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PHYSICAL, CHEMICAL & MINERALOGICAL CHARACTERISTICS OF SOME SELECTED GARDUD SOILS OF KORDOFAN REGION

BY

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We regret that some of the pages in this report may not be up to the proper legibility standards, even though the best possible copy was used for scanning

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خلاصة الأطروحة

لقد حظيت أراضى القردود بإهتمام كبير مؤخرا كبديل أساسى وأوحد لأراضى القيزان التى أنهكت تماما.

يكتنف أراضى القردود كثيرا من الغموض ونقص كبير فى المعلومات الخاصة بها. تم إختيار أربع مواقع مختلفة إعتمادا على متوسط سقوط الأمطار وهى البرداب، أم جمالة، النهود، سودرى لهذه الدراسة .

حيث تم حفر قطاعين بكل موقع يمثلان الأراضى المرتفعة والمنخفضة وكذلك أخذ عينات مركبة (Composite Sample) بغرض تمثيل المنطقة بين القطاعين .

أجريت دراسات مرفولوجية، كيميائية، فيزيائية ومنرولوجية للتربة . أهم الإختبارات الكيميائية هى درجة الحموضة (pH) ، التوصيل الكهربى (E.C) ، السعة التبادلية الكاتيونية (C.E.C) ، العناصر الغذائية الصغرى ، أكاسيد الحديد ، النسبة المئوية للفوسفور (PO_5%) ، كربونات الكالسيوم ($CaCo_3$) ، الكاتيونات والأيونات الذائبة ، المادة العضوية (O.M) ، النتروجين المئوي (N%) ، نسبة الكربون: النتروجين (C/N Ratio) ، نسبة الصوديوم المدمص S.A.R، النسبة المئوية للتشبع القاعدى (B.s%) .

أما أهم الخصائص الفيزيائية فقد إشتملت على التوزيع الحجمى للحبيبات ، الكثافة الظاهرية والحقيقية (D_B, D_P) ، المسامية ، بناء التربة ، التوصيل الهايدروليكى ومعدل التسرب.

أما معادن الطين والرمل فقد تم تحديدهما مستخدمين أشعة إكس (X.Ray diffraction) والميكروسكوب (Polorizing microscope) على التوالي.

أوضحت النتائج تباينا داخل وبين أراضى القردود المختلفة (أراضى قردود ، أراضى تشبه أراضى القردود) تبعا لتأثيرى المناخ والتبوغرافيا . الكاولنيت، المونتموريللونيت والاليت هى المعادن السائدة حسب الترتيب . الخصائص الكيميائية والفيزيائية ضعيفة . أهم المعوقات هى التجوية ، الحصى، قلة الخصوبة ، الصلابة ، الحموضة .

صنفت هذه الأراضى إعتمادا على النظام الأمريكى (١٩٩٤) كالآتى :-

(١) البرداب :

(أ) المنخفض:

- Kanhablic Rhodustalfs-fine clay, Kaolinite Isohyperthermic.

(ب) المنحدر:

- Kandic Paleustalfs. V.fine clay, Kaolinite, Isohyperthermic.

(٢) سودرى:

(أ) المنخفض:

- Typic comborthids-coarse loamy, mixed hyperthermic.

(ب) المنحدر:

- Typic comborthids-coarse loamy, mixed hyperthermic.

(٣) النهود (رهد السلك) :

(أ) المنخفض :

- **Rhodic paleustalfs, fine loamy, Kaolinite Isohyperthermic.**

(ب) المنحدر:

- **Aridic paleustalfs, fine loamy, Kaolinite Isohyperthermic.**

(٤) أم جمالة :

(أ) المنخفض:

- **Ustic Haplustalfs-fine loamy, Kaolinite Isohyperthermic.**

(ب) المنحدر:

- **Ustic paleustalfs-fine loamy-Kaolinite Isohyperthermic.**

كما أن الدراسة إشتملت على أهم المقترحات لإستصلاح وإستخدام هذه الأراضى.

Abstract

Recently much of the attention is given to Gardud soil as the main alternative for the depleted marginal sandy soils. A lack of exact knowledge regarding these soils are evident.

For studying Gardud soil four sites were chosen according to the annual rainfall. Two pits were excavated in each site to represent the concaved and convexed locations plus composite samples to cover the area between the two pits. Morphological, physical, chemical and mineralogical investigations were made.

The results showed that the Gardud soils were relatively differed within and between sites due to the climate and the topography. The dominant clay minerals are kaolinite, montmorillonite and illite. The chemical and physical characteristics were poor. Some of the restrictions limiting the use of these soils such as errosion hardness, fertility, stoniness, drought and acidity.

According to the American system of soil classification, the soils studied were given the following classification:

(1) Baradab soil:

(A) Kanhablic rhodustalf - fine clay, kaolinite, isohyperthermic (concaved).

(B) Kandic paleustalf - very fine clay kaolinite, isohyperthermic (convexed).

(2) Sodari:

(A) Typic comborthid - coarse loamy, mixed hyperthermic (concave).

(B) Typic comborthid - coarse loamy, mixed hyperthermic (convexed).

(3) Nihud (Rahad Elsilk):

(A) Rhodic paleustalf - fine loamy, kaolinite isohyperthermic (concaved).

(B) Aridic paleustalf - fine loamy kaolinite isohyperthermic (convexed).

(4) Umgamalla:

(A) Ustic haplustalf - fine loamy kaolinite isohyperthermic (concaved).

(B) Ustic haplustalf - fine loamy kaolinite isohyperthermic (convexed).

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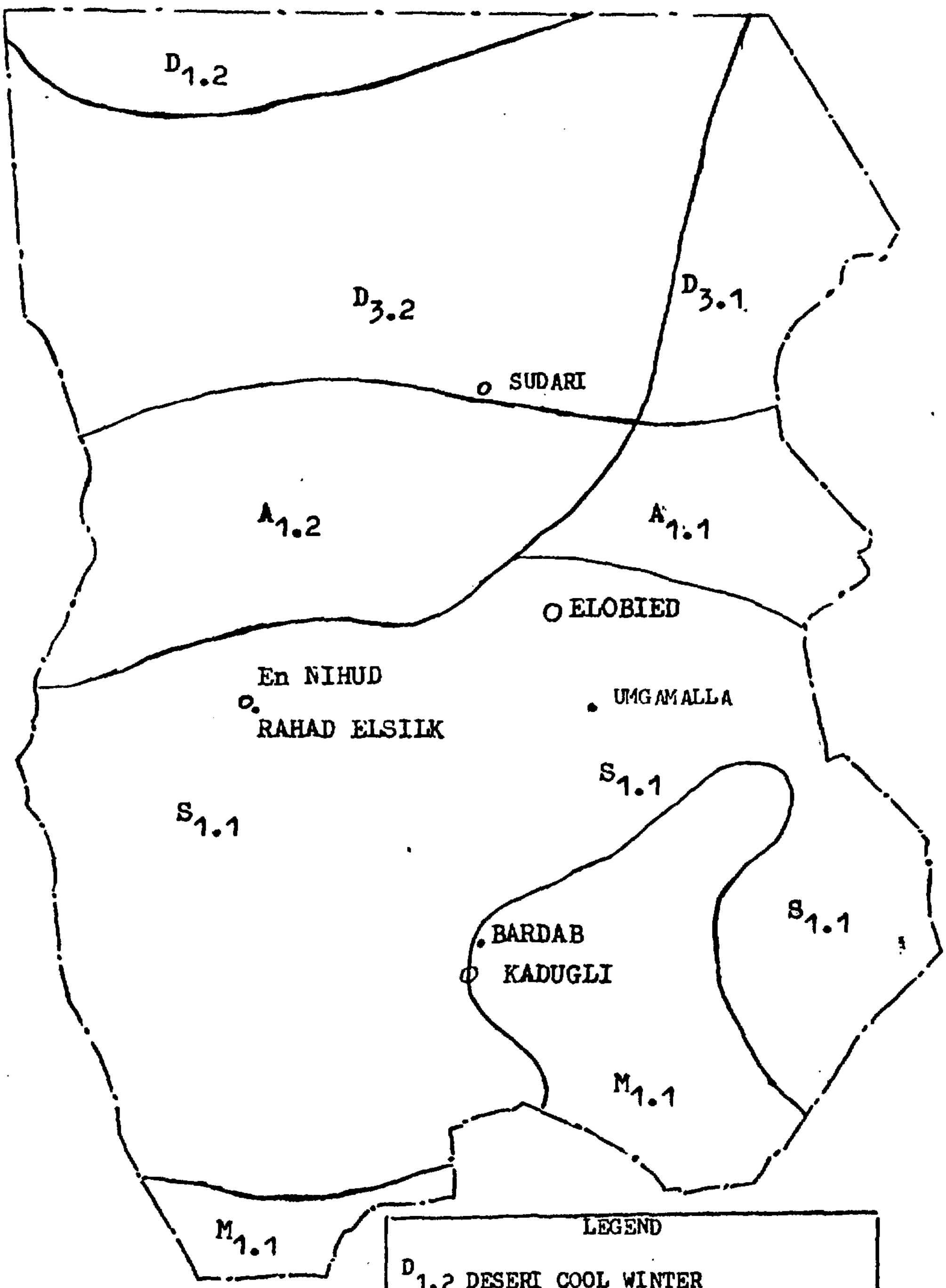
Thanks are also extended to the contribution of my family, friends and colleagues who did all to make work a success.

DEDICATION

TO MY BELOVED DISPLACED PEOPLE OF KORDOFAN

INVESTIGATED SITES AND CLIMATIC ZONES IN KORDAFAN STATE



SCALE 1:4000,000

LEGEND

$D_{1.2}$ DESERT COOL WINTER

$D_{3.1}$ SEMI-DESERT, WARM WINTER

$D_{3.2}$ SEMI-DESERT COOL WINTER

$A_{1.1}$ ARID WARM WINTER

$S_{1.1}$ SEMI-ARID WARM WINTER

$M_{1.1}$ DRY MONSOON- LONG DRY SEASON

INTRODUCTION

In most generalization, the traditional rainfed agriculture is practiced throughout Kordofan state except in the desert and semi-desert zones. The most used systems are shifting cultivation, Hareeg (burning) and bunds cultivation (terrace) in very small scales. All agricultural practices were executed once annually and only the superficial hoe was used in preparing the land.

In south Kordofan-where the clay plain- the new mechanized systems were introduced recently to suit the heavy clay texture (40-60% clay). Range activities are found beside the traditional rainfed agriculture throughout the region whereby the most hardy animals e.g goats and camels are grazing in the semi-desert region. The cattles, sheeps and goats in arid and semi-arid zones.

Due to the impact of overcultivation and over grazing the last decades, the soil are severely deteriorated. They can not fulfil the needs of the fast growing population any more. The low productivity of already depleted marginal sandy soil (Goz soil), in addition 1985 drought most of the animal were lost due to the lack of pastures and drinking waters. The inhabitants migrated to the south and south west areas.

Much attention is given to Gardud soil (local name) which is red gritty truncated, non-cracking soil occur in semi-desert, semi-arid and arid zones of Kordofan to ease the pressure from already exhausted sandy soil. A state of confusion and contradiction and lack of knowledge regarding these soils are evident. Hence the objectives of this study are:

(1) To determine the physical, chemical and mineralogical properties of Gardud soils.

(2) To identify the major constraints to their efficient agricultural utilization.

(3) To suggest ways and means for improving their agricultural use.

CHAPTER I

LITERATURE REVIEW

Location:-

Kordofan state is situated in the central part of the Sudan Latitudes 16° 30'N, 9° 30'S; Longitudes 27°E, 32° 25'E. It covers an area of about 380,000 Km^2 (15% of the total area of the Sudan).

Stratigraphy and Geological history:-

The rock formation that underlies Kordofan state include the basement complex, Nawa series, Nubian series, Laterite, Umrawaba series and surfacial deposits. Hunting, (1963) ; Warren, (1966) ; Rodis, (1975) ; Burymah (1971) showed the stratigraphy and the geological history of the Kordofan state.

The oldest rock in the region that now constitute the basement complex were formed in the Precambrian time. Following the emplacement of these rocks the region was subjected to a period of prolonged errosion which apparently lasted through most paleozoic.

Shallow seas invaded parts of the region in the late paleozoic and deposited the sediment of Nawa series. Before the close of paleozoic time, however the region was uplifted and most of Nawa sediment were removed by erosion. Only a few isolated remnants of Nawa series are now left in Kordofan as evidence of this once-extensive geologic deposition of rockforming materials in the area, did not a gain take place until Meso Zoic time when shallow continental seas covered much if not all the state. During this time the clastic sediments of Nubian series were laid in continental and/or near-shore marine environment and over a basement complex rocks surface of considerable relief. Near the close of Meso Zoic time the seas receded as the region was again uplifted and then subjected to prolonged erosion that apparently lasted until Pliocene time. During this interval the erosion of most of the Nuba rocks were stripped away and only those occupying the deeper basin in the basement rocks surface were left intact.

Extensive laterization of Nubian and possibly older rock occurred during early or middle tertiary time when climatic conditions were favorable to laterite formation prevailed in much of the state. Tectonic movement in Eastern Africa, prolonged during tertiary time resulted in the formation of several structural basins in the Nubian and basement rocks of Kordofan.

During Pliocene and early Pleistocene time these were filled with fluvial and Lacustrine deposits that now comprise the Umrawaba series. Several types of surfacial deposits were followed and laid down that new form a virtually continuous mantle over the Umrawaba and older rocks of Kordofan. In late Pleistocene time, the southern part of the state was subjected to widespread and recurrent flooding. The flood prolonged emanating in the Nile head water to the south. Strong northern wind prevailed in the northern part and denuded the land surface of much of it's residual soil cover.

A considerable part of eroded material was deposited in sand dunes (Goz) in the central part of the state, and the clay deposits in the south, stand today as evidence of the climatic conditions since late pleistocene.

Topography and drainage:-

The land surface of Kordofan is largely a plain of low relief, broken occasionally by isolated hills or by small cluster of jebels. The marked ones in the Nuba mountain. The altitude of most of the state ranges between 350m to 595m above sea level.

Most of the region lies within the drainage basin of the White Nile, but the northern part drains to the Nile river.

Climate:-

Continental climate prevail in the state. The southern part merge into dry mansoon zone and the northern part merge into the desert zone. Van der Kevie (1973) divided the state broadly into five major climatic zones: desert, semidesert, arid, semiarid and dry mansoon.

Rainfall in general are storm of short duration between July and September in the northern part and between April and October in the south. The mean annual air temperature for the state is 27°C with temperature extreme of 10°C and 46°C common to most areas. The mean relative humidity range between 21% in the dry season to 75% during the rainy season. The prevailing winds in winter are from the north while the winds during the rainy season are from the south west. Wind velocity are usually less than 8 km/hour.

Vegetation:-

A vegetation cover which is a reflection of those climatic zones and soil type range from a sparse growth of drought resistant grasses and dwarf scrub in the north through a belt of open wood and grass land in semi-arid central region to open forest in the well watered south. The common trees belong to species of genus Acacia. It includes mainly A. senegal (hashab) and A. seyal (Talh) in the northern central zone. Whereas the dominant species in the southern clayey part A. melifera (Kitir). In the arid zone prevail Salonite egyptica (Higlig) and Combretm sp. (habil). In the dry mansoon zone the dominant trees are Bonsellia papyritera The major genus are annual species like Schoenetedia grcidis, Tetrapegon cnchriformis and Chloris sp.

Soils of Western Sudan:-

There were very few references dealt with Goz soils, such as Hunting (1963) ; Jewitt and Manton (1954) ; Warrel (1961) ; Edward (1942) ; Buraymah (1971) ; Farah (1971) and Razig (1978). A detailed work on soil of Kordofan and Darfur was carried out by Hunting (1963) in which they described and suggested ways and means of their utilization. A comprehensive technical report about savanna development in the Sudan was written by FAO (1974), in which four soil orders were distinguished (Arenosols, Vertisols, Xerosols and Yermosols).

Three main types of soils are widely distributed in Kordofan state: sandy soil in the northern part (25 million feddans), clay soil in the southern part (17 million feddans) and Gardud soil (5 million feddans) distributed all over the state as stated by Kordofan Commercial Guidance Book (1992).

According to Pacheco and Dawoud (1978) the sandy and loamy soil are widely distributed in the desert zone whereas in the central stabilized area the soil has not been interrupted showing a cambic B horizon. In the less stabilized location the soil is usually without distinct diagnostic horizon (Entisols). The soil which is slightly undulating in the southern part of kordofan was believed to be formed from country rocks. The rest of the southern part include inter-mountain, plains, uplands, pediplains and low land which are mainly covered by dark cracking soil (Vertisols). A complex pattern of alluvial and aeolian soils occurs in the south-western corner.

Characteristics of arid and semi-arid soils:-

Bocquier and Margneim (1963) stated that reddish brown (2.5YR to 10YR) soil of arid and semi-arid zones were formed under hot and dry climate, where the annual rainfall rarely exceeded 500mm (D'Hoore, 1964). Buraymah (1971) showed that these soils are without clear differentiation of genetic horizons which could be due to the recently deposited parent materials or could be due to aridity in case of old relic parent materials. The dark brown and black soil color are found in the depressions and the lower part of the slope. They were described as Vertisols of the topographic depressions. It's parent material is oftenly sediments enriched with soluble constituents, all being derived directly or indirectly from the surrounding high lands.

The red soil (Alfisols) south of Sahara desert consists mainly of Ustalf on the upper part of the slopes. The texture of these soils is a loamy sand or sandy loam at the surface and a clay texture below and contains a few iron nodules further down the slope. The structure of these soils is poor due to the low content of clay and organic matter. However, iron concretions increased with depth and progressively impede drainage (Sanchez, 1976).

Kampnel (1979) shed some light on the main constrains of these soils such as the intense rainfall, unpredictable drought, short rainy season, low infiltration rate and wind errosion hazard. Alfisols often possess a surface layer of a compacted soil that inhibit root development and water percolation. The loamy sand texture of the top soil and the predominance of kaolinite among the clay minerals make these soils chemically weak in reaction (Charrean, 1977). Thus the non-cracking topsoil become very hard when dry. The structural instability of these soils will cause crusting when rain alternates with dry periods.

Gardud soil:-

Gardud soil comprise about 22% of the total area of Kordofan state where 8% lies in the northern part and 14% in the southern part of Kordofan. According to Razig (1978) Gardud soil represent 24% of the total available soils for cultivation, grazing and forestry. Other names such as Naga'a, Atmur, Moglad, Barasa, Hemira and Hadaba were given to Gardud soils.

The general characteristics of these soils is the partial truncation whereby the sandy top soil were removed by wind and hence the loamy subsoil is exposed to the impact of rain drops which render them hard and solid (Doxiadis, 1966). Two types of Gardud soils were described, Kazgail and Abu Zabad associations with reddish brown and reddish color respectively (Hunting, 1963). Dawoud (1978) indicated that the Gardud soil was developed from colluvial on slightly convex higher ridges, or it may be developed in situ from metamorphosed dikes in the clay plain. Whereas A. A. C. H. International (1992) suggested that Gardud soil is a soil with non-cracking clay may have crust that impedes infiltration. Madibo (1989) and Gaily, et.

al (1982) concluded that Gardud soil is a potential soil if properly managed. According to FAO (1974) the Gardud soil is severely erroded soils of Yermosols order. Pacheco and Dawoud (1976) classified Gardud soil as Rhodic haplustalfs (south of El Obied), whereas Razig (1978) classified the soil south of El Obied as Typic vertic comborthid.

CHAPTER II

MATERIALS AND METHODS

2.1 Profile description:-

The profile description was made according to the FAO guideline (1974). Two profiles were made for each site representing the low and the relatively high levels. Composite samples were also taken by auger to represent the area between the two profiles (Map).

2.2 Sampling:-

The samples were meant to represent the different sequence of horizons sedimentation.

2.3 Laboratory determination:-

All the physical and the chemical determinations were carried out according to the international procedures of soil analysis (Page, 1982 and Klute, 1986).

2.3.1 Physical analysis procedure:-

2.3.1.1 Particle size analysis:-

The particle size distribution was made using the modified hydrometer method Day (1965) and American Society for Testing & Materials. (A.S.T.M, 1985 d). The textural classes were determined according to the American system using the (U.S.D.A classification scheme).

2.3.1.2 Bulk & Particle Densities & Porosity :-

The bulk densities were determined using clod me hod, the particle density by Pycnometer method and the porosity was calculated according to the following formula:-

$$S = (1 - D_b/D_p)$$

Where:

S = total porosity

D_b = bulk density

D_p = particle density

2.3.1.3 Hydraulic Conductivity and infiltration rate:-

The hydraulic conductivity and infiltration rate measurements were made using the constant head method and the double ring infiltrometer, respectively.

2.3.2 Soil chemical properties:-

The chemical determinations were made according to the procedures outlined in the methods of soil analysis (Page, 1982).

2.3.2.1 Soil reaction:-

A pH meter Model No. (446/1) was used in measuring the soil pH in a soil paste and in a soil water ratio of 1:5.

2.3.2.2 Electrical conductivity of the saturation extract (ECe):-

It was measured by an EC meter Model No. (CC851).

2.3.2.3 Soluble cations and anions:-

Ethylene diamine tetraacetate (EDTA) was used for the determination of calcium plus magnesium. Sodium and potassium were measured using flame photometer.

The carbonate, bicarbonate were determined by titration against 0.01M sulfuric acid. The chloride was titrated against 0.005M silver nitrate. The sulfate was obtained by difference.

2.3.2.4 Cation exchange capacity (CEC):-

The cation exchange capacity was determined by saturating with sodium acetate and the displacement of adsorbed sodium by ammonium acetate.

2.3.2.5 Calcium carbonate

It was determined gravimetrically by carbon dioxide loss and volumetrically by calcimeter method.

2.3.2.6 Organic matter

Walkley and Black (wet oxidation) method was used in the determination of organic carbon. To obtain the organic matter a factor of 1.72 was used.

2.3.2.7 Nitrogen

Soil nitrogen was determined using macro Kjeldahl method

2.3.2.8 Phosphorous

It was determined according to Nelson et. al (1953).

2.3.2.9 Free iron oxides:-

The free iron oxides were determined using the citrate bicarbonate dithionite (C.B.D) and atomic absorption spectrophotometry.

2.3.2.10 Micronutrients:-

The method of Gough (1980) was used in the determination of trace elements.

2.3.3. Mineralogy:-

2.3.3.1 Clay Minerals

The clay minerals were identified according to the primary X-Ray diffraction (X.R.D) outlined as follows.

Preparation of samples.

1- Each sample was washed several times by distilled H_2O to remove drilling mud and contaminations.

2- Each sample was mortared in a porcelain carefully to the crystal lattice intact.

3- Each sample was disagregated and dispersed in distilled water using ultrasonic path.

4- The less than 2µm fraction was separated by centrifugation of the suspension and each sample was centrifuged for 2min at a speed of 2000 r.p.m.

5- The fine particles in suspension were filtered through a porous ceramic tube to reconcentrate the suspension.The filtration product which represents the clay fraction < 2µm was collected in dishes and kept in the oven under 60°C.

Analytical procedures:-

X-ray analysis was done on slides containing the < 2 µm fraction. The analysis was made at the University of khartoum by Siemens X-ray diffractometer using cobalt radiation. Three different patterns were obtained for each sample, air dried, ethylene glycol and heating.

(A) Air dried treatments

Each sample was kept in a desiccator for 24 hours to remove the water then exposed to X-rays. For the air-dried samples the measurements made between $30-33^\circ 2\theta$.

(B) Ethylene glycol treatment

each sample was kept in a desiccator filled in it's lower part by ethylene glycol and left for 48 hours. The measurements were carried out for the glycol samples between $30^\circ 2\theta$ and $33^\circ 2\theta$.

(C) Heating treatment:-

The fine diffraction pattern was obtained after the heating of each samples to 550°C for 6 hours. In this case the measurements were made between $3^\circ 2$ to $15^\circ 2$.

2.3.3.2 Sand minerals:-

The minerals were separated into light and heavy fractions and then identified microscopically according to their optical properties such as color, cleavage, form, relief and extinction angle using polarizing microscope.

Description for the analytical procedure:-

The selected grain-size range was 0.5-0.045 mm,(the potentially useful heavy minerals species occurring in this size range in suitable amount and suitable shape.

Removal of the magnetic and electromagnetic particles:-

These were done with the aid of horse shoe magnet and the Isodynamic separator respectively.

Heavy liquid separation:-

It depends on the difference between the density of the liquid and the density of the minerals. The samples were separated into light and heavy fraction using bromoform liquid (density 2.89 g/cm^3). The sample was poured into the liquid, the heavy mineral (density>2.89 g/cm^3) sank down whereas the light ones (density <2.89 g/cm^3) remained floating.

Identification of heavy minerals:-

Using polarizing microscope the heavy minerals were identified depending on their color, relief cleavage and extinction.

CHAPTER III

RESULTS

The physical & chemical data for Baradab, Sodari, Nihud (Rahad Elsilk), and Umgamalla are shown in Appendix 1, 2, 3, and 4, respectively.

3.1 Physical properties of soil:-

3.1.1 Particle size distribution:-

3.1.1.1 Baradab site:-

The textural class is clay. The clay increases with depth. The sand and silt decreased with depth. The texture at the bottom of the profile is sandy clay loam.

3.1.1.2 Sodari sites:-

The textural class sandy loam at the surface and loamy sand at the bottom of the slightly concaved profile. While the texture is sandy loam in the slightly convexed profile.

3.1.1.3 Nihud (Rahad Elsilk) sites:-

The texture is sandy clay loam in the two profiles.

3.1.1.4 Umgamalla sites:-

At Umgamalla the texture in the two profiles is sandy loam in the surface and sandy clay loam to sandy clay at the bottom.

3.1.2 Bulk and particle densities:-

Figures 1a,b shows the bulk densities at different sites and different depths. Sodari shows slightly high bulk densities (1.5 - 1.9 g/cc) flowed by Umgamalla (1.45 - 1.6 g/cc), Nihud(1.4 - 1.5 g/cc) and Baradab (1.3-1.5)

Fig. 1a Bulk density of Baradab
Sodari, Nihud and Umgamalla (Concave)

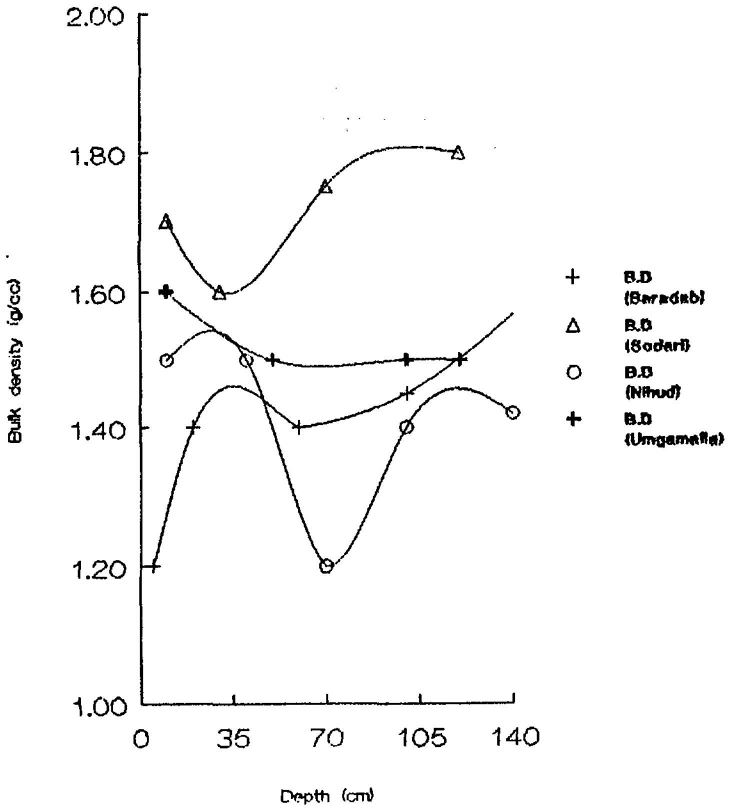
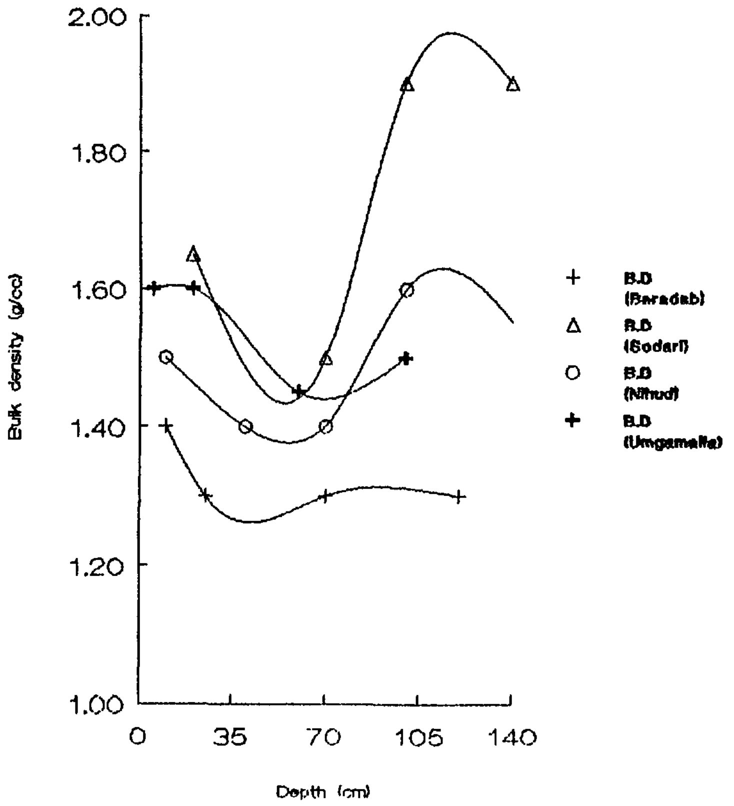


Fig. 1b Bulk density of Baradab
Sodari, Nihud and Umgamalla (Convex)



respectively. The particle densities are slightly decreasing with depth except in Sodari and Nihud sites. It ranges between 2.1 and 2.2 g/cc in Baradab and Umgamalla, and 2.4-2.5 g/cc in Sodari & Nihud profiles.

3.1.3 Hydraulic Conductivity:-

3.1.3.1 Baradab sites:-

The hydraulic conductivity slightly increased with depth. The hydraulic conductivity is higher at the slightly concaved profiles Fig.(2.1a,b).

3.1.3.2 Sodari sites:-

The two profiles layers is approximately shows a similar impermeability level, with notice the permeability is slightly increased with time in the concaved sites and slightly decreasing in the other, plus the relatively high permeability of the top layer of the concaved profile in comparison with the subordinated lower layers Fig. (2.2a,b).

3.1.3.3 Nihud sites:-

The permeability is decreased with time and slightly increased with depth,with regards to relatively less permeability of the slightly concaved profile, plus the presence of less permeable layers within the two profiles Fig.(2.3a,b).

3.1.3.4 Umgamalla:-

The permeability decreased with time and depth, with relatively high permeable top layer in the slightly concaved profile. Whereas in the slightly convexed profile, the permeability decreased with time and increased with depth Fig. (2.4a,b).

3.1.4 Intake (Infiltration Rate):-

Fig.2.1.a Hydraulic conductivity of Baradab (concave)

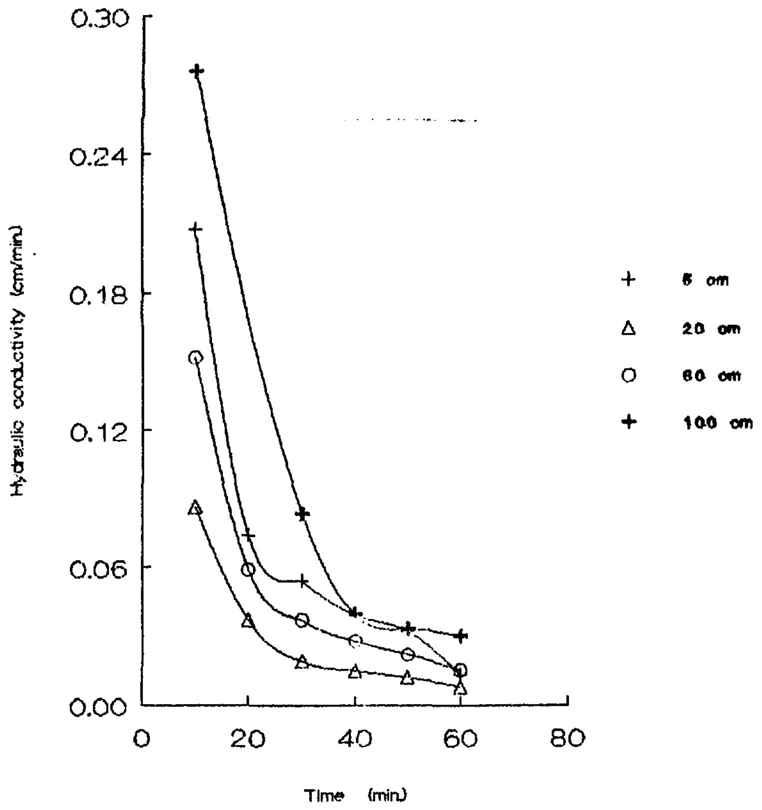


Fig.2.1.b Hydraulic conductivity of Baradab (convex)

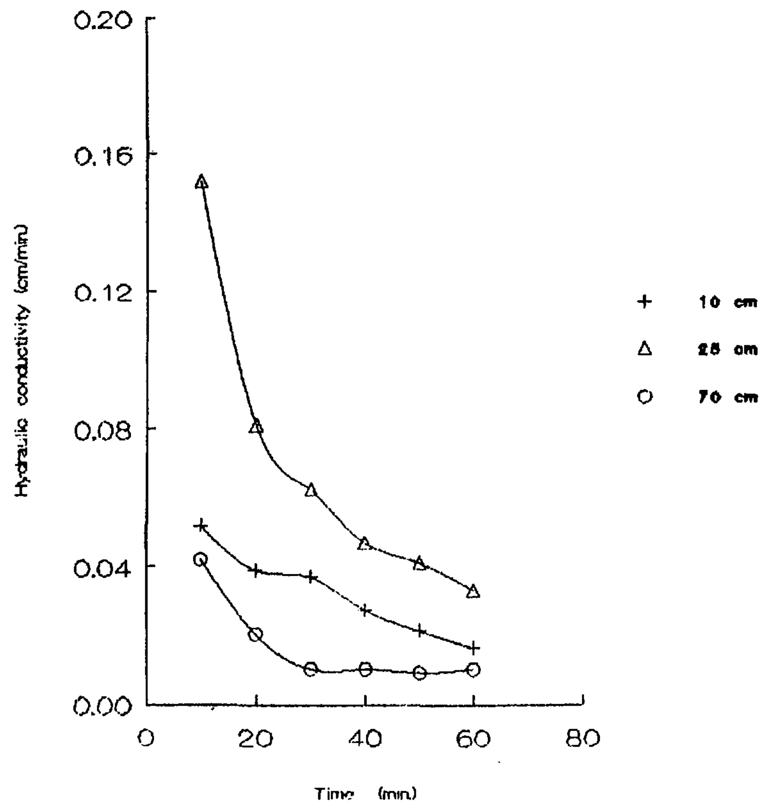


Fig.2.2.a Hydraulic conductivity of Sodari (concave)

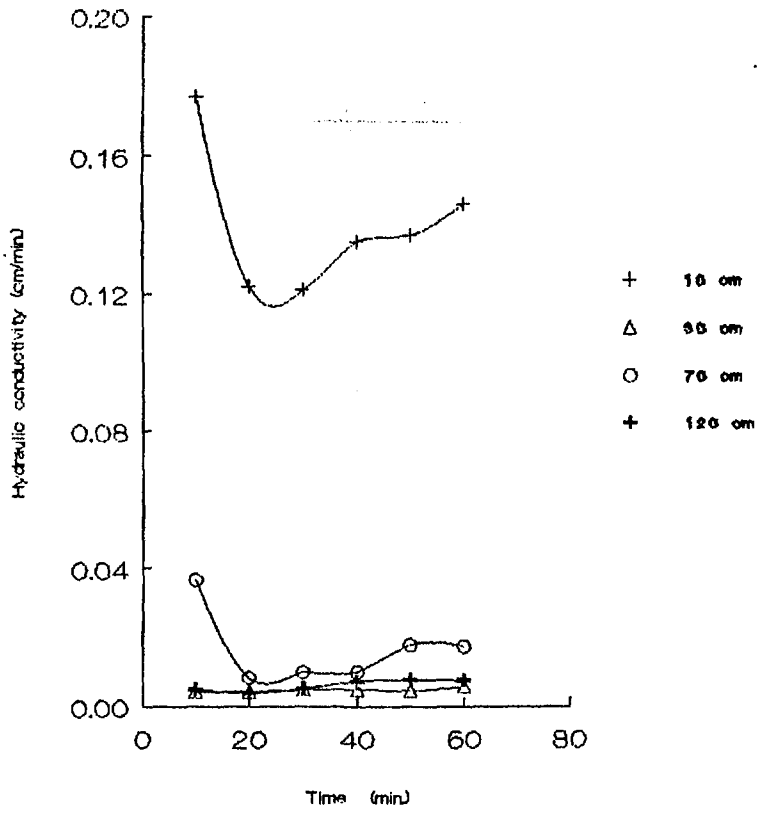


Fig.2.2.b Hydraulic conductivity of Sodari (convex)

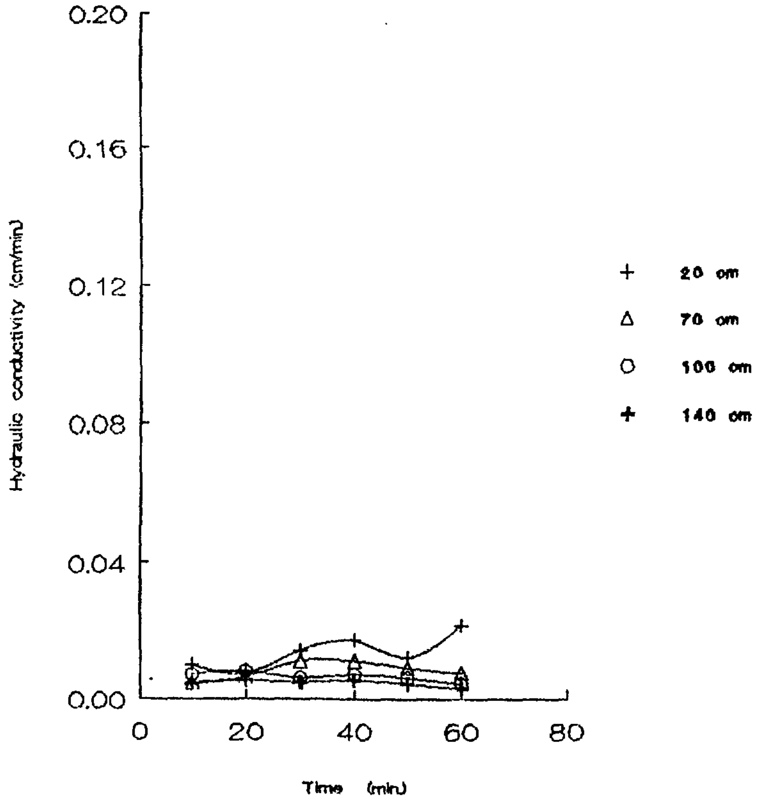


Fig.2.3.a Hydraulic conductivity of Nihud (concave)

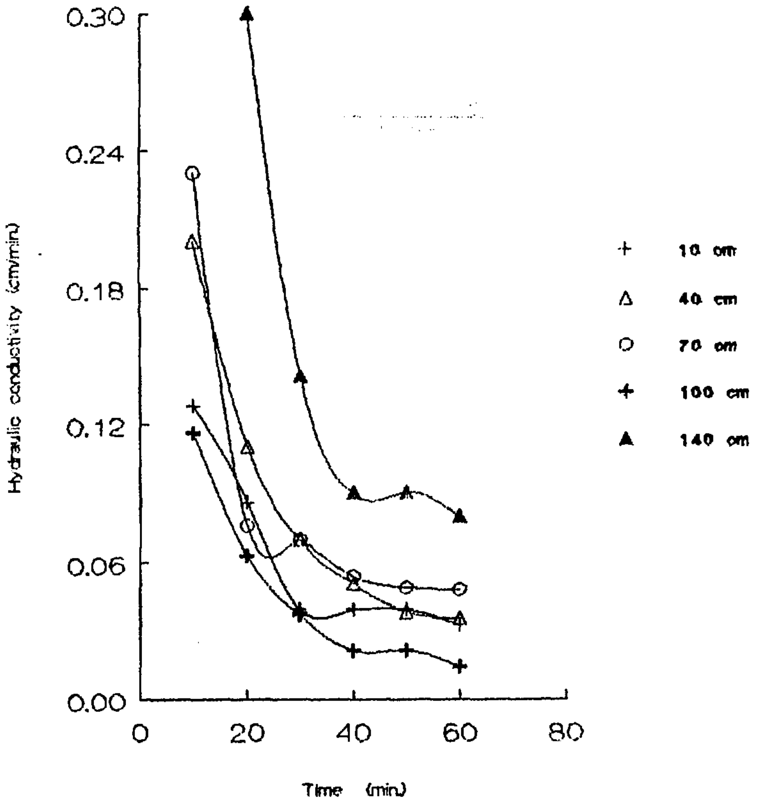


Fig.2.3.b Hydraulic conductivity of Nihud (convex)

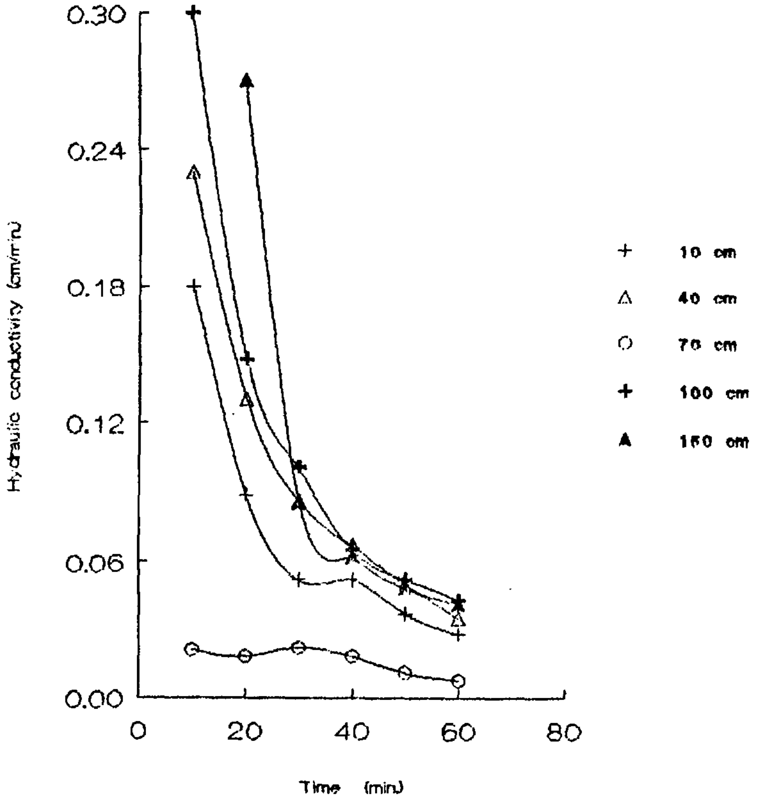


Fig.2.4.a Hydraulic conductivity of
Umgamalla (concave)

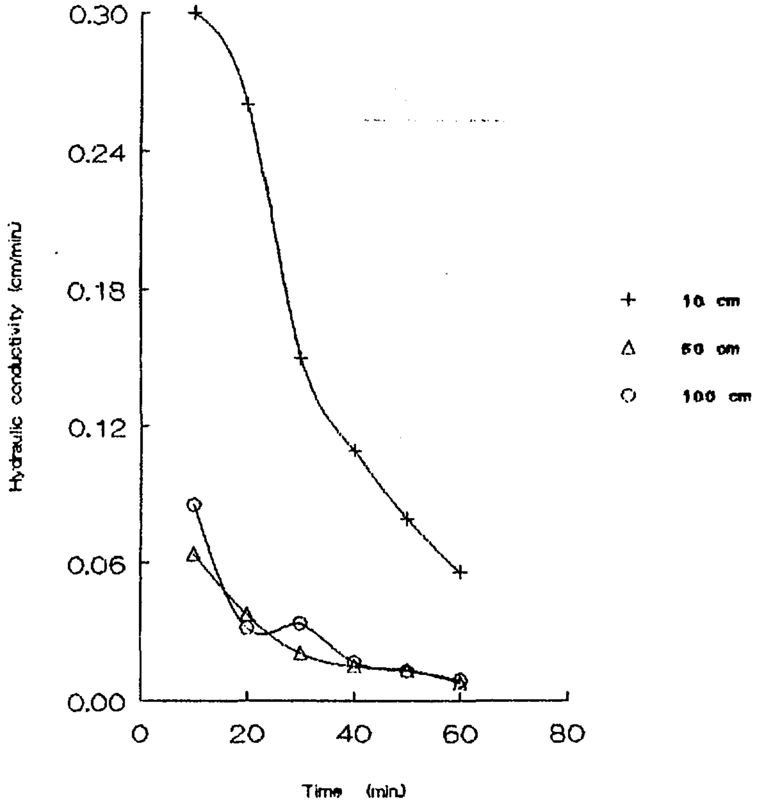
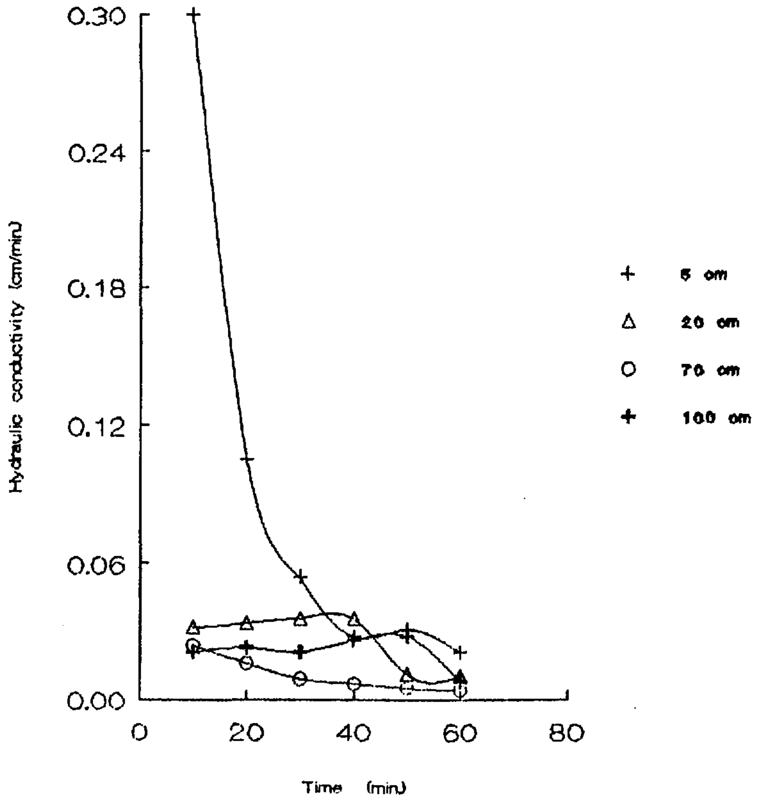


Fig.2.4.b Hydraulic conductivity of
Omgamalla (convex)



Baradab, Sodari & Umgamalla respectively exhibit a similar trend in the rate of infiltration. The steady state was reached after 50 minutes. The intake at Nihud site was opposite of the others. It began very low and increased to a high rate Fig. (3).

3.1.5 Porosity:-

The porosity vary from site to another and within the profile. The general trend at the concaved profiles was that the porosity decreased with depth (Nihud, Baradab, Umgamalla & Sodari respectively). At the convexed profile the porosity tend to increase with depth.

3.2 Chemical results:-

3.2.1 Soil reaction:-

Figure 4 illustrates the different values of pH in different sites.

Generally the soil reaction on 1:5 ratio gave relatively high value than that for the paste.

3.2.1.1 Baradab sites:-

The pH increased with depth from medium acid (5.7) to very mildly alkaline (7.1) in the slightly concaved profile, and medium acid throughout the profile with slight increase in the slightly convexed profile.

3.2.1.2 Sodari sites:-

The acidity increased with depth from very slightly acid (6.7) to medium acid (pH = 6.0) in the concaved sites, and from medium acid to very strong acid in the convexed ones.

3.2.1.3 Nihud sites:-

The two sites are exhibited an extremely acid pH throughout the two profiles, with the slight increase from 3.7 to 4.3 in the concaved and

Fig.3 Infiltration rate of Baradab, Sodari, Nihud and Umgamalla.

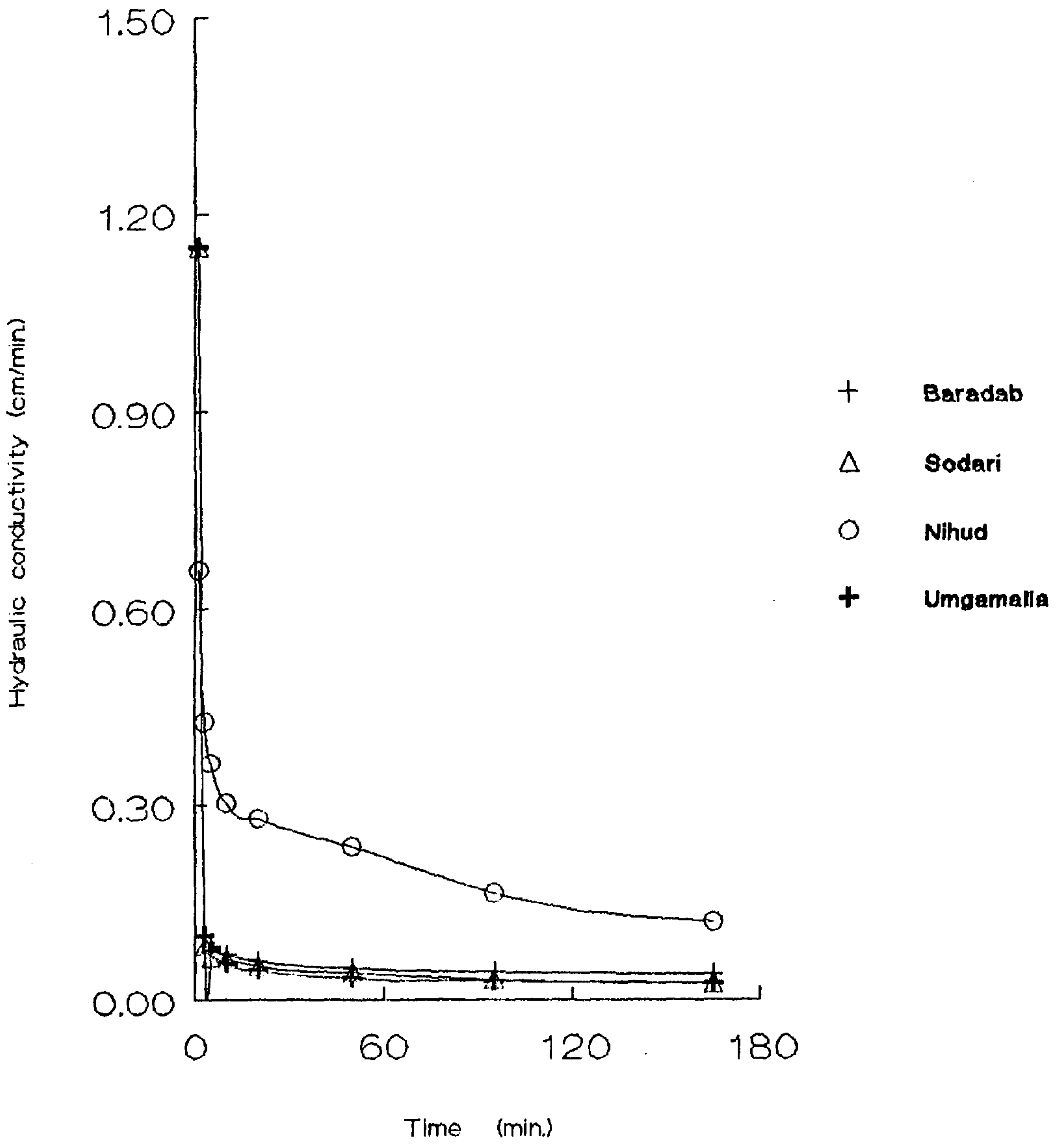


Fig. 4.a pH of Baradab, Sodari, Nihud and Umgamalla (Concave)

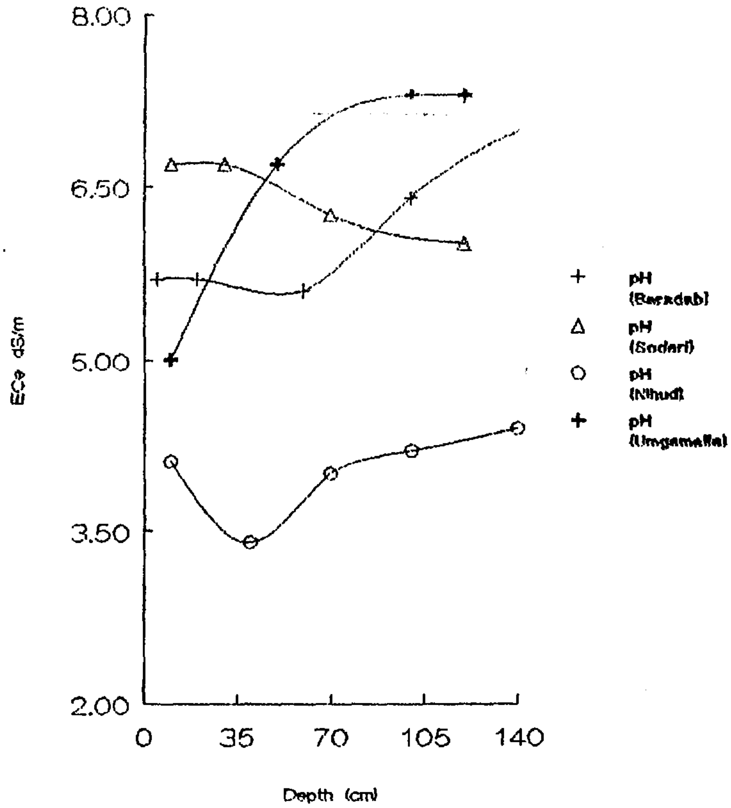
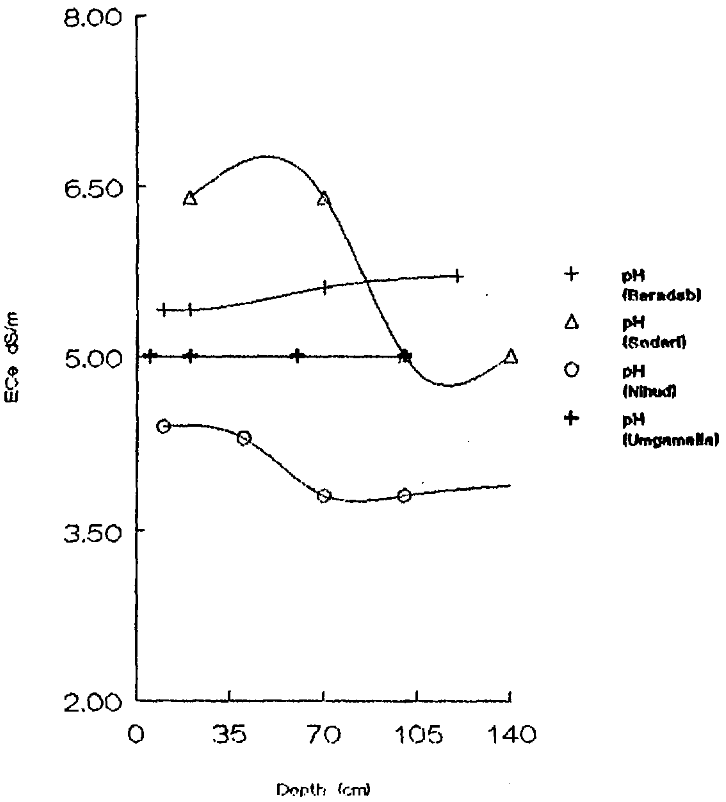


Fig. 4.b pH of Baradab, Sodari, Nihud and Umgamalla (Convex)



slightly decreasing from 4.3 to 3.8 in the convexed profile.

3.2.1.4 Umgamalla sites:-

The pH increased with depth from very strong acid (pH = 5) to slightly acid and mildly alkaline in the concaved profile, while the acidity is very strong throughout the convexed profile.

3.2.2 Electrical Conductivity (E.C):-

All the profiles are non-saline (less than 4 dS/m). The ECe is less at the convex compared to the concaved profile Fig. (5a,b).

3.2.3 Cation Exchange Capacity (C.E.C):-

Generally the cation exchange capacity is medium. Baradab C.E.C is ranging between 16-17 mmol/100g followed by Nihud 13-14, Umgamalla 12-16,and Sodari 11-13 mmol/100g Fig. (6a,b).

3.2.4 Soluble Cation & Anions:-

The soluble cations vary from one site to anther and within the profile. The Ca, Mg and Na are increasing with depth, while the potassium is decreasing with depth. A remarkable accumulation of sodium in Umgamalla slightly concaved profile was noticed.

The dominant anions are SO_4, Cl. and HCO_3.. Therefore the main salts could be the salts of sodium and potassium sulfate and chloride.

3.2.5 Organic matter, Nitrogen and Carbon/Nitrogen Ratio:-

Organic matter ranged from low in Baradab sites to very low in the other sites, with slight variation between the sites and within the profiles.

The Nitrogen is low, throughout the sites, degrading from Baradab. Nihud. Umgamalla & Sodari respectively. with slightly increasing with depth and there was no significant difference between the slightly convaced &

Fig. 5.a ECe of Baradab, Sodari, Nihud and Umgamalla (Concave)

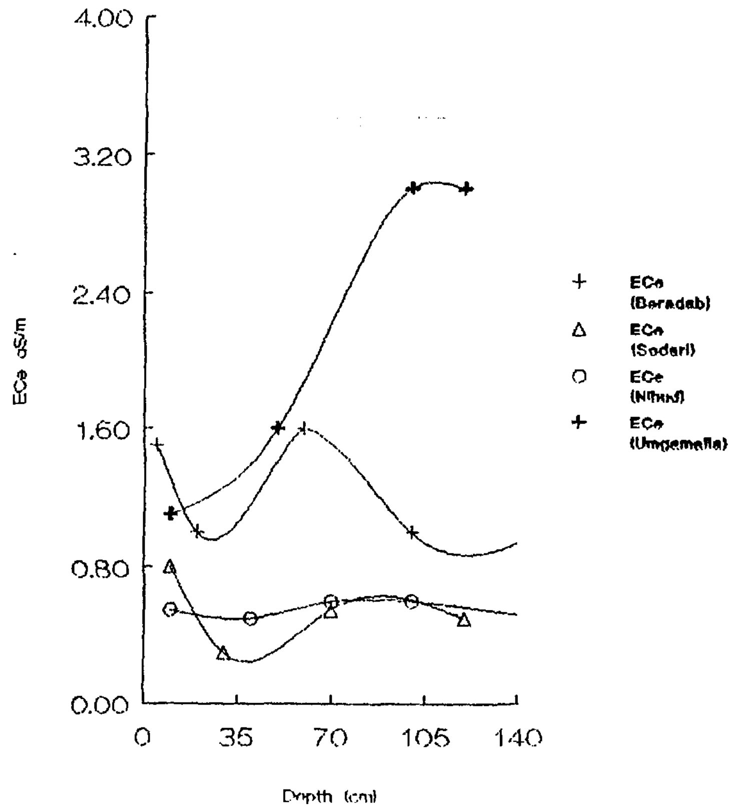


Fig. 5.b ECe of Baradab, Sodari, Nihud and Umgamalla (Convex)

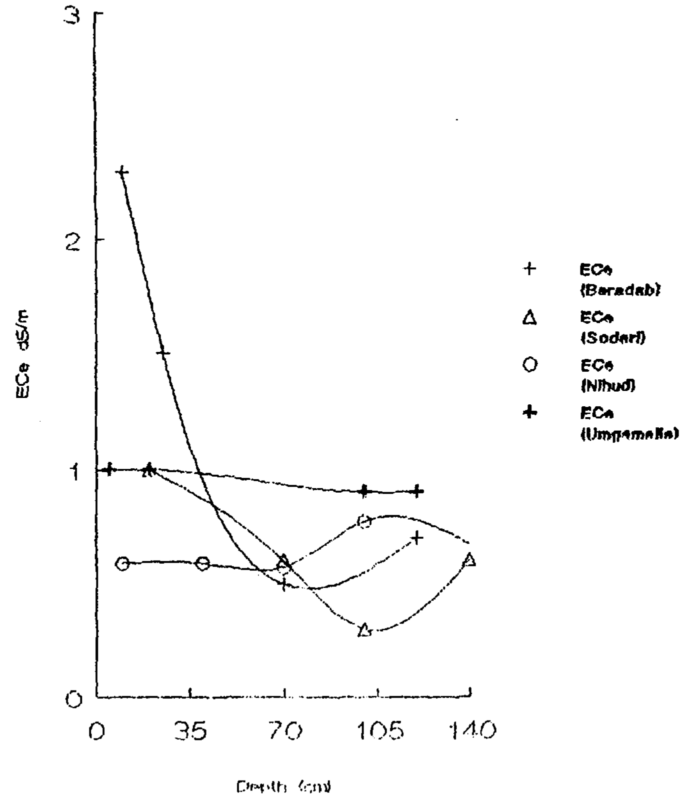


Fig. 7.a Organic matter of Baradab, Sodari, Nihud and Umgamalla (Concave)

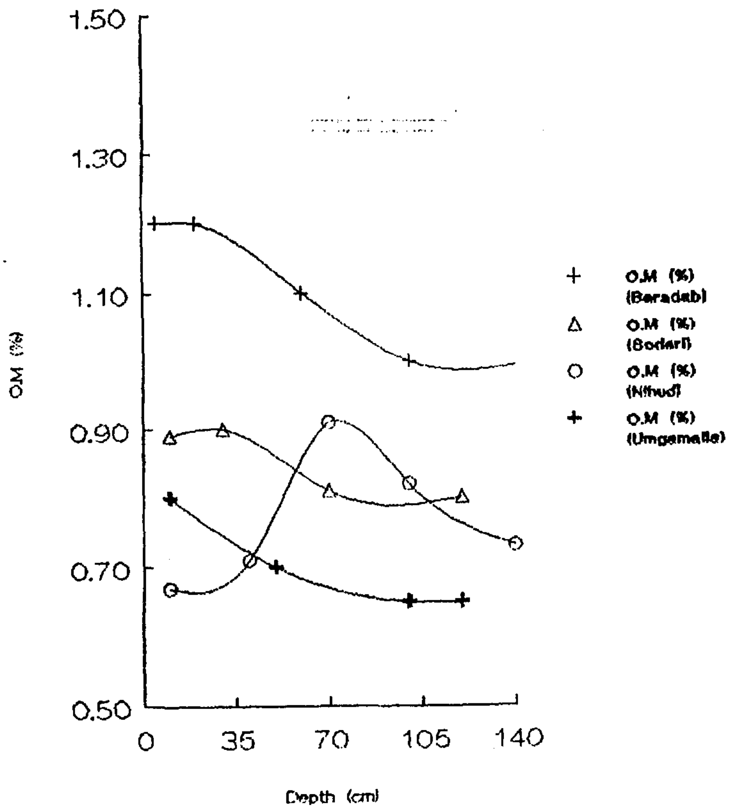


Fig. 7.b Organic matter of Baradab, Sodari, Nihud and Umgamalla (Convex)

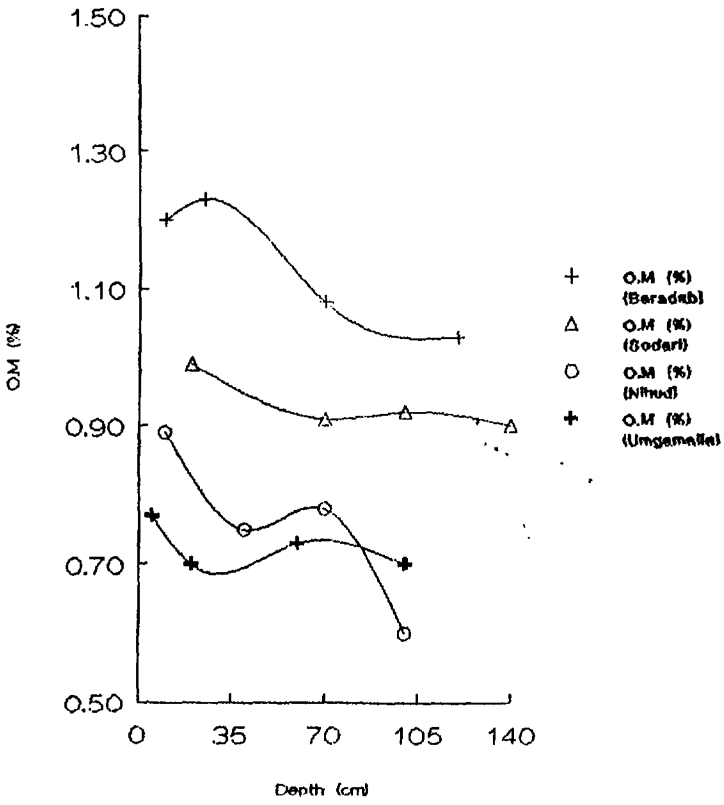


Fig. 8.a Nitrogen (%) of Baradab, Sodari, Nihud and Umgamalla (Concave)

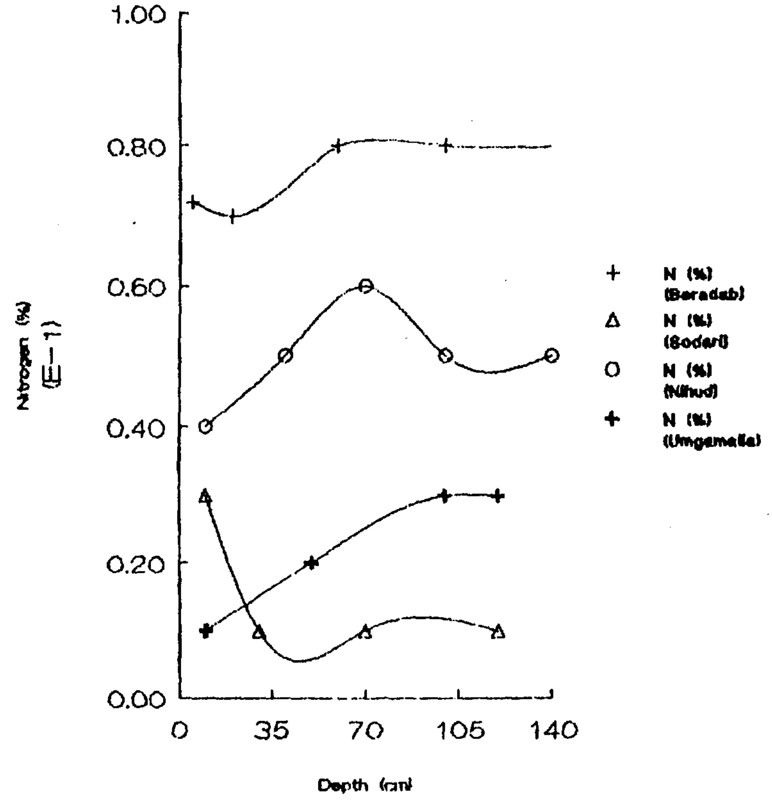


Fig. 8.b Nitrogen (%) of Baradab, Sodari, Nihud and Umgamalla (Convex)

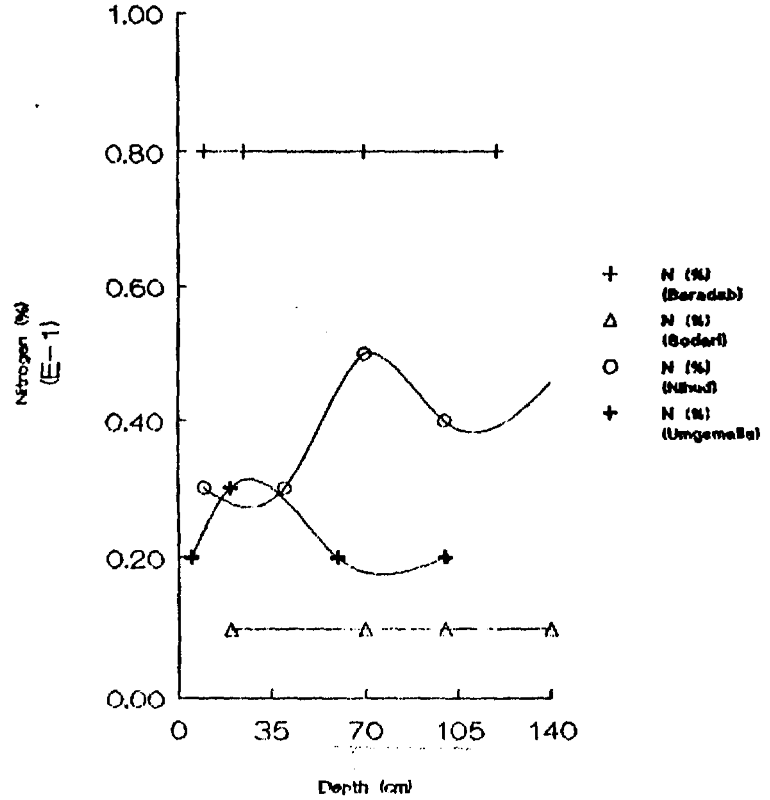


Fig. 9.a C/N ratio of Baradab, Sodari and Nihud (concave)

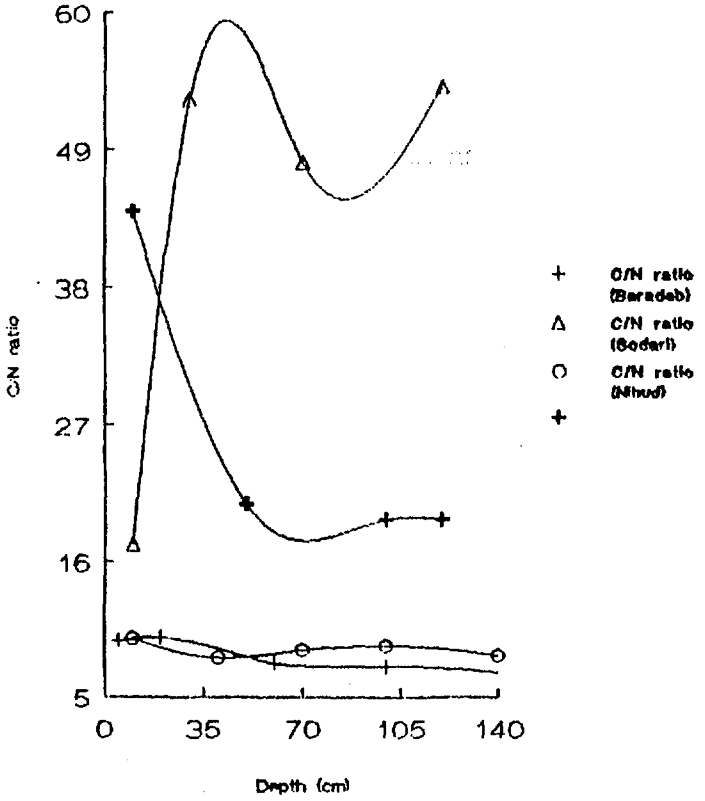


Fig. 9.b C/N ratio of Baradab, Sodari and Nihud (convex)

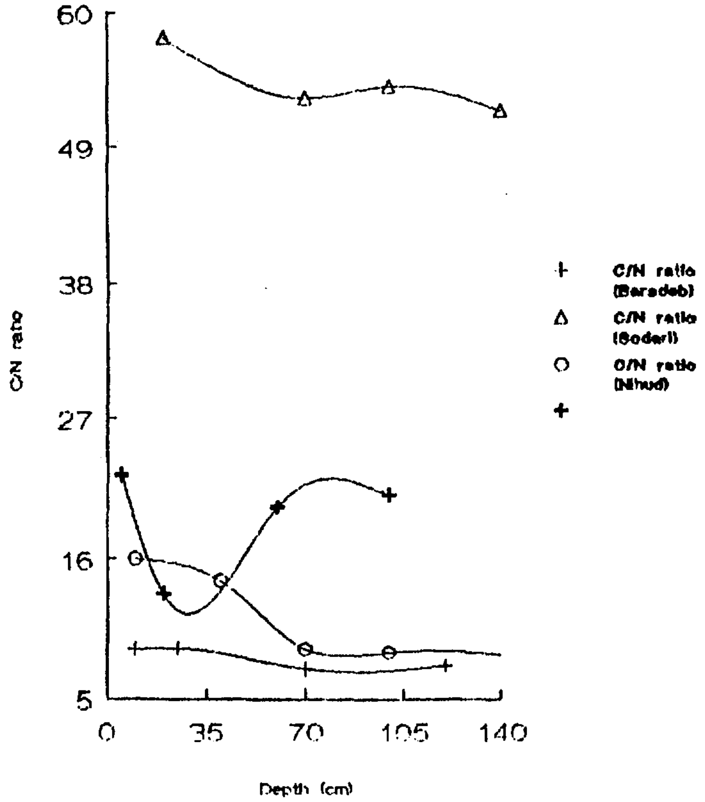


Fig. 10.a Phosphorous (%) of Baradab, Sodari, Nihud and Ungamalla (concave)

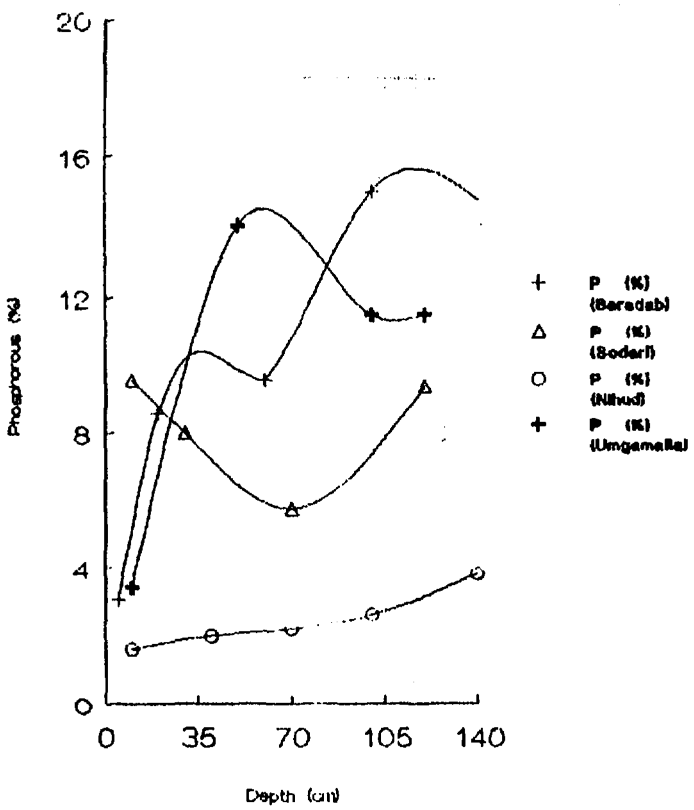


Fig. 10.b Phosphorous (%) of Baradab, Sodari, Nihud and Umgamalla (convex)

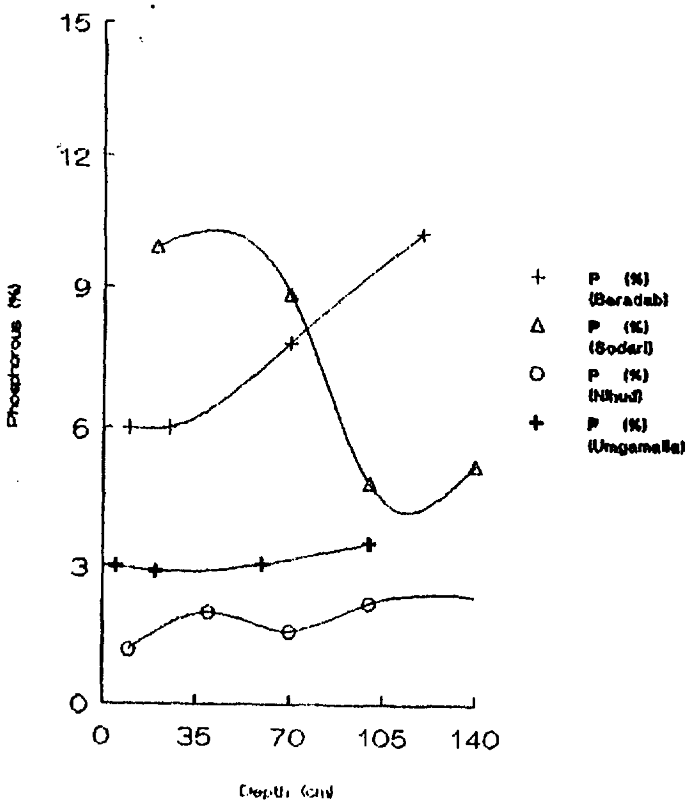


Fig. 11.a SAR of Baradab, Sodari Nihud and Umgamalla (concave)

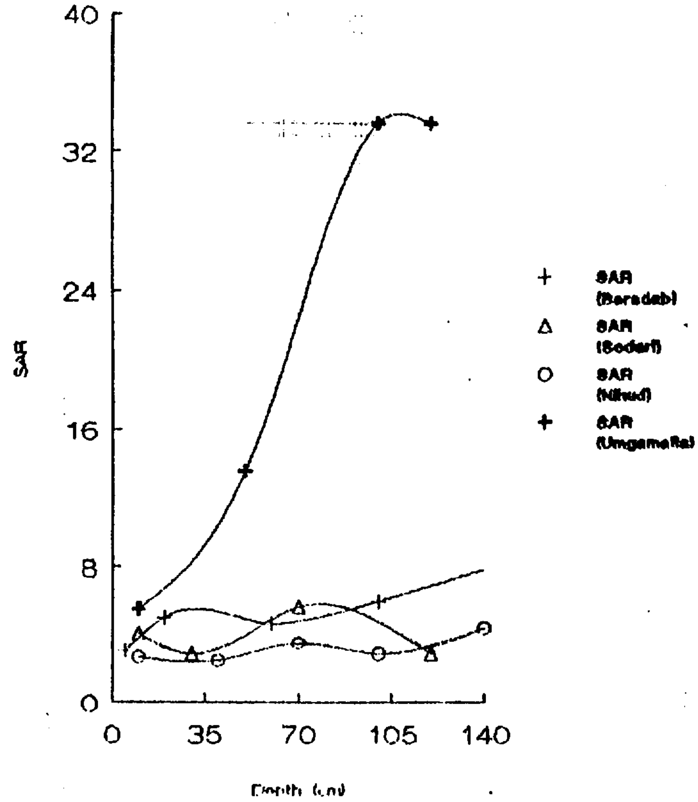


Fig. 11.b SAR of Baradab, Sodari Nihud and Umgamalla (convex)

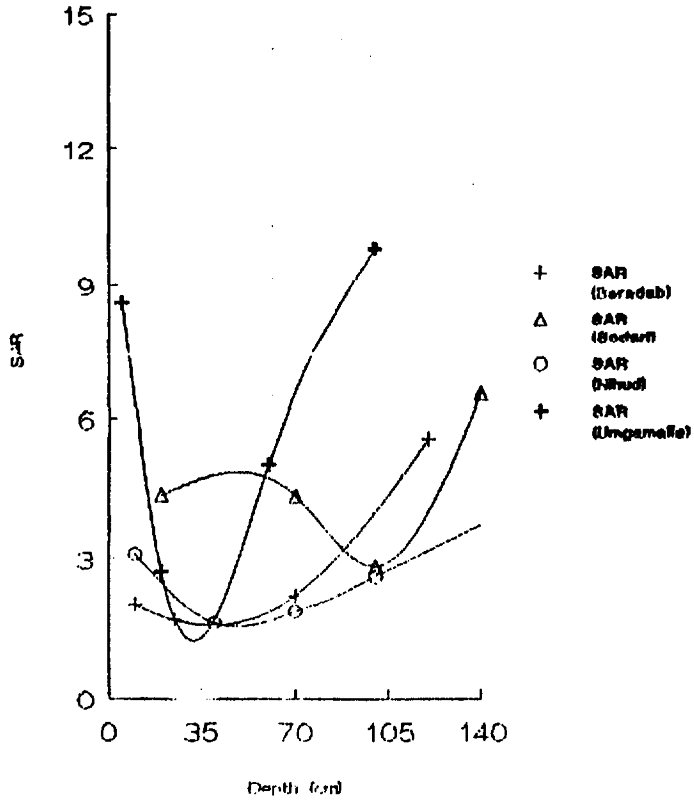


Table 1

Micronutrients concentration (ppm)

Site	Depth cm	Iron Fe^{+2}	Copper Cu^{+2}	Zinc Zn^{+2}	Manganese Mn^{+2}
Baradab AB_1	0-20	13.34	04.16	01.17	09.26
	20-60	06.64	05.14	01.11	07.80
	60-150	03.76	05.80	00.72	01.34
AB_2	0-25	06.48	01.44	00.66	09.80
	25-70	02.12	02.36	01.02	05.34
	70-120	02.18	02.78	00.74	06.95
Sodari AS_1	0-30	07.62	08.40	01.11	05.99
	30-70	03.42	06.32	01.36	04.75
	70-120	02.68	06.48	01.08	01.51
AS_2	0-20	00.82	04.36	01.03	01.95
	20-70	01.86	00.54	01.01	03.64
	70-140	00.62	08.18	00.84	02.33
Nihud AN_1	0-40	29.62	00.20	00.18	01.12
	40-100	03.78	02.88	00.37	04.41
	100-140	01.54	00.26	00.40	05.13
AN_2	0-40	03.46	05.34	00.89	00.71
	40-70	01.44	07.10	00.78	01.13
	70-100	00.90	06.44	01.22	00.24
	100-150	01.64	06.00	00.53	01.73
Umgamalla AU_1	0-10	07.90	01.32	00.14	03.73
	10-50	01.80	01.40	00.42	03.71
	50-100	00.60	01.88	00.18	00.32
AU_2	0-20	08.76	00.16	00.06	05.01
	20-100	02.88	00.22	00.08	03.35
	100-160	05.28	00.24	00.12	01.99

Baradab iron oxide concentration is (1926-3340 ppm). Iron oxides in the other sites ranged between 200 to 600 ppm. In the slightly concaved profiles iron oxides are higher than the slightly convexed ones Table (2).

3.3 Mineralogy:-

3.3.1 Clay mineralogy:-

X-ray diffraction technique was used in the identification and quantification of the dominant clay minerals. kaolinite, montmorillonite (smectite) and illite are the dominant clay minerals Table (3).

3.3.1.1 Baradab:-

In Baradab profiles the dominant clay is kaolinite, followed by montmorillonite. Kaolinite increased with depth in the slightly concaved and convexed profiles Fig. (12) and (13).

3.3.1.2 Sodari:-

In the slightly concaved profile the dominant clay mineral is montmorillonite (73% to 76%), followed by kaolinite and traces of illite increased with depth Fig. (14) But in the slightly convexed profile kaolinite is more at the surface and decreases with depth Fig. (15).

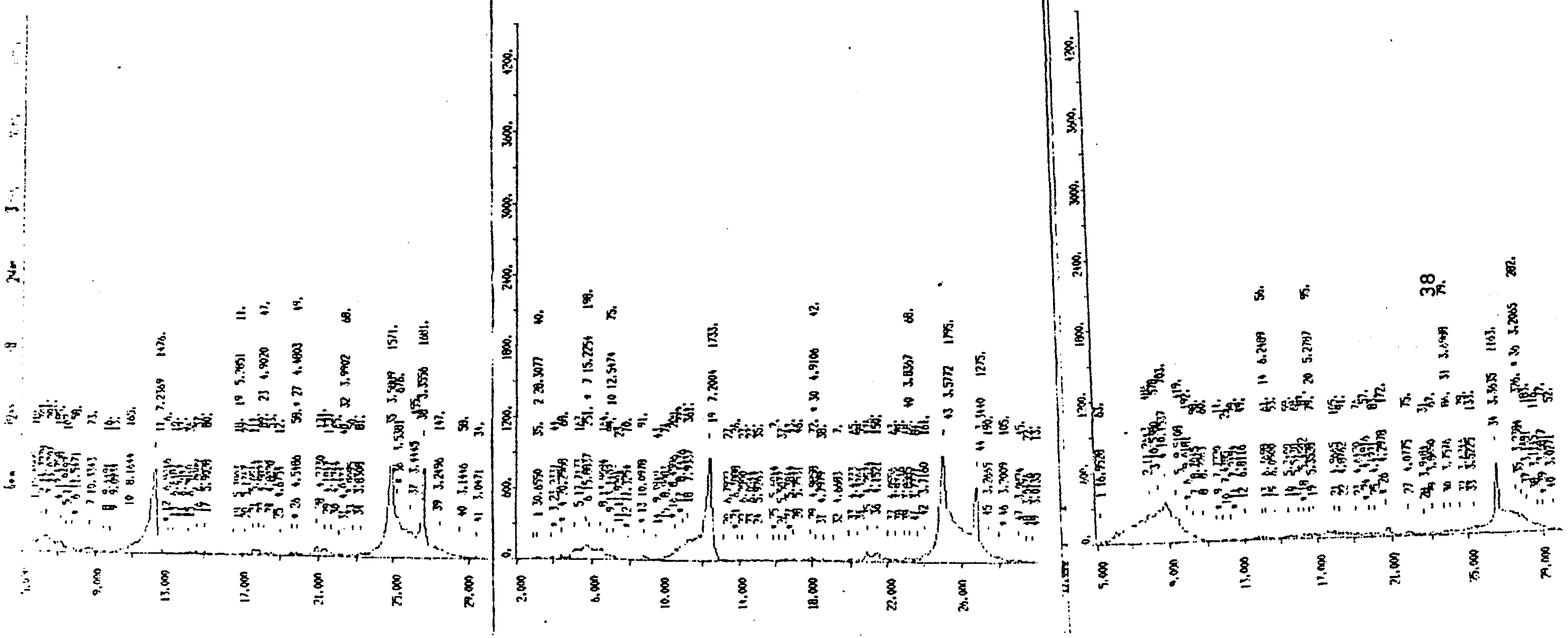
3.3.1.3 Nihud site:-

Kaolinite is dominant clay mineral (70% to 93%). It increased in the slightly concaved and convexed profiles with relatively high in the former Figs. (16,17).

3.3.1.4 Umgamalla:-

The dominant clay is kaolinite, 85% decreased sharply to 28% at the bottom of the slightly concaved profile Fig. (18), while in the slightly convexed profile kaolinite ranged from 63% to 57% Fig. (19).

Anode : Cu K 1·2
Time : 2,000
Step-size : 0.05



38

Normal treatment

Ethylene glycol treatment

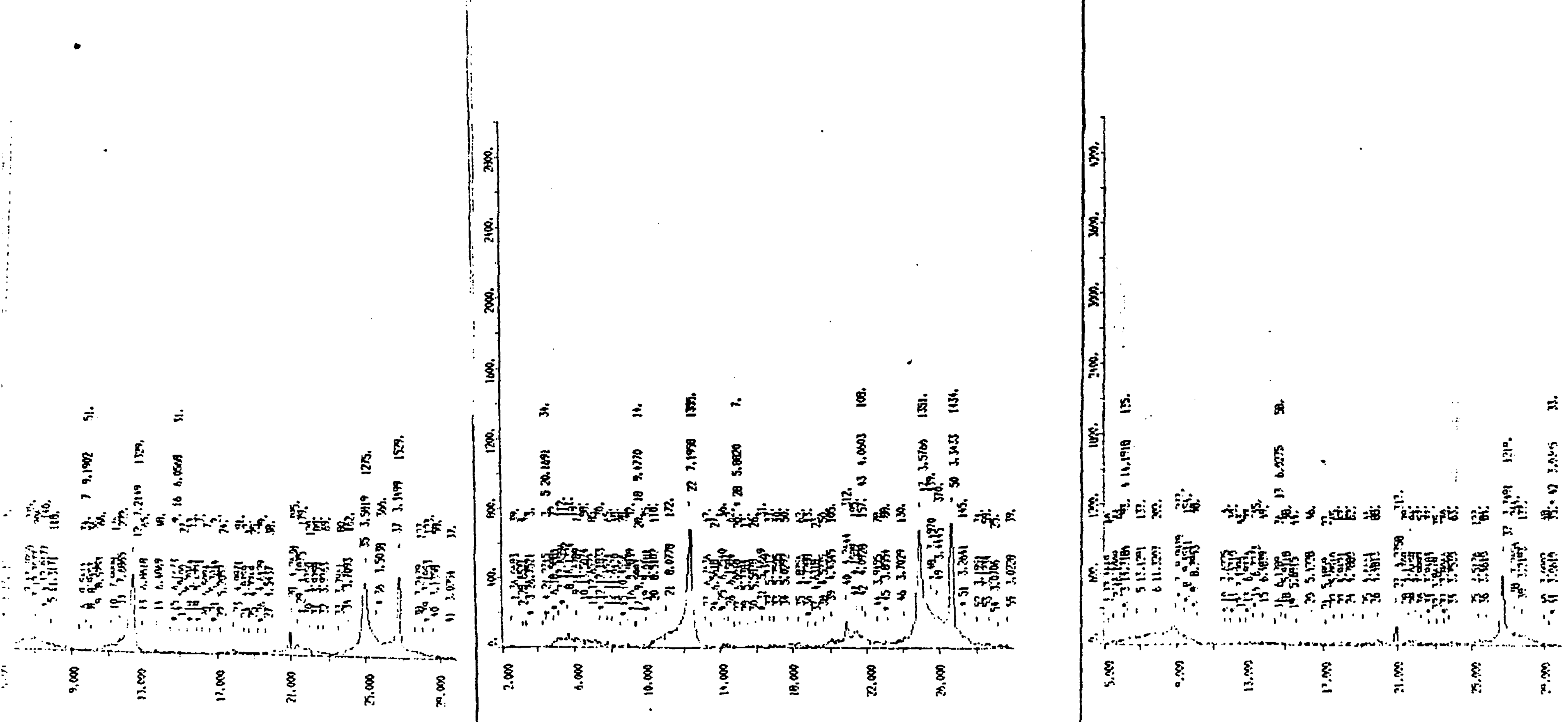
Heated treatment

title

Fig. 12

Clay mineralogy of Baldabe (Concaved)

Anode: Cu K α2
Time : 2,000
Step size: 0.05



Normal treatment

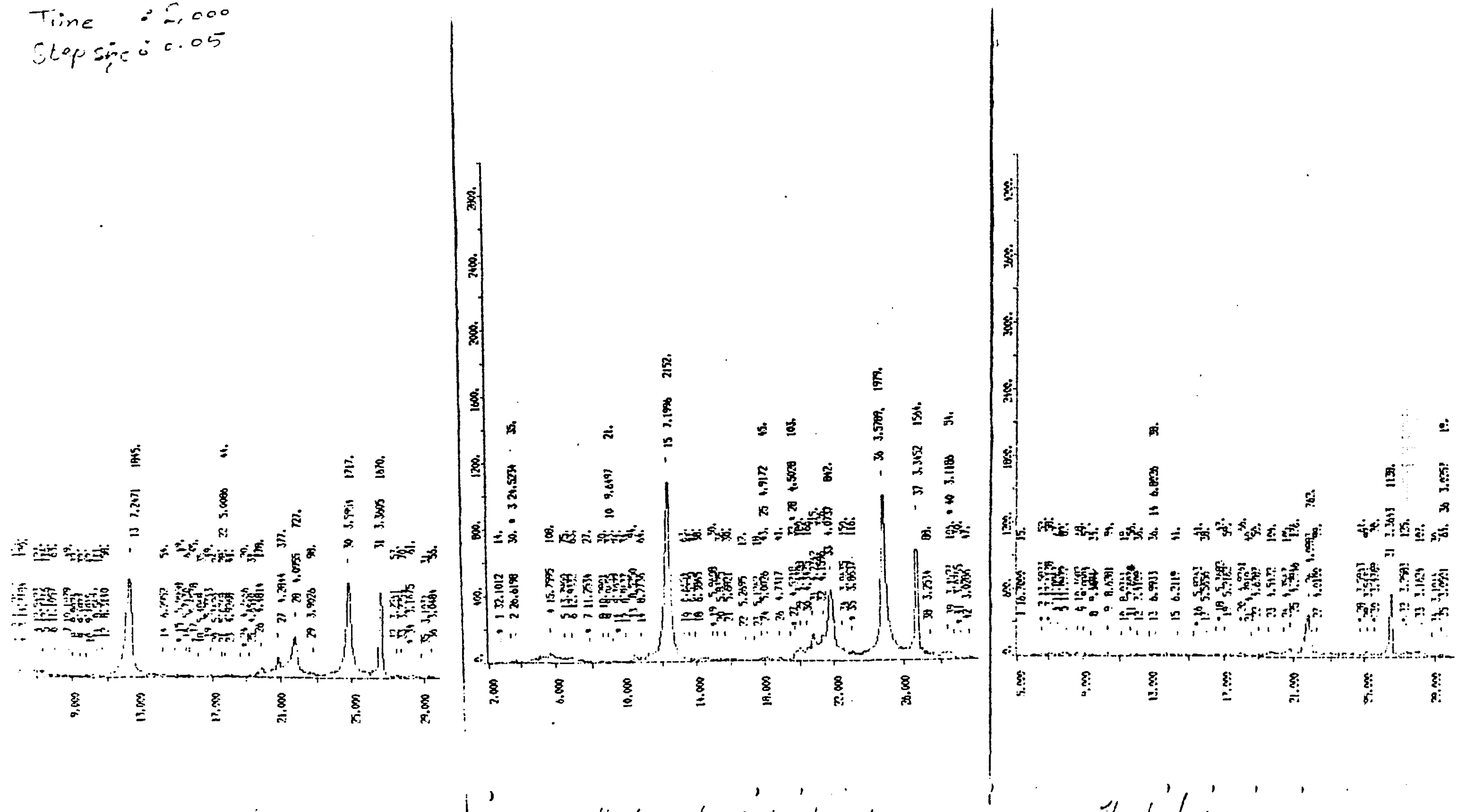
Ethylene glycol treatment

Heated treatment

Fig 13

Clay mineralogy of Baidab (Convexed)

Anode : Cu K1+2
Time : 2.000
Step size : 0.05



Normal treatment

Ethylene glycol treatment

Heated treatment

Fig 14

Clay mineralogy of Sodari (concaved)

40

Anode : Cu K 1.2
Time : 2,000
Step size : 0.05

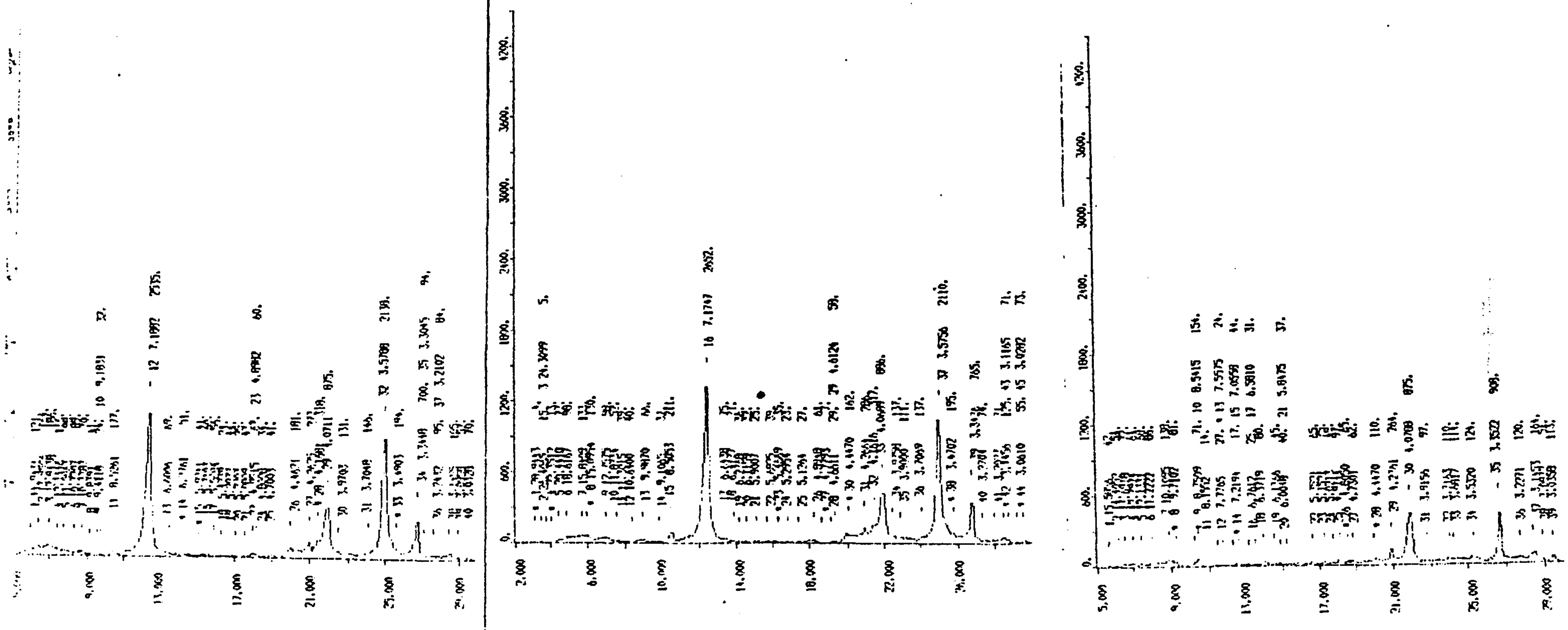


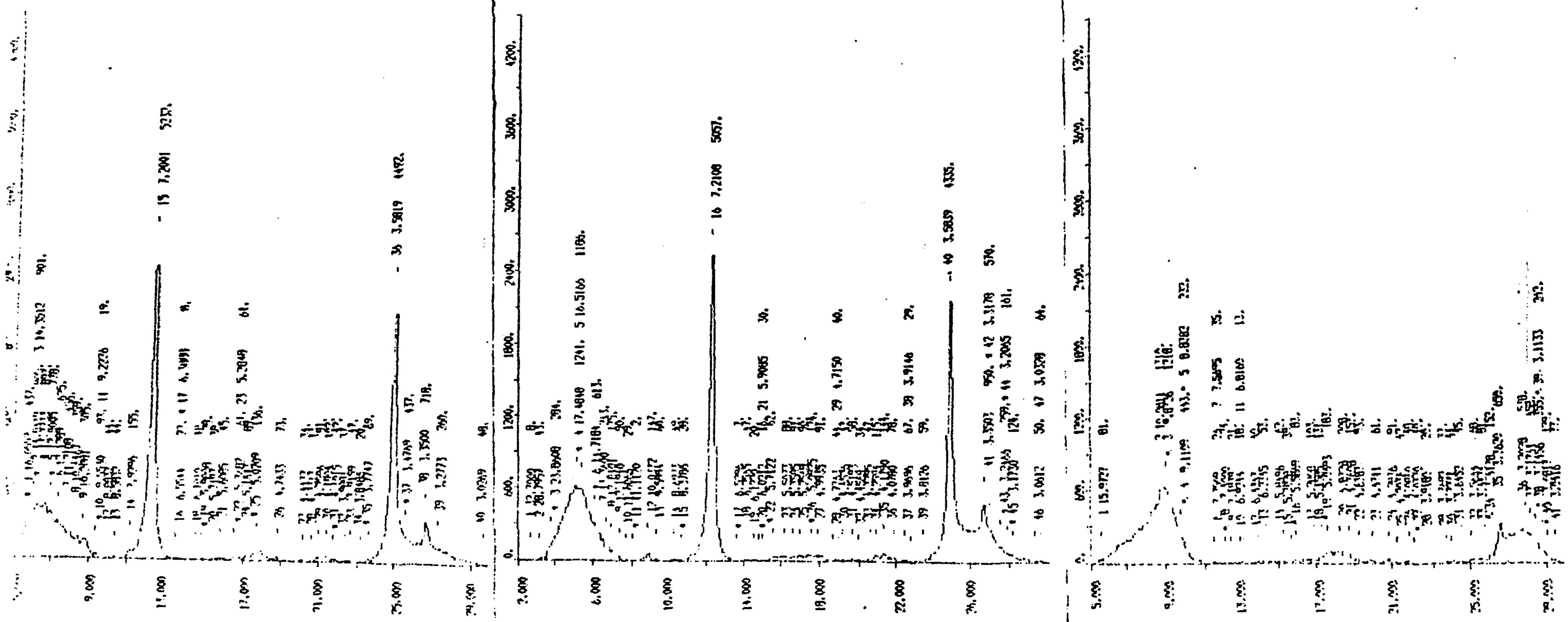
Fig. 15

clay mineralogy of Sodari (Convexed)

Anode : Cu K 1.2

Time : 2.000

Step size : 0.05



Normal treatment

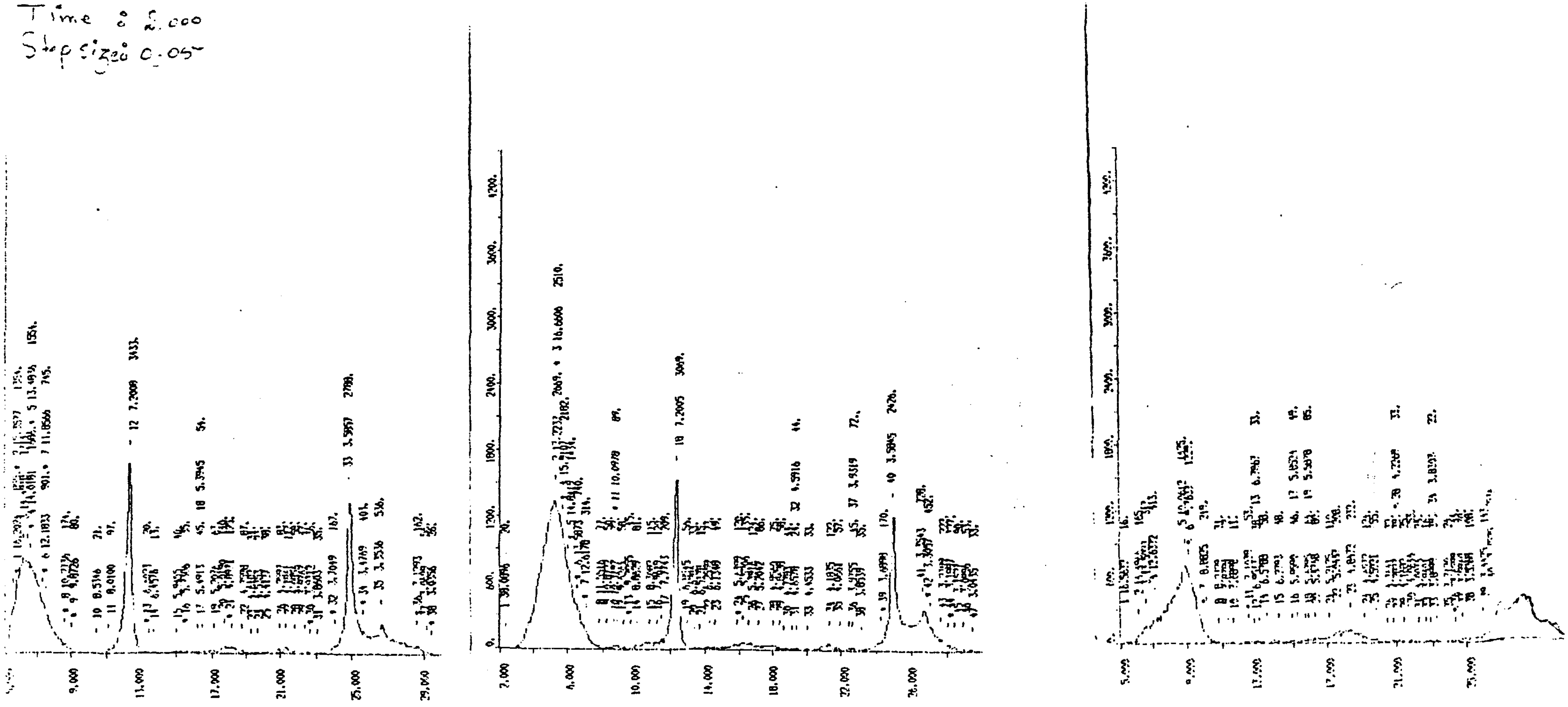
Ethylene treatment

Heated treatment

Fig 16

clay mineralogy of Nihud (Concaved)

F mode & Cu K1-2
Time : 2.000
Step size: 0.05



Normal treatment

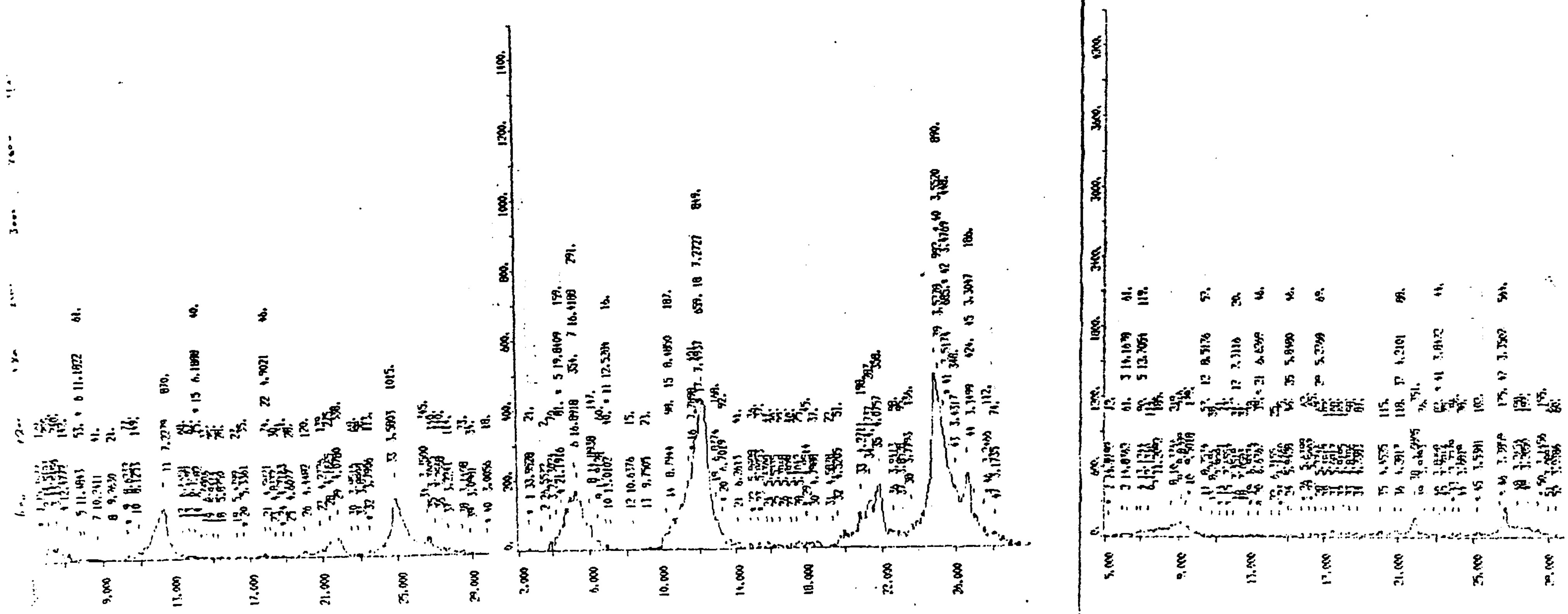
Ethylene glycol treatment

Heated treatment

Fig 17

Clay mineralogy of Nihud (Convexed)

Anode : Cu K 1·2
Time : 2.000
Stepsize : 0.05



Normal treatment

Ethylene glycol treatment

Heated treatment

Fig 18

Clay mineralogy of Um gamalla (Concluded)

Anoce : Cu K1+2
Time 2 2.000
Step size 0.05

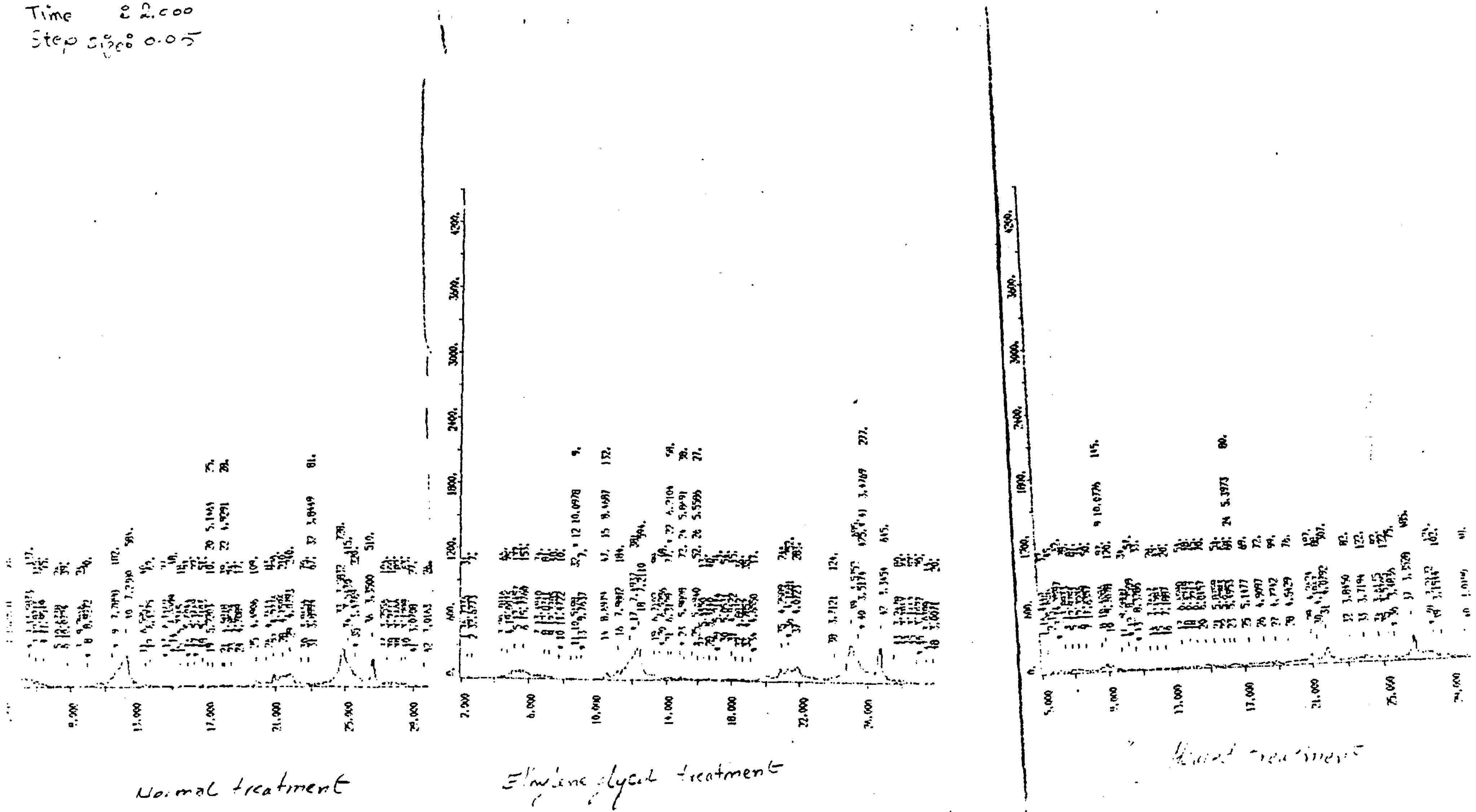


Fig. 19

Clay mineralogy of Lingamalla (convexed)

Table 2

Free iron oxides (ppm)

site	Depth cm	Free iron oxide
Baradab	0-20	1926
	20-60	3420
	60-150	2892
	0-25	1982
	25-70	432
	70-120	1704
Sodari	0-30	618
	30-70	624
	70-120	228
	0-20	294
	20-70	234
	70-140	246
Nihud	0-40	360
	40-100	300
	100-140	354
	0-40	246
	40-70	232
	70-100	270
	100-150	318
Umgamalla	0-10	576
	10-50	396
	50-100	708
	0-20	642
	20-60	258
	60-100	252

Table 3

Clay mineral (%) in the Gardud soils tested

Site	Depth cm	Kaolinite%	Smectite %	Illite%
Baradab	0–20	52	47	Traces
AB_1	20–60	42	50	8
	60–150	71	29	Traces
	0–25	47	53	Traces
AB_2	25–70	57	43	Traces
	70–120	67	33	Traces
Sodari	0–30	27	73	Traces
AS_1	30–70	25	75	Traces
	70–120	20	76	04.00
	0–20	56	40	04.00
AS_2	20–70	49	49	02.00
	70–140	37	61	02.00
Nihud	0–40	83	17	----
AN_1	40–100	66	33	----
	100–140	92	08	----
	0–40	79	16	02.00
AN_2	40–70	73	27	----
	70–100	75	25	----
	100–150	86	14	----
Umgamalla	0–10	85	15	----
AU_1	10–50	85	15	----
	50–100	26	70	----
	0–20	63	31	02.00
AU_2	20–100	65	31	06.00
	100–160	57	48	04.00

3.3.2 Sand Mineralogy:-

According to the optical properties, the flowing minerals has been identified, Zircon, Rautile, Tourmaline, Staurolite, Epidote, Hornblend, Kynite and Garnet. (Attached plates show their characteristics).

3.3.2.1 Baradab sites:-

The percentage of heavy & light minerals data is shown in Table 4.

Light Minerals:-

Comprised about 95.9% of the top soil, and dropped slightly to 95.66% at the subsoil, and are dominated by quartz 95% in the top and the subsoil.

Heavy Minerals:-

The heavy mineral constitutes of about 4% of the total minerals. More than 75% of which are opaques at the upper surface and 79% in subsoil . Zircon constituted about 4.3% and 12.8%), tourmaline was about (1.5% to.3%), rautile (2.9% and 4.3%), staurolite (1.5% and 0.0%), pyrite (70% and 0.0%), Epidote (6.0% and 0.0%), and Hornblend, (1.5% and 0.0%) at the surface and the subsoil.

3.3.2.2 Sodari sites:-

The percentage of heavy and light minerals data were illustrated in Table (5).

Light Minerals:-

They comprised of about 93.03% and 96.8% of the upper and sublayers respectively. Quartz is the dominant mineral.

Heavy Minerals:-

The opaque comprise 77% and 75% of the heavy minerals in the

Table 4

Baradab: Sand mineralogy

Depth	Light mineral%	Heavy mineral%
Surface	95.92	4.08
Subsurface	95.66	4.34

Depth cm	Light minerals (%)		Heavy mineral (%)					
	Quartz	Others	Zircon		Turmaline		Rautile	
			A	R	G	B	A	R
Surface	95%	5%	2.9	1.4	–	1.5	–	2.9
Subsurface	95%	5%	2.5	4.3	–	4.3	–	4.3

Depth cm	Heavy minerals (%)					
	Staurolite	Kynite	Epidot	Hornblend	Garnet	Opaque
Surface	1.5	7	6	1.5	–	75
Subsurface	–	–	–	–	–	79

A = Angular
R = Rounded
G = Green
B = Brown

Table 5

Sodari: Sand mineralogy

Depth	Light mineral (%)	Heavy mineral (%)
Surface	98.03	1.97
Subsurface	96.80	3.20

Depth cm	Light minerals (%)		Heavy mineral (%)					
	Quartz	Others	Zircon		Turmaline		Rautile	
			A	R	G	B	A	R
Surface	97%	3%	7	2	–	5	–	1
Sub surface	96%	4%	7	2	2	3.4	2	1

Depth cm	Stauro lite	Kynite	Epidot	Hornblend	Gar-net	Opaque
Surface	1	7		1.5	–	77
Sub surface	0.7	4.2	0.7	1.3	0.7	75

A = Angular
R = Rounded
G = Green
B = Brown

upper and sublayers respectively. And the rest of minerals are Zircon (9%) at the upper and sublayers. Tourmaline constituted about (5% and 4.4%), Rautile (1% and 2.3%), Staurolite (1% and 0.67%), Pyrite (7% and 4.18%), Epidote (0.0% and 0.67%), Hornblend (0.0% and 1.3%), and Garnet (0.0% and 0.67%).

3.3.2.3 Nihud site:-

The heavy and light minerals data is shown in Table (6).

Light Mineral:-

The light minerals comprised about 97.25% and 95.6% of the total sand minerals in the surface & subsurface soil respectively. Quartz is dominant mineral (98.5% & 97%) in the top and sublayers respectively.

Heavy Minerals:-

The opaque heavy minerals comprised 78% & 74% at the upper and subsoil,respectively. Zircon is (11.1% & 3.6%), at upper and lower horizons. Tourmaline (3.5 & 5.9), Rautile (1% & 0.0%). Staurolite (1% & o.o%) Kynite (0.7% & 1%), Hornblend (0.0% & 6.4%) and Garnet (0.7% & 0.77%).

3.3.2.4. Umgamalla:-

Table 7 shows the data of the heavy and light minerals.

Light minerals:-

They comprised 97.66% & 97.5% of the upper and subsoil layers. Quartz is the dominant mineral (94%) in the two layers.

Heavy minerals:-

They comprised 2.34% & 2.49% in the upper and lower layers. The opaque is dominant (75% & 77%) in the two layers, respectively. Zircon is (5.6% & 12.4%), Tourmaline (7.9% & 3.15%), Rautile (2.2% & 2.8%), Kynite (2.2%

Table 6

Nibud: Sand mineralogy

Depth	Light mineral (%)	Heavy mineral (%)
Surface	97.25	2.75
Subsurface	95.67	4.33

Depth cm	Light minerals (%)		Heavy mineral (%)					
	Quartz %	Others %	Zircon		Turmaline		Rautile	
			A	R	G	B	A	R
Surface	99	1.0	6.8	4.2	2.0	1.4	1.0	–
Sub surface	97	3.0	2.8	3.8	4.0	1.8	–	–

Depth cm	Heavy minerals (%)					
	Staurolite	Kynite	Epidot	Hornblend	Garnet	Opaque
Surface	1.0	4.3	2.7	–	0.7	78
Sub surface	–	5.2	1.0	6.4	0.8	74

A = Angular
R = Rounded
G = Green
B = Brown

Table 7

Umgarella: Sand mineralogy

Depth	Light mineral (%)	Heavy mineral
Surface	97.66	2.34
Subsurface	97.50	2.49

Depth	Light minerals (%)		Heavy mineral (%)					
	Quartz %	Others %	Zircon		Turmaline		Rautile	
			A	R	G	B	A	R
Surface	94	6	3.4	[illegible]	-	7.9	2.2	-
Subsurface	94	6	4.7	7.7	1.0	2.8	1.4	1.4

Depth	Heavy minerals (%)					
	Staurolite	Kynite	Epidot	Hornblend	Garnet	Opaque
Surface	-	2.2	4.5	1.1	1.1	75
Subsurface	-	2.8	-	-	-	77

A = Angular
R = Rounded
G = Green
B = Brown

Heavy minerals

(E) Subangular rautile : red in colour and character high relief .

(1) Subrounded rautile : reddish in colour and characterized by high relief.

(F) Kynite : show high relief , two sets of cleavage and contain some inclusions .

(D) Epidote : characterized by high relief , pitted and high altered.

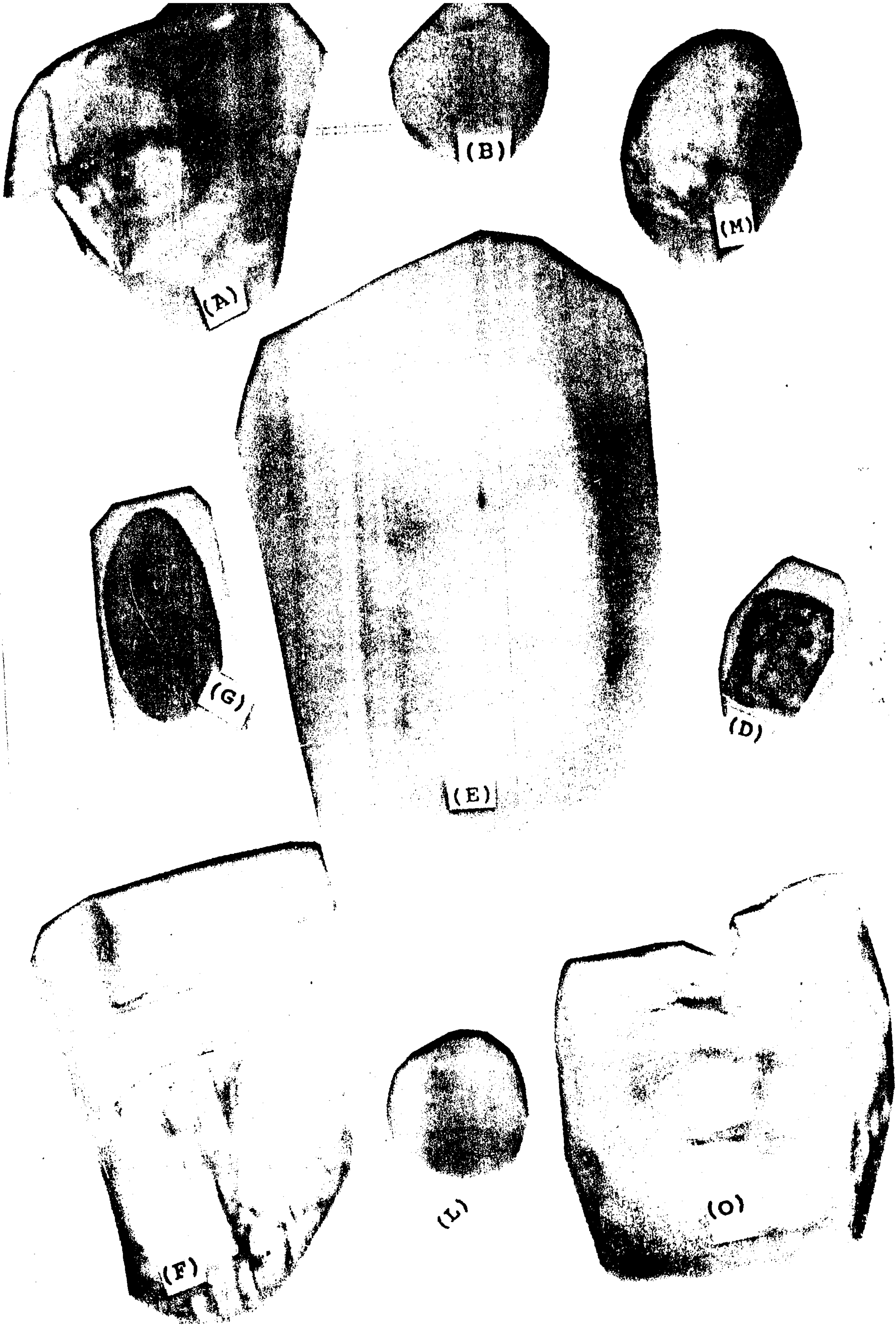
(G) Brown tourmaline: characterized by high relief .

(A) Staurolite: goldish in color and show relief.

(B) Green taurmaline: subangular to subrounded in form, characterized by lack of cleavage and weathered appearance.

(M) Zircon: green angular in form show high relief and contains some liquous inclusion.

(O) Garnet: characterized by high relief and irregular shape.


(A)
(B)
(M)
(E)
(G)
(D)
(F)
(L)
(O)

and 2.8%), Epidote (4.5% & 0.0%), Hornblend (1.1 & 0.0%) and Garnet (1.1 & 0.0) at the upper and sublayers respectively (Plate).

3.4 Soil Morphology:-

3.4.1 Baradab site:-

Appendix 5 shows the profile description of Baradab soil. The Gardud of Baradab sites occurred on flat surface, with some connected gullies. The soil is deep in the upper profile (slightly convexed), and the lower one (slightly concaved). The latter is subdivided to three clear layers according to their color.

Moist color for surface & subsurface in the slightly concaved profile are dark brown (7.5 YR 4/6) to dark reddish brown (2.5 YR 3/4), below which is dark yellowish brown (10 YR 4/6) to dark reddish brown (2.5 YR 3/4), below which is dark Yellowish brown (10 YR 4/6). The color of the surface & subsurface of the slightly convexed profile is dark reddish brown (5 YR 3/4) and (2.5 YR 3/4) respectively.

The textural class of the two profiles is gravely clay with Fe & Mn nodules and small quartz gravels, plus few patchy thin cutan. The structure of the two profiles surface is strong fine to medium granular. The subsurface layers are strong course subangular blocky, moderate to strong coarse subangular blocky, moderate-medium subangular blocky and weak medium subangular blocky in corcaved profile, while in the slightly convexed profiles sublayers structure are strong course subangular blocky and moderate-course to medium subangular blocky. The two profiles are non-calcareous, the soil reaction ranged between (pH = 5.7 to pH = 7.0).

3.4.2 Sodari:-

The Gardud soil of Sodari (Barasa) is deep occupied the flat surface with the evidence of moderate sand deposits.

The moist color is dark reddish brown(5YR 3/4) to reddish brown (5YR 4/4) at the surface and subsurface to dark brown (7.3 YR 3/4) at the bottom of the slightly concaved profile. The surface & subsurface of slightly convexed profile are distinguished by brown to dark brown (7.5YR 4/4) to yellowish (5 YR 4/6), respectively. Followed by yellowish red (5YR 5/6) at the bottom. The texture changed from sandy loam to loamy sand and sandy loam with depth in the slightly concaved profile, where as it is loamy sand all through in the slightly convexed profile. The structure is moderate to fine medium granular at the two profiles surface, but the subsurface are moderate coarse subangular blocky, weak to moderate medium subangular blocky, and massive in the slightly concaved profile, while in the slightly convexed profile the structure is moderate medium to coarse subangular blocky, moderate medium subangular blocky, and massive to weak medium subangular blocky. The two profile are non-calcareous, the soil pH is between (5 and 6.7) Appendix 6.

3.4.3 Nihud (Rahad Elsilk) Site:-

Appendix 7 shows the data of Nihud profile description.

Rahad Elsilk Gardud (Hemera) soil occured on an undulating surface with pronounced ridges, plus severe evidence of wind erosion.

The soil is deep and has two distinguished horizon and/or layers according to their color. The moist color for the surface and subsurface of the slightly concaved profile is red (5YR 4/6) and dark red (2.5 YR 3/6) respectively. The slightly convexed profile color is dark red (2.5YR 5/6) to dark red (2.5YR 3/6) in the surface and subsurface respectively. The texture is sandy clay loam for the two profiles, the structure is strong to fine medium granular in the surface, and the subsurface of the slightly concaved profile is strong medium subangular blocky, moderate medium subangular blocky. moderate medium subangular blocky, weak to moderate medium subangular blocky and massive to weak medium subangular blocky. While in the slightly convexed profile subsurfaces are moderate medium subangular blocky, weak to moderate medium subangular blocky, and massive to weak medium subangular blocky. The two profiles are non-calcareous, and the soil reaction is extremely acid (pH = 3.8 to pH = 4.3) in the two profiles.

3.4.4 Umgamalla Site:-

The surface of Umgamalla Gardud soil is flat with some connected gullies. The moist color of the surface and subsurface is dark brown (10YR 3/3) to dark yellowish brown (10YR 3/4) below which is brown to dark brown (10YR 4/3) in the slightly concaved profile. Whereas the color of the slightly convexed profile is brown to moderate brown (7.5YR 4/4) to yellowish red (5YR 4/6) in the surface and subsurface respectively. At the bottom is yellowish red (5YR 4/6). The texture is sandy loam to sandy clay in the slightly convcaved site, while its loamy sand & sandy clay in the slightly convexed profile. The structure is strong fine to moderate & moderate medium granular at the two profiles surfaces respectively, but the subsurface is moderate coarse subangular blocky, and weak course blocky in the slightly concaved profile, and strong coarse subangular blocky, moderate coarse subangular blocky and weak coarse subangular blocky. The two profiles are free from $CaCO_3$, non-calcareous, and the soil reaction is between 5 to 7 Appendix 8.

CHAPTER IV

DISCUSSION

4.1 Horizon:-

The different horizons has been identified based on the color. They were further subdivided into subhorizon according to the structure.

4.2 Color:-

Appendix (5, 6, 7, 8) show that the dominant colors are red, brown and yellow respectively. This can be explained by the behavior of iron in the soil as a function of their contrasting hydrology. The dominant iron minerals could be hematite, maghamite and geothite. Also the dark color may be due to the organic matter complexation. This finding is coinciding with finding of Hunting (1963), GTZ (1977), Dawoud (1978), Razig (1978) and Conventry (1982).

4.3 Texture and structure:-

Appendix (1, 2, 3, 4) show that the texture and structure were different from site to another and with depth. The enrichment of surface layer with coarse particles is assumed to be a result of erosion and the removal of proportionally greater amount of silt and clay than sand. The widespread occurrence of sedimentary, granite and gneiss parent material is an acceptable explanation for a sand nature of the top soil plus the downward elluviation of clay. At Sodari the top soil shows less sand than the subsoil, which could be attributed to the recent eolian depositions that contains higher amounts of silt and clays. The less granulation of the top surfaces compared with sublayers is due to the less organic matter, bare surface, hot temperature and less clay content. This result is in agreement with the finding of Razig (1978) at Umgamalla and Nihud sites and the finding of Dawoud (1978) and GTZ (1977) at Baradab site.

4.4 Soil Hardness:-

A marked hardening during the course of the dry season and friable when moist. with gritty thin laminar at the surface crust as a diagnostic characteristic of all detected Gardud soils. The hardness of these soils has no clear specific reason. Generally, this hardening may be due to the amorphous iron oxides while the crust is probably due to the dispersed clay and sedimentation on the silt and sand fractions. This interpretation coincide with that of Jones and Wild (1975), Dahrampet (1985) and El Swaify (1983).

4.5 Erosion:-

All Gardud soils undergo severe wind erosion and/or water erosion causing a truncated soil with exposed low layers. The wind erosion prevail at the northern part while the water erosion prevail at the southern part.

The field observation emphasized that the poor vegetation, the bare surface, the drought and the mankind were the main possible reasons of the erosion plus the intensive stormy erratic rainfall and the slope effect in the southern part. The gritty top layers and the rapidly breaking down of kaolinite crumbs in rainfall increased the erodability of the soil. This finding supports the finding of Rose (1962).

The principles upon which protective measures to combat water erosion are designed to prevent soil dispersion and to reduce surface run-off. The dispersion can be minimized by development of stable aggregates and vegetation cover to break rain dropping and to reduce it's dispersive force plus the role of the root system in binding the soil grains.

The reduction of run-off in the Gardud soil can be achieved by:-

- reduce the slope for rill to develop, since the run-off increases with the increase in percent slope.

- good vegetation cover negates completely the effect of climate and topography and soil erosion.

The prennials bunch types and fibrous root system are superior than annuals, Sod farming and tap rooting plants (Mirchandani, 1958). Raghunath (1963) stated that the run-off exceeds 2-3 times on bare soil and 400-600 times the soil loss as compared with the grass cover plots.

- strip cropping in closer rows and mulching may increase water intake.

- terracing the land in horizonated steps.

- early planting.

- deep ploughing (20-30cm) at the end of the season with earlier planting (Verney and Williame, 1965).

The reduction of the wind erosion could be accomplished with the increasing the colloidal content by application of farm yard manure and shelter belts of trees to form wind break beside keeping the soil covered with vegetation and residues of plants through the dry course.

4.6 Soil mineralogy:-

4.6.1 Clay mineralogy:-

Kaolinite and montmorillonite are the dominant clay minerals followed by traces of illite as shown in Table 3. The proportional constituents of these minerals are widely contrasting with depth and site. This could be due to the different pedogenic process with different periods and positions.

Different stages of weathering appeared in these soils. The presence of kaolinite and montmorillonite in abundant amount is an indication of intermediate stages of weathering, while quartz and illite are attributed to low level of weathering (weathering of clay size method (Townsend, 1972). This finding is similar to the finding of Farah (1971), Burymah (1971). GTZ (1977) and Razig (1978).

4.6.2 Sand mineralogy:-

Tables (4, 5, 6, 7) show that quartz dominated the light minerals (95-98%), while the opaques dominated the heavy minerals (74-78%). The presence of minerals such as quartz, rautile, zircon and tourmaline and the relatively absence of the weatherable minerals indicated that these soils developed on highly weathered parent materials Townsend (1972). The result also show different proportion of highly resistant mineral (zircon, tourmaline and rautile) at the surfaces and subsurfaces is a good indicator for their different source and/or encountered different pedogenic processes. The presence of angular and rounded structure also confirm the different sources. So these soils could be developed from transported and deposited material (colluvium) of different weathered material derived from the dominant rocks in the region which were mostly granite and gneiss.

The result were in agreement with the findings of Dawoud (1978) and Jones and Wild (1975) and in disagreement with the finding of Razig and Hunting (1974) who stated that these soils were developed insitu, originated from local materials, than from wind or water deposits.

4.7 Physical properties:-

4.7.1 Bulk, particle densities and porosity:-

Figures (1a,b) show that the bulk density increases with depth from south to north. The slightly concaved pits show relatively high values compared to the convexed ones. The values vary between 1.3–1.9 g/cm^3. The high value with depth may be due to the presence of compacted layers, less aggregation and the influence caused by the weight of the over laying layers. While the presence of appreciable clay content and relatively high organic matter and inturn good aggregation may affect the bulk density causing the lower values.

The particle densities vary between 2.2 and 2.5 g/cm^3 which is low in comparison with the usual particle densities of mineral soils (2.6–2.75 g/cm^3). The relative absence of the weatherable heavy minerals and incorporation of the organic matter with appreciable amounts could be responsible for the low values. The porosity increased from north to south and decreases with depth.

4.7.2 Hydraulic conductivity:-

Figures (2.1a,b : 2.2a,b : 2.3a,b : 2.4a,b) show the results of the hydraulic conductivity. From the permeability point of view (high 10^{0}), medium. (10^{-2}), low(10^{-4}), V.low(10^{-6}) practically impermeable(10^{-8} cm/s) Nihud appeared slow permeability. Baradab vary between very slow and impermeable. Sodari and Umgamalla showed throughout impermeable layers.

The permeability of Bardab was lower despite the high porosity. This may be due to the relatively high content of clay and montmorillonite clay mineral which clog the pores when dispared with water. While at Sodari and Umgamalla the impermeability could be attributed to the compacted layers and the appreciable accumulation of sodium cation, respectively. Beside the presence of montmorillonite clay in a relatively high content.

4.7.3 Infiltration rate:-

The infiltration results were shown in Fig. 3, where the impereability followed the same manner of the hydraulic conductivity i.e decreasing from Nihud to Bardab Sodari and Umgamalla . This may be due to the relatively high content of clay and montmorillnite clay mineral at Bardab, appreciable amount of sodium cation at Umgamalla and the compacted layer with appreciable amount of montmorillonite clay mineral at Sodari. This finding is in harmony with the conception that the infiltration rate is equal to the harmonic mean of hydraulic conductivity of the various layers, where there was a non uniform soil.

4.8 Chemical properties:-

4.8.1 Soil reaction and calcium carbonate :-

The pH value vary between extremely acid (pH = 3.8) and mildly alkaline (pH = 7.4), increasing with depth . The result show a slightly higher pH values in 1:5 soil water ratio compared to the soil paste due to less contact of the pH electrode in the soil paste.

The tendency of these soils may be due to the low amount of soluble alkaline salts which may be leached down. beside the presence of neutral salts (sulfate and chloride salts) in considerable amount decrease the pH. The acidic parent material (granite) and the presence of appreciable amounts of quartz and kaolinite minerals with their acidity condition and rare sources of O.M can be responsible of this acidity . These findings were agreed with Chapman et. al (1941), Baver (1938), GTZ (1977) and incontrast with the finding of Razig (1979) and Hunting (1974). The calcium carbonate was entirely absent of all the profiles. This could be explained by leaching.

4.8.2 Soluble cations and anions:-

Appendix (1, 2, 3, 4) show that the dominant cations and anions. The expected salts are potassium sulfate at the upper layers and sodium chloride, sodium bicarbonate at the bottom layers. This is because the arid-zone soils have alkaline subsoil and alkaline or neutral surface soil. The accumulation of sulfate salts at the upper layers is a phenomenon occur in the soil of arid region (Brady, 1974; Mengle and Kirkby, 1986). The electrical conductivity data shown in Figures (5a,b) reflect that the ECe is low . The increase at the surface layers could be due to the recent weathering deposits.

4.8.3 Organic matter, Phosphorus, Nitrogen, carbon/nitrogen ratio:-

Figures (7a,b ; 8a,b ; 9a,b) show that the organic matter, nitrogen, are low, while the C/N ratio is high in the north and low in the south due to the relatively good vegetation cover in the south and bare hot temperature in the northern area. The phosphorous content ranging between medium and low decreasing from south to north as shown in Figs. (10a,b). The phosphorous content increases with depth due to the decreasing pH with increasing depth.

4.8.4 Exchangeable cations:-

Appendix (1, 2, 3, 4) show that Calcium and magnesium are the dominant cations and increased with depth. Generally the exchangeable cations were low due to the highly-weathered status of these old soils. The low amount of magnesium could be due to the low amount of easily weatherable feromagnesium minerals and some secondary clay minerals such as chlorite, vermiculite, illite.

4.8.5 Cation exchange capacity (C.E.C):-

Figures (6a,b) show that the C.E.C. is low. The somewhat low values can be attributed to the high content of kaolinite mineral.

4.8.6 Sodium adsorption ratio (SAR):-

The SAR is low except at Umgamalla site. The SAR at Umgamalla site increased with depth due to the leaching of sodium.

4.8.7 Microelements:-

Table 1 shows that the content was low. This could be attributed to the strongly leached acid sandy soil and/or due to their original deficient parent material.

4.8.8 Free Iron oxides

The finding in Table 2 illustrates that Free- iron oxide was very high in Baradah in comparing with other site decreased with depth .

CONCLUSION AND RECOMMENDATIONS

Gardud soil is a local name given to truncated, gritty, non cracking clay soil with crusted surface. Erosion and compactionhazard is high. The Gardud soil (Alfisols) and Gardud-like soil (Aridisols or others) occur throughout the region under different names (Gardud, Barasa, Hadaba, Sala'a, Muglad, and Naga'a) mainly in arid and semi arid region as a part of the brown and reddish brown soil .

The physiomorphology, chemical, physical properties were influenced by the climate and the topography with different severe limitations such as (low fertility, stoniness, erosion and compaction).

According to soil taxon of American classification system

The different site classification as :-

-- Baradab sites:-

1- Kanhaplic rhodusalfs. Fine clay.kaoline. isohyperthermic (slightly concaved)

2- Kandic plaeustalfs. very fine clay kaoline, isohyperthermic (slightly convex)

-Nihud sites:-

1- Rodic

kandiustalf,fine loamy. Kaoline isohyperthermic

(slightly concave)

2- Arid paleustalfs. fine loamy. Kaoline isohyperthermic

(slightly convex)

-Umgamalla

1- Ustic haplustalfs . fine loam- kaoline isohyperthermic

(slightly-concave)

2- Ustic paleustalfs . fine loam-kaoline isohyperthermic

Sodari

1- Typic comborthid. coarse loamy - mixed-hyperthermic

(slightly concaved)

2- Typic comborthid- coarse loamy - mixed-hyperthermic

(slightly convexed)

Gardud soil posses a relatively better chemical and physical properties compared with already exploited sandy goz soil . To maintain and improve Gardud soils properties, however, the following suggestions and recommendations may contribute to achieve such an improvement:-

-Give no slope for rill to develop.

-Good vegetation cover .

-Terracing the land in horizontal steps.

-Increase the colloidal content (liming & Manure)

-Belt of wind broken trees.

-Supplementary irrigation (water harvesting)

-Deep ploughing at the end of season with early planting next year in strip and closer row .(in the south).

-Using hoe and/or animal traction in bare - sites (in the north) with early planting .

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Appendix I

Baradab

Soil type	Depth cm	pH		ECe dS/m	Text class	C.E.C mmol-/100g	Soluble cations (mmol/L)			
		1:5	Paste				Ca	Mg	Na	K
Baradab	0-5	6.60	5.70	1.50	C	16.00	0.20	0.50	1.80	9.90
	5-20	6.60	5.70	1.00	C	16.80	0.20	0.20	2.40	5.00
AB_1	20-60	6.60	5.60	1.00	C	15.80	0.40	0.20	3.00	8.30
	60-100	7.10	6.40	1.00	SC	16.50	0.50	0.30	3.90	3.60
	100-120	7.20	7.10	1.00	SC	16.50	0.60	0.30	6.50	6.20
	0-10	6.10	5.40	2.30	C	16.60	1.40	1.20	2.30	6.00
AB_2	10-25	6.20	5.40	1.50	C	16.50	0.80	2.40	2.10	8.90
	25-70	6.00	5.60	0.50	C	16.90	0.60	1.70	2.40	3.20
	70-120	7.00	5.70	0.70	C	16.80	0.40	0.20	3.00	2.20

Baradab (contd.)

Soil type	Depth cm	Exch. bases (mmol/100g)				N%	C/N ratio	P%	SAR	D_b g/cc	Porosity
		Ca	Mg	Na	K						
Baradab	0-5	8.20	1.40	0.10	0.03	0.07	9.70	7.00	3.10	1.20	52.0
	5-20	7.80	1.40	0.40	0.03	0.07	9.90	8.60	5.10	1.40	30.0
	20-60	8.90	2.30	0.00	0.10	0.08	7.70	9.60	4.70	1.40	33.0
AB_1	60-100	9.90	2.50	0.00	0.02	0.08	7.50	14.90	6.10	1.40	28.00
	100-150	9.90	4.10	0.00	0.02	0.08	6.90	14.00	8.30	1.60	24.00
	0-10	9.30	1.10	0.00	0.02	0.08	9.00	7.00	2.00	1.40	36.00
	10-25	9.60	1.20	0.00	0.03	0.09	9.10	6.00	1.70	1.30	40.00
AB_2	25-70	8.10	3.00	0.00	0.01	0.09	7.40	7.80	2.20	1.30	30.00
	70-120	9.00	3.20	0.00	0.01	0.08	7.60	10.20	5.60	1.30	38.00

Appendix II

Sodari

Soil type	Depth cm	pH		ECe dS/m	Text class	C.E.C mmol-/100g	Soluble cations mmol/L			
		1:5	Paste				Ca	Mg	Na	K
Sodari	0-10	7.40	6.70	0.80	SL	11.00	0.40	0.48	2.76	9.00
	10-30	7.40	6.70	0.30	SL	11.00	0.44	0.36	1.80	2.05
AS_1	30-70	7.20	6.25	0.83	LS	13.30	0.40	0.64	1.07	4.20
	70-120	6.80	6.00	0.50	SL	13.90	0.72	0.96	2.60	4.20
	0-20	7.40	6.40	1.00	LS	12.73	0.24	0.58	2.90	2.64
	20-70	7.30	6.40	0.60	LS	14.00	0.28	0.44	4.65	2.67
AS_2	70-100	6.60	5.00	0.30	SL	11.00	0.40	0.24	1.56	1.60
	100-140	6.50	5.00	0.60	SL	12.00	0.32	0.32	3.72	4.60

Sodari (contd.)

Soil type	Depth cm	Exch. bases				N%	C/N ratio	P%	SAR	D_b g/cc	Porosity
		Ca	Mg	Na	K						
Sodari	0-10	5.64	1.65	0.06	0.22	0.03	17.33	9.60	4.16	1.20	32.0
	10-30	3.55	1.67	0.06	0.10	0.01	53.00	8.00	2.84	1.60	22.0
AS_1	30-70	0.46	3.76	0.02	0.10	0.01	48.00	5.70	5.70	1.75	30.0
	70-120	6.37	1.54	0.01	0.17	0.01	54.00	9.40	2.83	1.80	29.0
	0-20	6.01	0.87	0.01	1.60	0.01	58.00	9.80	4.39	1.65	34.0
	20-70	5.21	1.22	0.01	0.10	0.01	53.00	8.85	4.37	1.50	40.0
	70-100	5.67	1.00	0.01	0.09	0.01	54.00	4.80	2.83	1.80	24.0
AS_2	100-140	6.36	2.68	0.01	0.09	0.01	52.00	5.20	6.57	1.90	24.0

Appendix III

Nihud

Soil type	Depth cm	pH		ECe dS/m	Text class	C.E.C mmol-/100g	Soluble cations mmol/L			
		1:5	Paste				Ca	Mg	Na	K
Nihud	0-10	5.90	4.10	0.55	SCL	18.50	0.46	0.32	1.52	3.70
	10-40	4.50	3.40	0.50	SCL	14.00	0.48	0.48	1.12	3.20
AN_1	40-70	6.10	4.00	0.60	SCL	14.50	0.32	0.40	1.12	2.30
	70-100	6.60	4.20	0.60	SCL	13.30	0.40	0.64	1.88	2.35
	100-140	6.80	4.40	0.70	SCL	14.00	0.32	0.32	2.72	2.00
	0-10	5.50	4.40	0.59	SL	14.00	0.16	0.46	1.52	2.40
	10-40	5.50	4.30	0.59	SCL	14.20	0.48	0.48	1.72	2.10
	40-70	4.50	3.60	0.57	SCL	14.00	0.32	0.40	2.12	1.80
AN_2	70-100	4.80	3.80	0.77	SCL	14.20	0.40	0.64	2.08	1.90
	100-150	5.50	3.90	0.50	SCL	14.30	0.20	0.20	1.98	2.35

Nihud (contd.)

Soil type	Depth cm	Exch. bases (mmol/100g)				N%	C/N ratio	P%	SAR	D_B g/cc	Porosity
		Ca	Mg	Na	K						
Nihud	0-10	3.01	1.32	0.01	0.01	0.04	9.75	1.60	2.68	1.50	46.00
	10-40	2.72	1.44	0.01	0.04	0.05	8.20	2.00	2.48	1.50	40.00
AN_1	40-70	2.62	1.77	0.01	0.01	0.06	8.83	2.20	3.53	1.20	52.00
	70-100	3.28	1.55	0.01	0.01	0.05	9.20	2.60	2.40	1.40	44.00
	100-140	2.77	2.01	0.01	0.00	0.05	8.40	3.80	4.80	1.42	43.00
	0-10	2.55	1.84	0.03	0.00	0.03	16.00	1.20	3.10	1.50	40.00
	10-40	2.33	1.92	0.00	0.01	0.03	14.30	2.00	1.61	1.40	36.00
AN_2	40-70	2.66	1.84	0.00	0.00	0.05	9.00	1.60	1.86	1.40	36.00
	70-100	4.57	0.01	0.00	0.00	0.04	8.75	2.20	2.60	1.60	36.00
	100-150	4.77	0.00	0.00	0.00	0.05	8.40	2.30	4.03	1.50	40.00

Appendix (V)

Baradab site

Information on the site:-

(a) Profile number: AB, AB_2

(b) Soil name: Gardud El baradab

(c) Higher category classification: kanhaplic rhodustalf, kandic paleustalf

(d) Date of examination: 15/5/1993

(e) Authors: Abdel Moneim A. I and Dawoud Mohamadani

(f) Location: Assalamat village, one Km north El Baradab village which is about 8 Km north west of Kadogli town.

(g) Elevation: 400-500 m.s.l

(h) Land form:

i- Physiographic position: high ridge

ii- Surrounding land form: almost flat

iii- Microtopography: nil

(i) Slope on which profile is sited: level to nearly level, the downward from north to south.

(j) Land use: At the time of examination land was under poor pasture

(k) Climate: The average annual rainfall is 600-850 mm. There is a pronounced dry season with 5 to 7 dry months. The growing season is 5 months. The mean annual temperature is 19.0°C with maximum daily average of 35.0°C.

(l) Vegetation: Kadad (Dichrostachys cirerea), Arad (Albizia amara), Habil (Combretum cordfanum). Sabah (Anogeisus leiocarpus), Aboney (Dalbergia melanoxylon), Um Shoka (Hygrophylle spinosa)

General information on the soil:-

(a) Parent material: Apparently, basement complex, mainly granite and schist

(b) Drainage: Well to moderately drained

(c) Moisture condition:

(d) Depth of ground water table: Unknown

(e) Presence of surface stones, rock outcrops: None

(f) Evidence of erosion: Slightly gullied erosion

(g) Presence of salt or alkali: None

(h) Human influence: None

Profile description:-

(a) Slightly concaved profile (AB_1)

0-5cm Strong brown (7.5YR 4/6) dry, and dark brown (7.5YR 3/4) moist, clay, strong fine to medium granular, sticky, plastic, friable moist, slightly hard dry, few fine pores, few small quartz and iron and manganese nodules, non-calcareous, few very fine roots, pH 5.7, abrupt smooth boundary.

5-20cm Strong brown (7.5YR 4/6) dry, dark brown (7.5YR 3/4) moist, clay, moist strong coarse subangular blocky, sticky, plastic, friable moist, slightly hard dry, few fine tubular pores, few small quartz and iron and manganese nodules, non-calcareous, few very fine roots, pH 5.7, clear smooth boundary.

20-60cm Dark reddish brown (2.5YR 3/4) dry and moist, moderate to strong coarse subangular blocky, sticky, plastic, friable moist, slightly hard dry, few fine patchy cutan, few fine tubular pores, few fine small quartz and iron and manganese nodules, non-calcareous, few very fine roots, pH 5.7, gradual smooth boundary.

60-100cm Dark yellowish brown (10YR 4/6) dry and moist, sandy clay, moderate medium subangular blocky, sticky, plastic, friable moist, hard dry, few fine tabular pores, non calcareous, few very fine roots, pH (6.4) gradual smooth boundary.

100-150cm Dark yellowish brown (10YR 4/6) dry and moist, sandy clay, weak medium subangular blocky, sticky, plastic, firm moist, hard dry, very fine tabular pores, non-calcareous, pH 7.1.

Slightly Convexed Profile(AB_4):-

0-10cm Yellowish red (5YR 4/6) dry, and dark reddish brown, (5YR 3/4) moist clay, strong fine to medium subangular blocky, sticky, plastic, firm moist, slightly hard dry, few medium tabular pores, few fine small quartz and Fe & Mn nodules, few fine to medium roots. pH (5.4) abrupt smooth boundary.

10-25cm Yellowish Red (5YR 4/6) dry, and dark reddish brown (5YR 3/4) moist, clay, strong course subangular blocky, sticky, plastic, friable moist, slightly hard dry, few medium tabular pores, few small quartz, Fe & Mn nodules, non-calcareous, few fine to medium roots, pH (5.4) abrupt smooth boundary.

25-70 cm Dark red (2.5YR 3/6) dry, and dark reddish brown (2.5YR 3/4) moist, clay, strong course subangular blocky, sticky, plastic, friable moist, slightly hard dry, few patchy thin cutan, few medium tabular pores, few small quartz Fe & Mn nodules, non-calcareous, few very fine roots pH (5.6) gradual smooth boundary.

70-100 cm Dark red (2.5YR 3/6) dry & dark reddish brown (2.5YR 3/4) moist, clay, moderate course to medium subangular blocky, sticky, plastic firm moist, slightly hard, few patchy thin cutan, few fine tabular pores, pH (5.7) gradual smooth boundary.

100-120 cm Dark red (2.5YR 3/6) dry & dark reddish brown (2.5YR 3/4) moist, clay, moderate medium subangular blocky, sticky, plastic, firm moist slightly hard dry, few patchy thin cutan, few fine tabular pores, non-calcareous, pH (5.7).

Appendix No.(VI)

Sodari Site:-

I. Information on the site:-

a) Profile No.: As_1, As_2

b) Soil name: Gardud Sodari (Barasa)

c) Higher category classification: Typic camborthids

d) Date of examination: 1.6.1993

e) Author : Abdelmoneim, A.1 & Dawoud Mohamdani

f) Location: 25 Km west Sodari town, 2 Km west Um-maharik Jepel and west Khur Elamin.

g) Elevation:

h) Land form:

i) Physiographic position: High ridge

ii) Surrounding land form: almost flat

iii) Microtopography: Nil

i) Slope on which profile is sited: level to nearly level the downward from south to north.

j) Land-use: very poor pasture to pare land.

k) Climate: The average annual rainfall is 100-225mm. The growing season of 1-2 months, with a pronounced dry season 10-11 months. The mean annual temp. is 24°C with maximum daily average of 40-42°C.

l) Vegetation: (Accia mellifra), (Accia nubica), (Accia tortitis) (A.nilotica), Oshr (Calotropis porcera) Korsan (Bosia senegalensis) (Aristida sp) (Eragrostis termula) (Cenchrub biflorus).

II. General Information on the Site:-

a) Parent material: Apparently, Basement complex, mainly granite, genesis and schist.

b) Drainage: well to moderately drained.

c) Moisture conditions : none

d) Depth of groundwater table: unknown

e) presence of surface stone, rock out crops: none

f) Evidence of erosion: sever wind erosion.

g) Presence of salt or alkali : none

h) Human influence: none.

III) Profile description

Sodari

Slightly Concaved Profile (As_1)

0----10cm Reddish brown (YR 4/4) dry and dark reddish brown (5YR 4/4) moist, sandy loam, moderate to fine granular, slightly sticky non plastic, friable moist, slightly hard dry, common tabular pores, non-calcareous, few fine, pH (6.7) clear smooth boundary.

10----30cm Reddish brown (5YR 4/4) dry and dark reddish brown (5YR 3/4) moist, sandy loam, moderate course subangular blocky, slightly sticky, non-plastic, friable moist, slightly hard dry, common tabular pores, non-calcareous, few fine roots, pH (6.7), clear smooth boundary.

30----70cm Yellowish red (5YR 4/6) dry, and reddish brown (5YR 4/3) moist, loamy sand, weak to moderate medium subangular blocky, slightly sticky, slightly plastic, non-calcareous, few very fine roots, pH (6.2) clear smooth boundary.

70----120cm Brown to dark brown (7.5YR 4/4) dry, and dark brown (7.5YR 3/4) moist, sandy loam, massive slightly sticky, slightly plastic, friable moist, hard dry, common moderate tabular pores, non-calcareous, pH (6.0).

Slightly Convexed Profile (As_1)

0----20cm Strong brown (7.5YR 5/6) dry and brown to dark brown (7.5YR 4/4) moist, loamy sand, fine to moderate medium subangular blocky, slightly sticky, nonplastic, friable moist, slightly hard dry, common fine tabular pores, non-calcareous few fine roots, pH (6.4), clear smooth boundary.

20----70cm Yellowish red (5YR 4/6) dry and moist, loamy sand, moderate medium to course subangular blocky, slightly sticky, nonplastic, friable moist, slightly hard dry, common fine tabular pores.

70-----100cm Yellowish red (5YR 6/8) dry, and yellowish red (5YR 5/6) moist, loamy sand, moderate medium subangular blocky, slightly sticky, slightly plastic, friable moist, hard dry, fine tabular pores, non-calcareous, pH (5.0).

100--140cm Yellowish red (5YR 6/8) dry, and yellowish red (5YR 5/6) moist, loamy sand, massive to weak medium subangular blocky, slightly sticky, slightly plastic, friable moist, hard dry, fine tabular pores, non-calcareous, pH (5).

Appendix (VII)

Nihud Site

I) Information on the site:

a) Profile No.AN1, AN2

b) Soil name: Gradud Elnihud (Hemera)

c) High category classification : Rhodic pale ustalfs/aridic paleustalfs

d) Date of examination: 30.6.1993

e) Author: Abdelmoncim, A.I & Dawoud Mohamdani

f) Location: 500m. west Rahad Elsilk, and about 25 Km south east Nihud town.

g) Elevation:

h) Land form:

i) Physiographic position: high ridge

ii) Surrounding land form : undulating

iii) Microtopography: none

i) Slope on which profile is sited: nearly level.

j) land use : poor pasture.

k) Climate: The average annual rainfall is 225–400mm, the growing season of 3–4 months, with a pronounced dry season 8–9 month. The mean annual temperature with maximum daily average of 40–42°c and minimum daily average of 13–17°c.

l) Vegetation: Korsan (Boscia senegalensis), Gobbaish (Guena senegalensis), (Accia senegal), Haskanit (Cenchrus sp), Umgalagil (Aristolochia sp).

II) General Information on the soil:-

a) Parent material: apparently, Basement complex, mainly granite, genesis and schist.

b) Drainage: well to moderately drained

c) Moisture condition:

d) Depth of the groundwater table. unknown

e) presence of the surface stone, rock outcrops: very few boulders

f) Evidence of erosion: moderately to sever wind erosion.

g) Presence of salt or alkali: none

h) Human influence: none

III) Profiles Description

Nihud

Slightly Concaved Profile (AN1)

0---10cm Red (2.5YR 5/6) dry, and dark red (2.5YR 3/6) moist, sandy.clay.loam, fine to moderate medium granular, slightly sticky, slightly plastic , firm moist, slightly hard dry, many medium tabular pores, non-calcareous, few fine roots, pH (4.1) clear smooth boundary.

10---40cm Red (2.5YR 5/6) dry and dark red (2.5YR 3/6) moist sandy clay loam, strong medium subangular blocky, slightly sticky, slightly plastic, friable moist, slightly hard dry, many medium tabular pores, non-calcareous, few roots, pH (3.4) gradual smooth boundary.

40---70cm Red (2.5YR 4/8) dry and dark red (2.5YR 3/6) moist, sandy clay loam, moderate medium subangular blocky slightly sticky, slightly plastic, friable moist, slightly hard dry, few patchy thin cutan, many medium to coarse tabular pores, non-calcareous, common fine to medium root, pH (4.0) gradual smooth boundary.

70--100cm Red (2.5YR 4/8) dry and dark (2.5YR 3/6) moist, sandy clay loam, weak to moderate medium subangular blocky, slightly sticky, slightly plastic, firm moist, few fine pores, non-calcareous few fine roots, pH (4.2) gradual smooth boundary.

100---140cm Red (2.5YR 4/8) dry and dark (2.5YR3/6) moist sandy clay loam, massive to weak medium subangular blocky, slightly sticky, slightly plastic, firm moist, slightly hard dry, few very fine pores, non-calcareous, pH (4.4).

Slightly Convexed Profile (AN2)

0----10cm Red (2.5YR 5/6) dry, and red (2.5YR 4/6) moist, sandy clay loam, strong medium granular slightly sticky slightly plastic, friable moist slightly dry many fine to medium pores non-calcareous, common fine roots, pH (4.4) clear smooth boundary.

10---40cm Red(2.5YR 5/6) dry, and red (2.5YR 4/6) moist, sandy clay loam, moderate medium subangular blocky, slightly sticky slightly plastic friable moist, slightly hard dry, many fine to medium tabular pores, non-calcareous, few fine roots, pH (4.3) clear smooth boundary.

40----70cm Red (2.5YR 4/8), and dark red (2.5YR 3/6) moist, sandy clay loam, moderate medium subangular blocky, slightly sticky, slightly plastic, friable moist, slightly hard dry, few patchy thin cutan. Many medium tubular pores, non-calcareous, few fine roots, pH (3.8), gradual smooth boundary.

70---100cm Red (2.5YR 4/8) dry, dark red (2.5YR 3/6) moist, sand clay loam, weak to moderate medium subangular blocky, slightly sticky, slightly plastic, friable moist, slightly hard dry, few fine pores, non-calcareous, very few fine roots, pH (3.8), gradual smooth boundary.

100--140cm Red (2.5YR 4/8) dry, and dark red (2.5YR 3/6) moist, sandy clay loam, massive to weak medium subangular blocky, slightly sticky, slightly plastic, friable moist, slightly hard dry, few fine pores, non-calcareous, pH (3.9).

Appendix (VIII)

Umgamalla:

I. Information on the Site:

a) Profile No. AU1, AU2

b) Soil name: Gardud Umgamalla.

c) High category classification: Ustic Haplustalfs/Ustic paleustalfs.

d) Date of examination: 1.5.1993

e) Author: Abdelmoneim.A.I., G.M. Madibbo and Dawoud Mohamdani.

f) Location: 500m north Umgamalla village, 100 km south El Obied city.

g) Elevation: 500-600 m.s.l

h) Land form:

i) Physiographic position: flat

ii) Surrounding land form: almost flat.

iii) Microtopography : none.

i) Slope on which profile is sited: level to nearly level.

j) Land use : at the time of examination land under rather poor pasture and shifting agriculture are practice.

k) The climate: The average annual rainfall is 400-500mm. The growing season of 3-4 months, with a pronounced dry season 8-9 month. The mean annual temp. is with maximum daily average of 39-40°c and minimum daily average of 13-17°C.

l) Vegetation: Korsan (Boscia senegalensis), Lawot (Accia nubica), Tabaldi (Adansonia digitata), Sidir (Ziziphus spinec-hristy), Diffra (Ecconochloa colaua), Aish elfar (Eragrotis termula) and (Borreria sp).

II. General Information on the Site:-

a) Parent material: apparently Basement complex, mainly granite, genesis and schist.

b) Drainage: well to moderate drained.

c) Moisture condition

e) Presence of surface stone or rock out crops: none

f) Evidence of erosion: slightly wind erosion

g) Presence of salt or alkali: none

h) Human influence: none

III. Profile Description

Slightly Concaved Profile (AU1)

0----10cm Yellowish brown (10YR 5/4) dry, and dark brown (10YR 5/3) moist, sandy loam, strong fine to moderate medium granular. slightly sticky, plastic, friable moist slightly hard dry, few very fine pores, non-calcareous, few fine roots, pH (5), abrupt smooth boundary.

10---50cm Dark yellowish brown (10YR 3/4) dry, and moist, sandy clay loam, moderate coarse subangular blocky sticky, plastic, friable moist, very hard dry, few patchy thin cutan, few very fine pores, non-calcareous, few fine roots, pH (6.7), gradual smooth boundary.

50---100cm Brown to dark brown (10YR 4/3) dry and moist, sandy clay, weak course blocky, sticky, plastic, friable moist, hard dry, few patchy thin cutan, very fine pore, non-calcareous, few fine roots, pH (7.3)......

Slightly Converted (AU2)

0----5cm Strong brow(7.5YR 4/6) dry, and brown to moderate brown (7.5YR 4/4) moist, sandy loam, moderate fine granular, slightly sticky, slightly plastic, friable moist, hard dry, few fine tabular pores, non-calcareous, few fine roots, pH (5), abrupt smooth boundary.

5----10cm Yellowish red (5YR 4/6) dry, and moist, sandy clay, strong course subangular blocky, slightly sticky, slightly plastic, friable moist, slightly hard dry, few patchy thin cutan, few very fine pores, non-calcareous, few very fine roots, pH (5), gradual smooth boundary.

20---60cm Yellowish red (5YR 4/6) dry and yellowish red (5YR 4/6) moist, sandy clay loam, moderate coarse subangular blocky, slightly sticky, slightly plastic, friable moist, hard dry, few fine patchy thin cutan, non-calcareous few very fine roots, pH (5) gradual smooth boundary.

60---100cm Yellowish red (5YR 5/6) dry, and yellowish red (5YR 4/6) moist, sandy clay loam, massive to weak course subangular blocky, slightly sticky, sticky plastic, friable moist, hard dry, non-calcareous