C.
CAVY

EVALUATION OF PHYSIOGRAPHIC UNITS IN BAQA'A AREA

BY

Mohammad Asa'ad Mustafa Abu Hmoud

A THESIS

Submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Soils and Irrigation

UNIVERSITY OF JORDAN

FACULTY OF AGRICULTURE

DEPARTMENT OF SOILS AND IRRIGATION

March 1986

Evaluation of Physiographic Units

in Baqa'a Area

by

Mohammad Asa'ad Mustafa Abu Hmoud

Under Supervision of :

1. Dr. Yasser Munir Adviser

2. Dr. Awni Taimeh Co-Adviser

EVALUATION OF PHYSIOGRAPHIC
UNITS IN BAQA'A AREA

by

Mohammad Asa'ad Mustafa Abu Hmoud

The examining committee consider this thesis satisfactory and acceptable for the award of the degree of master of science in soils and irrigation.

Examining Committee

Dr. Yasser Munir: Assistant Professor of Soil Survey and Land Use. Adviser.

Dr. Sudqi Khader: Professor of Soil Fertility Member of Committee.

Dr. Anwar Battikhi: Associate Professor of Soil Physics. Member of Committee.

Dr. Awni Taimeh: Associate Professor of Soil Genesis and Classification. Member of Committee.

March 31, 1986

TABLE OF CONTENTS

ABSTRACT

This study focuses on a detail physiographic analysis for part of the Baqa'a valley system by employing airphoto interpretation. Slope gradiant and topographic position are the main criteria to identify land facets. The investigation aims to find out:

1. Homogeneity and differences between facets in terms of soil and site condition, where slope, solum depth, and some other physical and chemical properties, were considered, and

2. the significance of each land attribute studied in classifying the study area into mapping units.

Panchromatic vertical airphotos (1:10,000) , covering the study area, were studied in detail, using a mirror stereoscope. A physiographic map was constructed and a soil sampling program was followed.Soil and site characteristics were recorded for each site from which two soil samples were taken. Soil samples were analyzed for physical and chemical properties and the data were statisticaly analysed. Results indicate that facets are homogeneous, for both the surface and the subsurface soil, in terms of altitude, rooting depth, field capacity, pH and extractable calcium. But they are variable in terms of gravel content. However, the results indicate that plain and Gentle Slope facets are homogeneous and can be treated as one population. Also moderate slope facet is homogeneous for both the surface and the subsurface soil in terms of slope, solum depth, clay content, CEC,carbonate content and extractable Mg. The same results can be applied for

steep slope facet except solum depth and extractable Mg. Terrace is homogeneous in terms of solum depth but it tends to be variable in terms of slope, clay content, CEC, carbonate content, extractable Mg and K. Plateau facet also tends to be variable in terms of slope,solum depth, clay content, carbonate content and extractable K.

Results also indicate that solum depth , clay content , field capacity, carbonate content and extractable Mg have played an important role in determining soil characteristics of different facets, while other attributes such as thickness of A horizon, gravel content, rooting depth, EC, and pH showd no significant role in classifying the study area into mapping units.

ACKNOWLEDGMENT

Sincere thanks and apprecation is expressed to my advisor, Dr. Yasser Munir for his teaching, guidance and encouragement. Special gratitude is also extended to Dr. A.Taimeh, Prof. S. Khader, and Dr. Battikhi for their kind help. Finally I wish to dedicate this thesis to my parents, wife, and my sons.

LIST OF FIGURES

LIST OF TABLES

I INTRODUCTION

The growing world population is causing an increasing pressure on land resources. This requires proper selection and wide use of the available land. Therefore, improvement of land use is inevitable, because there is only a limited extent of land available.

In Jordan , land is one of the most valuable natural resources to conserve and use. It is necessary to understand its condition and its capability for proper use (young,1968). Due to land misuse unfavorable effects have developped. They are:

1- Desertification as result of intense grazing,

2- extention of cities into agriculture land,

3- deforestation, and

4- comparatively low agriculture productivity.

The study of land suitability must be based on natural considerations which include climate, geology, geomorphology, vegetation, and soils. This involves the possible application of physiographic studies of the landscape which governs the distribution of other factors, such as gravel content, clay content, and solum depth, (Wooldrige, 1932; Webster, 1965; Areola, 1974; Howard and Mitchell, 1980; and Lodha , 1980). Also physiography exerts a strong influence on ecosystems (Sondheim et al., 1983), and has a close relationship with soil types (Buringh, 1960; and Sharma et al., 1980).

The increasing availability of aerial photography has lead to rapid survey at lower costs and better accuracy (Buringh, 1960; and Vinogradov, 1962). Mapping from airphotographs relies on the existence of close relationship between soils and land features. Facet as a mapping unit has more homogeneity than the landscape as a whole, and is sufficiently homogeneous for many practical purposes.

A terrian map is a useful addition for soil survey (Mew and Ball, 1932). Numerous investations have been carried out employing this approach both for reconnaissance and semi-detailed survey for development studies (Hunting Technical Services, 1956; Webster and Backett, 1964 and 1970; Mitchell and Howard, 1978; and Chartres,1982).

In this study a detailed physiographic analysis was carried out for an area of Baqa'a Valley based on airphoto interpretation using terrain and environmental parameters with the objectives to :

1- Study if the facets are homogeneous and significantly different from each other in terms of soil and site condition attributes such as slope, solum depth, and other physical and chemical properties, and

2- to determine the significance of each land attribute studied in partitioning the landscape into different mapping units.

II LITERATURE REVIEW

2.1 Physiographic approach

So far, there have been two approaches for land classification ; (i) The parametric approach; and (ii) the physiographic approach. The parametric approach classifies the land on the basis of selected attributes, while in the physiographic approach, the land itself, is divided, by the use of aerial photographs, into fundamental homogenous landscape units, which can be distingusihed and classified on the basis of surface form, geology, climate, soils, water regime, vegetation,and their inter-relationships (Mitchell,1973; Sharma et al., 1980; and Townshend 1981). The two approaches differ significantly from each other in terms of morphology and merits. The first approach is more quantitative compared to the second one, as, it requires detailed measurements and depends on difficult extrapolation of measurements into unknown areas. Thus, it is more suitable for the detailed survey of small areas rather than large ones. On the other hand, in less developed areas, the physiographic approach has a number of merits :-

1. It is suitable for airphoto interpretation (Buringh, 1960 ; Nakano, 1962 ; Webster and Beckett, 1970 ; Areola, 1974 ; and Howard and Mitchell, 1980),

2. it is relatively a more rapid survey at lower efforts and costs (Buringh, 1960 ; Areola, 1974 ; and Chartres, 1982),

3. landscape units are visible, devisable, and comprehensible.They could be classified by employing few characteristics which are easly memorized (Howard and Mitchell, 1980),

4. it assists reconnaissance studies, and helps in explaining the fundemental causes of landscape differentiation (Mabbut,1968),and
5. it permits prediction for soil and site conditions by analogy with similar units which have been surveyd in detail. This can be achieved with adequate reliability for reconnaissance and semi detailed surveys (Mitchell, 1973).

2.11 <u>Developments</u>

According to Mitchell,(1973),numerous investigations have been carried out since the beginning of this century to study the characteristics of land by dividing it into physiographic units. Bowman,(1914) , subdivided the United States into physiographic types which are related to land use. Bourne, (1931), in his physiographic studies defined the site as a unit which could provide throughout its extent, similar conditions of climate, physiography, geology, soils, and edaphic factors. The sites, which recurred in associations, were called regions. Milne, (1935), and Howard, (1970) introduced a new term, which was called land catena, to describe toposequence of soils which recurred on the same parent material and under similar climatic conditions.

The facet landscape concept was first developed by the Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia (Christian, 1958). This idea was taken up and elaborated upon in Britain by Military Engineering Experimental Establishment (MEXE), to develop and store information about terrain.

Directorate of Overseas Surveys, land Resources Division, used land system surveys for reconnaissance studies at scales of 1:250,000 and 1:10,000 or larger for development projects.

The Russian approach used land facet and defined it as an elementary landscape unit, which was expressed in terms of relief, soil, bedrock, microclimate, and having homogeneous habitat conditions (Prokoyev, 1962; and Vinogradov et al., 1962). Brink et al., (1965), was able to classify the landscape by coordinating land units which were used by other workers. The units were arranged in descending order of magnitude as follows: Land zone; land division; land province; land region; land system; land facet; and land element.

However, despite the differences in terminology and definition of land units, the underlying principles were common to all investigators; namely:-

1. The occurance of distinguishable units of landscape, which can be ranked into hierarchy, is almost universal,
2. these units and their components can be recognized and mapped using air photographs,
3. there is a broad agreement about two important levels of landscape units. They are land system and land facet, and
4. these units can be used for the economical collection indexing and retrieval of information on land resources.

2.12 Type of units

Brink et al., (1965); Mitchell and Howard, (1978) and Howard & Mitchell, (1980), provided a framework for land units which could justify their subdivision into a hierarchy and gave definitive criteria for each categoric level.

Basically there are two types of land units: the macro and micro units. The macro units are land zone, land division, and province, land subprovince, and land region. They are suitable for large areas (small scale mapping), and serve as a frame for smaller units. The identification of these units is based on climate, geography, and geology. On the other hand, microunits include land system, land catena, land facet, and land element. They are suitable for larger scale mapping in develoment studies. The identification of these units is based on their geomorphology. The most prominent units are land system and land facet which are employed for planning and development studies.

2.13 <u>The concept of facet</u>

The facet is a physiographic atom out of which the matter of regions is built (Wooldridge, 1932). It is envisioned as a geomorphic concept which can be identified by its morphology, surfacial material, water regime, and natural environment (Areola, 1977: and Fagbami,1978). Land facet can be identified as a morphological unit of landscape which has a uniform geological and hydrological characteristics and with a distinct association of soils, vegetation, and land use. It consists of one or more land elements grouped for practical purposes and are sufficiently homogeneous. Also it must be recognized on 1:10,000 to 1:50,000 air photos which can be mapped at scale in this range (Webster and Beckett, 1970; Areola, 1974; and Howard and Mitchell, 1980). The land facet as a soil mapping unit is based on the assumption that there is a correlation between soil conditions and landscape morphology (Areola, 1982). This is due to its characteristics as a small manageable unit with internal homogeneity, and it can be used for land use planning (Howard and Mitchell, 1980). Facets are grouped into units called land systems, which contain the same set of land facets with the same inter-relationships. The main function of the land system, in detailed planning, is to assist the identification of land facets at some points of interest (Christian 1958; Webster and Beckett, 1970).

2.14 Facets recognized by other investigators

Table 1 shows examples of facets recognized by a number of investigators, which are to some extent, similar to those, in the study area.

2.15 Results of the previous studies

The close relationship between physiography and soils has been widely recognized, (Sharma, 1980).
Mapping units interpreted from air photos based on geology or physiography are more homogenous with respect to their agronomic properties , compared to the landscape as a whole (Webster and Beckett, 1964) . Facets interpreted from aerial photographs, were shown to be sufficiently homogenous for many practical purposes, which could permit prediction of unvisited sites, (Webster and Backett, 1970 ; and Areola, 1974).
The physiographic analysis can lead to a strong correlation with the classification of stones in terms of their geomorphology, (Fagbami 1978). Also a land form-soil association mapping can be a useful means to identify irrigable areas, (Chartres, 1982).

Table 1- Facets recognized by other investigators.

Investigator	Year	Place	Facets recognized
King	1962*	South Africa	Crest, scrap, debris slope, and pediment.
Prokayev	1962	Uktus Mountains	Steep rocky slope, medium slope , gentle slope, shallow depression.
Dalrymple	1968*	NewZealand	Interfluve, seepage slope, convex creep slope, fall face 45°, Trans-portation midslope, coll vial foot-slope, Alluvial toeslope, channel wall, and bed.
Areola	1974	Montgomery	Plateau summit, upper slope 12-16°; hill slope 16°, foot slope, toe slope or terrace, and valley comples.
Fagbami	1978	Upper Don Basin	Crests, upper slopes, middle slope, foot slopes, morraines fluvioglacial terraces, stream alluvial, flushes and springs.
Areola	1982	Gwagwa plains Nigeria	Summit, upper slope, middle slope, and lower slope,

* Cited from Mitchell 1973.

2.151 Soil variability within land facets

Soil is a natural three dimentional body that results from the intergrated effect of living organisms acting upon parent material as modified by relief and climate through time, and provide plants with proper amounts of nutrients and mechanical support (Soil Survey Staff, 1975).

Each of the soil forming factors possesses characteristic spatial distribution producing soil variability, (Ebersohn and Lucas, 1965). Soils formed on transported material tend to be more variable than those weathered from bedrock in situe (Kantey and Morse, 1965). Natural landscape has less variation than cultivated landscape be-cuase human management increases soil variability (Grave et al 1961; Webster and Beckett, 1964; & Beckett and Webster, 1971). Also the variability increases with increasing sampled area (Mcintyre, 1967), especially when the sampling unit comprises more than one kind of soil (Wilding et al.; 1964).

Half of the variability present within one ha is already present within a few square meters (Ahn, 1965). However, soil variability is not the same throughout the depth, nor does it change with depth the same way for all properties (Mader 1963, and Towner, 1968). There are no specific standards for the magnitude of the variations in a given soil property, or several properties which should be allowed within a mapping unit appropriate to any given level of management intensity, (Beckett and Webster, 1971).

From the less variable properties are horizon thickness, and total clay content (c.vs = 12-20%), while chemical properties are more variable (c.vs 27-35%), (Widling et al., 1964).

Similar results reported by Mader,(1963), which indicated that textural properties were less variable than chemical properties. Further more, exchangeable Ca + Mg distribution reflect C.E.C status, (Pregitzer et al., 1983).

Generally the mapping units contain 15-40% inclusions of other soils (Powel and Spriger, 1965). As far as facets are concerned, they showed a fair amount of uniformity with respect to physical properties (c.vs = 20-25.5%), while chemical properties were very variable (c.vs 75-144%) which make prediction about sites carry little value, (Webster and Beckett, 1964). They attributed this variability to long history of different management practices and they expected a more profitable classification in an undeveloped area, where land is still undisturbed. Areola, (1974), stated that facets were sufficiently homogenous when c.v value of a certain property did not exceed 33% . He also reported that physical properties had c.vs 20-30%, while chemical properties were extremly variable (c.vs for extractable Ca, K, Na, and O.M were 177%. 109%, 140%, and 37-104%, respectively).

In 1982 the same author reported that the soil textural properties showed c.vs ranging between 20-40%, while chemical properties showed c.vs between 30-60% or more except for pH, which showed a remarkable uniformity throughout each facet (c.v = 1-8%).

Chartres, (1982), outlined that physical properties, i.e clay and field capacity had c.vs ranging from 17-90% and from 10-to 25 respectively. However, the soil chemical properties were mostly variable (c.vs more than 40%), except for soil pH (c.vs = 6-9%).

These studies indicated that land facets were mostly homogeneous in terms of soil physical properties.

2.152 Distinctness of facets (degree of separation between facets).

Beckett and Webster (1965c) reported that some physical properties (tension, soil strength, and clay content) showed a moderate to high degree of separation between facets in which r_i = 0.5-0.7. Chemical properties generally showed a poor separation between facets (r_i = less than 0.3). These properties did not warrant generalization, (Webster and Beckett, 1964; and Webster, 1965e). They ascribed this to a long history of diverse farming management and fertilizer practices. They concluded that physiographic classification could be more profitable in an underdeveloped area.

Chartres (1982) reported a similar degree of separation in terms of textural properties (r_i = 0.5-0.7), while chemical properties showed a poor degree of separation (r_i mostly less than 0.2).

2.153 Usefulness of facets for predicting land use potential

The use of physiographic approach, for assesment of land use potential, has been found to easely distinguishing patterns of landscape on air photographs. The component parts of landscape units were consistently recognisable, under the stereoscope.

Decisions on land planning for agriculture, and engineering projects can be made, taking into account land form characteristics similar to those of the soils. Webster, (1965),concluded that facets were sufficiently uniform for many practical purposes. It could be used for a wide range of information on land resources and to subdivide the landscape for detailed planning, (Astel et al., 1969).

The land classification scheme was drawn up, on the basis of limitations to land use crop growth, such as steep slopes, shallow soils, and low moisture retention, (Young, 1968).

The facets must be homogeneous enough to enable the generalization and grouping of the site parameters in one class, where the obtained information may be used to assess the suitability of the soil,(Christain 1958; Webster and Beckett, 1970). Consequently the usefulness of class is related to the degree of homogeneity (Tomlinson 1970; Webster and Beckett, 1964). The level of predictability for facets, increases with the decreasing geographic area, provided that analogy between land systems of local forms is used, (Areola, 1974).

As an example the agronomic value of facets were evaluated through its variability (Webster and Beckett, 1964). Also irrigable savana areas, were identified, and judged on the basis of its capability for irrigation. Planning has been based on the degree of separation between facets, and the degree of homogeneity within facets in terms of soil properties which are important for irrigation designs, in order to be treated uniformly, (Chartres 1982).

2.2 Scope of present study

In Jordan, Hunting Technical services, (1956), employed the landscape approach for range classification. Recently, Mitchell and Howard, (1978), presented a physiographic classification for Jordan employing LANDSAT imagery reinforced by some field studies. They divided the country into three climatic land zones:
Mediterranean, steppe, and desert. Within these, the main land divisions, regions, and land systems have been defined and mapped on the basis of phyto-geomorphology. The systems were accomplished with a brief study of facets recognized in each system. The present study has concentrated on a more detailed physiographic analysis for one of these systems (Baqa'a Valley), using air photo interpretation. Homogeneous facets were identified on the basis of morphology, surfacial material, and environmental conditions, and could be applied for invisible attributes. Once the validity of this assumption is materialized, it can be extented to other sites for predicting soil and site conditions by analogy with similar facets which have been surveyed in detail.

III MATERIALS AND METHODS

3.1 Study area

3.11 Location and extent

Baqa'a valley is situated in the high lands of East Jordan, North of Suwielih. The study area lies between 68-74 longitude, and 48 - 58 latitude, (Fig.1).

The extent of the study area is 3426 hectars, consisting of 1393 hectars of valley floor, and 2033 hectars of the hilly area.

3.12 Geomorphology and geology

Baqa'a Valley is part of the East Jordan plateau. It is a clearly defined depression with a gently undulating floor, incised by a number of streams. The geology of Baqa'a Valley is an eroded anticlinal fold belongs to Wadi Shueib compressional structure (Mikbel and Zacher, 1981). It consists of limestone, marly limestone, and marl (Fig.2), and dates back to the upper cretaceous age. The base of Valley is composed of friable sandstone, (Bender, 1968; Mikbel and Zacher, 1981), and covered with alluvial and colluvial material. The deep stoneless soils is an evidence of a mild erosive activities which have taken place for a long period of time (West, 1970).

The Mountain range consists of a primary dolomite or chalky limestone with some chert, (Salameh, 1980; and West, 1970).

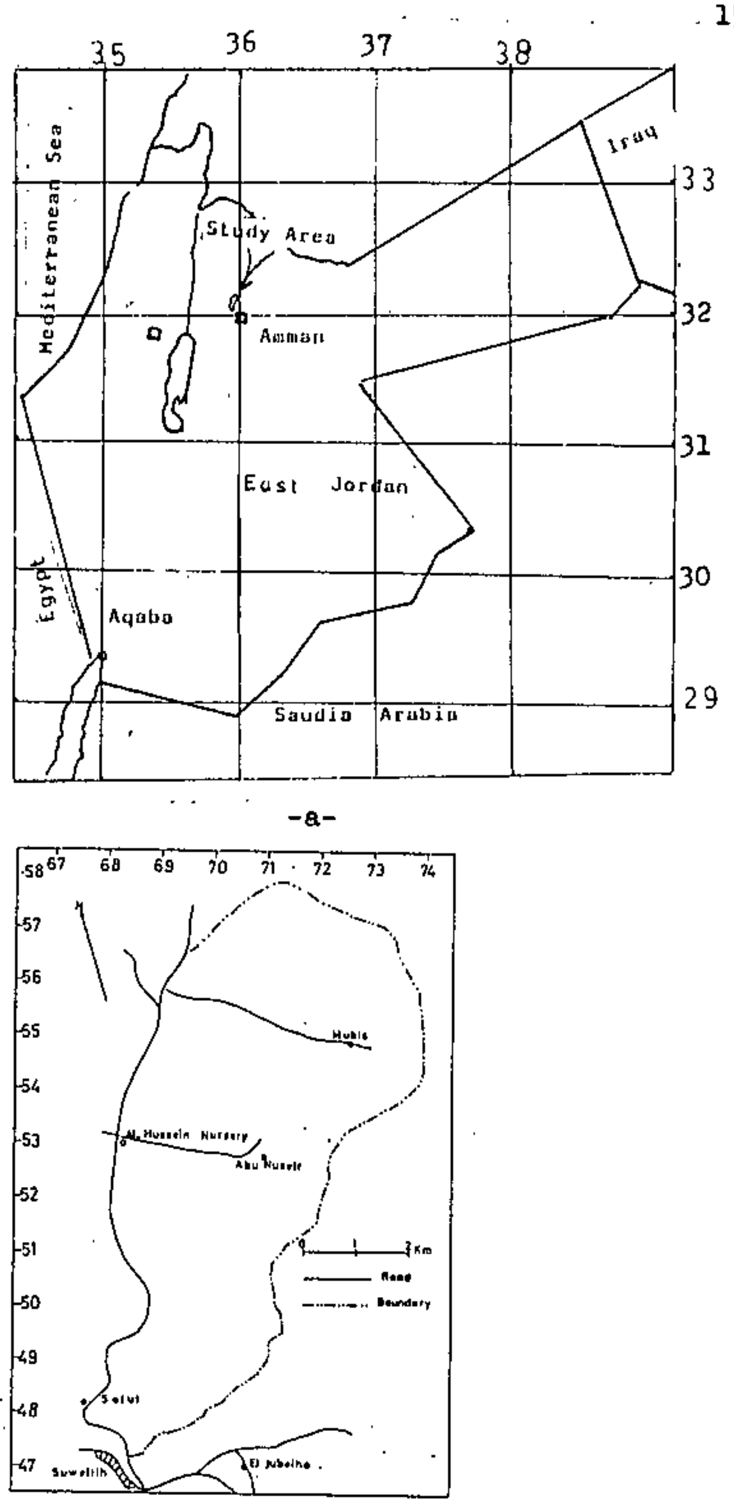


Fig.1 a- Location of the study area on the map of Jordan

b- Exact location with corrdinates.

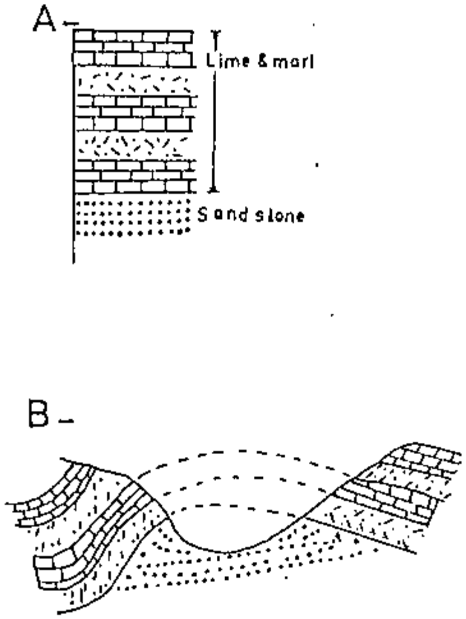


Fig. 2- The geological formation of the Baqa'a area

(A) Columnar section

(B) E - W Cross section

3.13 Climate

The climate is semiarid mediterranean with a strong continental influence. The summer is long, hot, and rainless, and the winter is cool. Rain occurs in the winter with a high variability in terms of amount, intensity, and distribution. Mean annual rainfall for ten years (1973-1983) at Hussein Nursery (Center of Baqa'a Valley), was 370 mm. Maximum precipitation was 614 mm, while the minimum precipitation was 198 mm.

The highest monthly mean maximum temperatures is 30°C and occurs in July, and the lowest monthly mean minimum temperature is 2.8°C and occurs in January. The highest monthly mean wind velocity is 9.2 km/hour which occurs in June, and the lowest monthly mean wind velocity is 6.1 km/hour which occurs in December and January.(Water authority of Jordan).

3.14 Soils

All soils in the Baqa'a Valley are derived primarily from limestone and marl. Some soil types adjacent to down-streams have been influenced by sandstone, compared to those of higher mountains which have been mainly derived from limestone, (West, 1970).

Soils of the mountains are weakly developed and have lost a significant part of topsoil by colluvial activity. The soils of valley bottom have been deposited as colluvial fans, sloping terraces, or valley fills. These soils crack widely as they dry out and form a dense, hard layer just under the tilled layer. Soluble salts have been removed by natural leaching, but soils are calcareous and gravel is found in varying degrees in most of the soils. Findingsby West, (1970), indicate that the majority of the soils are inceptisols and vertisols.

3.15 Vegetation and land use

The area has been farmed since Roman times, (West, 1970).Now all the soils have been plowed and a number of springs and wells are used to irrigate small fields. The rest of the area is dryfarmed. The main winter crops are: wheat, barley, grain, and legumes. The main summer crops are: tomatoes, tobacco, okra, melons, and sorghum. Fruit trees grown in this area, are olives, grapes, figs and almonds, with or without irrigation.

The uncultivated sloping areas have a sparse cover of shrubs.A partial list of native plants is included in Appendix A.

3.2 Office investigation

3.21 Selection of the study area

The study area was selected taking in account the following considerations:-

1. Representation of various land features i.e. Hilltops, slopes , and plains (Valley bottoms),
2. the feasibility for potential land use developments, and
3. the uniformity of parent material which facilitates a reliable comparisons between land units.

After the selection of study area, available information were utilized to fulfill the objectives of this study, such as topographic map (1:10,000), geologic maps, air-photos (1:10,000), Soil survey report (West, 1970), and description of Baqa'a Valley land system (Mitchell and Howard, 1978)..

3.22 Air photo interpretation

Panchromatic aerial photographs (1:10,000), with fifty percent overlap were used in this investigation, and they were indexed and checked.

Facets were defined in terms of geology, morphology, surfacial materials, and water regime. Identification of facets does not always require all the definitive descriptions since some of them are not readliy visible on air photos i.e. soil type, and drainage class. However, many of the definitive attributes i.e. topographic position of slope,and type of slope can be easly determined from the photographs (Sharma, 1980). A preliminary scan through the entire area covered by the photographs was carried out in order to mark the boundaries of the study area to obtain a general picture of the nature of the terrian and attempt to subdivide the landscape. The preliminary photo interpretation was followed by ground investigation to check the features recognized on the photographs and establish broad relationships between photo patterns and ground observations.

As the reconnaissance study progressed, the relation between photo imagery and field characteristics of the physiographic units were gradually refined to the extent that considerable reliance could be placed on aerial photo identification of facets, (Munir, 1982).

In the line with literature (2.14), many land features were recognized and the following facets were adopted:

			degree of gradient
(1)	Plain	(Pl)	0 - 2° *
(2)	Gentle slope	(Ge)	2.1 - 5° *
(3)	Moderate slope	(Mo)	5.1 - 13° *

(4)	Steep slope	(St)	$> 13^{o}$ *
(5)	Terrace	(Te)	Land feature
(6)	Plateau	(Pt)	Land feature

Some nonsignificant batches of land were excluded such as mountain peaks, streams, gullies and bare rocks. Also marginal areas were disregarded due to impure parent material. Figure 3 shows the approximate topographic occurrence of the facets.

Once the list of facets were established the aerial photos were systematically examined in detail with a mirror stereoscope. Magnifying binoculars were used in the early stages to pinpoint the boundaries between facets and to study tiny details. The established facets were drawn and numbered on acetate overlay sheets with a wax pencil.(Fig.4).

Occasionally, for some points, where photographs did not show a good stereoscopic image, the facets boundaries were checked in the field. The most pronounced facets were those with a marked change in slope, vegetation, and land use. Throughout the field work the gained personal experience has helped to correct the inaccurate facet boundaries, which are likely to occur between steep and moderate slopes.

---

* These ranges are in line with field studies and reports of other workers (Soil Survey Staff, 1951; Fitzpatrik , 1977).

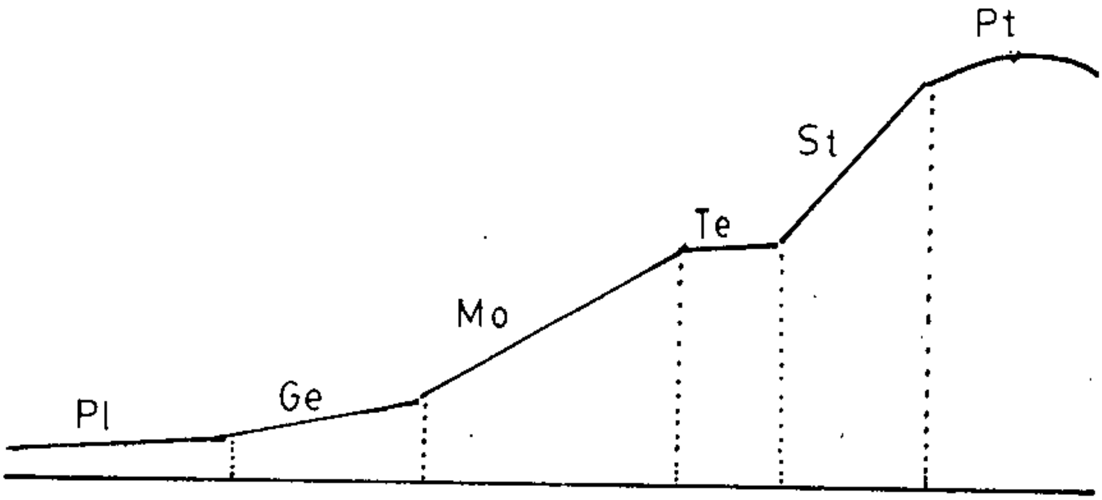


Fig 3 Topographic occurence of land facets within the study area and their angle of gradient

Pl	Plain	o – 2°
Ge	Gentle	2·1 – 5°
Mo	Moderate	5·1 – 13°
St	Steep	>13°
Te	Terrace	Variable
Pt	Plateau	Variable

Fig.4- Established facets on a pair of airphotos indicating a number of recognized facets.

3.23 Construction of physiographic map.

Facet boundaries were transferred from the air photos to a topographic map (1:10,000) by matching features. Sketch master was used for the construction of a physiographic map, which was employed to draw up a sampling program (see the associated map).

3.24 Selection of facet recurrences and locating sampling plots.

After the identification, drawing, and numbering of the facets have been completed, three recurrences from each facet type were randomly selected to be surveyed in detail. Within each recurrence, three sample plots were located and marked on air photoes employing figures from random tables which gave plot co-ordinates on transparent graph paper , (Munir, 1982).

3.25 Extent of facets

The extent of each facet was measured with a planometer. Results in Table 2 indicated that the total area was 3427 hectars, while the sampled facets cover 1468 hectars which comprised 42.8% of the study area.

3.3 Field investigation

Part of the field work was carried out to check the uniformity of the parent material. It was found that most of the soils were derived mainly from limestone and marl. However, it has been found that the soils of some facets were derived mainly from limestone, while others were facets on limestone affected by sandstone. These facets were excluded from the study, in order to minimize errors attributed to uncertainities and impurities.

3.31 Site and profile description

The sampling network as described was followed and the sites were located by the aid of air-photos. Soil pit was dug down to 50 cm depth for each observation. The following parameters were studied and recorded: altitude, angle of slope, aspect North, parent material, land use, stoniness, rock outcrop, horizon designation,

Table 2 Extent of facets expressed in hectars

Facet	Total recurrences.	Total area	%	Surveyed area	%
Pt	7	97	2.8	44	45.4
St	13	799	23.3	80	10.0
Te	20	110	3.2	22	20.0
Mo	12	1028	30.0	290	28.2
Ge	8	940	27.4	636	67.7
Pl	4	453	13.2	396	87.4
Total	64	3427		1468	
Average			100		42.8

distinct of boundaries, topography, thickness of horizons, color, structure, and soil consistancy. Also the depth, size, quantity and type of roots were measured and described.

Two soil samples were taken from each profile for laboratory analysis. The first sample was taken to represent A horizon, and the second one to represent the subsoil down to 45 cm depth.

In some cases where the soil was shallow, the depth to the rock was considered the sampling depth. A representative site and profile description for different facets are shown in Appendix B.

3.4 Laboratory work

The samples were air dried, weighed, and passed through a 2.0 mm sieve. Natural unground samples were kept for particle size distribution. Gravel content was determined. The fine earth (less than 2 mm diameter) was used for the following analysis:-

3.41 Particle size distribution

Natural unground subsamples were soaked in 0.5 N HCl to remove carbonates (Jackson, 1956). Organic matter was removed by heating the samples with 31% H_2O_2. Sodium hexametaphosphate 6%, and overnight shaking were used to maintain maximum dispersion. Clay was measured by pipette method (Kilmar and Alexander, 1949).

3.42 Field capacity (F C)

Field capacity was determined at 0.3 bar tension as described by U.S. Salinity Laboratory Staff (Richards,1949).

3.43 Cation exchange capacity (C E C)

Cation exchange capacity was determined by Bower method (1954).

3.44 Carbonate

Total carbonate was determined by acid neutralization method (Richards, 1954).

3.45 Organic matter (OM)

Organic matter was determined by wet oxidation method according to Walkely-Black method.

3.46 Soluble salts (EC)

Electrical conductivity was measured on soil paste extract using 1:2.5 soil-water ratio, (Bohn et al., 1979).

3.47 Soil-PH

Soil PH was determined in 1:1 soil to water ratio (Peech,1965).

3.48 Extractable cations

Extractable Ca, Mg, K, and Na were extracted by 1N NH_4OAC. Na and K were determined by the flame photometer, (Rich, 1965). Ca and Mg were determined by the versenate titration method, (Cheng et al., 1951).

3.5 Statistical analysis

Statistical analysis was carried out for the following attributes:-

1. Topographic attributes: Slope gradient, and altitude.
2. Soil attributes: Thickness of A horizon, rooting depth, and solum depth.
3. Physical properties: Gravel content, clay content, and field capacity.
4. Chemical properties: Cation exchange capcity, total carbonate, organic matter, electric conductivity (E C), pH, and extracable cations (Ca, Mg, K, and Na).

Raw data are shown in Appendix E and the following statistical tests were carried out:-

1. Test of significance between facet means for both surface and subsurface soil properties, (F test; Tables 11 and 12).

2. Coffecient of variation (CV%) was calculated in the usual way (the mean divided by standard deviation, as a percentage), and used to evaluate the homogeneity of soil and site attributes all over the study area and within each facet. Also CV was used for comparison between different properties (Tables 3-10).
CV calculation was based on that reported in section 2.151, especially that 50% variability in a field can be found within few square meters (Ahn, 1965; Beckett and Webster, 1971; and Mcintyre, 1967). Furthermore, there is no agreement between researchers on CV values for facet classification. It appears that values used will depend on the studied area (Wilding et al.,1964; and Mcintyre, 1967). It might also depend on the intensity of land use, and the type of studied properties, (Webster and Beckett, 1964, and 1971; Mader, 1963; and Areola, 1974 and 1982). However, Wilding and Drees, 1978, reported that the mean CV value was more than 18% within mapping units for many physical and chemical properties. Though the facet is considered homogeneous for a certin property if the CV value for that property does not exceed 20%, and is heterogeneous if CV value is more than 20%.

3. Calculation of interclass correlation (r_i*, Tables 11 and 12). It is used for evaluating the degree of separation between facets in terms of studied properties, also it is used for comparing the goodness of the classification for different properties. In the light of literature, (Webster, 1978, and Chartres, 1982), and regarding the nature of the study area, the degrees of separation were high, moderate, and poor, when r_i was equal to more 0.8, 0.6-0.8, and less than 0.6, respectively.

4. Comparison between facet means was performed by utilizing Duncan MRT, and the confidence interval at 95% level, (Munir, 1982).

---

* $r_i = \frac{S^2b}{S^2b + S^2w}$, where S^2b = Between facet variance, and S^2w = within facet variance.

IV RESULTS AND DISCUSSION

4.1 Topographic attributes

4.11 Slope gradient

The mean value of slope is 6.6° with a high coefficient of variation of 87% (Table 3). All the identified facets are homogeneous except plateau and Terrace (Table 15). F test indicates significant differences between facets. Interclass correlation indicates a high degree of separation between facets (r_i = 0.94). This means that 94% of the variations are attributed to variance between facets, S^2B(Table 11). Furthermore, comparison between facet means by utilizing Duncan's MRT and individual 95% confidence interval indicate that facets can be classified into four groups regarding their slope (Table 13). However slope for plateau (Pt) and Terrace (Te) facets are similar to that for Gentle slope facet (Ge), but are different with respect to topographic position on the landscape. Te facet can be grouped with the plain facet (Pl). It is only different in its togographic position. However Ge and Pl facets have the same slope and lie within the same togographic position.

In conclusion, the statistical tests (F test, r_i, D test, and confidence limit) suggested that slope was effective in partitioning the landscape into homogeneous mapping units, St, Mo, Ge, and plain facets were significantly different in their slope, and the slope is characterized by high visibility on stereo-image and had a correlation with the soil boundaries, (Howard and Mitchell, 1980; Sharma et el. 1980).

4.12 Altitude

The mean of altitude values for the study area is 813 meters, and CV% is 18.3% (Table3). As result of field mapping, the facets are homogeneous and show less variability than the larger area. The lowest variability **was found within Pt,Te,** Ge and pl facets (Tables 5,7,9 and 10 respectively), while the highest variability was found within St and Mo facets.

F test indicates significant differences between facets, also inter-class correlation indicates a moderate degree of separation between facets (r_i = 0.76; Table 11). Furthurmore, comparison between facet means, utilizing Duncan's MRT, indicates that the study area can be classified into four different groups (Table 13).

On the other hand, individual 95% confidence interval for facet means indicate that facets can be relatively classified into upland facets such as Pt and Te where altitude ranges between 837-1040 m, and low land facets such as Ge and pl facets where altitude ranges between 620-690 m. However St and Mo **facets lie within both altitudes and range** between 727 and 981 m (Table 13 and Fig 5*). Thus St and Mo facets can be divided into two facets when based on their altitude as a parameter for facet determination.

In conclusion, statistical tests (CV, D and Cl) indicate that the physiographic analysis classify the landscape into homogeneous facets that are significantly different from each others. Thus enables the surveyor to treat each facet uniformly and differently from others in term of altitude.

---

* Fig 5 through 10 are in appendix C.

4. 2 Soil attributes

4. 21 Morphology of the profile and physical properties

4.211 Rooting depth

The mean value of rooting depth for the entire study area is 17.9 Cm with CV = 14% (Table 3). As a result of the field mapping, the identified facets are homogeneous and show less variability than the larger area except Pt facet which shows the highest variability (CV = 15.7 % ; Table 5). This could be due to that this facet is highly exposed for erosion and is variable in slope and solum depth (Table 5). St facet shows the lowest variability (CV= 6.5%; Table 6). This can be attributed to that soils of this facet are mostly uncultivated and that vegetation there, develops a uniform rooting depth.

F test indicates significant differences between facets. But interclass correlation indicates a poor degree of separation (r_i=0.43; Table 11). This means that most of the variation is attributed to variability within facets, and can be attributed to different landuse and different cultivation practices within most facets. Comparison between facet means indicates that there are overlaping (D test; Table 13).The deepest rooting belongs to the St facet due to the lack of cultivation practices, while the shallowest rooting belongs to Pt facet where soil is shallow and highly exposed for erosion (Webster and Beckett, 1964). Individual 95% confedence interval for facet means indicates that rooting depth of facets can be relatively classified into shallow rooting depth such as pt facet (Cl= 13-17 Cm) and medium rooting depth such as St, Mo and Pl facets (Cl = 17-21 Cm). Te and Ge facets could have

shallow or medium rooting depths (Cl= 15-19 Cm; Fig.11)*.
In general the identified facets are homogeneous and can be treated uniformly, but the overlaping between facet means which resulted with a poor separation indicates that rooting depth is not effective in partitioning the landscape into mapping units.

4.212 Thickness of A horizon

Mean thickness of the A horizon for all facets is 19 Cm with a coefficient of variation of 15.74% (Table 3). As a result of field mapping, the identified facets are homogeneous except Te and Ge facets (Table 15). This variability can be attributed to a markedly different landuse and cultivation practices within these facet. However F test indicates that there are no significant differences between facets with respect to A horizon thickness. Interclass correlation strongly suggests the absence of any grouping with respect to A horizon thickness (r_i = 0.003 ; Table 11). This indicates that all of the variations come from variability within facets. Moreover, comparison between facet means utilizing Duncan's MRT, and the individual 95% confedence interval for facet means indicate that the study area can be regarded as one population with respect to A horizon thickness (Table 13 and Fig. 12).As a result it appears that A horizon thickness for St facet is as thick as for other facets inspite of the steep slope. This can be attributed to natural vegetation within this facet which decreases the effect of erosion by protecting the soil surface and by reducing the amount and

---

* Fig. 11 through 17 are in appendix D.

speed of water run-off.

In conclusion, in spite of the homogeneity within of most facets, other statistical tests (F test, r_i, D test and CL) indicate that A horizon thickness is not effective in partitioning the study area into different mapping units, and the failure of the physiographic approach to produce different mapping units can be attributed to several factors such as the spatial variation in vegetation type and intensity, and landuse and management practices. These factors are not taken into account in the physiographic analysis.

4.213 Solum depth

Solum depth mean for the study area is 80 cm with a coefficient of variation 29.7% (Table 3). This variability can be attributed to that the study area consists of different land features such as plateau and Terrace facets besides different slope facets which developed different solums. As a result of field mapping, the identified facets are homogeneous, except for Pt and St facets (Table 15). This is due to that the facets are highly exposed and susceptable to erosion due to their topographic position in the landscape (high altitude) beside the slope effect (Buring, 1960). Moreover slope characteristic (marked change in slope) and topographic position of Te, Ge and Pl facets (Fig.3) enhance the deposition of eroded material and has developed a uniform solum.

F test indicates significant differences between facets with respect to solum depth, also interclass correlation indicates to a high degree of separation (r_i = 0.89; Table 11). This indicates that 89% of variations can be attributed to differences between facets. Comparison between facet means utilizing Duncan's MRT, indicates that the study area can be classified into three different groups, (Table 13). 95% confidence interval for facet means also indicates that facets can be relatively classified into deep solum such as Te, Ge and Pl facets, medium solum depth such as Mo facet and shallow solum depth such as Pt and St facets (Fig.12).

The deepest solum is found in Te, Ge and pl facets since they lie on less sloping land and thus serve as a deposition site for colluvial materials from upper facets (Walker, 1966; and Sharma, 1980). The shallowest solum is recorded for Pt and St facet, because soils of these facets are highly exposed to erosion. While Mo facet shows an intermediate solum depth. This might be due to the fact that Mo facet has developed its solum under interactive result of erosional and depositional factors (Table 13 and Fig. 6).

In conclusion, the statistical tests (F test, r_i, D test and Cl) indicate that physiographic analysis classifies the study area into different units in terms of solum depth which can be treated differently for land-use planning. Moreover most of these facets are internally homogeneous which can be treated uniformly. It can be concluded that solum depth is effective in partitioning the landscape into different mapping units.

4.214 Gravel content

The statistical analysis of this variable data has resulted in the following findings:-

(i) Surface soil

The mean value of gravel content for surface soil of the whole area is 16.4% coupled with a high variability (CV=78%; Table 3). As a result of field mapping, the variability within the identified facets is lower than that before classification. But the facets are still heterogeneous and we cannot treat them uniformly. Nevertheless, Ge and Pl facets can be treated uniformly for practical purposes because they have a low gravel content ($\bar{X}$ = 5.8% and 1% respectively; Tables 9 and 10). The variability within Pl and Ge facets can be attributed to the low content of gravel (Mader, 1963), beside the spatial variation in gravel content found in the reccurences which close to Mo facet. On the other hand variability within other facets (Pt, St, Te, and Mo)can be attributed to human activity.

However, F test indicates significant differences between facet means, also interclass correlation indicates a moderate degree of separation between surface soil of facets (r_i=0.76; Table 12). Comparison between these means by utilizing Duncan's MRT, indicates that surface soil of facets can be classified into four different groups (Table 13). While individual 95% confidence interval for facet means indicates that facets can be relatively classified into; abundant gravel content such as Mo and St facets, frequent gravel content such as Pt and Te facets and few gravel content such as Ge and Pl facets (Fig. 12). The highest gravel content is found in Mo facet, followed by St facet. While the lowest amount is found within Ge and Pl facets. This can be attributed to the mild erosion occuring in the past cycle of erosion, with the concentrated gravel in the upper and steep facets. The fine material (relatively very low in gravel) is deposited in the relatively lower and less steep facets (West, 1970 and Walker, 1966; Fig.6).

In conclusion statistical tests (F, r_i, D and Cl) indicate that surface soil of facets can be treated differently in terms of gravel content, but we cannot treat any of these facets uniformly, because they are heterogeneous. Though the gravel content for surface soil is a poor tool in partitioning the landscape into mapping units.

(ii) Subsurface soil

Mean gravel content for the whole study area is 17% coupled with a very high variability (CV=102% ; Table 4). This indicates that the study area can be classified into different units. As a result of field mapping, the identified facets are still heterogeneous (Table 15). Thus, facets cannot be treated uniformly with respect to gravel content. However, Ge and Pl facets can be treated uniformly for practical purposes, because they have low gravel contents($\bar{X}$ =1.6% and 0.5% respectively; Tables 9 and 10). The variability within Pt and St facets, can e attributed to the variability in solum development within these facets (section 4.213). Variability within Pl and Ge facets can be attributed to the low content of gravel (Mader, 1963) beside the spatial variation found in the reccurences which close to Mo facet. F test indicates significant differences between subsurface soil of facets, also interclass correlation indicates a moderate degree of separation between facets (r_i = 0.67; Table 12). Comparison between facet means indicates that facets can be classified into three classes (Table 14). While individual 95% confidence interval for facet means, indicates that facets can be relatively classified into two classes; abundant gravel content such as St and Mo facets, and few gravel content such as Te, Ge and Pl facets (Fig.12). However, it appears that facets occuring on upper slope (Mo,St, and Pt) have shown higher gravel content than those occuring on relatively lower slope i.e. Te, Ge, and Pl can be treated as different populations. This can be attributed to mild erosion occuring in the past cycle of erosion, with the concentrated gravel in the upper facets, while the fine material (relatively low in gravel) is deposited in the lower facets or for facets of relatively uniform slope such as Te facet (West, 1970 and Walker,1966; Fig. 6). It can also be seen that the trend of gravel in subsurface soil is similar to that in surface soil, where gravel content decreases toward the valley bottom. Fig. 6 also shows that surface soil of Pt, Mo, and St facets contain lower gravel than subsurface soil. This can be attributed to human activity, in addition to the effect of past erosion. But the opposite observation is found in Pl , Ge, and Te facets, where the surface soil shows higher gravel content than the subsurface soil. This can be attributed to the addition of gravel from the upper facets by colluvial activity in the past erosion cycles.

In conclusion, statistical tests(F, r_i, D, and Cl) indicate that subsurface soil of facets can be classified into different units, but we do not treat any of the identified facets uniformly due to their heterogeneity. As a result, gravel content of subsurface soil also is not effective in partitioning the landscape into mapping units, and it apears that gravel content is highly variable within facets (West,1970; Areola, 1982).

4.215 Clay content

(i) Surface soil

Mean clay content for surface soil is 36.5% and coefficient of variation is 22.1% (Table 3). As a result of field mapping,the identified facets are homogeneous except for Te facet (CV=20.2%). This can be attributed to its variability in slope (Table 7) which has noticeable effect on clay formation and distribution (Areola, 1982). However, the lowest variability is found within Ge and Pl facets, because their soils are developed from well mixed colluvial materials deposited in the same topographic position (valley bottom) without any significant differences in slope (West, 1970).

F test indicates significant differences between facets, also interclass correlation indicates a moderate degree of separation (r_i=0.67; Table 11). Furthermore, comparison between facet means by utilizing Duncan's MRT, suggests that the surface soil of the study area can be classified into four different groups (Table 13). They are:1) Pl and Ge facets, 2) Te and Pt facets, 3) Mo facet, and 4) St facet. However, Mo overlaps with both Pt and St facets. Individual 95% confidence interval for facet means indicates that facets can be relatively classified into three classes; facets with high clay content such as Ge and pl facets, intermediate clay content such as Pt, Te, and Mo facets; and low clay content such as St facet (Fig. 13).

The differences between facets can be attributed to the slope and topographic position of each facet which has a great influence on formation and distribution of clay (Riecken, 1960; Walker, 1966). The highest clay content is found in Pl and Ge facets due to influx of clay from the upper facets by colluvial activity. Moreover, these facets do not differ significantly in their clay content, because they occur in the same topographic position (Valley bottom) without break in slope. Also their soils are developed from well mixed colluvial material associated with low erosion activity (West, 1970). On the other hand, the lowest clay content is found within St facet due to erosional factors. Also Te facet has higher clay content than those of surrounding facets (Mo and St), because it has a marked change in slope that can facilitate the deposition of fine material from the upper facets. But it is still less than Ge and Pl facets which reciev more colluvial material (Fig.7). Pt facet does not differ significantly from Te and Mo facets. This can be attributed to that this facet is level or gently sloping ($\bar{X}$ = 3.9; Table 5) and thus contains more clay (Webster and Beckett, 1964).

In conclusion, the homogeneity within surface soil of facets (except Te) and the grouping of facets into different clay classes (D test and Cl) enable the surveyor to treat these facets uniformly and differently from each other. Therefore, clay content for surface soil is effective in partitioning the landscape into different mapping units.

(ii) Subsurface soil

Mean clay content for the subsurface soil is 36.4 % and the coefficient of variation is 23.5% (Table 4). As a result of field mapping CV% data , the identified facets are internaly homogeneous and can be treated uniformly except Pt facet (CV=20.6%). This is possibly due to the high variation in slope, solum depth, and carbonate content (Table 5). The lowest variability is found in Ge and Pl facets, because their soils are developed from well mixed colluvial material deposited in the same topographic position without significant differences in slope.

F test indicates significant differences between facets. Also interclass correlation indicates a moderate degree of separation (r_i = 0.72 ;

Table 12). However, comparison between facet means by utilizing Duncan's MRT, suggests that the study area can be classified into four different groups (Table 14). Individua 95% confidence interval for facet means indicates that facets can be relatively classified into three levels; high clay content such as Pl and Ge facets; intermediate clay content such as Te, Mo, and Pt facets; and low clay content such as St facet (Fig.3). The higest amount of clay is found in both Pl and Ge facets. This is possibly due to their position at the lowest part of the valley which allowed them to recive sediments from upper facets (Sharma et al. 1980). Te facet ranks the second in clay content because it has a striking change in slope which causes a flux of clay from the upper facets (Pt, St, and Mo) in addition to site clay formation (Riecken, 1960). The lowest clay content is found in Pt facet, and this may be due to the fact that subsoil of this facet is less developed because of low effective precipitation and high surface runoff. However, Pt and Mo facets show an intermediate content of clay. This is due to the slope condition which permits more available water to penetrate through the soil, thus increasing clay formation.

It apears from Fig.7 that clay content for subsurface soil of facets shows an inverse relationship with slope. The steeper facets have the lowest clay content (Mo and St) and the higest clay content is found in Pl, and Ge facets. The figure also suggests that surface and subsurface soil of Pl, Ge and Te facets contain almost the same amounts of clay, because soils of these facets are probably developed from well mixed colluvial material without any significant movement of clay. The subsurface soil of Pt and St facets are relatively lower in clay content than the surface soil, while it is the opposite for Mo facet. This can be attributed to the degree of soil development within facets. In conclusion, the homogeneity within the subsurface soil of facets (except Pt) and their grouping into different clay classes (D test and Cl) enable surveyor to treat each facet uniformly and differently from others. Thus clay content for subsurface soil is also effective in partitioning the landscape into different mapping units.

4.216 Field capacity (FC)

Mean field capacity for the surface and the subsurface soil were 34.0 and 33.8% respectively. Coefficients of variation in field capacity for the two respective soils were 13.8 and 14.0% (Tables 3 and 4). As a result of field mapping the variability within facets for both the surface and the subsurface soil is reduced to less than 10% except for Te facet (Tables 5,6,8,9,and 10).

The uniformity within facets can be attributed to that each facet is uniform in terms of clay content. Furthermore, Te facet is relatively more variable than other facets due to its variability in clay content (Table 15).

F test indicates significant differences between field capacity values of facets for both the surface and the subsurface soil. Also interclass correlation indicates that the study area is moderatly separated into different facets for both the surface and the subsurface soil (r_i = 0.7 and 0.76, respectively; Tables 11 and 12). Moreover comparison between facet means by utilizing Duncan's MRT indicates that surface soil of the study area can be classified into three different groups (Table 13). They are 1) Ge and Pl facets, 2) Te and Pt facets, and 3) Mo and St facets. Also the same grouping is found for subsurface soil except that Mo and St facets are separated into two groups. This is due to that the facets are significantly different in terms of clay content (Table 14). Furthermore, individual 95% confidence intervals for facet means, for both the surface and the subsurface soil, indicate similar groupings to those obtained by Duncan's test . The study area can be relatively classified into three levels; high FC such as Ge and Pl facets; medium FC such as Te and Pt facets; and low FC such as Mo and St facets (Fig. 13). This trend of grouping can be attributed to clay content within each group for both the surface and the subsurface soil . Ge and Pl show the highest FC since they have the highest clay content, while the lowest FC is found within St facet, because it has the lowest clay content. Also Te and Pt facets show an intermediate values for both clay and FC (Tables 13 and 14).

From the previous discussion it appears that the indentified facets are homogeneous for both the surface and the subsurface soil. Besides these facets are significantly different from each other . A surveyor can treat each facet uniformly and differently from the others. Therefore, we can conclude that FC has a significant role in partitioning the landscape into mapping units.

4.22 Chemical properties

4.221 Cation exchange capacity (CEC)

The mean value of CEC for both the surface and the subsurface soil is relatively the same and variable ($\bar{X}$ = 30.6 and 30.3 me/100 g soil; CV = 23.3% and 25.5% respectively; Tables 3 and 4). After mapping, all facets (except Te) are homogeneous for both the surface and the subsurface soil and each facet can be treated uniformly. This homogeneity can be attributed to the homogeneity within clay content. Also the variability within Te facet can be attributed to variability within clay content (Table 15).

F test indicates significant differences between facets for the surface and the subsurface soil. Besids interclass correlation indicates a moderate degree of separation (r_i = 0.67 and 0.7; Table 11 and 12 respectively). This degree of separation is similar to that obtained for clay content.

Comparison between facet means utilizing Duncan's MRT indicates that the surface and the subsurface soil of facets can be classified into three different groups (Table 13 and 14). They are 1) Ge and Pl facets, 2) Te, Pt and Mo facets, and 3) St facet. Also individual 95% confidence interval for facet means (for both the surface and the subsurface soil) suggests that facets can relatively be classified into three levels: high CEC such as Ge and Pl facets; medium CEC such as Pl and Te facets; and low CEC such as St facet (Fig. 14).

This grouping can be attributed to clay content within facets, where Ge and Pl facets have the highest values in clay content and CEC. St facet has the lowest level of clay and CEC for both the surface and the subsurface soil. However, Pt and Mo facets show intermediate values of clay and CEC (Tables 13 and 14). In general, CEC decreases with increasing slope (Fig.7).

In conclusion the identified facets are mostly homogeneous and can be classified into different groups which enable the surveyor to treat each facet uniformly and differently from each others. Thus CEC has a significant role in partitioning the landscape into different mapping units.

4.222 Carbonate content

The mean value of carbonate for both the surface and the subsurface soil of facets is relatively high and variable ($\bar{X}$ = 38.0% and 40.0% ; CV = 32% and 33.3%, respectively, Tables 3 and 4).As a result of field mapping, the variability within the identified facets are reduced and could be treated uniformly except for the Te facet (Table 15). F test indicates significant differences between facets for both the surface and the subsurface soil. On the other hand, interclass correlation indicates a good separation between facets for both the surface and the subsurface soil (r_i = 0.79 and 0.78; Tables 11 and 12, respectively). This indicates that most of the variation can be attributed to differences between facets. For instance, the comparison between facet means for both the surface and the subsurface soil indicates that facets can be classified into three different groups (Tables 13 and 14). They are: 1- St and Mo facets 2- Pt and Te facets and 3- Pl and Ge facets. Also individual 95% confidence intervals for facet means indicate that both the surface and the subsurface soil can be relatively classified into three levels: very high carbonate content such as St and Mo facets; medium carbonate content such as Pt and Te facets; and relatively low carbonate content such as Pl and Ge facets (Fig. 14). It apears that the highest carbonate content has been found in the steep slope facets (St and Mo) and this is attributed to that soils of these facets are weakly developed due to erosion effect.The lowest carbonate content has been found in facets of low slope especially those which lie in the valley bottom (Ge and Pl facets). This can be attributed to that soils of these facets are relatively developed from more weatherd colluvial materials (West, 1970), and the generally decreasing carbonate content alongside with decreasing slope gradient (Fig.8). Moreover, the figure indicates that carbonates tend to increase with increasing depth for Pt, Mo and St facets, while other facets do not show any differences between the surface and the subsurface soils. This trend can also be related to the degree of maturity in terms of soil development.

In conclusion, the facets are mostly homogeneous and can be classified into different groups which is suitable for a various landuse planning. The carbonate content for both the surface and the subsurface soil of facets has a significant role in partitioning the landscape into different mapping units.

4.223 Organic matter (OM)

The mean organic matter for both the surface and the subsurface soil is relatively low and variable ($\bar{X}$ = 1.4% and 0.9% with CV= 49.5 and 54.5% , respectively; Tables 3 and 4). After mapping, the identified facets tend to be variable in OM(Table 15). The low OM content can be attributed to the effect of climate on OM accumulation while the variability can be attributed to different landuse and cultivation practices within each facet.

F test indicates significant differences between facets for both the surface and the subsurface soil. Also interclass correlation indicates a high degree of separation between the surface soil of facets and moderate degree of separation between the subsurface soil (r_i = 0.8 and 0.77, respectively, Tables 11 and 12). This is propably due to the fact that OM is affected by position in landscape (Webster and Beckett, 1964). However, comparison between facet means by utilizing Duncan's MRT indicates that facets can be classified into different populations (Tables 13 and 14). Also individual 95% confidence interval for facet means indicates that the study area can be relatively classified into low OM such as Pt and St facets, and very low OM such as Ge and Pl facets (Fig.15). The very low OM content in Ge and Pl facets can be attributed to intensive cultivation practices. However, St facet shows higher OM than other facets for both the surface and the subsurface soil. This may be due to that soils of this facet are not under cultivation which contributes to OM accumulation. Figure 8 also indicates that surface soils of facets have relatively higher OM than the subsurface soils and this trend increases where ever natural vegetation is found (St and MO facets). This is most probably due to accumulation of plant residues on the top of the soil.

In conclusion, the low and very low content of OM in this study area and its tendancy to be variable does not enable the surveyor to classify the area into mapping units. The OM contributes little in partitioning the study area into different mapping units.

4.224 Electrical conductivity (EC)

(i) Surface soil

The mean value of EC is 0.25 mmhos/cm with a CV of 17.3% Table 3). Thus the surface soil is free from salinity hazared, which is due to natural leaching and consequently, the classification is not required with respect to salanity. For instance, F test indicates that there is no significant difference between facet means. Also, the degree of separation between facets is negligable (r_i = Zero; Table 11). Moreover, comparison between facet means indicates that facets can be treated as one population (Table 13). Also, individual 95% confidence interval for facet means is overlapping and thus the surface soil of facets cannot be classified into different levels in terms of EC (Fig. 15). As a result, EC has no significant role in partitioning the study area into different mapping units.

(ii) Subsurface soil

The mean value of EC for the subsurface soil is 0.25 mmhos/cm with a CV of 22.3% Table 4). Thus the subsurface soil is also free from salinity hazord. After mapping, the identified facets are mostly homogeneous and F test indicates significant differences between facets with respect to EC . But interclass correlation indicates a poor separation between facets (r_i = 0.33; Table 12), suggesting that most of variation can be attributed to variability within facets. However, the small differences between facet means as outlined by Duncan's MRT(Table 14 and Fig.8) and the individual 95% confidence interval (Fig.15), indicate that EC does not have significant role in partitioning the study area into different mapping units.

4.225 Soil pH

The mean value of the pH for both the surface and the subsurface soil is 8.3 with CV of 1.7% and 1.8% respectively (Tables 3 and 4). After mapping, the identified facets show mean values for pH ranging between 8.2-8.5, coupled with a very low variability (CVs = 1-2.4%, Tables 5 through 10). It appears that among all chemical properties, soil pH is the least variable (Areola, 1974). The data of soil pH with the

very low variability can be attributed to that soil pH in this area is mainly controlled by carbonate. However, F test indicates significant differences between facets, while interclass correlation indicates a poor separation between facets (r_i = 0.5 and 0.26 for surface and subsurface soil, respectivly;(Tables 11 and 12). This suggests that most of variation is attributed to variance within facets. Comparison between facet means by utilizing Duncan's MRT and the confidence interval for facet means, suggests that the Study area can be classified into two groups (Tables 13 and 14, and Fig. 16). But the difference between these groups practically is not significant for landuse planning since soils are rich in carbonate. The relative high pH has been found within Ge and Pl facets, which can be attributed to the fact that soils are relatively higher in extractable Na and Mg coupled with a low OM content (Tables 13 and 14). In conclusion, the homogeneity of soil pH all over the study area coupled with small differences between facets, indicate that soil pH has no significant role in partitioning the study area into different mapping units.

4.226 Extractable calcium (Ca)

The mean value of extractable Ca for both the surface and the subsurface soil of facets are similar ($\bar{X}$ = 54.3 me/100g soil). It is the highest and the least variable cation among the extractable cations (CV = 10% and 10.3% ; Tables 3 and 4 respectively). As a result of field mapping, the variability within facets are markedly decreased for both the surface and the subsurface soil (CVs = 3-7% ; Tables 5 through 10), hence the facets can be treated uniformly. Furthermore, these facets are significantly different from each other

with a moderate degree of separation for both the surface and the subsurface soil (r_i = 0.78 and 0.71; Tables 11 and 12).
Comparison between facet means by utilizing Duncan's MRT indicates that surface soil of facets can be classified into five groups (Table 13).

The individual 95% confidence interval for facet means indicates that surface soil of facets can be relatively classified into three levels: low extractable Ca such as Pt, St and Te facets and; high extractable Ca such as Ge and Pl facets, with Mo facets lie in between (Fig. 16).
As far as the subsurface soil is concerned; facets can be classified into three groups.(D test, Table 14). These are:- 1- Ge and Pl facets, 2- Mo facet, 3- Te, St and Pt facets. Individual 95% confidence inteval for facet means indicates that the study area can relatively be classified into the same groups and thus can be regarded as high, medium and low extractable Ca, (Fig.16). The highest extractable Ca is found in Ge and Pl facets, because soils of these facets have the highest clay content and CEC. Mo facet ranks the second owing to its carbonate content. Thus Te and Pt facets do not differ significantly since they do not differ in terms of CEC, carbonate, and extractable Mg (Tables 13 and 14). Figure 9 indicates that the surface and the subsurface soil have approximately similar amounts of extractable Ca. This can largley be due to approximate similarities in clay content, CEC and carbonates for both layers (Fig. 7 and 8).
It is obvious from the above discussion that the extractable Ca is highly related to the clay content, CEC and carbonate content (Pregizer, 1963), and is highly correlated to the amount and the rate of weathering

on different slopes.

In conclusion, extractable Ca has significant role in partitioning the landscape into different mapping units since the identified facets are internally homogeneous and could be classified into different groups.

4.227 Extractable Magnesium (Mg)

The mean value of extractable Mg for both the surface and the subsurface soil is the second dominant cation after Ca, but it is variable (Tables 3 and 4). This is due to the fact that the parent material contains noticeable amounts of dolomite (Salameh, 1980; and West, 1970). As a result of field mapping, the varibility within the identified facets are markedly decreased and mostly homogeneous for both the surface and the subsurface soil except for St and Te facets. The variability within St facet can be attributed to minor variation in parent material composition. But variability within surface soil of Te facet can be attributed to its variability in terms of CEC, clay and carbonate content (Table 7). However, F test indicates significant differences between facet means, also interclass correlation indicates high degree of separation between facets for both the surface and the subsurface soils(r_i = 0.9 and 0.89 respectively). This means that most of variation can be attributed to the variance between facets(Tables 11 and 12).

Comparison between facet means using Duncan's MRT indicates that surface and the subsurface soil of facets can be classified into four groups (Tables 13 and 14). They are:- 1- Pl facet, 2- Ge facet, 3- Te and Pt facets, and 4- St and Mo facets. The individual 95% confidence interval for facet means indicates that the study area, for both the surface and the subsurface soil, can relatively be classified into three levels. They are : 1- high extractable Mg such as Ge and Pl facets, 2- medium extractable Mg such as Pt and Te facets, and 3- low extractable Mg such as St and Mo facets (Fig.16). Ge and Pl facets show relatively higher extractable Mg because soils of these facets are the highest in clay content and CEC level, while St and Mo facets show the lowest extractable Mg because soils of these facets relatively are the lowest in clay content and CEC level (Tables 13 and 14). Furthermore, Pt and Te facets are relatively medium in their clay content and CEC levels (Figures 13 and 14), and consequently show medium extractable Mg (Fig. 16).

Comparison between the surface and the subsurface soil within each facet, indicates that similar amounts of extractable Mg have been obtained (Fig.9). This is due to that surface and the subsurface soil for each facet relatively show the same amount of carbonate, clay, and CEC (Figures 7 and 8). In conclusion, the extractable Mg for both the surface and the subsurface soil have a significant role in partitioning the study area into different mapping units. The surface and the subsurface soil of each facet show the same extractable Mg and mostly homogeneous and significantly differ from each other which can be classify the study area into low, medium and high extractable Mg.

4.228 Extractable potassium (k)

The mean value of extractable K for surface soil is 2 me/100 g soil with a CV of 32.3% (Table 3). Compared to the subsurface soil which is lower and more variable ($\bar{X}$ = 1.4 me/100g soil and CV = 41.7% ; Table 4). As a result of field mapping, some of the identified facets are still variable for both the surface and the sub-surface soil, such as Pt, St and Te facets (Table 15). This variability can be attributed to spatial differences within facet. The homogeneity within Ge and Pl facets can be attributed to that soils are developed from well mixed colluvial material which relatively has the same degree of weathering.

Comparison between facet means, for both the surface and the subsurface soil, indicates that facets can be classified into three groups(Tables 13 and 14). They are: 1- Te,Ge and Pl facets, 2- Pt and Mo facets and 3- St facet. While individual 95% confidence interval for facet means, for both the surface and the subsurface soil of facets, indicates that the study area can be relatively classified into two levels. They are: low extractable K such as Te, Ge and Pl facets; and very low extractable K such as Pt, Mo and St facets (Fig. 17). This grouping can be attributed to clay content and CEC for each group (Tables 13 and 14). Figure 17 indicates that the surface soil has higher values of extractable K than the subsurface soil of facets (Hattar, 1973, Abu Jamous, 1984). This is due to the effect of aeolion sedimantation , higher OM, and greater level weathering,(Abu Jamous, 1984).

In conclusion, extractable K for both the surface and the subsurface soil of facets have little role in partitioning the study area into mapping units, It tends to be variable within facets and can hardly divide the study area into more than two levels.

4.229 Extractable Sodium (Na)

The mean value of extractable Na is low and variable for both the surface and the subsurface soil of facets ($\bar{X}$ = 0.55 and 0.60 me/100 g soil, and CV = 48% and 53.5% respectivley Tables 3 and 4). As a result of field mapping, the identified facets are homogeneous except Mo and Pl facets(Table 15).

F test indicates significant differences between facets for both the surface and the subsurface soil. Also interclass correlation indicates a moderate degree of separation between surface soil of facets, and it is high between subsurface soil of facets (r_i = 0.75 and 0.83; Tables 11 and 12 respectively). Furthermore, comparison between facet means indicates that surface soil can be classified into three groups (Table 13). They are: 1- Pl and Ge facets; 2- Te and Pt facets; and 3- Mo and St facets. Also the subsurface soil of facets can be classified into the same groups except Pl facet which shows higher extractable Na than Ge facet, and hence it is regarded as different group (Table 14). However, individual 95% confidence interval for facet means for both the surface and the subsurface soil indicates that the study area can be divided into two levels. They are: very low in extractable Na such as Pt, St, Te and Mo facets; and low extractable Na such as Ge and Pl facets (Fig.17).

In conclusion extractable Na within the study area has a little significance in partitioning the study area into different units, because it is relatively low, owing to the natural leaching of these soils

Table 3- Means ($\bar{X}$), standard deviations (S.D), coefficient of variations (C.V), for different properties within the area, surface soil.

Property	$\bar{X}$	S.D.	C.V.%
Thick.A. (cm)	18.96	2.98	15.74
Root depth (cm)	17.94	2.51	13.97
Solum depth (cm)	79.96	23.74	29.69
Slope (o)	6.63	5.77	87.03
Altitude. (m)	813.56	149.14	18.33
Gravel (%)	16.38	12.83	78.30
Clay (%)	36.50	8.07	22.12
F C (%)	33.95	4.68	13.79
C E C (%)	30.61	7.14	23.32
Carbonate (%)	38.94	12.47	32.03
O M (%)	1.39	0.69	49.53
E C (#)	0.25	0.04	17.34
pH	8.32	0.14	1.70
Ca (*)	54.29	5.46	10.07
Mg (*)	10.71	3.90	36.42
K (*)	1.98	0.64	32.32
Na (*)	0.55	0.26	48.07

* me /100g soil.

mmhos /cm.

Table 4- Means ($\bar{X}$), standard deviations (S.D), coefficients of variations (C.V), for different properties within the area, subsurface soil.

Property		$\bar{X}$	S.D.	C.V.%
Gravel	(%)	16.99	17.42	102.56
Clay	(%)	36.44	8.55	23.47
F C	(%)	33.76	4.70	14.03
C E C	(*)	30.34	7.73	25.48
Carbonate	(%)	40.12	13.37	33.33
O M	(%)	0.93	0.51	54.52
E C	(#)	0.25	0.06	22.31
P H		8.34	0.15	1.82
Ca	(*)	54.28	5.61	10.34
Mg	(*)	10.82	3.99	36.86
K	(*)	1.38	0.57	41.69
Na	(*)	0.61	0.33	53.52

* me /100g soil

mmhos /cm.

Table 5- Means($\bar{X}$), standard deviations(SD), coefficients of variation (CV), for plateau facet,(Pt),surface and subsurface.

Property		Surface			Subsurface		
		$\bar{X}$	SD	CV(%)	$\bar{X}$	SD	CV(%)
Gravel	(%)	16.50	5.40	32.70	23.50	16.7	71.10
Clay	(%)	33.40	5.80	17.50	32.00	6.60	20.60
F C	(%)	33.60	2.00	6.00	33.60	2.90	8.50
C E C	(*)	28.80	3.60	12.50	28.50	5.40	19.00
Carbonate	(%)	38.70	7.00	18.10	41.70	9.10	21.80
O M.	(%)	1.82	0.36	19.60	1.46	0.45	30.64
E C	(**)	0.24	0.04	15.00	0.23	0.06	24.89
pH		8.30	0.08	0.98	8.28	0.20	2.35
Ca	(*)	48.30	1.50	3.10	48.80	1.70	3.50
Mg	(*)	9.20	1.30	14.10	9.00	1.40	15.60
K	(*)	1.70	0.36	21.18	1.16	0.41	35.40
Na	(*)	0.50	0.03	6.00	0.51	0.04	7.80
Thick A horizon		18.60	1.50	8.10			
Root depth	(cm)	15.20	2.40	15.70			
Solum depth	(cm)	49.40	14.70	29.80			
Slope	(o)	3.90	1.40	35.10			
Altitude	(m)	1006.7	44.40	4.40			

* me /100g

** mmhos/cm

Table 6- . Means($\bar{X}$), standard deviations(SD), coefficients of variation (CV), for steep slope facet, (St) surface and subsurface.

Property		Surface			Subsruface		
		$\bar{X}$	SD	CV(%)	$\bar{X}$	SD	CV(%)
Gravel	(%)	25.90	12.00	46.30	32.50	14.20	43.70
Clay	(%)	27.40	3.40	12.40	25.80	3.00	11.60
F C	(%)	28.50	2.20	7.70	27.20	1.60	6.00
C E C	(*)	23.50	3.70	15.80	21.00	4.10	19.50
Carbonate	(%)	54.30	3.10	5.70	56.70	2.60	4.60
O M	(%)	2.19	0.44	20.10	1.39	0.23	16.60
E.C	(**)	0.26	0.02	7.70	0.24	0.02	8.30
pH		8.20	0.07	0.85	8.33	0.09	1.10
Ca	(*)	51.10	2.00	3.90	50.20	3.30	6.60
Mg	(*)	7.40	1.60	21.60	7.80	1.90	24.40
K	(*)	1.27	0.28	22.10	0.67	0.17	25.40
Na	(*)	0.26	0.05	19.20	0.25	0.05	20.00
Thick A horizon		19.80	2.10	10.60			
Root depth(Cm)		20.10	1.30	6.50			
Solum depth(Cm)		53.30	10.90	20.50			
Slope	(o)	17.30	2.20	13.00			
Altitude	(m)	876.70	135.90	15.50			

* me /100g

** m.mhos/cm

Table 7- Means($\bar{X}$), standard deviations(SD), coefficients of variation (CV), for terrace, (Te) surface and subsurface.

Property	Surface			Subsurface		
	$\bar{X}$	SD	CV(%)	$\bar{X}$		CV(%)
Gravel (%)	15.70	5.50	35.00	8.60	2.70	31.40
Clay (%)	37.10	7.50	20.20	37.70	6.49	17.00
F C (%)	34.30	5.00	14.60	34.60	4.30	12.40
C E C (*)	29.30	7.70	26.30	29.50	6.90	23.40
Carbonate (%)	37.00	10.00	27.00	37.40	9.00	24.10
O M (%)	1.37	0.25	18.30	0.95	0.16	16.80
E C (**)	0.25	0.05	20.00	0.20	0.01	5.00
pH	8.29	0.09	1.08	8.39	0.08	0.95
Ca (*)	50.70	3.10	6.10	50.70	3.40	6.70
Mg (*)	9.70	2.20	22.70	9.70	2.20	22.70
K (*)	2.62	0.78	29.80	1.95	0.57	29.20
Na (*)	0.53	0.04	7.60	0.54	0.06	11.10
Thick A horizon	20.30	4.80	23.70			
Root depth (cm)	16.70	2.20	13.20			
Solum depth(cm)	100.00	0.00	0.00			
Slope (o)	2.90	1.80	62.10			
Altitude (m)	886.90	64.70	7.30			

* me /100g

** m mhos/cm

Table 8- Means($\bar{X}$), standard deviations(SD), coefficients of variation (CV), for moderate slope facet,(Mo)surface and subsurface.

Property		Surface			Subsurface		
		$\bar{X}$	SD	CV(%)	$\bar{X}$	SD	CV(%)
Gravel	(%)	33.40	7.20	21.60	35.30	13.20	37.40
Clay	(%)	31.80	5.90	18.60	32.90	6.30	19.20
F C	(%)	30.10	1.80	6.00	30.30	1.90	6.30
C E C	(*)	25.50	4.50	17.70	26.00	4.60	17.70
Carbonate	(%)	51.20	7.60	14.80	52.2	9.90	19.00
O M	(%)	1.74	0.47	27.00	1.05	0.30	28.60
E C	(**)	0.25	0.03	12.00	0.24	0.02	8.30
pH		8.20	0.10	1.20	8.20	0.07	0.85
Ca	(*)	55.30	3.80	6.90	56.00	2.90	5.20
Mg	(*)	6.80	0.90	13.20	6.90	1.20	17.40
K	(*)	1.49	0.24	16.10	1.00	0.29	29.00
Na	(*)	0.30	0.12	40.0	0.37	0.18	48.70
Thick A horizon		18.80	1.90	10.10			
Root depth	(cm)	18.70	1.80	9.60			
Solum depth	(cm)	77.00	13.80	17.90			
Slope	(o)	10.40	1.80	17.30			
Altitude	(m)	805.60	101.30	12.60			

* me /100g

** mmhos /cm

Table 9 Means($\bar{X}$), standard deviations (SD), coefficients of variation (CV), for gentle slope facet,(Ge) surface and subsurface.

Property		Surface			Subsurface		
		$\bar{X}$	SD	CV(%)	$\bar{X}$	SD	CV(%)
Gravel	(%)	5.80	3.50	60.30	1.60	0.90	56.30
Clay	(%)	42.60	1.90	4.50	43.10	2.10	4.90
F C	(%)	38.90	2.10	5.40	38.50	1.30	3.40
C E C	(*)	38.40	2.70	7.00	38.90	2.70	6.90
Carbonate	(%)	24.80	1.50	6.10	25.20	1.50	6.00
O M	(%)	0.65	0.20	30.80	0.32	0.11	34.40
E C	(**)	0.26	0.06	23.10	0.29	0.05	17.24
pH		8.41	0.15	1.78	8.39	0.18	2.15
Ca	(*)	61.90	2.50	4.00	61.30	4.20	6.90
Mg	(*)	14.10	0.70	5.00	14.40	0.90	6.30
K	(*)	2.44	0.19	7.80	1.81	0.22	12.20
Na	(*)	0.82	0.13	15.90	0.89	0.17	19.10
Thick A horizon		17.40	3.70	21.30			
Root depth	(cm)	17.60	1.90	10.80			
Solum depth	(cm)	100.00	0.00	0.00			
Slope	(o)	3.30	0.50	15.20			
Altitude	(m)	674.40	22.10	3.30			

* me /100g

** mmhos /cm

Table 10- Means ($\bar{X}$), standard deviations (SD), coefficients of variation (CV), for plain facet, (Pl) surface and subsurface.

Property		Surface			Subsurface		
		$\bar{X}$	SD	CV(%)	$\bar{X}$	SD	CV(%)
Gravel	(%)	1.00	0.40	37.80	0.50	0.40	83.30
Clay	(%)	46.70	1.50	3.20	47.10	1.60	3.40
F C	(%)	38.40	1.60	4.20	38.40	1.40	3.70
C E C	(*)	38.20	0.90	2.40	38.20	0.70	1.80
Carbonate	(%)	27.50	0.80	2.90	27.60	1.70	6.20
O M	(%)	0.55	0.07	12.70	0.39	0.09	23.10
E C	(**)	0.23	0.05	21.70	0.30	0.08	26.70
pH		8.49	0.09	1.10	8.46	0.11	1.30
Ca	(*)	58.40	3.10	5.30	58.60	3.40	5.80
Mg	(*)	17.00	0.50	2.90	17.20	0.50	2.83
K	(*)	2.35	0.17	7.20	1.67	0.29	17.40
Na	(*)	0.86	0.24	27.90	1.10	0.23	20.90
Thick A horizon		18.90	2.40	12.70			
Root depth	(cm)	19.40	1.90	9.80			
Solum depth	(cm)	100.00	0.00	0.00			
Slope	(o)	1.90	0.30	15.80			
Altitude		631.10	13.90	2.20			

* me /100g

** mmhos /cm

Table 11- Within facet variance (S^2w), between facets variance (S^2B), F test, and interclass correlation (r_i) for the different properties within the area, surface layer.

Property		S^2w	B	S^2B	F calc**	r
Thick A horizon		8.90	9.20	0.03	1.00	0.003
Root depth	(cm)	3.80	29.80	2.90	7.80*	0.43
Solum depth	(cm)	87.30	5144.80	561.90	58.90*	0.87
Slope	(o)	2.30	329.20	36.30	143.10*	0.94
Altitude	(m)	5928.90	178900.20	19212.00	30.20*	0.76
Gravel	(%)	44.50	1313.80	141.00	29.50*	0.76
Clay	(%)	23.80	461.00	48.60	19.40*	0.67
F C	(%)	7.40	160.30	17.00	21.70*	0.70
C E C	(#)	19.00	359.90	37.90	18.94*	0.67
Carbonate	(%)	36.80	1297.60	140.00	35.26*	0.79
O M	(%)	0.11	3.96	0.43	36.00*	0.80
E C	(mmhos/cm)	0.002	0.002	0.00	1.00	0.00
PH		0.01	0.12	0.01	12.00*	0.50
Ca	(#)	7.60	242.50	26.10	31.90*	0.78
Mg	(#)	1.80	145.10	15.90	80.60*	0.90
K	(#)	0.16	2.85	0.30	17.81*	0.65
Na	(#)	0.02	0.57	0.06	28.50*	0.75

* Significant at 5% level.

** $F_{tab} = 2.41$.

me /100g soil.

Table 12- Within facet variace (S^2w), between facets variance (S^2_B), F test, and interclass correlation (r_i) for different properties within the area, subsurface layer.

Property		S^2w	B	S^2B	F calc**	r_i
Gravel	(%)	110.20	2155.30	227.20	19.60*	0.67
Clay	(%)	23.30	549.10	58.40	23.60*	0.72
F C	(%)	6.20	179.50	19.30	29.00*	0.76
C E C	(#)	20.30	441.40	46.80	21.70*	0.70
Carbonate	(%)	45.60	1458.10	156.90	32.00*	0.78
O M	(%)	0.07	2.11	0.23	30.14*	0.77
E C	(mmhos/cm)	0.002	0.01	0.001	5.00*	0.33
pH		0.02	0.08	0.007	4.00*	0.26
Ca	(#)	10.40	234.70	24.90	22.60*	0.71
Mg	(#)	2.10	148.60	16.30	70.80*	0.89
K	(#)	0.12	2.32	0.25	19.33*	0.68
Na	(#)	0.02	0.94	0.10	47.00*	0.83

** F tab = 2.41

* Significant at 5% level.

me /100g soil.

Table 13 — Mean ($\bar{X}$), Duncan's test (D), and 95% confidence interval for different properties within facets, surface layer.

Property	Facet	Mean $\bar{X}$	D**	95% confidence U. limit	Interval L. limit
Thick A horizon	Te	20.3	a	24.0	16.6
	St	19.8	a	21.4	18.2
	Pl	18.9	a	20.8	17.1
	Mo	18.8	a	20.3	17.3
	Pt	18.6	a	19.8	17.5
	Ge	17.4	a	20.3	14.6
Root depth (cm)	St	20.1	a	21.1	19.1
	Pl	19.4	ab	20.9	17.9
	Mo	18.7	ab	20.1	17.3
	GE	17.6	bc	19.1	16.1
	Te	16.7	cd	18.4	15.0
	Pt	15.2	d	17.4	13.4
Solum depth(cm)	Pl	100.0	a	100.0	100.0
	Ge	100.0	a	100.0	100.0
	Te	100.0	a	100.0	100.0
	Mo	77.0	b	87.6	66.4
	St	53.3	c	61.7	44.9
	Pt	49.4	c	60.7	38.1
Slope (o)	St	17.3	a	19.0	15.6
	Mo	10.4	b	11.8	9.0
	Pt	3.9	c	5.0	2.8
	Ge	3.3	cd	3.7	2.9
	Te	2.9	cd	4.3	1.5
	Pl	1.9	d	2.1	1.7
Altitude (m)	Pt	1006.7	a	1040.8	972.6
	Te	886.9	b	936.7	837.2
	St	876.7	bc	981.2	772.2
	Mo	805.6	c	883.5	727.7
	Ge	674.4	d	691.4	657.4
	Pl	631.1	d	641.8	620.4

Table 13 – (continued)

Property		Facet	Mean $\bar{X}$	D**	95% confidence U. limit	Interval L. limit
Gravel	(%)	Mo	33.4	a	38.9	27.9
		St	25.9	b	35.1	16.7
		Pt	16.5	c	20.7	12.4
		Te	15.7	c	19.9	11.5
		Ge	5.8	d	8.5	3.1
		Pl	1.0	d	1.3	0.7
Clay	(%)	Pl	46.7	a	47.9	45.6
		Ge	42.6	a	44.1	41.1
		Te	37.1	b	42.9	31.3
		Pt	33.4	bc	37.9	28.9
		Mo	31.8	cd	36.3	27.3
		St	27.4	d	30.0	24.8
F C	(%)	Ge	38.9	a	40.5	37.3
		Pl	38.4	a	39.6	37.2
		Te	34.3	b	38.2	30.5
		Pt	33.6	b	35.1	32.1
		Mo	30.1	c	31.5	28.7
		St	28.5	c	30.2	26.8
C E C	(*)	Ge	38.4	a	40.5	36.3
		Pl	38.2	a	38.9	37.5
		Te	29.3	b	35.2	23.4
		Pt	28.8	b	31.6	26.0
		Mo	25.5	bc	29.0	22.0
		St	23.5	c	26.4	20.7
Carbonate	(%)	St	54.3	a	56.7	51.9
		Mo	51.2	a	57.0	45.4
		Pt	38.7	b	44.1	33.3
		Te	37.0	b	44.7	29.3
		Pl	27.5	c	28.1	26.9
		Ge	24.8	c	26.0	23.7
O M	(%)	St	2.19	a	2.53	1.85
		Pt	1.82	b	2.10	1.54
		Mo	1.74	b	2.10	1.38
		Te	1.37	c	1.56	1.18
		Ge	0.65	d	0.80	0.50
		Pl	0.55	d	0.60	0.50

Table 13- (continued)

Property	Facet	Mean $\bar{X}$	D**	95% confidence U. limit	Interval L. limit
E C (mmhos/cm)	St	0.26	a	0.27	0.25
	Ge	0.26	a	0.31	0.21
	Te	0.25	a	0.29	0.21
	Mo	0.25	a	0.27	0.23
	Pt	0.24	a	0.27	0.21
	Pl	0.23	a	0.27	0.19
pH	Pl	8.49	a	8.56	8.42
	Ge	8.41	a	8.53	8.29
	Pt	8.30	b	8.36	.24
	Te	8.29	b	8.36	8.22
	Mo	8.20	b	8.28	8.12
	St	8.20	b	8.25	8.15
K (me/100g)	Te	2.62	a	3.20	2.00
	Ge	2.44	a	2.60	2.30
	Pl	2.35	a	2.50	2.20
	Pt	1.70	b	2.00	1.40
	Mo	1.49	bc	1.70	1.30
	St	1.27	c	1.50	1.10
Na (me/100g)	Pl	0.86	a	1.05	0.67
	Ge	0.82	a	0.92	0.72
	Te	0.53	b	0.56	0.50
	Pt	0.50	b	0.52	0.48
	Mo	0.30	c	0.39	0.21
	St	0.26	c	0.30	0.22
Ca (me/100g)	Ge	61.9	a	63.8	60.0
	Pl	58.4	b	60.8	56.1
	Mo	55.3	c	58.2	52.4
	St	51.1	d	52.6	49.6
	Te	50.7	de	53.1	48.3
	Pt	48.3	e	49.5	47.2
Mg (me/100g)	Pl	17.0	a	17.4	16.6
	Ge	14.1	b	14.6	13.6
	Te	9.7	c	11.4	8.0
	Pt	9.2	c	10.2	8.2
	St	7.4	d	8.6	6.2
	Mo	6.8	d	7.5	6.1

** At 5% level

Table 14- Mean ($\bar{X}$), Duncan's test (D), and 95%confidence interval for different properties within facets, subsurface layer.

Property		Facet	Mean $\bar{X}$	D**	95% confidence U. limit	Interval L. limit
Gravel	(%)	Mo	35.3	a	45.5	25.2
		St	32.5	ab	43.4	21.6
		Pt	23.5	b	36.3	10.7
		Te	8.6	c	10.7	6.5
		Ge	1.6	c	2.3	0.9
		Pl	0.5	c	0.8	0.2
Clay	(%)	Pl	47.1	a	48.3	45.9
		Ge	43.1	a	44.7	41.5
		Te	37.7	b	42.6	32.8
		Mo	32.9	c	37.8	28.1
		Pt	32.0	c	37.1	26.9
		St	25.8	d	28.1	23.5
F C	(%)	Ge	38.5	a	39.5	37.5
		Pl	38.4	a	39.5	37.3
		Te	34.6	b	37.9	31.3
		Pt	33.6	b	35.8	31.4
		Mo	30.3	c	31.8	28.8
		St	27.2	d	28.4	26.0
C E C	(me/100g)	Ge	38.9	a	41.0	36.8
		Pl	38.2	a	38.7	37.7
		Te	29.5	b	34.8	24.2
		Pt	28.5	b	32.7	24.4
		Mo	26.0	b	29.5	22.5
		St	21.0	c	24.2	17.9
Carbonate	(%)	St	56.7	a	58.7	54.7
		Mo	52.2	a	59.8	44.6
		Pt	41.7	b	48.7	34.7
		Te	37.4	b	44.3	30.5
		Pl	27.6	c	28.9	26.3
		Ge	25.2	c	26.4	24.1

Table 14- (continued)

Property		Facet	Mean $\bar{X}$	D**	95% confidence U. limit	Interval L. limit
O M	(%)	Pt	1.46	a	1.81	1.11
		St	1.39	a	1.57	1.21
		Mo	1.05	b	1.28	0.82
		Te	0.95	b	1.07	0.83
		Pl	0.39	c	0.46	0.32
		Ge	0.32	c	0.41	0.23
E C	(mmhos/cm)	Pl	0.30	a	0.36	0.24
		Ge	0.29	a	0.33	0.25
		Mo	0.24	b	0.26	0.23
		St	0.24	b	0.26	0.23
		Pt	0.23	bc	0.28	0.18
		Te	0.20	c	0.21	0.19
pH		Pl	8.46	a	8.55	8.37
		Ge	8.39	ab	8.53	8.25
		Te	8.39	ab	8.45	8.33
		St	8.33	abc	8.40	8.26
		Pt	8.28	bc	8.43	8.13
		Mo	8.20	c	8.25	8.15
K	(me/100g)	Te	1.95	a	2.39	1.51
		Ge	1.81	a	1.98	1.64
		Pl	1.67	a	1.89	1.45
		Pt	1.16	b	1.48	0.84
		Mo	1.00	b	1.22	0.78
		St	0.67	c	0.80	0.54
Na	(me/100g)	Pl	1.10	a	1.28	0.92
		Ge	0.89	b	1.02	0.76
		Te	0.54	c	0.59	0.49
		Pt	0.51	c	0.54	0.48
		Mo	0.37	d	0.51	0.23
		St	0.25	d	0.29	0.21
Ca	(me/100g)	Ge	61.3	a	64.5	58.1
		Pl	58.6	ab	61.2	56.0
		Mo	56.0	b	58.2	53.8
		Te	50.7	c	53.3	48.1
		St	50.2	c	52.7	47.7
		Pt	48.8	c	50.1	47.5

Table 14- (continued)

Property	Facet	Mean $\bar{X}$	D**	95% confidence U. limit	Interval L. limit
Mg (me/100g)	Pl	17.2	a	17.6	16.8
	Ge	14.4	b	15.1	13.7
	Te	9.7	c	11.4	8.0
	Pt	9.0	cd	10.1	7.9
	St	7.8	de	9.3	6.3
	Mo	6.9	e	7.8	6.0

* me / 100g

** At 5% level

Table 15- Homogeneity* within facets based on CV% for different properties for surface and subsurface soil.**

Facet		Pt	St	Te	Mo	Ge	Pl	Pt	St	Te	Mo	Ge	Pl
Property		Surface soil						Subsurface soil					
Slope	(o)	N	H	N	H	H	H						
Altitude	(m)	H	H	H	H	H	H						
Root depth	(cm)	H	H	H	H	H	H						
Thick of A horizon	(cm)	H	H	N	H	N	H						
Solum depth	(cm)	N	N	H	H	H	H						
Gravel	(%)	N	N	N	N	N	N	N	N	N	N	N	N
Clay	(%)	H	H	N	H	H	H	N	H	H	H	H	H
FC	(%)	H	H	H	H	H	H	H	H	H	H	H	H
CEC	(me/100g)	H	H	N	H	H	H	H	H	N	H	H	H
Carbonate	(%)	H	H	N	H	H	H	N	H	N	H	H	H
OM	(%)	H	N	H	N	N	H	N	H	H	N	N	N
EC	(mmhos/cm)	H	H	H	H	N	N	N	H	H	H	H	N
pH		H	H	H	H	H	H	H	H	H	H	H	H
Ca	(me/100g)	H	H	H	H	H	H	H	H	H	H	H	H
Mg	(me/100g)	H	N	N	H	H	H	H	N	N	H	H	H
K	(me/100g)	N	N	N	H	H	H	N	N	N	N	H	H
Na	(me/100g)	H	H	H	N	H	N	H	H	H	N	H	N

* H = Homogeneous, CV = less than 20%; N = Heterogeneous, CV = more than 20%.

** Extracted from tables 5 through 10.

V CONCLUSIONS

Based on this study the following conclusions can be derived:

1. Facets are homogeneous for both the surface and the subsurface soil in terms of altitude, rooting depth, FC,pH and extractable Ca. Also the facets are homogeneous (except Te) in terms of CEC and clay content, but they tend to be variable in terms of OM, extractable Mg, K, Na and completely variable in terms of gravel content.
2. Pt facet is variable in terms of slope and solum depth and tends to be variable for the subsurface soil in terms of clay,carbonate, and OM content.The St facet is variable in terms of solum depth, extractable Mg and K.
3. Te facet tends to be variable in terms of slope, thickness of A horizon, CEC, carbonate, extractable K,Mg, and clay content of the surface soil. The Mo facet is homogeneous in terms of most of the studied properties except for gravel content, OM and extractable Na.
4. Ge and Pl facets are homogeneous for both the surface and the subsurface. They are over defined and can be regarded as one population in terms of slope, altitude, rooting depth,solum depth, clay content, FC,CEC, Carbonate content, pH, and extractable K.
5. The following parameters have played a prominent role in determining soil characteristics of different land units: solum depth, clay content, FC,CEC, carbonate content, extractable Ca and Mg. However, some attributes such as thickness of A horizon, rooting

depth, EC, and pH have no significant role or effectiveness in partitioning the study area into different units.

6. Te facet has silimar slope to Ge, Pl and Pt facets, but it is significantly different from Ge and Pl facets in terms of altitude, gravel of the surface soil, clay content, FC, CEC, carbonate, OM, pH of the surface soil, extractable Na, Ca, and Mg. Also it is significantly differs from Pt facet in terms of altitude, solum depth, OM, and extractable K. On the other hand Pt facet has different soil properties compared to Ge and Pl facets indicating to the importance of topographic position on the processes of each facet.

7. The level of clay content, FC, CEC, and extractable cations increased toward valley bottom for St,Mo,Ge, and Pl facets. But gravel, carbonate, and OM content decreased toward valley bottom.

8. This type of studies has to be extended to other areas to investigate the effect of different parent material on soil characteristics. However, the constructed physiographic map can provide a useful basis for land use planning and soil manegment.

VI ENGLISH SUMMARY

A detailed physiographic analysis was carried out for part of the Baqa'a valley system by employing airphoto interpretation. The study area has been divided into land facets based on soil morphology, surfacial material, and natural enviroment. The facets are: Plateau, Steep slope, Terrace, Moderate slope, Gentle slope, and Plain. Physiographic map was constructed by transfering and marking facet boundaries from airphotos to a topographic map in order to carrey out the sampling program.

The field study was carried out using three randomly selected recurences for each facet and three random sites within each recurance, One pit was dug in each site and two samples were taken from each pit. The first sample represents "A" horizon and the second one represents the subsoil down to 45 cm depth. Soil and site characteristics such as slope, altitude, thickness of A horizon, rooting depth, and solum depth, were measured.

The soil samples were prepared and analysed to determine, the soil physical and chemical properties which include gravel content, clay content, field capacity, CEC, carbonate content, OM, pH, EC, and extractable Ca, Mg, K, and Na.

Statistical analysis of the data for both the surface and the subsurface soil was carried out by calculating the following statistical parameters: F test, interclass correlation, Duncan's test, confidence interval, coefficient of variation for studied properties for the whole area and within each facet. The results indicate that the

surface and the subsurface soil of the study area as a whole are variable in terms of significant soil and site characteristics such as slope, gravel content, solum depth, clay content, CEC, and carbonate content. This shows the advantage of land subdivision into facets.Having completed the mapping stage, all facets were found homogeneous for both the surface and the subsurface soil in terms of field capacity, pH, and extractable Ca. But they are variable in terms of gravel content. However, the results indicate that gentle slope and plain facets are homogeneous in both the surface and the subsurface soil in terms of altitude, slope, rooting depth, solum depth, clay, CEC, carbonate content,extractable Mg and K. Moderate slope facet is homogeneous in both the surface and the subsurface soil in terms of slope, altitude, rooting depth, solum depth, clay content, CEC, carbonate, and extractable Mg. The same trend could be applied for steep slope facet except for solum depth and extractable Mg. Terrace facet tends to be variable in terms of slope, clay, CEC, carbonate, extractable Mg and K, but it is homogeneous in terms of altitude and solum depth. Plateau facet also tends to be variable in terms of slope, solum depth, extractable K, clay and carbonate content of the subsurface soil.

The results of statistical tests indicate that altitude, solum depth, clay, field capacity, CEC, carbonate, extractable Ca and Mg have a significant role in partitioning the study area into different mapping units. However, other attributes such as thickness of A horizon, rooting depth, gravel content, EC, and pH have fialed to play such role.

الملخص بالعربيــــــه

تقييم الوحدات الطبيعيه للأراضي في منطقة البقعـــــــه

لقد تم اختيار حوض البقعه الواقع شمال مدينة صويلح لدراسة جزء منــــــه بطريقه تفصيليه وتم تقسيمه الى وحدات طبيعيه من خلال فحص الصور الجوّيه مستعمـــلا جهاز Stereoscope ومتخذا خصائص الشكل الخارجي وميزات الموقع الطبوغرافـــي كأساس لتقسيم الأرض . ولقد كان الفحص سهلا ودقيقا وذلك لسهولة تمييز اختلافــــات درجة الميل والارتفاعات خلال Stereoscope بالاضافه الى سهولة التأكد من هـــذه الاختلافات على الطبيعيه . واستنادا الى دراسة تفصيليه وشامله للصوّر الجويه الــتي تغطي منطقة الدراسه تم تحديد ستّة أنواع من الوحدات الطبيعيه لسطح الأرض وهـــي الهضاب ، الأراضي المنحدره ، الأراضي متوسطة الانحدار ، الأراضي بسيطة الانحدار ، السهول ، والشرفات .

لقد تم عمل خارطه فيزيوجرافيه بمقياس $\frac{١}{١٠٠٠٠}$ باستعمال جهاز Sketsh master لنقل حدود الوحدات من الصور الجويه الى خارطة المنطقه الطبوغرافيه وذلك لتساعـد في برنامج أخذ عينات التربه . ولقد تم اختيار ثلاثة مكرّرات لكل وحده وتم تعيـــين ثلاثة مواقع في كل مكرّر لدراستها بالتفصيل وذلك على أساس عشوائي . وفي كل موقـــع تم حفر قطاع لأخذ عينه تربه تمثل الأفق أ وعينه أخرى لتمثّل تخت التربه لعمق ٤٥ سم وتم تسجيل الملاحظات والقياسات الميدانيه من حيث الارتفاع عن سطح البحر ، درجـــة الميل ، عمق التربه ، وسمك الأفق أ ، وعمق الجذور .

هذا وقد تمّ اجراء تحليلات مخبريه لدراسة بعض الصفات الطبيعيه والكيماويه للتربـــه مثل نسبة الحصى ، الطين ، السعه الحقليه ، السعه التبادليه للكاتيونــــــات ، الكربونات ، المادّه العضويه ، الملوحه ، رقم التفاعل ، والكالسيوم والمغنيسيـــوم والبوتاسيوم والصوديوم القابل للاستخلاص .

تشير نتائج التحليل الاحصائي للبيانات لمجمل المنطقه سواء سطح التربه أو تحـــت سطح التربه أن لها صفات متباينه مما يؤثر على استعمال الأراضي مثل درجة الميـــل ، كمية الحصى ، عمق التربه ، نسبة الطين ، السعه التبادليه ، والكربونات في التربـــه .

لقد أكدت هذه النتائج على أن نظام التقسيم هذا يمكن أن يخدم أغراض التخطيط الزراعي .

ولقد تبيّن أيضا أن جميع أنواع الأراضي لأىّ وحدة تقسيم طبيعي بأنها متجانسه سواء في سطح التربه أو تحت سطح التربه من حيث السعه الحقليه ، رقم التفاعل ،الكالسيوم المستخلص . لكنها متباينه في محتوى الحصى .

ومن جهه أخرى تدل النتائج على أن أراضي الوحدات الطبيعيه بسيطه الانحدار والسهول بانها متجانسه سواء في سطح التربه أو تحت السطح وذلك في غالبية الصفات المدروسه مثل الارتفاع ، الميل ، عمق التربه ، محتوى الطين ، الكربونات ، السعه التبادليه ، والمغنيسيوم والبوتاسيوم المستخلص وأنه لا يوجد فروق معنويه بين هذين النوعين من الأراضي مما يجعل اعتبارهما وحده واحده أكثر احتمالا .

أما من ناحية الأراضي المتوسطه الانحدار فانها أيضا متجانسه سواء للسطح أو تحت السطح من حيث الارتفاع ، الميل ، عمق التربه ، محتوى الطين ، السعه التبادليه ، الكربونات ، والمغنيسيوم المستخلص . ونفس هذه النتائج ممكن اطلاقها على الأراضي المنحدره عدا عمق التربه والمغنيسيوم المستخلص .

أما الشرفات فانها تميل الى التباين في صفاتها من حيث الميل محتوى الطين ، السعه التبادليه ، الكربونات ، المغنيسيوم والبوتاسيوم المستخلص لكنها متجانسه في الارتفاع وعمق التربه . كذلك الهضاب أيضا فانها تميل لأن تكون متباينه من حيث الميل ، عمق التربه ، محتوى الطين ، الكربونات والبوتاسيوم المستخلص .

من جهه أخرى فان التحليلات الاحصائيه مثل المقارنه بين المتوسطات وحدود الشقه حول هذه المتوسطات تشير بأن نظام تقسيم هذه المنطقه قد كان فعالا من خلال دراسة الارتفاع ، عمق التربه ، محتوى الطين ، والسعه الحقليه ، والسعه التبادليه ، الكربونات ، الكالسيوم والمغنيسيوم المستخلص . لكن هناك بعض الصفات لم تكن فعاله في تقسيم المنطقه مثل سمك الأفق أ ، عمق الجذور ، محتوى الحصى ، الملوحه ، ورقم التفاعل .

VIII REFERENCES

Ahn, P.M. 1965. The heterogeneity of West African soils and their sampling for chemical analysis. Second F.A.O. conf. on soil fertility in West Africa.

Areola, O. 1974. Photo-interpretation of land facets as a soil mapping technique. Geoforum. 20/74: 25-38.

___ 1977. A review of land facets as soil mapping units with particular reference to the land resources division survey of the soils of the Western State Savanna Nigeria. Savana Vol. 6. No 1: 85-89.

___ 1982. Soil variability within land facets in areas of low smooth relief: A case study on the Gawagwa plains, Nigeria. Soil Survey and Land Evaluation V.2: 9-13.

Astel, W.L., R. Webster, and C.J. Lawrance 1969. Land classification for management planning in the Luangwa Valley of Zambia. J. Applied Ecol. 6: 143-169.

Beckett, P.H.T, and R. Webster 1971. Soil variability: A review, Soils and Fertilizers, 34: 1-15.

Bender, F. 1978. <u>Geologic Von Jordanien</u> Gebrude Borntraeger, Berlin: Geological map of Jordan (1:750,000).

Bohn, H.L., B.L. Mcneal, and G.A. Oconnor. 1979. <u>Soil Chemistry</u>. John Wiley and Sons: 223-224.

Bourne, R. 1931. Regional survey and its relation to stocktaking, of the agriculture resources of the British Empire, Oxford Forestry Memoris, No. 13.

Bower, C.A., R.F. Reitemeir and M. Fireman. 1952. Exchangeable cation analysis of saline and alkali Soils. Soil Sci. 73: 251-261.

Bowman, I. 1914. Forest physiography, physiography of the US and principle soils in relation to forestry. New York John Wiley.

Buringh, P. 1960. The application of aerial photographs in soil surveys. In R.L. Colwell (editor), Manual of photographic interpretation. Am. Soc. Photogrammetry, Washington, D.C., pp 633-666.

Buring, P., G.G.L. Steur, and A.P.A. Vink, 1962. Some techniques and methods of soil survey in the Netherlands. Neth. J. Agric. Sci. 10; 157-72.

Carroll, D.M., R. Evans, and V.C. Bondelow. 1977. Air photo interpretation for soil mapping. Soil Survey technical monograph no 8. Rothamsted Experimental Station, 5-28.

Chartres, C.J. 1982. The use of land form-soil associations in irrigation soil surveys in Northen Nigeria. Journal of Soil Science, 33: 317-328.

Cheng, K.L. and R.H. Bray. 1951. Determination of calcium and magnesium in soil and plant. Soil. Sci. 72: 449-458.

Christian, C.S. 1958. The concept of land units and land systems. Proceedings of the 9th Pacific Science Congress, 1957, 20; 74-81.

Dalrymple, J.R., R.J. Blong. and A.J. Conacher 1968. A hypothetical nine unit landsurface modele Zeitschrift für Geomorphologie, 12: 60-76.

Ebersohn, J.P., and P. Lucas 1965. Trees and soil nutrients in S.W. Queens land. Qd. J. Agric. Anim. sci. 22: 422-435.

Fagbami, A.A. 1978. The use of Random stone count for the evaluation of physiographic analysis. ITC Journal 3: 465-485.

Fitzpatrik. E.A., 1977. Soil description. Booklet, Department of Soil Science University of Aberdeen: pp2.

Grava, J., G.E. Spalding, and C.A. Caldwell 1961. Effect of drying upon the amounts of easily extractable K and P in Nicollet clay loam. Agron. J. 53: 219-221.

Hattar, B., and R.C. Paeth. 1973. The relationship of physical, chemical and mineralogical properties to the fertility of three selected soils from the Baqa'a Valley of Jordan. A thesis submitted to the American University of Beirut, pp 21-23

Howard, J.A. 1970. Multi-band concept of forested land units in International Symposium of Photo Interpretation International Archives of Photogrammotry, Dresden, Vol. 1, 287-291.

Howard, J.A., and C.W. Mitchell. 1980. Phyto-Geomorphic classification of the landscape. Geoform, Vol. 11: 85-106.

Hunting Technical services LTD. 1956. Report on the range classification survey of the Hashemite kingdom of Jordan: map no. 4.

Jackson, M.L. 1969. Soil chemical analysis advanced course. 2nd. Edd. puplished by author. Dept. Soil Sci., Univ. of Wisc. Mad. pp 237.

Jamous, M., and A. Taimech. 1984. Genesis and classification of some selected soils of Irbid region. MSc thesis. Univ. of Jordan. pp 40.

Kantey, B.A., and R.K. Morse. 1965. A modern approach to high way materials sampling. Proc. 6th int. Conf. Soil Mech. Fdh. Engng. 1/12: 55-58

Kilmar, V.J., and L.T. Alexander 1949. Methods of making mechanical analysis of soils Soil Sci. 68: 15-24.

King, L. 1962. The morphology of the earth: a study and synthesis of world scenery. Oliver and Boyed, Edinburgh.

Lodha, B.K., D.C. Joshi and S.V. Jain. 1982. Physiography and soil association in Rajasthan. J. Indian Soc. Soil Sci. vol. 30 (3) : 326-333.

Mabbut, J.A. 1968. Review of concepts of land classification in A.G. Stewart (1968). Land evaluation. Macmillan of Australia: 11-28.

Mader, D. L. 1963. Soil variability A serious problem in soil-site studies in the North East Soil Sci. Soc. Pro: 707-709.

Mew, G., and D.F. Ball. 1972. Grid sampling and air photography in upland soil mapping. Geog. J., 138: 8-14.

Mcintyre, G.A. 1967. Soil mapping for soil testing. J. Aust. Intr. Agric. Sci, 33: 308-320.

Mikbel, Sh. and W. Zacher. 1981. The Wadi Shueib structure in Jordan. N. Jb. Geol. Paläont. Mh., 1981(9): 571-576; Stuttgart.

Milne, G. 1935. Some suggested units of classification and mapping, particularly for East African Soils, Soil Research, 4, No.3:183-198.

Mitchell, C.W. 1973. Terrain Evaluation, Longman Group Limited 13-22, 28-30, 48-51.

Mitchell, C.W. and J.A. Howard. 1978b. Land system classification. A case history: Jordan. AGLT Bull. 2/78. FAO. ROME: 1-2,26-27.

Munir, Y.H.1982. The relationships between soils, land use potential and physiographic units on three bedrock types in N.E.Scotland. (Ph.D.Thesis).Aberdeen University.pp.79,86,87,137-138.

Nakano, T. 1962. Landform type analysis on aerial photographs its principle and its technique. Symposium photo interpretation, Delft: 150-152.

Peech, M., 1965. Hydrogen ion activity. In C.A. Black et al., (edl). Methods of soil analysis. Part 2: Chemical and microbiological properties. Am. Soc. of Agronomy., Madison, Wis. Agronomy 9:922-923.

Powell, J.C., and M.E. Springer. 1965. Composition and precision of several mapping units of the applied cecil and Lloyd series in Walton Co., Georgia. Soil Sci. Soc. Am. Proc. 29:454-458.

Pregitzer.K.S, B.V. Barnes, and G.D.Lemme. 1983. Relationship of topography to Soils and vegetation in an upper Michigon ecosystem. Soil Sci. Soc. of Am. J. Vol. 47(1): 117-123.

Prokayev, V.I. 1962. The Facies as a basic and Smallest unit in landscape Science. Soviet Geography, Review and Translation, 3, No. 6: 21-29.

Riecken, F.F., and E. Poetsch. 1960. Genesis and classification consideration of some prairie formed soil profiles from local alluvium in Adair County , Iowa; Iowa Acad. Sci., Vol. 67: 268-276.

Rich, C.I. 1965. Elemental analysis by flame photometry in C.A. Black et al., (edI). Methods of Soil analysis part 2: Chemical and Microbiological Properties: Am. Soc. of Agronomy.,Madison,Wis. Agronomy 9:1372-1375.

Richards, L.A. 1954. Diagnosis and Improvement of Saline and alkaline Soils. U.S. Goverment printing office, Wash., D.C: 105-109.

Salameh, E. 1980: The Suweilih Structure.-N. Jb. Geol. Paläont. Mh., H(7): 428-438 Stuttgart.

Sharma, R.C., T.R. Srinivasan, M.A. Mirajkar, and H.S. Iyer. 1980. Soils of Malnad Tract, Karnataka State I. Physiographic systems and elements of photo-interpretation in their mapping Mysore J. Agric. Sci., 14: 164 – 170.

Soil Survey Staff 1951. Soil Survey Manual. Agric. Hand book 18. Washington D.C. Department of agriculture: 161-164.

Soil survey staff. 1975. Soil Taxonomy-a basic system of soil classification for making and interpeting soil Surveys. SCS. USDA. pp.l.

Sondheim, M.W. and K. K. Klinka. 1983. The relationship of soil and Physiographic attributes to an ecological classification system. Can. J. Soil Sci. 63: 97-112.

Tomlinson, P.R. 1970. Variations in the usefulness of rapid Soil Mapping in the Nigerian Savanna. Journal of Soil Science. Vol. 21. No.1: 162-172.

Towner, C.D. 1968. Variability of Soil Moisture in the black cracking clay soil of North-Western New South Wales. Aust. J. Exp. Agric. Amm. Husb. 8: 252-254.

Townshend. J.R.G. 1981. Terrian analysis and remote Sensing. Ed. J.R.G. Townshend. George Allen Union: 80-110.

Vinogradov, B.V., K.I. Gerenchuk, A.G. Isachenko, K.G. Raman, and Y.T. CHuk. 1962. Basic principles of Landscape Mapping. Sov. Geog., 3(6): 15-20. Review and Translation.

Walkely, A., I.A. Black. 1934. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil. Sci. 37: 29-38.

Walker, P.H. 1966. Postglacial environments in relation to landscape and soils on the cary drift, Iowa: Iowa State Univ., Agri, and Home Econ. Exp. Sta. Res. Bull. 549: 835-875.

Water Authority of Jordan. 1984. Records of water resources division: 1973-1983.

Webster, R. 1965. Landscape and soils in the vale of White Horse, Berkshire (England) revue photo interpretation No.4. Fascicule 2: 13-14. Juillet-Aout Editions Technip, 7, Rue-Nelation, Paris Xve.

——— 1978a. Quantitative and numerical methods in soil classification and survey. Oxford . Oxford Univ. Press 77-83.

Webster, R., and P.H.T. Beckett, 1964. A study of agronomic value of soil maps interpreted from air photographs. 8th intern.Congress of soil Sci., Bucharest. Romania, Vol. 88:795-803.

——— 1970. Terrain classification and evaluating using air photography: A review of recent work at Ocford. Photogrammetria, 26: 51-75.

West, B.G. 1970. Soil Survey in the Baqa'a Valley. A working Paper Prepared for the Food and Agriculture Organization of the United Nations. FAO, Rome. 2, 10-12, 93.

Wilding, L.P., G.M. Schafer., and R.B.Jones. 1964. Morley and Blount Soils: A statistical summery of certain physical and chemical properties of some selected profiles from Ohio. Proc. Soil Sci. Soc. Am 23: 674-679.

Wilding, L.P., L.R.Deers 1978. Spatial variability: a pedologists viewpoint in diversity of soils in the tropics. Soil Sci. Soc. Am., spec. publ., 34:1:1-12.

Wooldridge, S.W. 1932. The cycle of Erosion and the Representation of Relief. Scottish Geographical Magazine Vol. 48:30-36.

Young, A. 1968. Natural Resource Surveys for Land Development in the Tropics. Geography 53: 229-248.

APPENDIX A

Partial list of native plants in the study area, tabulated in decending order according to relative intensity distribution (West,1970).

Botanical name	Arabic name
Poterium spinosum	نتش (بلان)
Cynodon dactylon	نجيل
Carthamus nitidus Boiss	قوص
Hordeum bulbosum L.	شعير برى
Sisymbrium iriol.	سليح
Convolvulus arvensis L.	مداده
Artemisa herba alba	شيح
Plantago coronopus L.	أذينه
Euphorbia SP.	لبين
Salvia syriaca	خويخه
Panicum coloratum L.	قصيبه
Centaurea calcitrapa L.	مرار
Alhagi maurorum medik	عاقول
Silybium marianum	شوك الجمل
Chrozophora tinctoria L. Ad. Juss.	غبيره
Medicago orbicularis	نفل
Capsella bursa-pastoris	كيس الراعي
Traganum nudatum	سويد

APPENDIX B

Representative site and profile description for the identified facets within the study area.

1. Plateau facet.
2. Steep slope facet.
3. Terrace.
4. Moderate slope facet.
5. Gentle slope facet.
6. Plain.

1. Plateau facet

(i) Facet Location

1- Facet type: Plateau (Pt) 2- Facet No: 6*

3- Pit No: 1*

(ii) General Information

1- Sampler: M. Assad 2- Date 21-2-1984

3- Parent material: Soft limestone + Marl

4- Landuse: Dry farming (orchards).

(iii) Topography

1- Altitude 1020 m 2- Slope angle: 5°

3- Aspect: 150° to the East 4- Form:Convex-linear

(iv) Profile Description

Horizon	Depth	
Ap	0-18cm	Brown to dark brown (7.5 YR 4/4);**; slightly gravelly loam; slightly hard; very friable; slightly sticky;plastic; moderate fine granular; many fine roots; stones 0.1%;gravel 22.6%; pH 8.2; clear wavy boundary.
B_2	18-35cm	Brown (7.5 YR 5/4)** gravelly loam; slightly hard;very friable;slightly sticky;plastic;moderate very fine sub-angular blocky;few fine roots;gravel 50.6%; pH 8; clear wavy boundary.
C	35+	Soft limestone.

* number on associated map.

** color for moist sample.

2. Steep Slope Facet

(i) Facet location

1- Facet type: steep slope (St)   2- Facet No. 2*

3- Pit No. 2*

(ii) General information

1- Sampler: M. Ass'ad   2- Date 20-12-1983

3- Parent material: collovial material derived from soft limestone and marl

4- Landuse: un cultivated

(iii) Topography

1- Altitude: 930 m   2- Slope angle: 19°

3- Aspect No. 45° to the west   4- Form:onvex-linear

(iv) Profile description

Horizon	Depth	
A1	0-20cm	Dark reddish brown (5YR 3/3)**; slightly gravelly loam; soft; very friable; slightly sticky; slightly plastic; moderate fine granular; common fine roots plus few medium woody roots; gravely 15%; pH 8.2; clear smooth boundary.
AB	20-35cm	Brown (7.5YR 5/4)**; slightly gravel loam, slightly hard; friable; slightly sticky; plastic; moderate very fine subangular blocky; gravel 22.2%; pH 8.2; clear smooth boundary.
B_2	35-45cm	Brown (7.5 YR 5/4)**; slightly gravelly loam, slightly hard; friable; sticky; plastic; moderate very fine subangular blocky; gravel 22.2%; pH 8.2; solum depth 45cm.
C	45+	Soft limestone.

* number on associated map

** color for moist sample

3. <u>Terrace</u>

(i) Facet location

1- Facet type: Terrace (Te)   2- Facet No. 1*

3- Pit No. 1*

(ii) General information

1- Sampler: M. Ass'ad   2- Date: 12-21-1983

3- Parent material:collovial material derived from soft lime + marl.

4- Landuse: Dry farming (Alomonds).

(iii) Topography

1- Altitude 810 m   2- Slope angle 1.5^{o}

3- Form of slope: Concave linear.

(iv) Profile description:

Horizon	Depth	
A_p	0.15cm	Dark reddish brown (5YR 3/4)**; slightly gravelly clay loam; soft; very friable; sticky; slightly plastic; moderate fine granular; few fine roots; gravel 17.3%, pH 8.2; clear smooth boundary.
B_1	15-25cm	Reddish brown (5YR 4/3)**; clay loam; slightly hard; friable; sticky; plastic; moderate very fine subangular blocky, few medium woody roots; gravel 10%; pH 8.4; clear smooth boundary.
B_2	25-45cm	Brown to dary brown (7.5 YR 4/4)**; clay loam; slightly hard; friable; very sticky; very plastic; moderate very fine angular blocky; gravel 10%; pH 8.4; solum depth more than 100 cm.

---

* number on associated map.

** color for moist sample.

4. Moderate slope facet

(i) Facet location

1- Facet type: Moderate slope (Mo) 2- Facet No. 10*

3- Pit No. 3*

(ii) General informations:-

1- Sampler: M. Ass'ad 2- Date: 2-11-1984

3- Parent material: Collovial material derived from soft limestone.

4- Landuse Uncultivated

(iii) Topography

1- Altitude 720 m 2- Slope angle 10.5°

3- Aspect No. 105° to west 4- Form: Convex-linear

(iv) Profile description

Horizon	Depth	
A_1	0-17cm	Brown to dark brown (7.5YR 4/4)**; gravelly loam; slightly hard; very friable slightly sticky; slightly plastic; moderatly fine granular; common fine roots gravel 32.4%; pH 8.3; abrupt smooth boundary.
B_1	17-30cm	Brown (7.5 YR 5/4)**; gravelly loam; slightly hard; very friable; slightly sticky; slightly plastic; weak very fine subangular; few medium woody roots; gravel 33.5%, pH 8.2; clear smooth boundary.
B_2	30-45cm	Brown (7.5YR 5/4)**; gravelly loam; slightly hard; very friable; slightly sticky; slightly plastic; weak very fine subangular blocky; gravel 33.5%; pH 8.2; solum depth 80cm.

* number or associated map.

** color for moist samples.

5. Gentle slope facet

(i) Facet location

1- Facet type: Gentle slope (Ge) 2- Facet No. 7*

3- Pit No: 2*

(ii) General information

1- Sampler: M. Assa'd 2- Date: 2-2-1984

3- Parent material: Alluvial matterial derived mainly from soft limestone and marl

4- Landuse: Dry farming (wheat, and tobaco).

(iii) Topography

1- Altitude: 675 m 2- Slope angle: 3^{o}

3- Form of slope: Linear.

(iv) Profile description

Horizon	Depth	
A_p	0-20cm	Reddish brown (5YR 4/4)**; clay; slightly hard; very friable; sticky; plastic; moderately fine granular, common fine roots; relatively free from gravel 0.8%; pH 8.5; clear smooth boundary.
B_{21}	20-40cm	Reddish brown (5YR 4 4)**; clay; hard; very friable; sticky; plastic; strong coarse angular blocky; free from gravel 0.6%; pH 8.6; clear smooth boundary.
B_{22}	40 +	Reddish brown (5YR 4/4)**; clay; very hard; very friable; very sticky; very plastic; strong very coars angular blocky, free from gravel 0.6%; having cracks 1-1.5cm wide and 30-50cm depth; pH 8.6; solum depth more than 100cm.

* number on associated map.

** color for moist sample.

6. Plain facet

(i) Facet location

1- Facet type: plain (Pl)   2- Facet No. 1*

3- Pit No. 1*

(ii) General information

1- Sampler: M. Assa'd   2- Date: 2-17-1984

3- Parent material: Alluvial material derived mainly from soft limestone and marl.

4- Landuse: irrigated vegetables (Potato, beans, Lettuce).

(iii) Topography:

1- Altitude 650 m   2- Slope angle 2^{o}

3- Form of slope: Linear

(iv) Profile description

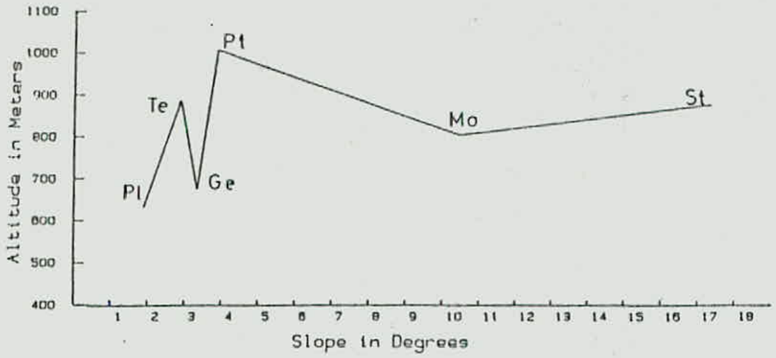
Horizon	Depth	
A_p	0-20cm	Reddish brown (5YR 4/3)**; clay; hard; very friable; sticky; plastic; moderate fine granular, common fine roots; relatively free from gravel 0.7%; pH 8.6; clear wavey boundary.
B_{21}	20-40cm	Reddish brown (5YR 4/3)**; clay; hard; very friable; very sticky; very plastic; strong coarse angular blocky; free from gravel 0.3; pH 8.4; clear smooth boundary.
B_{22}	40 +	Reddish brown (5YR 4/4)**; clay; very hard; very friable; very sticky; very plastic; strong very fine angular blocky; free from gravel 0.3%; having cracks 1-1.5cm wide and 30-50 cm depth; pH 8.4; solum depth more than 100cm.

* number on associated map.

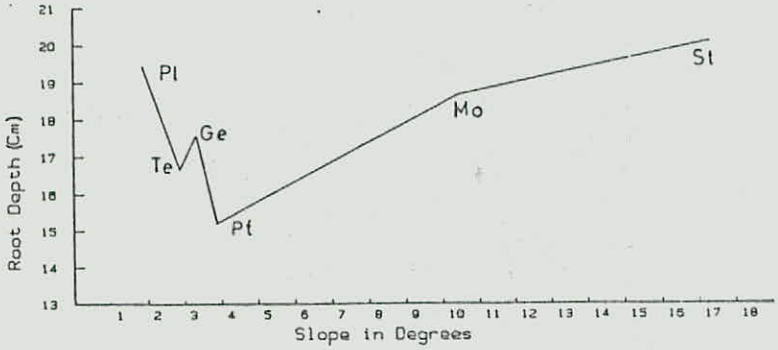
** color for moist sample.

APPENDEX C

A-



B-



C-

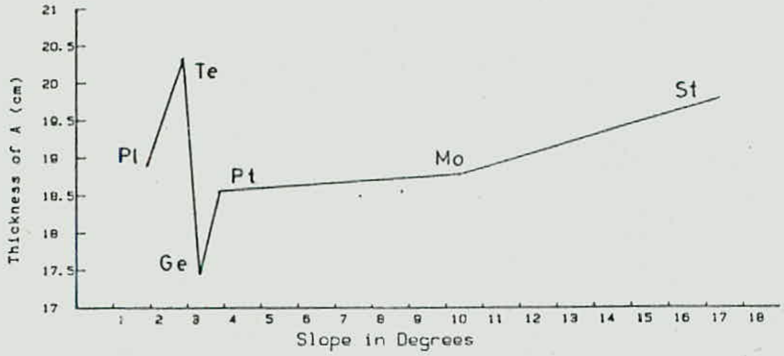


Fig.5 - The relationships between facets and their attributes.

A- Altitude.

B- rooting depth, and

C- thickness of horizon A.

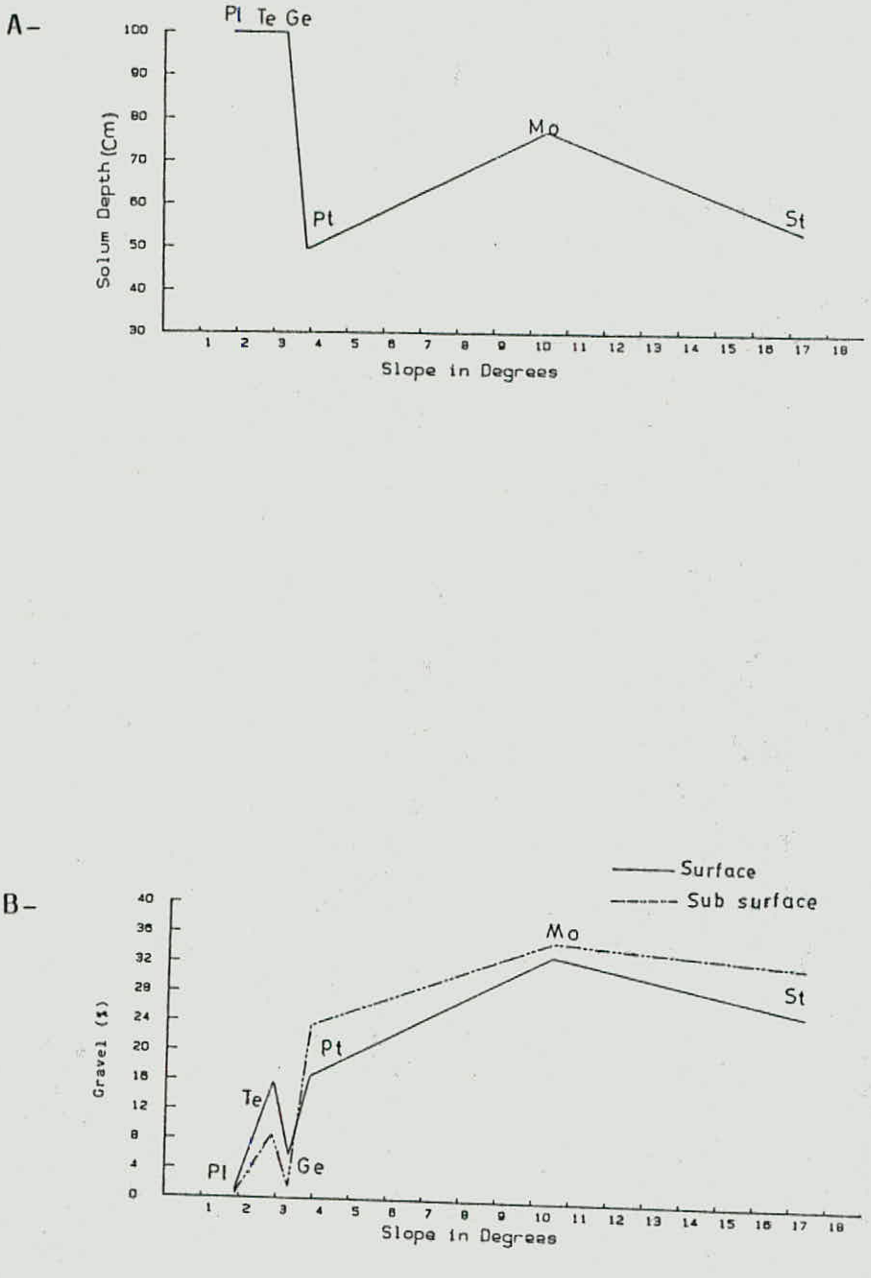


Fig. 6 - The relationships between facets and their attributes.

A- Solum depth, and

B- gravel content.

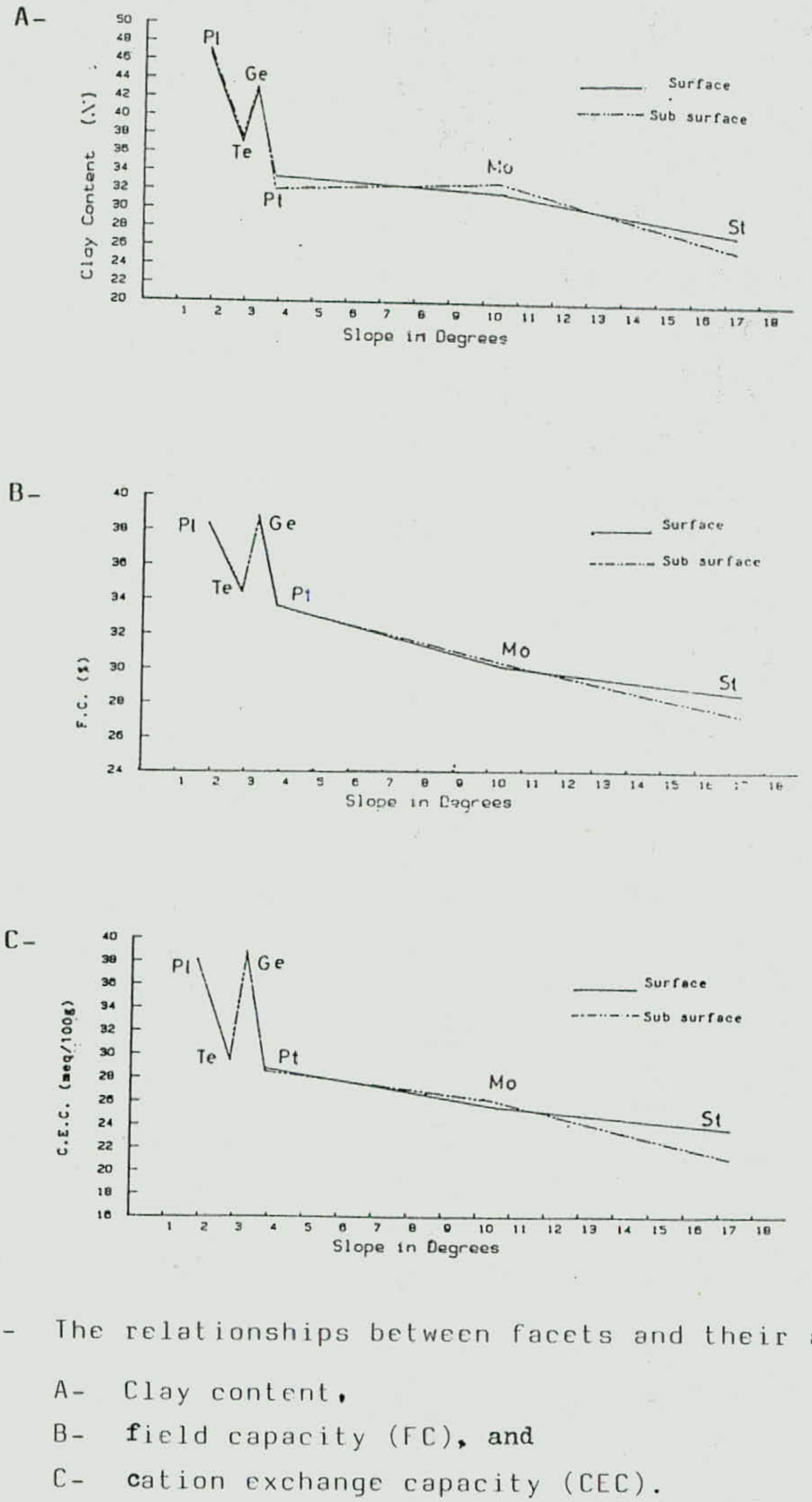


Fig.7 - The relationships between facets and their attributes

A- Clay content,

B- field capacity (FC), and

C- cation exchange capacity (CEC).

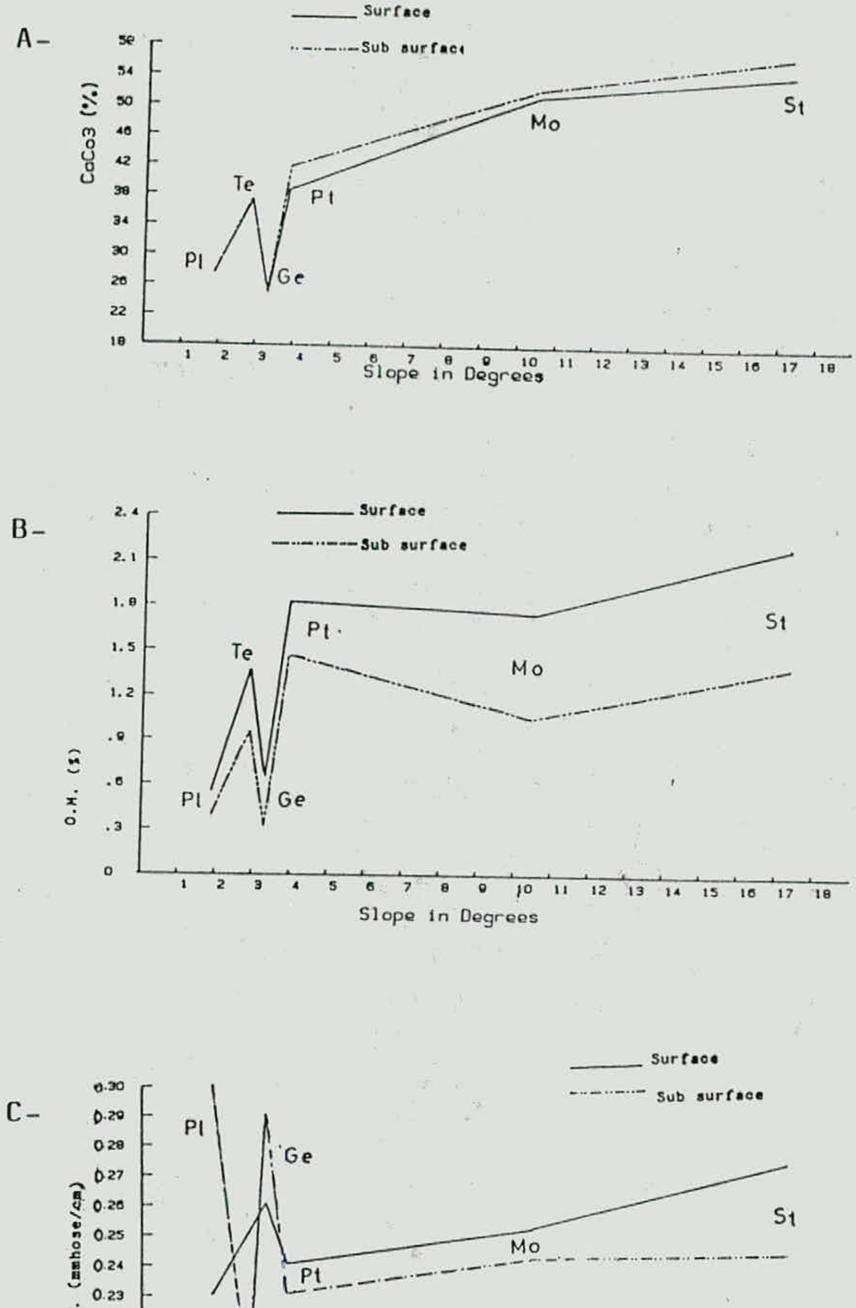


Fig. 8- The relationships between facets and their attributes:

A- Carbonate content,

B- organic matter (OM), and

C- electrical conductivity (EC).

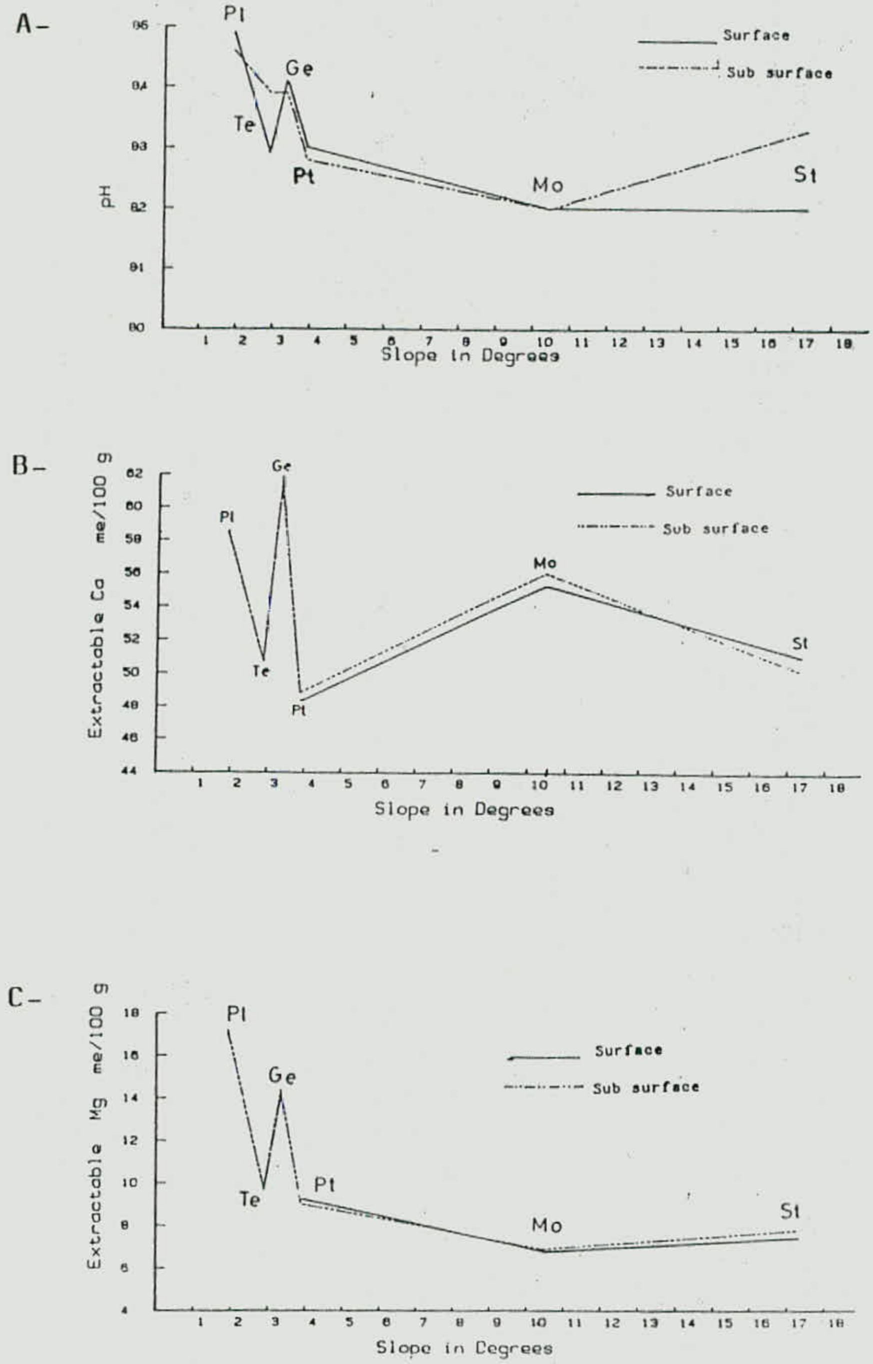


Fig. 9 - The relationships between facets and their attributes:

A- Soil reaction (pH),

B- extractable (Ca) ,and

C- extractable (Mg).

A-

B-

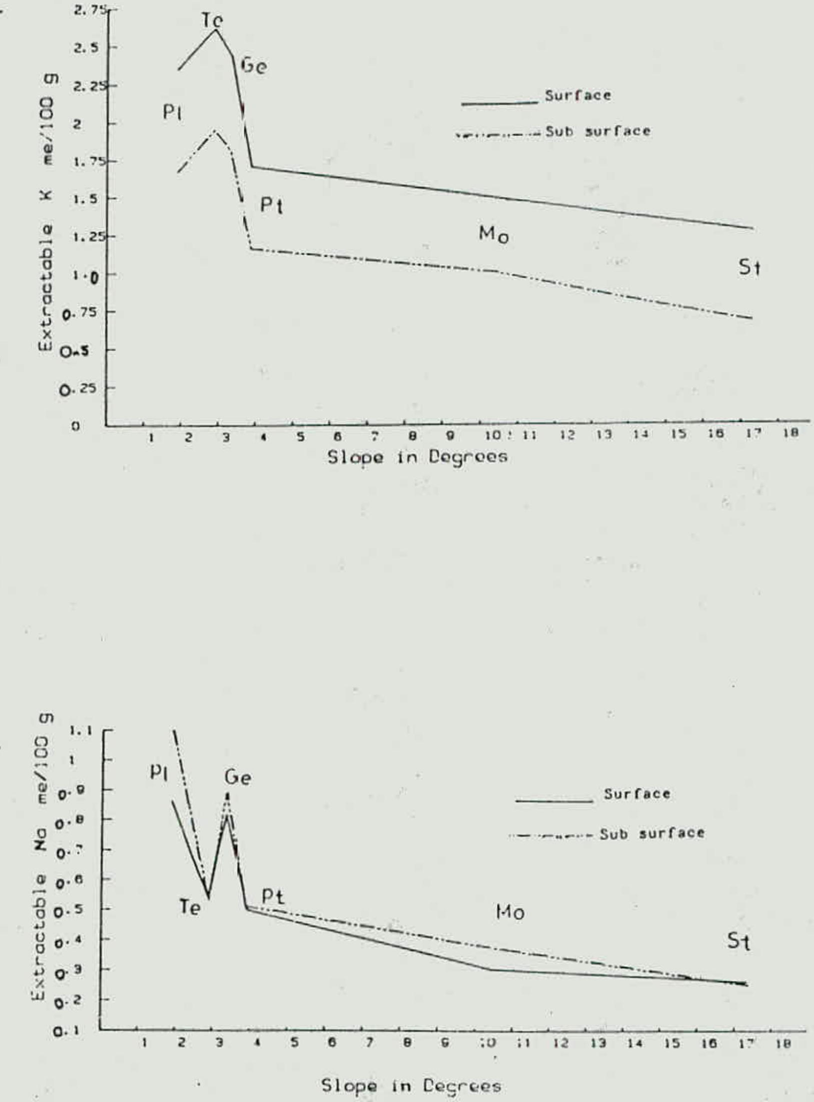


Fig. 10- The relationships between facets and their attributes:

A- Extractable K, and

B- extractable Na.

APPENDIX D

Figure | Page

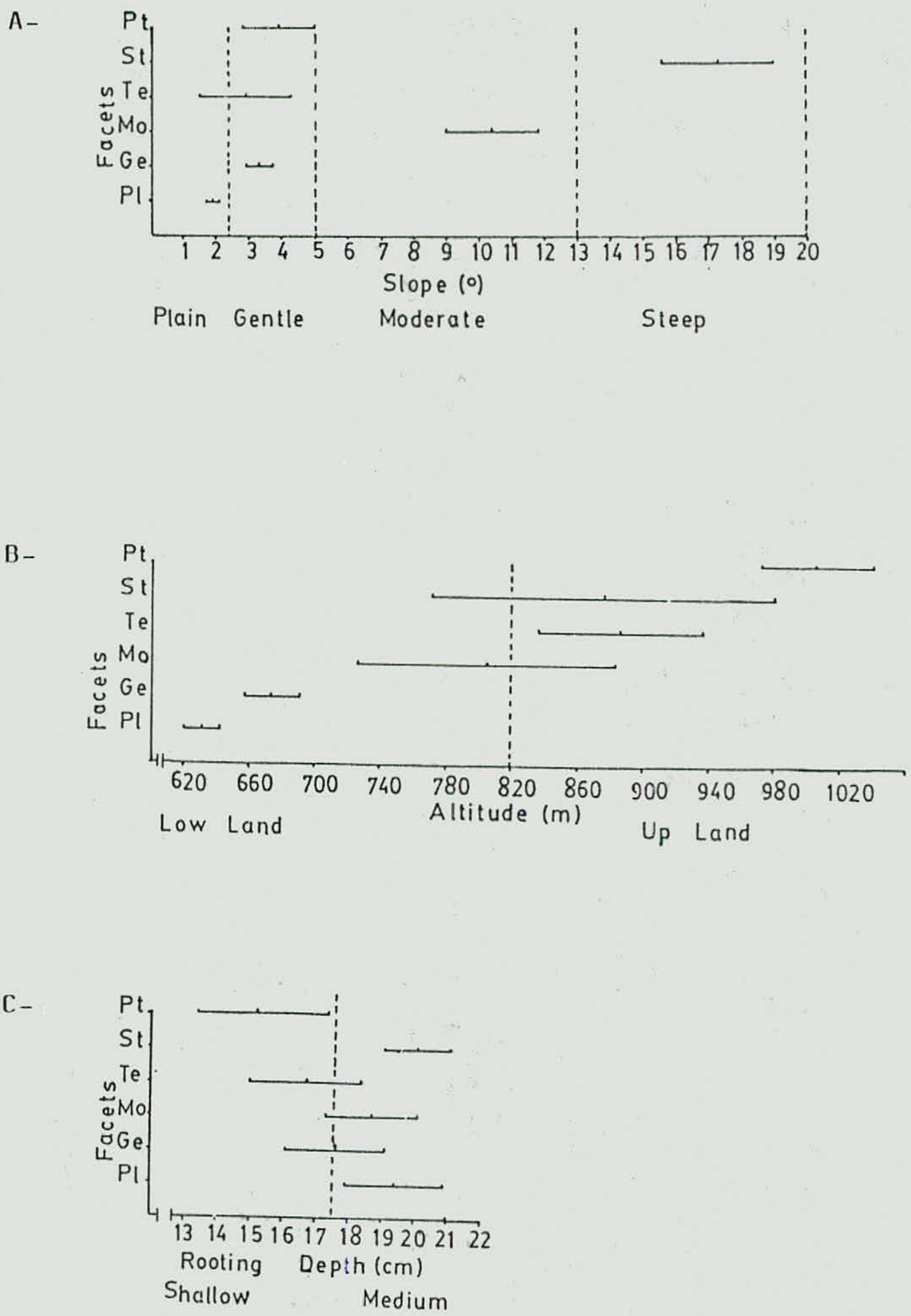


Fig. 11- Individual 95% confedence interval for facet means of:

A- Slope angle ,

B- altitude , and

C- rooting depth.

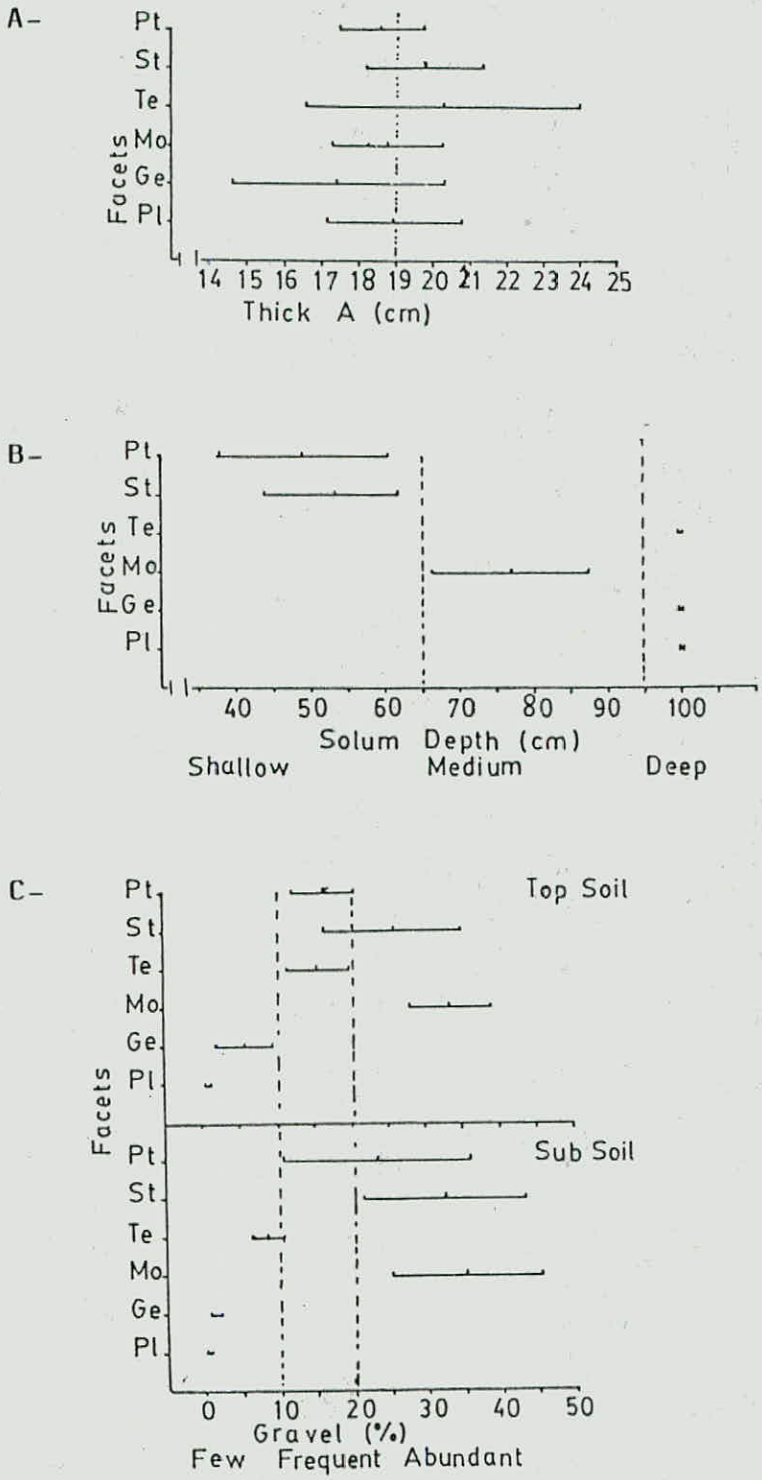


Fig.12- Individual 95% confidence interval for facet means of:

A- Thickness of horizon A ,

B- solum depth , and

C- travel content.

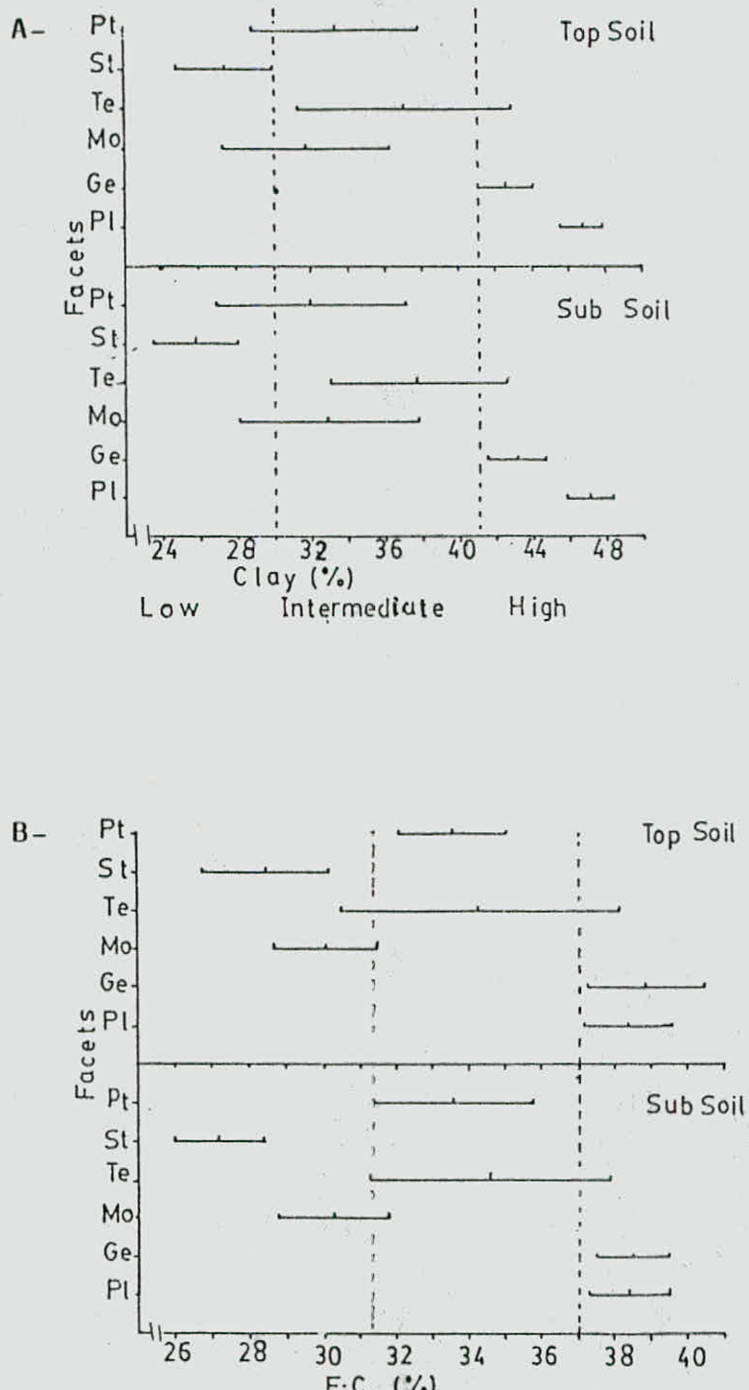


Fig. 13- Individual 95% confidence interval for facet means of:

A- Clay content , and

B- field capacity.

A-

B-

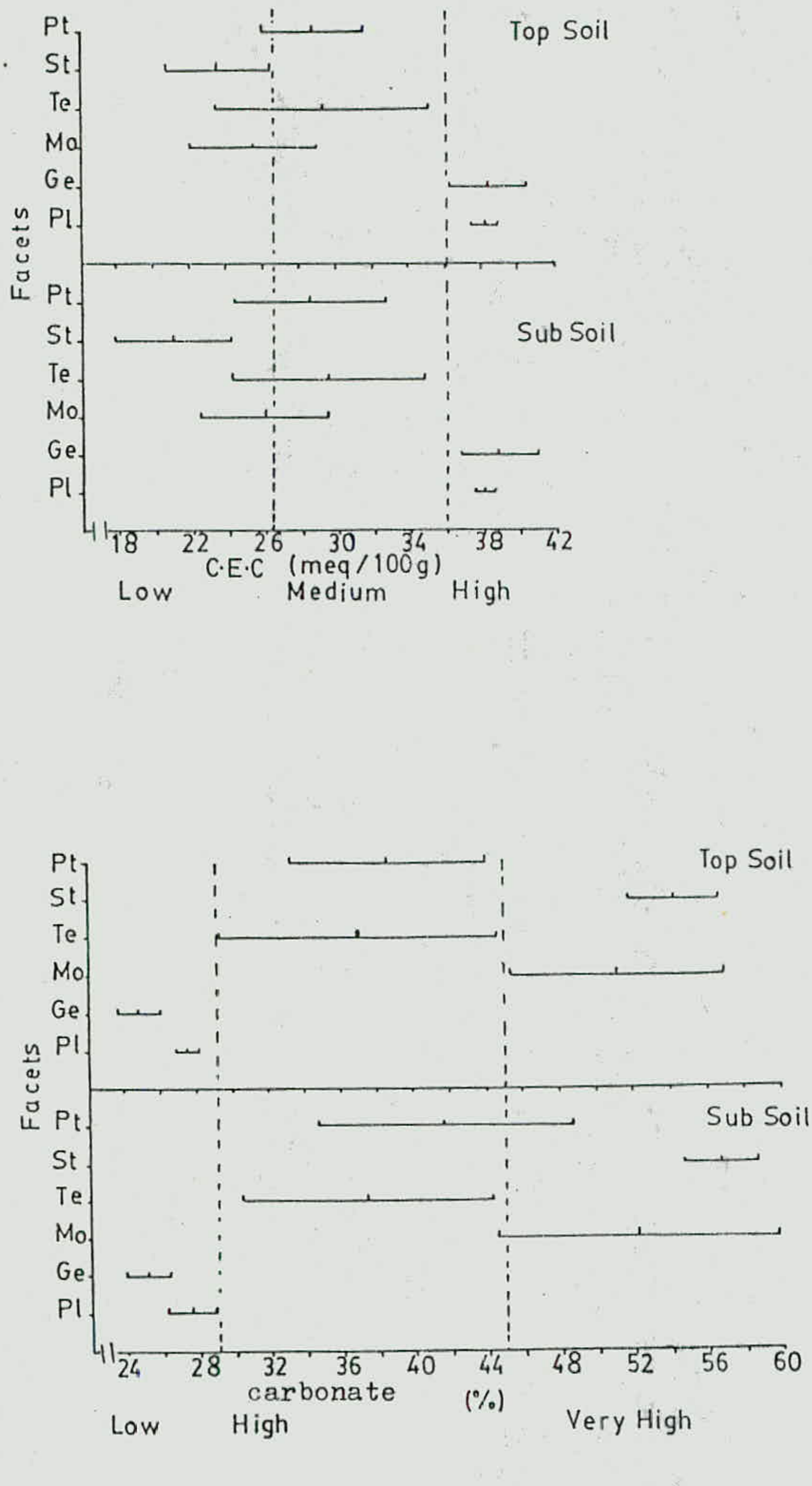


Fig. 14- Individual 95% confidence interval for facet means of:

A- Cation exchange capacity (CEC) , and

B- carbonate content.

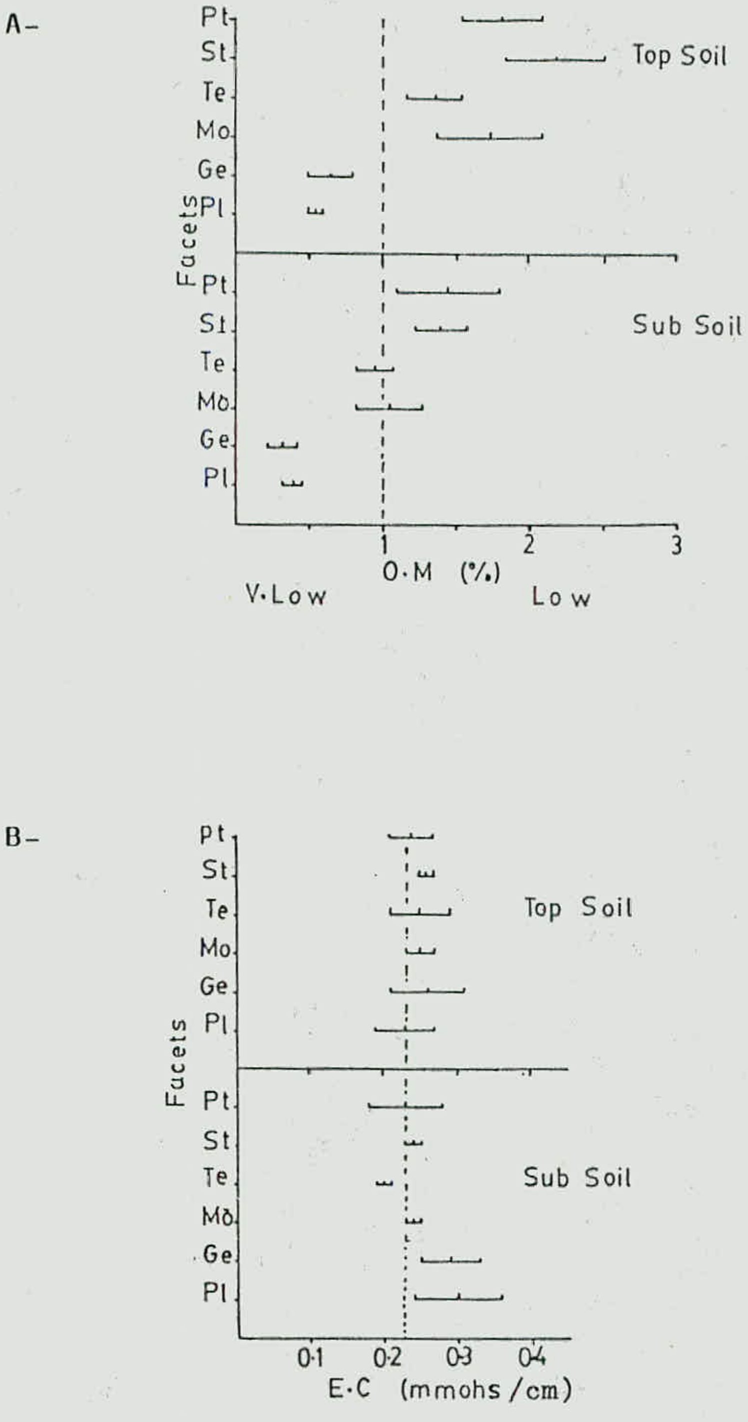


Fig. 15- Individual 95% confidence interval for facet means of:

A- Organic matter (OM), and

B- electric conductivity (EC).

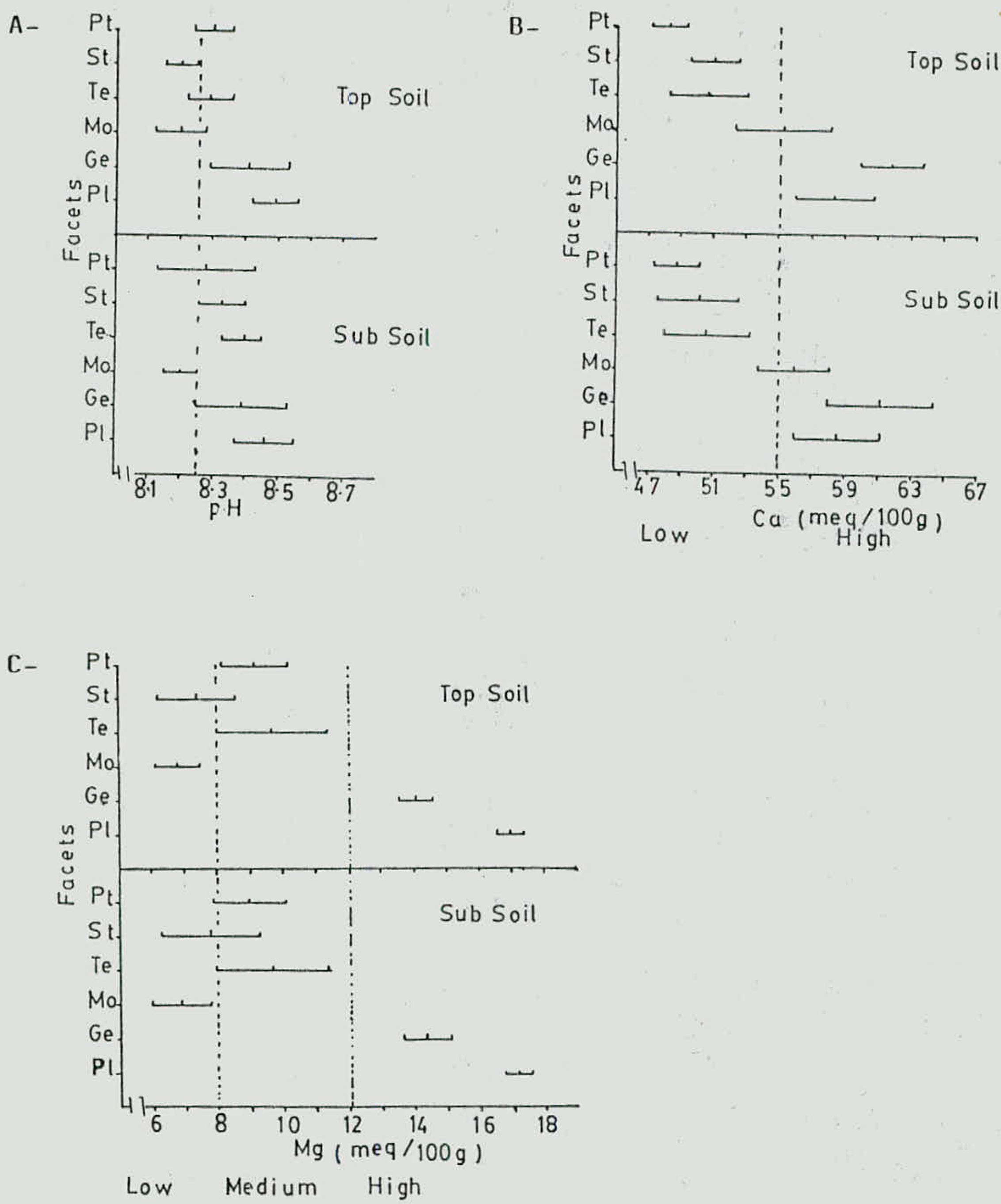


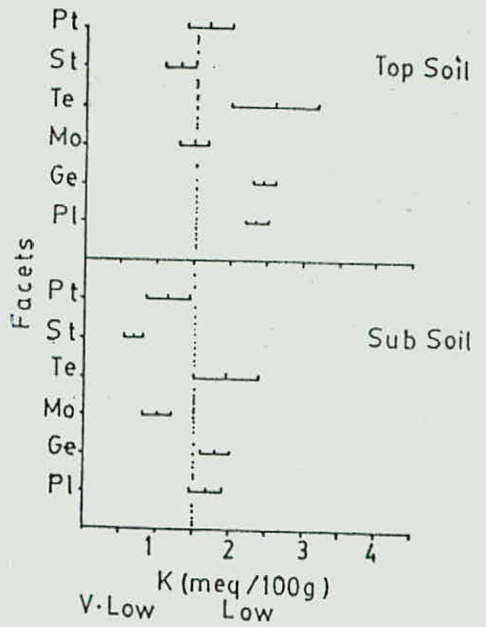
Fig. 16- Individual 95% confidence interval for facet means of:

A- Soil reaction (pH),

B- extractable Ca, and

C- extractable Mg.

A-



B-

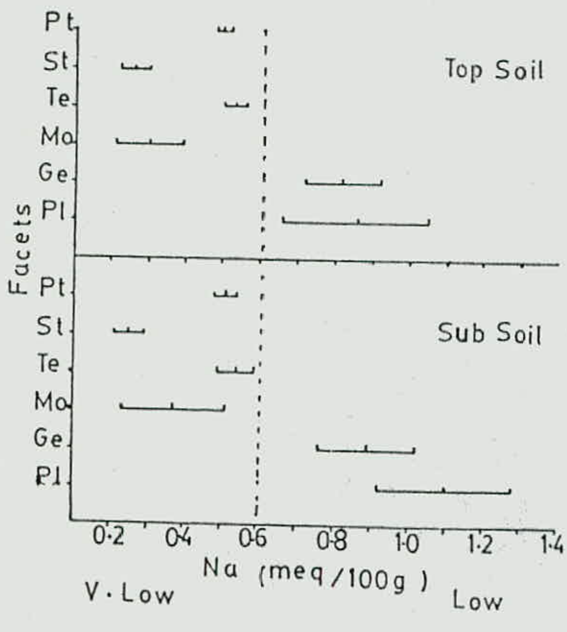


Fig. 17- Individual 95% confidence interval for facet means of:

A- Extractable K, and

B- extractable Na.

APPENDIX E

Table 16- Soil properties and site characteristics for plateau facet (Pt) measured on different recurrences, **for the surface layer.**

Recur. No.**		Pt2			Pt3			Pt6		
Obser. No.		1	2	3	1	2	3	1	2	3
Property										
Gravel	(%)	15.80	17.20	12.30	15.20	7.50	12.80	22.60	20.40	24.80
Clay	(%)	22.70	38.30	40.50	39.10	36.00	33.50	30.30	27.80	32.00
F C	(%)	30.49	35.35	36.40	33.69	34.58	31.12	32.68	32.92	35.37
C E C	(*)	23.80	31.00	34.90	31.40	29.10	25.20	27.40	25.20	30.80
Carbonate	(%)	44.20	34.70	28.40	27.20	40.50	41.60	45.00	46.10	40.90
O.M.	(%)	2.12	1.76	1.55	1.26	1.70	1.56	2.32	1.80	2.27
E C	(mmhos/cm)	0.33	0.25	0.21	0.22	0.22	0.22	0.23	0.23	0.25
pH		8.17	8.31	8.36	8.44	8.29	8.35	8.21	8.32	8.26
Ca	(*)	48.50	50.00	50.00	48.00	50.00	46.80	45.90	47.50	48.30
Mg	(*)	7.00	10.40	11.40	9.10	9.10	9.30	9.40	8.00	9.40
K	(*)	1.28	1.82	1.95	2.48	1.64	1.72	1.43	1.36	1.66
Na	(*)	0.47	0.57	0.54	0.51	0.48	0.47	0.49	0.48	0.50
Thick A	(cm)	20	17	20	16	18	20	18	20	18
Root depth	(cm)	13	12	14	13	16	15	18	18	18
Solum depth	(cm)	50	30	45	80	55	45	35	60	45
Slope	(o)	3	4	4	1	6	4	5	4	4
Altitude	(m)	1050	1050	1050	950	950	950	1020	1020	1020

*   me /100g soil
** number on associated map.

Table 17- Soil properties and site characteristics for plateau facet (Pt) measured on different recurrences, subsurface layer .

Recur. No.**	Pt2			Pt3			Pt6		
Obser. No.	1	2	3	1	2	3	1	2	3
Property									
Gravel (%)	25.80	19.30	15.30	8.80	7.50	13.60	50.60	18.60	51.90
Clay (%)	19.20	34.10	40.00	38.50	35.50	33.00	30.80	24.40	32.50
F C (%)	28.76	35.25	36.25	34.50	34.54	31.41	33.94	30.26	37.44
C E C (*)	20.00	32.70	34.40	30.80	29.10	24.60	28.00	21.80	34.80
Carbonate (%)	48.10	32.80	29.10	29.70	43.00	45.10	49.40	54.30	43.60
O M (%)	1.58	1.33	1.18	1.12	0.85	1.20	2.20	1.64	2.06
E C (mmhos/cm)	0.19	0.22	0.18	0.19	0.20	0.20	0.30	0.34	0.28
pH	8.51	8.13	8.38	8.36	8.50	8.44	8.05	8.00	8.19
Ca (*)	47.10	50.50	51.60	48.30	50.60	47.10	48.40	46.90	49.10
Mg (*)	6.50	9.80	11.30	8.90	9.00	9.10	9.40	7.40	9.60
K (*)	0.83	1.25	1.46	2.07	0.95	1.14	0.99	0.67	1.10
Na (*)	0.46	0.50	0.51	0.54	0.51	0.47	0.57	0.51	0.55

* me. /100g soil
** number on associated map.

Table 18 —Soil properties and site characteristics for steep slope (St) facet measured on different recurrences, **for the surface soil**

Recurr. No.**		St2			St6			St12		
Obser. No.		1	2	3	1	2	3	1	2	3
Property										
Gravel	(%)	29.30	15.20	16.00	16.40	18.20	20.00	28.40	45.70	44.20
Glay	(%)	34.00	24.70	28.60	26.80	24.40	30.50	23.10	27.90	26.80
F C	(%)	29.12	27.82	28.87	27.54	27.65	33.33	25.03	28.57	28.08
C E C	(*)	26.40	23.50	24.00	22.40	18.00	27.70	17.40	26.00	26.30
Carbonate	(%)	52.90	57.50	56.40	54.50	57.50	50.00	57.50	50.70	51.70
O M	(%)	1.99	2.86	2.07	2.42	2.22	2.73	1.43	2.13	1.88
E C	(mmhos/cm)	0.25	0.25	0.26	0.28	0.27	0.29	0.29	0.26	0.25
pH		8.20	8.22	8.12	8.18	8.17	8.13	8.19	8.32	8.30
Ca	(*)	52.10	50.90	48.30	51.40	50.50	52.30	48.10	51.70	54.30
Mg	(*)	6.90	4.60	9.10	6.50	7.20	8.10	8.20	9.80	6.30
K	(*)	1.36	1.23	1.06	1.50	1.00	1.66	0.77	1.50	1.36
Na	(*)	0.24	0.22	0.22	0.24	0.23	0.27	0.27	0.38	0.27
Thick	(cm)	23	20	21	15	20	20	20	19	20
Root depth	(cm)	23	20	20	20	20	20	20	20	18
Solum depth	(cm)	60	60	60	30	45	60	60	60	45
Slope	(o)	15	19	19	14	16	16	18	18	21
Altitude	(m)	1000	1000	1000	930	930	930	700	700	700

* me. /100g soil.

** number on associated map.

Tabl 19- Soil properties for steep slope facet(St), measured on different recurrences, for the subsurface layer

Recur. No**.		St2			St6			St12	
Obser. No.	1	2	3	1	2	3	1	2	3
Property									
Gravel (%)	40.60	22.20	19.70	15.00	32.20	60.40	23.50	42.20	36.40
Clay (%)	31.10	23.20	25.40	27.30	24.00	22.00	23.40	27.00	28.50
F.C. (%)	26.08	24.36	27.50	27.77	27.46	27.36	26.39	27.61	30.48
C.E.C. (*)	25.10	19.50	18.00	19.40	18.30	19.40	16.10	25.00	28.20
Carbonate (*)	54.60	58.00	58.30	57.40	57.90	58.20	59.90	53.60	52.20
O.M. (%)	1.31	1.56	1.29	1.42	1.65	1.78	1.11	1.21	1.22
E.C.(mmhos/cm)	0·22	0.22	0.27	0.25	0.22	0.26	0,23	0.27	0.23
pH	8.32	8.26	8.41	8.12	8.38	8.38	8.37	8.40	8.33
Ca (*)	51.90	47.40	50.00	49.90	47.60	49.30	46.10	56.60	53.10
Mg (*)	6.80	6.60	7.20	7.20	7.40	6.00	8.30	12.50	8.00
K (*)	0.76	1.00	0.56	0.54	0.56	0.51	0.51	0.72	0.83
Na (*)	0.22	0.19	0.23	0.24	0.23	0.23	0.24	0.38	0.28

* me /100g soil

** number on associated map

Table 20 —Soil properties and site characteristics for terrace facet (Te) measured on different recurrences, for the surface layer.

Recure. No.**		Te1			Te5			Te17		
Obser. No.		1	2	3	1	2	3	1	2	3
Property										
Gravel	(%)	17.30	12.20	11.80	12.30	11.30	9.20	23.90	22.50	21.00
Clay	(%)	37.00	41.30	36.00	40.30	48.00	46.00	28.80	28.00	28.50
F.C	(%)	33.95	35.81	33.25	35.75	42.44	40.95	28.67	28.45	29.72
C E C	(*)	30.00	34.40	27.70	33.30	39.40	38.30	20.50	20.00	20.20
Carbonate	(%)	39.50	34.30	44.80	24.60	24.80	25.30	46.40	49.40	44.10
O M	(%)	1.58	1.71	1.62	1.60	1.09	1.17	1.12	1.31	1.14
E C	(mmhos/cm)	0.24	0.24	0.23	0.27	0.20	0.36	0.22	0.21	0.25
pH		8.23	8.23	8.32	8.28	8.33	8.10	8.39	8.33	8.37
Ca	(*)	52.90	55.10	51.30	51.90	52.60	51.90	48.10	45.60	46.90
Mg	(*)	10.00	8.90	7.30	10.00	14.00	12.60	7.90	8.50	8.40
K	(*)	2.30	2.56	2.28	3.17	2.82	4.38	1.79	1.98	2.32
Na	(*)	0.50	0.55	0.49	0.59	0.57	0.58	0.50	0.50	0.48
Thick .A. horizon	(cm)	15	26	25	14	22	20	15	26	20
Root depth	(cm)	15	15	15	14	17	17	17	20	20
Solum depth	(cm)	100	100	100	100	100	100	100	100	100
Slope	(o)	2	2	3	1	2	1	4	6	5
Altitude	(m)	810	810	812	960	960	960	890	890	890

* me/100g soil

** number on assoicated map.

Table21 —Soil properties and site characteristics for terrace facet (Te) measured on different recurrences, **for subsurface soil.**

Recur. No.**		Te1			Te5			Te 17		
Obser. No.		1	2	3	1	2	3	1	2	3
Property										
Gravel	(%)	10.10	8.00	10.10	6.70	3.10	7.10	11.40	11.50	9.30
Clay	(%)	39.10	39.20	38.10	40.50	47.00	45.00	31.80	28.40	30.30
F C	(%)	32.78	36.01	32.65	35.41	41.99	40.32	32.32	28.65	31.03
C E C	(*)	30.00	34.40	27.70	33.30	38.80	37.10	22.70	20.20	21.60
Carbonate	(%)	41.70	39.80	42.50	26.70	25.50	25.50	44.50	48.50	42.20
O M	(%)	1.24	1.19	0.89	0.90	0.90	0.98	0.79	0.82	0.87
E C	(mmhos/cm)	0.19	0.21	0.21	0.20	0.18	0.19	0.21	0.22	0.21
pH		8.35	8.30	8.27	8.40	8.56	8.39	8.44	8.41	8.38
Ca	(*)	53.30	55.10	51.30	52.50	52.50	51.30	48.60	44.40	47.00
Mg	(*)	8.60	8.40	7.30	10.60	13.80	12.50	8.30	8.90	8.80
K	(*)	1.51	1.84	2.11	2.28	1.72	3.15	1.28	1.49	2.19
Na	(*)	0.49	0.50	0.49	0.64	0.58	0.59	0.57	0.50	0.51

* me /100g soil
** number on assoicated map.

Table 22 —Soil properties and site characteristics for moderate slope facet (Mo), measured on different recurrences, for the surface layer

Recur. No.**		Mo 3			Mo 6			Mo 10		
Obser. No.		1	2	3	1	2	3	1	2	3
Property										
Gravel	(%)	25.50	25.20	25.80	40.80	41.30	43.40	35.00	31.50	32.40
Glay	(%)	30.00	25.50	29.20	27.90	45.80	30.90	28.60	34.00	34.00
F C	(%)	30.01	31.83	28.70	28.97	33.46	30.42	27.55	28.87	30.61
C E C	(*)	25.30	31.10	23.10	20.30	32.60	22.60	20.10	27.70	26.90
Carbonate	(%)	52.80	48.70	56.50	63.30	37.60	57.90	51.70	44.80	47.80
O M	(%)	2.00	2.78	1.77	1.52	1.83	1.60	1.48	1.06	1.65
E C	(mmhos/cm)	0.24	0.32	0.28	0.22	0.23	0.27	0.23	0.23	0.24
pH		8.13	8.04	8.21	8.20	8.26	8.16	8.27	8.37	8.27
Ca	(*)	52.80	54.70	51.30	50.10	58.70	55.10	54.50	58.10	62.00
Mg	(*)	6.10	7.90	5.40	7.50	7.90	6.00	6.00	7.30	7.20
K	(*)	1.79	1.51	1.82	1.28	1.72	1.36	1.15	1.36	1.43
Na	(*)	0.25	0.23	0.27	0.24	0.32	0.28	0.25	0.61	0.22
Thick A.	(cm)	20	18	20	21	20	20	15	18	17
Root depth	(cm)	20	20	20	20	20	18	15	18	17
Solum depth	(cm)	85	58	88	87	75	50	85	85	80
Slope	(o)	12	10	9	13	8	12	11	8	11
Altitude	(m)	920	940	950	730	760	790	720	720	720

* me /100g soil
** number on assoicated map.

Table 23—Soil properties and site characteristics for moderate slope facet (Mo), measured on different recurrences, subsurface layer.

Recur. No.**		Mo 3			Mo 6			Mo 10		
Obser. No.		1	2	3	1	2	3	1	2	3
Property										
Gravel	(%)	20.00	21.50	22.20	57.60	31.40	38.10	46.80	47.00	33.50
Clay	(%)	31.00	25.30	31.80	29.50	45.50	26.00	34.00	38.30	34.80
F C	(%)	30.23	29.47	29.64	31.32	33.49	27.12	28.79	32.50	30.11
C E C	(*)	25.80	25.30	25.30	23.00	34.70	18.50	23.90	30.50	27.20
Carbonate	(%)	53.20	59.10	57.70	63.00	37.50	64.50	47.60	38.30	48.50
O M	(%)	0.75	1.80	1.10	1.08	1.05	0.85	0.95	0.91	0.99
E C	(mmhos/cm)	0.22	0.29	0.23	0.24	0.26	0.23	0.22	0.24	0.24
pH		8.19	8.15	8.10	8.19	8.19	8.15	8.26	8.35	8.25
Ca	(*)	53.40	55.00	52.30	53.90	58.80	55.50	55.40	60.70	59.40
Mg	(*)	5.60	5.60	6.40	7.60	8.90	6.80	5.50	8.30	7.40
K	(*)	1.51	0.83	1.25	1.00	1.18	0.54	0.83	1.10	0.83
Na	(*)	0.22	0.22	0.24	0.38	0.30	0.30	0.30	0.70	0.65

*   me /100g soil

** number on assoicated map.

Table 24 —Soil properties and site characteristics for gentle slope facet (Ge) measured on different recurrences, **for surface layer.**

Recur. No.**		Ge 3			Ge 5			Ge 7		
Obser. No.		1	2	3	1	2	3	1	2	3
Property										
Gravel	(%)	8.40	8.90	9.00	8.50	7.40	5.80	1.90	0.80	1.10
Clay	(%)	44.00	42.00	46.50	41.70	41.50	39.80	42.40	43.00	42.80
F C	(%)	40.53	41.03	42.61	36.33	37.57	36.69	38.36	38.39	38.18
C E C	(*)	41.60	41.10	42.70	36.60	37.10	34.90	36.60	37.20	37.40
Carbonate	(%)	22.60	26.40	23.10	25.10	23.20	25.70	26.30	26.20	25.00
O M	(%)	0.98	0.93	0.63	0.60	0.77	0.56	0.54	0.46	0.39
E C	(mmhos/cm)	0.40	0.28	0.30	0.24	0.22	0.20	0.21	0.21	0.24
pH		8.16	8.30	8.29	8.42	8.34	8.50	8.59	8.50	8.58
Ca	(*)	65.80	60.90	63.40	57.90	59.50	60.70	63.40	61.80	63.90
Mg	(*)	13.90	14.70	15.00	15.00	14.00	13.50	13.20	13.80	13.40
K	(*)	2.08	2.43	2.43	2.61	2.53	2.57	2.69	2.34	2.28
Na	(*)	0.95	0.85	0.77	0.70	0.71	0.63	0.85	0.94	0.99
Thick A	(cm)	25	12	15	17	18	19	15	20	16
Root depth	(cm)	20	15	15	17	18	19	18	20	16
Solum depth	(cm)	100	100	100	100	100	100	100	100	100
Slope	(o)	3	4	3	4	4	3	3	3	3
Altitude	(m)	700	700	700	655	650	645	665	675	680

* me /100g soil

** number on assoicated map.

Table 25 —Soil properties and site characteristics for gentle slope facet (Ge) on different recurrences, **for subsurface layer**

Recur. No.**	Ge 3			Ge 5			Ge 7		
Obser. No.	1	2	3	1	2	3	1	2	3
Property									
Gravel (%)	1.20	1.40	2.70	2.60	2.40	2.20	0.50	0.60	0.50
Clay (%)	45.50	44.00	46.50	41.80	40.00	40.50	43.50	43.40	43.00
F C (%)	40.37	39.44	39.87	36.70	37.35	36.83	38.68	38.51	38.55
C E C (*)	42.70	41.60	42.70	37.10	36.60	36.10	37.70	37.50	37.70
Carbonate (%)	22.60	26.60	22.90	25.90	24.90	25.80	26.90	26.10	24.80
O M (%)	0.43	0.36	0.36	0.39	0.48	0.27	0.23	0.13	0.26
E C (mmhos /cm)	0.37	0.31	0.33	0.30	0.26	0.22	0.22	0.25	0.34
pH	8.14	8.26	8.19	8.30	8.41	8.45	8.52	8.61	8.65
Ca (*)	68.10	63.10	62.30	59.70	60.20	63.20	60.60	52.40	62.10
Mg (*)	14.50	13.40	14.70	14.80	13.80	14.20	16.10	13.30	14.50
K (*)	1.41	1.51	1.95	2.07	1.92	1.77	1.79	1.95	1.88
Na (*)	0.95	0.95	0.70	0.75	0.71	0.83	1.12	0.87	1.15

* me /100g soil
** number on associated map.

Table 26 –Soil prperties and site characteristics for plain facet (Pl),measured on different recurrences, **for the surface layer.**

Recur. No.**		Pl 1			Pl 3			Pl 4		
Obser. No.		1	2	3	1	2	3	1	2	3
Property										
Gravel	(%)	0.70	1.90	1.00	1.00	1.00	1.00	0.80	0.70	0.70
Clay	(%)	45.80	48.00	43.50	46.30	46.20	47.00	47.30	48.30	48.00
F C	(%)	37.40	39.63	36.34	36.00	37.31	39.24	39.71	40.20	39.63
C E C	(*)	38.30	39.90	37.20	37.40	37.70	37.70	37.70	38.80	38.80
Carbonate	(%)	27.60	27.50	28.20	27.90	26.90	28.70	27.80	26.30	26.80
O M	(%)	0.58	0.71	0.50	0.50	0.50	0.55	0.55	0.55	0.49
E C	(mmhos/cm)	0.26	0.34	0.18	0.18	0.20	0.21	0.24	0.21	0.25
pH		8.57	8.39	8.67	8.57	8.47	8.44	8.41	8.44	8.48
Ca	(*)	62.40	61.50	60.60	60.80	59.40	56.10	55.90	54.90	54.40
Mg	(*)	16.20	17.00	17.40	16.90	17.80	16.30	17.10	17.30	17.10
K	(*)	2.24	2.51	2.07	2.19	2.20	2.48	2.50	2.48	2.48
Na	(*)	1.22	1.33	0.80	0.76	0.76	0.73	0.70	0.63	0.82
Thick. A	(cm)	20	22	20	15	20	20	18	15	20
Root depth	(cm)	20	22	20	20	20	20	18	15	20
Solum depth	(cm)	100	100	100	100	100	100	100	100	100
Slope	(o)	2	2	2	2	2	2	2	1	2
Altitude	(m)	650	650	635	610	625	640	618	622	630

* me. /100g soil
** number on assoicated map.

Table 27- Soil properties and site characteristics for plain facet (Pl) measured on different recurrences, for the subsurface layer

Recur. No.**		Pl 1			Pl 3			Pl 4		
Obser. No.		1	2	3	1	2	3	1	2	3
Property										
Gravel	(%)	0.30	1.50	0.20	0.50	0.40	0.50	0.40	0.30	0.20
Clay	(%)	46.30	46.20	44.00	49.00	46.20	47.20	48.30	48.50	48.50
F C	(%)	37.49	38.03	36.47	36.38	38.10	39.19	40.12	39.85	39.79
C E C	(*)	38.80	38.30	37.40	37.70	37.20	37.70	38.80	38.80	38.80
Carbonate	(%)	29.90	27.30	29.40	27.30	29.40	27.80	24.80	26.30	26.00
O M	(%)	0.30	0.35	0.23	0.36	0.42	0.49	0.49	0.47	0.44
E C (mmhos/cm)		0.34	0.49	0.25	0.21	0.29	0.25	0.28	0.27	29.00
pH		8.39	8.27	8.61	8.63	8.39	8.51	8.45	8.42	8.50
Ca	(*)	63.00	62.10	60.10	60.80	60.90	55.40	55.40	54.80	54.80
Mg	(*)	17.00	17.30	17.70	17.70	17.30	16.20	17.60	16.80	17.10
K	(*)	1.31	1.36	1.46	1.51	1.66	1.88	1.77	2.19	1.88
Na	(*)	1.40	1.40	1.05	1.00	0.98	0.91	1.05	0.78	1.34

* me /100g soil
** number on associated map.