4. RESULTS AND DISCUSSION

In general, the desert soils of Kharga Oasis have been classified as weakly developed desert soils. This may be due to the hot dry climate which was the main soil forming factor responsible for the characteristics that distinguish the desert soils from other soils groups .

4.1. The Geomorphic Units of the studied area:

The studying soil profiles of the area under investigation reveal that these soils have multi environmental conditions of sediment deposition. This is due to the action of water as well as to climatic changes that took place within the succession of the geoloical period (Ball 1939).

From the field work and the previous soil Map (3), the most potential homogeneous soil units for agricultural purpose could be selected considering the dominant land utilizations in the area. The geomorphic units Map (4) were identified as follows:

A. The Peneplain (P):

This unit is located in the middle part of the studied area which represent about 3055 Km^2 and it was subjected to deposition of alluvium fine materials transported by old river Nile and wind blown sand transported by the prevailing north- western winds (Abu El Ezz 1971). Therefore, the land of that part is covered with sand and / or sandy loam layer of variable thickness, depending on the surface feature of the underlaying layer of sediments or rocks.

In general, the depth of these soils increases, to reach several meters. The surface of this unit is either flat or undulating or rolling the vegetation cover consists of scarce native vegetation, grasses, shrubs, date palms and dom. Besides, there are large areas of field crops around the wells. The main part of the land is uncultivated.

Eleven soil profiles and also thirty auger holes were made to investigate the soils of this unit.

The soils were developed in deep to very deep alluvial loamy as well as sandy materials with varying gravel contents.

B. The Pediplain (Pd):

This unit is located in El-Kharga Oasis around the eastern part (scarpment), and represented an area of about 990 Km^2. One profile (profile No. 12) in addition ten deep auger holes were made to investigate the soils of this unit.

The soils are moderatly deep 60 - 90 cm., residual or alluvial sandy clay loam and sandy material with varying gravel contents. The largest part of this unit is covered with a thick (1 to 25 cm) layer of overblown loamy sand. The topography is nearly level and in some locations it is gently undulating, but the land form is rolling.

Most of the soils identified in this unit are Typic Torriorthents.

C. The Sand Dunes (Sd):

This unit is dominated by crecent- shaped barchan dunes and occasionally some with save dune. They reach height of 10- 15 meters. Their surface is bare of vegetation except in the relatively level areas between them, and they are drift very slowly to the south east.

The soils have been classified as follows: The main indentified families are Typic Torripsamments, sandy, mixed, hyperthermic, very deep. The inclusion soils are Typic Torriothents, sandy, mixed hyperthermic, very deep.

Some of these dunes are located in the western and others are in the northern part of the studied area.

They are called "Abu El- Mohariq", and extended 350 Km from El Bahariya south to El Kharga along an old course of Libyan River. They make the elongated shape of the depression. They commonly break into fields of barchans and barchanoid ridges. These barchans are Typical of the sand trapping dunes that form transverse to the prevailing wind in topographically low areas (Bread et al (1978).

4.1.1. The soil components of El Kharga Oasis:

Each of the aforementioned geomorphic units include two or more soil components according to landforms as shown in Table (2) and Map (4). These soil components are discussed in the following mapping units:

4.1.1.1- El-Kharga soil of the (Flat peneplain):

This mapping unit (Map 4) is located east of the sand dunes. It consists of mainly alluvium deposits covering the peneplain and occupying most of the low flat lands of the studied area. It covered about 71905 feddans represents about7.5 % of the studied area. It includes about 80 % soils of El Kharga and 20 % inclusion soils of El Gazair and Baris.

Table (2) Soil components of the different studied geomorphic units.

Geomorphic unit	Land form	Soil Components	Percent
Peniplain	Flat	Elkharga	80
		Inclusion (ElGazair and Baris)	20
Peniplain	Undulating	Elkharga	30
		ElGazair	30
		Baris	20
		Inclusion (Ain El Gazal and Ain El Eila)	20
Peniplain	Rolling	Elkharga	50
		Qasr Zaiyan	30
		Inclusion (ElGazair and Baris)	20
Peniplain	Rolling	El Aguz	80
		Inclusion (Ain El Gazal and Qasr Zaiyan)	20

El Kharga series consists of very deep soils with rapid permeability. They are formed of alluvium sandy clay loam and / or sandy loam and clay substrata.

They contain around 3.0 % calcium carbonate. The surface of El-Kharga series is mainly gently sloping and occasionally almonst flat. Soil structure is predominantly massive and occasionally sub angular blocky. When moist the matrix is commonly firm and occasionally friable.

The hue of the soil solum is predominantly 10 YR, the value is commonly 7 and sub commonly 5; the chroma is commonly 6 followed by 4 and 2. Slope ranges from 0 - 8%.

These soils are placed to Typic Torriorthents, fine loamy, mixed, hyperthermic, very deep.

Typical pedon of ElKharga loamy sand (profile No 4), on 1/2 % slopes in rangeland.

The A horizon is loamy sand or sandy loam in its uppermost layer then sandy loam in the underlying layer which ranges from 20 to 50 cm. Soil structure is predominantly massive and occasionally angular and / or subangular blocky.

Profile No. : 4

Location : About 400 m. west Felastin, Baris

Elevation : 100 m. (a.s.l)

Geomorphic unit : Peneplain

Land Form : Flat

Slope : Almost flat

Soil classification : Typic, Torriorthents, fine loamy, mixed; hyperthermic, very deep.

Land use : Cultivated with field crops and vegetables.

Irrigation source : Garmashin well

Surface cover : Small crust of gravels.

Depth (cm)	Description
0 - 20	Light brown (7.5 YR 6/4 dry), to brown (7.5 YR 5/4 moist); loamy sand; massive; non sticky, non plastic, soft; many coarse pores; few fine to medium healthy roots; strongly effervescence; few soft lime accumulations; gradual smooth boundary.
20 - 50	Light brown (7.5 YR 5/4 dry), to brown (7.5 YR 4/4 moist); sandy loam; massive; slightly sticky slightly plastic, slightly hard; common fine and medium pores; very few fine healthy roots; slightly effervescence; few fine soft lime accumulations; gradual wavy boundary.
50 - 80	Brownish yellow (10 YR 6/6 dry), to brown (7.5 YR 5/4 moist); loamy sand; massive; non sticky, non plastic, soft; common medium pores; slightly effervescence; common fine and medium gravels; abrupt smooth boundary.
80 - 150	Weak red (10 YR 4/3 moist); many medium reddish mottlings (5 y 6/3 moist); clayey; moderate fine angular blocky; very sticky, very plastic, very hard; common fine pores; slightly effervescence; few fine soft lime accumulations; few fine gypsum nodules; few fine gravels.

The soil matrix is moderately calcareous and predominantly friable and occasionally firm when moist.

The A horizon has matrix hue which is predomonantly 10 YR and occasionally predominantly 7.5 YR. The value is commonly 5 and subcommonly 6. The chroma is mainly 3 and occasionally 4.

The C horizon is sandy loam and / or clay or loamy sand 50 cm. to more than 120 cm. thick. The soil structure is predominantly massive. The soil consistance is predominantly firm and occasionally friable when moist. It contains few soft accumulations and hard concretions of lime and few fine gypsum nodules. The effervescence is mainly moderate and occasionally slight.

The C horizon has matrix hue which is predominantly 10 YR and occasionally 7.5 YR and the value is mainly 6 and occasionally 5 followed by 5 and 4. The chroma is commonly 3 and subcommonly 6 followed by 4.

4.1.1.2. El Kharga, El Gazzair and Baris complex soils (undulating peneplain soils):

This mapping unit (map 4) is located in The middle part of the studied area, between the eastern scarpment and barchan sand dunes which extends from the north to the south of the studied area. Another part is located on the northen part surrounded by scarpments and pediplain.

This complex unit consists mainly of alluvium covered peneplain, the soils of this unit are represented by profiles 2, 3, 5, 6, and 11. This mapping unit covers 412381 feddans which represent 42.8 % of the investigated area. It makes up 30 % of El Kharga , 30 % of El Gazzair, 20 % of Baris and 20 % inclusion soils of Ain El Gazzal and Ain El Siwa.

The Baris series consist of very deep soils with rapid permeability. They are formed of alluvium sandy clay loam over loamy sand and loamy sand substrata. The slope ranges from 0 to 4 %. The surface of Baris is gently sloping. The soil structure is subangular blocky and / or platy.

The soils contain 3.5% calcium carbonate. The hue for the solum is 10 YR, the value is commonly 6 and subcommonly 7, and the chroma ranges from 2 to 4.

These soils are Typic Torriorthents, fine loamy over sand, mixed, hyperthermic very deep.

Profile No. : 2

Location : About 3.75 Km. north Baris, east Sidi Ahmed.

Elevation : 50 m. (a.s.l)

Geomorphic unit : Peneplain

Land Form : Undulating

Slope : Gently Sloping

Soil classification : Typic, Torriorthents, fine loamy over sand,mixed, hyperthermic, very deep

Land use : Barren

Surface cover : Few fine crust of gravels.

Depth (cm)	Description
0 - 15	Light yellowish brown (10 YR 6/4 dry), to grayish brown (10 YR 5/2 moist);sandy clay loam; massive; slightly sticky, slightly plastic, slightly hard ;common medium pores; stronghly effervescence; few medium soft accumulations and hard lime concretions; diffuse smooth boundary.
15 - 65	Light gray (10 YR 7/2 dry), to grayish brown (10 YR 5/2 moist); sandy clay loam; weak medium subangular blocky; sticky and plastic, hard; common medium pores; slightly effervescence; diffuse smooth boundary.
65 - 80	Light yellowish brown (10 YR 6/2 dry), to yellawish brown (10 YR 5/4 moist); sandy clay loam; weak thin platy; slightly sticky, slightly plastic, slightly hard; common medium pores; strongly effervescence; abrupt wavy boundary.
80 - 150	Pale brown (10 YR 6/3 dry), to grayish brown (10 YR 5/2 moist); loamy sand; massive; non sticky, non plastic, soft; many coarse pores; stronghly effervescence.

Profile No. : 3

Location : About 8 Km. north east El Gaga, Baris

Elevation : 50 m. (a.s.l)

Geomorphic unit : Peneplain

Land Form : Undulating

Slope : Gently Sloping

Soil classification : Typic, Torriorthents, fine loamy, mixed, hyperthermic, very deep

Land use : Barren

Surface cover : Many fine gravels.

Depth (cm)	Description
0 - 10	Pale brown (10 YR 6/3 dry), to Light yellawish brown (10 YR 6/4 moist); sandy loam; massive; slightly sticky, slightly plastic, slightly hard; many medium pores; very strongly effervescence; common fine soft accumulations and lime concretions; clear smooth boundary.
10 - 25	Brownish yellow (10 YR 6/6 dry), to pale brown (10 YR 6/3 moist); sandy clay loam; weak fine sub-angular blocky; slightly sticky, slightly plastic, slightly hard ;common medium pores; very strongly effervescence; common fine soft accumulations and lime concretions; a brupt smooth boundary.
25 - 55	Light yellowish brown (10 YR 6/4 dry), to pale brown (10 YR 6/3 moist); clayey; massive; in place broken to weak medium angular blocky; very sticky, very plastic, very hard; common fine pores; very strongly effervescence; common fine soft lime and gypsum accumulations gradual smooth boundary.

55 - 130 Light gray (10 Y 7/2 dry), to pale olive (5 Y 6/3 moist); sandy clay loam; moderate medium sub angular blocky; sticky and plastic, hard; common medium pores; slightly effervescence; few fine lime concretions; common fine soft gypsum accumulations

Profile No. : 5

Location : About 4 Km. east El Gazair, Bolaq

Elevation : 50 m. (a.s.l)

Geomorphic unit : Peneplain

Land Form : Undulating

Slope : Gently Sloping

Soil classification : Typic, Torriorthents, Sandy over fine loamy, mixed, hyperthermic, very deep.

Land use : Cultivated with field crops, vegetables, Orchards and palm trees

Irrigation source : El Gazair well

Depth (cm)	Description
0 - 25	Yellowish brown (10 YR 5/4 dry), to reddish brown (10 YR 5/3 moist); sandy loam, massive; non sticky, non plastic, slightly hard; common medium pores; few fine and medium healthy roots; strongly effervescence; few fine soft lime accumulations and hard concenterations; few fine gravels; wavy boundary.
25 - 40	Brownish yellow (10 YR 6/6 dry), to yellawish brown (10 YR 5/6 moist); loamy sand; massive; non sticky, non plastic, slightly hard; common medium pores; few fine and medium healthy roots; strongly effervescence; few soft lime accumulations; few fine gravels; clear smooth boundray.

15 - 40	Brown to dark brown (10 YR 4/3 moist); few fine dark brown mottlings (10 YR 3/3 moist); weak fine sub-angular blocky; very sticky, very plastic, very firm; common fine and medium pores; few fine and medium healthy roots; strongly effervescence; few soft lime accumulations diffuse smooth boundary.
40 - 60	Dark grayish brown (10 YR 4/2 moist); common medium dark brown mottlings (10 YR 3/3 moist); clayey; moderate fine platy ;very sticky, very plastic, very firm; few fine and medium pores; few fine healthy roots; slightly effervescence; many soft accumulations and gypsum nodules; diffuse smooth boundary.
60 - 150	Grayish brown (10 YR 5/2 moist); common medium Yellowish red and Yellow mottlings (10 YR 5/8 and YR 7/6 moist); clayey; moderate medium and coarse platy ;very sticky, very plastic, very firm; few fine and medium pores; very slightly effervescence; common soft gypsum accumulations.

Profile No. : 11

Location : At Ain Om El-Qusour,34 Km north ElKharga

Elevation : 120 m. (a.s.l)

Geomorphic unit : Peneplain

Land Form : Undulating

Slope : Gently Sloping

Soil classification : Typic Torripsamments, sandy, mixed, hyperthermic, very deep

Land use : Cultivated with orchards and field crops

Irrigation source : Om El-Quasur well

Depth (cm)	Description
0 - 30	Yellow (10 YR 8/6 dry) and (10 YR 7/6 moist); sand; single grains ;non sticky, non plastic, loase; many coarse pores; many fine to coares; healthy roots; strongly effervescence; few soft lime accumulations; diffuse smooth boundary.
30 - 60	Yellow (10 YR 8/6 dry),to brownish yellow (10 YR 6/6 moist); sand; massive; non sticky, non plastic, soft; many coarse pores; common medium healthy roots; strongly effervescence; gradual wavy boundary.
60 - 150	Very Pale brown (10 YR 8/4 dry), to yellowish brown (10 YR 5/6 moist); loamy sand; massive; non sticky, non plastic, soft; many medium and coarse pores; Very strongly effervescence; few soft lime accumulations.

Typical pedon of Baris, sandy clay loam, loamy sand substrata on 2% slopes in rangeland, is represented by profile No. 2 in El Kharga area.

The A horizon is sandy clay loam (15 cm) thick and the soil structure is massive. The soils are non calcareous and contained few soft accumulations and hard concretions of lime.

The C horizon is a sandy clay loam forming a thickness between 15 cm to more than 150 cm soil structure is subangular and platy. The soil is moderately effervescent. The C horizon has matrix Hue of 10 YR; a value of mainly 6 and occasionally 7, a chroma of 2 to 4.

The El Gazzair Series consists of very deep soils with rapid permeability. They are alluvium loamy sand over clay loam and sandy clay loam substrata. The slope ranges between 0 to 4%. They contain 2.5% calcium carbonate. Soil structure is angular blocky and / or platy. The hue of the solum is 10 YR, the value ranges from 5 to 7 and the chroma is from 2 to 6.

These soils are placed to <u>Typic</u> <u>Torriorthents</u>, <u>sandy</u> over <u>fine loamy</u>, <u>mixed</u>, <u>hyperthermic</u>, <u>very deep</u>. The typical pedon (profile No 5) of El Gazzair sandy loam has a slope of 2% in rangeland.

The A horizon is sandy loam having a thickness of 25 cm. The soil structure is massive. The soil is moderatly calcareous and contains few soft lime accumulations and hard lime concretions, it has a matrix colour of 10 YR 5/4.

The C horizon is sandy clay loam or clay loam having a thickness of 25 cm to more than 150 cm. Soil structure is subangular blocky or platy. The soil consistence is friable when moist. It contained a few soft lime accumulations and hard lime concretions.

The C horizon has matrix Hue of 10 YR, and a value of 5 to 7, and chroma of 2 to 8.

Ain El Gazal series consists of very deep soils with rapid permeability. They are aeoline sand over alluvium loamy sand. The slope ranges between 3-8 %. They contain 6.4 % calcium carbonate. Soil structure is single grain and / or massive. The hue for solum, is 10 YR. The value ranges from 5 to 8 and the chroma is 4 and 6.

There soils are placed to <u>Typic</u> <u>Torripsamments,</u> <u>mixed,</u> <u>hyperthermic,</u> <u>very deep</u>. The Typical pedon of (profile No.

11), Ain El Gazal sandy has slope of 5% in rangeland.

The A horizon is sand having a thickness of about 30 cm. The soil structure is massive. The soil is calcareous and contained few soft lime accumulations. It has matrix color of 10 YR 8/6.

The C horizon is sand or loamy sand having a thickness of 30 cm. to more than 150 cm. Soil structure is massive. It contained a few soft lime accumulations.

The C horizon has matrix hue of 10 YR, and a value of 8, and a chroma of 4 and 6.

Ain El Eila series consists of very deep, somewhat poorly drained soils with slow permeability. They are alluvium clay. The slopes ranges between 0-4%. They contain 1.62% calcium carbonate. Soil structure is sub-angular blocky and / or platy. The hue for the solum is 10 YR, the value ranges from 3 to 5 and the chroma is 2 and 3.

These soils are placed to <u>Vertic</u> <u>Torriorthents</u>, <u>clayey</u>, <u>mixed</u>, <u>hyperthermic</u> <u>very deep</u>. Typical pedon of (profile 6) Ain El Eila clayey has a slope of 0.5% in rangeland.

The C horizon is clayey having a thickness more than 150 cm.. The soil consistance is very firm when moist. The soils is slightly effervescent. It has few soft lime accumulations and common soft gypsum accumulations.

The C horizon has matrix hue of 10 YR, a value of mainly 5 and occasionaly 4, a chroma of 2 to 4.

4.1.1.3. El Kharga and Qasr Zaiyan association soils (Rolling peneplain soils):

This mapping unit (Map 4) is located in two parts. The first is in the middle of the studied area between the eastern scarpment and the barchan sand dunes. The second is in the far south of the studied area. It is surrounded by the eastern scarpment and barchan sand dunes.

This association unit consists of alluvium covered peneplain and has many scatered sand dunes. This unit is represented by profiles 1, 7, 8, 9 and 10, and covers 243095 feddans making 25.2% of the studied area. It is included 50% El Kharga soils, 30% of Qasr Zaiyan soils, and 20% of the inclusion soils of El Gazzair and Baris.

The Qasr Zaiyan Series consists of very deep, well

Profile No. : 1

Location : About 150 m.east of Dosh well,Baris

Elevation : 125 m. (a.s.l)

Geomorphic unit : Peneplain

Land Form : Rolling

Slope : Gently Sloping

Soil classification : Typic Torriorthents, mixed, hyperthermic, very deep

Land use : Cultivated with field crops, Palm trees and grasses.

Irrigation source : Dosh well (natural ground water)

Surface cover : Few scattered Salts.

Depth (cm)	Description
0 - 10	Brown (10 YR 5/3 dry), to brown to dark brown (10 YR 4/3 moist); Sandy clay loam; massive; sticky and plastic, hard; many medium healthy roots; very strongly effervescence; common soft lime accumulations clear smooth boundary.
10 - 50	Brownish yellow (10 YR 6/6 dry), to yellowish brown (10 YR 5/6 moist); sandy loam; massive; slightly sticky, slightly plastic, soft; common medium pores; many medium healthy roots; very strongly effervescence; common soft accumulations and lime concretions; clear smooth boundary.
50 - 90	Reddish yellow (7.5 YR 7/6 dry), to light yellowish brown (10 YR 6/4 moist); loamy sand; massive; non sticky, non plastic, soft; many coarse pores; few fine healthy roots; strongly effervescence; few soft accumulations and lime nodules;many fine gravels;abrupt wavy boundary.

90 - 130	Pale brown (10 YR 6/3 dry), to grayish brown (10 YR 5/2 moist); clayey; moderate medium subangular blocky; very sticky, very plastic, very hard; common fine pores; few fine healthy roots; strongly effervescence; few fine soft accumulations and lime concretions; clear smooth boundary.
130 - 170	Brown (7.5 YR 5/4 dry), to reddish brown (5 YR 5/3 moist); sandy clay loam; massive; slightly sticky, slightly plastic, slightly hard; common medium pores; strongly effervescence;

Profile No. : 7

Location : South-east Qaser Zaiyan,Bolaq

Elevation : 35 m. (a.s.l)

Geomorphic unit : Feneplain

Land Form : Rolling

Slope : Gently Sloping

Soil classification : Typic Torriorthents, Sandy, mixed hyperthermic, very deep

Land use : Cultivated with field crops, and vegetables

Irrigation source : Bolaq well No. 3

Depth (cm)	Description
0 - 30	Yellow (10 YR 7/6 dry), to yellowish brown (YR 5/4 moist); sandy loam; massive; slightly sticky, slightly plastic, slightly hard; many fine and medium pores; many fine and medium healthy roots; slightly effervescence; clear smooth boundary.
30 - 60	Yellow (10 YR 7/6 dry), to brownish yellow (10 YR 6/6 moist); loamy sand; massive; non sticky, non plastic, soft; medium pores; few fine healthy roots; strongly effervescence; few soft lime accumulations; gradual wavy boundary.

60 - 150	Very Pale (10 YR 7/3 moist); common fine yellow mottlings (10 YR 7/8 moist); loamy sand; massive; slightly sticky, slightly plastic, friable; many coarse pores; very strongly effervescence; common soft lime accumulations .

Profile No. : 8

Location : About 4 Km. north west ElKharga

Elevation : 150 m. (a.s.l)

Geomorphic unit : Peneplain

Land Form : Rolling

Slope : Gently Sloping

Soil classification : Typic Torriorthents, fine loamy, mixed, hyperthermic, very deep

Land use : Cultivated with orchards

Irrigation source : Mostafa Khashif and Heabis wells

Depth (cm)	Description
0 - 20	Yellowish brown (10 YR 5/4 dry), to brown to dark brown (10 YR 4/3 moist); Sandy clay loam; massive; slightly sticky, slightly plastic, hard; many medium pores; many medium healthy roots; few fine strongly effervescence; few soft accumulations and lime concretions; common medium gravels; diffuse smooth boundary.
20 - 50	Brown to dark brown (10 YR 4/3 moist); few fine gray mottlings (2.5 y 6/0 moist); Sandy clay loam; massive; slightly sticky, slightly plastic, firm; common medium pores; few fine healthy roots; strongly effervescence; common soft accumulations and lime concretions; few fine gravels; diffuse smooth boundary.

50 - 80 Light grayish brown (10 YR 6/4 dry), to dark yellowish brown (10 YR 4/4 moist); Sandy clay loam; weak fine sub- angular blocky, sticky and plastic, hard; common fine pores; very strongly effervescence; few soft accumulations and lime concretions; few fine gravels; gradual smooth boundary.

80 - 120 Brownish yellow (10 YR 6/8 moist); few fine gray mottlings (2.5 YR 6/6 moist); clayey; moderate medium platy; very sticky, very plastic, very firm; few fine pores; slightly effervescence; very few soft accumulations and lime concretions.

Profile No. : 9

Location : East Mohamed Khalil village El-Kharga

Elevation : 50 m. (a.s.l)

Geomorphic unit : Peneplain

Land Form : Rolling

Slope : Gently Sloping

Soil classification : Typic Torriorthents, sandy, mixed hyperthermic, very deep

Land use : Cultivated with field crops and vegetables

Irrigation source : Well No. 39 El-Kharga

Depth (cm) Description

0 - 30 Light yellowish brown (10 YR 6/4 dry), to pale brown (10 YR 6/3 moist); sandy clay loam; massive; slightly sticky, slightly plastic, slightly hard; common fine and medium pores; common fine and medium healthy roots; very strongly effervescence; few soft lime accumulations; common fine and medium gravels; abrupt wavy boundary.

30 - 60 Yellow (10 YR 8/6 dry) and (10 YR 7/6 moist); sand; massive; non sticky, non plastic, soft; many coarse pores; few fine healthy roots; strongly effervescence; diffuse wavy boundary.

60 - 100 Yellow (10 YR 8/6 dry) and (10 YR 7/6 moist); sand; massive; non sticky, non plastic, soft; many medium and coarse pores; strongly effervescence; diffuse wavy boundary.

100 - 150 White (10 YR 8/2 dry), to pale yellow (2.5 Y 8/4 moist); sand; single grain; many coarse pores; slightly effervescence; few soft lime accumulations.

Profile No. : 10

Location : Kerata, ezbt Halfa, El-Kharga

Elevation : 100 m. (a.s.l)

Geomorphic unit : Peneplain

Land Form : Rolling

Slope : Gently Sloping

Soil classification : Typic Torriorthents, fine loamy, mixed, hyperthermic, very deep

Land use : Cultivated with rice, palm trees, and vegetables

Irrigation source : Kerata well No. 57.

Depth (cm) Description

0 - 20 Yellowish brown (10 YR 5/3 dry), to brown to yellowish brown (10 YR 4/3 moist); sandy loam; massive; slightly sticky, slightly plastic, slightly hard; many medium pores; many medium and coarse healthy roots; slightly effervescence; few fine gravels; diffuse smooth boundary.

20 - 40	Brown (10 YR 5/4 dry), to brown to yellowish brown (10 YR 4/3 moist); sandy loam; massive; slightly sticky, slightly plastic, slightly hard; many medium pores; common fine to coarse healthy roots; slightly effervescence; few soft lime accumulations; few fine gravels; clear wavy boundary.
40 - 60	Yellowish brown (10 YR 5/6 dry), to brown (10 YR 5/4 moist); sandy clay loam; massive; sticky and plastic, hard; common fine and medium pores; very few healthy roots; very strongly effervescence; common soft accumulations and lime concretions; common fine and medium gravels; diffuse smooth boundary.
60 - 150	Yellow (10 YR 7/6 dry), to brownish yellow (10 YR 6/6 moist); sandy clay loam; massive; sticky and plastic, hard; common fine pores; very strongly effervescence; many soft accumulations and lime concretions; many fine and medium gravels.

drained soils with rapid permeability. They are formed of alluvium sandy loam or sandy clay loam over sand or loamy sand.

The slope ranges from 0 to 4 percent. They contain 4.5% calcium carbonate. The surface of Qasr Zaiyan series is mainly rolling and occasionally undulating. The soil structure is predominantly massive and occasionally single grains. The consistence is very friable when moist.

The hue for the solum is predominantly 10 YR. The value is commonly 8 and subcommonly 7. The chroma is predominantly 6 and occasionally 4.

These soils are placed to Typic Trriorthents, sandy, mixed, hyperthermic, very deep.

Typical pedon (profiles No. 7 and No. 9) of Qasr Zaiyan sandy loam and Qasr Zaiyan sandy clay loam on 1 and 3 percent slopes in rangeland.

The A horizon is a sandy loam and sandy clay loam of 30 cm thick. The soil structure is predominantly massive. The soil is calcareous and has a consistence which is friable when moist, and there are few soft accumulations and hard, concretions of lime.

The A horizon has matrix hue of 10 YR, a value of 6 to 7 and a chroma of 4 or 6.

The C horizon is sandy or loamy sand, with a thickness of 30 cm and extenting more than 150 cm.

Soil structure is mainly massive, and the soil matrix is predominantly friable when moist. The effervescence is predominantly very strong and occasionally moderate, with total calcium carbonate of 5%.

The C horizon has matrix Hue of 10 YR, and a value of 8 and occassionally 7, the chroma is predominantly 6.

4.1.1.4. El Aguz soils (Rolling pediplain soils):

This mapping unit (Map 4) consists of a mainly colluvium covered pediplain that occupies most of the higher lands of the studied area. This map unit covers 235714 feddans, and represents 24.5% of the studied area.

This mapping unit includes 80% of Agouz soils and 20% as inclusion soils of Ain El Gazal and Qasr Zaiyan.

El Agouz series consists of moderatly deep soils with moderately rapid permeablity. They are formed of aeolian and colluvium loamy sand over sandy clay loam. The slope ranges between 5% and 15%. They contain 15% total carbonate. Their total soft gypsum is 0.8%.

These soils are placed to Typic Torriorthents, sandy over fine loamy, mixed, hyperthermic, moderately deep.

Typical pedon of El Agouz loamy sand is represented by profile No. 12. It has 5 to 8% slope in rangeland.

The solum ranges from 60-90 thickness, and the depth to the limestone bedrock is commonly the same as this thickness.

The C horizon is about 60 cm thick, the texture of C horizon is predominantly sandy clay loam, and the structure is predominantly massive.

The soil matrix is strong calcareous. The hue of the solum is predominantly 10 YR and a value is commonly 7 and subcommonly 8. Chroma is commonly 6 and subcommonly 4.

Profile No. : 12

Location : About 46.5 km. north El-Kharga

Elevation : 170 m. (a.s.l)

Geomorphic unit : Pediplain

Land Form : Rolling

Slope : Sloping

Soil classification : Typic Torriorthents, sand over fine loamy, mixed, hyperthermic, moderately deep

Land use : Barren

Surface cover : Many coarse gravels and stones.

Depth (cm)	Description
0 - 25	Very pale brown (10 YR 8/4 dry), to pale brown (10 YR 6/3 moist); loamy sand; massive; non sticky, non plastic, hard; many coarse pores; very strongly effervescence; many soft accumulations and lime nodules; few soft gypsum accumulations; abrupt smooth boundary.
25 - 75	Yellow (10 YR 7/6 dry), to brownish yellow (10 YR 6/6 mcist); sandy clay loam; massive; sticky and plastic, hard; common fine and medium pores; very strongly effervescence; few soft lime accumulations.

4.2. Soil physical properties:

4.2.1. Particle size distribution:

The soils of Kharga belong to the pliestocene period, and are characterized by a deep profile with the exception of profiles 8 and 12 which have depths reaching the rock at 120 and 75 cm, respectively. In addition, their texture ranged from coarse to fine (sandy to clayey).

Morphological description and data of Table (3), show alternative pattern of soil texture in most of the soil profiles. This may be due to the sediment origin, physiographic positions, land forms and the nature of the environmental deposition.

On the other hand, the texture is not variable along the profile depth in some profiles such profiles as No. 7, 9 and 11 (sand to loamy sand), and profile 6 (clayey).

The texture of profiles 2, 3, 8, 11 and 12 are generally medium texture class (ranges between sandy loam to sandy clay loam). While the texture classes of profiles 1 and 5 are medium in the surface and deepest layers, but the layers in between are of heavy texture, except for the

Table (3) Particle size distribution and texture classes of the studied soil profiles.

Profile	Depth	Gravel %	Sand %						Silt %	Clay %	Texture
No	cm	>2mm	V. Coarse 2-1 mm	Coarse 1-0.5 mm	Medium 0.5-0.25 mm	Fine 0.25-0.1 mm	V. Fine 0.1-0.05 mm	Total sand	50-2 µm	<2 µm	class
1	0 - 10	0	2.16	5.09	14.08	31.23	12.24	64.80	11.60	23.50	S.C.L
	10 - 50	0	5.30	12.00	23.01	27.09	10.38	77.78	8.50	13.72	S.L
	50 - 90	35	22.86	25.37	19.94	13.65	3.13	84.95	5.58	9.47	L.S
	90 - 130	0	0.58	1.28	1.43	6.35	11.29	20.93	20.05	59.02	C.
	130 - 170	10	5.37	12.57	9.79	17.89	21.81	67.43	12.32	20.25	S.C.L
2	0 - 15	5	4.07	25.39	15.01	16.38	4.30	65.75	14.18	20.07	S.C.L
	15 - 65	0	0.30	3.36	6.08	21.65	23.56	54.95	13.15	31.90	S.C.L
	65 - 80	0	0.37	5.52	9.30	29.96	21.90	67.05	10.40	22.55	S.C.L
	80 - 150	0	0.30	3.48	61.00	15.34	2.38	82.50	7.18	10.32	L.S
3	0 - 10	10	0.59	3.47	6.86	39.18	4.66	54.76	25.60	19.64	S.L
	10 - 25	0	0.16	3.80	17.83	24.23	13.73	59.75	16.05	26.20	S.C.L
	25 - 55	0	0.00	7.48	3.21	9.35	16.39	36.43	22.85	40.75	C.
	55 - 130	0	0.13	2.59	3.53	6.93	34.17	47.35	20.53	32.12	S.C.L
4	0 - 20	0	4.22	13.21	23.73	35.50	7.92	84.58	4.80	10.62	L.S
	20 - 50	0	2.05	15.09	17.51	28.78	10.32	73.75	6.48	19.77	S.L
	50 - 80	10	3.64	27.80	24.66	26.76	4.27	87.13	3.27	9.60	L.S
	80 - 150	3	1.01	5.54	8.03	22.28	6.87	43.73	11.90	44.37	C.
5	0 - 25	5	11.06	9.02	13.52	26.51	13.44	73.55	6.48	19.97	S.L
	25 - 40	7	14.06	13.16	19.66	24.53	13.04	84.45	3.28	12.27	L.S
	40 - 70	0	3.83	6.08	6.55	10.46	13.88	40.80	21.85	37.35	C.L
	70 - 150	0	3.88	4.81	2.91	33.49	11.94	57.03	13.05	29.92	S.C.L
6	0 - 15	0	4.89	3.81	10.39	14.44	8.52	42.05	14.98	42.97	C.
	15 - 40	0	0.53	2.98	7.62	15.29	6.83	33.25	17.35	50.40	C.
	40 - 60	0	0.23	2.17	13.53	11.24	5.83	33.00	23.63	43.37	C.
	60 - 150	0	0.43	2.48	7.34	12.48	4.77	27.50	24.85	47.65	C.
7	0 - 30	0	0.25	5.89	38.38	23.94	6.14	74.60	8.87	16.53	S.L
	30 - 60	0	0.07	7.39	28.34	39.87	7.80	83.47	5.58	10.95	L.S
	60 - 150	0	0.17	16.30	26.96	34.54	4.75	82.72	7.18	10.10	L.S
8	0 - 20	10	1.29	3.51	9.76	39.18	13.06	66.80	8.47	24.73	S.C.L
	20 - 50	5	3.48	2.01	7.29	29.89	19.73	62.40	12.27	25.33	S.C.L
	50 - 80	5	1.35	3.01	7.83	28.90	16.53	57.62	14.38	28.00	S.C.L
	80 - 120	7	0.72	2.57	4.03	13.51	10.12	30.95	20.62	48.43	C.

Table (3) Cont'd

Profile No	Depth cm	Gravel % >2mm	Sand % V. Coarse 2-1 mm	Coarse 1-0.5 mm	Medium 0.5-0.25 mm	Fine 0.25-0.1 mm	V. Fine 0.1-0.05 mm	Total sand	Silt % 50-2 µm	Clay % <2 µm	Texture class
9	0 - 30	12	2.62	7.21	14.27	28.96	10.36	63.42	10.78	25.80	S.C.L
	30 - 60	7	8.30	18.30	19.33	32.03	10.61	88.57	5.00	6.43	S.
	60 - 100	0	10.81	9.28	17.98	36.36	13.57	88.00	3.95	8.05	S.
	100 - 150	0	0.56	10.17	75.19	7.93	0.77	94.62	0.18	5.20	S.
10	0 - 20	5	1.04	3.89	10.38	45.75	15.84	76.90	3.90	19.20	S.L
	20 - 40	2	1.24	4.31	13.14	42.45	16.73	77.87	3.80	18.33	S.L
	40 - 60	10	2.24	5.75	21.05	33.13	4.58	66.75	5.47	27.58	S.C.L
	60 - 150	16	1.63	5.47	13.28	25.20	14.49	60.07	12.40	27.53	S.C.L
11	0 - 30	0	0.13	25.85	32.96	24.82	7.74	91.50	1.25	7.25	S.
	30 - 60	0	0.09	32.94	32.37	22.32	3.98	91.70	1.12	7.18	S.
	60 - 150	0	0.10	10.42	33.35	38.21	6.49	88.57	0.68	10.75	L.S
12	0 - 25	0	10.60	21.04	12.93	23.51	15.54	83.68	7.87	8.61	L.S
	25 - 75	0	1.11	7.87	7.41	22.69	28.04	67.12	7.15	25.73	S.C.L

S=Sand, L=Loam, C=Clay.

subsurface layer of profile 5 which is of coarse texture.

Profile No. 4 has a coarse texture in the surface and 50-80 cm/layer depth, while the subsurface layer and the deepest layers have medium and heavy texture classes respectively.

Gravels cover the soil surface as in profiles 2 and 3, or found within the upper layers as in profiles 5 and 9, or the deep layers as in profiles 1 and 4. Also gravels may be scattered within the whole soil depths as in profiles 8 and 10. In general gravels are small in size and mainly affected by the physiographic position. They cover the surface layers in profiles 2, 3, 5 and 9, which are at an elevation of 50 m. above sea level. Their pattern was in a reverse way in profiles 1 and 4 which are at the elevation of 100-125 m. above sea level.

4.2.2. Grain size analysis:

The statistical grain size parameters were determined according to the formula given by Folk and Ward (1957). The four parameters were (1). graphic mean, (2) inclusive graphic standard deviation, (3) inclusive graphic skewness and (4) graphic Kurtosis.

Grain size parameters:

A. Mean size:

The mean size is described using the graphic mean (MZ). Calculated by the formula:

$$Mz\phi = \frac{\phi_{16} + \phi_{50} + \phi_{84}}{3}$$

The graphic mean of Folk and Ward (1957), as measure of the average size, is more than the median diameter (Md) of Trask (1932) or the phi mean of Inman (1952).

B. Sorting:

Folk and Ward (1957) introduced the inclusive graphic standard deviation (σ_I) as a measure of sorting. This is calculated by the formula:

$$\sigma_I = \frac{\phi_{84} - \phi_{16}}{4} + \frac{\phi_{95} - \phi_5}{6.6}$$

The same authors gave a sorting scale to be used in describing the sorting of sediments in conjunction with the results of this parameter as follows:

	Sorting range	indication
1.	σ_I less than 0.35 ϕ	very well sorted.
2.	σ_I 0.35 - 0.50 ϕ	well sorted.
3.	σ_I 0.50 - 0.70 ϕ	moderately well sorted.
4.	σ_I 0.70 - 1.00 ϕ	moderately sorted.
5.	σ_I 1.00 - 2.00 ϕ	poorly sorted.
6.	σ_I 2.00 - 4.00 ϕ	very poorly sorted.
7.	σ_I greater than 4.00 ϕ	Extremely poorly sorted.

C. Skewness:

Skewness measures the symmetry of the frequency distribution and marks the position of the mean with respect to the meadium. Folk and Ward (1957) used the inclusive graphic skewness SK_I as a measure of symmetry. This is calculated by the formula:

$$SK_I = \frac{\phi_{16} + \phi_{84} - 2\phi_{50}}{2(\phi_{84} - \phi_{16})} + \frac{\phi_5 + \phi_{95} - 2\phi_{50}}{2(\phi_{95} - \phi^5)}$$

They gave the following scale to discribe the symmetry of sediments when using SK^I as the skewness measure:

	Range of skewness	indication
1.	-1.00 to -0.30	strongly coarse skewed.
2.	-0.30 to -0.10	coarse skewed.
3.	-0.10 to +0.10	near symmetrical.
4.	+0.10 to +0.30	fine skewed.
5.	+0.30 to +1.00	strongly fine skewed.

D. Kurtosis (K^G):

Kurtosis measures the degree of sorting in the extremes of the distribution compared with the sorting in the central part, and as such, it is a sensitive and valuable test of normality of the distribution. Folk and Ward (1957), gave the graphic Kurtosis K^G calculated by the formula:

$$K^G = \frac{\phi^{95} - \phi^{5}}{2.44(\phi^{75} - \phi^{25})}$$

They suggested the following scale to be used on discribing the Kurtosis of sediments:

	Kurtosis range	indication
1.	=< 0.67	very platykurtic.
2.	0.67 - 0.90	platykurtic.
3.	0.90 - 1.11	mesokuric.
4.	1.11 - 1.50	leplokurtic.
5.	1.50 - 3.00	very leplokurtic.
6.	>= 3.00	extremely leplokurtic.

Considering the mode of deposition of these sediments, the general idea being that transportation by water or weathering *in situ* form poorly sorted sediments. On the other hand transportation by wind leads to well-sorted sediments, (Inman, 1952).

Data of the particle size distribution were plotted as cumulative curves using (O) units where:

$$\phi = - \frac{\log (d)}{\log 2}$$

Where:

(d) is the diameter in mm.

The soils of El-Kharga Oasis are represented by profiles 1 to 12 their statistical size parameters are given in Table (4), and their cumulative curves are illustrated in Figs (5) and (6).

Values inclusive graphic standard deviation (Sorting), range between 0.43 and 1.66 indicating that the soil sediments of the area are characterized by poor sorting of sediments throughout the whole soil profile, and there were some exceptions. These were in the following profiles: 2 (80-150 cm. depth), 4 (80-150 cm. depth), 7 (30-60 cm.

Table (4) The statistical size parameters of the studied soil profiles according to Folk and Hard (1957) and Sahu (1964).

Profile No	Depth cm	ϕ 5	ϕ 16	ϕ 25	ϕ 50	ϕ 75	ϕ 84	ϕ 95	Folk and Hard (1957) MZ	σ	SK	KG	Sahu (1964) Y1	Y2	Y3	Y4
1	0 - 10	-0.20	0.80	1.30	2.00	2.90	3.30	3.90	2.03	1.25	0.60	1.05	15.05	164.74	-16.00	10.43
	10 - 50	-0.80	0.20	0.30	0.70	2.50	3.00	3.80	1.30	1.40	0.80	0.86	12.91	179.53	-20.67	10.09
	50 - 90	-2.10	-1.10	-0.60	0.30	1.42	2.00	3.70	0.40	1.65	0.81	1.18	13.49	221.66	-27.64	10.89
	90 - 130	0.70	2.10	2.60	3.60	3.75	3.90	4.20	3.20	0.98	0.28	1.25	18.28	141.40	-8.81	10.42
	130 - 170	-1.00	0.00	0.50	2.30	3.30	3.50	3.80	1.93	1.60	0.56	0.70	17.34	222.81	-24.59	7.83
2	0 - 15	-0.60	-0.10	0.25	1.15	2.45	3.70	3.85	1.58	1.62	0.69	0.83	16.50	227.07	-25.88	9.12
	15 - 65	0.40	1.50	1.80	2.65	3.45	3.75	3.95	2.63	1.10	0.94	0.88	14.66	154.52	-14.40	12.39
	65 - 90	0.30	1.20	1.50	2.30	3.20	3.65	3.90	2.38	1.16	0.55	0.87	15.04	151.74	-13.76	9.48
	80 - 150	0.50	0.75	0.90	1.25	1.70	2.20	3.70	1.40	0.05	0.25	1.64	12.23	104.44	-7.12	11.15
3	0 - 10	0.90	1.55	1.70	2.30	3.70	3.80	4.10	2.55	1.05	0.57	0.66	13.96	134.88	-11.69	8.73
	10 - 25	0.75	1.30	1.40	2.30	3.50	3.60	4.00	2.40	1.07	0.31	0.63	14.13	130.07	-10.84	6.69
	25 - 55	0.20	1.00	1.80	3.10	3.70	3.80	4.15	2.63	1.30	0.45	0.85	17.36	176.10	-16.22	8.75
	55 - 130	0.60	1.25	1.40	2.20	3.40	3.70	4.00	2.38	1.13	0.41	0.70	14.55	142.82	-12.49	7.67
4	0 - 20	-0.50	0.40	0.60	1.60	2.20	2.40	3.70	1.47	1.14	0.30	1.08	12.80	133.82	-12.34	8.28
	20 - 50	-0.30	0.30	0.50	1.65	2.40	2.80	3.80	1.58	1.25	0.70	0.88	12.71	156.35	-16.63	9.88
	50 - 80	-0.40	0.30	0.30	1.00	1.70	2.00	3.20	1.10	0.97	0.54	1.05	9.56	86.39	-10.52	9.61
	80 - 150	0.00	0.80	1.40	2.10	3.30	3.70	4.00	2.20	1.33	0.58	0.83	15.78	135.84	-17.67	9.16
5	0 - 25	-1.80	-0.40	0.40	1.60	2.50	3.00	3.80	1.40	1.33	0.81	1.09	13.25	132.29	-19.01	11.52
	25 - 40	-1.80	-0.60	0.80	1.35	2.25	2.60	3.40	1.12	1.59	0.74	1.47	16.41	224.25	-25.38	12.55
	40 - 70	-0.80	0.42	1.00	2.80	3.70	3.80	4.10	2.34	1.59	0.70	0.74	18.56	229.11	-24.87	9.30
	70 - 150	-0.70	0.90	1.50	2.20	3.10	3.70	4.00	2.27	1.41	0.80	1.20	17.54	202.86	-20.62	12.58
6	0 - 15	-1.70	0.50	1.00	2.20	3.60	3.70	4.00	2.13	1.66	0.95	0.90	18.63	248.26	-28.14	11.60
	15 - 40	0.30	1.20	1.50	2.35	3.80	3.85	4.10	2.47	1.24	0.52	0.68	15.54	161.69	-15.28	8.26
	40 - 60	0.50	1.20	1.30	2.80	3.80	3.90	4.20	2.63	1.24	0.39	0.59	16.11	160.18	-14.66	7.03
	60 - 150	0.40	1.30	1.70	3.40	3.80	3.90	4.25	2.87	1.23	0.35	0.75	17.45	164.56	-14.10	7.73
7	0 - 30	0.35	0.70	0.85	1.40	2.30	2.80	3.80	1.63	1.05	0.48	0.98	11.95	124.78	-11.50	9.16
	30 - 60	0.30	0.75	1.00	1.80	2.25	2.40	3.70	1.65	0.93	0.23	1.11	12.07	107.36	-8.19	8.26
	60 - 150	0.10	0.40	0.60	1.50	2.15	2.35	3.75	1.42	1.02	0.30	0.97	11.32	112.97	-10.12	7.75
8	0 - 20	0.30	1.30	1.55	2.00	2.75	3.20	3.80	1.17	1.01	0.54	1.20	10.57	117.33	-11.19	10.42
	20 - 50	0.00	1.30	1.60	2.35	3.20	3.60	4.00	2.42	1.18	0.63	1.02	15.65	159.65	-14.54	10.83
	50 - 80	0.30	1.40	1.70	2.40	3.40	3.70	4.00	2.50	1.14	0.55	0.89	15.36	150.96	-13.33	9.69
	80 - 120	0.40	1.50	1.90	3.00	3.70	3.85	4.15	2.78	1.16	0.45	0.85	16.61	155.82	-13.16	9.00

Table (4) cont'd

Profile No	Depth cm	0 5	0 16	0 25	0 50	0 75	0 84	0 95	Folk and Ward (1957) MZ	0	SK	KG	Sahu (1964) Y1	Y2	Y3	Y4
9	0 - 30	-0.30	0.60	1.10	1.85	2.75	3.45	3.90	1.97	1.35	0.64	1.04	15.70	181.42	-18.49	10.50
	30 - 60	-0.10	0.00	0.30	1.50	2.30	2.60	3.70	1.37	1.23	0.37	0.78	12.15	141.99	-14.63	7.26
	60 - 100	-1.80	0.00	0.55	1.60	2.40	2.70	3.50	1.43	1.48	0.81	1.17	12.17	202.63	-22.68	11.79
	100 - 150	0.20	0.50	0.60	0.90	1.20	1.30	1.70	0.90	0.43	0.49	1.03	7.17	54.17	-3.71	9.33
10	0 - 20	0.30	1.30	1.50	2.00	2.50	2.80	3.60	2.03	0.97	0.48	1.35	14.92	127.28	-9.94	11.45
	20 - 40	0.20	1.10	1.40	2.00	2.50	2.80	3.50	1.97	0.93	0.47	1.23	13.08	118.94	-9.26	10.74
	40 - 60	-0.20	0.70	0.90	1.60	2.30	2.40	3.80	1.57	1.03	0.47	1.17	12.19	124.45	-11.08	10.05
	60 - 150	-0.10	0.85	1.30	2.10	3.25	3.70	4.00	2.22	1.33	0.62	0.86	15.86	178.12	-17.86	9.60
11	0 - 30	-0.30	0.30	0.40	1.00	1.80	2.20	2.90	1.17	0.96	0.58	0.94	9.31	106.76	-10.53	9.35
	30 - 60	-0.20	0.20	0.30	0.80	1.55	1.80	2.60	0.93	0.67	0.50	0.92	6.80	70.13	-6.07	8.73
	60 - 150	0.00	0.60	0.80	1.50	2.00	2.20	2.70	1.43	0.81	0.49	0.92	9.16	91.38	-7.70	8.94
12	0 - 25	-1.50	-0.30	0.10	1.50	2.50	3.00	3.80	1.40	1.63	0.78	0.91	16.03	227.45	-26.66	10.00
	25 - 75	0.00	0.85	1.50	2.40	3.15	3.50	3.85	1.92	1.25	0.54	0.96	14.50	160.26	-15.73	9.48

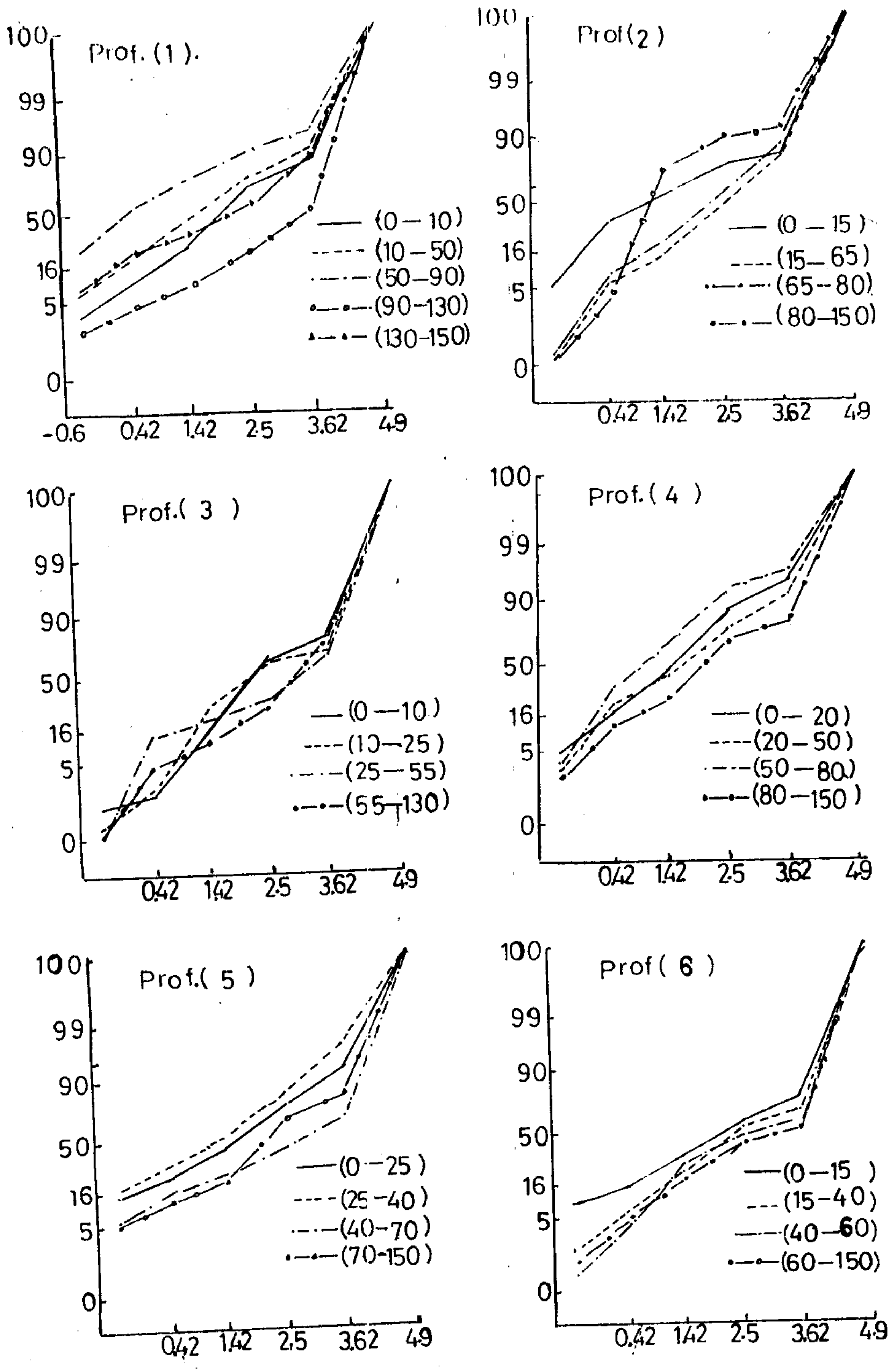


Fig (5) Cumulative Curves of the studied soil profiles (1 to 6).

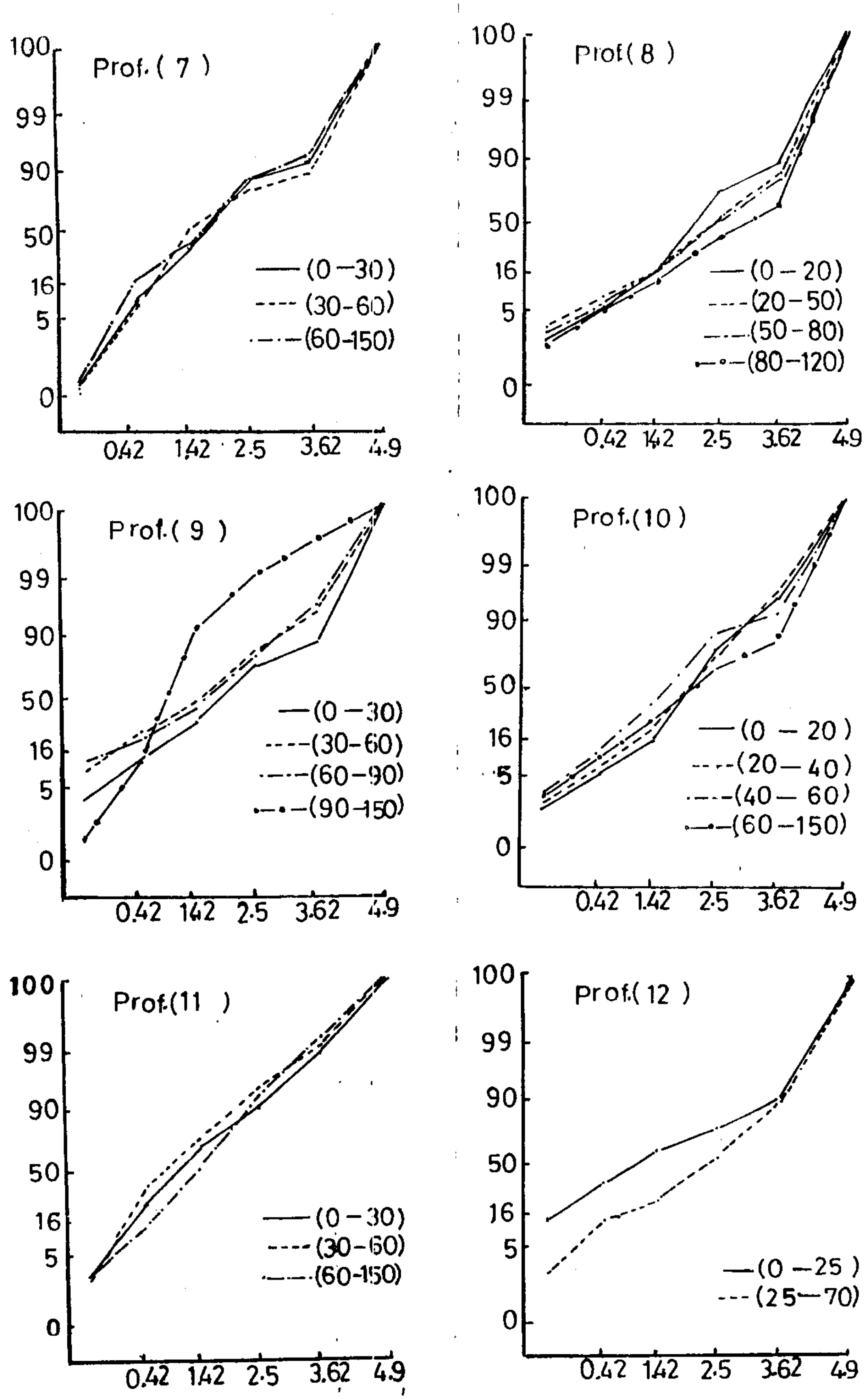


Fig (6) Cumulative Curves of the studied soil profiles (7 to 12).

depth), 9 (90 - 150 cm. depth), 10 (0 - 40 cm. depth), and profile 11 (the whole profile).

Profile 11 possesses moderately sorted or moderately well sorted sediments.

Profile 9 is charactrized by well sorted sediments. The poorly sorted nature of soil sediments suggests that these sediments are mainly transported and deposited by water action or that they were weathered in situ. The moderatly sorted or moderatly well sorted sediments are transported and deposited under the combined effect of water and wind. The deeper sediments of profile 9, seem to have been transported and deposited by wind.

As to the Skewness of the soil materials, all layers within the profiles are strongly fine skewed, except for the (90 - 130 cm.), (80 - 150 cm.) and (30 - 60 cm.) layers of profiles 1, 2 and 7 respectively, which are fine skewed.

Data of Kurtosis indicate that sediments of profile 1 are mesokurtic in the surface layer, changing into platykurtic in the sub-surface and deepest layers, while the 50 - 90 cm. and 90 - 130 cm. layers are leptokurtic. Profiles 2 and 6 are platykurtic in all layers except for the deepest and (40 - 60 cm.) layers respectively which are very platykurtic. In profile 3, the uppermost surface layers are very platykurtic, while the deepest layer is platykurtic.

In profile 4 the surface and the 50-80 cm layers are mesokurtic, while the 20-50 cm. and the deep layers are platykurtic. Graphic kurtosis shows that the sediments are misokurtic in the surface layer of profile 5, changing to leptokurtic in the 25-40 cm. and 70-150 cm layers, while the 40-70 cm layer is platykurtic. Soils in all layers of profiles 7, 11 and 12 are mesokurtic sediments. This indicates that these sediments are formed under the combined action of wind and water. In profile 9, graphic kurtosis in the surface and deepest layers is mestokurtic, while the middle layers are platykurtic and leptokurtic.

Mesokurtic, Leptokurtic and very liptokurtic values indicate some involvement of wind and water in the formation of the current soils. Platykurtic values indicate that water is the main factor in soil formation.

Kurtosis indicate that water and wind played part in formation and transportation of parent sediments.

Statistical parameters are summerized in Table (5) for

Table (5) Summary of the statistical size parameters indications of the studied profiles.

Profile No	Depth cm	Sorting σ_1	Skewness SKI	Kurtosis KG
1	0 - 10	Poorly sorted	Strongly fine skewed	Mesokurtic
	10 - 50	Poorly sorted	Strongly fine skewed	Platykurtic
	50 - 90	Poorly sorted	Strongly fine skewed	leptokurtic
	90 - 130	Poorly sorted	Fine skewed	leptokurtic
	130 - 170	Poorly sorted	Strongly fine skewed	Platykurtic
2	0 - 15	Poorly sorted	Strongly fine skewed	Platykurtic
	15 - 65	Poorly sorted	Strongly fine skewed	Platykurtic
	65 - 80	Poorly sorted	Strongly fine skewed	Platykurtic
	80 - 150	Moderately sorted	Fine skewed	Very leptokurtic
3	0 - 10	Poorly sorted	Strongly fine skewed	Very platykurtic
	10 - 25	Poorly sorted	Strongly fine skewed	Very platykurtic
	25 - 55	Poorly sorted	Strongly fine skewed	Platykurtic
	55 - 130	Poorly sorted	Strongly fine skewed	Platykurtic
4	0 - 20	Poorly sorted	Strongly fine skewed	Mesokurtic
	20 - 50	Poorly sorted	Strongly fine skewed	Platykurtic
	50 - 80	Moderately sorted	Strongly fine skewed	Mesokurtic
	80 - 150	Poorly sorted	Strongly fine skewed	Platykurtic
5	0 - 25	Poorly sorted	Strongly fine skewed	Mesokurtic
	25 - 40	Poorly sorted	Strongly fine skewed	leptokurtic
	40 - 70	Poorly sorted	Strongly fine skewed	Platykurtic
	70 - 150	Poorly sorted	Strongly fine skewed	leptokurtic
6	0 - 15	Poorly sorted	Strongly fine skewed	Platykurtic
	15 - 40	Poorly sorted	Strongly fine skewed	Platykurtic
	40 - 60	Poorly sorted	Strongly fine skewed	Very platykurtic
	60 - 150	Poorly sorted	Strongly fine skewed	Platykurtic
7	0 - 30	Poorly sorted	Strongly fine skewed	Mesokurtic
	30 - 60	Moderately sorted	Fine skewed	Mesokurtic
	60 - 150	Poorly sorted	Strongly fine skewed	Mesokurtic
8	0 - 20	Poorly sorted	Strongly fine skewed	leptokurtic
	20 - 50	Poorly sorted	Strongly fine skewed	Mesokurtic
	50 - 80	Poorly sorted	Strongly fine skewed	Platykurtic
	80 - 120	Poorly sorted	Strongly fine skewed	Platykurtic

Table (6) Some moisture characteristics of the selected soil samples of the studied soil profiles of Kharga area.

Profile No	Depth cm	Moisture characteristics (% per weight) F.C	W.P	A.W
1	0 - 10	35.85	14.35	21.50
	10 - 50	23.79	10.07	13.72
	50 - 90	20.91	9.58	11.33
	90 - 130	44.24	22.82	22.42
	130 - 170	28.93	11.53	17.40
2	0 - 15	28.90	13.03	15.87
	65 - 80	30.25	12.10	18.15
3	0 - 7	27.26	14.70	13.19
4	0 - 20	22.20	8.60	13.60
	20 - 50	27.07	10.75	16.32
	80 - 150	41.87	19.10	22.47
5	25 - 40	21.27	10.02	11.45
6	0 - 15	43.56	20.40	23.16
7	30 - 60	20.55	9.45	11.10
	60 - 150	19.63	10.03	9.60
8	0 - 20	36.00	13.20	22.80
9	30 - 60	18.64	8.92	9.72
10	0 - 20	27.54	11.20	16.34
11	0 - 30	16.81	7.26	9.55

F.C : Field capacity

W.P : Wilting point

A.W : Available water

Profiles 7 (30 - 60 and 60 - 150 cm. depth), 9 (30 - 60 cm. depth) and 11 (0 - 30 cm. depth), have low moisture and low clay contents. Available moisture has similar trends such as those of field capacity. Wilting point was highest (23.16 %) in 0 - 15 cm. of profile 6 and lowest 9.55 % in 0 - 30 of profile 11.

4.3. Soil chemical properties:

4.3.1. Soil salinity:

The value of electrical conductivity (EC_e) are listed in Table (7). They differ widely among the different sites as well as among the different layers. EC_e ranged between 0.6 dS/m in profile 9 and high as 104.9 mmhos/cm/25 C in profile 12.

Categorizing the soil salinity results show the following:

1. Profiles 4, 7, 8, 9, 10 and 11 represent soils which are non saline throughout their depths.

2. Profile 1 is moderately saline in the surface layers but non saline in the sub - surface ones.

3. Profiles 5 and 6 are non - saline in their surface layers but saline in the deep layers.

Table (7) Soil paste extract analysis of the studied soil profiles.

Profile	Depth	E.C	Soluble cations meq./L				Soluble anions meq./L				pH
No	cm	dS/m	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3	HCO_3	Cl	SO_4	(paste)
1	0 - 10	8.5	25.4	15.2	42.5	4.2	0.0	5.5	36	45.8	7.5
	10 - 50	8.8	13.8	25.4	49.1	3.4	0.0	4.0	52	35.7	7.5
	50 - 90	3.4	1.5	1.5	26.7	2.2	0.0	4.0	20	7.9	8.3
	90 - 130	3.0	2.8	3.2	23.4	1.3	Trace	4.0	15	12.2	8.6
	130 - 170	6.0	3.9	5.8	50.8	2.6	0.0	3.5	38	21.6	7.9
2	0 - 15	40.0	100.3	56.1	484.1	1.5	0.0	1.5	384	256.5	7.3
	15 - 65	31.2	33.1	14.0	344.5	1.2	0.0	2.5	269	121.3	7.5
	65 - 80	23.7	14.3	5.7	228.6	0.6	0.0	2.5	182	64.7	8.2
	80 - 150	18.7	5.5	3.2	210.3	0.6	0.0	2.0	147	70.6	8.0
3	0 - 10	88.7	27.0	3.3	1830.0	6.0	0.0	2.5	1730	133.8	7.9
	10 - 25	25.7	11.6	6.3	391.5	1.5	0.0	2.0	340	68.9	8.2
	25 - 55	23.1	14.3	8.4	325.0	1.5	0.0	2.0	294	53.2	8.0
	55 - 130	24.2	14.9	20.3	402.5	2.3	0.0	1.0	360	79	8.0
4	0 - 20	1.4	3.4	6.8	4.3	1.9	0.0	4.0	5	7.4	8.1
	20 - 50	2.6	4.4	10.2	13.4	1.5	0.0	3.0	11	15.5	8.0
	50 - 80	4.2	11.6	10.8	20.3	1.8	0.0	2.0	17	25.2	7.7
	80 - 150	3.3	3.9	9.4	21.0	0.5	0.0	2.0	16	16.8	7.8
5	0 - 25	1.9	7.7	6.4	4.6	1.3	0.0	4.0	4	12	7.7
	25 - 40	1.6	3.8	8.5	3.1	1.0	0.0	3.0	3	10.4	7.9
	40 - 70	4.8	19.8	18.0	10.1	2.6	0.0	1.0	9	40.5	7.5
	70 - 150	5.7	25.9	12.0	19.4	3.6	0.0	2.0	18	40.9	7.4
6	0 - 15	3.0	13.8	7.9	8.8	1.7	0.0	3.0	8	21.2	7.4
	15 - 40	9.6	25.4	14.7	57.0	2.5	0.0	1.5	40	58.1	7.4
	40 - 60	11.1	24.3	13.6	91.5	2.2	0.0	1.5	76	54.1	7.4
	60 - 150	11.8	18.7	8.4	111.3	1.8	0.0	1.5	82	57.7	7.7
7	0 - 30	0.8	2.2	2.1	3.2	0.8	0.0	2.0	3	3.3	7.9
	30 - 60	1.4	5.5	54.0	4.3	0.9	0.0	2.0	5	9.1	7.7
	60 - 150	0.9	2.8	2.6	3.1	0.7	0.0	2.5	4	2.9	7.7
8	0 - 20	0.7	3.3	2.7	1.8	0.4	0.0	4.5	2	1.7	7.5
	20 - 50	0.6	1.7	2.7	1.8	0.4	0.0	3.0	2	1.6	7.7
	50 - 80	1.0	2.8	2.6	3.6	1.0	0.0	3.5	3	3.2	7.8
	80 - 120	1.8	6.5	7.0	4.0	1.2	0.0	2.0	4	9.7	7.7

Table (7) Cont'd

Profile No	Depth cm	E.C dS/m	Soluble cations meq./L Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Soluble anions meq./L CO_3	HCO_3	Cl	SO_4	pH (paste)
9	0 - 30	1.0	2.8	2.6	4.0	0.9	0.0	3.5	4	3.0	7.7
	30 - 60	0.8	2.1	2.1	3.4	0.4	0.0	3.0	3	2.0	7.9
	60 - 100	1.0	2.1	2.7	4.9	0.4	0.0	3.0	5	2.1	8.0
	100 - 150	0.6	1.7	2.2	2.0	0.3	0.0	1.5	3	1.7	8.2
10	0 - 20	1.2	3.3	2.7	4.9	2.1	0.0	5.0	4	4.0	7.9
	20 - 40	1.4	4.4	3.7	4.9	2.3	0.0	2.0	4	9.3	7.5
	40 - 60	1.3	3.3	4.3	4.6	2.0	0.0	5.0	6	3.2	7.7
	60 - 150	1.4	3.3	3.2	6.7	1.5	0.0	2.5	6	6.2	7.8
11	0 - 30	1.5	5.5	4.8	5.4	1.0	0.0	3.0	6	7.7	7.9
	30 - 60	1.0	3.9	1.5	6.3	0.4	0.0	3.0	5	4.1	7.8
	60 - 150	3.0	16.5	6.2	8.8	0.9	0.0	3.0	8	21.4	7.6
12	0 - 25	50.4	37.5	11.2	645.0	4.5	0.0	2.5	533	162.7	7.8
	25 - 75	104.9	64.5	18.9	1462.5	7.5	0.0	3.0	1230	320.4	7.4

4. Profiles 2, 3 and 12 have EC_e values of between 18.7 and 104.9 dS/m and are thus extremely saline throughout their layers. Salinity of these soils may be related to inherited salts drived from the parent material.

Besides, the climate being arid and soils being not used properly render salinity high in these soils. Salt crust covers were found in many of the saline soils of this area.

4.3.2. Soluble cations and anions:

Table (7), shows contents of soluble ions. Sodium was the predominant cation especially in profiles 1, 2, 3, 6 and 12. In profiles 5, 8 and 11 calcium and magnesium were dominent. Soluble potasium was very low. Chloride was the dominant anions followed by sulphate then carbonate.

4.3.3. Soil reaction (pH):

Data in Table (7) show values of soil pH which range between practically neutral (of pH 7.3) and strongly alkaline (pH 8.6), according to the USDA (1952). Top soil of profile 2 has pH 7.3, while profiles 6, 7, 8, 10 and 11 were mildly to moderatly alkaline (pH 7.4 to 7.9).

Profile 3 has moderately alkaline soils (pH 7.9 to 8.2).

Profiles 1, 2, 9 and 12 are characterized by their mildly alkaline surface and thier moderately to strongly alkaline subsurface.

Profiles 4 and 5 have moderately alkaline surface and slightly alkaline subsurfaces.

4.3.4. Calcium carbonate contents:

Table (8) shows contents of calcium carbonate which varies between 0.86 and 28.87%. This is an alternating pattern of $CaCO_3$ distribution, which mainly due to the differences of soil relief, soil sediment types and their environmental conditions of sedimentation.

In general, the soils of profiles 2 and 6, which are located at the center part of the area have relatively low contents of $CaCO_3$ throughout their profiles. This may be related to the relatively medium and fine texture and low physiographic possitions.

The soils located at the southern part, which are represented by profiles 1, 3, 4 and 5, are characterized by their moderate contents of $CaCO_3$ in the surface layers and

Table (8) Cation exchange capacity, exchangeable cations, CaCo3 %, gypsum % and organic matter content of the studied soil profiles.

Profile No	Depth cm	Exchangable cations me/100 g soil Ca^{++}	Mg^{++}	Na^{+}	K^{+}	C.E.C meq/100 g soil	$CaCO_3$ %	Gypsum %	Organic matter %
1	0 - 10	6.53	7.74	1.96	1.82	18.05	5.67	2.14	1.92
	10 - 50	5.07	2.46	0.93	0.72	9.18	5.25	0.15	0.71
	50 - 90	3.27	1.73	0.79	0.46	6.25	1.78	0.13	0.65
	90 - 130	20.68	14.97	10.71	2.74	49.10	2.10	0.07	0.63
	130 - 170	5.55	7.50	1.11	1.92	16.08	3.78	0.21	0.95
2	0 - 15	10.91	3.40	1.32	0.64	16.27	2.20	0.95	0.58
	15 - 65	18.86	5.83	2.65	0.54	27.88	2.31	0.01	0.73
	65 - 80	5.50	9.59	2.39	0.96	18.44	3.25	0.11	0.60
	80 - 150	4.42	3.20	0.85	0.38	8.85	3.36	0.11	0.61
3	0 - 10	8.85	2.81	1.97	1.52	15.15	5.56	1.47	0.83
	10 - 25	9.90	8.73	3.12	1.04	22.79	5.35	0.12	0.73
	25 - 55	20.86	4.62	4.47	2.00	31.95	6.06	1.69	0.65
	55 - 130	15.49	3.76	3.68	2.04	24.97	1.05	1.04	0.75
4	0 - 20	4.69	1.79	0.59	0.12	7.18	4.62	0.01	1.10
	20 - 50	6.30	5.19	1.90	0.98	14.37	0.84	0.06	0.68
	50 - 80	3.97	1.67	0.50	0.34	6.48	1.89	0.22	0.66
	80 - 150	17.70	13.67	4.90	1.49	37.76	2.41	3.39	0.82
5	0 - 25	6.70	6.75	1.63	0.38	15.46	4.62	0.24	1.34
	25 - 40	4.71	3.78	1.31	0.17	9.92	5.04	0.25	0.74
	40 - 70	24.23	2.42	1.81	0.81	29.27	1.68	1.39	0.87
	70 - 150	16.20	1.90	2.93	0.95	21.81	0.73	0.77	0.71
6	0 - 15	20.22	10.84	4.21	0.92	36.19	2.41	0.17	1.31
	15 - 40	25.77	10.09	5.56	1.30	42.72	2.31	0.08	1.05
	40 - 60	26.82	7.32	4.79	0.56	39.49	1.86	2.00	0.86
	60 - 150	28.08	5.33	6.04	2.38	41.83	1.26	0.62	1.02
7	0 - 30	8.21	3.73	1.05	0.17	13.16	2.73	0.10	0.30
	30 - 60	4.71	1.40	0.87	0.16	7.14	4.72	0.11	0.07
	60 - 150	4.81	1.06	0.79	0.18	6.84	5.67	0.18	0.18
8	0 - 20	13.62	12.28	1.65	0.24	17.79	2.25	0.16	2.11
	20 - 50	11.56	7.23	1.99	0.36	21.14	1.78	0.17	0.55
	50 - 80	10.44	8.86	2.42	0.21	21.93	6.09	0.21	0.43
	80 - 120	20.20	11.86	4.99	0.93	37.98	1.15	0.10	0.11

Table (8) Cont'd

Profile No	Depth cm	Exchangable cations me/100 g soil Ca^{++}	Mg^{++}	Na^{+}	K^{+}	C.E.C meq/100 g soil	$CaCO_3$ %	Gypsum %	Organic matter %
9	0 - 30	10.52	6.33	1.96	0.77	19.58	11.13	0.17	0.61
	30 - 60	3.60	1.21	0.31	0.17	5.29	5.46	0.18	0.05
	60 - 100	4.07	1.90	0.53	0.23	6.73	5.46	0.18	0.04
	100 - 150	3.04	0.56	0.16	0.11	3.87	1.05	0.17	0.04
10	0 - 20	10.00	3.36	0.92	0.56	14.84	1.36	0.12	1.16
	20 - 40	10.35	2.62	0.63	0.58	14.18	1.05	0.16	1.04
	40 - 60	12.11	4.99	2.21	0.48	19.79	4.62	0.16	0.46
	60 - 150	13.48	4.44	2.77	0.46	21.15	12.49	0.12	0.45
11	0 - 30	3.99	0.82	0.27	0.22	5.30	5.46	0.21	0.09
	30 - 60	5.03	0.66	0.15	0.23	6.07	5.46	0.18	0.05
	60 - 150	6.45	0.52	0.29	0.29	7.55	7.06	0.07	0.11
12	0 - 25	3.40	1.77	0.26	0.35	5.78	28.87	2.05	0.13
	25 - 75	13.03	4.18	2.11	0.45	19.77	7.35	0.23	0.39

low content of $CaCO_3$ in the subsurface layers.

Soils of profiles 7, 8 and 10 have high contents of $CaCO_3$ in the subsurface and low contents in the surface. This may be due to their calcareous parent material drived from the limestone plateau.

A relatively high content of $CaCO_3$ is found at the surface layers of profiles 9 and 12, in addition to the deeper layers of profile 11, this is mainly due to the effect of calcareous parent material which are drived from the neighborhood limestone plateau.

4.3.5. Gypsum content:

The soils have gypsum ranging between 0.01 and 3.39% (Table 8). This is reflection of their arid climatic nature.

4.3.6. Soil Organic matter:

The arid climate of these soil lead to rapid decomposition of soil organic matter. Also scanty of natural vegetation and lack of agricultural utilization contribute to the very low contents of organic matter (0.13 to 0.83%) as shown in Table (8).

Coarse textured soils of profiles 7, 11 and 12 have between 0.09 to 0.39% organic matter.

The fine to medium textured soils of profiles 6 and 8 contain 1.31 and 2.11% organic matter.

4.3.7 Cation exchange capacity and exchangable cations:

Table (8), shows cation exchange capacity (CEC) as well as the and exchangeable cations. CEC ranges between 3.87 to 49.1 meq/100 g soil. The highest in the fine textured clayey soil (90-130 cm. depth of profile 1). The lowest CEC is in the coarse textured sandy soil (profile 9). The ESP are less than 15% with the exception of layer 90-130 cm. in profile 1 which had ESP of 21.81%.

The predominant exchangeable cation is Ca^{++} followed by Mg^{++} and Na^{+} then K^{+}.

The exchaneable Ca^{++}, Mg^{++}, Na^{+}, K^{+} ranges between 3.04 to 28.08, 0.52 to 14.97, 0.15 to 10.71 and 0.11 to 2.74 meq/100g soil, respectively.

4.4. Soil mineralogical properties :

4.4.1. Cryslalline minerals of the clay fraction:

Clay minerals content and distribution in soils are considered as a criterion for soil origin, genesis and prevailing environmental conditions involved in soil formation. Moreover, the type of clay minerals and their contents are of paramount importance as they control most, of all soil properties. Forinstance, they affect skrinkage, swelling, plasticity, moisture holding properties, permeability, ion exchange, adsorption, fixation and release of plant nutrients such as K, NH_4. Also they affect rockweathering.

The technique of X-ray differaction is most effective in identification of clay minerals. It is based on the presence of diagnostic diffraction maxima for each mineral. The intensity and sharpness of these maxima are affected by particle size, chemical composition, crystal orientation, crystal imperfection, amorphous materials and the presence of a mixture of clay minerals.

Using the diffractometer scans of the oriented clay fractions separated from the studied soils for identification of clay minerals according to the diagnostic criteria established by (Whittig and Jackson 1955, Brown 1961, Black 1965, and El-Attar and Jackson 1973.). These diagnostic criteria could be summarized as follows:

1. Randomaly interstratified minerals such as; smectite illite, detected by basal reflection at 9.7 A for glycerol solvated treatment, and illite chlorite 13.6 A in all treatment. Regularly interstratified mineral such as; smectite chlorite (19.19 - 31.5 A) in

glycerol treatment and smectite-mica (24 A°) in Mg saturated air dryed sample, which is shifted to 26 A° after glycerolation and collabse to 10 A° after K saturated and heating at 550 C.

2. Smectite (montmorillonite) is indicated by the basal spacings in the range of 14.1-14.6 A°, in the Mg treated. Glycerol treatment of the oriented samples results in expansion of basal reflections up to 16.8-17.1 A°, while the thermal treatments at 550 C, collapsed the hydrated layers to 9.9-10.28 A°.

3. Kaolinite is identified by the prominant basal reflections of 001 and 002 at 7.07 and 3.19 A°, respectively. These reflactions are unaffected by different treatments except at 550 C, these reflactions disapear as a result of collapse kaolinite structure.

4. Vermiculite and chlorite are indentified by their characteristic diffraction peak at 14 A° all over the applied treatments. The only exception is when heating to 550 C, and vermiculite peak is contracted to 10 A°, while chlorite shows an increase in the intensity of the second order due to the particle decomposition of

the interlayer brucite sheet.

5. Hydrous mica is detected from the persistence of basal maximum 10 A° peak throughout the different treatments.

6. Palygorskite has the characteristic diffraction peak at 1048 A°, 6.45 A° and 4.2-4.3 A° irrespective of treatments.

7. The high sharp peak at 3.35 A° through all treatments indicates admixture of quartz.

8. Feldspars are distingiushed by the spacing at 4.16-3.25 A°, 6.31-6.37 A°.

X-ray diffraction analysis was undertaken for 15 samples representing the soils containing appreciable amounts of clay. The x-ray diffractograms obtained from the diffractometer scans of oriented samples Figs (7 to 26) and Table (9) are used for the identification of clay and accessory minerals following the criteria established by Whittig and Jackson (1955), Brown (1961) and Black (1965).

__Clay mineralogy of the studied soils:__

The x-ray diffraction patterns of the clay fraction separated from the different layers of profile 1, Table (9), Figures (7 to 10) showed that montmorillonite and vermiculite are the dominant minerals in the fine clay (<1 μm) fraction of the upper as well as the deeper layers. Kaolinite on the other hand, is the dominant mineral in the coarse clay fraction of these layers. Interstratified minerals, palgorskite, vermiculite, hydrous mica, and feldspars are present in less pronounced amounts in both coarse and fine clay of 10-50 cm layer. While interstratified minerals, montmorillonite, vermiculite and hydrous mica are found in traces in the coarse clay of the 130-170 cm layer. In the same layer sepiolite is found in moderate amounts in the fine clay with traces of chlorite and palygorskite in both clay subfractions. On the other hand fine clay of both layers (10-50 and 130-170 cm) contained traces of quartz and feldspars. In the coarse clay the two same minerals were in marked amounts.

Clay minerals in profile 2 Table (9), Figures (11 and 12), in the surface layer are dominated by vermiculite, followed by kaolinite. Interstratified minerals, palygorskite, sepiolite, montmorillonite, hydrous mica and feldspars are detected in few amounts, along with traces of quartz and chlorite. On the other hand, in layer 65-80 cm.

Table (9) Semi-quantitative mineralogical composition of the clay fraction (< 2 μ), fine clay (< 1μ) and coarse clay fractions (2-1 μ) selected from some of the studied soil profiles.

Profile No	Depth cm	Size of clay particle	inter-stratified mineral	Clay minerals: Kaol-inite	Palygo-rskite	Sepi-otite	Mont.	Verm.	Hydraus mica	Chlo-rite	Accessory minerals: Quartz	Feld.
1	10 - 50	Fine	Few	Mod.	Few	Mod.	Mod.	Few	Few	Tr.	Tr.	Few
		Coarse	Few	Mod.	Few	---	Tr.	Few	Few	Tr.	Com.	Few
	130 - 170	Fine	Few	Few	Tr.	Mod.	Few	Mod.	Few	Tr.	Tr.	Few
		Coarse	Tr.	Few	Tr.	---	Tr.	Tr.	Tr.	Tr.	Dom.	Few
2	0 - 15	Total	Few	Mod.	Few	Few	Few	Mod.	Few	Tr.	Tr.	Few
	65 - 80	Total	Mod.	Tr.	Few	Few	Mod.	Few	Few	Tr.	Few	Tr.
3	0 - 10	Total	Few	Mod.	Few	Mod.	Mod.	Tr.	Few	Tr.	Few	Tr.
4	0 - 20	Total	Few	Few	Mod.	Few	Few	Tr.	Few	Tr.	Few	Few
	20 - 50	Fine	Mod.	Few	Few	Few	Few	Few	Few	Tr.	Tr.	Tr.
		Coarse	Tr.	Mod.	Few	Few	Few	Tr.	Few	Tr.	Com.	Few
	80 - 150	Fine	Few	Tr.	Mod.	Mod.	Mod.	Tr.	Mod.	Tr.	Tr.	Few
		Coarse	Tr.	Com.	Tr.	Tr.	Tr.	Tr.	Few	Tr.	Com.	Few
5	25 - 40	Total	Tr.	Few	Few	Few	Few	Com.	Tr.	Tr.	Few	Few
6	0 - 15	Fine	Tr.	Few	Tr.	Few	Few	Tr.	Tr.	Tr.	Few	Tr.
		Coarse	Tr.	Mod.	Tr.	Few	Few	Tr.	Tr.	Tr.	Dom.	Few
7	30 - 60	Total	Few	Few	Tr.	Few	Few	Com.	Tr.	Tr.	Few	Tr.
8	0 - 20	Total	Tr.	Com.	Few	Tr.	Tr.	Tr.	Few	Few	Mod.	Few
9	30 - 60	Total	Few	Com.	Few	Few	Few	Tr.	Tr.	Few	Tr.	Tr.
10	0 - 20	Total	Few	Com.	Few	Few	Few	Tr.	Few	Tr.	Few	Tr.
11	0 - 30	Total	Few	Mod.	Mod.	Mod.	Few	Mod.	Tr.	Tr.	Tr.	Tr.

Dom. = Dominant > 40%
Com. = Common 25 - 40%
Mod. = Moderate 15 - 25%
Few = 5 - 15%
Tr. = Trace < 5%
--- = Absent

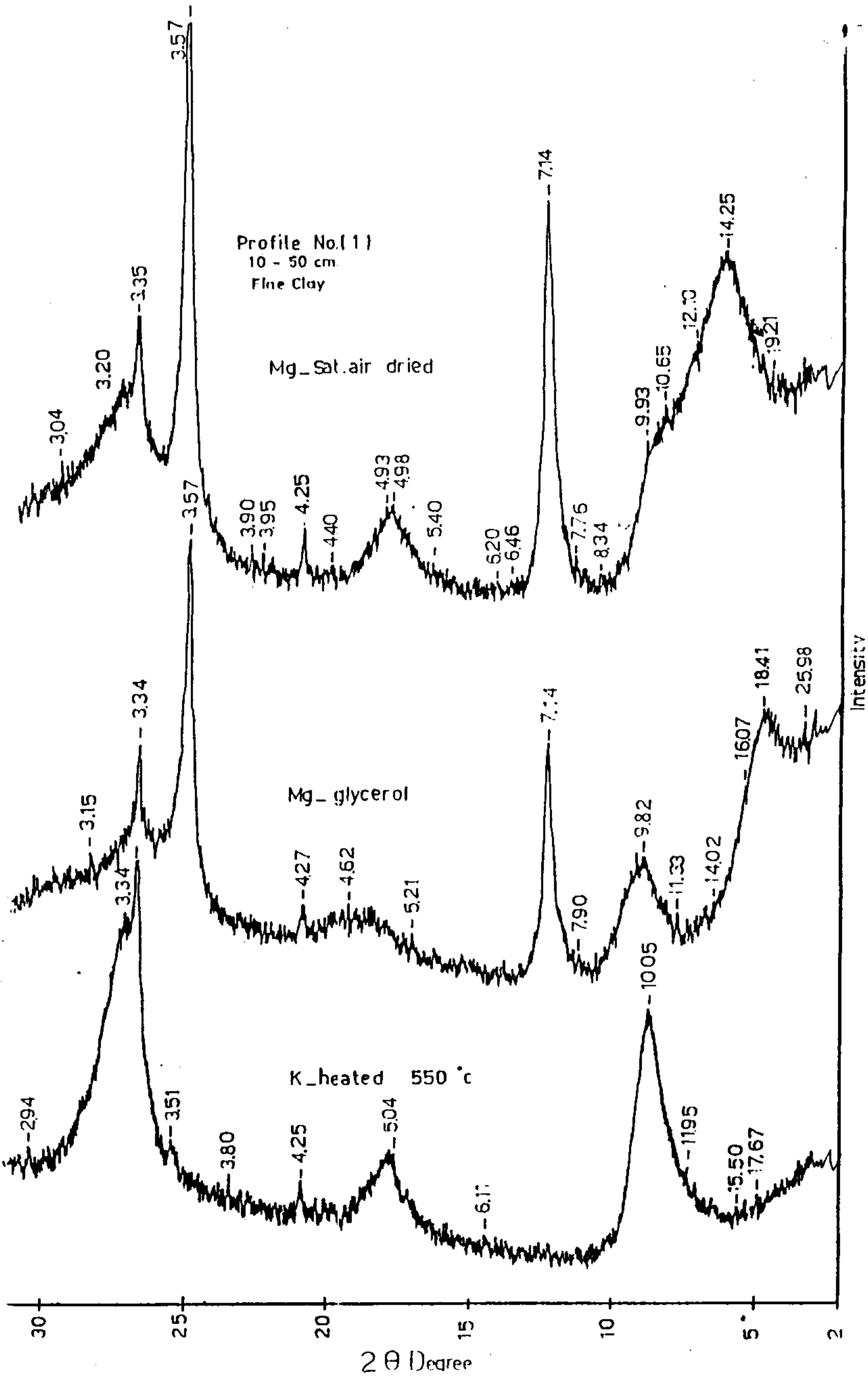


Fig (7) X-ray diffraction patterns of the fine clay (<1 μ) fraction separated from the (10 - 50) cm) layer of profile 1 El-Kharga Oasis.

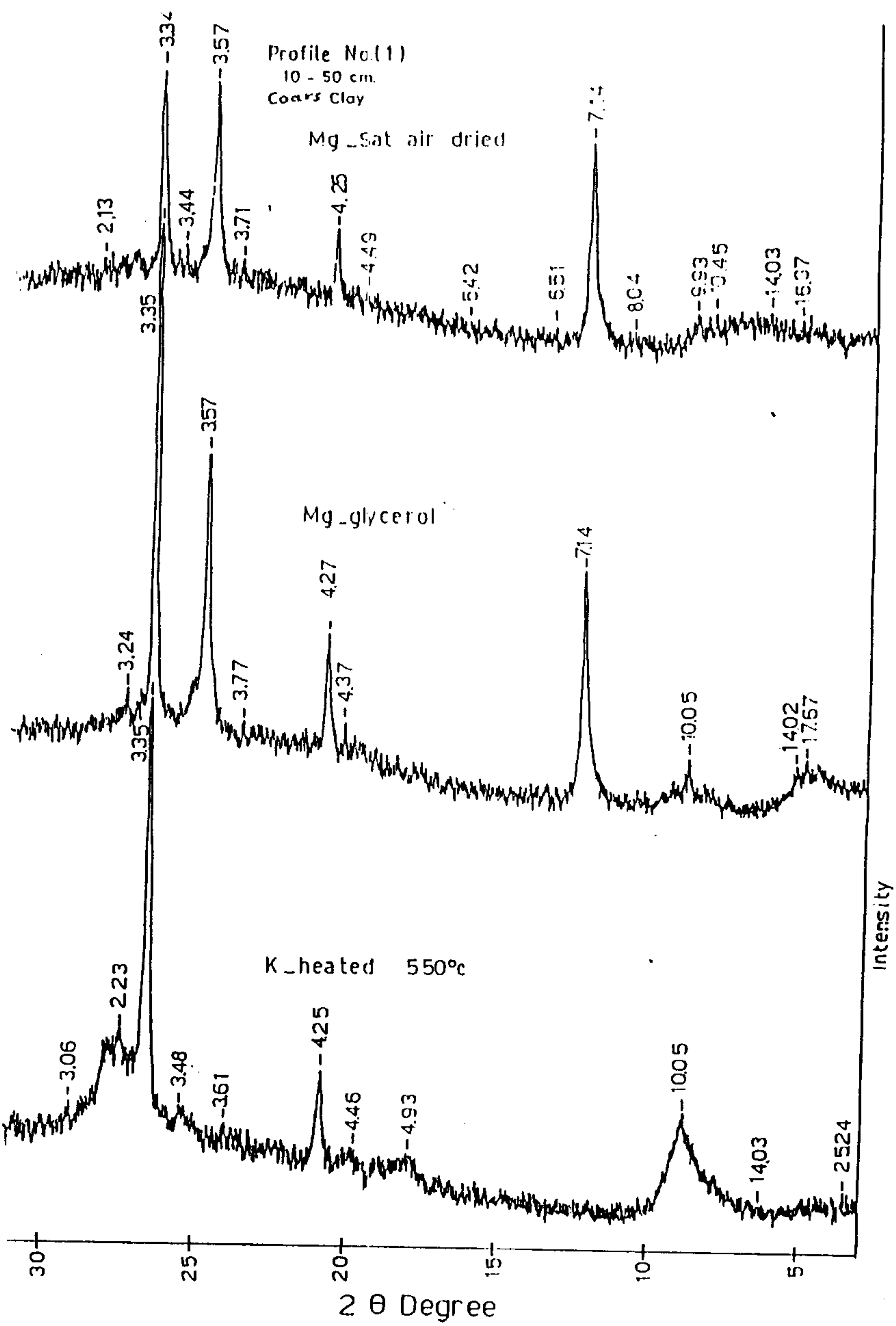


Fig (8) X-ray diffraction patterns of the coarse clay (1-2 μ) fraction separated from the (10 - 50) cm layer of profile 1 El-Kharga Oasis.

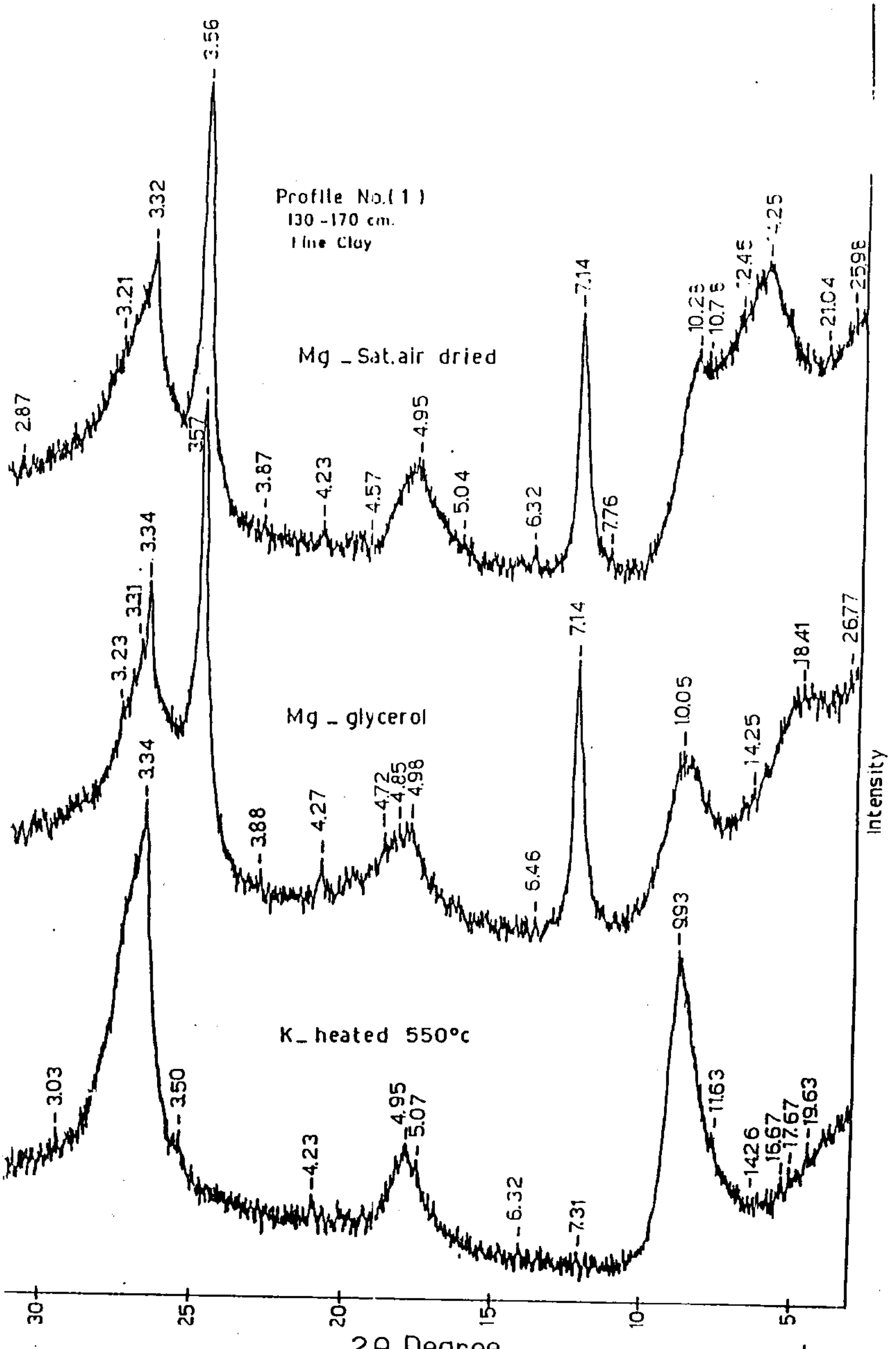


Fig (9) X-ray diffraction patterns of the fine clay (<1 μ) fraction separated from the (130 -170) cm layer of profile 1 El-Kharga Oasis.

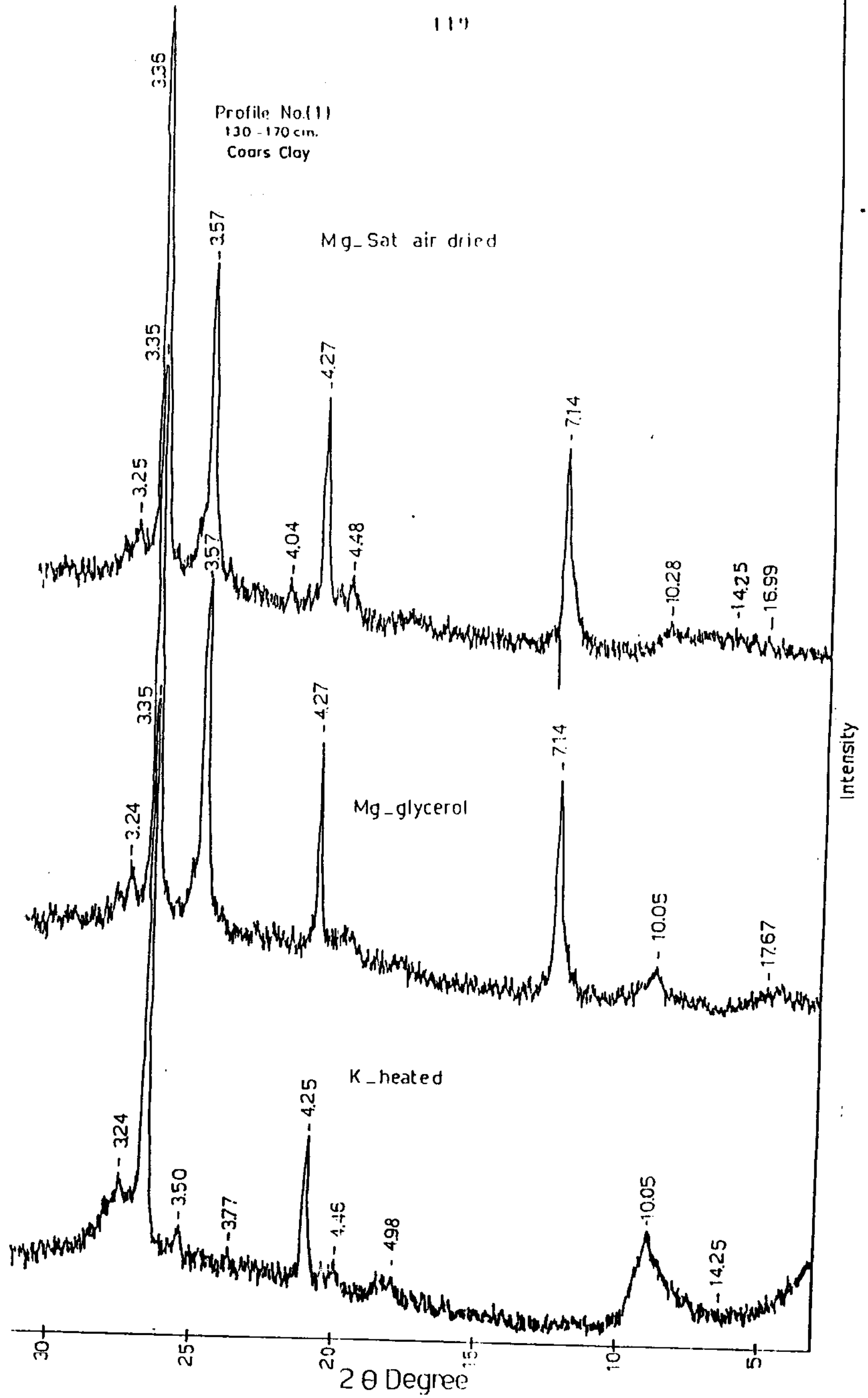


Fig (10) X-ray diffraction patterns of the coarse clay (1-2 μ) fraction separated from the (130 -170) cm layer of profile 1 El-Kharga Oasis.

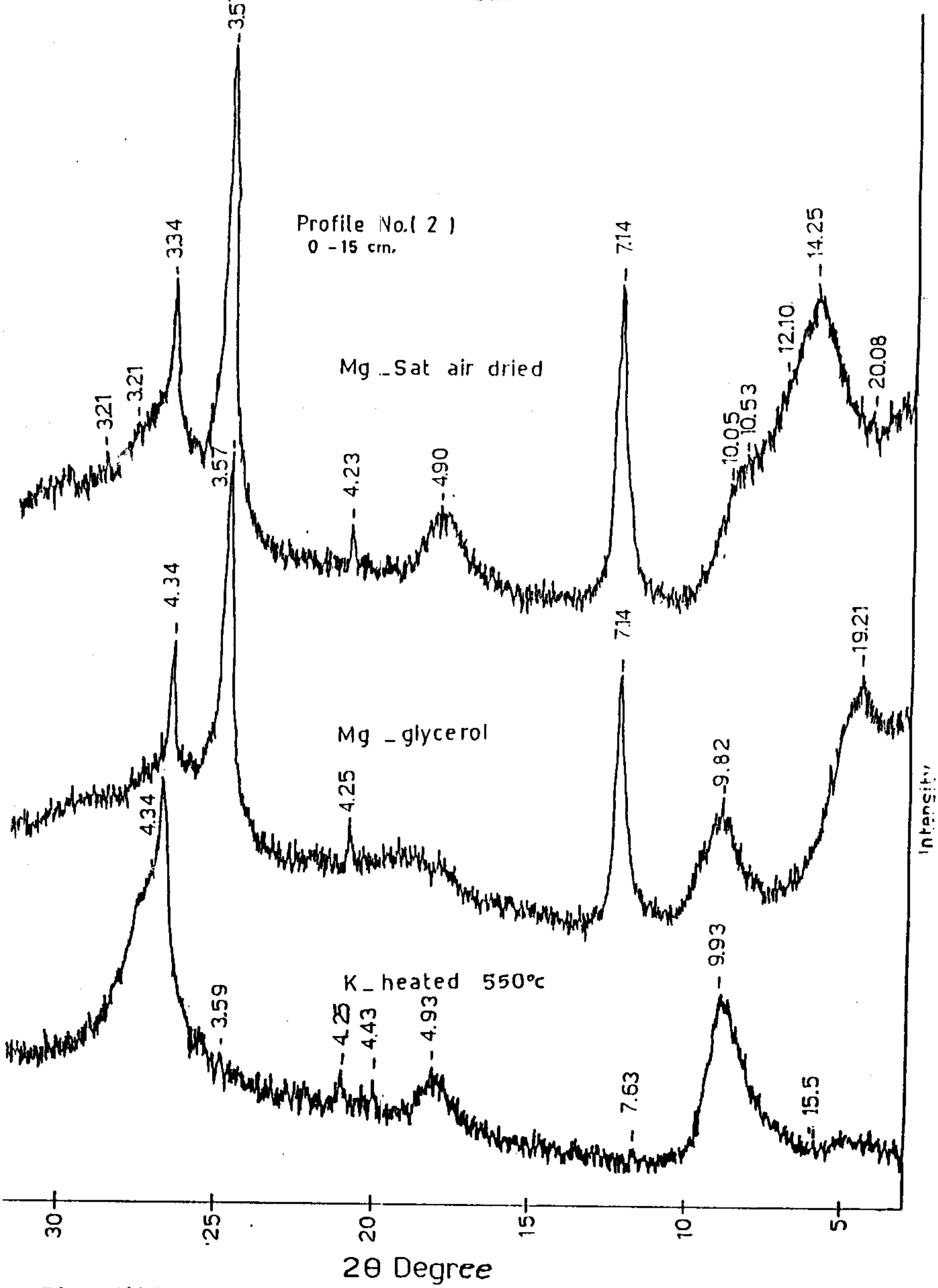


Fig (11) X-ray diffraction patterns of the clay fraction separated from the (0 - 15) cm layer of profile 2 El-Kharga Oasis.

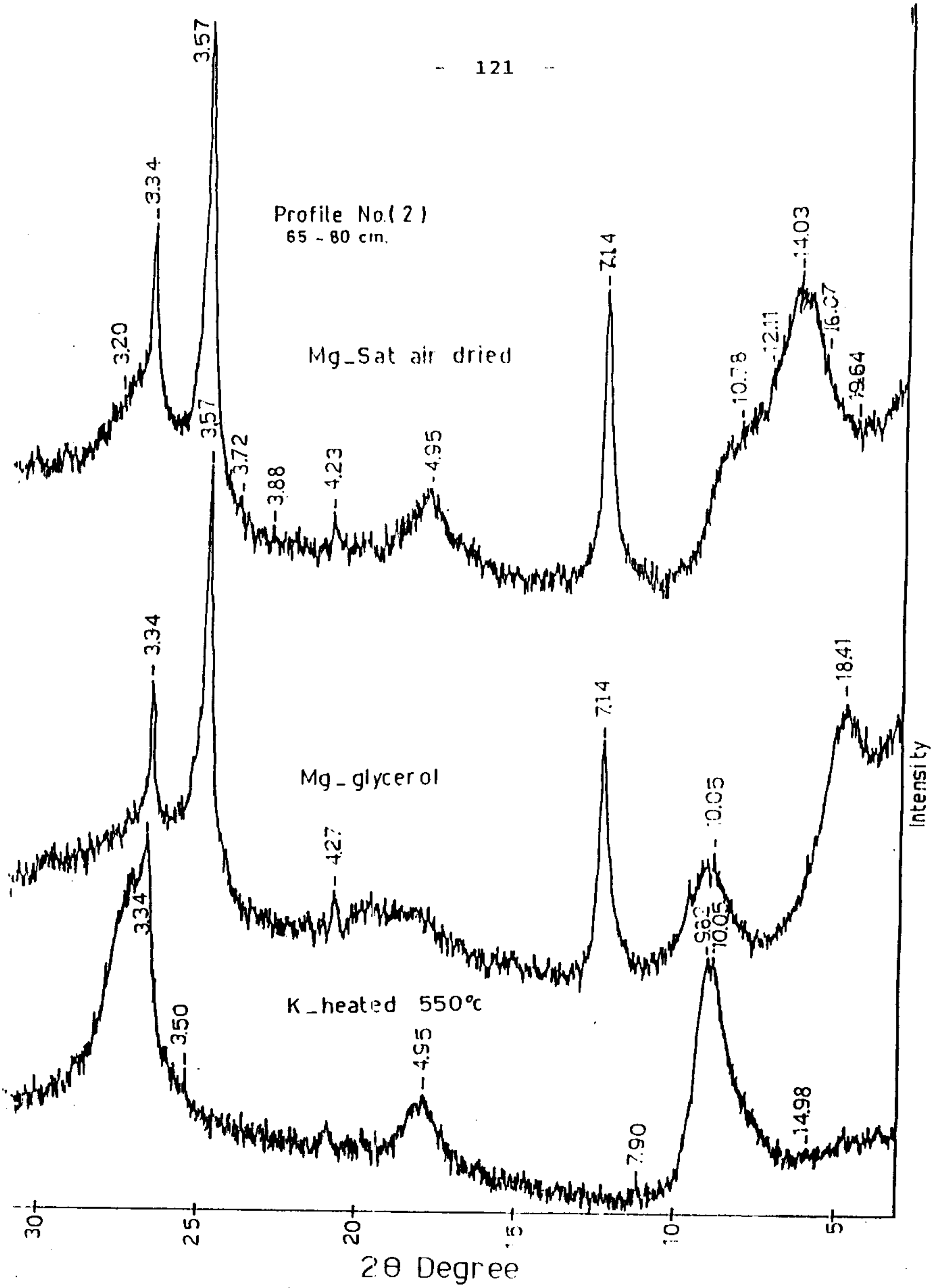


Fig (12) X-ray diffraction patterns of the clay fraction separated from the (65 - 80) cm layer of profile 2 El-Kharga Oasis.

montmorillonite and interstratified minerals are dominant. In the same layer palygorskite, sepiolite, vermiculite, hydrous mica, and quartz are in few amounts with traces of kaolinite, chlorite and feldspars.

In the clay fraction of profile 3, Table (9), Figure (13), montmorillonite as the dominant followed by kaolinite and sepiolite. Interstratified minerals, palygorskite, hydrous mica and quartz are present in few amounts in the surface (0-10 cm) layer, with traces of chlorite, vermiculite and feldspars.

Concerning profile 4, Table (9), Figures (14 to 18), palygorskite is the dominant mineral followed by quartz, montmorillonite, kaolinite, sepiolite, hydrous mica, interstratified minerals and feldspars which are in few amounts with traces of vermiculite and chlorite in the surface 0-20 cm layer. In the sub surface layer (20-50 cm.), montmorillonite is dominant in the fine clay followed by interstratified minerals. In the coarse clay, quartz and kaolinite are dominant.

palygorskite, sepiolite, hydrous mica are in few amounts in both fine and coarse clays. Interstratified minerals and montmorillonite are traces to moderate amounts

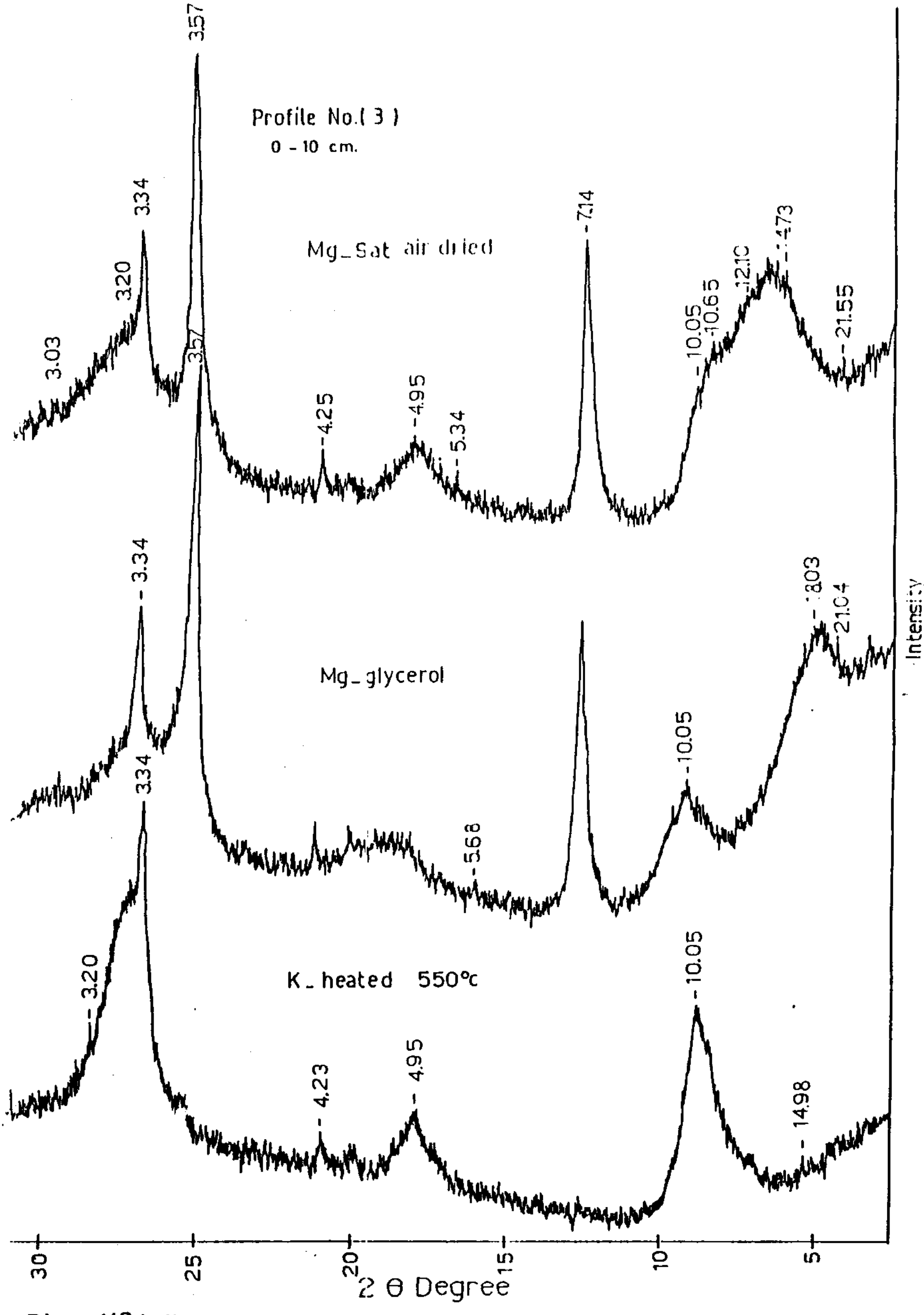


Fig (13) X-ray diffraction patterns of the clay fraction separated from the (0 -10) cm layer of profile 3 El-Kharga Oasis.

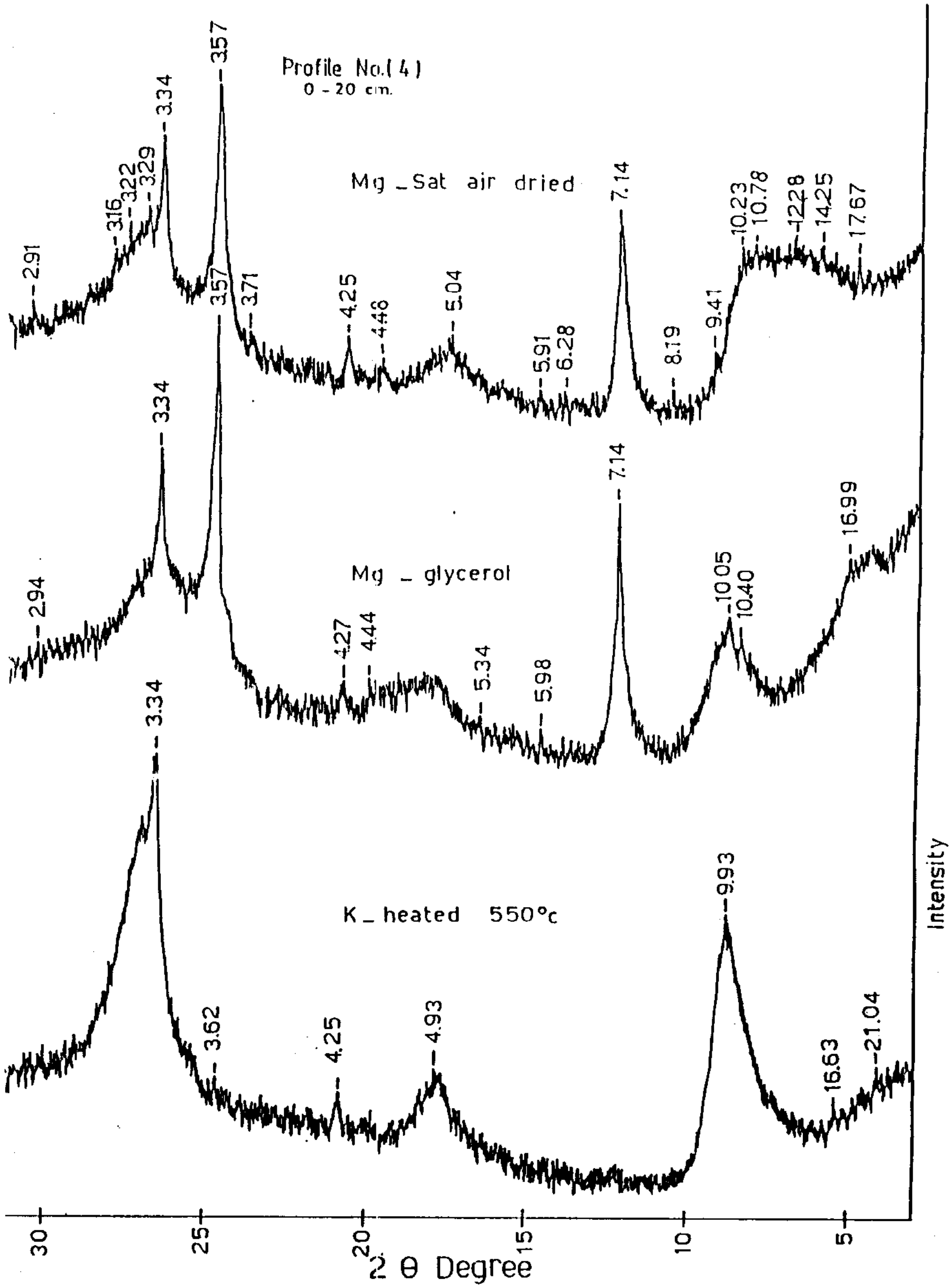


Fig (14) X-ray diffraction patterns of the clay fraction separated from the (0 -20) cm layer of profile 4 El-Kharga Oasis.

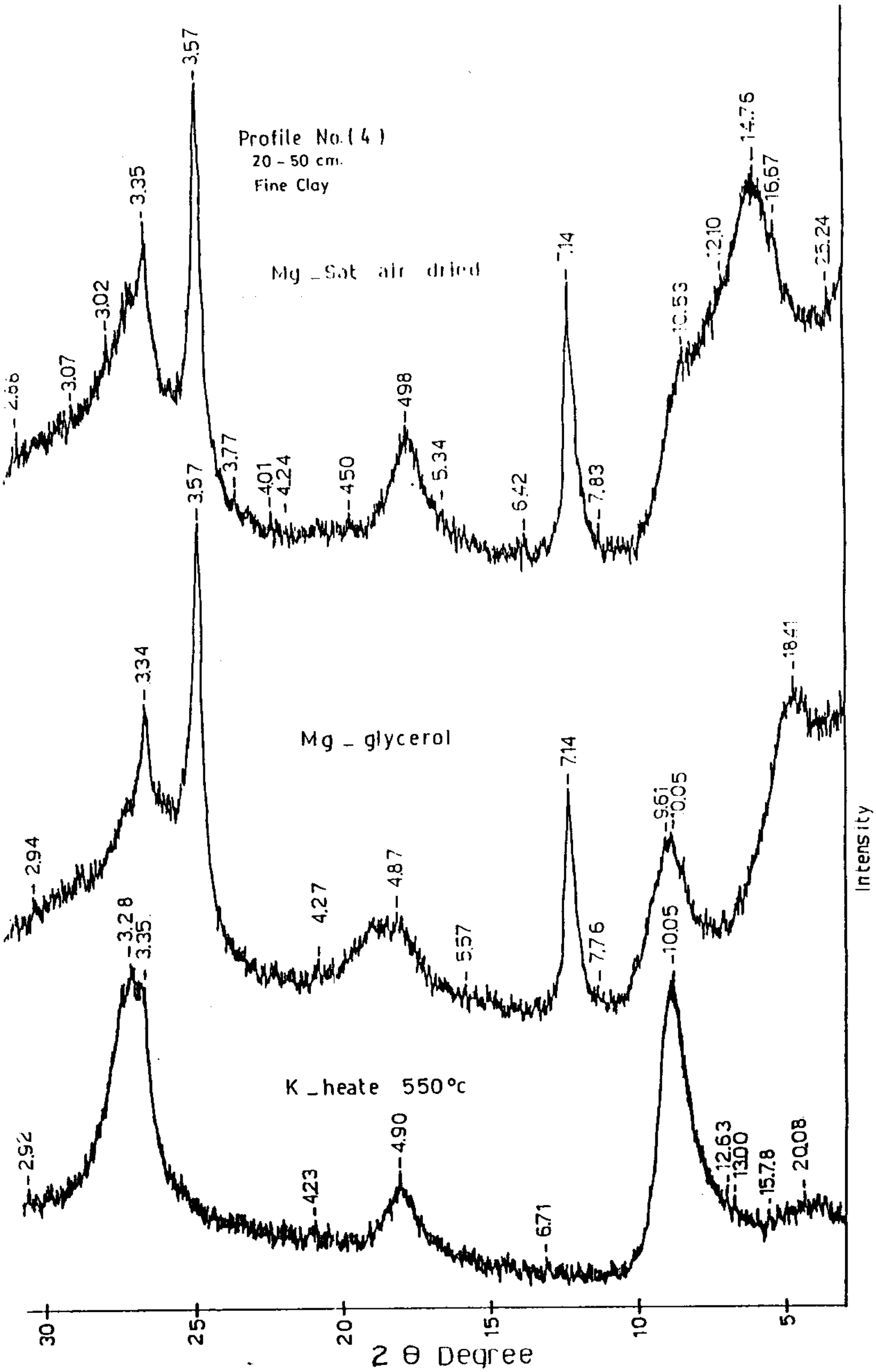


Fig (15) X-ray diffraction patterns of the fine clay (<1 μ) fraction separated from the (20 -50) cm layer of profile 4 El-Kharga Oasis.

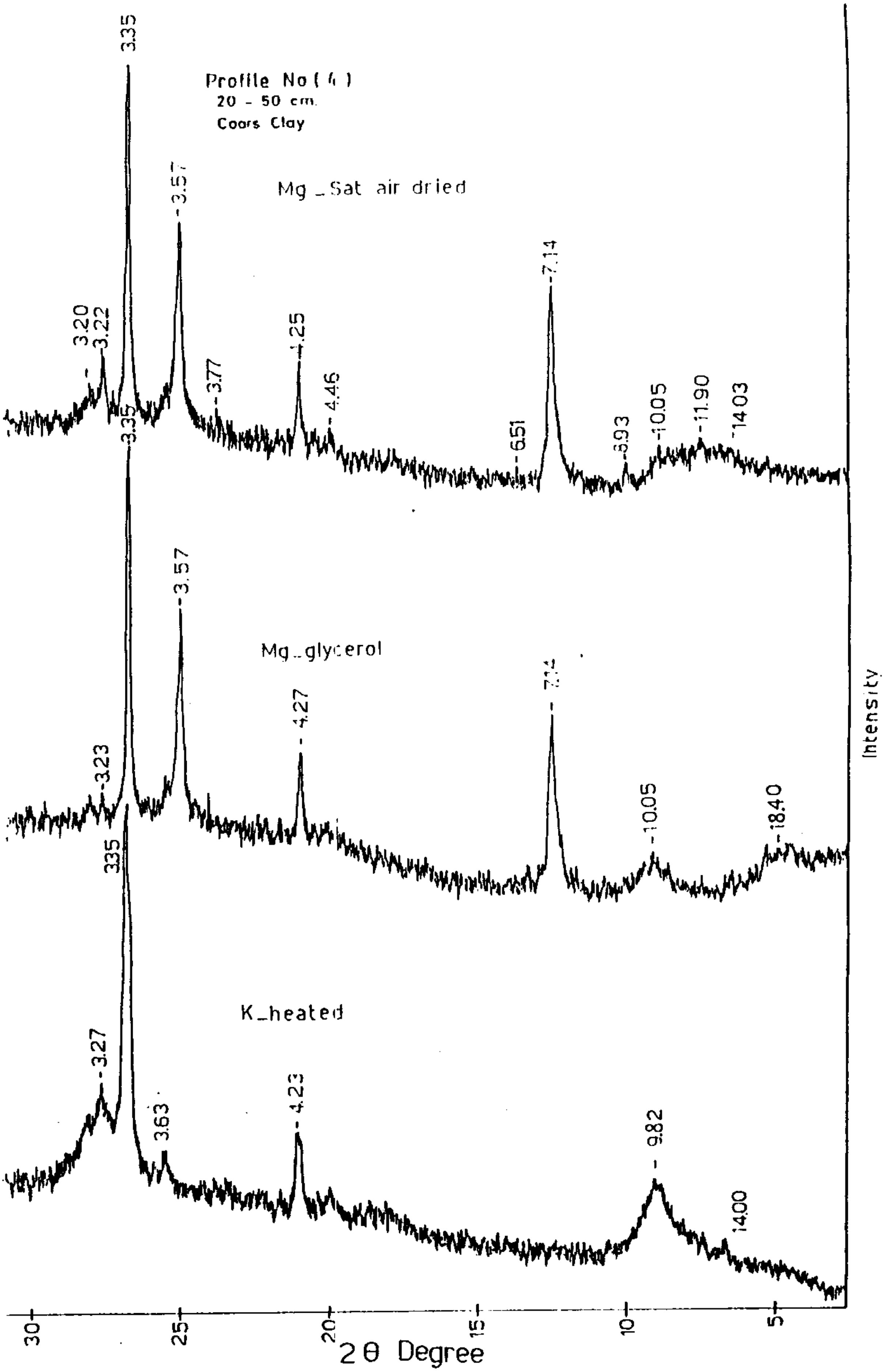


Fig (16) X-ray diffraction patterns of the coarse clay (1-2 µ) fraction separated from the (20 -50) cm layer of profile 4 El-Kharga Oasis.

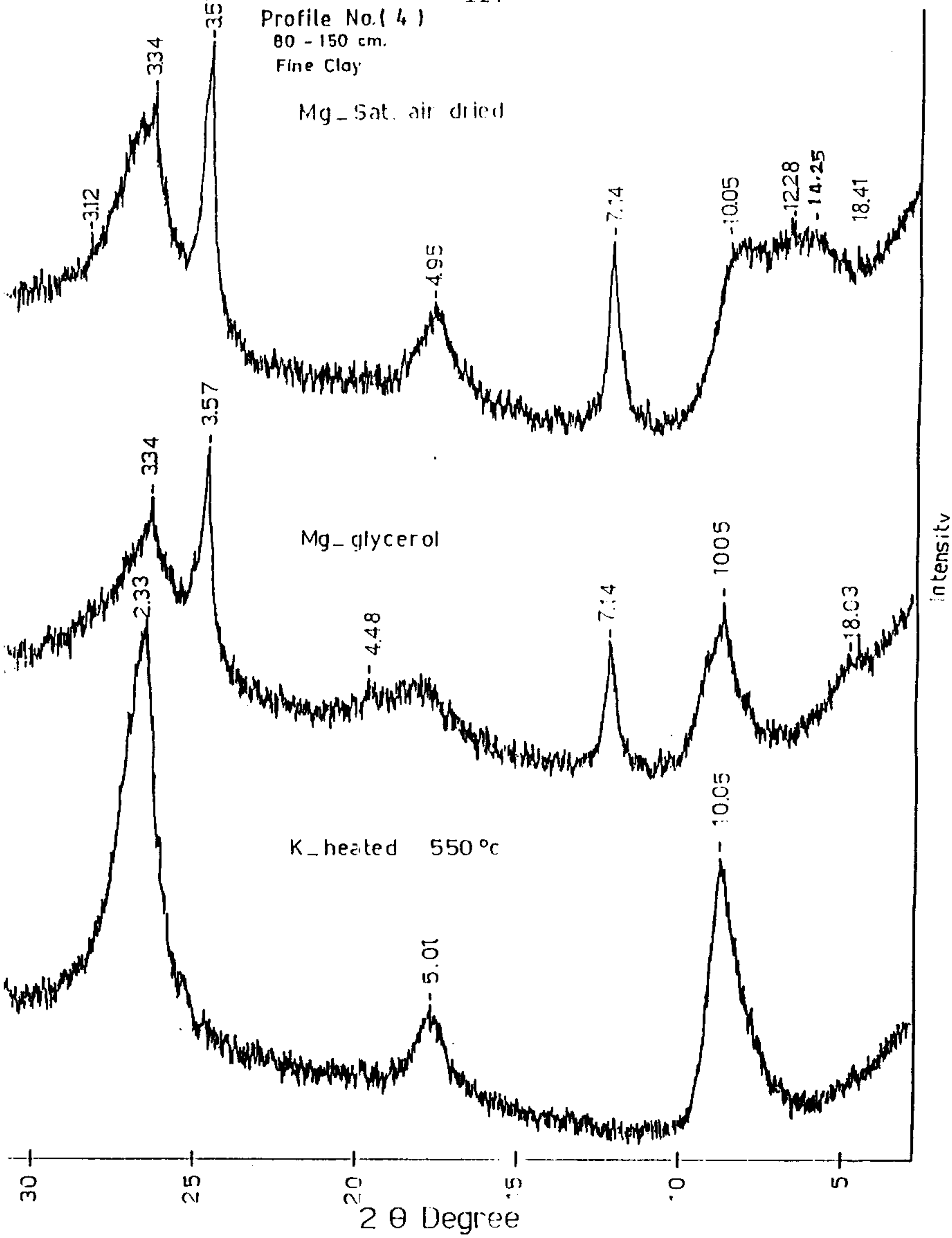


Fig (17) X-ray diffraction pattern of the fine clay (<1 μ) fraction separated from the (80-150) cm layer of profile 4 El-Kharga Oasis.

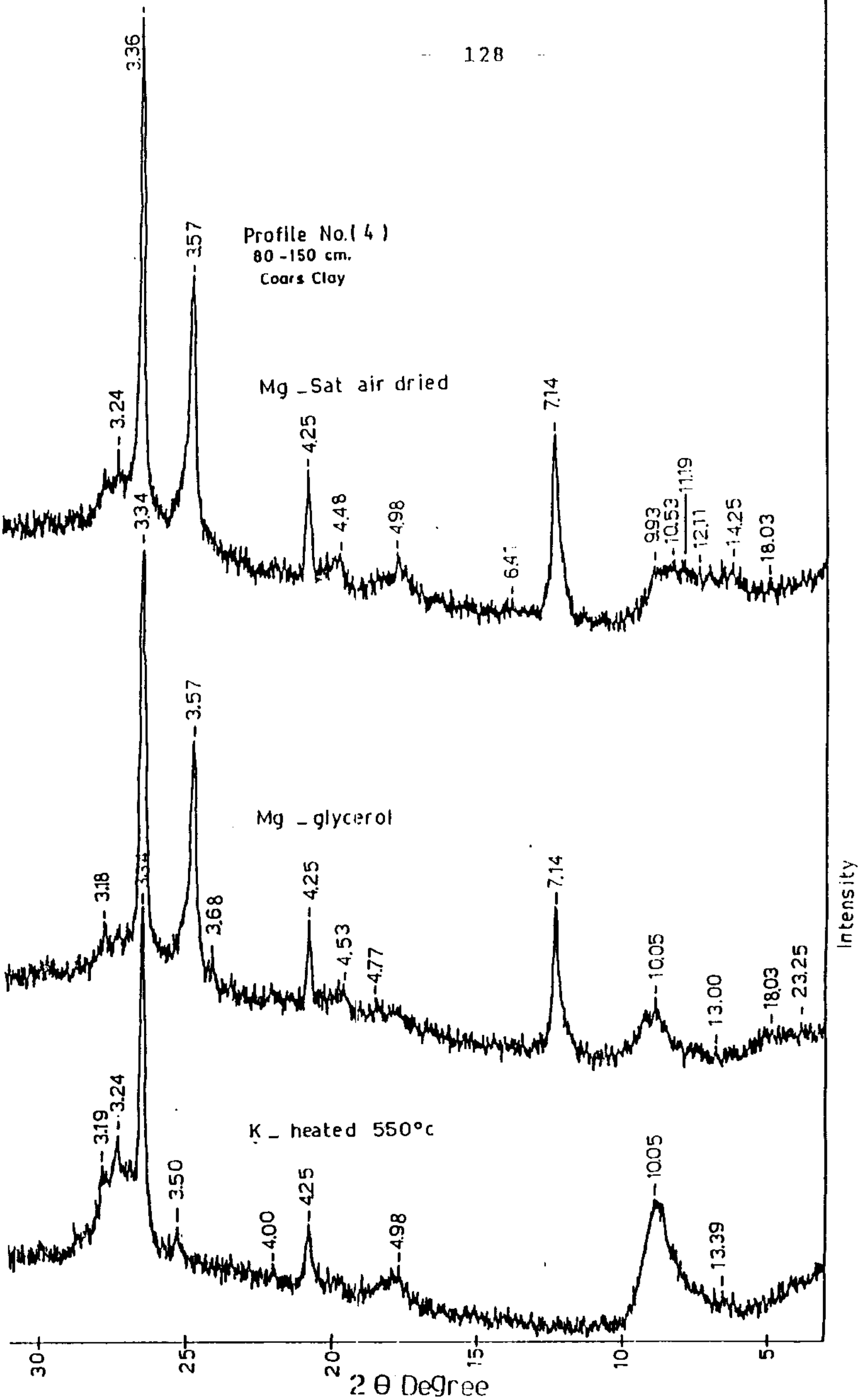


Fig (18) X-ray diffraction patterns of the coarse clay (1-2 µ) fraction separated from the (80-150) cm layer of profile 4 El-Kharga Oasis.

in both fine and coarse clays in the two layer of 20-50 cm and 80-150 cm. In the same two layers, vermiculite chlorite and feldspars are in traces or moderate amounts in fine and coarse clays.

In the 80-150 cm layer palygoriskite is dominant, followed by hydrous mica and sepiolite in the fine clay with moderate amounts of interstratified minerals, feldspars and montmorillonite. Kaolinite, quartz, vermiculite and chlorite were in traces. In the coarse clay, kaolinite and quartz are in moderate amounts with few contents of hydrous mica and feldspars in along with traces of palygoriskite and sepiolite.

In profile 5, Table (9), Figure (19) which represented by layer 25-40 cm., the dominant mineral is vermiculite followed by montmorillonite; kaolinite, palygoriskite, sepiolite, feldspars and quartz are detected in few amounts.

In profile 6, Table (9), Figure (20 and 21) the 0-15 cm. layer has montmorillonite as the dominant clay mineral in the fine clay with few contents of kaolinite, sepiolite and quartz.

In the coarse clay quartz and kaolinite are the dominant minerals followed by few amounts of montmorillonite

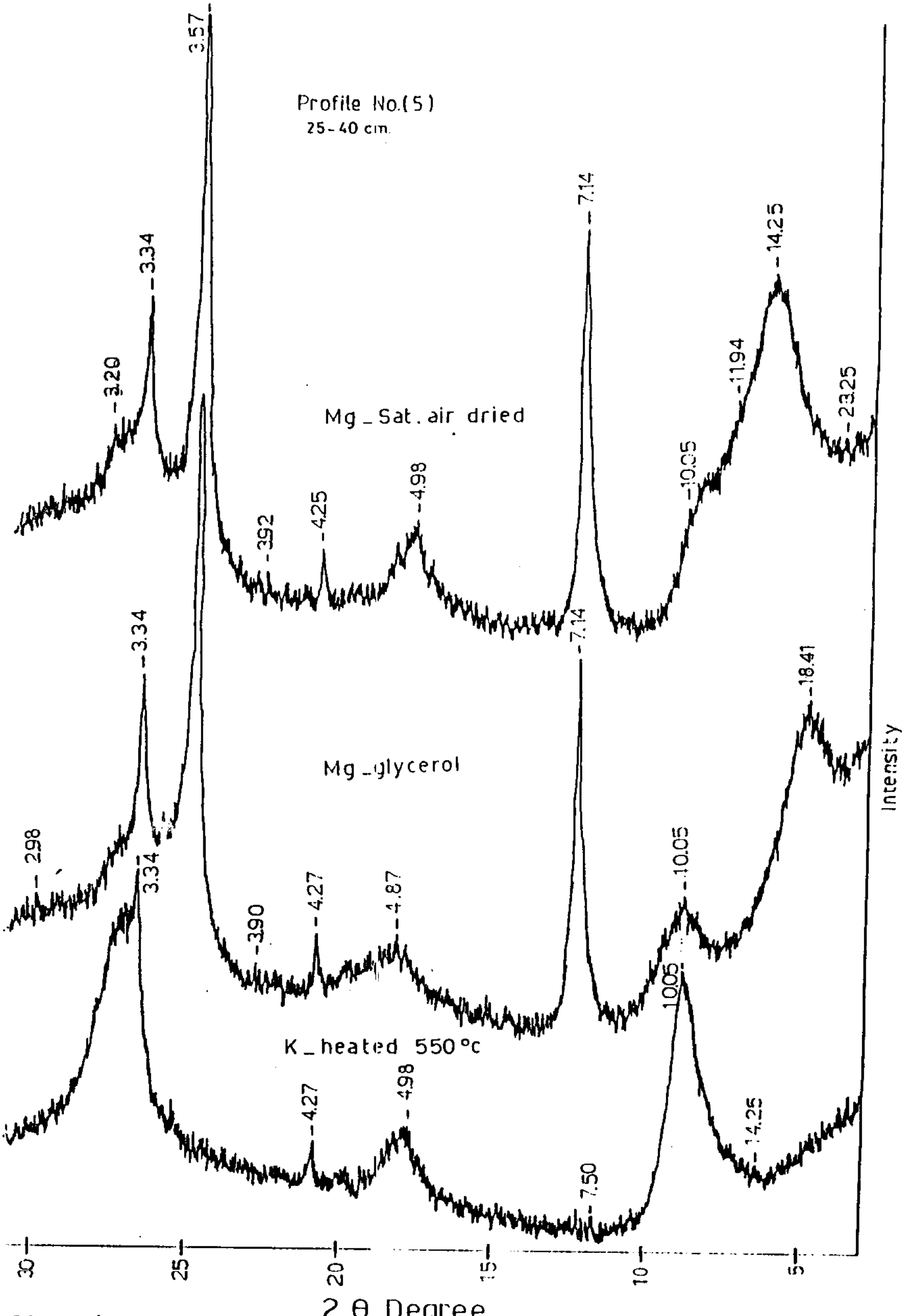


Fig (19) X-ray diffraction patterns of the clay fraction separated from the (25 -40) cm layer of profile 5 EL-Kharga Oasis.

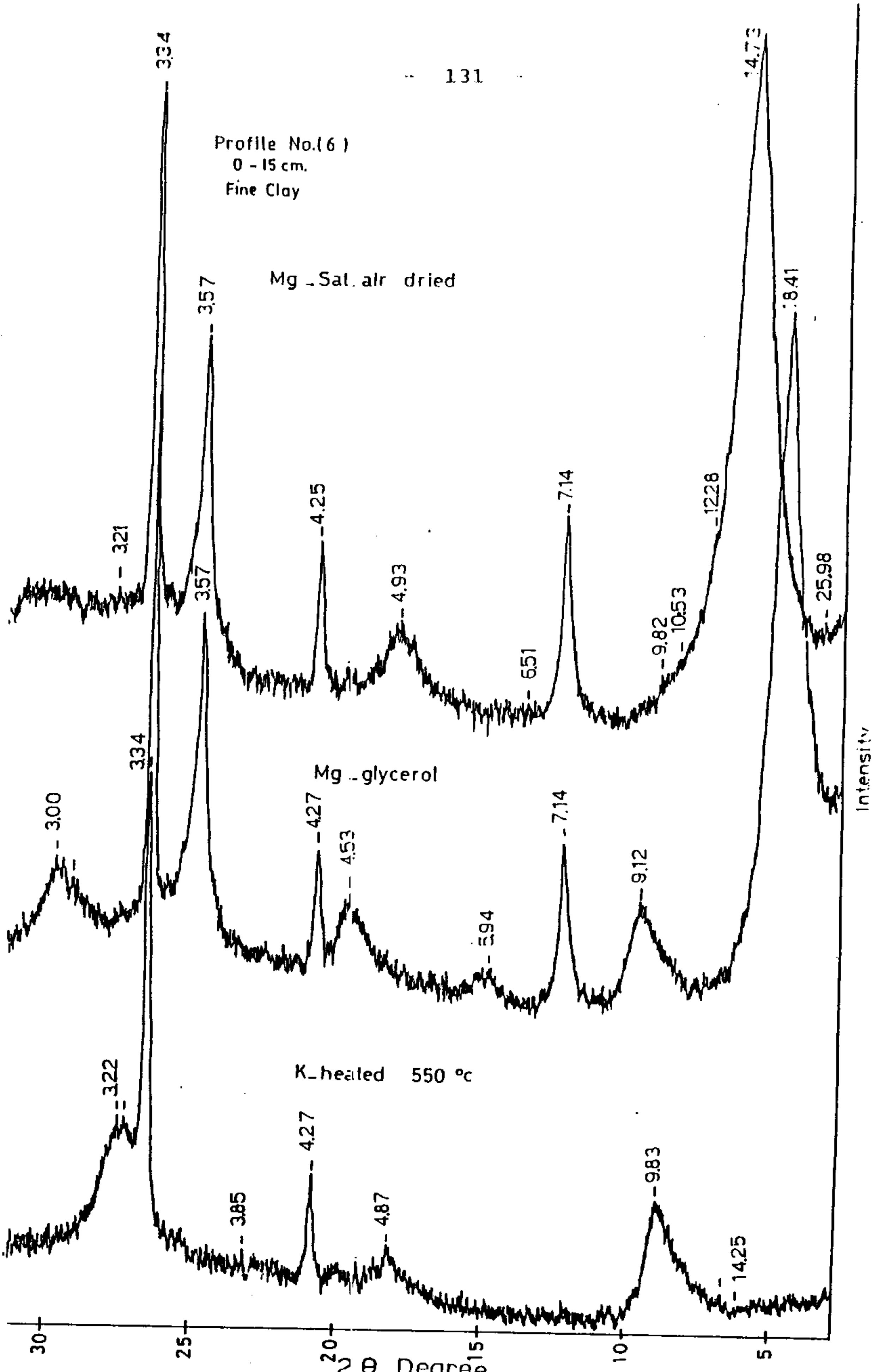


Fig (20) X-ray diffraction patterns of the fine clay (<1 μ) fraction separated from the (0 - 15) cm layer of profile 6 El-Kharga Oasis.

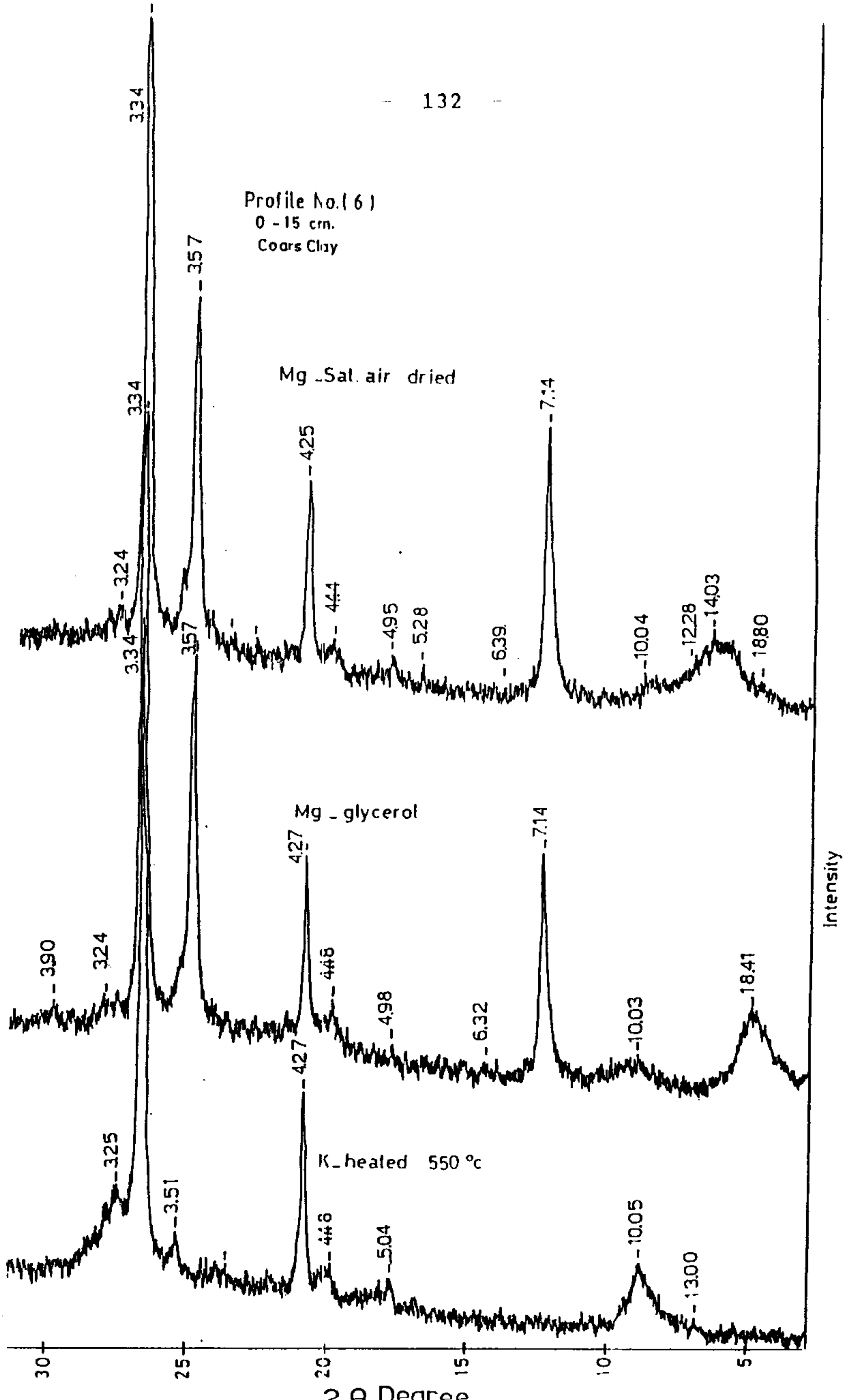


Fig (21) X-ray diffraction patterns of the coarse clay (1-2 μ) fraction separated from the (0 - 15) cm layer of profile 6 El-Kharga Oasis.

sepiolite and feldspars.

In both fine and coarse clay fractions interstratified minerals, palygorskite, vermiculite, hydrous mica and chlorite are present in trace amounts.

In profile 7 Table (9), Figure (22) the 30-60 cm. layer has montmorillonite as the dominant mineral followed by vermiculite.

Interstratified minerals, kaolinite, sepiolite and quartz are detected in few amounts while palygoriskite, hydrous mica, chlorite and feldspars are in trace amounts.

In profiles 8, 9, 10 and 11 (Table (9) and Figuress 23 to 26), kaolinite is the dominant mineral in the surface layers in profiles 8 and 10 and subsurface layer (30-60 cm) of profile 9, while vermiculite is the dominant minerals followed by moderate amounts of kaolinite and sepiolite in the surface layer of profile 11.

Interstratified minerals, palygorskite and montmorillonite are in few amounts, except for the surface layers of each of profile 8 which has traces of interstratified and profile 11 which has traces of palygorskite. There are traces of sepiolite in the surface

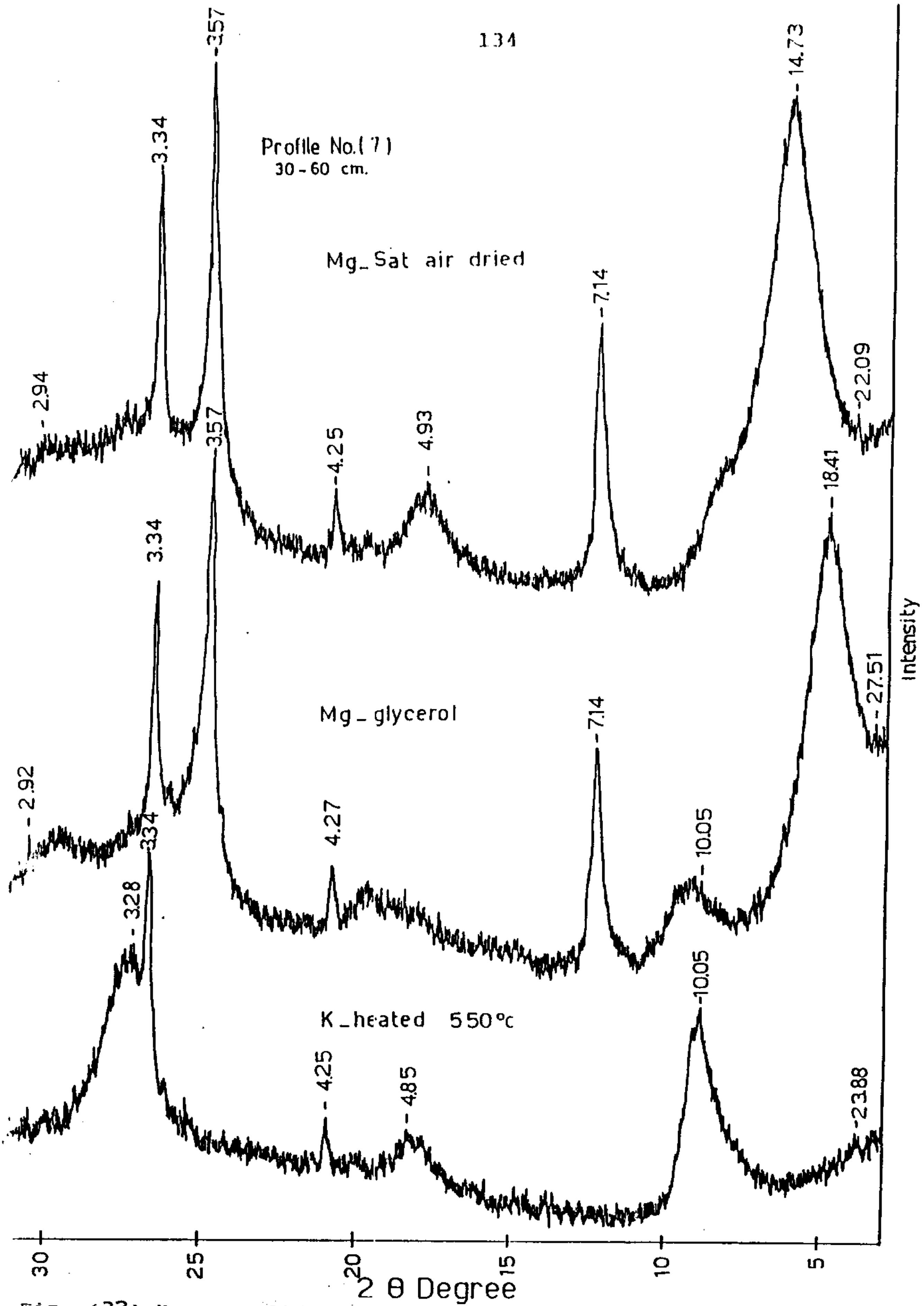


Fig (22) X-ray diffraction patterns of the clay fraction separated from the (30 -60) cm layer of profile 7 El-Kharga Oasis.

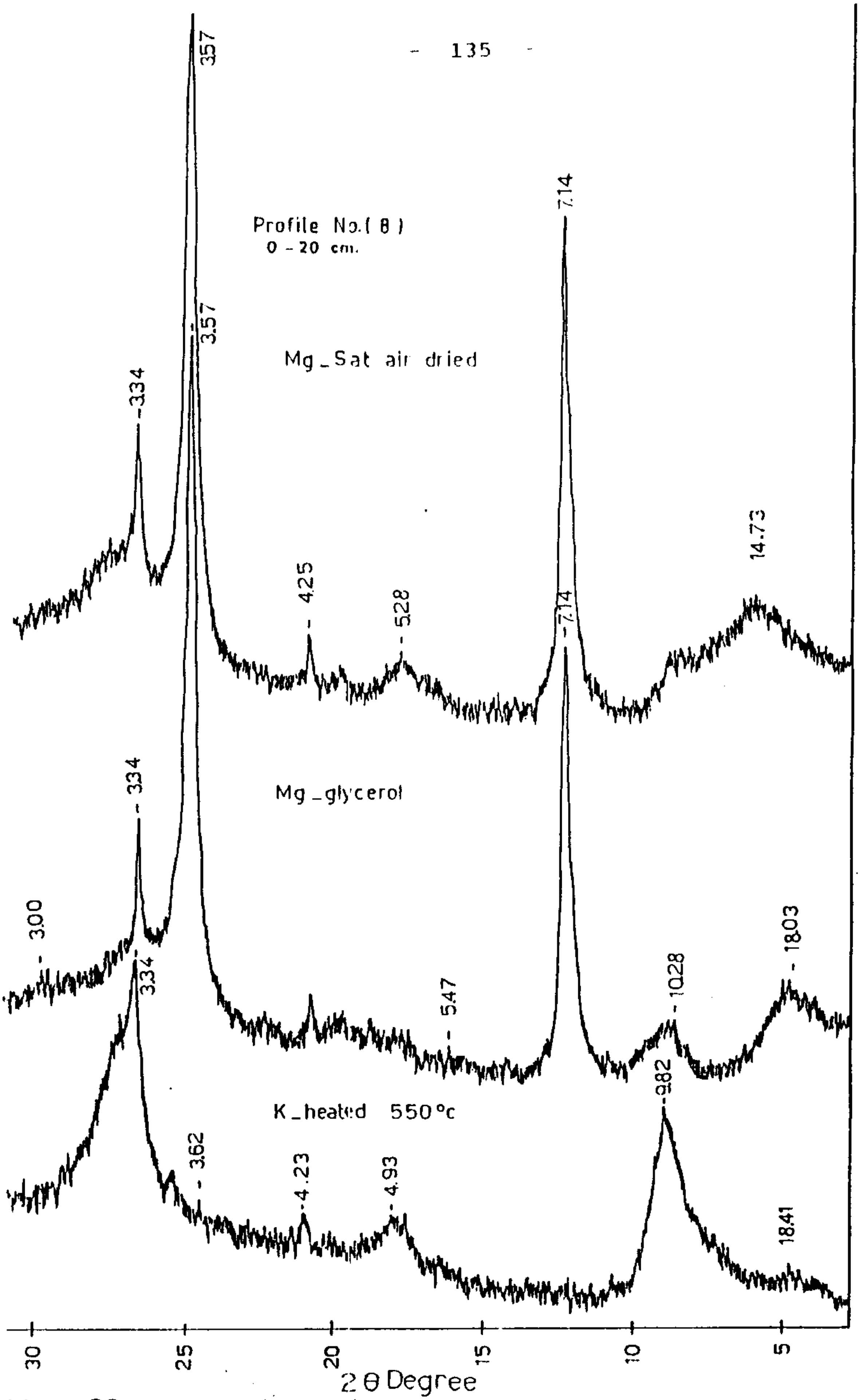


Fig (23) X-ray diffraction patterns of the clay fraction separated from the (0 -20) cm layer of profile 8 El-Kharga Oasis.

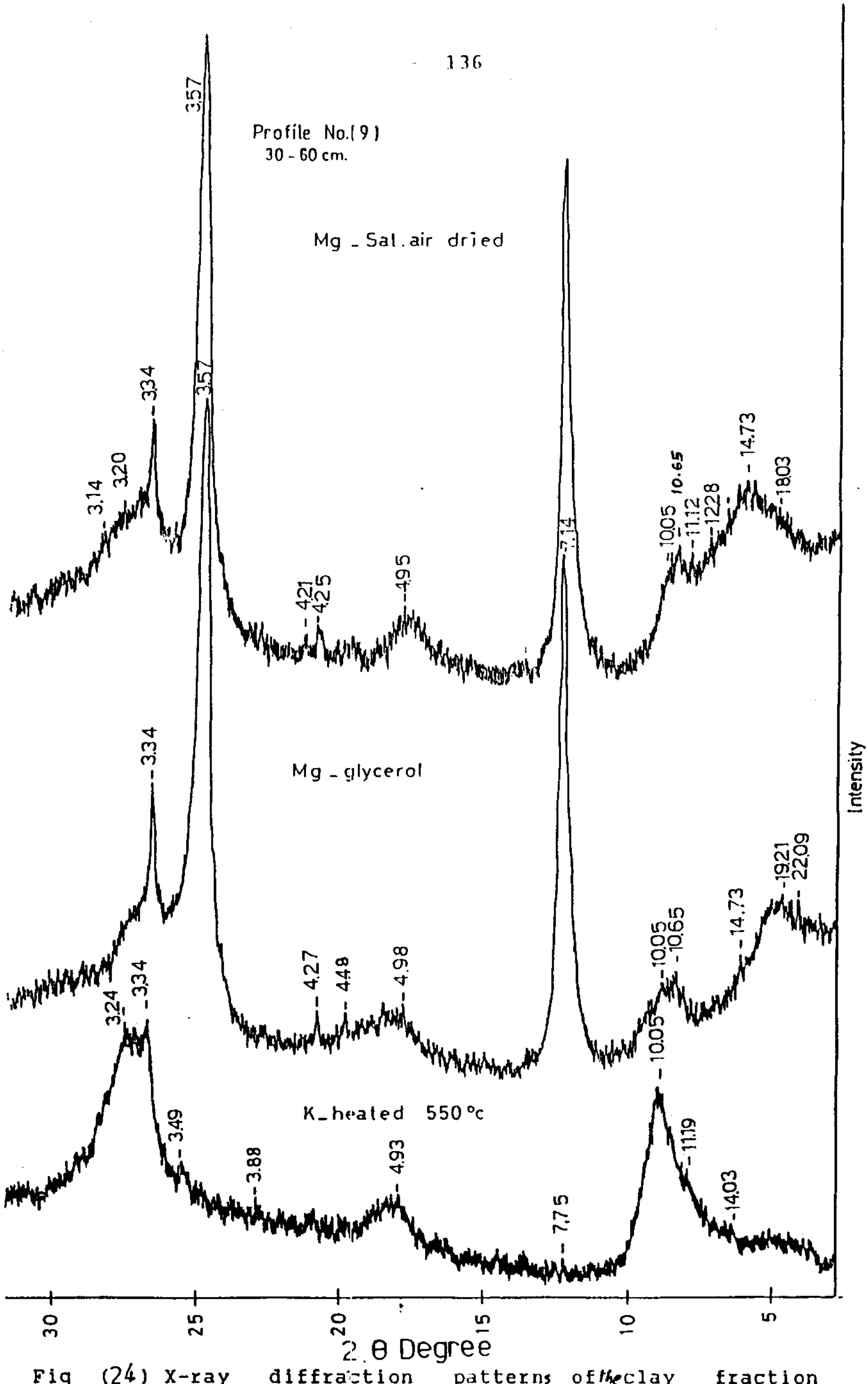


Fig (24) X-ray diffraction patterns of the clay fraction separated from the (30 -60) cm layer of profile 9

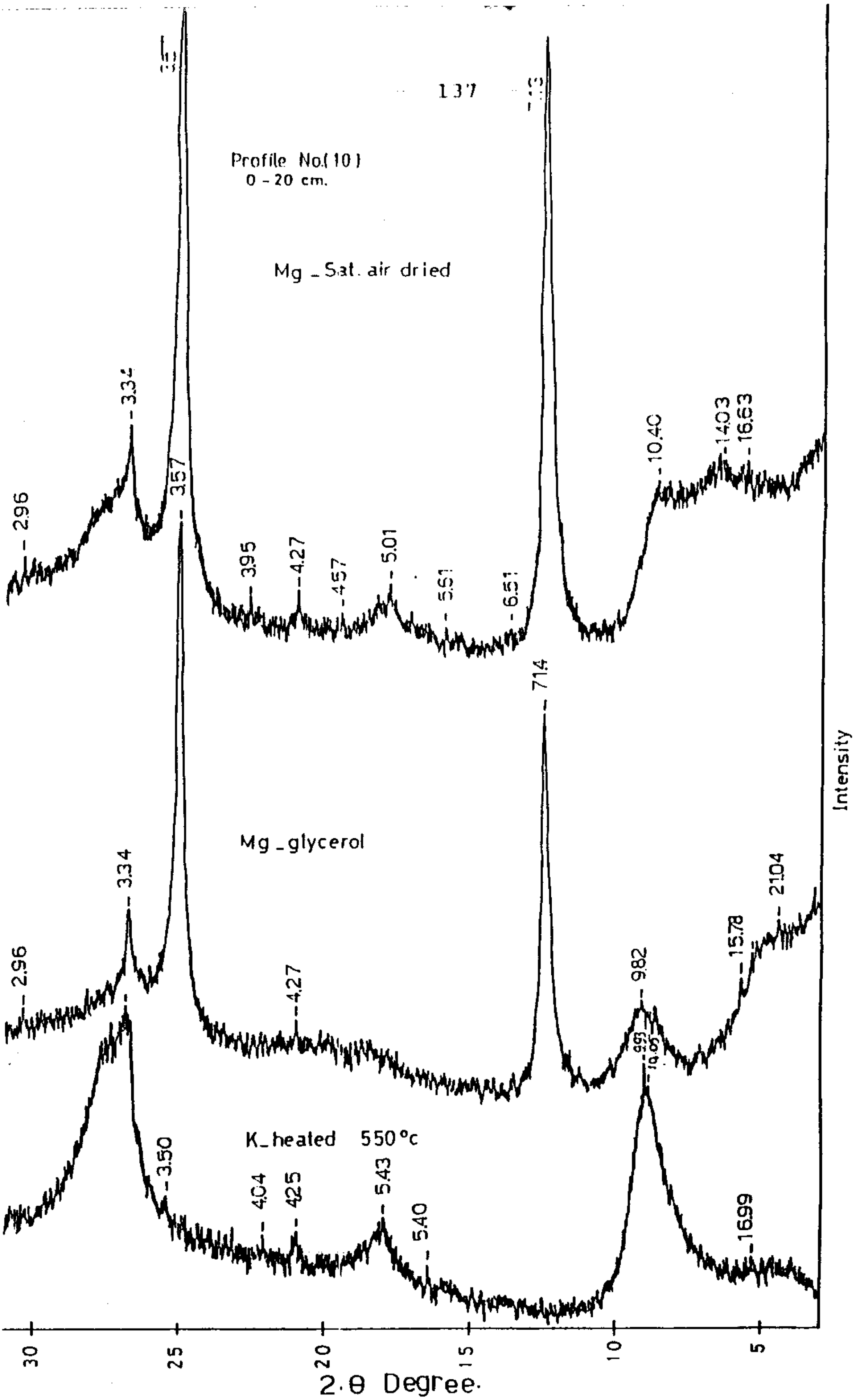


Fig (25) X-ray diffraction patterns of the clay fraction separated from the (0 - 20) cm layer of profile 10 El-Kharga Oasis.

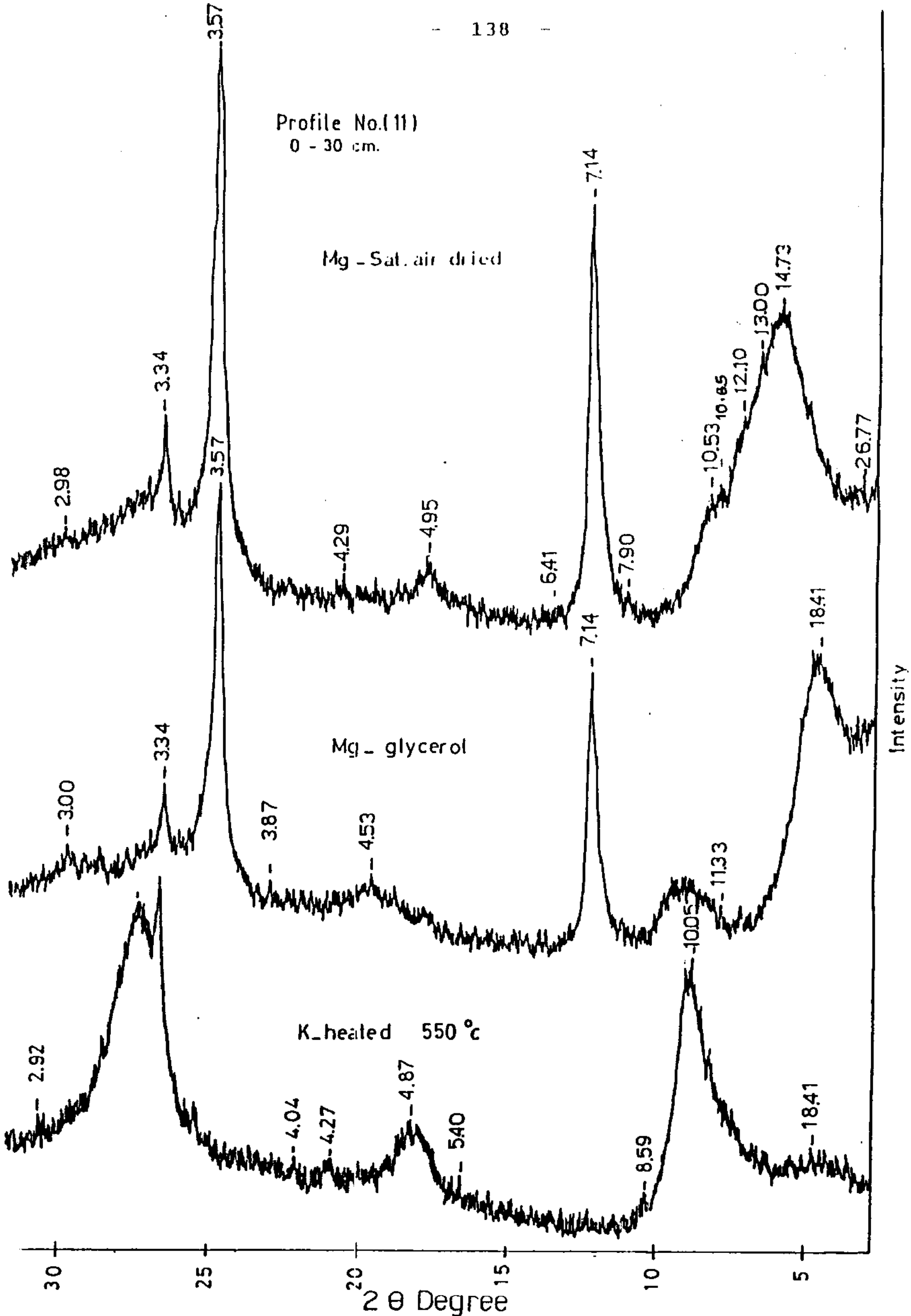


Fig (26) X-ray diffraction patterns of the clay fraction separated from the (0 -30) cm layer of profile 11 El-Kharga Oasis.

layer of profile 8 while few amounts of it in the sub surface and the surface layers of profiles 9 and 10. Vermiculite is found in trace amounts in the selected layers of profiles 8, 9 and 10. Hydrous mica is in few amounts in the surface layer of each of profiles 8 and 10, but in trace amount in the sub-surface and the surface layers of profiles 9 and 11, respectively. Chlorite is in few amounts in the surface and sub-surface layers of profiles 8 and 9, but in trace amounts in the surface layers of profiles 10 and 11. Quartz is in moderate amounts in the surface layer of profile 8 and few amounts in the surface layer of profile 10.

In the sub surface layer of profile 9 and the sub surface layer of profile 11 quartz is in trace amounts. Feldspars are in trace amounts in all layers except in surface layer of profile 8 where they are in few amounts.

Implications of mineralogical composition, the mineralogical composition of the clay fraction of these soils indicates the following:

1. Since montmorillonite is generally dominant this indicates that the contribution of water in the formation of these soils was significant.

Montmorillonite is favoured by alkali and alkali earth elements enrichment of the pedoenvironment. Under arid conditions, this mineral is usually formed by inheritance from the parent material prior, or to just after sedimentation since the aridity dose not allow formation of clay minerals.

2. The presence of interstratified minerals either in regular or random interstratified forms, points to a formation of the soil under water action in a pre-wet climatic conditions. These minerals represent transitional stage during formation of clay minerals. Through present in small amounts, their presence suggests weathering of clay and non-clay minerals at least during the wet period of weathering.

3. Kaolinite is the dominant mineral in the coarse clay fraction, hydromorphic condition of soils must have been prevailing some time during weathering. Also this mineral seems to be mostly inherited from parent sediments during the drastic leaching of soils in the past humid climate.

4. The Presence of palygorskite and sepiolite refers to the calcareous sandstone nature of the sediments which

are rich in Mg and Ca. These sediments are widly spread in the area under study. Such formation is favoured by the presence of alkali and alkali earth metals dominating the environments.

5. The presence of vermiculite, hydrous mica and chlorite is explained in the light of the prevailing of Mg conditions which stimulate their formation either through diagenesis or neogenesis.

6. The presence of quartz and feldspars as major accessory minerals reflects the physical weathering of sandstone. Quartz persists due to its high stability. Besides, it may be transported by aeolian action. The presence of feldspars indicates that the soils are pedologically young.

7. The variations in the mineralogical composition of the clay are mainly ascribed to the multi-origin of sediments, i.e. multi-parent materials.

The relative abundance of minerals could be presented as follows:

a. In the clay fraction: Kaolinite > Montmorillonite > Sepiolite > Vermiculite > Palygorskite >

Interstratified minerals > Quartz > Hydrous mica > Feldspars > Chlorite.

b. In the coarse part of the clay fraction: Quartz > Kaolinite > Feldspars > Hydrous mica > Sepiolite > Palygorskite > Interstratified minerals > Montmorillonite > Vermiculite > Chlorite.

c. In the fine part of the clay fraction: Montmorillonite > Sepiolite > Palygorskite > Hydrous mica > Interstratified minerals > Vermiculite > Kaolinite > Quartz > Feldspars > Chlorite.

4.4.2. Amorphous materials of the clay fraction:

Amorphous inorganic materials in the soils of Kharga Oasis are given in Table (10).

The amorphous materials in the soil dominated by iron. The content of amorphous materials ranged between 1.36 and 3.58 %. The highest value is in the surface layer (0 - 20 cm.) of profile 8, while the lowest one is in the deep layer (80 - 150 cm.) of profile 4.

Iron oxides are the main constituents of amorphous material. It comprises 65 to 88 % of such materials.

Table (10) Amorphous inorganic materials content in the clay fraction of some selected layers from the studied soil profiles.

Profile No	Depth cm	Al_2O_3%	SiO_2%	Fe_2O_3%	Total	Fe_2O_3% in amorphous materials	SiO_2/Al_2O_3 Molar ratios
1	10 - 50	0.15	0.96	2.07	3.18	65	10.86
	130 - 170	0.40	0.19	1.57	2.16	72	0.81
2	0 - 15	0.44	0.36	1.72	2.52	68	1.39
	65 - 80	0.28	0.30	2.22	2.80	79	1.82
3	0 - 10	0.50	0.15	1.57	2.22	71	0.51
4	0 - 20	0.27	0.17	2.07	2.51	82	1.07
	20 - 50	0.26	0.17	1.65	2.08	79	1.11
	80 - 150	0.25	0.11	1.36	1.72	79	0.75
5	25 - 40	0.41	0.15	1.86	2.42	77	0.62
6	0 - 15	0.37	0.15	2.36	2.88	82	0.69
7	30 - 60	0.32	0.08	2.43	2.83	86	0.42
8	0 - 20	0.30	0.17	3.58	4.05	88	0.96
9	30 - 60	0.42	0.13	2.79	3.34	84	0.53
10	0 - 20	0.95	0.56	2.93	4.44	66	1.00
11	0 - 30	0.65	0.41	2.50	3.56	70	1.07

Silica and alumina were in very low contents. Silica ranged from 0.08% (sub-surface layer 30-60 cm., profile 7 to 0.96% subsurface layer 10-50 cm. profile 1). Most samples had around 0.20%. Alumina ranged between 0.15% (sub-surface layers 10-50 cm. profile 1) to 0.95% (sub- surface layer 0-20 cm. profile 10). Most samples had 0.30-0.40 %.

The striking feature of the distribution of amorphous materials, is their relatively higher contents in the upper layers. With regard to the silica / alumina ratio (SiO^2 $/Al_2O_3$), it varies between 0.42 and 10.86. The highest value is in the 10 - 50 cm. layer of profile 1, the lowest one is in the sub- surface 30 - 60 cm. layer of profile 7.

The high ratios of SiO_2/Al_2O_3 for the studied samples may be taken as an indications of the presence of siliceous allophanes in the sandy soils as reported by Briner and Jackson (1969), or to siliceous Mubian sandstone in the study area.

The presence of such very low to low amorphous minerals in the soil indicates some degree of mineral degradation and weathering during the pre- wet climatic conditions, despite the high resistance of minerals and rock forming the soil parent material, and aridity of the region.

Low contents of amorphous materials bear some relationship with soil texture, which were mainly of coarse texture.

4.4.3. Cofficient of Linear extensibility "COLE" in relation to some soil properties:

Data of "COLE" are shown in Table (11). The highest (0.146) is in the surface layer 0-15 cm. of profile 6, the lowest (0.021) is in the surface layer 0-20 cm. of profile 4.

Clay may be the primary factor behind the degree of shrinkage and swelling. The highest value is observed in the soil of the second highest clay content and the highest content of montmorillonite. Thus high values are shown by clayey montmorillonitic soils.

However, correlation with clay is significant, but not so with montmorillonite content.

The significant correlation with cation exchange capacity is a function of the relation with clay content.

These results are in agreement with those of Andreson *et al* (1973), McChormick and Wilding (1975) who stated that the effect of clay is possibly due to its high charge density which effects the thickness of oriented water films.

Table (11) Coefficient of lineer extensibility "COLE" in relation to some soil properities.

Profile No	Depth cm	COLE values	Shrink • Swell hazard	Clay %	Montmor-illonit %	C.E.C me/100g	Organic matter %	$CaCO_3$ %	E.C mmhos/cm 25 C	E.S.P	EMgP.
1	10 - 50	0.032	Moderate	13.72	18.00	9.18	0.71	2.25	8.8	10.13	26.80
	130 - 170	0.128	Very severe	29.02	8.00	49.10	0.63	2.10	3.0	21.81	30.50
2	0 - 15	0.055	Moderate	20.07	10.00	16.27	0.58	2.20	40.0	8.11	20.08
	65 - 80	0.080	Severe	22.55	16.00	18.44	0.60	3.25	23.7	12.96	52.00
3	0 - 10	0.068	Severe	19.64	21.00	15.15	0.83	5.56	88.8	13.00	18.55
4	0 - 20	0.021	Slight	10.62	13.00	7.18	1.10	4.62	1.4	8.22	24.90
	20 - 50	0.045	Moderate	19.77	19.00	14.37	0.68	0.84	2.6	13.22	36.11
	80 - 150	0.108	Very severe	44.37	8.00	37.76	0.82	2.41	3.3	12.98	36.20
5	25 - 40	0.042	Moderate	12.27	16.00	9.92	1.34	4.62	1.6	13.21	38.10
6	0 - 15	0.146	Very severe	42.97	49.00	36.19	1.31	2.41	3.0	11.63	29.95
7	30 - 60	0.030	Slight	10.95	31.00	7.14	0.72	4.72	1.4	12.18	19.60
8	0 - 20	0.073	Severe	24.73	5.00	17.79	2.11	2.25	0.7	9.27	12.81
9	30 - 60	0.050	Moderate	6.43	9.00	8.29	0.05	5.46	0.8	5.86	22.87
10	0 - 20	0.041	Moderate	19.20	9.00	14.84	1.16	1.36	1.2	6.20	22.64
11	0 - 30	0.070	Severe	7.25	14.00	5.30	0.09	5.46	1.5	5.09	15.47
Correlation coefficient /(r)				** 0.86101	ns 0.27086	** 0.88160	ns 0.08448	ns -0.36386	ns 0.00888	ns 0.48841	ns 0.22505

• = Limits shrink-swell hazard were determined according to Soil Conservation Service USDA (1971), ** = Significant at the 1% level.

r : ** = significat at 0.01, ns = not significant at 0.05

CEC = Cation exchange capacity me/100g; EC_e : electric conductivity;

ESP : exchangeable sodium percent; EMgP : exchangeable magnesium percent.

Correlation with other properties of organic matter, electrical conductivity (EC), exchangeable sodium percent (ESP), exchangeable magnisium percent (EMgP), and calcium carbonate are not significant at 0.05 level of probability.

Correlation with ESP has an "r" value of nearly 0.5 which is rather sizable (through not significant) as compared with the other non significant correlation coefficients. This indicates that increased exchangeable sodium may have a marked effect on the swelling of soil due to the high water holls of sodium cations (Richerds, 1954.

4.5. Taxonomy classification of soils:

Soils of Kharga are calssified on the basis of field observations, morphological characteristics and the analytical data according to the system of Soil Taxonomy (1975).

As all the soils are mainly mineral and young, they mostly lack evidence of profile development with no diagnostic horizons, except for an ochric epipedon, the refore, they belong to Entisols. They lie on actively eroding slopes and in recent alluvial deposits, they belong to the suborder Orthents and Psamment.

The soils belong to the Great Group Torriorthents formed mostly in aeolian, colluvium and local alluvium on piedmont slopes. They are mostly deep to very deep and their texture includes sand, loamy sand, sandy loam, sandy clay loam and clay. They are slightly gravelly to very gravelly soils. The most widespread Torriorthents in the area range from non- saline soils to very strongly saline ones. With regard to the soil Series and soil morphology the descriptions are arranged in alphabetic order. Soil charactristics are identified the typical pedon of series is described.

1. Aguz Series:

This series has a moderatly rapid permeability. The soils are formed of aeolian and alluvium loamy sand over sandy clay loam. Slope of 5% to 15%.

A typical pedon is a loamy sand having 5 to 8% slope in the range land observation No. 12. These soils belong to the family Typic Torriorthents, sand over fine loamy, mixed, hyperthermic, moderatly deep.

2. Ain El Gazal Series:

This series is very deep, excessively drained, very rapidly permeable formed of aeolian calcareous sands. Slope of 3% to 8%.

A typical pedon is sand having 5% slope in rangeland observation No. 11.

The soil familyis typic torripsamments, mixed, hyperthermic, very deep.

3. Ain El Eila Series:

This series is very deep, rather poorly drained with slow permeability, formed of alluvium clay. They are flat to nearly flat with slpoe of up to 1 %.

A typical pedon is a clay soil having 0.5 % slpoe in the rangeland, observation No. 6.

The soil familyis vertic torriorthents, clayey, mixed, hyperthermic, very deep.

4. Baris Series:

This series consists of very deep well drained soils, with rapid permeability. They are formed of alluvium and aeolian sandy clay loam over loamy sand. They are flat or nearly flat with a slope of up to 1 %.

A typical pedon is sandy clay loam having 0.5 % slope in the rangeland, observation No. 2.

The soil family is typic torriorthents, fine loamy over sand, mixed, hyperthermic, very deep.

5. El Gazair Series:

This series consists of very deep well drained soils, with rapid permeability. They are formed of alluvium loamy sand over clay loam with 0 to 1% slope.

A typical pedon is a sandy loam on 0.5 % slope in rangeland, observation No. 5.

The soil family is typic torriorthents, sandy over fine loamy, mixed, hyperthermic, very deep.

6. Qasr Zaiyan Searies:

This series consists of very deep, well drained soils with rapid permeability. They are formed of alluvium and aeolian sandy loam or a sandy clay loam over sand or loamy sand. Their slope ranges from 8 % to 16 %.

A typical pedon is a sandy loam and sandy clay loam having 8 % to 10 % slpoe in rangeland; observation No. 7 and 9.

The soil family is typic torriorthents, sandy, mixed, hyperthermic, very deep.

7. El-Kharga Series:

This series consists of deep, well drained soils with rapid permeability. They are formed of alluvium sandy clay loam and / or sandy loam and / or clay. They are flat or gently sloping having up to 8 % slope.

A typical pedon is a loamy sand on 0.5 % slope in rangeland, observation Nos. 1, 3, 4, 8 and 10.

The soil family is typic torriorthents, fine loamy, mixed, hyperthermic, very deep.

4.6. Land capability classification of the soils:

The soils are classified according to 2 systems. The first system is that of Sys and Verheye (1978) and depends on the quantitative features, It provides an evalution for irrigation purposes. The other system is that of the USDA (1975) and depends on the qualitative soil properties,It is based on economic and Sociologic considerations.

A. classification according to the USDA system:

Table (12), gives a summary of this system. It has three major classes.

Capability classes concerning the degree of damage risk or the limitation in land use these become progressively greater moving from class one to class eight (i.e class I to class VIII).

The soils of Kharga area are classified according to their capability into four classes, Map(5). The description of these classes area given as follows:

Class II:

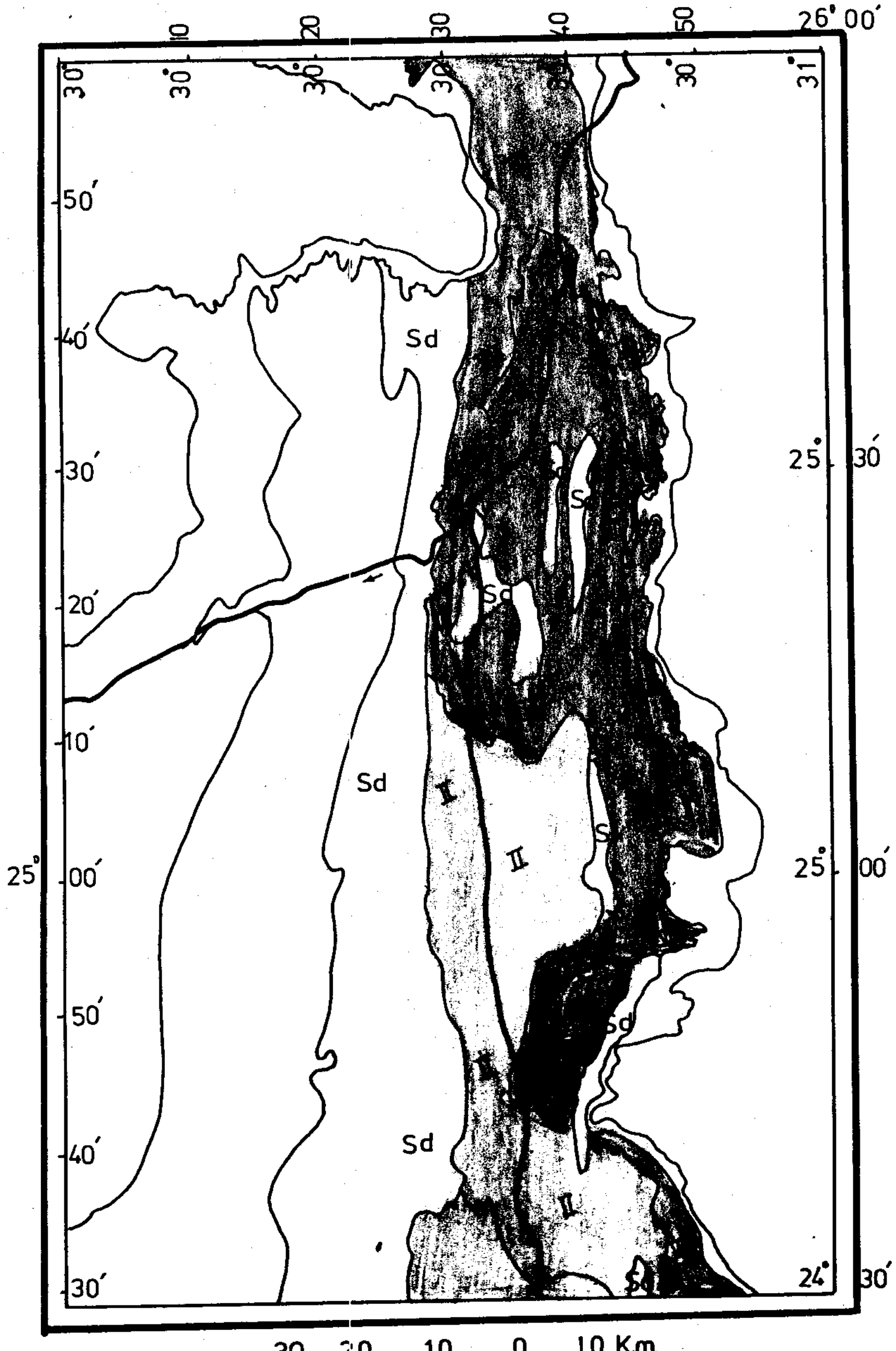
Soils of this class have some limitations that reduce the choice of plants and require moderate conservation practices. The limitations are few and the practices are easy to apply. The soils may be used for cultivated crops, pasture, range and cover.

This class is represented by profiles 1,4 and 5. Soils belonging to this class are deep sandy loam to sandy clay loam. They cover an area in about 321524 feddans.

These soils are almost flat with a moderate susceptibility to wind erosion. Their water holding

Table (12): Examples of limitations (type and degree) in land capability classification of the USDA.

Example of limitations: Type / Degree	Capability classes I	II	III	IV	V	VI	VII	VII
1- Climatic	Nil	Slight	Moderate	Moderate	Have climatic limitations	Severe	Severe	Very severe
2- Susceptibility to erosion	Very low	Moderate	High	Severe	Severe	Severe	Severe	Excessive
3- Overflow hazard	Very low	Occasional	Frequent	Frequent	Frequent	Excessive	Excessive	Excessive
4- Fast erosion hazard	Very low	Low	Severe	Severe	Severe	Severe	Severe	Very severe
5- Wetness	Very low	Low to moderate	Some continuing water - logging after drainage		Excessive	Excessive	Excessive	Excessive
6- Permeability of sub-soil	Adequate	Adequate	Very slow	--	--	--	--	--
7- Slope	Level	Very gently sloping	Moderately steep	Steep	May be level	Steep slope	Very steep	Very steep
8- Structure & workability	Favourable	Some what unfavourable	Moderately unfavourable		Unfavourable	Unfavourable	Unfavourable	Unfavourable
9- Salt or sodium hazard	Slight	Slight to moderate		Severe	Severe to very severe		Very severe	Extremely severe
10- Water holding capacity	Adequate	Low	Low	Low	Low	Low	Very low	Extremely low*
11- Depth to bedrock	Deep to very deep		Shallow		Stony shallow rooting zone		Very shallow	Rocky
12- Response to fertilizers	Very high	High	Low	Low	Very low	Very low	Very low	
13- Degree of limitations (single or in combination	Few	Some	Severe	Very severe	Very severe & are impractical to remove	Very severe but range improvement could be under taken	Very severe & range improvement is impractical to apply	Extremely severe



Map(5) Land Capability Classification Of Kharga Area by Using USDA System(1975) capacity and permeability are favourable. Their salinity is slight and have high response to fertilizers and low wetness limitations.

When used for cultivation their excess of salts should be leached out. Precautions to protect them from wind action should be applied.

Class III:

They have severe limitations that reduce the choice of plants and require special conservation practices.

These soils are sandy to sandy clay loam. Also they include moderately deep sandy clay loam to clay soils. These soils cover an area approximately 386571 feddans .

They are represented by profile 6 which is deep with a soft pan of clay at a depth of 60 cm. The soils is almost flat, moderately saline with very low permeability and low response to fertilizer application. It has a moderately unfavourable structure and workability, with a moderate susceptibility to wind erosion and excessive wetness limitation.

The soils are represented by the sandy and sandy loam, profiles of 7, 9 and 11. They are deep soils, almost flat to gently sloping with high susceptibility to wind erosion. They are non saline low in their water holding capacity; with moderate unfavourable structure and workability, they have common fine and medium surface gravels in some parts.

The other soils representing this class are represented by profiles 2,8 and 10. They are deep soils, almost flat to gently sloping with high susceptibility to wind erosion; mostly saline, with low response to fertilizer application. They have moderately unfavourable structure and workability; with few fine surface gravels. Before putting these soils under agriculture ,their limitations should be overcome.

For example their structure should be improved. Their sand (if they are sandy) should be stabilized to protect them from wind erosion, their salinity (if they are saline) should be reduced and excess salts leached out. Their drainage system should be improve if they are of low permeability .

With the use of suitable conservation practices,the soils of both classes II and III could successifully be cultivated by a number of various field crops ,vegetables and trees.

Class VI:

These soils are presented by profile 3. They have shallow cemented hard pans of clay. They are sandy clay loam in texture and comprising about 21310 feddans. They are deep, gently sloping with severe susceptibility to wind erosion; they have very low permeability and are extremely saline, with unfavourable structure and workability .

The soils are generally unsuited for cultivation but more suited for pasture or grassland for grazing .

Class VII:

These soils have very severe limitations that make them generally unsuitable for cultivation and restrict their use largely to grazing. They cover an area of about 233690 feddans and are characterized by shallow loamy sand. They are extremely saline ,sloping with severe susceptibility to wind erosion. They have unfavourable structure and workability ,with many fine to coarse surface gravels and high content of calcium carbonate. These soils are represented by profile 12 .

B. Classification according to Sys and Verheye system :

This system has the same specific guidlines for definitions of the orders (S and N) and classes S1,S2,S3.N1 and N2). The soil as a medium for plant growth under irrigation should in the first place be provided with the necessary water and plant nutrients in available forms, and in an economic way. The characteristics influencing land suitability with regard to its irrigation capability can be grouped according to the sub classes of the framwork and suitability indices for irrigation (ci).

Calculations are as follows :-

$$Ci = t \times \frac{W}{100} \times \frac{S1}{100} \times \frac{S2}{100} \times \frac{S3}{100} \times \frac{S4}{100} \times \frac{n}{100}$$

Where:-

t = Topographic limitations .

W = wetness limitations, mainly based on drainage conditions.

S = limitation with regard to soil physical conditions.

S1 = texture and stoniness.

S2 = soil depth.

S3 = calcium carbonate .

S4 = gypsum.

n = salinity and alkalinity.

Based on these limitations,definitions of suitability orders and classes are suggested, with S being suitable for irrigation and N being not suitable .

Using above mentioned prinicIples, the soils of Kharga area are classified according to their capability (Table (13) and Map (6))into four classes as follows :-

Class S1:

Areas represented by profile 5

Class S2:

Areas represented by profiles 4 and 8

Class S3:

Areas represented by profiles 1,2,6,7,9,10 and 11

Class N2:

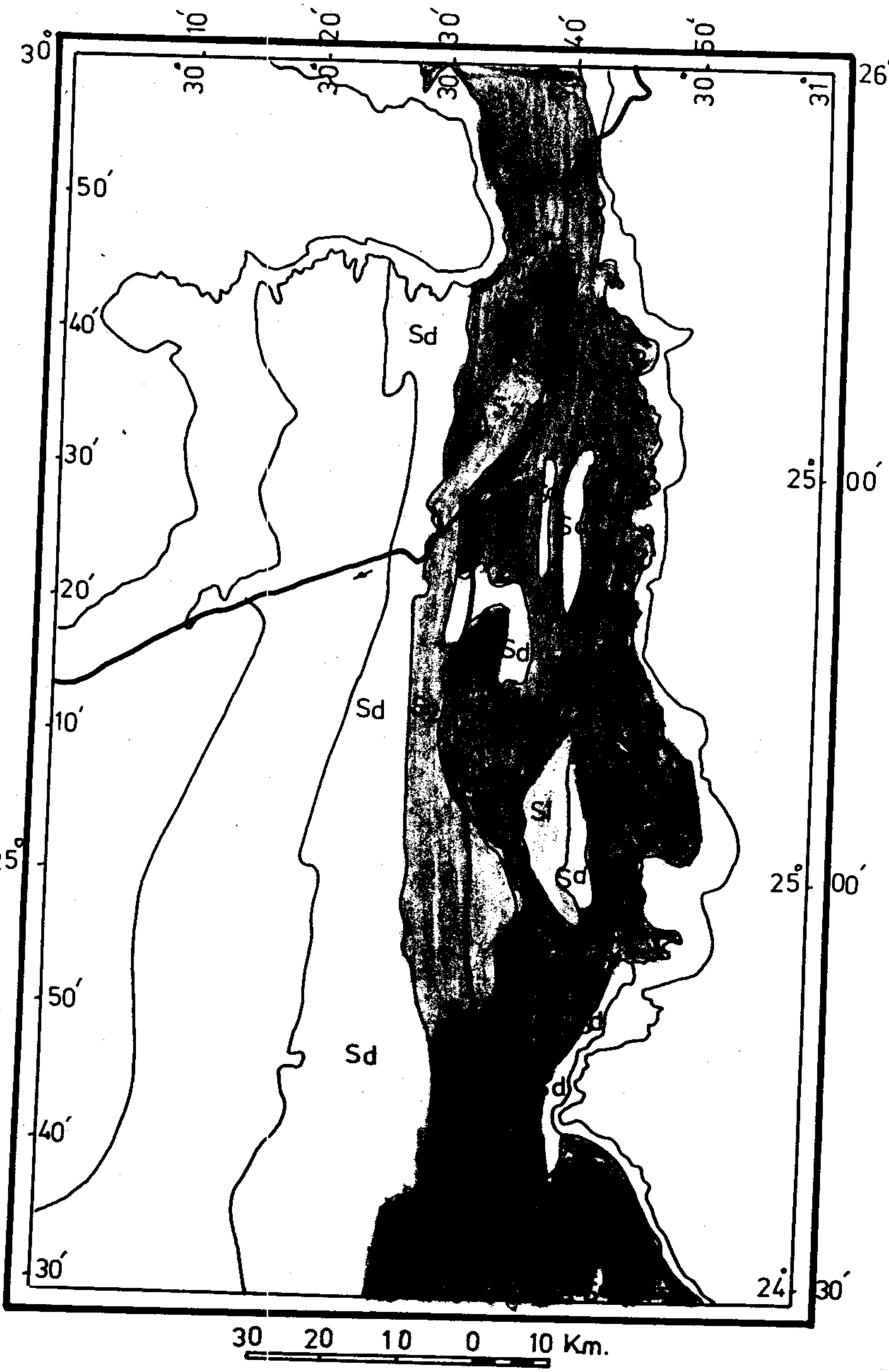
Areas repesented by profiles 3 and 12 .

C. Comparison of the two land capability systems:

Comparing the qualitative system of USDA and the quantitative system of Sys and Verheye ,the results (Table 14) show no clear variations ,where the two system are similar regarding soils which are grouped into the suitable and unsuitable classes.

Table (13) Rating of the suitability indexes of SYS and Verheye system of the studied profiles.

Profile No	Topography t	Wetness W	Texture s_1	Soil depth s_2	$CaCO_3$ % s_3	Gypsum % s_4	Salinity Alkalinity n	Suitability indies Ci	Suitability Class
1	100	90	75	90	95	90	93	48.31	S3
2	100	100	95	100	95	90	60	48.73	S3
3	95	55	95	55	95	90	50	11.62	N2
4	100	90	75	90	95	90	100	51.94	S2
5	100	100	95	100	95	90	93	75.54	S1
6	100	75	85	75	95	90	93	38.00	S3
7	95	100	55	100	95	90	100	44.67	S3
8	95	90	95	90	95	90	100	62.50	S2
9	100	100	55	100	95	90	100	47.03	S3
10	95	75	95	75	95	90	100	43.40	S3
11	95	100	30	100	95	90	100	24.37	S3
12	85	55	55	55	90	100	80	10.18	N2



Map (6) Land Capability Classification Of Kharga Area By Using Sys and Verheye System (1978).

Table (14) Comparison between the quantitative and qualitative systems for land use capability classification of the studied area.

USDA 1975		SYS and Verheye (1978)	
Suitability	Soil profiles	Suitability	Soil profiles
Suitable		Suitable	
Class I	---	Class S1	5
Class II	1,4 and 5	Class S2	4 and 8
Class III	2,6,7,8,9,10 and 11	Class S3	1,2,6,7,9,10 and 11
Class IV	---		
Unsuitable		Unsuitable	
Class V	---	Class N1	---
Class VI	3	Class N2	3 and 12
Class VII	12		
Class VIII			

The slight shifting of profile distributions within the two systems is mainly due to the differance of the class categorization within each one ,beside the differances of soil parameters which are used for each system.

D. Practical recommandation on land capability:

Generally,when such promising soils are put under agriculture they need several carfull management practices.

Examples of such management are as follows:

1. Stabilization of the sand dunes. This could be done in many ways including building a pavement of gravels on the dunes. Also by having wind breakes such as high trees to nullify the power of wind.

2. Improvement of the soil physical properties such as permeability and water retension.

3. Leaching the excess salts.

4. Amelioration of soil structure.

5. Improving the nutritive status of soil.

6. Using modern irrigation methods.