4	91	0.3																
OWA-41/2	6.9	1717	0.1																
OWA-41/3	8.8	4050	0.1																
OWA-41/4	9.2	4790	0.0																
OWA-42/1	5.7	51	0.2	93.8	2.7	3.5	0.7			6.6	57	1	1	11	1	10	2.6	0	0
OWA-42/2	5.7	103	0.1	92.2	2.9	4.9	1			7.4	186	1	1	8	1	5	0	2.5	0
OWA-42/3	8.1	1233	0.1	88.6	2.8	8.6	2.4			8.0	2170	3	3	60	1	5	91	5	0
OWA-42/4	8.1	3210	0.0	84.5	3.6	11.9	4.4			7.8	2560	7	6	81	1	25	320	5	0
OWA-42/5	8.4	4330	0.0	96.6	1.1	2.3	7.9			7.9	2780	2	6	112	1	40	301	2.5	0
OWA-43/1	5.5	12	0.1																
OWA-43/2	5.1	11	0.1	76.7	5.3	18													
OWA-43/3	5.3	40	0.0	41.4	3.9	54.7													
OWA-44/1	7.3	465	0.8	63.4	0.1	36.6													
OWA-44/2	7.8	2190	0.3	76.1	4.4	19.5													
OWA-44/3	8.2	3260	0.1	74.1	4.4	21.5													
OWA-44/4	8.4	1810	0.1	40.5	1.6	57.9													
OWA-45/1	7.5	78	0.3	37.5	5.2	57.3													
OWA-45/2	9.3	337	0.1	87.5	4.1	8.3													
OWA-45/3	9.4	530	0.0	86.7	4	9.3													
OWA-45/4	9.9	1275	0.0	85.1	0.4	14.5													
OWA-45/5	9.9	1189	0.1	79.8	4.1	16.1													

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OWA-46/1	6.6	31	0.1																
OWA-46/2	5.3	20	0.0																
OWA-46/3	5.2	34	0.2																
OWA-47/1	7.1	29	0.1	45.2	3.2	48.6													
OWA-47/2	7.5	75	0.1	34.9	2.3	62.8													
OWA-47/3	7.4	10	0.1	32.6	0.6	66.8													
OWA-48/1	7.8	581	0.2	35.7	1.7	62.6													
OWA-48/2	8.8	833	0.1																
OWA-48/3	9.8	672	0.1																
OWA-48/4	9.7	719	0.1																
OWA-49/1	8.5	1340	0.3	56.1	8.3	35.6				7.9	2290								
OWA-49/2	8.8	297	0.3	33.3	10	56.7				9.6	2350								
OWA-49/3	9.0	361	0.1	32.2	9.9	57.9		5		9.9	3870								
OWA-49/4	9.6	284	0.0	55.3	8.5	36.1		21		9.2	4250								
OWA-50/1	6.9	26	0.1																
OWA-50/2	7.2	38	0.1																
OWA-50/3	9.2	77	0.1																
OWA-50/4	9.8	171	0.1																
OWA-51/1	6.8	19	0.2																
OWA-51/2	9.0	206	0.1																
OWA-51/3	9.5	143	0.1																
OWA-52/1	8.3	831	0.3																
OWA-52/2	9.4	237	0.1					22											
OWA-52/3	9.6	243	0.1																
OWA-52/4	9.7	204	0.1																
OWA-53/1	6.8	20	0.2																
OWA-53/2	7.1	32	0.1																
OWA-53/3	7.6	13	0.1																
OWA-53/4																			
OWA-54/1	6.7	61	0.3																
OWA-54/2	7.8	328	0.2																
OWA-54/3	8.6	1550	0.1																
OWA-55/1	7.5	45	0.1	95.8	1.1	3.1	0.8												
OWA-55/2	6.9	14	0.1	95.6	2	2.4	1												
OWA-55/3	6.6	10	0.1	96.3	1.3	2.3	1												
OWA-55/4	6.9	8	0.0	96.4	2.2	1.4	7.7												
OWA-56/1	8.0	482	0.0	74.1	1.2	24.8													
OWA-56/2	7.6	245	0.3	84.5	3.1	12.4		0	3										
OWA-56/3	8.2	380	0.1	76.8	2.6	20.6		2	8										
OWA-57/1	7.8	160	0.4																
OWA-57/2	8.1	1098	0.8																
OWA-57/3	8.7	915	0.4																
OWA-57/4	8.8	925	0.1																
OWA-58/1	7.0	27	0.2																
OWA-58/2	7.8	51	0.1																
OWA-58/3	9.3	526	0.1																
OWA-58/4	8.6	189	0.1																
OWA-58/5	8.7	92	0.1																
OWA-59/1	7.7	63	0.3																
OWA-59/2	8.4	146	0.2																
OWA-59/3	8.4	306	0.2																
OWA-60/1	7.6	59	0.3																
OWA-60/2	9.5	527	0.1																
OWA-60/3	10.3	137	0.1																

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OWA-60/4	10.2	110	0.0																
OWA-61/1	8.6	364	0.2																
OWA-61/2	9.3	143	0.2																
OWA-61/3	9.4	267	0.1																
OWA-61/4	9.7	175	0.1																
OWA-62/1	7.7	22	0.2																
OWA-62/2	7.0	12	0.1																
OWA-62/3	7.7	17	0.1																
OWA-63/1	7.4	17	0.1	95.7	1.9	2.4	0.96												
OWA-63/2	6.8	15	0.2	74.6	3	22.4	0.46												
OWA-63/3	6.6	39	0.1	78.7	2.8	18.6	9.97												
OWA-63/4	6.8	16	0.1	77.8	4.7	17.5	11.82												
OWA-64/1	6.7	12	0.2																
OWA-64/2	6.2	8	0.1																
OWA-64/3	8.0	16	0.1																
OWA-64/4	8.0	12	0.1																
OWA-65/1	7.0	26	0.3	92.9	3	4.1	1.81												
OWA-65/2	7.4	15	0.1	96.6	0.9	2.5	1.14												
OWA-65/3	7.0	16	0.2	83.8	0	16.2	8.02												
OWA-65/4	6.7	16	0.1	77.9	2.3	19.9	9.96												
OWA-66/1	8.5	96	0.3																
OWA-66/2	8.8	100	0.3																
OWA-66/3	8.9	139	0.3																
OWA-66/4	8.8	132	0.2																
OWA-67/1	6.7	40	0.2																
OWA-67/2	5.6	12	0.1																
OWA-67/3	6.2	11	0.0																
OWA-68/1	9.0	1320	0.3																
OWA-68/2	9.9	2580	0.2																
OWA-68/3	10.0	2360	0.1																
OWA-68/4	9.9	2160	0.1																
OWA-69/1	7.7	67	0.3	92.8	3.4	3.8													
OWA-69/2	9.5	625	0.3	85.3	4.2	10.5				8.9	1350								
OWA-69/3	9.1	1620	0.1	85.3	3.9	10.8				8.4	3300								
OWA-69/4	9.4	1290	0.0	83.4	5	11.6		1		8.7	2850								
OWA-70/1	8.1	41	0.2																
OWA-70/2	8.0	43	0.1																
OWA-70/3	8.9	1320	0.1																
OWA-70/4	8.7	1580	0.0																
OWA-70/5	8.6	1590	0.1																
OWA-71/1	6.9	12	0.2																
OWA-71/2	6.2	8	0.1																
OWA-71/3	6.4	14	0.1																
OWA-71/4	6.0	10	0.1																
OWA-71/5	6.6	14	0.0																
OWA-72/1	8.3	342	0.1																
OWA-72/2	9.7	508	0.1																
OWA-72/3	9.7	327	0.0																
OWA-73/1	7.7	14	0.1																
OWA-73/2	7.5	12	0.1																
OWA-73/3	6.7	17	0.1																
OWA-73/4	7.9	200	0.1																
OWA-73/5	8.5	45	0.1																
OWA-74/1	8.1	22	0.3																

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OWA-74/2	9.4	179	0.1																
OWA-74/3	10.1	67	0.1																
OWA-74/4	10.1	81	0.1																
OWA-75/1	7.6	17	0.1																
OWA-75/2	7.6	18	0.1																
OWA-75/3	7.6	14	0.0																
OWA-76/1	6.3	48	0.5																
OWA-76/2	6.1	30	0.2																
OWA-76/3	6.2	47	0.2																
OWA-76/4	6.5	56	0.1																
OWA-77/1	7.3	121	0.1																
OWA-77/2	9.5	616	0.1																
OWA-77/3	10.2	1596	0.1																
OWA-77/4	9.6	213	0.0																
OWA-77/5	10.1	207	0.1																
OWA-78/1	7.1	14	0.2																
OWA-78/2	7.5	13	0.1																
OWA-79/1	7.4	12	0.2																
OWA-79/2	5.0	26	0.1																
OWA-79/3	5.2	9	0.0																
OWA-80/1	6.5	19	0.2	93.6	4.1	2.3				7.6	34	4	1	10	2		1		
OWA-80/2	8.0	29	0.1	95.2	1.7	3.1				6.2	55	2	2	14	2	12	0	5	0
OWA-80/3	9.2	81	0.0	89.7	3.4	6.8				8.4	280	2	1	16	2	55	0	0	5
OWA-80/4	9.6	231	0.0	89.6	9.3	1.1				8.4	620	2	1	19	2	40	0	0	5
OWA-80/5	9.5	317	0.1	84.9	3.2	11.9		0		9.0	9380	2	2	22	3	35	0	0	0
OWA-81/1	8.7	79	0.3	88	4.3	7.7													
OWA-81/2	8.7	102	0.4	78.3	8	13.7		9											
OWA-81/3	8.7	115	0.3	76.7	9	14.3		15											
OWA-81/4	8.8	131	0.2	76.1	9.8	14.1		20											
OWA-82/1	7.2	23	0.2																
OWA-82/2	9.4	121	0.1																
OWA-82/3	10.1	664	0.1																
OWA-82/4	6.5	378	0.0																
OWA-83/1	9.8	24	0.1																
OWA-83/2	9.8	218	0.0																
OWA-83/3	10.1	520	0.0																
OWA-83/4	10.1	442	0.0																
OWA-84/1	6.4	98	0.6	53.7	28	18.3													
OWA-84/2	6.2	57	0.2	52.9	20.5	26.5													
OWA-84/3	6.5	62	0.2																
OWA-85/1	7.2	35	0.4																
OWA-85/2	7.7	58	0.2																
OWA-85/3	8.5	42	0.1																
OWA-86/1	6.6	39	0.3	77.3	10.8	11.9													
OWA-86/2	6.7	17	0.2	70.3	4.9	24.8													
OWA-86/3	7.2	23	0.1	73.2	5.4	21.5													
OWA-86/4	8.3	110	0.1	71.6	7.5	20.8		7											
OWA-87/1	6.5	21	0.1																
OWA-87/2	7.2	11	0.1																
OWA-88/1	6.8	31	0.3																
OWA-88/2	6.8	19	0.1																
OWA-88/3	7.1	35	0.1																
OWA-89/1	8.1	40	0.2	95.1	2.6	2.3				8.3	115	1	1	9	2	30	0	0	5
OWA-89/2	8.6	313	0.2	88.7	2.7	8.6				8.4	6460	1	1	24	3		3		

Horizon Reference	pH	E.C. (microS/cm)	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-89/3	9.3	1264	0.1	85.3	3.5	11.1		2		8.6	1760	2	2	30	2	40	1	0	10
OWA-90/1	7.5	27	0.1					0											
OWA-90/2	6.9	15	0.1																
OWA-90/3	7.3	37	0.1																
OWA-90/4	7.5	35	0.1																
OWA-91/1	7.4	24	0.2	90.6	3.6	5.9		xxx	xxx										
OWA-91/2	8.9	172	0.1	78.2	3.1	18.7		0	4										
OWA-91/3	7.5	1608	0.1	78.3	1.5	20.3		1	23										
OWA-92/1	7.9	14																	
OWA-92/2	7.1	19																	
OWA-92/3	7.6	15																	
OWA-93/1	7.0	120		69.1	6.6	24.3				xxx									
OWA-93/2	8.2	769		69.9	9.2	20.9				xxx									
OWA-93/3	7.8	2860		70.2	0.3	29.6			58	xxx									
OWA-94/1	7.7	15																	
OWA-94/2	7.9	16																	
OWA-94/3	8.1	13																	
OWA-94/4	7.3	14																	
OWA-94/4																			
OWA-95/1	6.6	1071	0.4	75.6	6.7	17.7													
OWA-95/2	7.8	6360	0.4	39.3	1.1	59.6													
OWA-95/3	8.2	5380	0.1	60.9	0.5	38.6		2	14										
OWA-96/1	6.4	1225	0.1	75.6	6.1	18.3		2											
OWA-96/2	8.0	3070	0.1	73.9	5.7	20.4		1	12										
OWA-96/3	9.0	6760	0.1	43.5	3	53.5		7	71	6.2	13								
OWA-96/4	8.7	7130	0.1	40.9	2.2	56.9			78	6.3	15								
OWA-97/1	9.9	2660	0.2	88.5	3.7	8.4				5.3	15								
OWA-97/2	9.9	4280	0.1	86.4	2.6	10.9		2		5.6	19								
OWA-97/3	9.7	3010	0.0	84.2	2.8	13		6		7.8	4880								
OWA-97/4	9.6	1945	0.0	82.5	2.6	15		0		9.2	8310								
OWA-98/1	6.5	12	0.2																
OWA-98/2	6.0	10	0.1																
OWA-98/3	6.1	9	0.0																
OWA-99/1	7.9	4520	0.2	47.7	7.1	45.2													
OWA-99/2	8.3	9730	0.2	29.9	10.7	59.4		5	50										
OWA-99/3	8.8	9740	0.1	33.5	1.6	65		17	61										
OWA-99/4	8.8	8640	0.1	39	1.7	59.2		7	52										
OWA-100/1	6.0	6	0.1																
OWA-100/2	5.5	9	0.1																
OWA-100/3	5.4	7	0.1																
OWA-101/1	8.7	368	0.2	74.7	0.4	24.9													
OWA-101/2	10.1	1498	0.1	74.9	3.1	22		3		8.2	5550								
OWA-101/3	10.4	1672	0.0	47.3	3.8	48.9		3		8.6	4180								
OWA-102/1	8.8	87	0.2																
OWA-102/2	8.9	544	0.3																
OWA-102/3	9.4	1485	0.2																
OWA-102/4	8.3	2470																	
OWA-102/5	8.1	2210																	
OWA-103/1	7.0	37																	
OWA-103/2	7.1	12																	
OWA-103/3	6.7	80																	
OWA-103/4	6.9	25																	
OWA-104/1	7.1	17																	
OWA-104/2	7.0	17																	

Horizon Reference	pH	E.C. (microS/cm)	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-104/3	6.9	42																	
OWA-105/1	8.7	76																	
OWA-105/2	8.9	95																	
OWA-105/3	9.4	223																	
OWA-105/4	9.8	679																	
OWA-106/1	8.4	43																	
OWA-106/2	9.3	2140																	
OWA-106/3	9.9	1280																	
OWA-106/4	9.6	1118																	
OWA-107/1	6.9	21		94.2	3.2	2.6													
OWA-107/2	9.3	191		87.6	2.2	10.2													
OWA-107/3	9.8	876		86	2.5	11.6		0		8.6	990	2	1	32	2	35	1	0	10
OWA-107/4	8.7	1028		87.6	0.6	11.7				7.9	1290	1	1	32	2	35	1	2.5	0
OWA-108/1	7.2	83																	
OWA-108/2	7.7	36																	
OWA-108/3	8.2	33																	
OWA-109/1	8.7	62																	
OWA-109/2	8.8	82																	
OWA-110/1	7.4	67																	
OWA-110/2	8.7	65																	
OWA-110/3	9.0	96																	
OWA-111/1	8.9	921																	
OWA-111/2	9.9	4180																	
OWA-111/3	9.8	3710																	
OWA-112/1	7.1	17																	
OWA-112/2	8.2	28																	
OWA-112/3	10.2	714																	
OWA-112/4	10.1	772																	
OWA-113/1	8.9	224																	
OWA-113/2	10.4	2590																	
OWA-113/3	10.3	2250																	
OWA-114/1	7.2	79		70.1	7.2	22.7													
OWA-114/2	7.3	94		63	8.2	29.8													
OWA-114/3	7.4	128		66.6	5.6	27.6													
OWA-115/1	8.2	76																	
OWA-115/2	7.7	40																	
OWA-115/3	7.7	50																	
OWA-115/4	7.8	29																	
OWA-116/1	9.0	84		93.4	6	0.6													
OWA-116/2	9.1	46		95.5	0.6	3													
OWA-116/3	6.4	29		80.2	1.8	18.1													
OWA-117/1	8.8	65		86.7	4.8	8.5		0											
OWA-117/2	9.1	60		82.6	5.4	12		0											
OWA-117/3	8.9	78		69.3	16.1	14.6		2											
OWA-118/1	7.3	21		92.6	4.3	3.1													
OWA-118/2	8.7	111		87.6	4.6	7.8													
OWA-118/3	9.3	412		77.8	7.4	14.8													
OWA-118/4	8.2	398		80.2	5.8	14													
OWA-119/1	6.7	12		90.2	3.8	6													
OWA-119/2	6.0	11		88.4	3.8	7.8													
OWA-119/3	6.0	13		84.3	4.7	10.9													
OWA-120/1	8.3	29		91.9	3.3	4.8	3.14												
OWA-120/2	7.6	16		88.8	3.5	7.6	5.49												
OWA-120/3	7.8	23		85.1	3.7	11.2	6.75												

Horizon Reference	pH	E.C. (microS/cm)	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-121/1	6.0	13																	
OWA-121/2	5.2	10																	
OWA-121/3	4.9	13																	
OWA-122/1	7.4	17																	
OWA-122/2	6.8	29																	
OWA-122/3	7.0	21																	
OWA-122/4	5.7	23																	
OWA-123/1	6.4	16																	
OWA-123/2	5.7	8																	
OWA-123/3	5.8	13																	
OWA-124/1	8.5	52																	
OWA-124/2	8.7	62																	
OWA-124/3	9.0	61																	
OWA-125/1	7.8	26																	
OWA-125/2	7.7	22																	
OWA-125/3	7.5	24																	
OWA-125/4	8.0	42																	
OWA-126/1	7.8	23																	
OWA-126/2	6.7	19																	
OWA-126/3	6.6	10																	
OWA-127/1	7.8	53		88.2	7.4	4.4		0											
OWA-127/2	7.8	15		91.2	0.5	8.3		1											
OWA-127/3	7.4	19		86.8	3.1	10.1		1											
OWA-128/1	7.6	18																	
OWA-128/2	9.1	440																	
OWA-128/3	10.2	708																	
OWA-128/4	10.3	18																	
OWA-129/1	7.8	21																	
OWA-129/2	6.3	7																	
OWA-129/3	5.5	3																	
OWA-130/1	7.6	19																	
OWA-130/2	7.2	10																	
OWA-130/3	7.5	20																	
OWA-130/4	7.8	26																	
OWA-131/1	7.2	12		93.5	4	2.6	6.87												
OWA-131/2	6.5	12		92.3	2.3	12.2	1.3												
OWA-131/3	6.5	19		85.6	2.2	12.2	11.87												
OWA-131/4	7.4	21		81.2	4.5	14.3	6.98												
OWA-132/1	6.9	36																	
OWA-132/2	5.6	8																	
OWA-132/3	5.2	9																	
OWA-133/1	7.6	58																	
OWA-133/2	9.2	522																	
OWA-133/3	8.7	2690																	
OWA-133/4	8.8	1978																	
OWA-134/1	6.7	23																	
OWA-134/2	8.5	825																	
OWA-134/3	10.0	1210																	
OWA-134/4	9.7	1393																	
OWA-135/1	8.3	80		89.2	2.7	8.1													
OWA-135/2	9.1	751		75.1	3.5	21.5		3		8.4	1480	1	1	23	2	40	1	2.5	10
OWA-135/3	9.2	659		72.7	6	21.3		2		8.5	539	1	1	25	3	35	35	0	5
OWA-136/1	7.0	16		91.5	4.6	3.9	1.9												
OWA-136/2	6.8	14		89.3	4.6	6.1	2.6												

Horizon Reference	pH	E.C. (microS/cm)	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-136/3	7.5	18		83.1	4.5	12.4	6.01												
OWA-137/1	5.1	39																	
OWA-137/2	9.5	585																	
OWA-137/3	9.2	1754																	
OWA-138/1	6.8	37																	
OWA-138/2	6.9	21																	
OWA-138/3	7.4	19																	
OWA-139/1	6.7	15																	
OWA-139/2	6.7	12																	
OWA-139/3	6.8	36																	
OWA-140/1	9.3	371		92	1.8	6.2				8.5	721								
OWA-140/2	10.2	3050		85.8	6.2	8		1		10.0	6330								
OWA-140/3	10.4	2980		81.3	7.5	11.1		0		10.4	5590								
OWA-141/1	7.0	61		96.3	2	1.7													
OWA-141/2	9.2	505		87.6	2.7	9.7				8.4	1020								
OWA-141/3	9.5	1080		86.7	1.6	11.7		2		8.7	1998								
OWA-141/4	9.8	85		85.6	2.4	12		6		9.0	1940								
OWA-141/5	9.7	83		86.3	1.2	12.5		2		8.8	2110								
OWA-142/1	9.6	24		92.5	3.3	4.2				8.9	670	1	0	21	2	35	0	0	5
OWA-142/2	8.1	3330		77.4	7.7	15		1	9	7.8	2830	4	3	98	3	30	7	0	10
OWA-142/3	9.8	1860		77	8.4	14.6		8	10	8.1	760	2	1	43	2	40	5	0	0
OWA-143/1	9.9	1310		85.3	3.4	11.3				8.6	430	1	0	45	3	30	3	0	0
OWA-143/2	10.7	3910		80.6	3.1	16.4		2	24	10.1	6290	1	0	121	3	45	8	5	15
OWA-143/3	10.5	2930		77.8	4.9	17.3		4	10	10.1	4310	2	2	103	4	35	5	5	20
OWA-143/4	10.6	2280		79	3.4	17.6		4	2	10.1	2190	1	1	51	3	35	4	0	20
OWA-144/1	7.8	98																	
OWA-144/2	10.6	1160																	
OWA-144/3	10.6	1358																	
OWA-144/4	6.6	80																	
OWA-145/1	8.0	3		89.1	4.6	6.3													
OWA-145/2	8.8	6		78.5	0.9	20.6		1											
OWA-145/3	7.3	48		77.3	8.2	14.5		1											
OWA-146/1	7.1	6																	
OWA-146/2	9.8	64																	
OWA-146/3	9.8	1446																	
OWA-147/1	8.9	6																	
OWA-147/2	10.1	63																	
OWA-147/3	10.3	1240																	
OWA-147/4	10.4	1030																	
OWA-148/1	9.6	620		94.5	2.9	2.6		0		8.2	480	1	2	29	3	40	2	0	5
OWA-148/2	9.0	4630		82.4	6.8	10.8		0		8.0	9790	13	7	196	6	25	9	0	0
OWA-148/3	10.0	2570		81.7	5.6	12.7		2		8.3	2570	3	3	51	4	40	4	0	5
OWA-148/4	10.1	1930		85.1	3.1	11.8		2		8.8	3970	3	3	52	4	40	3	0	10
OWA-149/1	7.5	1540		69.3	7.3	23.3				7.9	7150	2	3	40	3	10	0	0	0
OWA-149/2	7.7	4330		71.3	3.6	25		1	19	8.2	5410	7	5	39	4	65	3	0	0
OWA-149/3	8.3	3450		67.3	4.4	28.3		1	11	7.5	940	11	5	108	3	65	8	0	0
OWA-150/1	7.7	185																	
OWA-150/2	8.4	1440																	
OWA-150/3	8.9	3290																	
OWA-151/1	7.1	19																	
OWA-151/2	8.1	815																	
OWA-151/3	9.5	1420																	
OWA-151/4	9.1	935																	
OWA-152/1	7.5	32		94.6	3.8	1.5													

Horizon Reference	pH	E.C. (microS/cm)	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-152/2	8.9	2780		74.5	2	23.5				8.5	5539								
OWA-152/3	9.6	3860		81.7	1.8	16.5		2	15	8.6	3760								
OWA-153/1	7.4	4		93.9	2.3	3.9													
OWA-153/2	8.2	1980		82	4.5	13.4													
OWA-153/3	9.2	3240		82.1	13	5		4											
OWA-153/4	8.3	2870		82.1	4.2	13.7													
OWA-154/1	6.6	7410																	
OWA-154/2	9.1	9260																	
OWA-155/1	6.3	45																	
OWA-155/2	6.1	51																	
OWA-155/3	7.5	61																	
OWA-155/4	8.2	469																	
OWA-155/5	9.1	909																	
OWA-156/1	6.1	38		95.4	3.6	1	0.59												
OWA-156/2	7.8	453		85.8	4.5	9.7	2.54												
OWA-156/3	8.7	1950		83.1	1.1	15.8	10.95			7.6	2870	2	2	51	2	60	3	5	0
OWA-157/1	6.4	12		94.3	3.2	2.4													
OWA-157/2	8.9	30		96	2.8	1.2													
OWA-157/3	8.9	185		89.9	4.7	5.5													
OWA-157/4	9.5	573		85.4	0.7	13.9													
OWA-158/1	6.9	57		94.7	1	4.3	0.81												
OWA-158/2	8.3	1280		71.6	17.8	10.7	8.89			8.1	3670	4	6	121	2	65	68	5	0
OWA-158/3	9.4	5600		78.1	8.7	13.2	21.54			8.0	6470	4	2	184	2	100	4	5	0
OWA-158/4	9.4	6710		77.9	8.2	13.9	24.65			8.1	6270	3	2	240	3	150	6	5	0
OWA-159/1	8.9	2330		72.1	14.9	13				8.6	3760								
OWA-159/2	9.7	3270		44.8	7.4	47.8		3		9.6	6370								
OWA-159/3	9.4	2820		37.7	1.3	61		2		9.3	4980								
OWA-159/4	9.4	2060		69.7	15.6	14.7		20		9.1	3470								
OWA-160/1	8.8	4830		79.3	3.6	17.1				8.1	2470	6	3	150	2	35	6	5	0
OWA-160/2	9.0	9940		76.6	2.5	20.9		1	15	7.7	4570	17	1	458	3	120	10	5	0
OWA-160/3	8.6	9150		75.2	2.2	22.6		1	16	7.6	9470	3	2	265	3	115	10	5	0
OWA-160/4	9.3	5720		76.7	2.6	20.7		1	15	8.4	5950	3	1	196	2	125	4	2.5	0
OWA-161/1	6.6	62																	
OWA-161/2	7.3	32																	
OWA-161/3	7.0	24																	
OWA-162/1	8.4	663		93.4	2.7	4					xxx								
OWA-162/2	9.8	2470		85.5	2.7	11.9				8.6	7380	3	1	125	2	90	2	5	0
OWA-162/3	9.7	3360		82.9	2	15.1		1		8.3	4930	3	1	139	2	85	3	5	0
OWA-162/4	9.6	3220		76.3	8.5	15.2		2		8.5	xxx	6	5	91	2	90	4	10	0
OWA-163/1	7.4	22																	
OWA-163/2	7.9	18																	
OWA-163/3	8.7	80																	
OWA-164/1	7.9	33																	
OWA-164/2	9.7	291																	
OWA-164/3	9.8	834																	
OWA-164/4	10.0	933																	
OWA-164/5	6.4	38																	
OWA-165/1	7.1	15																	
OWA-165/2	6.8	12																	
OWA-165/3	8.0	18																	
OWA-165/4	9.1	77																	
OWA-166/1	6.6	13																	
OWA-166/2	7.4	42																	
OWA-166/3	9.2	166																	

Horizon	pH	E.C.	O.C.	Sand	Silt	Clay	C.E.C.	CaCO3	Gypsum	pH (paste)	E.C.(paste)	Ca	Mg	Na	K	Cl	SO4	HCO3	CO3
Reference		(microS/cm)	(%)	(%)	(%)	(%)	(cmol+/kg)	(%)	(%)		(microS/cm)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)
OWA-167/1	8.6	106		94.7	3.7	1.6				7.9	221								
OWA-167/2	10.1	427		90.8	3.6	5.6				9.3	741								
OWA-167/3	10.4	1746		88.2	0.5	11.4				9.9	3140								
OWA-167/4	10.2	3370		84.1	1.4	14.5				10.0	5490								
OWA-168/1	7.4	9		81.1	8	10.9													
OWA-168/2	7.9	2		95.7	1.2	3													
OWA-168/3	7.9	2		42.8	24.8	32.4													
OWA-168/4	6.6	4		80.8	1.8	17.4													
OWA-169/1	8.3	1300		61.7	9.3	29.1				8.2	4290	3	1	116	2	70	1	5	0
OWA-169/2	8.6	315		57.2	3.9	38.9		5	10	8.0	5960	5	7	108	2	90	2	5	0
OWA-169/3	8.9	2860		60.5	3.7	35.9		3	15	8.2	5870	3	5	62	2	70	4	5	0
OWA-169/4	8.3	3190		64.9	2.7	32.4		2	16	7.9	3580	10	8	60	3	65	3	5	0
OWA-170/1	7.6	281		82.2	2.3	15.5				8.5	xxx	2	1	89	2	35	0	5	0
OWA-170/2	9.1	1267		79.6	2.2	18.1		1	7	8.4	890	2	2	8	2	40	1	5	0
OWA-170/3	8.5	1825		78.9	2.3	18.8		1	12	8.1	6430	7	16	55	2	55	3	5	0
OWA-171/1	6.5	40		95.1	0.4	4.6													
OWA-171/2	6.3	36		87.4	9.2	3.4													
OWA-171/3	7.4	18		78.3	16.1	5.6													
OWA-172/1	6.0	2200		74.3	1.7	24													
OWA-172/2	8.1	8430		47.5	2.4	50.1		2	40										
OWA-172/3	8.4	4720		59.5	1.3	39.2		1	29										
OWA-173/1	7.5	1182																	
OWA-173/2	9.0	4440																	
OWA-173/3	9.9	2470																	
OWA-174/1	8.7	2																	
OWA-174/2	7.9	23																	
OWA-175/1	8.3	1819		53.7	9.3	37.1			28	8.0	4090								
OWA-175/2	10.0	5560		91.4	0.1	8.5		1	61	10.0	9780								
OWA-175/3	10.2	2860		74.3	1.7	24		0		10.1	4890								
OWA-176/1	7.4	19																	
OWA-176/2	6.0	11																	
OWA-177/1	7.2	25		94	2.8	3.2				7.4	53								
OWA-177/2	9.0	486		90.1	2.4	7.5				8.4	1244								
OWA-177/3	9.4	1231		85.6	3.7	10.7		0		9.1	2110								
OWA-178/1	8.9	506																	
OWA-178/2	10.2	5360																	
OWA-179/1	6.2	109																	
OWA-179/2	6.7	587																	
OWA-179/3	9.4	1290																	
OWA-180/1	6.9	12																	
OWA-180/2	7.3	15																	
OWA-180/3	7.7	70																	
OWA-181/1	6.4	64																	
OWA-181/2	8.4	851																	
OWA-181/3	9.7	2090																	
OWA-182/1	6.5	17																	
OWA-182/2	6.3	578																	
OWA-182/3	8.5	1820																	
OWA-183/1	6.2	52																	
OWA-183/2	7.8	434																	
OWA-183/3	8.1	891																	
OWA-183/4	9.3	1920																	
OWA-184/1	8.5	997																	
OWA-184/2	9.6	3310																	

Horizon	pH	E.C.	O.C.	Sand	Silt	Clay	C.E.C.	CaCO3	Gypsum	pH (paste)	E.C.(paste)	Ca	Mg	Na	K	Cl	SO4	HCO3	CO3
Reference		(microS/cm)	(%)	(%)	(%)	(%)	(cmol+/kg)	(%)	(%)		(microS/cm)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)	(meq/l)
OWA-184/3	8.7	4020																	
OWA-184/4	9.4	2050																	
OWA-184/5	8.4	1530																	
OWA-185/1	7.4	1450																	
OWA-185/2	8.5	3760																	
OWA-185/3	8.3	6330																	
OWA-186/1	6.3	433																	
OWA-186/2	8.4	3850																	
OWA-186/3	9.1	3680																	
OWA-187/1	6.1	70																	
OWA-187/2	8.7	907																	
OWA-187/3	9.0	2890																	
OWA-187/4	9.1	1560																	
OWA-188/1	7.9	2170		72	3	25													
OWA-188/2	8.6	5700		81.6	6.7	11.7													
OWA-188/3	9.1	5870		70.9	8	21.1		6											
OWA-189/1	7.6	1173																	
OWA-189/2	8.8	3130																	
OWA-189/3	8.3	7070																	
OWA-189/4	8.8	4290																	
OWA-189/5	9.5	5180																	
OWA-190/1	6.4	34																	
OWA-190/2	8.9	1006																	
OWA-190/3	7.5	49																	
OWA-190/4	9.2	1862																	
OWA-191/1	8.2	35																	
OWA-191/2	7.6	212																	
OWA-191/3	8.2	1595																	
OWA-191/4	7.5	3850																	
OWA-191/5	7.5	2210																	
OWA-192/1	6.1	46																	
OWA-192/2	6.4	264																	
OWA-192/3	8.4	1010																	
OWA-192/4	9.3	2240																	
OWA-193/1	7.1	113																	
OWA-193/2	8.2	2990																	
OWA-193/3	9.0	6240																	
OWA-194/1	8.1	4270																	
OWA-194/2	8.7	6510																	
OWA-195/1	9.0	1902																	
OWA-195/2	8.6	5580																	
OWA-195/3	8.6	4540																	
OWA-196/1	5.2	16	0.1	93.7	3.1	3.2													
OWA-196/2	4.7	21	0.1	92.2	3.6	4.3													
OWA-197/1	5.9	29	0.3	94.1	3.4	2.5													
OWA-197/2	5.3	15	0.1	93.2	3.6	3.1													
OWA-197/3	5.0	16	0.1	93.2	3.5	3.3													
OWA-197/4	7.3	41	0.0	94.6	4.8	0.6													
OWA-198/1	6.6	64	0.3	84	6.7	9.3													
OWA-198/2	8.1	210	0.4	76.6	7.7	15.7													
OWA-198/3	7.4	107	0.2	72.5	6.3	21.2													
OWA-198/4	6.8	89	0.2	75.3	5.4	19.2													
OWA-199/1	6.5	86	0.1	90.8	3.9	5.3													
OWA-199/2	7.0	15	0.0	87.8	3.4	8.7													

Horizon Reference	pH	E.C. (microS/cm)	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-199/3	7.5	25	0.1	86.1	4.7	9.3													
OWA-200/1	7.2	14																	
OWA-200/2	7.3	16																	
OWA-200/3	9.0	54																	
OWA-200/4	9.4	230																	
OWA-201/1	6.5	226																	
OWA-201/2	7.5	132																	
OWA-201/3	8.5	461																	
OWA-202/1	6.4	21																	
OWA-202/2	7.2	875																	
OWA-202/3	8.1	2670																	
OWA-202/4	8.7	4000																	
OWA-203/1	6.6	21																	
OWA-203/2	6.9	26																	
OWA-203/3	7.4	69																	
OWA-203/4	8.6	630																	
OWA-203/5	9.3	1566																	
OWA-204/1	7.5	347		42.2	14.9	42.9													
OWA-204/2	7.8	3090		41.4	6.4	52.3		2	49										
OWA-204/3	8.0	4090		39.4	3.6	57		0	51										
OWA-205/1	8.0	69																	
OWA-205/2	9.8	1135																	
OWA-206/1	8.2	53																	
OWA-206/2	7.9	265																	
OWA-206/3	9.2	611																	
OWA-206/4	9.7	1024																	
OWA-207/1	8.9	89																	
OWA-207/2	8.4	257																	
OWA-207/3	8.7	1411																	
OWA-208/1	6.9	19																	
OWA-208/2	6.8	14																	
OWA-208/3	7.1	21																	
OWA-209/1	9.1	3380																	
OWA-209/2	9.9	5120																	
OWA-210/1	7.7	28																	
OWA-210/2	7.0	15																	
OWA-210/3	6.8	49																	
OWA-211/1	7.3	19																	
OWA-211/2	6.6	29																	
OWA-211/3	7.7	634																	
OWA-212/1	6.7	6160		55.4	4.1	40.4													
OWA-212/2	8.5	13860		34	4.9	61.6		3											
OWA-212/3	8.5	10130		50.8	3.3	45.9		2											
OWA-213/1	6.9	28																	
OWA-213/2	7.0	22																	
OWA-214/1	7.1	76		91.7	4.5	3.8													
OWA-214/2	8.2	2020		84.3	5.3	10.4													
OWA-214/3	8.9	2510		82.4	4.7	12.9		1											
OWA-215/1	7.4	25																	
OWA-215/2	6.8	8																	
OWA-215/3	6.6	16																	
OWA-216/1	6.7	608		86.3	3.2	10.5				6.6	2170								
OWA-216/2	8.9	2510		74.9	1.6	23.5		0		8.4	5930								
OWA-216/3	9.4	2680		72.4	0.9	26.7		0		8.8	3790								

Horizon Reference	pH	E.C. (microS/cm)	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-217/1	6.4	19																	
OWA-217/2	6.4	34																	
OWA-217/3	8.8	15																	
OWA-218/1	6.9	21		92.3	4.3	3.5													
OWA-218/2	6.9	46		89.1	5.5	5.4													
OWA-218/3	8.9	507		82	6.5	11.4		0	7										
OWA-218/4	9.2	1427		63	3.8	33.2		0	10										
OWA-219/1	7.9	1172																	
OWA-219/2	8.6	620																	
OWA-219/3	7.7	29																	
OWA-219/4	9.5	250																	
OWA-220/1	9.5	2250																	
OWA-220/2	8.2	3870																	
OWA-220/3	8.5	1620																	
OWA-221/1	7.6	84		91.6	4.9	3.5													
OWA-221/2	8.8	414		84.8	6.9	8.2													
OWA-221/3	9.2	871		84.7	4.8	10.6		3		8.4	3230								
OWA-221/4	9.2	1085		84	6.2	9.8		0		8.4	4250								
OWA-222/1	7.5	81																	
OWA-222/2	7.7	76																	
OWA-222/3	7.9	181																	
OWA-222/4	9.9	393																	
OWA-223/1	5.9	59																	
OWA-223/2	7.7	593																	
OWA-223/3	8.2	2610																	
OWA-223/4	8.3	3680																	
OWA-223/5	8.8	3670																	
OWA-224/1	6.9	20																	
OWA-224/2	7.3	11																	
OWA-224/3	6.6	542																	
OWA-224/4	7.2	2430																	
OWA-225/1	6.5	35																	
OWA-225/2	8.6	387																	
OWA-225/3	8.6	964																	
OWA-225/4	9.4	1820																	
OWA-226/1	7.1	46																	
OWA-226/2	8.6	529																	
OWA-226/3	8.8	2620																	
OWA-226/4	9.1	1820																	
OWA-227/1	8.2	4230																	
OWA-227/2	8.2	8440																	
OWA-227/3	9.4	5300																	
OWA-228/1	7.4	44																	
OWA-228/2	8.4	779																	
OWA-228/3	8.4	2690																	
OWA-228/4	8.5	3210																	
OWA-228/5	9.5	2290																	
OWA-229/1	7.0	53																	
OWA-229/2	6.7	54																	
OWA-229/3	7.3	19																	
OWA-229/4	8.8	206																	
OWA-229/5	8.5	323																	
OWA-230/1	6.9	12																	
OWA-230/2	7.5	1569																	

Horizon Reference	pH	E.C. (microS/cm)	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-230/3	8.6	3380																	
OWA-230/4	8.7	2200																	
OWA-231/1	9.0	2440																	
OWA-231/2	10.2	5060																	
OWA-231/3	10.3	5410																	
OWA-232/1	9.5	1491																	
OWA-232/2	10.3	3940																	
OWA-232/3	10.2	3520																	
OWA-233/1	8.3	33																	
OWA-233/2	8.9	1163																	
OWA-233/3	8.8	3700																	
OWA-233/4	8.8	2300																	
OWA-234/1	7.1	54																	
OWA-234/2	7.2	1400																	
OWA-234/3	9.0	3010																	
OWA-234/4	8.7	5160																	
OWA-234/5	9.2	3490																	
OWA-235/1	7.7	88																	
OWA-235/2	7.7	1380																	
OWA-235/3	8.3	2570																	
OWA-235/4	8.2	3370																	
OWA-235/5																			
OWA-236/1	9.0	1490																	
OWA-236/2	8.3	3580																	
OWA-236/3	9.1	2370																	
OWA-237/1	7.4	4910																	
OWA-237/2	8.6	8090																	
OWA-237/3	9.0	5590																	
OWA-238/1	7.8	56																	
OWA-238/2	8.3	1455																	
OWA-238/3	8.2	3470																	
OWA-238/4	8.3	4120																	
OWA-239/1	7.9	43																	
OWA-239/2	8.7	425																	
OWA-239/3	8.9	1410																	
OWA-239/4	8.5	2180																	
OWA-240/1	6.4	44																	
OWA-240/2	6.6	276																	
OWA-240/3	8.4	133																	
OWA-240/4	9.0	2530																	
OWA-241/1	6.4	32																	
OWA-241/2	7.4	1340																	
OWA-241/3	8.1	2150																	
OWA-242/1	6.7	47																	
OWA-242/2	7.9	512																	
OWA-242/3	9.4	1400																	
OWA-242/4	8.6	3380																	
OWA-242/5	8.3	1930																	
OWA-243/1	7.3	23		91.9	4.9	3.3													
OWA-243/2	7.4	23		82.9	7.1	10													
OWA-243/3	9.1	169		78.2	4.8	16.9		0		8.3	5600								
OWA-243/4	9.7	328		75.1	7.2	17.6		1		8.8	863								
OWA-244/1	7.2	55		91	5.6	3.4													
OWA-244/2	8.2	337		82.3	6.4	11.3													

Horizon Reference	pH	E.C. (microS/cm)	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-244/3	8.7	2970		74.8	8	17.1		0											
OWA-245/1	6.6	47																	
OWA-245/2	7.9	495																	
OWA-245/3	8.6	3320																	
OWA-245/4	8.8	2780																	
OWA-246/1	7.3	154		69.8	8.5	21.7													
OWA-246/2	8.1	2440		55.5	4.9	39.6		0	3										
OWA-246/3	7.9	3370		51.6	0.6	47.8		0	22										
OWA-246/4	8.3	3480		55.4	7.8	36.8		1	78										
OWA-247/1	6.5	124																	
OWA-247/2	7.6	383																	
OWA-247/3	8.1	3460																	
OWA-248/1	6.8	49																	
OWA-248/2	8.2	119																	
OWA-248/3	7.7	576																	
OWA-249/1	7.0	425																	
OWA-249/2	8.8	2250																	
OWA-249/3	8.4	2890																	
OWA-250/1	8.2	56																	
OWA-250/2	7.4	25																	
OWA-250/3	8.1	38																	
OWA-251/1	6.3	83																	
OWA-251/2	6.9	171																	
OWA-251/3	8.9	1980																	
OWA-251/4	9.7	2520																	
OWA-251/5	9.5	2630																	
OWA-252/1	7.1	23																	
OWA-252/2	8.2	1600																	
OWA-253/1	7.2	57																	
OWA-253/2	7.4	674																	
OWA-253/3	7.8	4350																	
OWA-253/4	8.3	5020																	
OWA-254/1	6.9	108																	
OWA-254/2	7.4	1721																	
OWA-254/3	7.9	4030																	
OWA-254/4	9.0	3500																	
OWA-255/1	8.2	1610																	
OWA-255/2	7.9	8200																	
OWA-255/3	9.0	9710																	
OWA-256/1	8.7	173																	
OWA-256/2	7.8	1756																	
OWA-256/3	7.7	5640																	
OWA-256/4	8.0	4860																	
OWA-257/1	8.6	38																	
OWA-257/2	8.8	40																	
OWA-257/3	9.9	407																	
OWA-258/1	7.7	542																	
OWA-258/2	7.7	2280																	
OWA-258/3	8.7	2550																	
OWA-259/1	8.6	97																	
OWA-259/2	9.7	2020																	
OWA-259/3	9.5	5570																	
OWA-260/1	7.2	2290																	
OWA-260/2	8.1	8610																	

Horizon Reference	pH	E.C. (microS/cm)	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-260/3	9.0	5250																	
OWA-261/1	7.9	1031																	
OWA-261/2	8.4	2450																	
OWA-261/3	8.3	3080																	
OWA-262/1	7.2	60																	
OWA-262/2	8.1	1907																	
OWA-262/3	8.0	5280																	
OWA-262/4	8.3	5050																	
OWA-263/1	7.7	33																	
OWA-263/2	6.9	19																	
OWA-263/3	7.1	22																	
OWA-264/1	6.6	14																	
OWA-264/2	6.8	17																	
OWA-264/3	8.2	70																	
OWA-265/1	7.5	51																	
OWA-265/2	7.6	585																	
OWA-265/3	8.6	3810																	
OWA-265/4	7.1	16																	
OWA-266/1	6.8	23		84.5	9.2	6.2													
OWA-266/2	7.7	513		78.3	5.6	16													
OWA-266/3	9.2	1650		70.8	5.9	23.2		3	18	8.7	4340								
OWA-266/4	9.1	1695		78.8	3.8	17.4		0	12	8.4	5470								
OWA-267/1	7.3	127																	
OWA-267/2	8.8	104																	
OWA-267/3	9.5	427																	
OWA-267/4	9.2	1106																	
OWA-267/5	8.8	1139																	
OWA-268/1	8.7	138																	
OWA-268/2	8.4	2560																	
OWA-269/1	7.6	23																	
OWA-269/2	9.3	114																	
OWA-269/3	9.8	159																	
OWA-270/1	6.4	99																	
OWA-270/2	8.3	3790																	
OWA-270/3	8.8	4870																	
OWA-270/4	9.2	4370																	
OWA-271/1	6.1	22		88.3	3.4	8.3													
OWA-271/2	8.9	723		80.1	5.2	14.7													
OWA-271/3	8.3	1652		77.8	15.6	6.6		0	14										
OWA-271/4	8.6	2500		76.8	5.9	17.4		0	12										
OWA-272/1	6.9	28																	
OWA-272/2	8.2	1087																	
OWA-272/3	8.2	3600																	
OWA-273/1	6.5	30																	
OWA-273/2	8.2	340																	
OWA-273/3	7.9	1274																	
OWA-274/1	6.8	34																	
OWA-274/2	6.6	18																	
OWA-274/3	7.0	12																	
OWA-274/4	7.7	111																	
OWA-275/1	7.0	26																	
OWA-275/2	6.5	19																	
OWA-275/3	7.4	47																	
OWA-275/4	7.7	108																	

Horizon Reference	pH	E.C. (microS/cm)	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-276/1	7.9	57																	
OWA-276/2	7.5	988																	
OWA-276/3	9.8	2810																	
OWA-276/4	9.5	3960																	
OWA-277/1	7.7	93																	
OWA-277/2	9.1	3100																	
OWA-277/3	10.0	3980																	
OWA-277/4	10.0	4710																	
OWA-278/1	7.8	68																	
OWA-278/2	7.3	49																	
OWA-278/3	9.7	447																	
OWA-279/1	7.0	1872																	
OWA-279/2	8.8	2710																	
OWA-279/3	9.2	3380																	
OWA-280/1	7.6	106																	
OWA-280/2	8.2	352																	
OWA-280/3	9.5	554																	
OWA-281/1	7.4	52																	
OWA-281/2	9.0	1484																	
OWA-281/3	9.7	1608																	
OWA-282/1	7.8	46																	
OWA-282/2	7.5	27																	
OWA-282/3	7.5	39																	
OWA-282/4	8.0	43																	
OWA-283/1	8.1	100																	
OWA-283/2	8.9	1045																	
OWA-283/3	9.0	3250																	
OWA-283/4	9.4	1968																	
OWA-284/1	6.7	192																	
OWA-284/2	7.9	1378																	
OWA-284/3	9.2	3000																	
OWA-284/4	8.5	4180																	
OWA-285/1	7.1	1195																	
OWA-285/2	8.0	7690																	
OWA-285/3	8.5	7000																	
OWA-285/4	8.8	4990																	
OWA-286/1	7.1	132																	
OWA-286/2	8.1	165																	
OWA-286/3	8.8	165																	
OWA-286/4	9.2	577																	
OWA-286/5	9.0	1498																	
OWA-287/1	7.7	447		71.7	4.3	23.9													
OWA-287/2	8.3	3030		48.9	5.5	45.7		1	42										
OWA-287/3	8.0	5920		48.7	0.9	50.4		1	95										
OWA-287/4	8.4	3780		54.5	2	43.5		1	55										
OWA-288/1	7.2	36																	
OWA-288/2	8.5	2160																	
OWA-288/3	9.1	3820																	
OWA-288/4	9.6	2860																	
OWA-289/1	8.6	87																	
OWA-289/2	9.7	34																	
OWA-289/3	9.0	1281																	
OWA-289/4	9.0	1261																	
OWA-290/1	7.2	54																	

Horizon Reference	pH	E.C. (microS/cm)	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-290/2	9.0	4120																	
OWA-290/3	8.3	301																	
OWA-291/1	6.1	13																	
OWA-291/2	6.2	11																	
OWA-291/3	6.2	8																	
OWA-292/1	7.2	93																	
OWA-292/2	7.7	25																	
OWA-292/3	8.7	125																	
OWA-293/1	7.2	53																	
OWA-293/2	9.1	1437																	
OWA-293/3	8.6	275																	
OWA-293/4	9.3	1610																	
OWA-294/1	6.0	12																	
OWA-294/2	5.6	13																	
OWA-294/3	5.2	13																	
OWA-295/1	7.2	36																	
OWA-295/2	8.8	943																	
OWA-295/3	8.8	1922																	
OWA-295/4	8.3	3560																	
OWA-296/1	6.8	21		97.5	0.6	1.9													
OWA-296/2	9.1	1308		82	4.7	13.4				8.7	3580								
OWA-296/3	9.7	1419		81.8	5.1	13.1				9.2	3010								
OWA-297/1	7.4	35																	
OWA-297/2	8.2	1716																	
OWA-297/3	9.5	1948																	
OWA-298/1	7.0	23																	
OWA-298/2	7.1	230																	
OWA-298/3	8.2	516																	
OWA-298/4	9.6	566																	
OWA-299/1	8.5	53		71.2	4.9	24		0											
OWA-299/2	9.4	352		69.9	4.3	25.7		1		8.6	1060								
OWA-300/1	7.3	20																	
OWA-300/2	7.2	22																	
OWA-300/3	8.7	84																	
OWA-300/4	8.3	92																	
OWA-301/1	8.7	52																	
OWA-301/2	9.6	128																	
OWA-301/3	9.3	584																	
OWA-301/4	8.1	1879																	
OWA-302/1	8.2	652		36.4	31.9	31.6				7.4	2660								
OWA-302/2	8.3	6710		57.2	13.2	29.6		2		8.0	13140								
OWA-302/3	8.5	6130		44.8	3.9	51.2		3		8.2	13340								
OWA-302/4	8.7	4620		50	14.9	35.1		14		8.5	12420								
OWA-303/1	8.6	58																	
OWA-303/2	8.8	145																	
OWA-303/3	8.7	674																	
OWA-304/1	7.4	29																	
OWA-304/2	9.3	608																	
OWA-304/3	9.4	1027																	
OWA-305/1	7.2	39																	
OWA-305/2	6.7	17																	
OWA-305/3	7.7	68																	
OWA-305/4	8.8	221																	
OWA-306/1	8.0	34																	

Horizon Reference	pH	E.C. (microS/cm)	O.C. (%)	Sand (%)	Silt (%)	Clay (%)	C.E.C. (cmol+/kg)	CaCO3 (%)	Gypsum (%)	pH (paste)	E.C.(paste) (microS/cm)	Ca (meq/l)	Mg (meq/l)	Na (meq/l)	K (meq/l)	Cl (meq/l)	SO4 (meq/l)	HCO3 (meq/l)	CO3 (meq/l)
OWA-306/2	9.4	115																	
OWA-306/3	9.4	2880																	
OWA-306/4	8.9	3570																	
OWA-306/5	9.5	1920																	
OWA-307/1	8.0	118																	
OWA-307/2	9.0	1074																	
OWA-307/3	8.9	3160																	
OWA-307/4	9.0	2070																	
OWA-308/1	9.2	19040		59.6	7.6	32.7				8.4	675								
OWA-308/2	9.1	2220		62.1	9	28.9		10		8.7	6570								
OWA-308/3	9.0	1920		70.2	3.8	26		3		8.5	3820								
OWA-309/1	7.8	43																	
OWA-309/2	8.3	47																	
OWA-309/3	8.5	57																	
OWA-311/1	8.1	198																	
OWA-311/2	9.3	655																	
OWA-311/3	9.3	2360																	
OWA-312/1	8.7	58																	
OWA-312/2	8.6	35																	
OWA-312/3	9.1	54																	
OWA-312/4	9.3	200																	
OWA-313/1	8.8	2070																	
OWA-313/2	9.2	8900																	
OWA-314/1	7.1	67																	
OWA-314/2	8.2	37																	
OWA-315/1	6.4	25																	
OWA-315/2	5.6	8																	
OWA-315/3	5.7	12																	
OWA-316/1	6.8	26																	
OWA-316/2	5.6	82																	
OWA-316/3	6.4	21																	
OWA-317/1	7.1	36																	
OWA-317/2	9.6	380																	
OWA-317/3	10.1	1447																	
OWA-317/4	10.2	1918																	
OWA-318/1	9.4	372																	
OWA-318/2	7.5	38																	
OWA-318/3	10.4	1716																	
OWA-318/4	10.5	2600																	
OWA-319/1	7.6	60																	
OWA-319/2	8.7	97																	
OWA-319/3	9.8	2280																	
OWA-319/4	9.7	2040																	
OWA-320/1	8.3	1420		51.9	9.6	38.5													
OWA-320/2	8.3	8130		51	5	44		3	57										
OWA-320/3	8.7	6310		49.2	7.1	43.7		4	85										

8.1. Introduction

The main objective of the project is to hand over to the AEZ Office of the Ministry of Agriculture, Water and Rural Development of Namibia the soil map at scale 1:1.000.000. In order to accomplish this task, it has been evident the necessity to provide them with a tool capable to manage in an effective way the following aspects:

- compilation and management of a great amount of descriptive data.
- geographic representation of the databases.
- carrying out of the data spatial analysis.
- spatial representation of the results.

For these reasons, it was decided to organize and store the whole information in a Geographic Information System (GIS). A GIS is a tool that combines the work capacity of a relational database and the spatial representation of the related entities. So, it is able to work with databases associated to geographic entities.

The fact of using a GIS to manage the data allows to reach a double objective. On one hand, make the soil map (a basic tool for the AEZ) and, on the other hand, create a tool capable to calculate the AEZ adding new information.

8.2. GIS development

8.2.1. GIS design

The gathered information has been compiled in four georeferenced digital maps at different scales with related attribute databases:

- Geometric database (digital maps): a cartographic base, which correspond to the geometric entities of the data, that is to say, the geographic limits of the soil maps.
- Attribute database: it is the computerized database that contains an inventory of soils and their descriptions, as well as the whole information compiled to make the map.

The GIS makes possible to establish a relationship between the geometric and the attribute databases, and to obtain for each soil map unit, the corresponding description. In this way, it provides information about the soil associations, their components and their attributes.

Firstly, it has to be decided witch would be the more suitable software to develop the project. From the beginning, the option of designing a product made for the purpose was discarded, due to the maintenance and migration problems involved. So, it was decided to search for a commercial software. Among the options available in Namibia, it was chosen the Arcview 3.2 by ESRI, which fulfils the technical requirements, while it is a simple and powerful GIS with a friendly and adaptable environment, and an easy computer language. Moreover, the mentioned software had already some implementation at the Ministry of Agriculture of Namibia.

This software works on a model of vectorial data: the geographic elements are captured as points, lines and polygons, which allows an accurate representation of the reality. Although, its analysis capability is limited when working with a great amount of data. As the final objective of the soil map was to integrate it on a great group of thematic maps in order to calculate the AEZ, it was decided to use a raster data model to make the analysis: the Spatial Analyst extension of GIS Arcview. This extension lets to convert the vectorial data into raster so as to achieve more capacity and speediness in the analysis process.

The GIS environment was discarded for the capture of the database information. So, the priority was centred on finding an economical software able to create easily an environment of data capture and management, and a simply integration on the GIS. Among the market options, we shown our preference for Microsoft Access.

One of the aspects highly valued was the technical possibility to establish a direct connexion between the GIS and the database in Ms Access (through ODBC connection and SQL queries). Nevertheless, finally a robustness option was chosen which consists of integrate directly the different tables of the database on the GIS.

According to the technical specifications, four soil cartographies were made at different scales and geographic sites:

- Soil cartography at scale 1:100.000 of the Kavango river area.
- Soil cartography at scale 1:100.000 of the Northern Central Namibian area (Owambland).
- Soil cartography at scale 1:250.000 of the area with growing period 2 and 3.
- Soil survey at scale 1:1.000.000 of Namibia.

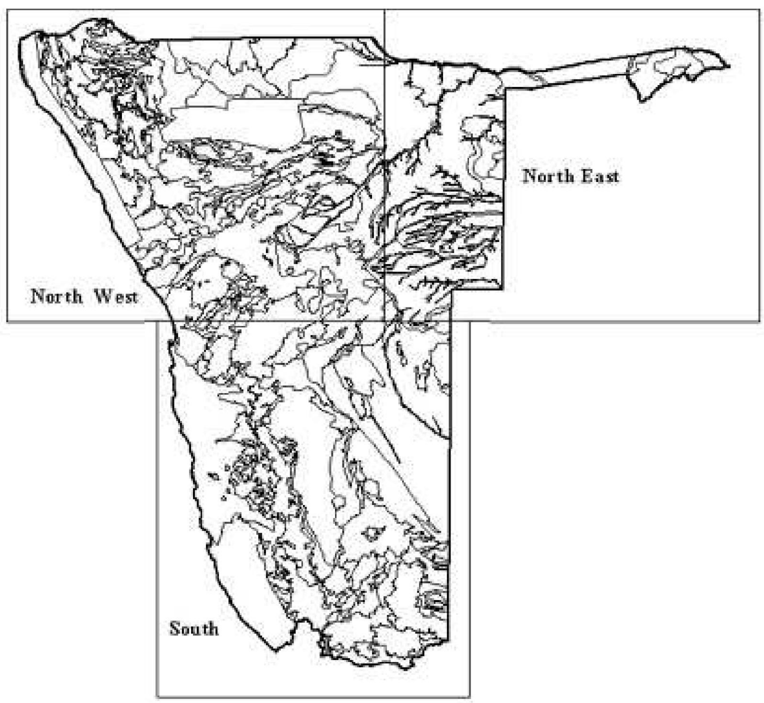

Figure 8.1: Sheet distribution o soil cartography at 1:1.000.000 scale.

Each of the above maps has its own database, therefore each area has a digital soil cartography and a database in Access.

8.2.2. Projection System

One of the key aspects when working with a GIS is the correct data indexation. Firstly, the cartographic base and the reference system to be used have to be clear. At Namibia, two standard reference systems have been defined used depending on the sheet scales:

The map series at scale 1:250.000 and 1:100.000, classified according to the following projection system:

Projection Gauss Conformal
Spheroid: Bessel (Schwarzeck Datum)
Central Meridian: 13,15,17,19 and 21 E of Greenwich
Reference Latitude: 22 S

Scale factor: 1
False Easting: 0.0
False Northing: 0.0

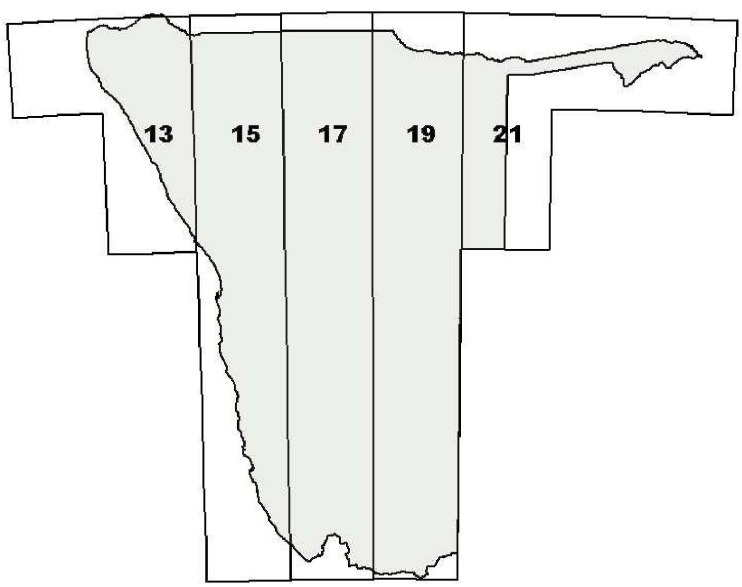

Figure 8.2: Distribution of the Central Meridian parameter of the Gauss Conformal Projection System.

Each sheet at scale 1:250.000 has as axis the corresponding central meridian (Fig. 8.2) with the dimension of two grades of longitude per one grade of latitude. Each of them are divided into eight sheets at scale 1:100.000 of one grade of longitude per one grade of latitude.

Regarding small scale cartography (lower than 1:500.000), the projection system used is the following:

Projection: Albers Equal Area Conic
Spheroid: Bessel (Schwarzeck Datum)
Central Meridian: 18:30 E of Greenwich
Reference Latitude: 22 S

Standard Parallel 1:20 S
Standard Parallel 2: 26 S
False Easting: 0.0
False Northing: 0.0

The base cartography used has been the processed satellite images geometrically corrected following the technical specifications of the project (see chapter: Satellite Map Production). In consequence, the soil maps are referenced to the satellite images according to there study area and scale.

In the case of scales larger than 1:500.000, in order to obtain continuous maps and to avoid there division in different geographic zones, the soil maps were captured on geographic coordinates. In this way, the soil maps have been obtained in a continuous form on the cartographic base.

8.2.3. Database Construction

8.2.3.1 Design of the database

The first step consisted of the design and construction of the related database in MS Access. It has been designed an structure that shows in a plain and organized way the different kind of information collected, gathered in a range of attribute thematic tables that describe similar aspects. For each table an own index is set and a series of fields that allow to establish their relationships. Additionally, there have been included forms and dictionaries for each table to assist and control the data input, and specific software to manage and export them.

According to the technical specifications of the project, the soil map database would have to respond to the SOTER structure. The SOTER database was developed by the Food and Agriculture Organization (FAO,1993) of the United Nations Organization to assist and standardize the soil cartographies at regional scale. This is a general database that allows to cover a wide range of aspects related to soil descriptions. Therefore, it represents an ideal tool to apply to the Namibian soil maps at scale 1:1.000.000. It was also decided to use it for the soil cartography at scale 1:250.000, as a test to value its performance.

However, to work at more detailed scales (for example scale 1:100.000), a suitable database was designed for the purpose: the ICC100, since it retains all the information compiled during the cartography.

As a result, during the project, two database structures have been used: the SOTER and the ICC100.

8.2.3.1.2. SOTER Database

It is designed on a group of files (Fig. 8.3) as to be used in a Related Database System (RDBS) and a Geographic Information System (GIS). To define an unit, the SOTER methodology applies certain discrimination criteria step by step to reach an accurate identification. In this way, the SOTER unit progressively obtains its definition on terrain terms, terrain components and soil components.

The SOTER unit is defined according to the parameters of the following tables (Annex 4.1.1):

Terrain table : describes in a general way the SOTER unit.
Terrain component (terrcomp) table: indicates the SOTER unit to which the terrain belongs and the proportion that it occupies in the unit.
Terrain component data (tcdata) table: contains all the specific attributes of the terrain component.
Soil component (soilcomp) table: specifies the soil different components included in each terrain/terrain combination and its position.
Profile table: presents all the attributes of the soil components.
Horizon (rephoriz) table: contains the description of each horizon of the profiles. In order to give a certain grade of variability this table is supported on two more tables (**horizon minimum value table** and **horizon maximum value table**) that show the maximum and minimum values referred to the available profiles.

The SOTER database also incorporates a set of associated tables with additional information:

Land use table, Source map table, Laboratory table, Laboratory methods table, Analytical method table, Climate station table, Climate data table and **Data source table**.

The **Codes_GB table**: attribute dictionaries for the different tables form (Annex 4.1.2)

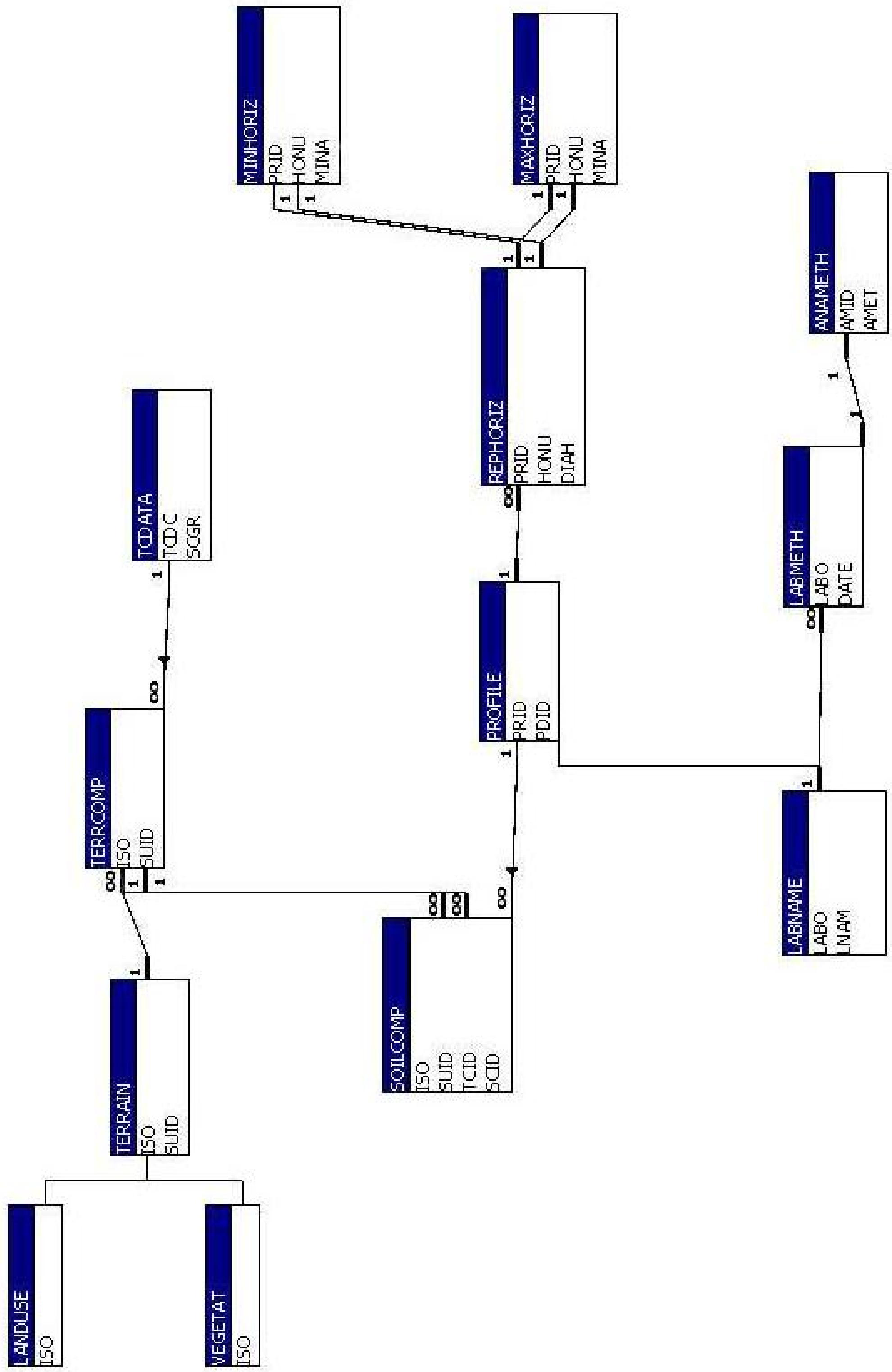

Figure 8.3: SOTER database structure. Main tables and relations (1:1, one to one relation; 1:∞, one to many relation).

8.2.3.1.1. ICC100 Database

It has been designed as a relational database, which structure is a set of specific tables that are related through common files (Fig. 8.4). The tables have been planed in such a way that each one has a file that acts as an index.

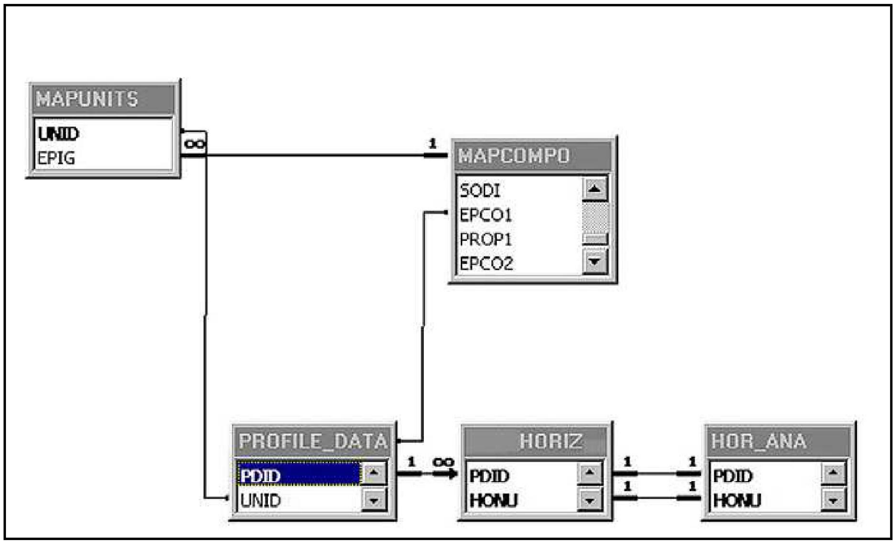

Figure 8.4: ICC100 database structure. Main tables and relations (1:1, one to one relation; 1:∞, one to many relation).

The database is made up of five tables with there corresponding specially made data input forms (Annex 4.2.1 and 4.2.2). These tables are the following:

Mapunits table: contains de required fields to relate the database with the digital map.
Mapcompo table: contains the generic description of the soil unit, with there corresponding soil associations.
Profile_data table: includes general information about the profiles and where they have been located.
Horiz_data Table: descriptions of the horizons presented in the profiles.
Hor_ana table: analysis of the soil samples (referred to the horizons).
Codes_hz table: attribute dictionaries for the horizon table form.
Codes_pro table: attribute dictionaries for the Profile data table form.
Codes_ma table: attribute dictionaries for the Mapcompo table form.

8.2.3.2. Input of field data

The first information that is collected is the field data recorded on a set of specific cards alike to the database input forms (Fig 8.5). The mentioned data corresponds to the soil different profiles made throughout the country which includes: profile sites, description of their zone, a detailed explanation of the soil type and the analytical data of the samples. Therefore, it is an specific information on the space georeferenced by its coordinates.

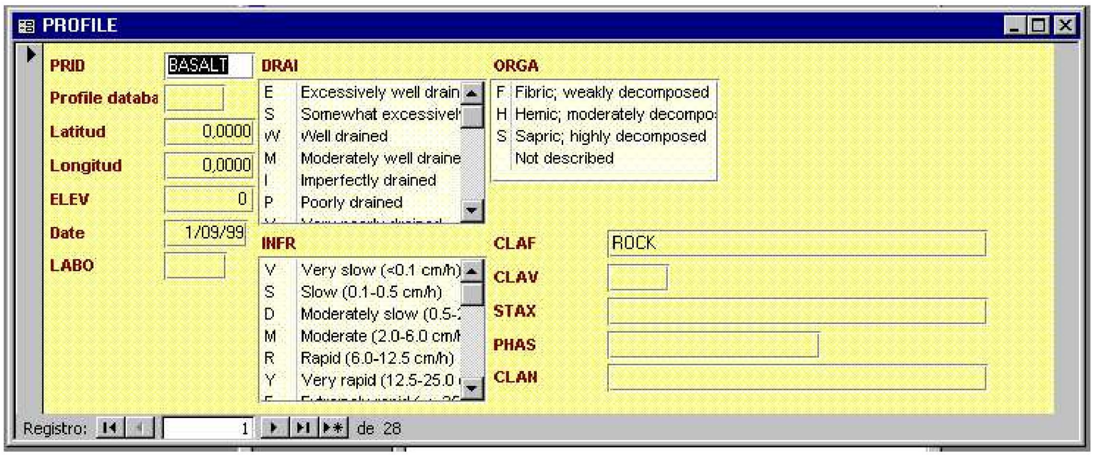

Figure 8.5: SOTER profile data entry form.

8.2.3.3. Input of map derived data

The analysis of the data profiles, combined with the satellite images interpretation, gives the definition of the soil units. These are standard soil associations that describe territory areas showing the same soil types and proportions, and that are represented as polygonal entities delineated on the satellite images. At this stage, it is possible to extract the topographic and landscaping characteristics which describe the established soil associations and complete the database with the whole information referred to the soil map (Fig 8.6): occupied surface, association descriptions and relation to the standard profiles. Nevertheless, the digital representation as a polygon entity it is yet to be settled.

The first result is a database for each study area:

NSDkava: corresponding to the Kavango area at scale 1:100.000
NSDowa: corresponding to the Northern Central Namibia area at scale 1:100.000
NSD250: corresponding to the country NE area at 1:250.000
NSD1000: corresponding to the Namibian cartography at 1:1.000.000

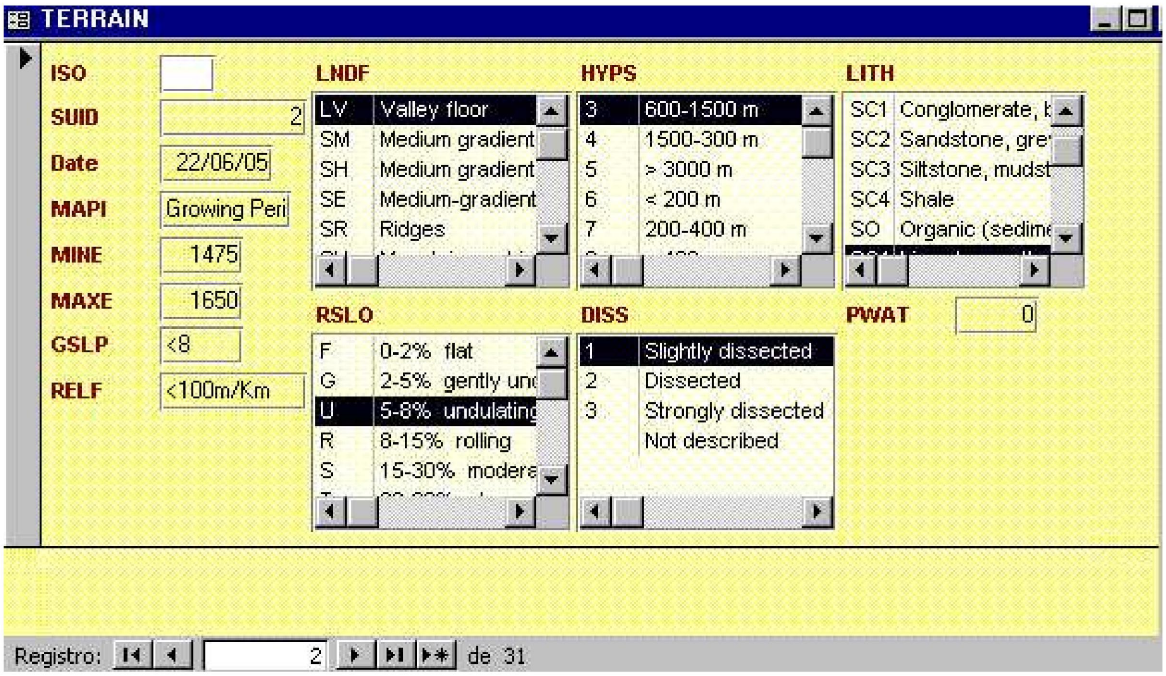

Figure 8.6: SOTER Terrain data entry form.

8.2.4. GIS construction

8.2.4.1. Map computerization

Once the soil units have been drawn on the rectified satellite images, the digital delineation is made. The process has been made at the same GIS ArcView environment, using the available CAD tools, through the capture on the screen of each soil association as a polygonal entity. This process is carried out with the satellite images displayed on the screen so as to assure a higher accuracy (Fig 8.7). The mentioned method of digitalisation avoids the fitting and registering problems that may appear when working with a digitiser table, simplifying the quality and topology controls. At the same time, working on a GIS environment permits to capture the data at the corresponding reference system (thanks to the fact that the satellite images are rectified), in a way that the soil map digital information is stored in geographic coordinates to have a continuous map and facilitate the data conversion between the zones.

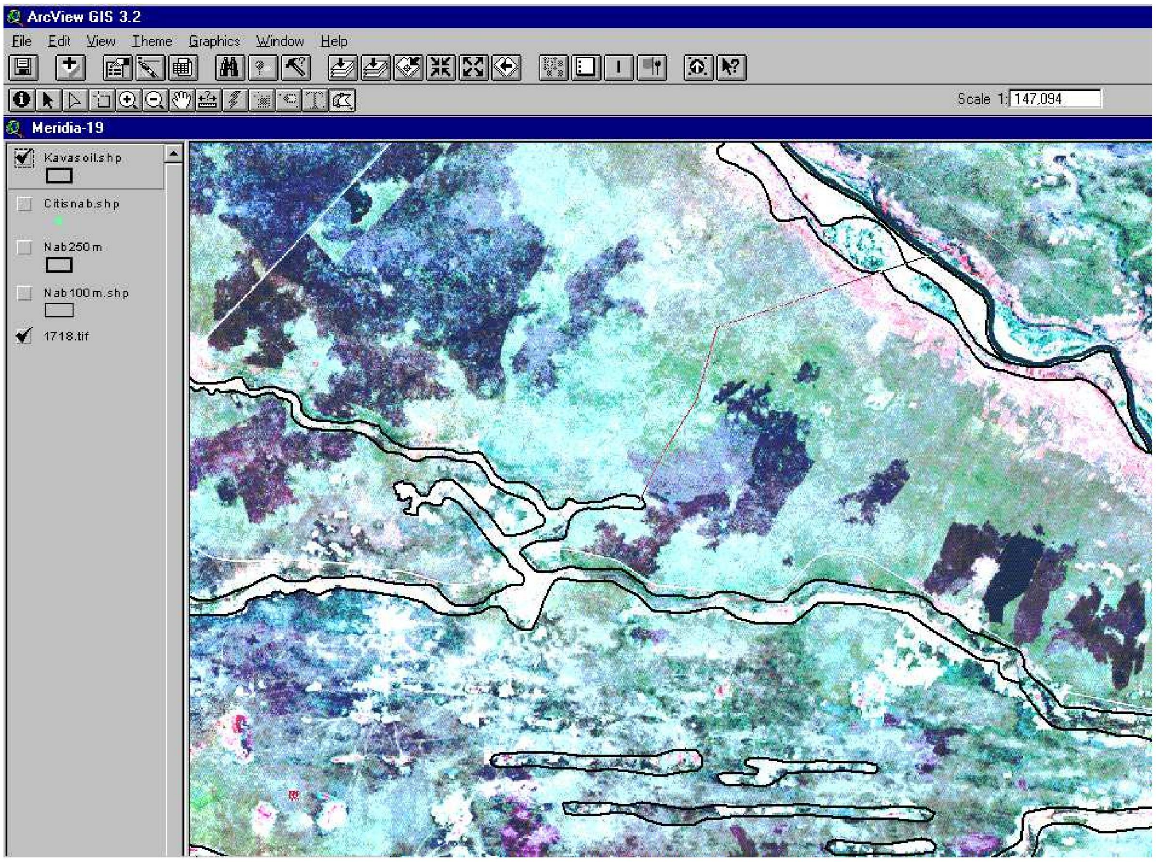

Figure 8.7: Detail of the digitising environment: the satellite image rectified at the Central Meridian 19 as a base map reference.

The result is a shapefile (table 8.1) with a single indicator for each polygon, creating a table that contains the single indicator and the soil equivalent association code. The table is used to codify the shapefile and, finally, to obtain the soil map with the soil unit code of the database. The following soil digital cartographic bases have been obtained for each area:

Table 8.1 Resume of the obtained shapefiles

Soil Map	Area (km^2)	Number of polygons
Kavasoil	13.183	198
Owasoil	87.645.5	300
Soil250	141.550	153
Soil1000	824.813	321

8.2.4.2. Database inclusion

After the soil digital map is obtained, the database are loaded on the GIS. The tables that conform the Access database are exported to files on a dBase III format (*dbf*).

Once we have the tables on *dbf* format, they are loaded directly on the GIS environment, establishing again the relational structure. Any modification made on the Access database has only to be exported at the table on *dbf* format (replacing the existing one), and the change is automatically reflected on the GIS as it reads directly *dbf* files.

8.2.4.3. Digital map combination – Database tables

This is the final step in the GIS construction. It consists of setting up the links between the digital map and the database tables: common files have to be related, that is to say, the file that identifies the soil unit at the table of the map and the same file at the main table of the database. Taking advantage of the mentioned process, as well as to improve the management and analysis of the soil map with the SOTER database, a required application have been prepared in order to automate the combination and restructuring of this database (Annex 4.1.3). The ICC100 database was designed considering the GIS environment management, consequently, the combination with the digital map is easier (Annex 4.2.3). Thus, when SOTER database tables are included on the GIS a series of changes are made:

- the table associated to the polygons combines the information of the **Terrain table** with the data of the soil types and proportions extracted from the **Mapcombo table** and the **Profile table**. The process is do it defining a new intermediate table: the **soilmap table**
- from the coordinates of the **Profile table** the geographic situation of the profiles is presented with its corresponding information.
- The profiles and the soil map are associated by the soil type.

A cartographic base including all profiles made during the project has also been prepared: the **Soilpro**, which is the 'embryo' of the soil profile database of the whole country.

8.2.4.4. GIS structure

Although a single application could be made to manage all the soil maps, finally a GIS project has been developed for each map in order to facilitate the management and analysis of the data. They are open applications, characterized for the possibility of adding and extracting information and modifying when necessary. Each application, based on an ArcView structure, is organized according to the following components:

8.2.4.4.1. Views

View is a GIS component that allows to visualize and manage the cartographic elements as an interactive map: the visualization parameters, the different elements and the symbolization are here defined.

The **Soilmap** view has been created (Fig 8.8): the data are stored as geographic coordinates and can be visualized in the projection of the corresponding scale (new button **C**, let to change the Central Meridian in the Gauss Conformal Project System) . In this view we have:

- the corresponding soil map: soil250.shp, owasoil.shp and soil1000.shp.
- the defined profile types: Profile.shp.

There is also the complete reference cartographic information (satellite images).

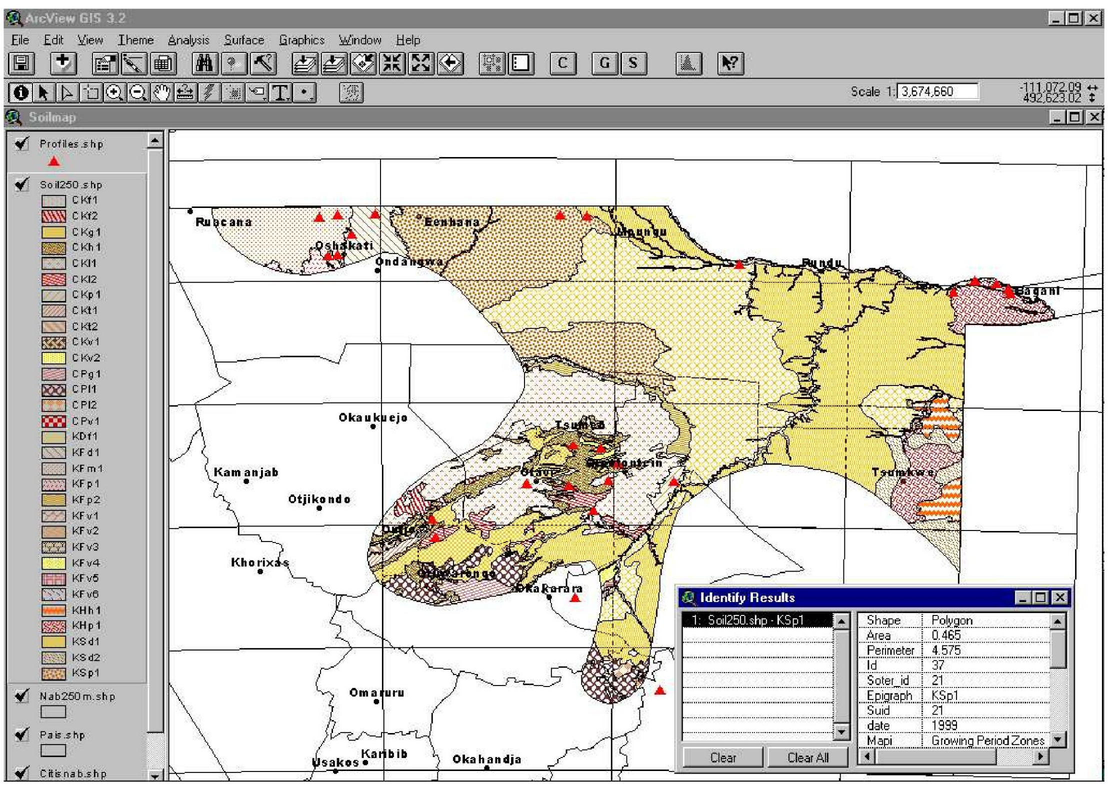

Figure 8.8: View of the soil map at scale 1:250.000: interface and identify utility

8.2.4.4.2. Tables

It is the database management environment (Fig 8.9)where the descriptive information is found. In this case we have the database tables and the cartographic elements attribute tables (profiles and soil maps). The tables work in two ways:

- the tables directly linked of the cartographic elements of the View, so that any selection of the cartographic elements is reflected on the table and vice versa (the tables called "*Attributes of* ...".
- and the non spatial attribute tables that are related to the cartographic elements, according to the relations established on the former tables.

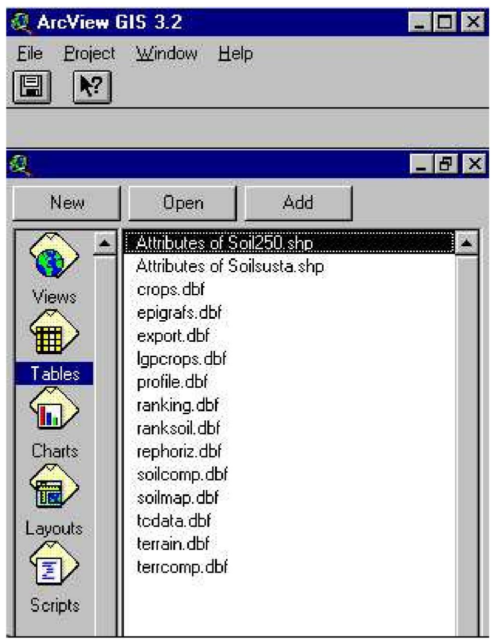

Figure 8.9: Tables environment (original MS Access tables in DBF format and geometric databases)

8.2.4.4.3 Layouts

It is the environment to prepare and compose the graphic documents for the final printing. At this point, the elements which made up the application are combined.

8.2.4.4.4. Scripts

It is the programming environment of the GIS (in **Avenue** language oriented to objects) where the application is developed and where all the software made to manage the data is stored. The software have been made to adapt the SOTER database structure to our management environment:

- **Central_M**: let to change the Central Meridian parameter in the Gauss Conformal Projection (Annex 4.4.1).
- **addfieldsoil**: modifies the attribute table of the soil map adding new files (Annex 4.4.2).
- **addfre**: calculates the number of soils integrated by each soil association (Annex 4.4.3).
- **soilprop**: adds on the attribute table of the soil map the composition and proportion of each soil (Annex 4.4.4).

8.3. Soil evaluation

With the aim of show the possibilities of the GIS developed during this project a computer simulation has been prepared. It represents a simplification of the Agro-ecological zoning, which is a procedure carried out by the Food and Agriculture Organization (FAO) of the United Nations Organization to estimate the soil capacity for agriculture uses on small scale.
The simulation shows the analytical capacities of the vector-raster GIS (formed by ArcView 3.2 + Spatial Analyst): it allows to work the vector data in a faster and more efficient way as the data is converted and manipulated into raster format.

8.3.1. Evaluation concepts

The evaluation has been performed in two steeps:

Steep 1: Establishment of the soil suitability of individual soils that appear in the different map units. This steep means a preliminary evaluation.

Steep 2: Modification of the preliminary evaluation by making yield deductions for likely agro-climatic constraints in a given length of the growing period.

The establishment of the soil suitability of individual soils is based on the ratings of all soil units of the FAO/Unesco Soil Map of the World obtained during the application of the methodology to assess the potential land use of agro-ecological zones in Africa (FAO, 1978). For the establishment of the map unit suitability, the weight of the individual soils that make up the map unit is taken into account.

The ratings are based on how far the soil conditions of a soil unit meet crop requirements. The appraisal has been effected in four basic classes for each crop: very suitable (S1), suitable (S2), marginally suitable (S3) and not suitable (N). A rating of S1 indicates that there are no limitations to production of the crop, provided that the climatic conditions are suitable. The rating of S2 was given when the soils present few limitations to production of the crop. The rating of S3 was given when it was considered that soil limitations are such that they would markedly affect production of the crops. A rating of N was given when the soil limitations appear to be so severe that crop production is not possible.

The agro-climatic constraints considered to modify the preliminary evaluation are those imposed by rainfall variability, by climate-related pests and diseases, by factors affecting yield formation and quality and by factors that arise from difficult workability and handling of produce. These groups of agro-climatic constraints are expressed in terms of reduction ratings on an ordinal scales to reflect the severity of constraints in each length of the growing period. (Table 8.2)

Table 8.2. Severity of fhe agro-climatic constraints in the growing period zones 2 and 3

GROWIN G PERIOD ZONE	RATINGS								
	Millet abcd	**Sorghum abcd**	**Maize abcd**	**Soya abcd**	**Cotton abcd**	**S. Potato abcd**	**Wheat abcd**	**Potato abcd**	**Beans Abcd**
2	1000	2100	2110	2010	2110	2010	2010	2010	2010
3	2010	2110	2120	2020	2000	2010	2010	2010	2020

The severity of a particular group of constraints is rated as follows:

Rating 0: slight constraints, if any, causing no significant yield loses.
Rating 1: moderate constraint, resulting in yield loses of 25%.
Rating 2: severe constraint, resulting in yiedl loses of 50%.

The final suitability of each map unit is obtained after calculating the reductions from the preliminary assessment.

8.3.2. Design of the application for the evaluation

The evaluation has been done using the soil cartography at scale 1:250 000 and, therefore, developed within the soil250 project. It has been necessary to add new data and make the following modifications:

8.3.2.1. New view

A new view has been created called **Crop_quality**. The raster data operations have to be made in real measures, consequently it is not possible to work with data on geographic coordinates. Therefore, firstly the required information has been converted on a metric projection system: specifically the Albers Conformal, instead of the Gauss Conformal as it would be necessary according to the map scale, to avoid the distortion problems as we move away from the central meridian.

The following information have been used:

- **GPZ.shp**: Preliminary Growing Period Zones (GPZ) of Namibia.(Fig 8.10)
- **soilsusta.shp**: soil map from original scale 1:250.000 (Fig 8.11)

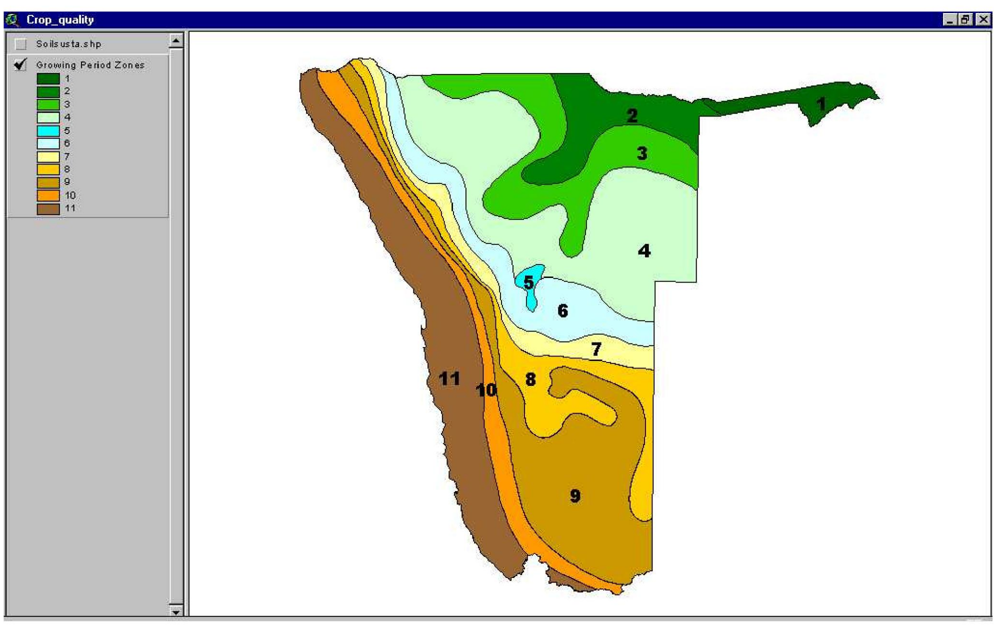

Figure 8.10: Preliminary Growing Period Zones of Namibia

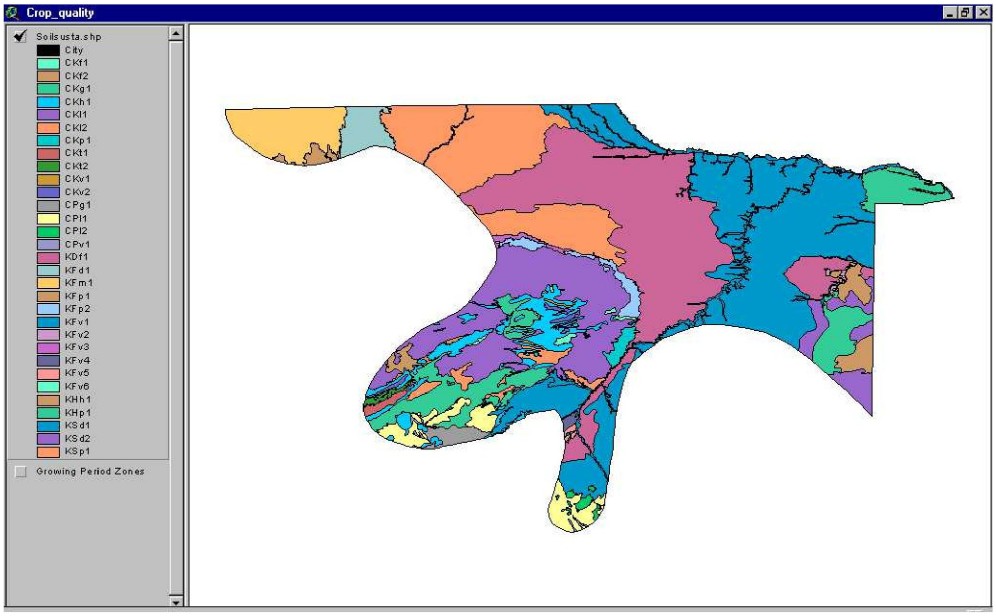

Figure 8.11: Soil Map of the areas with growing period 2 and 3 in Albers Projection System

8.3.2.2. New tables

A series of new tables have been included to calculate the soil capacity:

- **crops.dbf** a matrix of capacity that relate the soil type to the crop type. (Annex 4.3.1)
- **lgpcrops.dbf** a reductor matrix of capacity that relate the GPZ to the crop type. (Annex 4.3.2)
- **ranksoil.dbf** converts the crop capacity parameters into a numeric table. (Annex 4.3.3)

8.3.2.3. New applications

Finally, a series of new applications have been developed for evaluation purposes:

- **Soil_qua**: calculates the capacity of each crop of the soil map. (Annex 4.4.5)
- **ConvertGrid:** request the vector to raster conversion parameters. (Annex 4.4.6)
- **SurfaceGridAez**: transforms vector data into raster data. (Annex 4.4.7)

8.3.3. Execution

The application is run through two new buttons added at the **Crop_qualit**y view.

8.3.3.1. S Button

The first button requests the crop object (Fig. 8.12) of the evaluation and calculates a preliminary estimation of the soil map according to the types and proportions of each soil (Fig 8.13).

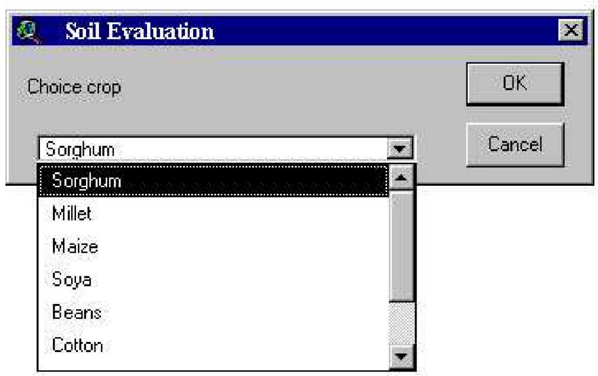

Figure 8.12: Button S execution. Crop selection.

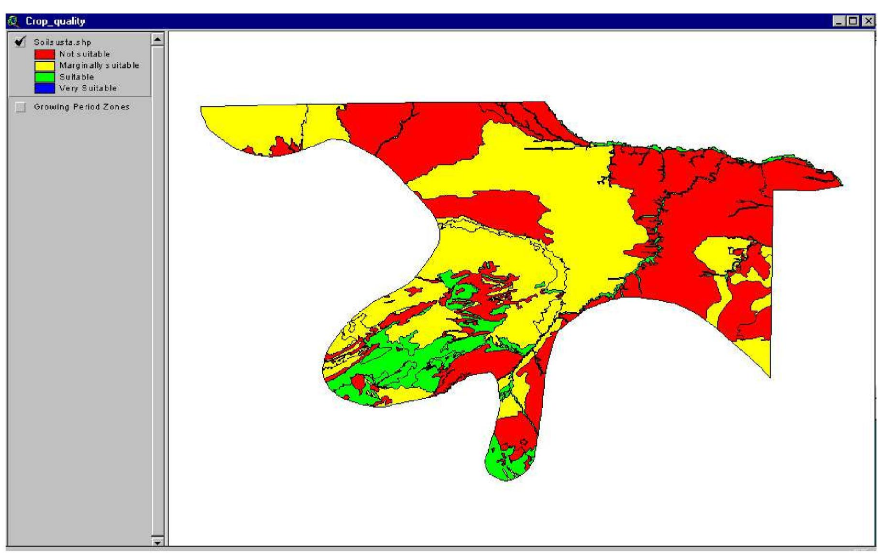

Figure 8.13: Button **S** execution. Preliminary evaluation according to crop and soil type.

8.3.3.2. G Button

The second button executes the evaluation with the raster data (it is mandatory to use the **S** button previously):

- requests the conversion parameters and the raster model resolution that will depend on the scale and level of accuracy whished on the analysis results. According to the soil map characteristics, the application defaults to a 100 x 100 m. resolution (Fig. 8.14).
- requires the GPZ map name (Fig 8.15).
- asks for the soil map name to be used (Fig 8.16).
- asks for the name of the soil map and the GPZ map in the raster format

Finally, it operates with the two raster models obtaining a new raster model (Fig. 8.17) that includes the values of the final evaluation of the studied crop.

To save the results use the option "**convert to grid**" of the **theme** menu

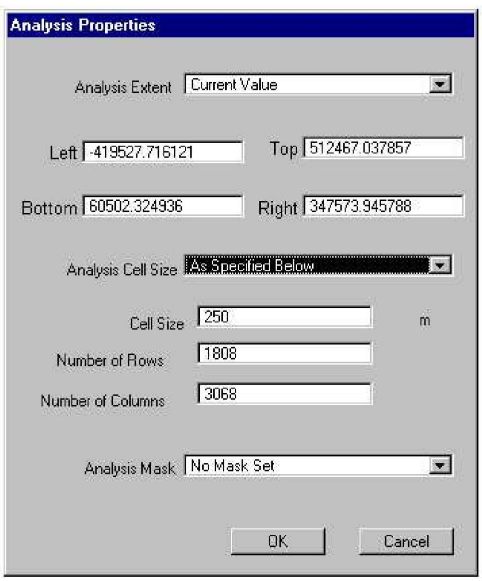

Figure 8.14: Button **G** execution. Defining the Analysis raster environment.

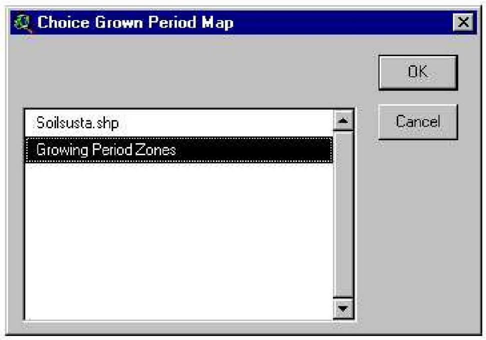

Figure 8.15: Button **G** execution. Choice the Growing Period Map

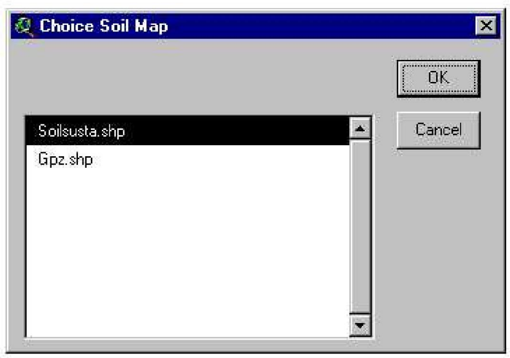

Fig 8.16. Button **G** execution. Select the soil map to use (soilsusta.shp)

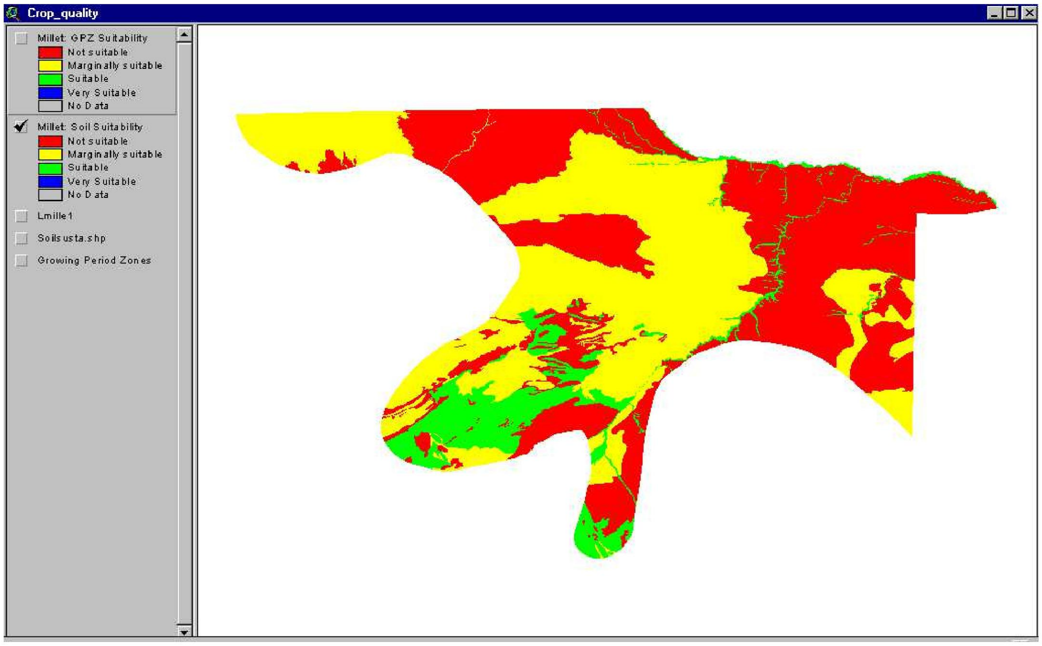

Figure 8.17A: Button **G** execution. Results: Preliminary Soil suitability (raster model) for the selected crop.

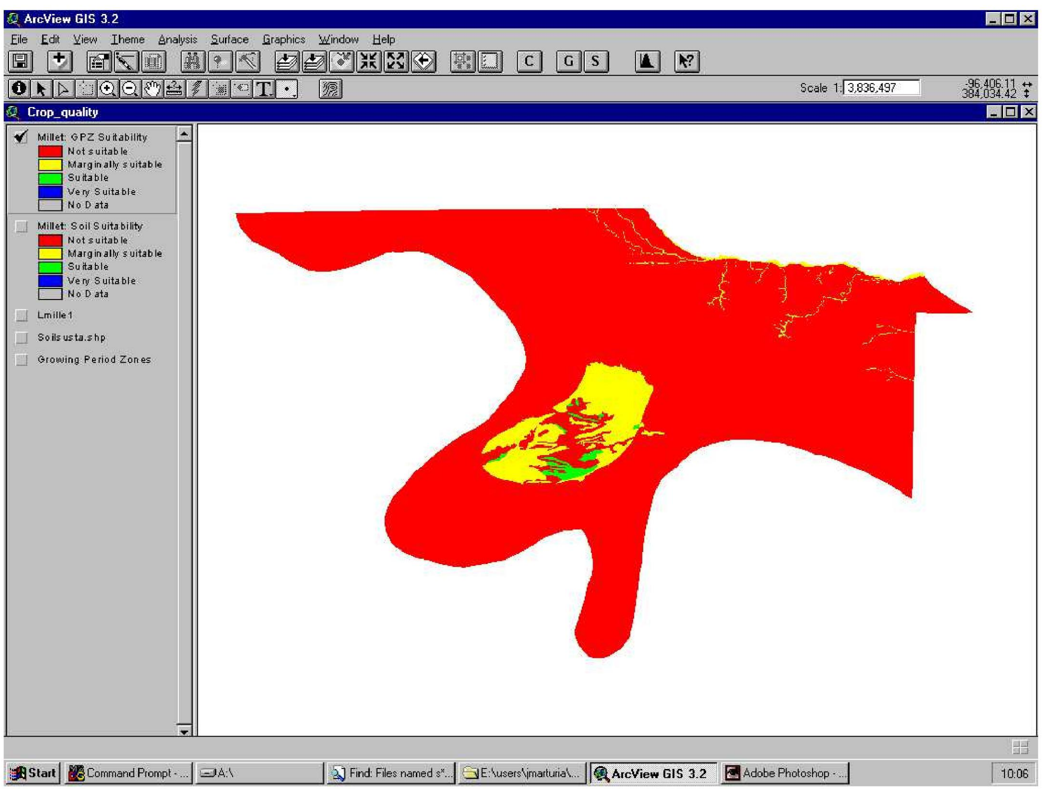

Figure 8.17B: Button **G** execution. Results: GPZ suitability map (raster model) for the selected crop.

9. Glossary

Aeolian. Pertaining to processes or materials associated with transportation or deposition by wind.

Alluvial. Pertaining to processes or materials associated with transportation or deposition by water.

Argic horizon. A mineral soil horizon that is characterized by the illuvial accumulation of layer-lattice silicate clays. The argic horizon has a certain minimum thickness depending on the thickness of the solum, a minimum quantity of clay in comparison with an overlying eluvial horizon depending on the clay content of the eluvial horizon, and usually has coatings of oriented clay on the surface of pores or peds or bridging sand grains.

Association (Soil association). A kind of map unit used in soil surveys comprised of delineations, each of which shows the size, shape and location of a landscape unit composed of two or more kinds of component soils or component soils and miscellaneous areas, plus allowable inclusions in either case. The bodies of component soils and miscellaneous areas are large enough to be delineated individually at the scale of 1:24.000. Several to numerous bodies of each kind of component soil or miscellaneous area are apt to occur in each delineation and they occur in a fairly repetitive and describable pattern. The proportions of the components may vary appreciably from one delineation to another and all of the components need no occur in every delineation though they will be present in most delineations.

Calcic horizon. A mineral soil horizon of secondary carbonate enrichment that is > 15 cm thick, has a $CaCO_3$ equivalent of > 150 g kg^{-1}, and has at least 50 g kg^{-1} more $CaCO_3$ equivalent than the underlying C horizon

Cambic horizon. A mineral soil horizon that has a texture of loamy very fine sand or finer, has soil structure rather that rock structure, contains some weatherable minerals, and is characterized by the alteration or removal of mineral material as indicated by mottling or gay colors, stronger chromas or redder hues than in underlying horizons or the removal of carbonates. The cambic horizon lacks cementation or induration and has too few evidences of illuviation to meet the requirements of the argilic or spodic horizon.

Cation exchange capacity (CEC). The sum of exchangeable cations that a soil, soil constituent, or other material can adsorb at a specific pH. It is usually expressed in centimoles or charge per kilogram or exhanger ($cmol_c$ kg^{-1}).

Clay. (i) A soil separate consisting of particles < 0.002 mm in equivalent diameter. (ii) A textural class given by soil material that contains 40% or more clay, < 45% sand and < 40% silt.

Coarse fragments. Rock or mineral particles > 2.0 mm in diameter

Complex (Soil Complex). A kind of map unit used in soil surveys comprised of delineations, each of which shows the size, shape and location of the landscape unit composed of two or more kinds of component soils, or component soils and a miscellaneous area, plus allowable inclusions in either case. The bodies of component soils and the miscellaneous area are too small to be individually delineated at the scale of 1:24.000. Several to numerous bodies of each kind of component soil or the miscellaneous area are apt to occur in each delineation. The proportions of the components may vary appreciably from one delineation to another and all of the components need not occur in every delineation though they will be present in most delineations.

Consistence. The manifestation of the forces of cohesion and adhesion acting within the soil at various water contents, as expressed by the relative ease with which a soil can be deformed or ruptured.

Consociation (Soil consociation) . A kind of map unit comprised of delineations, each of which shows the size, shape and location of a landscape unit composed of one kind of component soil, or one kind of miscellaneous area, plus allowable inclusions in either case. The size, shape and locations of each component-soil body or miscellaneous area is shown as exactly as mapping intensity and inclusions permit.

Drainage (Soil drainage). Ability of the soil to remove the excess of surface and subsurface water. The soil drainage class reflect the combined effects of climate, landscape and soil.

Effective rooting depth. Depth of the soil from which crops extracts most of the water and nutrients needed. Is the depth that can be effectively exploited by plant roots.

Electric conductivity. Measure of the quantity of soluble salts in the soil. It is expressed in dS/m.

Field capacity. The content of water, on a mass or volume basis, remaining in a soil 2 or 3 days after having been wetted with water and after free drainage is negligible.

Horizon (Soil horizon). A layer of soil or soil material approximately parallel to the land surface and differing from adjacent genetically related layers in physical, chemical and biological properties or characteristics such as color, structure, texture, consistency, kinds and number of organisms presents, degree of acidity or alkalinity, etc.

Hydraulic conductivity. The proporcionality factor in Darcy's law as applied to the viscous flow in soil, i.e., the flux of water per unit gradient of hydraulic potencial.

Inclusions. A soil or miscellaneous land area within a delineation of a map unit that is not identified by the map unit name; i.e., is not one of the named component soils or named miscellaneous area components. Such soils or areas are either too small to be delineated separately without creating excessive map or legend detail, or occur too erratically to be considered a component, or are not identified by practical mapping methods.

Mollic horizon (epipedon). A surface horizon of mineral soil that is dark colored and relatively thick, contains at least 5.8 g kg^{-1} organic carbon, is not massive and hard or very hard when dry, has a base saturation of >50% when measured at pH 7, has < 110 mg P kg^{-1} soluble in 0.05 M citric acid, and is dominantly saturated with bivalent cations.

Munsell color system. A color designation system that specifies the relative degrees of the three simple variables of color: hue, value and chroma.

Natric horizon. A mineral soil horizon that satisfied the requirements of an argillic horizon, but that also has prismatic, columnar, or blocky structure and a subhorizon having more than 15% saturation with exchangeable Na.

Ochric horizon (epipedon). A surface horizon of mineral soil that is too light in color, too high in chroma, too low in organic carbon, or too thin to be a plaggen, mollic, umbric, anthropic or histic epipedon, or that is both hard and massive when dry.

Permanent wilting point. The largest water content of a soil at which indicator plants, growing in that soil, wilt and fail to recover when placed in a humid chamber. Often estimated by the water content at -1.5 Mpa soil matric potential.

Petrocalcic horizon. A continuous, indurated calcic horizon that is cemented by calcium carbonate and, in some places, with magnesium carbonate. It cannot be penetrated with a spade or auguer when dry, dry fragments do not slake in water, and it is impenetrable to roots.

Salinity. Is an excess of soluble salts in the soil. It is expressed in dS/m (at 25ºC).

Sand. (i) A soil particle between 0.05 and 2.0 mm in diameter. (ii) A soil textural class consisting of soil material that contains 85 % or more of sand; percentage of silt, plus 1.5 times the percentage of clay, shall not exceed 15.

Silt. (i) A soil separate consisting of particles between 0.05 and 0.002 mm in equivalent diameter. (ii) A soil textural class consisting of soil material that contains 80% or more silt and < 12% clay.

Sodicity. Is an excess of exchangeable sodium in the exchange complex. It is expressed by means of the sodium adsorption ratio (SAR).

Sodium adsorption ratio (SAR). A relation between soluble sodium and soluble divalent cations which can be used to predict the exchangeable sodium percentage of soil equilibrated with a given solution. It is defined as follows:

SAR = (Sodium)/(Calcium + Magnesium)$^{1/2}$

Soil reaction. The degree of acidity or alkalinity of a soil, usually expressed as a pH value.

Structure. The combination or arrangement of primary soil particles into secondary particles, units or peds. These secondary units may be, but usually are not, arranged in the profile in such a manner as to give a distinctive characteristic pattern. The secondary units are characterized and classified on the basis of size, shape and degree of distinctness into classes, types and grades respectively.

Texture. The relative proportions of the various soil separates in a soil as described by the classes of soil texture.

Umbric horizon (epipedon). A surface layer of mineral soil that has the same requirements as the mollic epipedon with respect to color, thickness, organic carbon content, consistence, structure and phosphorus content, but that has a base saturation < 50% when measured at pH 7.

Vertic horizon. A mineral soil horizon that has 30% or more clay throughout, wedged-shaped or parallelepiped structural agrregates with a longitudinal axis tilted between 10° and 60° from the horizontal, and intersecting slickensides.

Water holding capacity. Is the portion of the water in the soil that can be readily absorved by plant roots. The water holding capacity has customarily been regarded as the difference between the soil moisture contents at "field capacity" and "wilting point".