4. RESULTS & DISCUSSION.

4. RESULTS AND DISCUSSION

4.1. REMOTE SENSING INVESTIGATION.

According to ***Goosen (1967)***, the physiographic analysis technique is followed to perform knowledge of the relation between physiography and soil as well as upon the study of features which are the results of some dynamic processes. The interpretation of false colour composite image provides information for mapping of the main land units in El-Alamain and El-Hammam areas Fig. (6).

The main soil units are:

1. Marine sediments, almost flat, locally logged with halophytic vegetation (M).
2. Lacustrine sediments (L):
   2.1 Lacustrine sediments, almost flat (L1).
   2.2 Lacustrine sediments over consolidated bed, very gently undulating (L2).
3. Fluvio-lacustrine deposits, almost flat, cultivated (FL).
4. Aeolian plain (E).
   4.1 Very gently undulating to almost flat (E1).
   4.2 Very gently undulating, partly xerophytic vegetation (E2).
   4.3 Undulating to gently undulating, locally rock outcrops (E3).
5. Miscellaneous land types.
   5.1. Consolidated aeolio-marine ridges (R1).
   5.2. Dissected rockland (R2).
   5.3. Back shore with settlement-encroachment (BS).
   5.4. Submerged marine sediments (S).

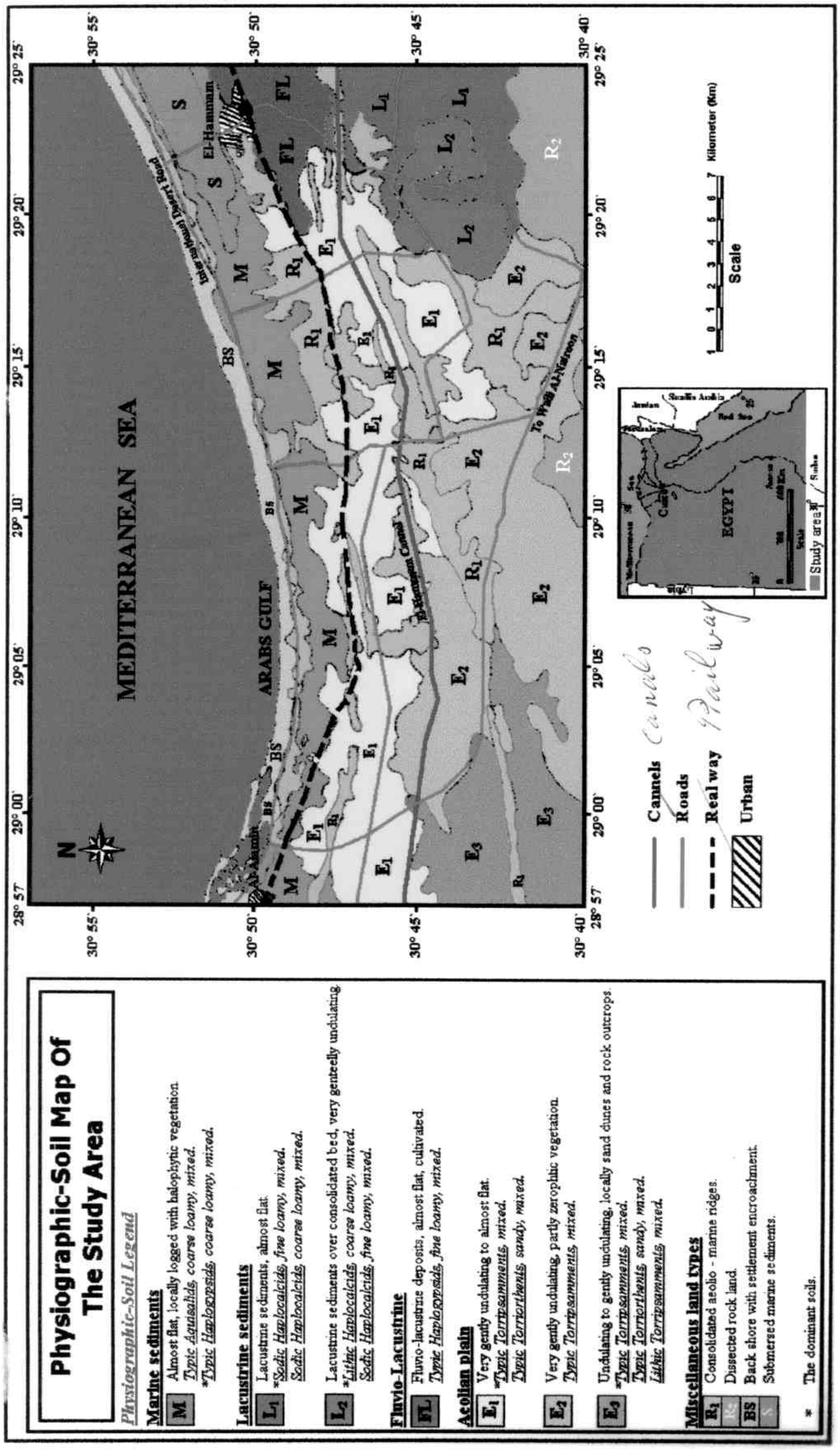


Fig.(6): Physiographic-soil map of the study area

4. Rustles & Desiccation

4.2. SOIL CHARACTERISTICS.

The most relevant morphological, physical and chemical properties of the soils representing the main physiographic units of the area under study are considered. In this accord, the morphological description of the representative soil profiles is given hereafter.

4.2.1. Soils of marine sediments. (M)

Marine sediments stretch immediately in a rather wide strip south of the consolidated aeolio-marine ridges. This physiographic unit is represented by profiles Nos. 8, 16, 17, 18, 19 and 20. Topography of this physiographic unit is almost flat. The soils mostly have deep profiles. Soil dry color varies between yellowish brown (10YR 5/4) to white (10YR 8/2), while moist color varies from dark yellowish brown (10YR 4/4) to light gray (10YR 7/2).

The structure is massive in all profile layers, except for the deepest layer of profile 17 which is subangular blocky. Soil consistence coincides well with soil texture, being moderately sticky to sticky, moderately plastic to plastic. The analysis given in Tables (2) and (3) show that the soil reaction is mildly alkaline to moderately alkaline as the pH values range from 7.4 to 8.0. The electrical conductivity values indicate a condition of high salinity (0.84-28.2 dSm^{-1}). The highest value is detected in the subsurface layer of profile 16, while the lowest value is found in the surface layer of profile 8. Chemical analysis of the soil saturation extract, Table (2), indicates that the dominant cations are Na^+ followed by Ca^{2+} and Mg^{2+}, while k^+ is the least abundant soluble cation. The anionic composition is dominated by Cl^- followed by SO_4^{2-} and HCO_3^-.

Table (2) Chemical composition of the soil saturation extract, gypsum content, CEC and exchangeable cations of soils on the marine sediments.

Profile No.	Depth (cm)	Gypsum %	pH	EC (dSm^{-1})	Soluble ions (me / l) Cations Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Anions CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	C.E.C me / 100g.	Exchangable Cations (me/100g soil) Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Exchangable Cations % Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}
8	0-25	0.19	7.7	0.84	2.89	2.21	5.20	0.17	..	2.20	6.00	2.27	4.57	2.54	1.43	0.38	0.22	55.58	31.29	8.32	4.81
	25-75	0.23	7.7	1.45	2.31	1.26	13.50	1.10	..	3.80	11.00	6.37	4.08	1.83	1.38	0.48	0.39	44.85	33.82	11.76	6.62
	75-150	0.26	7.8	1.31	5.20	2.96	7.50	1.50		2.60	8.00	6.56	3.74	1.72	1.11	0.64	0.27	45.99	29.68	17.11	7.22
16	0-25	1.77	7.5	14.74	19.65	10.97	180.00	3.50	..	4.60	170.00	39.52	6.43	2.65	1.60	1.90	0.28	41.21	24.88	29.55	4.35
	25-50	1.70	7.6	28.20	28.90	20.59	240.00	3.70	..	2.20	250.00	40.99	6.30	2.75	1.30	1.80	0.45	43.65	20.63	28.57	7.14
	50-150	1.51	7.5	21.95	25.40	7.74	242.50	2.65	..	2.00	187.00	88.32	6.70	2.70	2.10	1.55	0.35	41.64	31.24	23.13	5.22
17	0-20	1.32	7.7	12.02	7.70	7.50	119.00	0.23	..	1.98	88.40	88.40	7.00	2.40	1.90	2.15	0.55	34.29	27.14	30.71	7.86
	20-60	1.67	7.8	22.21	67.70	22.30	147.20	3.30	..	4.40	200.00	36.20	7.85	3.60	1.90	1.65	0.70	45.86	24.20	21.02	8.92
	60-150	1.58	7.9	21.59	42.00	15.20	171.40	0.83	..	7.00	170.00	56.80	7.70	2.30	2.15	2.30	0.95	29.87	27.92	29.87	12.34
18	0-20	1.22	8.0	1.86	5.75	5.25	7.70	0.14	..	0.80	8.00	10.04	6.11	1.96	1.65	1.85	0.65	32.10	27.00	30.28	10.64
	20-70	1.41	8.0	1.47	4.60	0.35	8.80	0.12	..	1.20	8.00	4.67	6.00	1.85	2.10	1.80	0.25	30.80	35.00	30.00	4.20
	70-150	2.84	7.9	2.21	10.35	3.95	9.00	0.36	..	0.80	5.00	17.86	6.44	2.36	1.60	2.20	0.28	28.73	24.84	34.16	4.35
19	0-25	0.53	7.5	11.24	19.80	5.50	80.00	4.25	..	4.60	6.00	44.90	6.20	2.60	1.30	2.00	0.30	41.94	20.97	32.26	4.84
	25-85	0.62	7.9	21.19	66.40	28.40	235.00	3.00	..	1.89	298.00	33.10	6.50	2.55	1.45	1.85	0.65	39.23	22.31	28.46	10.00
	85-150	1.56	7.7	21.94	28.30	27.80	183.00	3.00	..	2.60	182.00	58.00	7.70	2.95	1.85	2.20	0.70	38.31	24.03	28.57	9.09
20	0-20	1.45	8.0	12.42	29.00	27.05	110.29	0.45	..	0.99	184.10	41.70	7.70	2.70	2.15	2.10	0.75	35.06	27.92	27.27	9.74
	20-70	0.45	7.4	21.73	27.70	28.30	182.00	3.00	..	2.60	182.00	57.00	6.20	2.10	2.00	1.65	0.45	33.87	32.26	26.61	7.26
	70-150	0.22	7.7	22.60	24.00	25.20	285.00	3.20	..	2.20	245.00	90.40	6.80	2.00	1.85	2.40	0.55	29.67	27.21	35.29	8.09

Table (3) Particle size distribution, texture class, $CaCO_3$ and organic matter content in the soil profiles of the marine soils.

Profile No.	Depth (cm)	Gravels % vol.	Particle size distribution with $CaCO_3$ %					Particle size distribution without $CaCO_3$ %					$CaCO_3$ %	O.M %
			C.Sand	F.Sand	Silt	Clay	Texturel class	C.Sand	F.Sand	Silt	Clay	Texturel class		
8	0-25	--	11.60	67.80	5.60	15.10	Sandy clay loam	26.88	11.99	36.38	24.75	Clay loam	7.90	0.48
	25-75	--	11.80	46.00	14.10	28.10	Sandy clay loam	33.50	3.90	36.75	25.85	Light clay	10.50	0.27
	75-150	--	18.20	34.50	29.30	18.00	Clay loam	19.85	3.55	33.85	42.75	Light clay	12.60	0.13
16	0-25	--	9.50	53.50	19.00	18.00	Sandy clay	5.00	22.00	33.00	40.00	Light clay	12.60	0.10
	25-50	--	9.50	51.30	20.25	19.45	Clay loam	7.00	27.50	30.50	35.00	Light clay	19.40	0.12
	50-150	--	10.50	53.85	17.00	18.65	Sandy clay loam	4.50	30.50	31.00	34.00	Light clay	13.70	0.38
17	0-20	--	11.00	53.25	16.50	19.25	Sandy clay	5.40	29.60	29.00	36.00	Light clay	19.20	0.75
	20-60	--	18.00	51.80	13.00	17.20	Sandy clay loam	7.00	23.00	33.00	37.00	Light clay	16.80	0.50
	60-150	--	13.00	55.75	12.50	18.75	Sandy clay loam	6.50	63.50	25.00	32.00	Light clay	23.10	0.43
18	0-20	--	15.00	42.85	23.75	18.40	Clay loam	5.00	33.00	27.00	35.00	Light clay	14.40	0.63
	20-70	--	17.00	35.25	28.75	19.00	Clay loam	3.50	24.50	30.00	42.00	Light clay	21.90	0.70
	70-150	--	18.00	44.55	21.25	16.20	Clay loam	5.20	28.80	26.00	40.00	Light clay	12.40	0.45
19	0-25	--	9.50	47.50	24.00	19.00	Clay loam	6.50	33.50	29.00	41.00	Light clay	13.70	0.63
	25-85	--	19.00	31.70	29.00	20.30	Clay loam	5.00	24.00	31.00	40.00	Light clay	11.10	0.35
	85-150	--	17.50	41.00	24.50	17.00	Clay loam	4.50	26.50	30.00	39.00	Light clay	13.40	0.50
20	0-20	--	18.00	41.25	21.75	19.00	Clay loam	3.50	30.50	26.00	40.00	Light clay	11.20	0.38
	20-70	--	9.85	42.52	27.63	20.00	Clay loam	8.17	20.83	41.00	30.00	Light clay	8.04	0.18
	70-150	--	14.74	35.95	30.00	19.31	Clay loam	15.57	17.68	27.25	39.52	Light clay	6.43	0.14

The cation exchange capacity (CEC) in the marine soils is very low in most of the studied samples as its values ranged from 3.74 to 7.85 me /100g. soil. Also, the obtained data of the different exchangeable cations are presented in Table (2), the data show that exchangeable Ca^{2+} predominated the other cations on the exchange complex followed by Na^{+}, Mg^{2+} then k+, except for the deepest layer of profile 20 where exchangeable Na^{+} ions exceeded Ca^{+2} ones. Gypsum content ranges between 0.19 and 2.84 %. The gypsum formations are mostly found in the lower horizons, owing to the direct contact between sea-water seepage and calcareous materials, or the relatively high solubility of gypseous compounds. Considering the depthwise distribution of gypsum content, data indicate two patterns of distribution throughout the entire of profiles depth; a tendency of increase downwards (profiles 8, 17, 18 and 19), and a tendency of decrease downwards (profiles 16 and 20).

Results of the particle size distribution of the marine soil profiles are given in Table (3). It is evident that soil texture varies from sandy clay to clay loam. Considering the distribution of mechanical separates, Table (3), it is apparent that coarse sand constitutes 9.0 to 19.0 %, fine sand constitutes 31.7– 67.8 % of the fine earth and its content does not portray any specific pattern with depth. Silt content is also widely variable between 5.6 and 30.0 %. Clay content varies from 15.1 to 28.3 % with an irregular distribution pattern with depth. The lowest clay content is found in the surface layer of profile 8, whereas the highest content is associated with the subsurface layer of the same profile.

Data presented in Table (3) show the distribution of total carbonate in the marine soil profiles. The data indicate that the total carbonate is generally high and varies among the studied profiles, where it ranges from 6.43 to 23.10 %. The lowest content is detected in the deepest layer of profile

20, while the highest content is found in the 60-150 cm layer of profile 17. High percentage of these carbonates is due to the calcareous nature of the deposits from which the soils are formed.

Organic matter content is very low and does not exceed 0.75 %. The extremely low contents of organic matter are expected due to prevailing aridity of the region and its very scanty vegetation.

The morphological description of the representative soil profiles are briefly outlined in the following:

Profile No. (8):

Location	: About 5 km North of El-Hammam city (At the point of km 17).
Physiographic unit	: Marine sediments.
Topography	: Almost flat.
Slope	: Almost flat.
Surface cover	: Few fine gravels.
Vegetation	: Fig
Water table	: More than 150 cm depth.
Soil classification	: *Typic Haplogypsids, coarse loamy, mixed, hyperthermic*

Depth (cm)	Description
0-25	Brownish yellow (10YR 6/6, dry) to yellowish brown (10YR 5/6, moist) sandy clay loam; massive; friable; moderately sticky, moderately plastic; many fine to coarse pores; common soft lime concretions; many fine roots; moderately calcareous; clear smooth boundary,
25-75	Brownish yellow (10YR 6/8, dry) to yellowish brown (10YR 5/6, moist) sandy clay; massive; friable; moderately sticky, moderately plastic; many fine to medium pores; common soft lime concretions; many fine roots; moderately calcareous; diffuse smooth boundary,
75-150	Brownish yellow (10YR 6/8, dry) to yellowish brown (10YR 5/6, moist) clay loam; massive; friable; moderately sticky, moderately plastic; many fine pores; common soft and hard lime concretions; moderately calcareous.

Profile No. (16):

Location	: About 3.5 Km. South of Burg El-Arab – El-Alamin Railway (At the point of km 55).
Physiographic unit	: Marine sediments.
Topography	: Gently undulating
Slope	: Undulating
Surface cover	: Desert shrubs and sand dunes.
Vegetation	: Many desert shrubs.
Water table	: More than 150 cm depth.
Soil classification	: *Typic Haplogypsids, coarse loamy, mixed, hyperthermic*

Depth (cm)	Description
0-25	Yellow (10YR 7/6, dry) to brownish yellow (10YR 6/6, moist) sandy clay; massive; soft; moderately sticky, moderately plastic; many fine to coarse pores; common soft lime concretions; moderate soft gypsum dots; moderate fine roots; moderately calcareous; clear smooth boundary,
25-50	Yellow (10YR 7/6, dry) to brownish yellow (10YR 6/6, moist) clay loam; massive; soft; moderately sticky, moderately plastic; moderate fine pores; many soft lime concretions; many soft gypsum crystals; strongly calcareous; clear smooth boundary,
50-150	White (10YR 8/2, dry) to light gray (10YR 7/2, moist) sandy clay loam; massive; soft; moderately sticky, moderately plastic; few fine pores; common soft lime concretions; few soft gypsum crystals; moderately calcareous.

Profile No. (17):

Location	: About 600 m. North of Burg El-Arab – El-Alamin Railway (At the point of km 55).
Physiographic unit	: Marine sediments.
Topography	: Gently undulating
Slope	: Undulating
Surface cover	: Desert shrubs, many broken shales and many hummocks.
Vegetation	: Many desert shrubs.
Water table	: More than 150 cm depth.
Soil classification	: *Typic Haplogypsids, coarse loamy, mixed, hyperthermic.*

Depth (cm)	Description
0-20	Yellow (10YR 7/6, dry) to brownish yellow (10YR 6/6, moist) sandy clay; massive; soft; moderately sticky, moderate plastic; moderately fine and medium pores; common soft lime concretions; moderate soft gypsum dots; moderately calcareous; clear smooth boundary,
20-60	Yellow (10YR 7/6, dry) to brownish yellow (10YR 6/6, moist) sandy clay loam; massive; soft; moderately sticky, moderately plastic; few fine pores; many soft lime concretions; many soft gypsum crystals; strongly calcareous; clear smooth boundary,
60-150	Yellowish brown (10YR 5/4, dry) to dark yellowish brown (10YR 4/4, moist) sandy clay loam; weak coarse subangular blocky; friable; moderately sticky, moderately plastic; very few fine pores; many soft and hard lime concretions; few soft gypsum dots; strongly calcareous.

Profile No. (18):

Location	: About 2 Km. South of Burg El-Arab – El-Alamin Railway (At the point of km 51).
Physiographic unit	: Marine sediments.
Topography	: Gently undulating
Slope	: Undulating
Surface cover	: Desert shrubs, hummocks and many broken shales.
Vegetation	: Many desert shrubs.
Water table	: More than 150 cm depth.
Soil classification	: *Typic Haplogypsids, coarse loamy, mixed, hyperthermic.*

Depth (cm)	Description
0-20	Very pale brown (10YR 7/4, dry) to yellow (10YR 7/6, moist) clay loam; massive; friable; moderately sticky, moderately plastic; many fine to medium broken shales; common soft lime concretions; few soft gypsum dotes; many fine roots; moderately calcareous; clear smooth boundary,
20-70	Very pale brown (10YR 7/4, dry) to yellow (10YR 7/6, moist) clay loam; massive; friable; moderately sticky, moderately plastic; many soft lime concretions; moderate soft gypsum dots; few fine roots; strongly calcareous; clear smooth boundary,
70-150	Very pale brown (10YR 7/3, dry) to yellow (10YR 7/6, moist) clay loam; massive; friable; moderately sticky, moderately plastic; common soft lime concretions; few soft gypsum concretions; moderately calcareous.

Profile No. (19):

Location : About 2 Km. North of Burg El-Arab – El-Alamen Railway (At the point of km 44).
Physiographic unit : Marine sediments.
Topography : Gently undulating
Slope : Undulating
Surface Cover : Many fine to medium gravels.
Vegetation : Many desert shrubs.
Water table : More than 150 cm depth.
Soil classification : *Typic Haplogypsids, coarse loamy, mixed, hyperthermic*

Depth (cm)	Description
0-25	Yellow (10YR 7/6, dry) to brownish yellow (10YR 6/6, moist) clay loam; massive; soft; moderately sticky, moderately plastic; many fine to medium pores; common soft lime concretions; few fine roots; moderately calcareous; diffuse smooth boundary,
25-85	Yellow (10YR 7/6, dry) to brownish yellow (10YR 6/6, moist) clay loam; massive; soft; moderately sticky, moderately plastic; many fine pores; common soft lime concretions; moderately calcareous; diffuse smooth boundary,
85-150	Very pale brown (10YR 7/4, dry) to brownish yellow (10YR 6/6, moist) clay loam; massive; slightly hard; moderately sticky, moderately plastic; few fine pores; common soft and hard lime concretions; few soft gypsum dotes; moderately calcareous.

Profile No. (20):

Location : About 2 Km. North of Burg El-Arab – El-Alamin Railway (At the point of km 36).
Physiographic unit : Marine sediments.
Topography : Gently undulating
Slope : Undulating
Surface cover : Many desert shrubs, hummocks and broken shales.
Vegetation : Many desert shrubs.
Water table : More than 150 cm depth.
Soil classification : *Typic Haplogypsids, coarse loamy, mixed, hyperthermic*

Depth (cm)	Description
0-20	Yellow (10YR 7/6, dry) to yellowish brown (10YR 5/6, moist) clay loam; massive; soft; moderately sticky, moderately plastic; moderate fine to coarse pores; common soft lime concretions; few soft gypsum dotes, many fine to coarse roots; moderately calcareous; clear smooth boundary,
20-70	Yellow (10YR 7/6, dry) to yellowish brown (10YR 5/6, moist) clay loam; massive; soft; moderately sticky, moderately plastic; few fine pores; common soft lime concretions; few fine roots; moderately calcareous; diffuse smooth boundary,
70-150	Yellow (10YR 7/6, dry) to brownish yellow (10YR 6/6, moist) clay loam; massive; soft; moderately sticky, moderately plastic; few fine pores; common soft lime concretions; moderately calcareous.

4.2.2. Soils of lacustrine sediments (L).

This physiographic unit is located in the south eastern part of the studied area. It is mainly situated in the transitional zone between the aeolian plain soils and dissected rockland and divided into two sub units namely: (L1) almost flat and (L2) very gently undulating. The soils of lacustrine sediments are represented by three profiles Nos.5, 6 and7. Topography is almost flat to very gently undulating with moderate to deep soil profile. Soil dry color is white (10YR 8/2) to brownish yellow (10YR 6/6). Moist color is light gray (10YR 7/1) to yellowish brown (10YR 5/5). Regarding the gravel content, the deepest layers of profiles 6 and 7 are gravelly. Soil texture fluctuates between sand and sandy clay loam. Soil structure is undeveloped, where the single grains and massive structures are the only identified forms. Soil consistence coincides well with soil texture as non sticky to moderately sticky and non plastic to moderately plastic.

The results given in Tables (4) and (5), show that soil reaction is neutral to mildly alkaline as the pH value ranges between (7.2 and 7.6). The electrical conductivity values indicate a condition of low salinity (0.41 to 2.11 dSm^{-1}) except for the subsurface layer of profile 5 and the deepest layer of profile 6 which are slightly saline. The cationic composition of the soil saturation extract is dominated by Na^+ followed by Ca^{2+} and Mg^{2+}, while K^+ is the least abundant soluble cation, excepts for the surface and deepest layers of profile 6 where Ca^{2+} exceed Na^+. The anionic composition is dominated by Cl^- followed by SO_4^{2-} and HCO_3^-.

The CEC values range from 5.65 me/100g soil in the subsurface layer of profile 7 to 11.68 me/100g soil in the deepest one. The exchangeable Ca^{2+} is the predominant cation followed by Mg^{2+}, Na^{+} then K^{+}. Gypsum content is considerably very low; it ranges from o.11 to o.21 % with an irregular distribution pattern with depth.

Table (5) presents the particle size distribution of the soils of lacustrine sediments. From the table, it is obvious that texture classes vary between sand and sandy clay loam. These textural variations are due to the modes of deposition of lacustrine deposits with interfering aeolian sand carried by wind activities.

Calcium carbonate content is considerably high, it ranges between 12.10 and 30.30 % with tendency of increase downward the entire profile depth.

Organic matter content is very low, being in the range 0.10 to 0.60 %. The low content of organic matter is expected due to the dry scanty vegetation and the prevailing arid climatic conditions.

The morphological description of studied soil profiles are given hereafter:

Profile No. (5):

Location	: About 6 Km. South of Burg El-Arab – El-Alamin Railway (At the point of km 20).
Physiographic unit	: Lacustrine sediments.
Topography	: Gently undulating
Slope	: Undulating
Surface cover	: Few desert shrubs.
Vegetation	: None
Water table	: Shallow.
Soil classification	: *Lithic Haplocalcids, fine loamy, mixed, hyperthermic*

Depth (cm)	Description
0-20	Brownish yellow (10YR 6/6, dry) to yellowish brown (10YR 5/6, moist) sandy loam; massive; soft; slightly sticky, slightly plastic; many fine to medium pores; many soft lime concretions; strongly calcareous; clear smooth boundary,
20-40	Brownish yellow (10YR 6/6, dry) to yellowish brown (10YR 5/6, moist) sandy loam; massive; soft; slightly sticky, slightly plastic; many fine to medium pores; many soft and hard lime concretions; strongly calcareous.

Profile No. (6):

Location : About 5 km. South El-Gharbniat Railway station (At the point of km 15).
Physiographic unit : Lacustrine sediments.
Topography : Gently undulating
Slope : Gently undulating
Surface cover : Few stones.
Vegetation : Many desert shrubs
Water table : More than 150 cm depth.
Soil classification : *Sodic Haplocalcids, fine loamy, mixed hyperthermic*

Depth (cm)	Description
0-20	Brownish yellow (10YR 6/6, dry) to yellowish brown (10YR 5/6, moist) sand; massive; soft; non sticky, non plastic; many fine pores; common soft lime concretions; few fine roots; moderately calcareous; clear smooth boundary,
20-45	Brownish yellow (10YR 6/6, dry) to yellowish brown (10YR 5/6, moist) sandy loam; massive; soft; slightly sticky, slightly plastic; many fine pores; many soft lime concretions; strongly calcareous; clear smooth boundary,
45-150	White (10YR 8/1, dry) to light gray (10YR 7/1, moist) sandy loam; massive; slightly hard; slightly sticky, slightly plastic; few fine pores; many fine to medium gravels and few stones, many soft and hard lime concretions; strongly calcareous.

Profile No. (7):

Location	: About 11 km. South El-Gharbniat Railway station (At the point of km 15).
Physiographic unit	: Lacustrine sediments.
Topography	: Gently undulating
Slope	: Gently undulating
Surface cover	: Sand dunes and many desert shrubs.
Vegetation	: Many desert shrubs.
Water table	: More than 150 cm depth.
Soil classification	: *Sodic Haplocalcids, fine loamy, mixed, hyperthermic*

Depth (cm)	Description
0-20	Yellow (10YR 7/8, dry) to brownish yellow (10YR 6/8, moist) sand; single grains; loose; non sticky, non plastic; many fine to medium pores; common soft lime concretions; many fine roots; moderately calcareous; clear smooth boundary,
20-65	Yellow (10YR 7/8, dry) to brownish yellow (10YR 6/8, moist); loam; massive; soft; slightly sticky, slightly plastic; few fine pores; many soft and hard lime segregation's; few fine roots; strongly calcareous; clear smooth boundary,
65-150	White (10YR 8/2, dry) to light gray (10YR 7/2, moist); sandy clay loam; massive; soft; moderately sticky, moderately plastic; few fine pores; many fine to medium gravels; many soft and hard lime concretions; strongly calcareous.

Table (4) *Chemical composition of the soil saturation extract, gypsum content, CEC and exchangeable cations of soils on the lacustrine sediments.*

Profile	Depth	Gypsum	pH	EC(dSm^{-1})	Soluble ions (m / l)								C.E.C me	Exchangable Cations (me/100g soil)				Exchangable Cations %			
					Cations				*Anions*												
No.	(cm)	%			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	/ 100g.	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}
5	0-20	0.14	7.6	0.94	4.62	1.52	5.20	0.28	...	3.00	7.00	1.62	9.56	6.75	1.35	1.07	0.39	70.61	14.12	11.19	4.08
	20-40	0.11	7.5	7.89	17.92	16.06	45.00	1.50	...	1.60	37.00	41.88	9.05	4.75	2.39	1.77	0.14	52.49	26.41	19.56	1.55
6	0-20	0.12	7.4	0.41	2.31	0.75	1.50	0.20	...	1.60	3.00	0.16	6.03	2.23	2.35	1.16	0.29	36.98	38.97	19.24	4.81
	20-45	0.19	7.2	2.19	4.62	4.99	14.50	1.30	...	3.60	16.00	5.81	10.06	5.24	2.89	1.44	0.49	52.09	28.73	14.31	4.87
	45-150	0.16	7.5	5.71	30.64	5.08	25.00	2.10	...	1.40	31.00	30.42	9.19	5.00	2.54	1.38	0.27	54.41	27.64	15.02	2.94
7	0-20	0.21	7.6	0.43	2.31	1.26	2.50	0.20	...	1.80	4.00	0.47	4.37	1.85	1.19	1.12	0.21	43.25	27.23	25.63	4.81
	20-65	0.14	7.4	0.42	1.73	0.82	3.50	0.14	...	1.20	3.00	1.99	5.65	2.65	1.50	1.36	0.23	46.90	26.55	24.07	6.90
	65-150	0.16	7.6	0.92	4.62	1.50	7.60	0.18	...	3.00	8.00	2.90	11.68	6.75	3.36	1.18	0.39	57.79	28.77	10.10	3.34

Table (6) *Chemical composition of the soil saturation extract, gypsum content, CEC and exchangeable cations of soils on the fluvio-lacustrine sediments.*

Profile	Depth	Gypsum	pH	EC (dsm^{-1})	Soluble ions (m / l)								C.E.C me	Exchangable Cations (me/100g soil)				Exchangable Cations %			
					Cations				*Anions*												
No.	(cm)	%			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	/ 100g.	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}
1	0-25	0.22	7.4	2.56	4.62	0.99	19.30	1.06	...	3.60	16.00	6.37	10.16	5.83	2.63	1.48	0.22	57.38	25.89	14.57	2.17
	25-80	0.16	7.6	0.83	4.62	2.01	2.70	0.36	...	2.80	5.00	1.89	8.18	4.61	2.25	1.14	0.18	56.36	27.63	13.94	2.20
	80-150	0.20	7.8	0.70	4.05	1.56	3.00	0.53	...	3.00	5.00	1.14	7.91	4.95	2.10	0.59	0.27	62.58	26.55	7.46	3.41
2	0-20	0.15	7.5	0.95	4.62	2.52	4.00	0.28	...	3.00	7.00	1.42	2.09	1.19	0.55	0.28	0.07	56.94	26.32	13.40	3.35
	20-60	0.23	7.3	0.89	3.47	2.14	3.50	0.30	...	2.40	4.00	3.01	1.99	1.37	0.37	0.21	0.04	68.84	18.59	10.55	2.01
	60-100	0.20	7.1	1.38	6.36	1.80	5.50	0.56	...	2.60	7.00	4.62	11.83	7.25	2.89	1.58	0.17	61.28	24.43	13.36	1.44
	100-150	0.19	7.6	0.81	2.89	1.19	4.60	0.50	...	2.60	5.00	1.58	3.20	1.25	1.19	0.48	0.28	39.06	37.19	15.00	8.75
4	0-25	0.19	7.2	0.69	2.31	0.75	6.00	0.18	...	1.80	6.00	1.44	4.15	2.10	1.65	0.23	0.17	50.60	39.76	5.54	4.10
	25-75	0.16	7.3	0.91	5.20	1.43	4.20	0.28	...	3.20	5.00	2.91	10.67	4.89	3.25	2.02	0.51	45.83	30.46	18.93	4.78
	75-150	0.22	7.8	0.71	3.47	0.61	4.30	0.25	...	2.60	5.00	1.03	7.55	3.05	2.70	1.59	0.21	40.40	35.76	21.06	2.78

Table (5) Particle size distribution, texture class, $CaCO_3$ and organic matter content in the soil profiles of the lacustrine sediments.

Profile No.	Depth (cm)	Gravels % vol.	Particle size distribution with $CaCO_3$ %					Particle size distribution without $CaCO_3$ %					$CaCO_3$ %	O.M %
			C.Sand	F.Sand	Silt	Clay	Texturel class	C.Sand	F.Sand	Silt	Clay	Texturel class		
5	0-20	--	42.90	28.85	17.75	10.50	Sandy loam	10.98	20.85	35.48	32.69	Light clay	28.30	0.15
	20-40	--	42.55	29.45	14.75	13.25	Sandy loam	20.54	8.57	34.41	36.48	Light clay	30.30	0.10
6	0-20	--	79.90	14.10	2.75	3.25	Sand	25.48	15.57	27.91	31.04	Light clay	12.10	0.60
	20-45	--	43.30	31.30	16.00	9.25	Sandy loam	11.12	24.80	31.71	32.37	Light clay	16.50	0.13
	45-150	30	47.70	33.05	7.75	11.50	Sandy loam	28.43	11.00	23.72	36.85	Light clay	19.60	0.12
7	0-20	--	67.95	33.80	3.50	4.75	Sand	14.47	22.52	22.00	41.01	Light clay	12.10	0.45
	20-65	--	11.20	41.70	41.20	5.90	Loam	16.42	11.11	23.22	39.25	Light clay	15.60	0.29
	65-150	30	14.80	47.00	16.10	23.10	Sandy clay loam	25.62	7.28	41.75	25.35	Light clay	18.40	0.16

Table (7) Particle size distribution, texture class, $CaCO_3$ and organic matter content in the soil profiles of the fluvio-lacustrine soils.

Profile No.	Depth (cm)	Gravels % vol.	Particle size distribution with $CaCO_3$ %					Particle size distribution without $CaCO_3$ %					$CaCO_3$ %	O.M %
			C.Sand	F.Sand	Silt	Clay	Texturel class	C.Sand	F.Sand	Silt	Clay	Texturel class		
1	0-25	--	14.35	35.90	20.00	29.75	Sandy clay loam	13.47	12.34	45.42	28.50	Light clay	28.00	0.62
	25-80	--	34.10	32.15	17.75	16.00	Sandy clay loam	31.23	10.37	43.75	14.65	Loam	25.00	0.27
	80-150	--	43.70	31.55	13.50	11.25	Sandy loam	41.86	13.95	22.42	21.77	Light clay	23.00	0.17
2	0-20	25	31.65	37.60	10.00	20.75	Sandy clay loam	16.85	16.36	35.75	31.04	Light clay	16.00	0.89
	20-60	25	23.65	30.60	22.50	23.25	Clay loam	22.65	11.33	40.75	25.27	Light clay	19.00	0.55
	60-100	25	71.90	34.25	13.75	24.50	Sandy clay loam	17.40	14.14	45.25	23.47	Clay loam	25.00	0.29
	100-150	25	21.75	40.00	18.00	20.25	Sandy clay loam	19.92	12.29	39.25	28.54	Light clay	17.00	0.16
4	0-25	--	42.80	32.20	10.75	14.25	Sandy loam	8.23	15.05	30.65	36.07	Light clay	12.50	0.65
	25-75	--	21.70	22.30	24.75	31.25	Light clay	11.59	15.96	45.80	26.65	Light clay	18.50	0.19
	75-150	--	32.30	17.45	20.50	29.75	Sandy clay loam	21.32	7.72	41.32	29.64	Light clay	24.60	0.12

4.2.3. Soils of fluvio-lacustrine deposits (FL).

This physiographic unit is located in the eastern part of the studied area between lacustrine sediments and consolidated aeolian marine ridges. This physiographic unit is represented by three soil profiles Nos. 1, 2 and 4. Topographically, the landscape is almost flat with deep soil profiles. Soil dry color is yellowish (10YR 7/6) to brownish yellow (10YR 6/6). Moist color is brownish yellow (10YR 6/6) to yellowish brown (10YR 5/4). With regard to gravels content, profile 2 is characterized by moderate amounts of gravels. Soil texture ranges from sandy loam to light clay. Soil structure in this unit is undeveloped where the massive forms are the dominant. Soil consistence being slightly sticky to very sticky and slightly plastic to very plastic thus coincides well with soil texture.

Chemical composition of the soil saturation extract, Table (6), indicates that the fluvio lacustrine soils are neutral to mildly alkaline as shown by pH values which range from 7.1 to 7.8. The soils are non saline as EC values range from 0.69 to 2.56 dSm^{-1}. the dominant soluble cations are Na^+ and /or Ca^{2+} followed by Mg^{2+} and K^+, while the soluble anions have the descending order $Cl^- > HCO_3^- > SO_4^{2-}$. Cation exchange capacity ranges from 1.99 to 11.83 me/100g soils. The highest and lowest values are detected in the middle layers of profile 2. Exchangeable cations are characterized by the dominance of Ca^{2+} followed by Mg^{2+}, Na^+ and K^+. Gypsum content is very low, being in the range of 0.15 to 0.23%.

Data in Table (7) show that textural class of the soils of fluvio-lacustrine fluctuates between sandy loam and light clay. In profiles 1 and 2, the texture is sandy clay loam throughout the entire profiles depth, while in profile 4 the texture is sandy loam and light clay in the uppermost surface layers and changed into sandy clay loam and clay loam in the deepest layers.

Calcium carbonate content varies from 12.5 to 25.0 % Table (7). The highest content is recorded in the 60-100 cm depth, while the lowest content is detected in the surface layer of profile 4. Ca CO_3 content tends to increase with depth in profile 4, while in profile 1 its content tends to decrease with depth and displays an irregular distribution pattern with depth in profile 2.

Organic matter content is very low (0.12-0.89 %), Table (7) and showed relative decreases with depth. The morphological description of the representative profiles are briefly outlined in the following:

Prophiel No(1):

Location	: About 1.5 km south of Burg El-Arab – El- Hammam Railway (At the point of km 4 from Burg El-Arab).
Physiographic unit	: Fluvio-lacustrine sediments.
Topography	: Gently undulating
Slope	: Undulating
Surface cover	: Very few fine gravels and stones.
Vegetation	: Fig
Water table	: More than 150 cm depth.
Soil classification	:*Typic Haplogypsids, fine loamy, mixed, hyperthermic*

Depth (cm)	Description
0-25	Yellow (10YR7/6, dry) to brownish yellow (10YR 6/6, moist) sandy clay loam; massive, soft; moderately sticky, moderately plastic; many soft lime concretions; many fine to coarse roots; strongly calcareous; clear smooth boundary,
25-80	Yellow (10YR7/6, dry) to brownish yellow (10YR 6/6, moist) sandy clay loam; massive; soft; moderately sticky, moderately plastic; many soft and hard lime concretions; few fine roots; strongly calcareous; diffuse smooth boundary,
80-150	Very pole brown (10YR 7/4, dry) to light yellowish brown (10YR 6/4, moist) sandy loam; massive; slightly hard; slightly sticky, slightly plastic; many soft and hard lime concretions; strongly calcareous.

Profile No (2):

Location	: About 500 m. South El-Gharbniat Railway station (At the point of km 15).
Physiographic unit	: Fluvio-lacustrine sediments.
Topography	: Almost flat.
Slope	: Almost flat.
Vegetation	: Clover.
Water table	: More than 150 cm depth.
Soil classification	: *Typic Haplogypsids, fine loamy, mixed , hyperthermic*

Depth (cm)	Description
0-20	Light yellowish brown (10YR 6/4, dry) to yellowish brown (10YR 5/4, moist) sandy clay loam; massive; friable; moderately sticky, moderately plastic; many fine pores; many fine to medium gravel's; many soft lime concretions; many fine roots; strongly calcareous; clear smooth boundary,
20-60	Very pale brown (10YR 7/4, dry) to light yellowish brown (10YR 6/4, moist) clay loam; massive, friable, moderately sticky, moderately plastic; many fine pores; many fine gravels; many soft lime concretions; moderately fine roots; strongly calcareous; diffuse smooth boundary,
60-100	Very pale brown (10YR 7/4, dry) to light yellowish brown (10YR 6/4, moist) sandy clay loam; massive, soft, moderate sticky, moderately plastic; moderately fine pores; many fine gravels; many soft and hard lime concretions; strongly calcareous; clear smooth boundary,
100-150	Brownish yellow (10YR 6/6, dry) to yellowish brown (10YR 5/6, moist); sand clay loam; weak coarse sub angular blocky, firm; moderately sticky, moderately plastic; moderately fine pores; many fine gravel's; many soft and hard lime concretions; strongly calcareous.

Profile No. (4):

Location	: About 3 km. South El-Gharbniat Railway station (At the point of km 15).
Physiographic unit	: Fluvio-lacustrine sediments.
Topography	: Almost flat.
Slope	: Almost flat.
Vegetation	: Fig and clover.
Water table	: More than 150 cm depth.
Soil classification	: *Typic Haplogypsids, fine loamy, mixed, hyperthermic*

Depth (cm)	Description
0-25	Brownish yellow (10YR 6/6, dry) to yellowish brown (10YR 5/6, moist) sandy loam; massive; soft; slightly sticky; slightly plastic; many fine to coarse pores; common soft lime concretions; many fine to coarse roots; strongly calcareous; clear smooth boundary,
25-75	Brownish yellow (10YR 6/6, dry) to yellowish brown (10YR 5/6, moist) light clay; massive; friable; very sticky, very plastic, many fine to coarse pores; many soft lime segregations; many fine to coarse roots, strongly calcareous; diffuse smooth boundary,
75-150	Brownish yellow (10YR 6/6, dry) to yellowish brown (10YR 5/6, moist) sandy clay loam; massive; soft; moderately sticky, moderately plastic; moderate fine pores; many soft and hard lime segregations; many fine to coarse roots, strongly calcareous.

4.2.4. Soils of aeolian plain (E).

This physiographic unit is mainly divided into three types according to the surface cover and slope namely; very gently undulating to almost flat (E1), very gently undulating partly xerophytic vegetation (E2) and undulating to gently undulating locally rock outcrops (E3).

The soils of aeolian plain cover a large area between dissected Rockland in the South and marine sediments in the North. This physiographic unit is represented by eight soil profiles Nos. 3, 9, 10, 11, 12, 13, 14 and 15. Topographically, the landscape is almost flat to undulating with deep soil profiles. Soil dry color varies from yellow (10YR 8/5) to brownish yellow (10 YR6/8). Moist color is yellowish brown (10YR 5/4) to yellow (10YR 7/6).

With the exception of the deepest layers of profile 10, which is moderately gravelly to gravelly, these soil are free from gravels. Soil texture is restricted between sand and sandy clay loam. The structure in these soils is undeveloped where the single grains and massive forms are the dominant. The soil stickiness, and plasticity have generally low grades of non sticky non plastic moderately sticky and plastic, these grades coincide well with soil texture.

The results given in Tables (8) and (9) show that the soil reaction ranges from 7.0 to 7.9, indicating that the soils are neutral to moderately alkaline. The electrical conductivity values are non-saline to extremely saline as the EC values range from 0.42 to 21.7dSm^{-1}. The soluble cations are dominated with Na^+ followed by Ca^{2+}, Mg^{2+} and K^+, while the anions are dominated by Cl^- followed by SO_4^{2-} and HCO_3^-.

Table (8) Chemical composition of the soil saturation extract, gypsum content, CEC and exchangeable cations of the aeolian plain soils.

Profile	Depth	Gypsum	pH	EC (dsm⁻¹)	Soluble ions (me /l)								C.E.C me	Exchangable Cations (m/100g soil)				Exchangable Cations %			
					Cations				Anions												
No.	(cm)	%			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	/100g.	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}
3	0-20	0.15	7.5	0.42	2.31	1.26	2.90	0.20	..	1.80	4.00	0.87	4.90	2.65	1.50	0.36	0.39	54.08	30.61	7.35	7.96
	20-55	0.25	7.9	0.75	2.31	0.75	4.50	0.25	..	2.60	4.00	1.21	2.77	1.25	1.12	0.22	0.18	45.13	40.43	7.94	6.50
	55-80	0.21	7.4	0.97	4.62	1.50	4.50	0.40	..	3.00	5.00	3.02	4.15	2.23	1.37	0.36	0.19	53.73	33.01	8.67	4.58
	80-150	0.22	7.5	0.84	3.47	1.63	5.20	0.35	..	2.20	6.00	2.45	4.11	2.19	1.16	0.48	0.28	53.28	28.22	11.68	6.81
9	0-20	0.31	7.6	0.54	2.31	0.75	3.40	0.14	..	1.60	4.00	1.00	6.70	2.10	2.50	1.50	0.60	31.34	37.31	22.39	8.96
	20-80	0.24	7.8	0.53	1.73	0.82	2.50	0.12	..	1.60	3.00	0.57	5.51	1.80	2.15	1.30	0.26	32.69	39.02	23.59	4.72
	80-150	0.26	7.9	0.58	2.31	0.75	3.60	0.16	..	1.40	4.00	1.42	5.78	1.90	2.18	1.20	0.50	32.87	37.72	20.76	8.65
10	0-25	0.16	7.0	1.41	4.62	1.50	7.00	1.06	..	2.60	8.00	3.58	4.16	1.06	1.20	1.45	0.45	25.48	28.85	34.86	10.82
	25-55	0.18	7.0	20.10	25.43	7.74	178.00	2.90	..	3.00	187.00	24.07	7.50	3.50	2.15	1.15	0.70	46.67	28.67	15.33	9.33
	55-110	0.17	7.3	14.70	32.37	25.80	95.00	2.30	..	3.40	92.00	60.07	8.95	4.70	2.40	1.10	0.75	52.51	26.82	12.29	8.38
	10-150	0.19	7.2	14.55	37.92	22.24	108.00	3.20	..	6.80	104.00	60.61	4.95	1.30	1.90	1.15	0.60	26.26	38.38	23.23	12.12
11	0-30	0.23	7.4	0.52	2.31	0.75	4.50	0.14	..	1.60	5.00	1.10	6.95	2.90	1.50	2.10	0.45	41.73	21.58	30.22	6.47
	30-80	0.26	7.5	0.44	1.16	1.39	2.00	0.12	..	1.60	2.00	1.07	7.01	2.06	2.20	2.15	0.60	29.39	31.38	30.67	8.56
	80-150	0.22	7.5	0.52	1.73	0.82	3.80	0.16	..	1.60	4.00	0.91	6.68	2.48	1.60	1.80	0.80	37.13	23.95	26.95	11.98
12	0-25	0.14	7.6	0.48	2.31	0.75	3.40	0.18	..	1.40	3.00	2.24	5.78	2.35	1.80	1.18	0.45	40.66	31.14	20.42	9.79
	25-80	0.12	7.8	0.45	1.16	1.39	2.10	0.15	..	1.60	2.00	1.20	6.60	2.60	2.10	1.50	0.40	39.39	31.82	22.73	5.30
	80-150	0.25	7.5	0.48	2.31	0.75	2.50	0.12	..	1.60	3.00	1.08	5.35	2.45	1.10	1.45	0.35	45.79	20.56	27.10	6.54
13	0-30	1.52	7.8	0.47	1.16	1.39	2.20	0.14	..	1.60	2.00	1.29	5.26	2.30	1.40	1.30	0.26	43.73	26.62	24.71	4.94
	30-110	1.24	7.9	12.62	18.49	12.13	144.00	3.20	..	4.60	154.00	19.21	9.10	4.90	2.15	1.60	0.45	53.85	23.63	17.58	4.95
	110-150	1.30	7.7	21.70	24.28	25.21	250.00	3.00	..	2.20	244.00	56.29	10.05	4.30	3.50	1.85	0.40	42.79	34.83	18.41	3.98
14	0-20	0.34	7.6	0.73	3.47	1.63	3.10	0.16	..	2.80	4.00	1.56	4.41	1.17	1.14	1.80	0.30	26.53	25.85	40.82	6.80
	20-100	0.27	7.4	0.68	4.05	1.05	3.40	0.14	..	2.00	4.00	2.64	7.84	4.30	2.15	1.13	0.26	54.84	27.42	14.41	3.32
	100-150	0.22	7.2	3.79	18.49	3.49	19.00	1.87	..	3.20	32.00	7.63	6.01	2.18	1.13	2.20	0.50	36.27	18.80	36.61	8.32
15	0-30	0.21	7.1	0.81	4.62	1.50	4.80	0.17	..	2.80	6.00	2.29	4.85	1.50	1.10	1.90	0.35	30.93	22.68	39.18	7.22
	30-70	0.67	7.3	3.97	18.65	3.33	22.00	1.20	..	3.00	32.00	10.18	5.29	2.10	1.90	1.03	0.26	39.70	35.92	19.47	4.91
	70-120	0.47	7.6	12.65	21.97	13.75	148.00	3.20	..	5.60	150.00	31.32	9.61	4.90	2.20	2.06	0.45	50.99	22.87	21.44	4.68
	120-150	0.53	7.4	8.08	17.34	15.32	52.00	2.80	..	2.80	68.00	14.14	7.70	3.80	1.85	1.72	0.30	49.35	24.03	22.08	3.90

Table (9) Particle size distribution, texture class, $CaCO_3$ and organic matter content in the soil profiles of the aeolian plain soils.

Profile No.	Depth (cm)	Gravels % vol.	Particle size distribution with $CaCO_3$ %					Particle size distribution without $CaCO_3$ %					$CaCO_3$ %	O.M %
			C.Sand	F.Sand	Silt	Clay	Texturel class	C.Sand	F.Sand	Silt	Clay	Texturel class		
3	0-20	--	69.20	24.55	2.50	3.75	Sand	45.67	16.88	11.97	25.48	Sandy clay	15.00	0.75
	20-55	--	56.60	25.50	8.50	9.00	Sand	33.73	7.98	22.93	35.36	Llight clay	19.00	0.29
	55-80	--	54.60	26.15	7.75	11.50	Sandy loam	33.74	14.32	24.32	27.11	Light clay	23.00	0.19
	80-150	--	54.75	25.50	10.00	9.75	Sand	30.32	9.54	24.75	35.39	Light clay	19.50	0.13
9	0-20	--	16.75	59.75	18.60	5.00	Sandy loam	5.00	27.00	35.00	33.00	Light clay	12.50	0.55
	20-80	--	10.50	54.35	21.75	13.40	Sandy loam	4.50	33.00	27.00	35.50	Light clay	17.00	0.29
	80-150	--	17.00	57.00	15.50	10.50	Sandy loam	7.00	22.00	33.00	38.00	Light clay	15.00	0.12
10	0-25	--	13.50	42.35	29.00	15.15	Sandy loam	4.50	35.00	30.50	30.00	Light clay	13.00	0.10
	25-55	25	12.50	38.10	26.25	23.15	Sandy clay loam	6.50	28.50	38.00	27.00	Llight clay	17.00	0.15
	55-110	20	8.50	34.85	25.50	31.15	Sandy clay loam	5.00	27.00	33.00	35.00	Light clay	18.00	0.18
	110-150	15	12.00	32.85	24.25	31.25	Sandy clay loam	4.50	27.50	28.00	40.00	Light clay	14.50	0.12
11	0-30	--	10.00	70.90	11.75	7.35	Sandy loam	3.00	18.50	37.50	41.00	Light clay	12.60	0.62
	30-80	--	13.50	68.60	9.50	8.40	Fine sand	4.60	30.40	29.00	36.00	Light clay	11.20	0.45
	80-150	--	7.50	77.05	8.50	7.45	Fine sand	5.20	29.80	35.00	30.00	Light clay	11.80	0.29
12	0-25	--	9.50	75.95	7.25	7.30	Fine sand	3.50	33.50	32.00	31.00	Light clay	10.70	0.30
	25-80	--	12.00	70.25	9.00	8.75	Fine sand	5.00	36.00	27.00	32.00	Light clay	10.90	0.34
	80-150	--	17.00	67.80	9.50	5.70	Fine sand	5.20	32.80	29.00	33.00	Light clay	12.60	0.19
13	0-30	--	15.00	58.05	13.75	13.20	Fine sand	7.00	30.50	27.50	35.00	Light clay	13.40	0.20
	30-110	--	10.50	43.75	28.75	17.00	Sandy clay loam	6.50	22.50	31.00	40.00	Light clay	23.50	0.18
	110-150	--	14.50	47.30	20.75	17.45	Sandy clay loam	3.50	34.50	30.00	32.00	Light clay	19.70	0.12
14	0-20	--	17.00	63.10	15.75	4.15	Sandy loam	5.00	33.00	28.00	34.00	Light clay	12.80	0.68
	20-100	--	16.00	59.75	16.00	8.25	Sandy loam	4.50	34.50	26.00	35.00	Light clay	14.60	0.17
	100-150	--	18.00	62.60	12.25	7.15	Sandy loam	3.20	35.80	29.00	32.00	Light clay	14.40	0.25
15	0-30	--	11.50	81.50	4.00	3.00	Fine sand	3.60	38.40	30.00	28.00	Light clay	12.20	0.19
	30-70	--	15.70	69.90	6.25	8.15	Fine sand	4.50	26.50	32.00	37.00	Llight clay	13.60	0.10
	70-120	--	10.50	51.10	21.00	17.35	Clay loam	5.40	32.60	28.00	34.00	Light clay	18.40	0.12
	120-150	--	7.50	52.75	31.75	18.00	Clay loam	6.40	34.70	26.00	33.00	Light clay	15.40	0.15

With regard to the exchange characteristics, the CEC values range between 2.77 and 10.05 me/100g soil. The exchangeable Ca2+is the predominant cation followed by Mg^{2+}, Na^{+} and then K^{+}, and exchangeable Mg^{2+} may exceed Ca^{2+} in some layers of profiles 9, 10 and 11.

Gypsum content is very low and ranges from 0.12 to 1.52 %. The lowest percent is found in the subsurface layer of profile 12, while the highest content is detected in the surface layer of profile 13.

Analytical data, Table (9), shows that the soil texture is sand or sandy loam throughout the entire depths of profiles 3, 9, 11, 12, 14 and 15, while in profiles 10 and 13 the texture changes from sandy loam or sandy clay loam in the surface layers to sandy clay loam or clay loam in the deepest layers.

Calcium carbonate content varies from 7.9 to 23.5 % with an irregular distribution pattern with depth, except for profile 8 where $CaCO_3$ content tends to increase with depth.

Organic matter content is extremely low, not exceeding 0.68 %.

The morphological description of the representative soil profiles 3, 9, 10, 11, 12, 13, 14 and 15 are given below:

Profile No. (3):

Location : About 3 km South of El-Hammam city (At the point of km 17).
Physiographic unit : Aeolian plain.
Topography : Almost flat.
Slope : Almost flat.
Vegetation : Clover.
Water table : More than 150 cm depth.
Soil classification : *Typic Torriorthents, sand, mixed, hyperthermic*

Depth (cm)	Description
0-20	Yellow (10YR 7/6, dry) to brownish yellow (10YR 6/6, moist) sand; massive, soft; non sticky, non plastic; many fine to coarse pores; many soft lime concretions; many fine to coarse roots; strongly calcareous; clear smooth boundary,
20-55	Yellow (10YR 7/6, dry) to brownish yellow (10YR 6/6, moist) sand; massive, soft; non sticky, non plastic; many fine pores; many soft lime concretions; strongly calcareous; diffuse smooth boundary,
55-80	Yellow (10YR 7/6, dry) to brownish yellow (10YR 6/6, moist) sandy loam; massive; soft; slightly sticky, slightly plastic; moderate fine pores; many soft lime concretions; few fine roots; strongly calcareous; clear smooth boundary,
80-150	Yellow (10YR 7/8, dry) to yellow (10YR 7/6, moist) sand; massive; slightly hard; non sticky, non plastic; few fine pores; many soft and hard lime concretions; strongly calcareous.

Profile No. (9):

Location	: About 1.5 Km. South of Burg El-Arab – El-Alamin Railway (At the point of km 28).
Physiographic unit	: Aeolian plain.
Topography	: Almost flat.
Slope	: Almost flat.
Surface cover	: Many fine to coarse gravels.
Vegetation	: None.
Water table	: More than 150 cm depth.
Soil classification	: *Typic Torriorthents, sand, mixed, hyperthermic*

Depth (cm)	Description
0-20	Very pale brown (10YR 8/4, dry) to very pale brown (10YR 7/4, moist) sandy loam; massive; soft; slightly sticky, slightly plastic; many fine to coarse pores; common soft lime concretions; few fine roots; moderately calcareous; clear smooth boundary,
20-80	Yellow (10YR 7/6, dry) to brownish yellow (10YR 6/6, moist) sandy loam; massive; soft; slightly sticky, slightly plastic; many fine to coarse pores; many soft lime concretions; strongly calcareous; diffuse smooth boundary,
80-150	Yellow (10YR 8/6, dry) to yellow (10YR 7/6, moist) sandy loam; massive; soft; slightly sticky, slightly plastic; moderately fine pores; many soft lime concretions; moderately calcareous.

Profile No. (10):

Location : About 8 Km. South of Burg El-Arab – El-Alamen Railway (At the point of km 36).

Physiographic unit : Aeolian plain.

Topography : Gently undulating

Slope : Undulating

Surface cover : Many fine to coarse gravels.

Vegetation : Many desert shrubs.

Water table : More than 150 cm depth.

Soil classification : *Typic Torripsamments, sand, mixed, Hyperthermic*

Depth (cm)	Description
0-25	Yellow (10YR 7/6, dry) to yellowish brown (10YR 5/6, moist) sandy loam; massive; soft; slightly sticky, slightly plastic; many fine to medium pores; common soft lime concretions; few fine roots; moderately calcareous; clear smooth boundary,
25-55	Very pale brown (10YR 7/4, dry) to light yellowish brown (10YR 6/4, moist) sandy clay loam; massive; soft; moderately sticky, moderately plastic; few fine pores; many fine to medium gravels; many soft and hard lime concretions; few fine roots; strongly calcareous; clear smooth boundary,
55-110	Very pale brown (10YR 7/4, dry) to light yellowish brown (10YR 6/4, moist) sandy clay loam; massive; soft; moderately sticky, moderately plastic; few fine to medium gravels; many soft and hard lime concretions; strongly calcareous; clear smooth boundary,
110-150	Very pale brown (10YR 7/4, dry) to light yellowish brown (10YR 6/4, moist) light clay; massive; slightly hard; very sticky, very plastic; few fine gravels; common soft and hard lime concretions; moderately calcareous.

Profile No. (11):

Location : About 3 Km. South of Burg El-Arab – El-Alamin Railway (At the point of km 36).
Physiographic unit : Aeolian plain.
Topography : Gently undulating
Slope : Undulating
Surface cover : Many fine to coarse gravels.
Vegetation : Many desert shrubs.
Water table : More than 150 cm depth.
Soil classification : *Typic Torripsamments, sand, mixed, hyperthermic*

Depth (cm)	Description
0-30	Yellow (10YR 7/6, dry) to yellowish brown (10YR 6/6, moist) sand; massive; soft; non sticky, non plastic; many fine pores; common soft lime concretions; many fine to coarse roots; moderately calcareous; clear smooth boundary,
30-80	Yellow (10YR 7/6, dry) to brownish yellow (10YR 6/6, moist) sand; massive; soft; non sticky, non plastic; many fine pores; common soft lime concretions; moderately calcareous; clear smooth boundary,
80-150	Yellow (10YR 7/6, dry) to brownish yellow (10YR 6/6, moist) sand; massive; soft; non sticky, non plastic; few fine pores; common soft lime concretions; moderately calcareous.

Profile No. (12):

Location	: About 10 Km. South of Burg El-Arab – El-Alamin Railway (At the point of km 44).
Physiographic unit	: Aeolian plain.
Topography	: Gently undulating
Slope	: Undulating
Surface cover	: Many fine to coarse gravels.
Vegetation	: Many desert shrubs.
Water table	: More than 150 cm depth.
Soil classification	: *Typic Torripsamments, sand, mixed, hyperthermic*

Depth (cm)	Description
0-25	Yellow (10YR 7/6, dry) to brownish yellow (10YR 6/6, moist) sand; massive; soft; non sticky; non plastic; many fine to coarse pores; common soft lime concretions; many fine roots; moderately calcareous; clear smooth boundary,
25-80	Yellow (10YR 7/6, dry) to brownish yellow (10YR 6/6, moist) sand; massive; soft; non sticky, non plastic; many fine pores; common soft lime concretions; few fine roots; moderately calcareous; clear smooth boundary,
80-150	Yellow (10YR 7/6, dry) to brownish yellow (10YR 6/6, moist) sand; massive; soft; non sticky; non plastic; few fine pores; common soft lime concretions; moderately calcareous.

Profile No. (13):

Location : About 3.5 Km. South of Burg El-Arab – El-Alamin Railway (At the point of km 44).

Physiographic unit : Aeolian plain.

Topography : Almost flat.

Slope : Flat.

Surface cover : Desert shrubs, hummocks and few broken shales.

Vegetation : Many desert shrubs.

Water table : More than 150 cm depth.

Soil classification :*Typic Torripsamments, sand, mixed, hyperthermic*

Depth (cm)	Description
0-30	Yellow (10YR 8/6, dry) to yellowish brown (10YR 5/4, moist) sand; massive; soft; non sticky; non plastic; many fine pores; common soft lime concretions; many fine roots; moderately calcareous; clear smooth boundary,
30-110	Yellow (10YR 7/8, dry) to yellow (10YR 7/6, moist) sandy clay loam; massive; soft; moderately sticky; moderately plastic; moderate fine pores; many soft lime concretions; few soft gypsum dots; strongly calcareous; diffuse smooth boundary,
110-150	Yellow (10YR 7/8, dry) to yellow (10YR 7/6, moist) sandy clay loam; massive; slightly hard; moderately sticky, moderately plastic; few fine pores; many soft and hard lime concretions; few soft gypsum concretions; strongly calcareous.

Profile No. (14):

Location	: About 12 Km. South of Burg El-Arab – El-Alamin Railway (At the point of km 55).
Physiographic unit	: Aeolian plain.
Topography	: Gently undulating
Slope	: Undulating
Surface cover	: Many fine gravels.
Vegetation	: Many desert shrubs.
Water table	: More than 150 cm depth.
Soil classification	: *Typic Torripsamments, sand, mixed, hyperthermic*

Depth (cm)	Description
0-20	Yellow (10YR 7/6, dry) to light yellowish brown (10YR 6/4, moist) sandy loam; single grains; loose; slightly sticky; slightly plastic; many fine to medium pores; common soft lime concretions; few fine roots; moderately calcareous; clear smooth boundary,
20-100	Yellow (10YR 7/6, dry) to light yellowish brown (10YR 6/4, moist) sandy loam; massive; soft; slightly sticky; slightly plastic; many fine pores; common soft lime concretions; few shales; moderately calcareous; diffuse smooth boundary,
100-150	Yellow (10YR 7/6, dry) to light yellowish brown (10YR 6/4, moist) sandy loam; massive; soft; slightly sticky; slightly plastic; many fine pores; common hard lime concretions; few shales; moderately calcareous.

Profile No. (15):

Location	: About 7.5 Km. South of Burg El-Arab – El-Alamin Railway (At the point of km 55).
Physiographic unit	: Aeolian plain.
Topography	: Gently undulating
Slope	: Undulating
Vegetation	: None
Water table	: More than 150 cm depth.
Soil classification	: *Typic Torriorthents, sand, mixed, hyperthermic*

Depth (cm)	Description
0-30	Yellow (10YR 7/6, dry) to brownish yellow (10YR 6/6, moist) sand; single grains, loose; non sticky; non plastic; common soft lime concretions; moderate fine roots; moderately calcareous; clear smooth boundary,
30-70	Yellow (10YR 7/6, dry) to brownish yellow (10YR 6/6, moist) sand; massive; soft; non sticky; non plastic; common soft lime concretions; few fine roots; moderately calcareous; clear smooth boundary;
70-120	Very pale brown (10YR 8/2, dry) to light gray (10YR 7/2, moist) clay loam; massive; soft; moderately sticky; moderately plastic; many soft and hard lime concretions; strongly calcareous; clear smooth boundary,
120-150	Yellow (10YR 7/6, dry) to brownish yellow (10YR 6/6, moist) clay loam; massive; soft; moderately sticky, moderately plastic; many soft lime concretions; strongly calcareous.

4.3. FIELD MORPHOLOGY RATING OF THE STUDIED PROFILES REPRESNTING DIFFERENT AREAS:

The field morphology rating system ***(Bilizi and Ciolkosz, 1977)*** was used to determine: (1) Relative Horizon Distinctness (RHD), by comparing two adjacent horizons; (2) Relative Profile Development (RPD) by comparing each horizon with the C-horizon within each pedon. Because the soils considered here occur in a Mediterranean environment (Warm, dry summers; Cool, moist winters) and are well drained, dry consistence was substituted for the occurrence of mottles in the Bilizi and Ciolkosz criteria. The criteria used are standard soil survey and stratigraphic definitions and classes ***(Soil Survey Manual, 1951)***. The soils were evaluated and points assigned as described soils by ***Meixner and Signer (1981)*** as follows:-

<u>1.Colour (dry and wet):</u> One point is assigned for any class change in hue and for any unit change in value or chroma. For example, a change from 10YR 4/6 to 5YR 3/8 would have a value of 5 for the twofold class change, the one unit change in value, and the two-unit change in chroma. Where two or more colours are observed (other than mottles), each one is compared, and the average difference is used.

2.Texture: One point is assigned for each class change on the textural triangle. In addition, a change from non gravelly to gravelly or very gravelly is assigned one or two points, respectively.

3.Structure: One point is assigned for any change in type of aggregated structure, for each unit change in grade (1, 2, 3) and for each class change in size (vf, f, m, c, vc), irrespective of the aggregate type. For example, a change from weak, very fine sub-angular blocky (1 vf sbk) to moderate, medium angular blocky (2 m abk) is assigned a value of 4. When the change is from non aggregated to aggregated structure (or vice versa), however, only the grade of the aggregate type is evaluated, in addition to the one point assigned for the type change.

4.Consistence; one point is assigned for any class change in dry (lo, so, sh, h, vh, eh) and moist (lo, vfr, fr, fi, vfi, efi) consistence.

5.Boundaries: points are assigned according to the distinctness of the lower or shared horizon as follows; diffuse-0, gradual-1, clear-2, abrupt-3 and very abrubt-4.

Table (10) shows the morphological description of twenty soil profiles covering the different physiographic units. The soils were evaluated and prospective points were assigned as described by ***Meixner and Signer (1981)*** and the soil rating scale as applied.

4.3.1- Relative Horizon Distinctness (RHD).

Soils of marine sediments which are represented by profiles 8, 16, 17, 18, 19 and 20 have RHD ratings between 1 and 13. Table (11), which indicates very slight horizonation of the soils of profiles 8, 18, 19 and 20. Texture, both colour and structure all combined with lower boundary contributing to the $1^{st}/2^{nd}$ and $2^{nd}/3^{rd}$ transitions. Data in Table (11) reveal that profiles 17 and 18 have RHD ranging between 1 and 13, which indicate very clear horizonation. The RHD of profiles 17 and 18 are 1 and 13 for the $1^{st}/2^{nd}$ and $2^{nd}/3^{rd}$, respectively, which indicates a very clear distinctness of the $2^{nd}/3^{rd}$ horizons. Colour in both (dry & moist), and lower boundary contribute to the relative distinctness of the 2^{nd} /3^{rd} horizon in the soils of profiles 17 and 18.

Table (10) : Filed morphological description of the studied soil profiles.

Physio. unit	profile No.	Depth cm	Texture	Structure			Colour		Lower boundary	Consistence	
				Type	Size	Grade	Dry	Moist		Dry	Moist
Marine sediments	8	0-25	SCL	massive	coarse	weak	10YR 6/6	10YR 5/6	clear	sh	fr
		25-75	CS	massive	coarse	weak	10YR 6/8	10YR 5/6	diffuse	sh	fr
		75-150	CL	massive	coarse	weak	10YR 6/8	10YR 5/6		sh	fr
	16	0-25	SC	massive	coarse	weak	10YR 7/6	10YR 6/6	clear	so	v.fr
		25-50	CL	massive	coarse	weak	10YR 7/6	10YR 6/6	clear	so	v.fr
		50-150	SCL	massive	coarse	weak	10YR 8/2	10YR 7/2		so	v.fr
	17	0-20	SC	massive	coarse	weak	10YR 7/6	10YR 6/6	clear	so	v.fr
		20-60	SCL	massive	coarse	weak	10YR 7/6	10YR 6/6	clear	so	v.fr
		60-150	SCL	sbk	coarse	weak	10YR 5/4	10YR 4/4		sh	fr
	18	0-20	CL	massive	coarse	weak	10YR 7/4	10YR 7/6	clear	sh	fr
		20-70	CL	massive	coarse	weak	10YR 7/4	10YR 7/6	clear	sh	fr
		70-150	CL	massive	coarse	weak	10YR 7/3	10YR 7/6		sh	fr
	19	0-25	CL	massive	coarse	weak	10YR 7/6	10YR 6/6	diffuse	so	v.fr
		25-85	CL	massive	coarse	weak	10YR 7/6	10YR 6/6	diffuse	so	v.fr
		85-150	CL	massive	coarse	weak	10YR 7/4	10YR 6/6		sh	fr
	20	0-20	CL	massive	coarse	weak	10YR 7/6	10YR 5/6	clear	so	v.fr
		20-70	CL	massive	coarse	weak	10YR 7/6	10YR 5/6	diffuse	so	v.fr
		70-150	CL	massive	coarse	weak	10YR 7/6	10YR 6/6		so	v.fr
Lacustrine sediments	5	0-20	SL	massive	coarse	weak	10YR 6/6	10YR 5/6	clear	so	v.fr
		20-40	SL	massive	coarse	weak	10YR 6/6	10YR 5/6		so	v.fr
	6	0-20	S	massive	coarse	weak	10YR 6/6	10YR 5/6	clear	so	v.fr
		20-45	SL	massive	coarse	weak	10YR 6/6	10YR 5/6	clear	so	v.fr
		45-150	SL	massive	fine	mod.	10YR 8/1	10YR 7/1		sh	fr
	7	0-20	S	sin.grain	...	..	10YR 7/8	10YR 6/8	clear	lo	lo
		20-65	L	massive	coarse	weak	10YR 7/8	10YR 6/8	clear	so	v.fr
		65-150	SCL	massive	coarse	weak	10YR 8/2	10YR 7/2		so	v.fr
Fluvio-lacustrine sediments	1	0-25	SCL	massive	coarse	weak	10YR 7/6	10YR 6/6	clear	so	v.fr
		25-80	SCL	massive	coarse	weak	10YR 7/6	10YR 6/6	diffuse.	so	v.fr
		80-150	SL	massive	coarse	weak	10YR 7/4	10YR 6/4		sh	fr
	2	0-20	SCL	massive	coarse	weak	10YR 6/4	10YR 5/4	clear	sh	fr
		20-60	CL	massive	coarse	weak	10YR 7/4	10YR 6/4	diffuse	sh	fr
		60-100	SCL	sbk	coarse	weak	10YR 7/4	10YR 6/4	clear	h	fi
		100-150	SCL	sbk	coarse	strong	10YR 6/6	10YR 5/6		h	fi
	4	0-25	SL	massive	coarse	weak	10YR 6/6	10YR 5/6	clear	sh	fr
		25-75	C	massive	coarse	weak	10YR 6/6	10YR 5/6	diffuse	sh	fr
		75-150	SCL	massive	coarse	weak	10YR 6/6	10YR 5/6		so	v.fr

Table (10): Cont.

Phy.Un.	profile No.	Depth cm	Texture	Structure			Colour		Lower boundary	Consistence	
				Type	Size	Grade	Dry	Moist		Dry	Moist
Aeolian plaine	3	0-20	S	massive	coarse	weak	10YR 7/6	10YR 6/6	clear	so	v.fr
		20-55	S	massive	coarse	weak	10YR 7/6	10YR 6/6	diffuse	so	v.fr
		55-80	SL	massive	coarse	weak	10YR 7/6	10YR 6/6	clear	so	v.fr
		80-150	S	massive	fine	moderat	10YR 7/8	10YR 7/6		sh	fr
	9	0-20	SL	massive	coarse	weak	10YR 8/4	10YR 7/4	clear	so	v.fr
		20-80	SL	massive	coarse	weak	10YR 7/6	10YR 6/6	diffuse	so	v.fr
		80-150	SL	massive	coarse	weak	10YR 8/6	10YR 7/6		so	v.fr
	10	0-25	SL	massive	coarse	weak	10YR 7/6	10YR 5/6	clear	so	v.fr
		25-55	SCL	massive	coarse	weak	10YR 7/4	10YR 6/4	clear	so	v.fr
		55-110	SCL	massive	coarse	weak	10YR 7/4	10YR 6/4	clear	so	v.fr
		110-150	SCL	massive	coarse	weak	10YR 7/4	10YR 6/4		sh	fr
	11	0-30	SL	sin.grean	..	..	10YR 7/6	10YR 6/6	clear	lo	lo
		30-80	F.S	sin.grean	..	..	10YR 7/6	10YR 6/6	diffuse	lo	lo
		80-150	F.S	massive	coarse	weak	10YR 7/6	10YR 6/6		so	v.fr
	12	0-25	F.S	sin.grean	..	..	10YR 7/6	10YR 6/6	clear	lo	lo
		25-80	F.S	sin.grean	..	..	10YR 7/6	10YR 6/6	diffuse	lo	lo
		80-150	F.S	massive	coarse	weak	10YR 7/6	10YR 6/6		so	v.fr
	13	0-30	F.S	massive	coarse	weak	10YR 8/6	10YR 5/4	clear	so	v.fr
		30-110	SCL	massive	coarse	weak	10YR 7/8	10YR 7/6	diffuse	so	v.fr
		110-150	SCL	massive	coarse	weak	10YR 7/8	10YR 7/6		sh	fr
	14	0-20	SL	sin.grain	..	..	10YR 7/6	10YR 6/4	clear	lo	lo
		20-100	SL	massive	coarse	weak	10YR 7/6	10YR 6/4	diffuse	so	v.fr
		100-150	SL	massive	coarse	weak	10YR 7/6	10YR 6/4		so	v.fr
	15	0-30	F.S	sin.grean	..	..	10YR 7/6	10YR 6/6	clear	lo	lo
		30-70	F.S	massive	coarse	weak	10YR 7/6	10YR 6/6	clear	so	v.fr
		70-120	CL	massive	coarse	weak	10YR 8/2	10YR 7/2	clear	so	v.fr
		120-150	CL	massive	coarse	weak	10YR 7/6	10YR 6/6		so	v.fr

C = clay
L = Loam
S = Sand
F.S = Fine sand

sbk = subangular blocky
sin = single

so= soft
lo= loose
fr = friable
sh = slightly hard

v.fr = very friable
fi =firm

Soils of the lacustrine sediments which are represented by profiles 5, 6 and 7 have RHD rating range between 2, 1-19 and 5-17, respectively. In profile 7, the RHD ratings are 5 and 17 for $1^{st}/2^{nd}$ and $2^{nd}/3^{rd}$. This indicates a very clear distinctness between the $2^{nd}/3^{rd}$ layers in comparison to the above layers. Profile 5 has the lowest RHD rating which is 2 for the $1^{st}/2^{nd}$ layers indicating slight horizonation.

The values of RHD of the soils of fluvio-lacustrine sediments which are represented by profiles 1, 2 and 4 are shown in Table (11). The data show that the soils of fluvio-lacustrine sediments (cultivated soils) have RHD rating ranging between 2 to 7, 5 to 10 and 4 to 3 for the 1^{st} / 2^{nd}, 2^{nd} / 3^{rd}, 3^{rd} / 4^{th} in profiles 1, 2 and 4, respectively. This indicates the relative moderate distinctness of the subsurface horizon in comparison to the surface horizon. Colour in (dry & moist), texture and lower boundary contribute to the successive RHD rating, respectively.

With regard to the soils of aeolian plain which are represented by profiles 3, 9, 10, 11, 12, 13, 14 and 15, the RHD ratings range between 0 to 12 which indicates slight distinctness of each horizon in comparison to the subsequent. Lower boundary, colour (dry & moist) and texture combined with the consistence contribute to the successive RHD rating, respectively.

Table (11) : RHD ratings of the studied soil profiles.

Physio. unit	P. No.	Transition	Texture	Structure	Colour		Lower boundary	Consistance		RHD
					Dry	Moist		Dry	Moist	
Marine sediments	8	1st/2nd	1	0	2	0	2	0	0	5
		2nd/3rd	1	0	0	0	0	0	0	1
	16	1st/2nd	1	0	0	0	0	0	0	1
		2nd/3rd	1	0	5	5	2	0	0	13
	17	1st/2nd	1	0	0	0	0	0	0	1
		2nd/3rd	0	1	4	4	2	1	1	13
	18	1st/2nd	0	0	0	0	0	0	0	0
		2nd/3rd	0	0	1	0	2	0	0	3
	19	1st/2nd	0	0	0	0	0	0	0	0
		2nd/3rd	0	0	2	0	0	1	1	4
	20	1st/2nd	0	0	0	0	2	0	0	2
		2nd/3rd	0	0	0	1	0	0	0	1
Lacustrine	5	1st/2nd	0	0	0	0	2	0	0	2
	6	1st/2nd	1	0	0	0	0	0	0	1
		2nd/3rd	0	2	7	7	2	1	1	19
	7	1st/2nd	2	1	0	0	0	1	1	5
		2nd/3rd	1	0	7	7	2	0	0	17
Fluvio-lacustrine	1	1st/2nd	0	0	0	0	2	0	0	2
		2nd/3rd	1	0	2	2	0	1	1	7
	2	1st/2nd	1	0	1	1	2	0	0	5
		2nd/3rd	1	1	0	0	2	1	1	6
		3rd/4th	0	2	3	3	2	0	0	10
	4	1st/2nd	2	0	0	0	2	0	0	4
		2nd/3rd	1	0	0	0	0	1	1	3
Aeolian plain	3	1st/2nd	0	0	0	0	2	0	0	2
		2nd/3rd	1	0	0	0	2	0	0	3
		3rd/4th	0	2	2	1	2	1	1	9
	9	1st/2nd	0	0	3	3	2	0	0	8
		2nd/3rd	0	0	1	1	0	0	0	2
	10	1st/2nd	1	0	2	3	0	0	0	6
		2nd/3rd	0	0	0	0	0	0	0	0
		3rd/4th	0	0	0	0	2	1	1	4
	11	1st/2nd	1	0	0	0	2	0	0	3
		2nd/3rd	0	1	0	0	0	1	1	3
	12	1st/2nd	0	0	0	0	2	0	0	2
		2nd/3rd	0	1	0	0	0	1	1	3
	13	1st/2nd	2	0	3	4	2	0	0	11
		2nd/3rd	0	0	0	0	0	1	1	2
	14	1st/2nd	0	1	0	0	2	1	1	5
		2nd/3rd	0	0	0	0	0	0	0	0
	15	1st/2nd	0	1	0	0	0	1	1	3
		2nd/3rd	2	0	5	5	0	0	0	12
		3rd/4th	0	0	5	5	2	0	0	12

4.3.2- Relative Profile Distinctness (RPD).

Values of RPD ratings of the studied soil profiles are listed in Table (12). It appears that the marine soils profiles have RPD ratings that range between 1 and 14, on basis of colour, texture and lower boundary. Its surface layers on the contrary to all other profiles, have almost the same RPD rating in comparison to the subsequent deep layers. The ratings clearly reflect the very weak distinctness of these soils.

Soils of lacustrine sediments have RPD ratings that range between 2, 21 - 19 and 21 – 18 in profiles 5, 6 and 7, respectively. These soils are very weakly distinct in respect to their surface horizons. The RPD variations are evaluated on the basis of all the investigated properties.

With regard to the soils of fluvio-lacustrine sediments which are represented by profiles 1, 2 and 4. The RPD ratings ranged between 3-5, 9-10 and 7-9 for profiles 1, 2 and 4, respectively. These soils have slight distinctness based on the soil colour and lower boundary.

Soils of aeolian plain which are represented by profiles 3, 9, 10, 11, 12, 13, 14 and 15 have ratings that range from 8 to 9, 6 to 2, 10 to 4, 6 to 3, 5 to 3, 13 to 4, 5 to 0 and 4 to 12, respectively. In the soils of profiles 3, 10, 13 and 14, the RPD ratings are clearly higher in the surface horizon transition, on the basis of all the investigated properties.

From the above-mentioned discussion it can be concluded that the high RHD and RPD ratings in the studied area may by due to some environmental factors such as sedimentation pattern of recent materials and activity of cultivation processes in this area.

Table (12) : RPD ratings of the studied soil profiles.

Physio. unit	Profile No	Transition	Texture	Structure	Colour		Lower boundary	Consistance		RPD
					Dry	Moist		Dry	Moist	
Marine sediments	8	1st/last	1	0	2	0	2	0	0	5
		2nd/last	1	0	2	0	0	0	0	3
	16	1st/last	1	0	5	5	2	0	0	13
		2nd/last	1	0	5	5	2	0	0	13
	17	1st/last	1	1	4	4	2	1	1	14
		2nd/last	0	1	4	4	2	1	1	13
	18	1st/last	0	0	1	0	2	0	0	3
		2nd/last	0	0	1	0	2	0	0	3
	19	1st/last	0	0	2	0	0	1	1	4
		2nd/last	0	0	2	0	0	1	1	4
	20	1st/last	0	0	0	1	2	0	0	3
		2nd/last	0	0	0	1	0	0	0	1
Lacustine	5	1st/last	0	0	0	0	2	0	0	2
	6	1st/last	1	2	7	7	2	1	1	21
		2nd/last	0	2	7	7	2	1	1	19
	7	1st/last	2	1	7	7	2	1	1	21
		2nd/last	2	0	7	7	2	0	0	18
Fluvio-lacustrine	1	1st/last	1	0	2	2	2	1	1	9
		2nd/last	1	0	2	2	0	1	1	7
	2	1st/last	0	1	2	2	2	1	1	9
		2nd/last	1	1	3	3	0	1	1	10
		3rd/last	0	2	3		2	0	0	10
	4	1st/last	1	0	0	0	2	1	1	5
		2nd/last	1	0	0	0	0	1	1	3
Aeolian plain	3	1st/last	0	2	2	1	2	1	1	8
		2nd/last	0	2	2	1	0	1	1	7
		3rd/last	1	2	2	1	2	1	1	9
	9	1st/last	0	0	2	2	2	0	0	6
		2nd/last	0	0	1	1	0	0	0	2
	10	1st/last	1	0	2	3	2	1	1	10
		2nd/last	0	0	0	0	2	1	1	4
		3rd/last	0	0	0	0	2	1	1	4
	11	1st/last	1	1	0	0	2	1	1	6
		2nd/last	0	1	0	0	0	1	1	3
	12	1st/last	0	1	0	0	2	1	1	5
		2nd/last	0	1	0	0	0	1	1	3
	13	1st/last	2	0	3	4	2	1	1	13
		2nd/last	2	0	0	0	0	1	1	4
	14	1st/last	0	1	0	0	2	1	1	5
		2nd/last	0	0	0	0	0	0	0	0
	15	1st/last	2	1	0	0	2	1	1	7
		2nd/last	2	0	0	0	2	0	0	4
		3rd/last	0	0	5	5	2	0	0	12

4. 4. MICROELEMENTS OF THE STUDIED SOILS

Sixteen elements are known to be essential for the plant growth. Among these elements are "trace elements" or "micro nutrients", such as Fe, Mn, Zn, Cu, B, and Ni.

Geochemical distribution of trace elements has devoted attention owing to their possible use in the differentiation between geologic sediments that may act as parent materials for soils, ***Aubert and pinta (1977)***. In the same connection, the levels of these elements could be used as a guide for substantiation of the nature of parent materials, together with the pedogenic aspects which lead to the prediction of soil genesis and formation, ***(Hassan1979, El-Demerdashe et al. 1980, Abd El-Hamid 1981*** and ***Hassona et al. 1995)***.

The current study evaluates Fe, Mn, Zn and Cu distribution as related to physiographic aspects in soils of the studied area. It also includes a study of the factors governing the total content of these elements.

A brief discussion of each of the concerned trace elements is given hereafter.

4.1. Total iron

Total iron contents in the studied soils, Table (13) shows that soils of marine sediments which are represented by profiles 8, 16, 17, 18, 19 and 20 have total Fe content that ranges from 14710 to 54475 mg kg^{-1}. The lowest value is found in the surface layer of profile 8, while the highest value is found in the deepest layer of profile 20. Depthwise distribution of total iron content does not portray any specific pattern with depth, except for profile 16, where iron content tends to increase with depth.

Table (13) Total Fe, weighted mean (W), trend (T) and specific range (R) of the studied soil profiles

Physiographic Unit	Profile No.	Depth (cm)	Total Fe mg kg^{-1}	W	T	R
Marine sediments	8	0-25 25-75 75-150	14710.00 35827.50 22057.50	25422.92	0.42	0.83
	16	0-25 25-50 50-150	16930.00 25542.50 29060.00	26452.08	0.36	0.46
	17	0-20 20-60 60-150	28412.50 21817.50 50527.50	39922.82	0.29	0.55
	18	0-20 20-70 70-150	21512.50 14775.00 34500.00	26065.33	0.17	0.75
	19	0-25 25-85 85-150	25077.50 51327.50 47272.50	45195.33	0.45	0.58
	20	0-20 20-70 70-150	28395.00 23570.00 54445.00	40680.00	0.30	0.76
Lacustrine	5	0-20 20-40	40655.00 16557.50	25422.92	0.42	0.83
	6	0-20 20-45 45-150	9687.50 17972.50 15900.00	26452.08	0.36	0.46
	7	0-20 20-65 65-150	13600.00 16532.50 14847.50	39922.82	0.29	0.55
Fluvio-lacustrine	1	0-25 25-80 80-150	25970.00 22930.00 56947.50	26065.33	0.17	0.75
	2	0-20 20-60 60-100 100-150	22040.00 15717.50 13772.50 12765.00	45195.33	0.45	0.58
	4	0-25 25-75 75-150	17400.00 26745.00 13077.50	40680.00	0.30	0.76

Table (13): Cont.

Physiographic Unit	Profile No.	Depth (cm)	Total Fe mg kg^{-1}	W	T	R
Aeolian plain	3	0-20 20-55 55-80 80-150	39535.00 12718.00 6250.00 6555.00	12339.53	-0.69	2.70
	9	0-20 20-80 80-150	41467.50 19465.00 17362.50	21417.50	0.48	1.13
	10	0-25 25-55 55-110 110-150	20630.00 18283.00 17235.00 29610.00	21310.43	0.03	0.58
	11	0-30 30-80 80-150	38017.50 15115.00 5874.00	15382.93	-0.60	2.09
	12	0-25 25-80 80-150	6885.50 30747.50 17917.50	20783.17	0.67	1.15
	13	0-30 30-110 110-150	34410.00 25515.00 21117.50	26121.33	0.24	1.67
	14	0-20 20-100 100-150	11602.50 8807.50 5164.00	7965.67	-0.31	0.81
	15	0-30 30-70 70-120 120-150	15827.50 23250.00 29175.00 30147.50	25120.00	0.37	0.57

Notes:

$$W = [\sum(cxd) \div p]$$

where:

c= cocentration of element in layer.
d= thickness of layers.
p= depth of profile (i.e sum. of thickness of all layers of profile).

$$T = (W - S) / W \text{ for cases of } W > S. \text{ or}$$

$$T = (W - S) / S \text{ for cases of } S > W.$$

(S being contents of uppermost surface layer and W the weighted mean).

$$R = (H - L) / W.$$

(H being the highest concentration and L the lowest one).

Table (13) reveals that total Fe in soils of lacustrine sediments which are represented by profiles 5, 6 and 7 ranges between 9687.5 and 40655 mg kg^{-1}. The vertical distribution of total Fe shows a relative concentration in the middle layers of profiles 6 and 7, and in the surface layer of profile 5.

With regard to the soils of fluvio-lacustrine sediments which are represented by profiles 1, 2 and 4, total Fe content ranges from 12765 to 56947.5 mg kg^{-1} with an irregular distribution pattern with depth. The lowest content is detected in the deepest layer of profile 2, whereas the highest content is found in the 80-150 cm layer of profile 1.

Soils of aeolian plain (profiles 3, 9, 10, 11, 12, 13, 14 and 15) contain total Fe that varies from 5164 to 41467 mg kg^{-1} with an irregular distribution pattern with depth, except for profiles 9, 11 and 14 where total Fe tends to decrease with depth. The least content is found in the deepest layer of profile 14, whereas the highest is in the surface layer of profile 9.

From the data, it is clear that the soil profiles representing the soils of marine sediments are characterized by high content of total iron as compared with the other studied soils where the lowest content of total Fe is found in soil profiles representing soils of aeolian plain and lacustrine sediments which are coarse textured.

To substantiate the role of some soil constituents on controlling total Fe content, the correlation coefficient between total Fe and each of these factors were computed, Table (14). The obtained coefficients imply that there is a positively significant correlation between total Fe and each of silt %, pH and EC. These correlations show that, the increasing of silt content, pH and EC leads to correspondent increase in total Fe in the studied soils.

Assessment of W, T and R parameters

Considering the weighted mean (W) data presented in Table (13) reveal that such measure for total Fe is characteristic for each physiographic unit.

For soils of marine sediments, a value of "W" varies widely between 25422.92 and 45195.33 mg kg^{-1} with a tendency of increase toward the fine texture. The computed trend "T" indicates a more symmetrical distribution of total Fe in soil profile 17 than that of the other representative profiles. The specific range "R" of total Fe indicates that the soils of profiles 17, 19, 18 and 20 are composed of homogeneous soil materials, while the other profiles are formed of heterogeneous soil materials.

In the soils of lacustrine sediments, values of "W" range between 15186.67 and 28606.28 mg kg^{-1} with a tendency to increase from East to West.

Values of "T" indicate that profile 7 displayed a small T value, thus being more symmetrical than the other profiles, and values of "R" indicate that the soils are formed of heterogeneous materials.

With regard to the soils of fluvio-lacustrine sediments, values of "W" for Fe range from 15057.67 to 39311.50 mg kg^{-1} with a tendency of increase eastwards. Values of "T" indicate that Fe distribution in profile 4 is more symmetrical than in other profiles, and soils of fluvio-lacustrine sediments are formed of heterogeneous materials as indicated by the values of "R".

Table (14) : Correlation coefficients between total Fe, Mn, Zn and Cu and some soil variable of the sudied soil profiles

Soil variables	Fe	Mn	Zn	Cu
Coarse sand %	-0.166	-0.190	0.086	0.076
Fine sand %	-0.068	0.195	-0.273	0.306 *
Silt %	0.262 *	0.065	0.126	0.116
Clay %	0.174	-0.048	0.4 **	0.413 **
CaCO3 %	-0.053	-0.171	0.128	0.201
OM %	0.099	0.087	0.059	0.126
pH	0.327 **	0.128	0.005	0.067
EC (dS/m)	0.385 **	0.079	-0.106	-0.036

** Significant at 5 % = 0.250*

*** Highly significant at 1 % =0.325*

Soils of aeolian plain, have weighted mean "W" of Fe that ranges between 7965.67 and 26121.33 mg kg^{-1} with a tendency of increase in the North direction. The computed trend "T" indicates that the soils of profile 10 are more symmetrical than the other profiles. The "R" values indicate that the soil material of all profiles representing the soils of aeolian plain are composed of heterogeneous materials.

4.2. Total manganese

The results of total Mn content in the soils under consideration are shown in Table (15). The data indicate that total Mn content in the soils of marine sediments which are represented by profiles 8, 16, 17, 18, 19 and 20 ranges from 102.5 to 775 mg kg^{-1}. The lowest content of Mn is in the deepest layer of profile 16, while the highest content exists in the surface layer of profile 19. The vertical distribution of total Mn tends to increase with depth, except for profile 19 where Mn content tends to increase with depth. In profiles 16 and 20 the vertical distribution of total Mn does not portray any specific pattern with depth.

Soils of lacustrine sediments show total Mn that ranges from 137 t0 407.5 mg kg^{-1} with an irregular distribution pattern with depth. The lowest content is in the 20-40 cm layer of profile 5, while the highest content is in the 20-65 cm layer of profile 7.

With regard to the soils of fluvio-lacustrine sediments which are represented by profiles 1, 2 and 4, total Mn content ranges from 147 to 492.5 mg kg^{-1}. The lowest content is recorded in the surface layer of profile 4, while the highest is recorded in the 80-150 cm layer of profile 1.

Soils of aeolian plain have total Mn content of between 97.5 and 1019.5 mg kg^{-1} with an increase with depth in profiles 9, 14 and 15, while in profiles 10 and 12 total Mn content tends to decrease with depth. In profiles 3, 11 and 13 the vertical distribution pattern of total Mn does not portray any specific with depth.

The correlation coefficients and relationships between some soil variables and total Mn indicate that Mn is not affected by any of these soil variables as there are insignificant relationships.

Assessment of W, T and R parameters

Table (15) shows that the computed weighted mean "W" of total Mn in soils of marine sediments, ranges between 179.17 and 525.03 mg kg^{-1}, with a tendency of increase toward the fine texture. The values of trend "T" indicate more symmetrical Mn distribution in profiles 8, 19 and 20, as indicated by their small "T" values. The specific range "R" of Mn deducts that the soils of profiles 18, 19, and 20 are homogeneous, whereas, other soil profiles are heterogeneous.

Soils of lacustrine sediments show weighted mean "W" ranging from 185.67 to 263.35 mg kg^{-1} with a tendency of increase in a South direction. The computed trend "T" shows that the soils of profile 7 are more symmetrical than those of profiles 5 and 6. The specific range "R" shows that the materials of these soils are heterogeneous.

With regard to the soils of fluvio-lacustrine sediments, the weighted mean "W" of Mn ranged from 247.92 to 410.38 mg kg^{-1} with a tendency of increase in the north direction. The computed trends "T" indicates that profile 2 are more symmetrical than the other profiles. The specific range "R" shows that the soil materials of these profiles displayed heterogeneous distribution.

Table (15) Total Mn, weighted mean (W), trend (T) and specific range (R) of the studied soil profil

Physiographic Unit	Profile No.	Depth (cm)	Total Mn mg.kg^{-1}	W	T	R
Marine sediments	8	0-25 25-75 75-150	292.50 407.50 435.00	402.08	0.27	0.35
	16	0-25 25-50 50-150	307.50 357.50 102.50	179.17	-0.42	1.42
	17	0-20 20-60 60-150	132.50 460.00 555.00	473.33	0.72	0.89
	18	0-20 20-70 70-150	210.00 290.00 435.00	356.67	0.41	0.63
	19	0-25 25-85 85-150	775.00 500.00 452.00	525.03	-0.32	0.62
	20	0-20 20-70 70-150	235.00 230.00 452.00	349.07	0.33	0.64
Lacustrine	5	0-20 20-40	235.00 137.00	186.00	-0.21	0.52
	6	0-20 20-45 45-150	255.00 322.00 140.00	!85.67	-0.27	0.98
	7	0-20 20-65 65-150	221.00 407.50 197.50	263.35	0.16	0.80
Fluvio-lacustrine	1	0-25 25-80 80-150	200.00 401.50 492.50	410.38	0.51	0.71
	2	0-20 20-60 60-100 100-150	242.50 457.50 305.00 257.50	321.50	0.25	0.62
	4	0-25 25-75 75-150	147.50 362.50 205.00	247.92	0.41	0.87

Table (15): Cont.

Physiographic Unit	Profile No.	Depth of layer	Total Mn mg kg^{-1}	W	T	R
Aeolian plain	3	0-20	617.50	277.01	-0.55	1.94
		20-55	570.00			
		55-80	80.00			
		80-150	103.70			
	9	0-20	145.00	297.00	0.51	0.81
		20-80	245.00			
		80-150	385.00			
	10	0-25	385.00	344.84	-0.10	0.27
		25-55	367.10			
		55-110	352.50			
		110-150	292.50			
	11	0-30	975.00	760.00	-0.22	0.98
		30-80	277.50			
		80-150	1019.50			
	12	0-25	602.50	327.50	-0.46	1.18
		25-80	342.50			
		80-150	217.50			
	13	0-30	470.00	478.53	0.02	0.25
		30-110	520.00			
		110-150	402.50			
	14	0-20	97.50	153.83	0.37	1.07
		20-100	100.00			
		100-150	262.50			
	15	0-30	207.50	303.67	0.32	0.66
		30-70	290.00			
		70-120	310.00			
		120-150	407.50			

Considering soils of aeolian plain, the weighted mean "W" ranges from 153.83 to 760 mg kg^{-1} with a tendency of decrease to the South direction. The computed trend "T" shows that the soils of profiles 10 and 13 are more symmetrical than the other soil profiles. The specific range "R" shows that the soil materials of aeolian plain are heterogeneous.

4.3. Total zinc

Total zinc content in the studied soils, Table (16), indicates that soils of marine sediments which are represented by profiles 8, 16, 17, 18, 19 and 20 have total Zn content that ranges from 23.5 to 76.2 mg kg^{-1}. The lowest Zn content characterizes the 85-150 cm depth of profile 19, while the highest content is in the surface layer of profile 8.

Total Zn content ranges from 30.2 to 59.8 mg kg^{-1} in the soils of lacustrine sediments with an irregular distribution pattern with depth. The lowest and highest contents are detected in the surface and subsurface layers of profile 7, respectively.

With regard to the soils of fluvio-lacustrine sediments which are represented by profiles 1, 2, and 4, Table (16) indicates that these soils have total Zn content that ranges between 49.3 and 79.7 mg kg^{-1}. The highest content is recorded in the surface layer of profile 1, while the lowest content characterizes the surface layer of profile 2. The vertical distribution of total Zn content does not portray any specific pattern with depth.

Considering the soils of aeolian plain which are represented by profiles 3, 9, 10, 11, 12, 13, 14 and 15, total Zn content ranges from 18.5 to 47.2 mg kg^{-1} with an irregular distribution pattern with depth, except for profiles 12 and 13 where Zn content tends to increase with depth. The lowest value is detected in the 55-110 cm layer of profile 10, while the highest value is found in the surface layer of profile 9.

With respect to the relation between total Zn and some soil variables in the studied soils, data presented in Table (14) illustrate a highly significant positive correlation between total Zn and clay %. On the other hand, total Zn displays a significant negative correlation with fine sand %, this indicates that, the increasing clay % and decreasing fine sand contents lead to the increase of total Zn content in the studied soils.

Assessment of W, T and R parameters

The statistical measures of *Oertel and Giles (1963)* reveal that the Zn weighted mean "W" in the soils of marine sediments ranges between 30.86 and 65.25 mg kg^{-1} with a tendency to decrease in the North direction. Also, the computed trend "T" indicates a symmetrical distribution in profile 16 than the other profiles. The specific range "R" shows that the soil parent materials are heterogeneous, while profiles 18 and 19 are characterized by homogeneous soil parent materials.

Regarding the soils of lacustrine sediments (profiles 5, 6 and 7), the weighted mean of total Zn ranges from 37.0 to 54.32 mg kg^{-1}. The highest value is detected in profile 7, while the lowest one is found in profile 5. The values of trend "T" show that the soils of profile 5 are more symmetrical than the other representative soil profiles. Specific range "R" shows that the soil parent materials are heterogeneous.

Table (16) Total Zn, weighted mean (W), trend (T) and specific range (R) of the studied soil profile

Physiographic Unit	Profile No.	Depth (cm)	Total Zn mg kg^{-1}	W	T	R
Marine sediments	8	0-25 25-75 75-150	76.20 65.10 61.70	65.25	-0.14	0.22
	16	0-25 25-50 50-150	51.20 45.70 47.30	47.68	-0.07	0.16
	17	0-20 20-60 60-150	45.90 49.20 32.10	38.50	-0.16	0.44
	18	0-20 20-70 70-150	52.60 33.40 33.20	35.85	-0.32	0.54
	19	0-25 25-85 85-150	40.30 34.90 23.50	30.86	-0.23	0.54
	20	0-20 20-70 70-150	34.20 34.70 72.50	54.79	0.38	0.70
Lacustrine sediments	5	0-20 20-40	31.20 42.80	37.00	0.16	0.31
	6	0-20 20-45 45-150	58.10 38.90 41.20	43.07	-0.26	0.45
	7	0-20 20-65 65-150	30.20 59.80 57.10	54.32	0.44	0.54
Fluvio-lacustrine	1	0-25 25-80 80-150	79.70 57.00 68.90	66.34	-0.17	0.34
	2	0-20 20-60 60-100 100-150	49.30 57.80 77.10 76.40	68.01	0.28	0.41
	4	0-25 25-75 75-150	61.60 74.80 55.20	62.80	0.02	0.31

Table (16): Cont.

Physiographic Unit	Profile No.	Depth of layer	Total Zn mg kg^{-1}	W	T	R
Aeolian plain	3	0-20	23.10	23.38	0.01	0.11
		20-55	21.90			
		55-80	24.50			
		80-150	23.80			
	9	0-20	47.20	33.31	-0.30	0.58
		20-80	28.10			
		80-150	33.80			
	10	0-25	22.90	24.49	0.06	0.75
		25-55	22.90			
		55-110	18.50			
		110-150	34.90			
	11	0-30	22.60	27.15	0.17	0.43
		30-80	21.40			
		80-150	33.20			
	12	0-25	27.40	30.46	0.10	0.19
		25-80	28.50			
		80-150	33.10			
	13	0-30	30.20	32.63	0.07	0.18
		30-110	31.80			
		110-150	36.10			
	14	0-20	29.90	37.59	0.20	0.30
		20-100	41.20			
		100-150	34.90			
	15	0-30	23.70	33.46	0.29	0.46
		30-70	35.60			
		70-120	39.20			
		120-150	30.80			

Table (16) reveals that the weighted mean of total Zn in the soils of fluvio-lacustrine sediments varies from 62.8 to

68.01 mg kg^{-1} with a tendency to increase toward North direction. The computed trend indicates more symmetrical distribution in the soils of profile 4 than those of profiles 1 and 2. The specific range dictates that these soils are formed of heterogeneous parent materials.

Soils of aeolian plain, have weighted mean of total Zn that ranges from 23.38 to 37.59 mg kg^{-1} with a tendency of increase in the south-west direction. The computed trend indicates that profiles 3, 10, 12 and 13 are more symmetrical than the other profiles. The specific range indicated that the soils of profiles 12 and 13 are formed of homogeneous parent material, whereas the other profiles constitute heterogeneous soil materials.

4.4. Total Copper

The results of total copper in the studied soils are given in Table (17). The obtained data indicate that, soils of marine sediments which are represented by profiles 8, 16, 17, 18, 19, and 20 have a total Cu content that ranges from 12.5 to 35.0 mg kg^{-1} with an irregular distribution pattern with depth, except for profile 19 where Cu content tends to decrease with depth. The lowest value is detected in the deepest layer of profile 19, while the highest value is found in the subsurface layer of profile 8.

Soils of lacustrine sediments which are represented by profiles 5, 6 and 7 have a total Cu content that ranges from 15.0 to 27.5 mg kg^{-1} with an increase with depth. The lowest value is recorded in the surface layer of profile 5, while the highest value is found in the subsurface layer of profile 7.

With regard to the soils of fluvio-lacustrine sediments (profiles 1, 2 and 4), Table (17) shows that total Cu content varies within a narrow limit from 27.5 to 35.o mg kg^{-1}. The lowest value is in the surface layer of profile 4, while the highest value characterizes the surface and deepest layers of profiles 1, 2 and 4, respectively. Depthwise distribution of total Cu displays an irregular pattern with depth.

The amounts of total Cu content in the soils of aeolian plain, Table (17), range from 7.5 mg kg^{-1} in the soils of profile 10 to 25 mg kg^{-1} in the soils of profile 9. As to the vertical distribution of total Cu, it displays an irregular pattern, except for profile 3 where Cu tends to increase with depth, in contrast to profile 13.

The relationship between total Cu and some soil variables could be elucidated from the correlation coefficients presented in Table (14). Values show that total Cu is highly significant positively correlated with clay %. In contrast, total Cu is negatively correlated fine sand percent. Those correlations indicate that, decreasing with fine sand content and increasing clay content lead to the increase of total Cu in the studied soils.

Assessment of W, T and R parameters

The computed weighted mean "W" of soils of marine sediments ranged from 16.17 to 29.17 mg kg^{-1} with no particular pattern. The computed trend "T" reveals that Cu distributions of profiles 16 and 17 are more symmetrical than the other profiles. The specific range "R" of the total Cu shows that, with the exception of profiles 17, 18 and 19 which are homogeneous, soil materials of all other profiles are formed of heterogeneous soil materials.

With regard to the soils of lacustrine sediments, the weighted mean of total Cu ranges from 20.0 to 24.33 mg kg^{-1} with a tencey of increase in the North direction. The computed trend indicates that total copper distribution in

Table (17) Total CU, weighted mean (W), trend (T) and specific range (R) of the studied soil profil

Physiographic Unit	Profile No.	Depth (cm)	Total Cu mg kg^{-1}	W	T	R
Marine sediments	8	0-25	22.50	29.17	0.23	0.43
		25-75	35.00			
		75-150	27.50			
	16	0-25	25.00	27.92	0.10	0.27
		25-50	32.50			
		50-150	27.50			
	17	0-20	24.00	22.37	-0.07	0.67
		20-60	32.50			
		60-150	17.50			
	18	0-20	27.50	19.33	-0.30	0.65
		20-70	15.00			
		70-150	20.00			
	19	0-25	22.50	16.17	-0.28	0.62
		25-85	17.50			
		85-150	12.50			
	20	0-20	17.50	22.83	0.23	0.44
		20-70	17.50			
		70-150	27.50			
Lacustrine	5	0-20	15.00	20.00	0.25	0.50
		20-40	25.00			
	6	0-20	20.00	24.33	0.18	0.21
		20-45	25.00			
		45-150	25.00			
	7	0-20	15.20	21.61	0.30	0.57
		20-65	27.50			
		65-150	20.00			
Fluvio-lacustrine	1	0-25	35.00	30.14	-0.14	0.23
		25-80	28.10			
		80-150	30.00			
	2	0-20	32.50	32.67	0.01	0.15
		20-60	32.50			
		60-100	30.00			
		100-150	35.00			
	4	0-25	27.50	23.92	-0.13	0.31
		25-75	32.50			
		75-150	35.00			

Table (17): Cont.

Physiographic Unit	Profile No.	Depth of layer	Total Cu mg kg^{-1}	W	T	R
Aeolian plain	3	0-20 20-55 55-80 80-150	10.00 15.00 15.00 12.20	13.03	0.23	0.38
	9	0-20 20-80 80-150	25.00 12.50 21.50	18.37	-0.27	0.71
	10	0-25 25-55 55-110 110-150	10.10 12.40 7.50 15.00	10.91	0.07	0.69
	11	0-30 30-80 80-150	12.50 17.50 12.50	14.17	0.12	0.35
	12	0-25 25-80 80-150	15.00 10.00 12.50	12.00	-0.20	0.42
	13	0-30 30-110 110-150	17.50 10.00 10.00	11.50	-0.34	0.65
	14	0-20 20-100 100-150	17.50 17.50 17.50	17.50	0.00	0.00
	15	0-30 30-70 70-120 120-150	10.00 15.00 17.50 15.00	14.80	0.33	0.51

profile 6 is more symmetrical than the other profiles. The specific range "R" dictates that the soil materials of these soils are formed from heterogeneous soil materials.

As shown in Table (17), the computed weighted mean of total Cu of the fluvio-lacustrine sediments soils have Cu range from 23.92 to 32.67 mg kg^{-1} with tendency of increase in the North direction. The computed trend "T" indicates that total Cu distribution in profile 2 is more symmetrical than in the other representative profiles. The specific range shows that the soils of fluvio-lacustrine sediments are composed of heterogeneous soil materials.

With regard to the soils of aeolian plain, Table (17) shows that these soils have a weighted mean "W" of total Cu that ranges in a narrow limit between 10.91 and 18.37 mg kg^{-1} due to the coarse texture of soils in this physiographic unit. The values of trend indicate that Cu distribution in profiles 10, 11 and 14 are more symmetrical than the other profiles. Specific range of Cu indicates that these soils are composed of heterogeneous materials.

4.5. MINRALOGY OF SOIL MATERIALS

4.5.1. MINRALOGY OF SAND FRACTION

The study of minerals of the sand fraction could be used as a tool for evaluating soil profile uniformity or discontinuity, development, soil genesis, weathering sequence, losses and gains, as well as predicting the major processes involved in soil formation. Residual minerals particularly those termed "heavy minerals" are either inherited from the parent material or being a product of alteration along the course of soil formation. In this accord, **Haseman and Marshall (1945)** stated that the origin of the soil is reflected on the kind and amount of heavy minerals present and that qualitative and rough quantitative determination of such minerals are usually sufficient to establish soil origin. Their suggestion is seemingly valid, provided that the kind and relative abundance of heavy minerals in the possible soil material are well defined.

The frequency distribution of sand minerals within the entire depth of each soil profile is set out in Tables (18 and 19) which show the pattern of light and heavy minerals in the studied profiles. The heavy minerals are further distinguished into opaques and non-opaques, and the individual members of the non-opaques which are more concerned are given due consideration. Worth mentioning that these minerals are identified by their optical characteristics as seen under the polarized microscope. For convenience, an account of their distribution in the studied soil profiles as related to sub group classification is given hereafter:

4.5.1.1. Light minerals.

Light minerals of the sand fraction are those minerals having a specific gravity less than 2.85 g/cm^3. Light minerals are composed mainly of quartz and feldspars. The data reveal that quartz grains composed most of this component (95.0-98.0). Quartz consists generally of single or composed grains having homogenous extinction, extinguishes completely between crossed nichols. The data show also that feldspars could be arranged in the order of abundance as orthoclase, plagioclase and microcline. It is evident that these minerals constitute 2.0 to 5.0 % of the light minerals. Orthoclase is the main constituent of these feldspars, while microcline is present as trace in some samples.

The quartz grains are generally colourless to turbid. They mostly show stain shadow and vary from sub angular to well rounded. Most quartz grains are single with uniform to undulate extinction. Other associated light minerals are mainly orthoclase, plagioclase and microcline which are detected in minute amounts. Orthoclase generally occurs in altered cloudy grains of white to grey interference coloures, the grains are cleavable of rectangular to irregular shape. The grains of detected plagioclase feldspars are rectangular in shape, altered and show familiar twining between crossed nichols, while microcline grains are platy in shape, colourless, cloudy and show cross hatching between crossed nicols and weak relief in canada balsam.

Data in Table (18) show that the soils of the marine sediments which are represented by profiles 8 and 19 have quartz percentage ranges from 96.5 to 98.0 %. The lowest value is found in the deepest layer of profile No. 8, while the highest value is that of the surface layer of profile No. 8. Feldspars constitute 2.0 % to 3.5 % with apparent predominance of orthoclase and /or plagioclase.

presence of feidspars could be taken as an indication of the extent of weathering prevailed during soil formation which was not so drastic to cause a complete decay of these minerals susceptible to weathering.

4.5.1.2. Heavy minerals

Heavy minerals are defined as those having specific gravity higher than 2.85 g/cm3. Their occurrence in rocks may be essential as accessory, they are usually primary, but occasionally, they are secondary ***(Mitchell 1975)***. The main constituents of the heavy fraction are opaque minerals, while the non opaques are defined as amphiboles, pyroxenes, epidote, tourmaline, zircon, rutile, garnet, kyanite, staurolite and biotite which are present in subordinate amounts. Their frequency distribution is illustrated in Table (19). The results indicate that opaque minerals besides amphiboles, pyroxenes and epidote are the most abundant minerals.

Zircon, rutile, garnet, kyanite, and staurolite are present in relatively moderate amounts, while the remaining minerals are found in less pronounced amounts.

Opaque minerals:

Opaques are mostly composed of iron ores such as hematite, ilmenite, limonite, magnetite and pyrite. These minerals are characterized by being isotropic between cross nicholas, black colored in plane light, non peleochroic and having rounded to sub-rounded angular grain. Iron ores constitute a large portion of the opaque minerals as their frequency ranges between 33.4 % in aeolian plain (profile No. 12) and 50.1 % in fluvio-lacustrine sediment (profile No. 2), Table (19). Depthwise distribution of opaque minerals does not portray any specific pattern with depth, except for profiles 2 and 12 where opaques tend to increase with depth.

Table (19) Frequency distribution of the heavy minerals of the sand fraction (0.125-0.063 mm) in the studied soil profiles.

Physiog. Unit.	profile	Depth (cm)	Opaques %	Non opaques %	Pyroboles %		Parametamorphic %				Ubibuitous %			Biotite %	Epidote %	Monazite %	Glauconite %	Titanite %	Apatite %	Andalusite %
					Pyroxenes	Amphiboles	Garnet	Staurolite	Kyanite	Silimanite	Zircon	Rutile	Tourmaline							
Marine	8	0-25	38	62	33.1	23.9	1.8	2.5	1.8	1.8	12.3	3.1	3.1	3.1	9.2	2.5	1	1.2	0.5	1.8
		25-75	38.9	61.1	33	19.7	1.9	2.6	1.3	1.3	12.7	3.2	5.7	5.1	9.6	2.6	1.2	1.3	0.4	1.3
		75-150	38.6	61.4	27	30.2	1.3	2.5	1.3	1.3	12.61	2.5	3.1	1.9	12.5	1.9	1.5	1.4	0.6	1.9
	19	0-25	37.3	62.7	36.1	26.4	2	1.9	1.7	1.2	9.7	4.7	4.7	1.7	6.5	2	0.8	1.1	0.5	1.4
		25-85	36.9	63.1	36.8	28.6	1.8	2.3	1.8	1.2	8.8	2.3	4.7	1.7	5.8	1.8	1.2	1.3	0.4	1.2
		85-150	39.4	60.6	37.6	27.3	2	2	1.3	1.3	9.7	4.5	3.3	1.9	6.5	2	1.4	1.3	0.6	0.6
Lacustrine	6	0-20	43.3	56.7	15.2	26.7	3.8	3	1.5	1.5	7.6	3	3.8	9.9	15.2	3	1.5	1.5	0.7	1.5
		20-45	42.5	57.5	14.3	25.6	4.2	3.2	1.3	0.9	4.3	2.4	2.4	5.4	13.3	1.5	1.9	0.9	0.6	1.4
		45-150	45	55	16.4	41	2.4	2.4	1.6	1.6	4.1	1.6	4.1	2.4	14.7	0.8	2.4	1.6	0.8	1.6
Fluvio-lacustrine	2	0-20	42.2	57.8	12.9	25.8	6.4	8.2	4.3	1.1	5.1	0.9	2.1	1.4	31.7	0.1	1	1.2	0.6	1.2
		20-60	45	55	21.7	39.9	2.4	2.6	5.1	1	5.9	4.2	2.5	1.2	14.1	0.4	..	0.5	0.5	1
		60-100	48.2	51.8	23.4	46.7	4.6	3.2	3.7	1.3	3.5	3.3	1.2	0.2	8.9	0.1	..	1.3	0.4	1.3
		100-150	50.1	49.9	31.8	24.5	7.7	6.1	5.3	0.1	5.7	2.6	1.2	0.1	14.8	0.2	..	0.5	-1.1	1.7
	4	0-25	37.3	62.7	34.5	29.1	1.8	1.2	1.2	1.2	11.9	1.8	4.8	1.8	8.9	1.2	..	1.2	0.6	0.6
		25-75	33.5	66.5	33	28.4	2.4	2.4	1.2	1.2	8.9	3	4.7	1.8	8.8	2.4	1.2	1.3	0.7	1.8
		75-150	37.6	62.4	30.7	22.9	1.8	1.8	1.8	1.2	15.1	4.2	4.2	1.8	9.1	2.4	0.7	1.3	0.7	1.8
Aeolian plain	12	0-25	33.4	66.6	31.1	28.6	2	2	1	1.5	12.6	2.5	2.5	1	12.6	2.3	0.6	1	0.4	2
		25-80	36.8	63.2	29.1	30.9	2.3	2.9	1.7	1.7	11.6	2.9	2.3	1.8	11.6	1.2	0.3	1.2	0.6	1.2
		80-150	36.8	63.2	29.1	27.9	2.3	3.5	2.3	1.7	13.4	4.7	5.8	1.8	2.9	1	0.4	1.3	0.7	2.3
	14	0-20	38.8	61.2	26.4	31.7	1.6	1.6	2.1	1.5	5.3	2.6	2.6	1.3	18.5	2.1	0.6	0.5	0.3	1.6
		20-100	36.8	63.2	20.2	27.7	1.1	1.6	2.2	1.6	13.8	2.7	5.5	1.6	13.8	2.7	0.5	1.1	0.5	1.6
		100-150	36.5	63.5	22.1	28.7	1.7	1.7	1.7	1.1	17.2	2.9	5.7	2.9	11.5	1.7	0.7	1.1	0.6	1.1

Non opaque minerals:

The non-opaque minerals are those formed from the rocks containing them. Their occurrence is either essential or accessory. The essential minerals constitute the major portion of rock and / or necessary to give its character as a whole (***Nelson,*** *1967* and ***Mitchell*** *1975*). These minerals are prevailed as ferro-mangnesian ino-silicates "pyroboles and epidote", while their accessory minerals are zircon, rutile...etc.

a)- Pyroxenes:

This group of minerals is represented by augite, hyperthene and diopside. The minerals are characterized mainly by being anisotropic, having oblique or parallel extinction and are non-paleochroic. They are identified as grains having sub angular to sub rounded shape. Pyroxenes in total, varied widely from 12.9 % in the surface layer of profile No.2 (fluvio-lacustrine sediments) to 37.6 % in the deepest layer of profile No.19 (marine sediments).

b)- Amphiboles:

This group of minerals is mainly represented by hornblende, glaucophane and actinolite. They have common microscopic features in being peleochroic, having oblique extinction and anisotropy. In general, these minerals are detected as sub-rounded-shaped grains. The amphiboles content ranges from 19.7 % in the subsurface layer of profile No.8 of marine sediments soils to 46.7 % in the subsurface layer of profile 2 of fluvio-lacustrine soils. Amphibole minerals display an irregular distribution pattern through the entire depth of profiles.

Parametamorphic minerals.

a- Garnet:

Garnet mineral is characterized by being isotropic between cross nichols and having colourless or glassy pink colour in plane light. It is found in sub-angular shape. It is present in all the studied samples and its frequency varies between 1.1 % in the subsurface layer of profile No.14 of aeolian plain soils and 7.7 % in profile No.2 of fluvio-lacustrine sediments. Its vertical distribution does not show any particular trend with depth.

b- Staurolite:

Characters of staurolite mineral in the studied soils are defined by its golden yellow colour between cross nichols and plane light, being non-pleochroic and has parallel extinction and sub-angular shaped grains. It's recorded in all examined samples with variable percentages ranging from 1.2 % in the surface layer of profile No.4 of fluvio-lacustrine sediments to 8.2 % in the surface layer of profile No. 2 of fluvio-lacustrine soils. No particular trend is observed in its vertical distribution.

c- Kyanite:

Kyanite grains are characterized by subangular grains, having two perpendicular sets of cleavage, oblique extinction and it gives abnormal interference colour between cross nichols. Its percentage ranges from 1.0 in the surface layer of profile No.12 of aeolian plain soils to 5.3 % of the non-opaque in the deepest layer of profile No.2 of fluvio-lacustrine soils.

d- Silimanite:

Silimanite is identified by its characteristics, which are somewhat similar to kyanite except for having parallel extinction. It's the least abundant mineral among the parametamorphic minerals; it constitutes 0.1 to 1.8 of the non opaques with no specific pattern with depth. The highest value is found in the surface layer of profile No.8 of marine sediments soils, while the lowest content is recorded in the deepest layer of profile No.2 of fluvio-lacustrine soils.

Ubibuitous minerals:

1- Zircon:

Zircon grains are recorded in a frequency ranging from 4.1 to 17.2 % of the non opaques in all the studied samples. It is characterized by prismatic grains with sub-rounded edges. It is usually present in a colourless variety white, pink and yellow grains are rarely met. Zircon has very high relief and parallel extinction. The lowest content is found in the deepest layer of profile 6 (lacustrine sediments), while the highest content is detected in the deepest layer of profile 14 (aeolian plain), with no specific distribution trend with depth. The studied soils are arranged in a descending order, namely:

aeolian plain > marine sediments > fluvio-lacustrine > lacustrine.

2- Rutile:

Rutile is present in bloody red colour between cross nicols and plane light; it is detected as sub angular grains with high relief and parallel extinction. Its content ranges from o.9 to 4.7 % of the non opaques. The highest content is detected in the surface layer of profile No. 19 of marine sediments soils, while the lowest ones characterized the surface layer of profile No.2 of fluvio-lacustrine sediments soils.

3- Tourmaline:

Tourmaline grains mostly occurred in prismatic grains exhibiting a strong pleochrism. Table (19) revealed that tourmaline content in the studied area ranges between 1.2 % to 5.8 % of the non opaque minerals. The lowest values are mainly associated with the deepest layer of profile No. 2 of fluvio-lacustrine soils, while the highest content is detected in the deepest layer of profile No. 12 of aeolian plain soils.

Biotite:

This mineral is identified by being strong peleochroic in plane light, becomes dark on horizontal line, and having sub rounded and rounded shaped grains. Data in Table (19) reveal that biotite mineral constitutes 0.1 % to 9.9 % of the non opaque minerals. The highest content is found in the surface layer of profile No. 6 of (lacustrine soils) while the lowest content is detected in the deepest layer of profile No. 2 of fluvio-lacustrine soils. From the pedological point of view, the presence of biotite as potassium-bearing mineral in the studied area is very important in clay mineral formation by weathering processes.

Epidote:

Epidote is generally found as angular to sub angular grains, greenish yellow in colour, anisotropic, highly pleochroic and having parallel extinction. Table (19) shows that epidote mineral is detected in all the studied samples, with frequency ranging from 2.9 % to 31.7 % of the non opaque minerals and no distribution trend downwards. The relatively low amounts of epidote is recorded in the deepest layer of profile No. 12 of aeolian plain soils, while the highest content is recorded in the surface layer of profile No. 2 of fluvio-lacustrine soils.

Monazite:

Monazite is characterized by its yellow or yellowish-brown colour, very high relief, prismatic and / or oval shape and parallel extinction. It constitutes 0.1 % to 3.0 % of the non opaque minerals, Table (19). The highest percentage of the mineral is recorded in the surface layer of profile No. 6 (lacustrine soils), while the lowest content is recorded in the surface layer of profile No.2 (fluvio-lacustrine sediments).

Glouconite:

This mineral is identified by its dirty green colour, being non pleochroic and has parallel extinction. It is found in less pronounced amount relative to the other minerals constituting the non opaques in the studied area (0 - 2.4 %).

Titanite:

Titanite is usually present in sub-angular to sub-rounded grains of a brownish variety, often with dark dusty interior. Table (19) reveals that titanite constitutes 0.5 % to 1.5 % of the non opaque minerals. The lowest content is recorded in the subsurface, deepest layer of profile No. 2 (fluvio-lacustrine soils) and surface layer of profile No.14 (aeolian plain soils), while the highest content is detected in the deepest layer of profile No.6 (lacustrine sediments soils).

Apatite:

Apatite is recorded in colourless elongated prismatic grains. Round grains that sometimes show minute inclusions of iron oxides are also met with apatite is recorded in a maximum frequency vivisecting 1.1 % of the non opaque minerals in the deepest layer of profile No. 2 (fluvio-lacustrine soils), while the lowest content is recorded in the surface layer of profile No. 14 (aeolian plain soils).

Andalusite:

It is present as colourless, sub-angular, more or less irregular, and rarely prismatic grains. Data in Table (19) show that andalusite mineral ranges from 0.6 % to 2.3 %. The highest content is detected in the deepest layer of profile No. 12 (aeolian plain soils), while the lowest value is present in the deepest layer of profile No. 19 (marine soils).

4.5.2. MINRALOGY OF THE CLAY FRACTION

The mineralogical composition of the clay fraction separated from some representative soil profiles was carried out by X-ray diffraction analysis. This method is considered one of the most important applied methods for identifying soil clays. In this study, samples are collected from soils of the different physiographic units in the studied area to get a regional picture assemblage in relation to physiographic units and other environmental factors.

X-ray diffraction technique depends basically on the presence of characteristic diffraction peaks for each mineral in the samples. The intensity of the sharpness of these peaks are dependent not only on the number and the corresponding diffraction plains present in the examined sample, but also on the particle size, chemical composition, crystal imperfection, crystal orientation and the pre-treatments during clay separation, ***Whittig (1965)***. Identification of clay minerals by X-ray diffraction analysis was carried out following the essential principles established by ***Whittig and Jackson (1955), Brown (1961), Black (1965)*** and ***Dixon and Weeds (1977)***.

Semi-quantitative mineralogical determinations were estimated by measuring the area under peaks, according to ***Gjems (1967)***. In brief, clay minerals are identified as follows:

1. Smectite minerals are identified by the expansion of the basal reflection (001) from 14 A° in the Mg-saturated sample to 18 A° upon glycerol solvation and its collapse to about 10 A° in the K-saturated sample, heated to 550°C for four hours.
2. Kaolinite is detected by the presence of very sharp peaks at about 7.18 A° and 3.57 A° in the Mg-saturated samples. These peaks are not affected by glycerol

solvation and they disappear upon heating to 550°C for four hours.

3. Hydrous mica (illite) minerals are identified by the presence of the basal maximum 10 A° peaks upon Mg-saturation, which remains constant throughout the different treatments.
4. Palygorskite mineral is identified from the basal reflection (001) of strong intensity at a spacing of 10.2 A° peak in the Mg-saturated sample which is not affected by the glycerol solvation treatment. The presence of other diffraction peaks of moderate intensity at 6.44, 5.42, 4.5, 3.68, 3.24 and 2.15 A°, further confirm its presence.
5. Vermiculite is identified by the presence of the 14 A° peak which is contracted to 10 A° in the K-saturated sample, heated to 550 °C for four hours.
6. Chlorite can be distinguished from vermiculite by the presence of 14 A° peak after the heating treatment. It is also known that chlorite shows an increase in intensity of its basal reflection and a decrease in the second order at 7.13 A° after heating at 550°C due to the partial decomposition.
7. Interstratified clay minerals are characterized by the presence of small peaks around 20 A° in the air-dried sample. It is evidenced also by tailing of the 10 A° towards the 14 A° and 19 A° peaks.
8. Quartz usually gives two fairly strong peaks at 3.35 A° and 4.26 A°. The former being over twice as intense as the latter.
9. Feldspars, calcite and dolomite are identified by their characteristic diffraction peaks at (3.1 - 3.29), 3.03 and 2.81 A°, respectively.

X-ray diffraction analysis was undertaken for 10 samples representing the soils containing appreciable amounts of clay. The X-ray diffractograms obtained from the diffractometer scans of oriented samples of clay and accessory minerals were interpreted following the criteria established by ***Whittig and Jackson (1955), Brown (1961)*** and ***Black (1965)***.

A semi-quantitative estimation of the clay minerals is given in Table (20).

Description of the mineralogical composition of the separated clay samples is given in the following.

4.5.2.1. Clay mineralogy of the marine soils:

Soils of this physiographic unit are represented by profiles 8 and 19. X-ray diffractograms of these profiles are depicted in Figs. (7 and 8). The data in Table (20) show that the clay minerals are dominated by palygroskite followed by kaolinite. Palygorskite dominates clay minerals as detected from the presence of high and sharp peak at 10.52 A° in the Mg-saturated air dried sample and Mg-glycerol salvation and over lapped with basal reflection peak of 2:1 minerals upon heating to 550 °C for four hours. Kaolinite minerals constitute common amounts in all the studied soil samples.

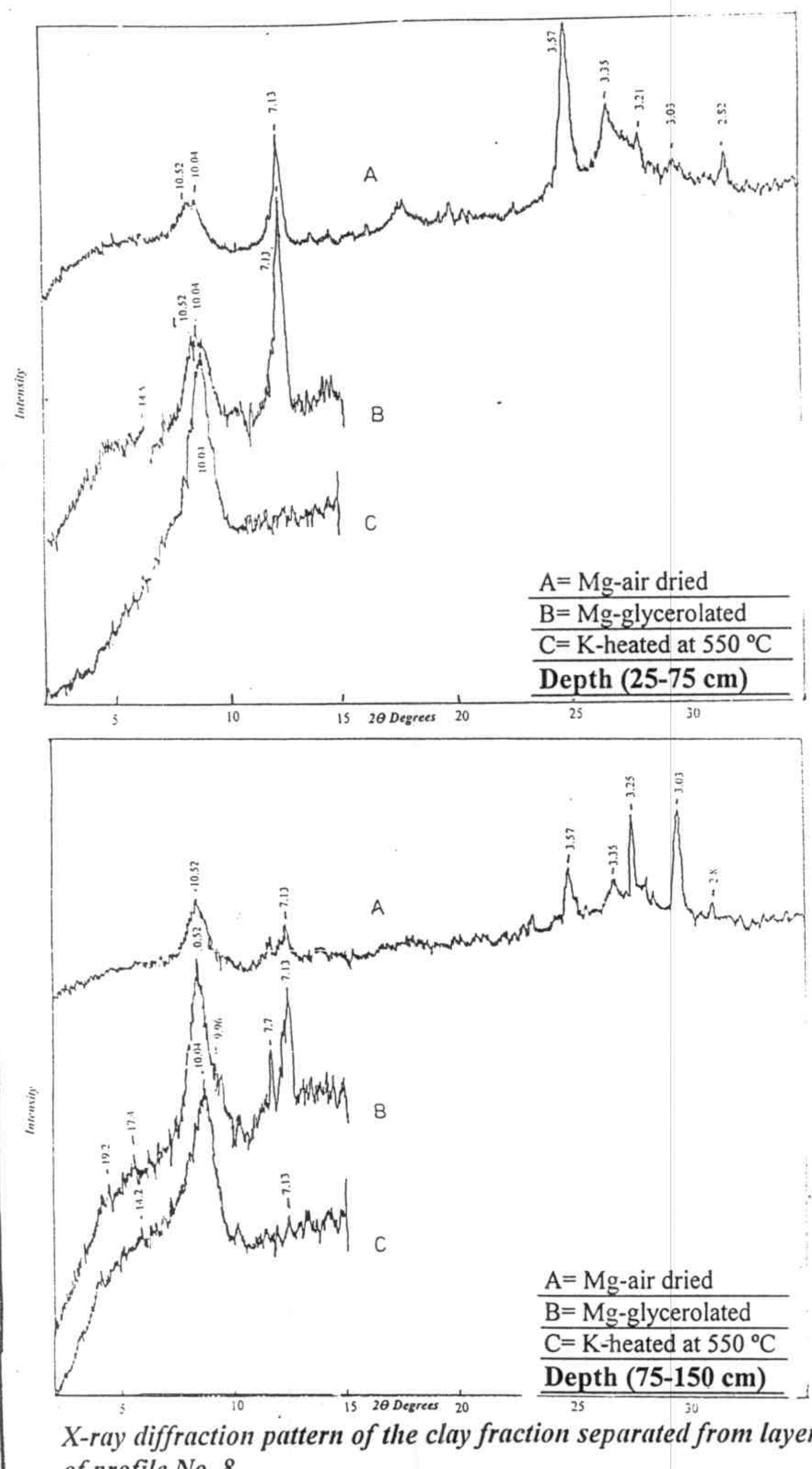
Montmorillonite and illite minerals are detected in few amounts, except for the clay fraction of the 25-75 cm layer of profile 8 which contains moderate amounts of illite. Interstratified minerals, chlorite and vermiculite minerals are found in traceable amounts.

The identified accessory minerals are mainly dominated by quartz followed by feldspars, while calcite is found in traces to few amount. Dolomite is detected in few and trace amounts in the subsurface and deepest layers of profile 8, while only detected in few amounts in the deepest layers of profile19.

Table (20) : Semi - quantitative mineralogical composition of the clay fraction (<0.002 mm) separated from the studied soil profiles.

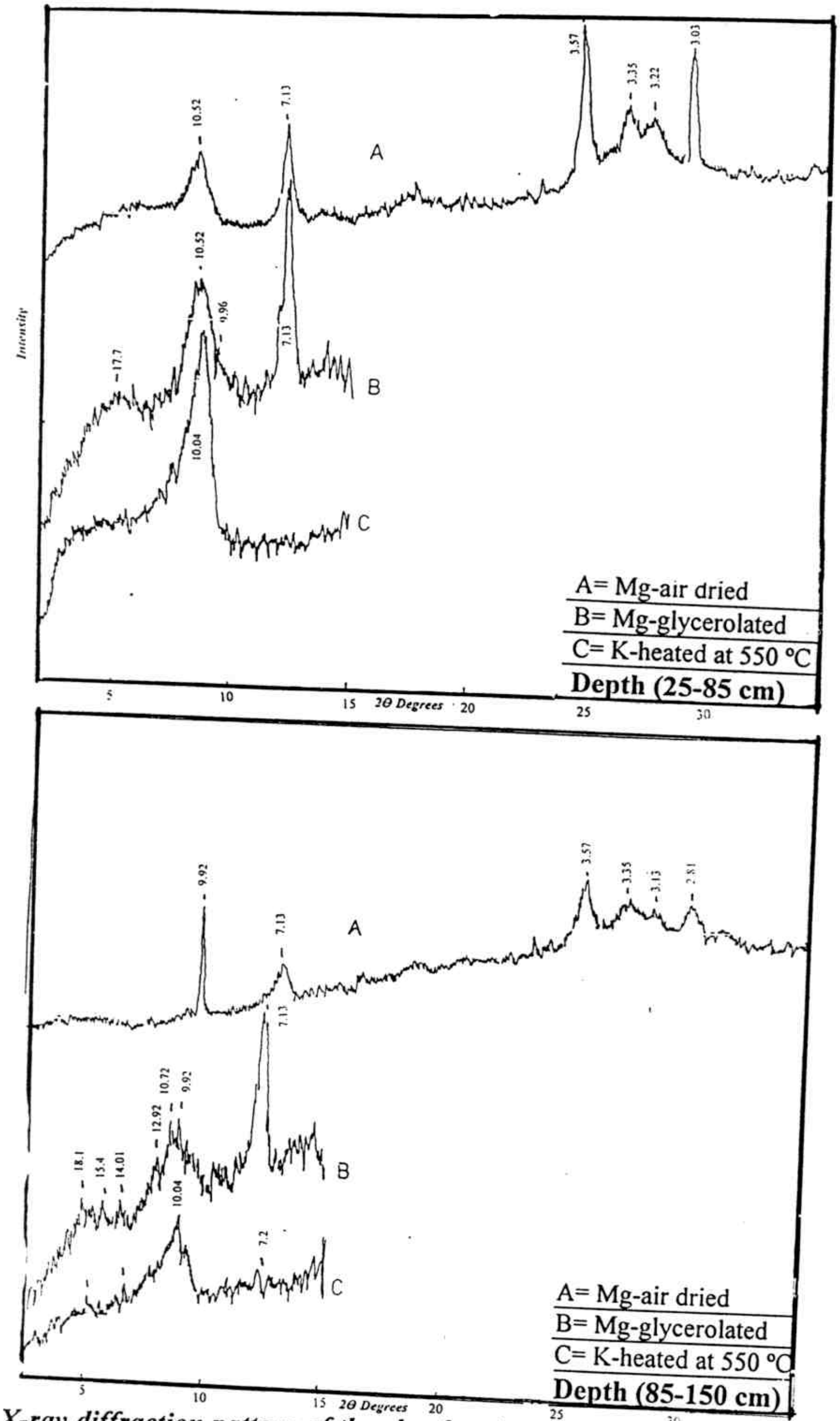
physiograph-ic unit	Profile No.	Depth (cm)	Interstratfied Minerals	Clay Minerals						Accessory Minerals			
				Kaolinite	Montmorillinite	Vermiculite	Chlorite	Illite	Palygorskite	Quartz	Feldspars	Calcite	Dolomite
Marine	8	25-75	Tra	Com.	Few	-----	-----	Mod	Com	Few	Tra	Tra	Few
		75-150	Tra	Com.	Few	Tra	Tra	Few	Dom	Few	Few	Few	Tra
	19	25-85	Tra	Com.	Few	Tra	-----	Few	Dom	Few	Few	Few	-----
		85-150	Tra	Com.	Few	-----	Tra	Few	Com	Few	Tra	-----	Few
Lacustrine	6	20-45	Tra	Dom.	Few	Tra	Tra	Mod	Com	Few	Tra	Tra	-----
		45-150	Tra	Dom.	Few	Tra	Tra	Mod	Com	Few	Tra	Tra	-----
Fluvio -	2	20-60	Tra	Mod.	Few	-----	Tra	Mod	Com	Tra	Tra	Few	-----
		60-100	Tra	Com.	Few	Tra	Tra	Mod	Few	Tra	Tra	Few	-----
	4	25-75	Tra	Com.	Few	-----	-----	Mod	Com	Tra	Tra	Few	Few
Lacusrine		75-150	-----	Com.	Few	-----	Tra	Mod	Dom	Few	Tra	Tra	-----

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



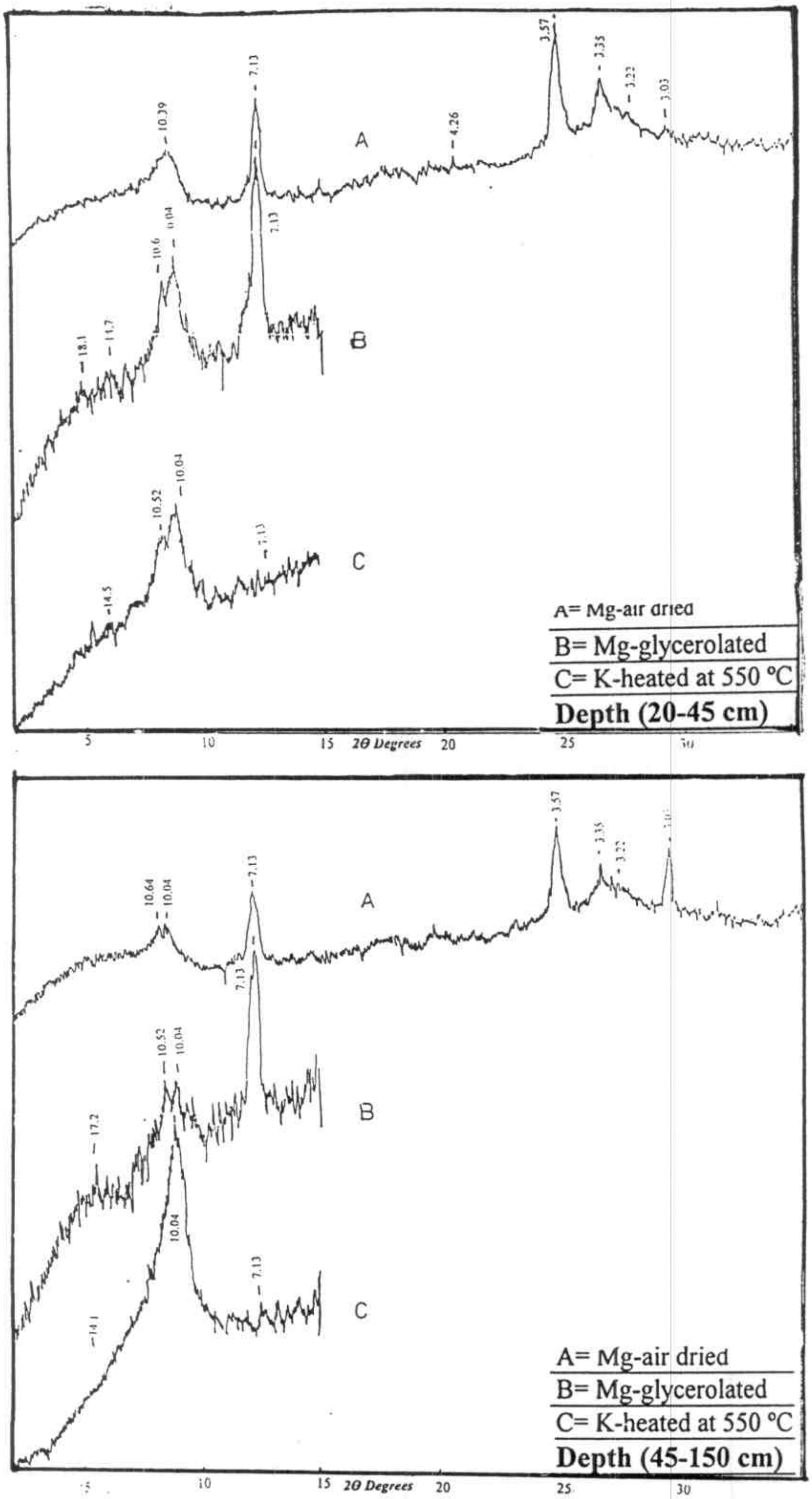
X-ray diffraction pattern of the clay fraction separated from layers of profile No. 8

Fig. (7).



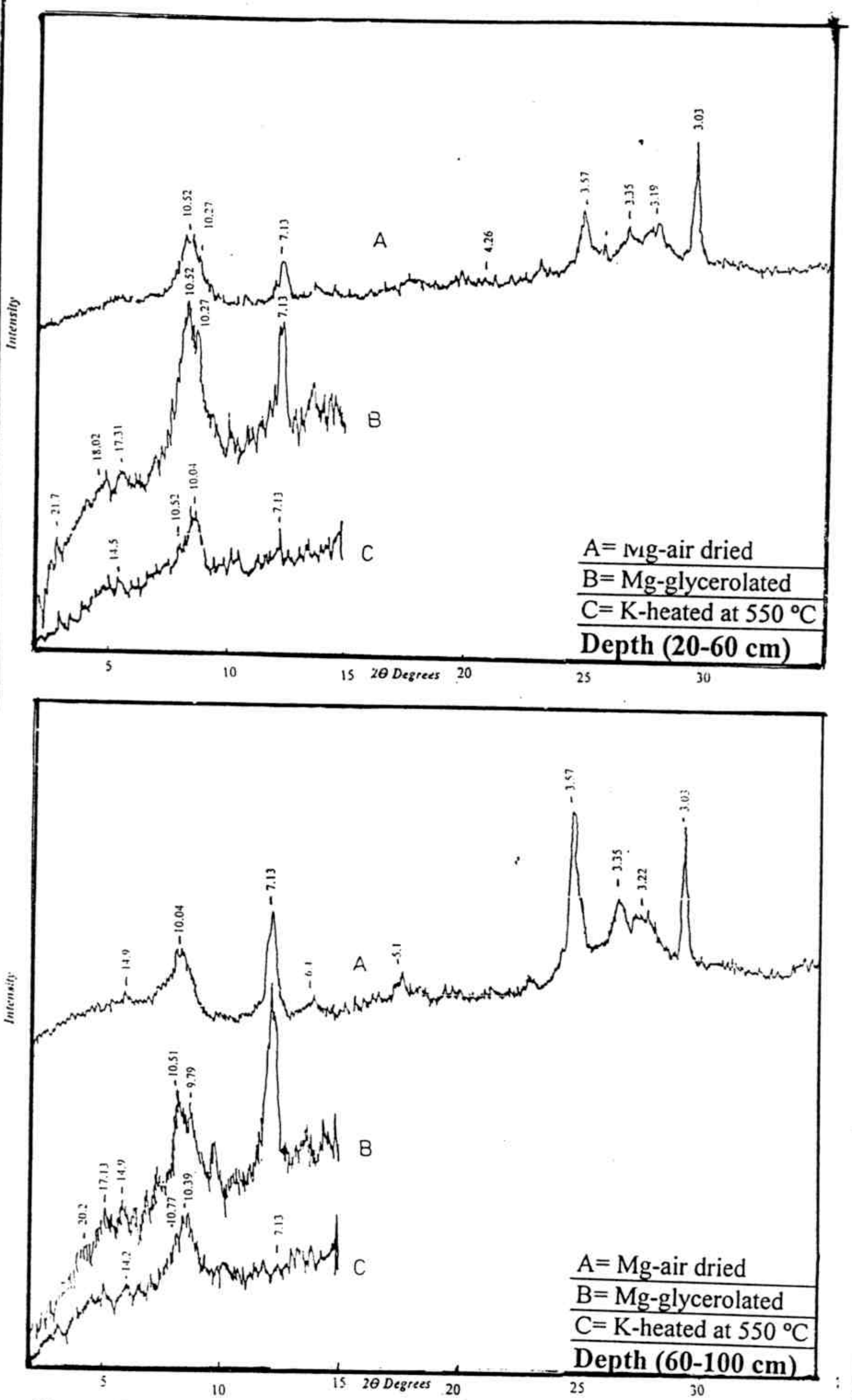
X-ray diffraction pattern of the clay fraction separated from layers of profile No. 19

Fig. (8).



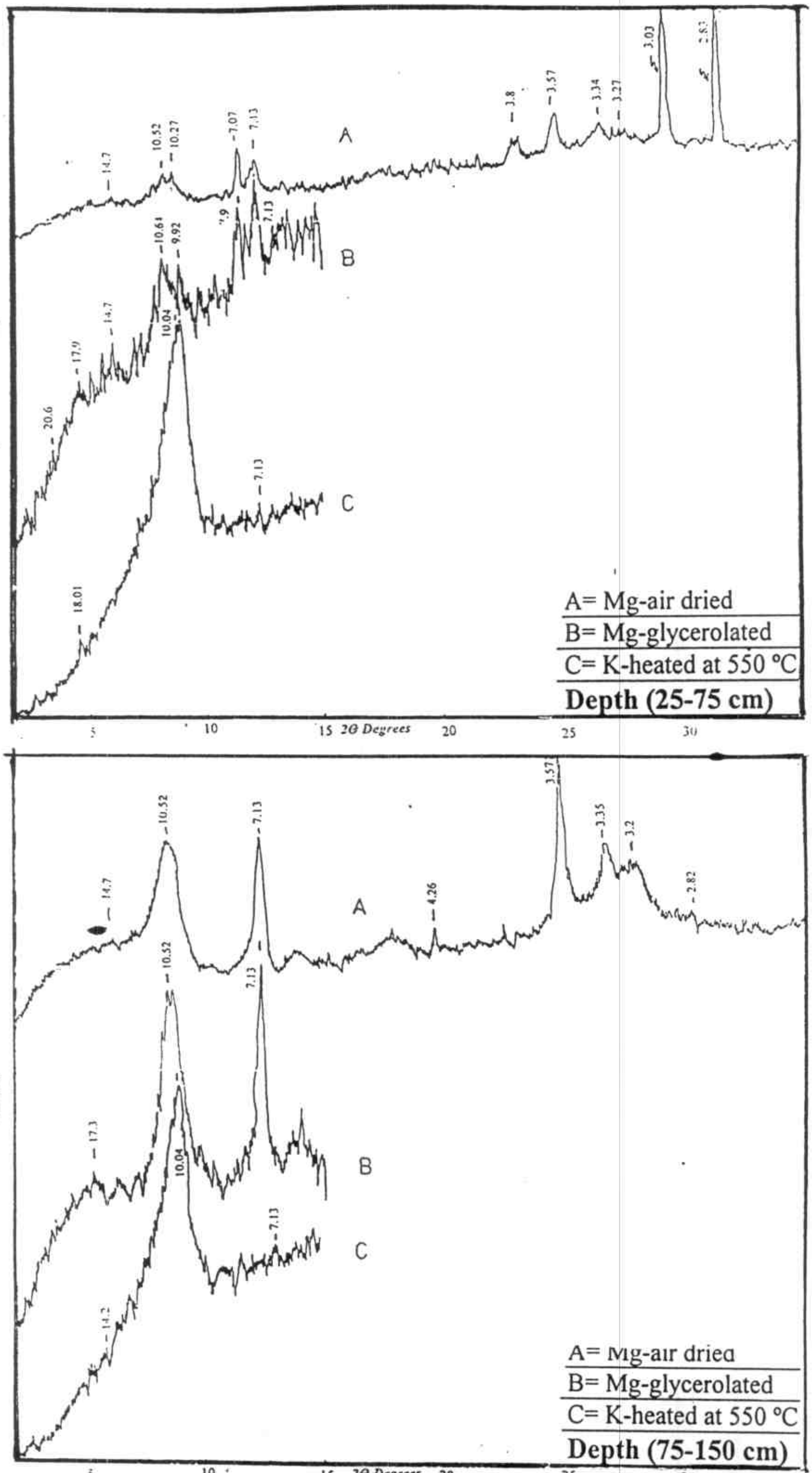
X-ray diffraction pattern of the clay fraction separated from layers of profile No. 6

Fig. (9).



X-ray diffraction pattern of the clay fraction separated from layers of profile No. 2

Fig. (10).



X-ray diffraction pattern of the clay fraction separated from layers of profile No. 4

Fig. (11).

4.5.2.2. Clay mineralogy of the lacustrine soils:

The clay minerals assemblage of profile 6 which represents the soils of lacustrine origin, Table (20) and Fig. (9) is characterized by the dominance of kaolinite mineral followed by palygorskite. Interstratified minerals, vermiculite and chlorite minerals are detected in trace amounts in all layers. Montmorillonite mineral is found in few amounts, while illite mineral is present in moderate amounts.

The associated non-clay minerals are mainly represented by quartz followed by feldspars, while calcite is detected in trace amounts.

4.5.2.3. Clay mineralogy of the fluvio-lacustrine soils:

X-ray diffraction pattern of the clay fractions separated from the fine-texture layers of profiles 2 and 4, which represent the soils of fluvio- lacustrine are shown in Figs. (10 and 11) and Table (20).

The diffraction patterns revealed that the clay fractions of these soils are dominated by palygorskite followed by kaolinite. Interstratified minerals and chlorite are detected in traceable amounts. Smectite (montmorillonite) is found in few amounts. Vermiculite is detected only in the 60-100 cm layer of profile 2 where it forms trace amounts. Illite mineral is present in moderate amounts in all layers.

The identified accessory minerals are mainly dominated by calcite followed by quartz and feldspars, while dolomite is detected only in the 25-75 cm layer of profile 4.

4.5.2.4. Genesis of the clay minerals:

The formation of clay minerals in soils and the type of clay minerals present depend on a number of factors, parent material, climate, relief, intensity of weathering, efficiency of drainage system, level of water table, pH value and time, ***Mackenzie (1967)***.

From the above mentioned presentation of the clay minerals present in the different physiographic units in the studied area, it can be concluded that:-

1. Palygorskite is the predominant clay mineral in the marine and fluvio-lacustrine soils, while kaolinite and /or palygorskite are the predominant clay minerals in the soils of lacustrine sediments.
2. Palygorskite mineral is detected in large amounts of the clay fraction separated from the marine sediments and fluvio-lacustrine soils. These soils have high content of $CaCO_3$ and soluble salts. These conditions favor palygorskite formation. Similar results were reported about the presence of palygorskite in the calcareous soils of northwestern desert ***(Ghoniem 1971, Harga 1971*** and ***Metwaly 1987)***.
3. Kaolinite takes the second place in the clay fraction. It confirms the hydromorphic condition of soils and is mostly inherited from parent sediments during the drastic leaching of soils in the past humid climate.
4. Montmorillonite occurrence is confirmed by the prevailed aridity and the low content of vermiculite is as transitional stage between non-expanding mica and the fully expanding smectite / montmorillonite, it expected that they are mostly inherited from parent material from which the soils are derived.
5. The presence of vermiculite, illite and chlorite is explained on the premise that Mg-affected conditions stimulate their formation either through diagenesis or neogenesis.
6. The presence of interstratified clay minerals in soil samples may be due to pedogenic formation and transformation processes, ***Mackenzie (1967)*** stated

that some transformation of mica to illite and di-octahedral smectite may take place.

7. The presence of quartz and feldspars minerals as a major constituent of an accessory minerals may be due to physical weathering occurring at the surface layers of these profiles producing clay size quartz and feldspars which were then translocated to the deeper layers.
8. The presence of calcite and dolomite may suggest a contribution of calcareous parent material (calcareous sandstone and / or limestone).
9. The variations in mineralogical composition of the clay fraction in the study area, are mainly ascribed to the multi-origin of sediments (multi-parent materials).

4.6. UNIFORMITY OF SOIL MATERIALS:

Evaluation of soil uniformity is necessary for recognizing the degree of development of soil profile. Two approaches are used for establishing this concept, both dealing with soil fraction which gives an indication of the initial state of soil materials "Parent material", ***Barshad (1964)***. The first one deals with the statistical treatment of the particle size distribution of the soil fraction. The other is the mineralogical analysis of the heavy residue of the fine sand fraction.

The first approach depends on the assumption that horizon differentiation is due to the processes acting within the mobile unstable fraction of soil material, while the immobile skeleton grains "non-clay fraction" are unaffected or slightly affected, so they reflect the initial state of parent material, ***Simson (1959)*** and ***Barshad (1964)***.

The second approach is based on the assumption that certain minerals do not undergo any significant change during the course of soil formations. Such minerals are termed the index minerals. Discussion of these approaches is given in the following.

4.6.1. THE GRANULOMETRIC ANALYSIS.

The analysis depending on the statistical treatments of the mechanical analysis data may be shown as cumulative curve called "the sedimentation curve". From this curve, percentage of particles within any limit of size diameter could be computed. A number of important points representing the size values of particles (in mm.) corresponding to the three successive quarters of the total weight. Percent (100) of particles, i.e., Q_1, Md and Q_3 are identified on the curve, and are called "Quartiles" ***(Pettijohn, 1957)***. These values are eased to find the "statistical measures" (or parameters) which assess the degree of particle "Sorting" and "the symmetry of particle size distribution". Of these statistical parameters, the following two are of particular importance ***(Pettijohn, 1957)***.

1- Coefficient of sorting "So"

This is a parameter for the degree of statistical sorting of particles. "Perfectly sorted" sediment has a coefficient of 1.0 and "well sorted" sediment has a value within 2.5. Values exceeding 4.5 indicate "Badly sorted" ***(Trask 1950)***. This parameter is computed as follows: -

$$So = \sqrt{Q3 / Q1}$$

Considering the mode of deposition of these sediments, the general index is that transportation by water or weathered in situ from badly-sorted particles, while the transportation by wind leads to well-sorted particles. ***Inman (1952)***.

2- Coefficient of skewness "Sk"

This is a measure of the degree of "symmetry or asymmetry" of particle size distribution curve. It shows prevalence of coarse or fine particles in the total mixture of particles. It is computed as follows:

$$Sk = \sqrt{Q_1 . Q_3} / Md^2$$

. The discussion of the obtained data of the statistical measures for the studied soil profiles, Tables (21, 22, 23 and 24) and their cumulative curves, Figs. (12 to 18), are given hereafter.

4.6.1.1- Soils of marine sediments

The statistical size parameters of the soils of marine sediments which are represented by profiles (8, 16, 17, 18, 19 and 20) are illustrated in Figs. (12 and 13) and their computed statistical size parameters are given in Table (21).

Sorting data show that the sediments constituting these profiles fall in badly, moderately and well sorted class. In this accord, profiles 17, 18, 19 and 20 constitute badly sorted sediments, except for the 20-80 cm layer of profile 17 which has moderately sorted sediments. Profile 8 constitutes well sorted sediments in the surface layer and badly sorted in the deepest layer, while profile 16 is characterized by moderately sorted sediments throughout the entire profile depth. Values of skewness indicate that all layers of the studied profiles are coarse skewed. Therefore, water or water and wind are expected to be responsible for the transport and deposition of these soils. This could lead to the presence of different materials forming these soils.

Table (21) Statistical size parameters of the soils of Marine sediments.

Ph.Unit	profile No.	Depth (cm)	Q_1	Md	Q_3	So	So indicator	Sk	Log Sk	Sk indicator
Marine sediment	8	0-25	25.0	55.0	125.0	2.24	Well-Sorted	0.98	-0.01	Ward to coarse
		25-75	0.0	30.0	100.0	...	....	....	0.00	Ward to coarse
		75-150	4.3	24.0	125.0	5.39	Badly-Sorted	0.97	-0.01	Ward to coarse
	16	0-25	6.0	35.0	105.0	4.18	Moderately-Sorted	0.72	-0.14	Ward to coarse
		25-50	5.0	32.0	99.0	4.45	Moderately-Sorted	0.70	-0.15	Ward to coarse
		50-150	7.0	38.0	110.0	3.96	Moderately-Sorted	0.73	-0.14	Ward to coarse
	17	0-20	4.5	38.0	110.0	4.94	Badly-Sorted	0.59	-0.23	Ward to coarse
		20-60	8.0	50.0	140.0	4.18	Moderatly-Sorted	0.67	-0.17	Ward to coarse
		60-150	6.5	45.0	145.0	4.72	Badly-Sorted	0.68	-0.17	Ward to coarse
	18	0-20	3.5	30.0	120.0	5.86	Badly-Sorted	0.68	-0.17	Ward to coarse
		20-70	3.2	24.0	120.0	6.12	Badly-Sorted	0.82	-0.09	Ward to coarse
		70-150	5.0	40.0	140.0	5.29	Badly-Sorted	0.66	-0.18	Ward to coarse
	19	0-25	3.4	28.0	95.0	5.29	Badly-Sorted	0.64	-0.19	Ward to coarse
		25-85	3.0	21.0	130.0	6.58	Badly-Sorted	0.94	-0.03	Ward to coarse
		85-150	4.5	33.0	130.0	5.37	Badly-Sorted	0.73	-0.14	Ward to coarse
	20	0-20	3.9	35.0	150.0	6.20	Badly-Sorted	0.69	-0.16	Ward to coarse
		20-70	3.8	25.0	90.0	4.90	Badly-Sorted	0.73	-0.14	Ward to coarse
		70-150	3.5	20.0	110.0	5.60	Badly-Sorted	0.97	-0.01	Ward to coarse

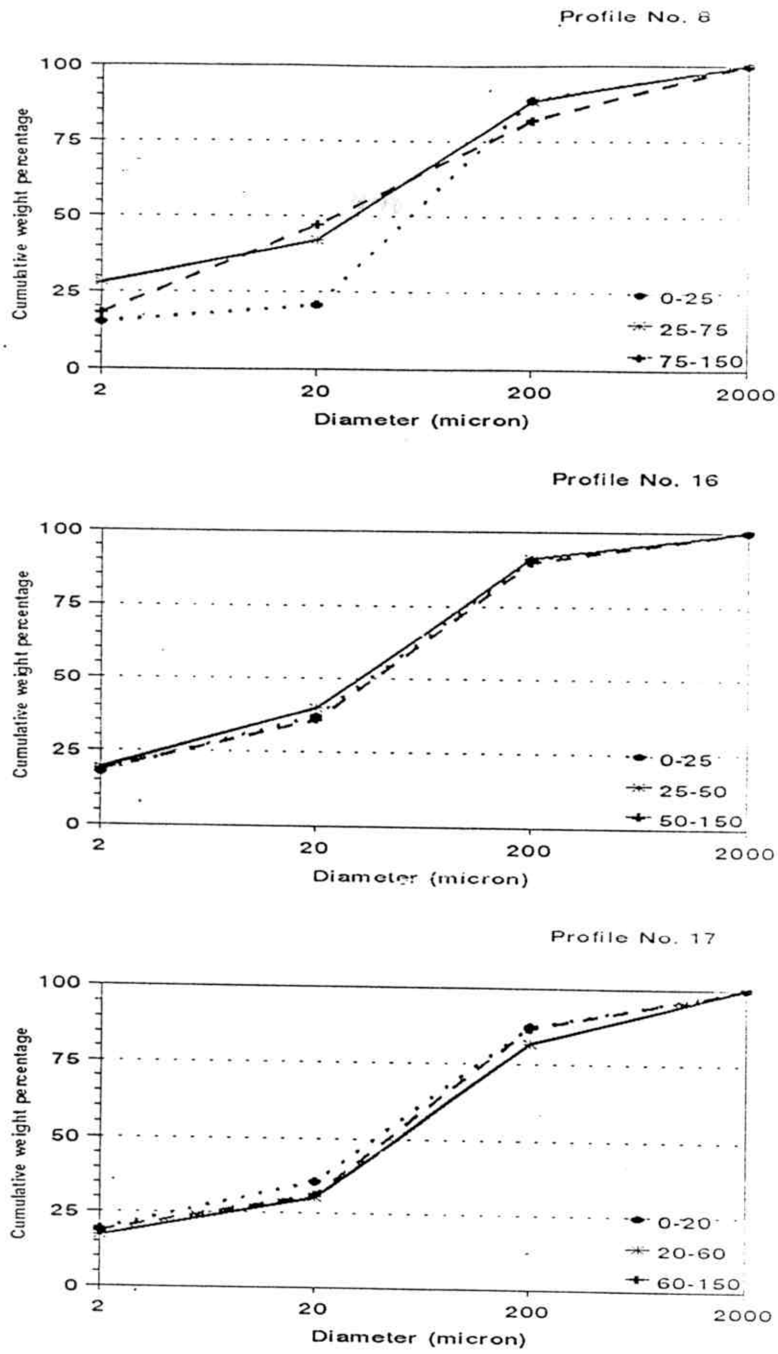


Fig. (12): Cumulative Frequency Curves of the Marine soil profiles 8, 16 and 17.

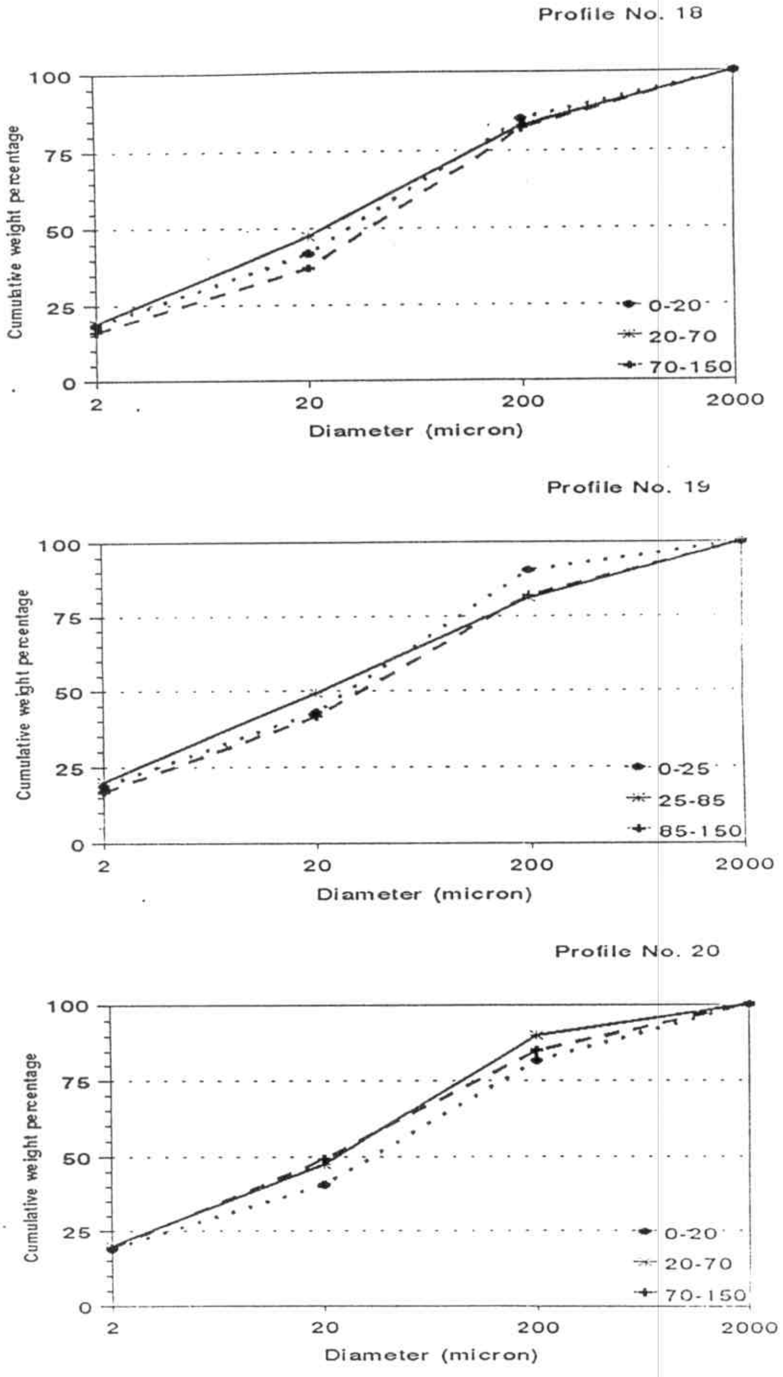


Fig. (13): Cumulative Frequency Curves of the Marine soil profiles 18, 19 and 20.

4.6.1.2- Soils of lacustrine sediments

Cumulative curves of the lacustrine sediments soils (represented by profiles 5, 6 and 7) are illustrated in Fig. (15) and computed statistical size parameters are given in Table (22). From the table, it is seen that the sediments constituting these profiles are characterized by badly-sorted sediments throughout their depths except for the surface layer of profile 6 and the uppermost surface layers of profile 7 which attain normal and moderately sorted sediments. The skewness values indicate that the sediments constituting the soil profiles are coarse-skewed throughout the entire profile depth. These sorting values are true reflection of the common transport and deposition of sediments under water action, except for the uppermost-surface layers of profile 7 whose sorting value suggests a superiority of confined water and wind over water action.

4.6.1.3- Soils of fluvio-lacustrine sediments

Cumulative curves of the soils of fluvio-lacustrine sediments which are represented by profiles 1, 2 and 4 are given in Fig. (14) and their statistical size parameters are computed in Table (23). The data reveal that these soils are characterized by badly-sorted sediments throughout the entire profile depth, except for the surface layer of profile 4 which has moderately sorted sediments. The sediments are generally skewed towards coarser admixtures. The pattern suggests two modes of transport and deposition, i.e., water in all layers of profiles 1 and 2, and water and wind action in the surface layer of profile 4.

Table (22) Statistical size parameters of the soils of Lacustrine sediments.

Ph.Unit	profile No.	Depth (cm)	Q_1	Md	Q_3	So	So indicator	Sk	Log Sk	Sk indicator
Lacustrine sediments	5	0-20	13.0	115.0	550.0	6.50	Badly-sorted	0.74	-0.13	Ward to coarse
		20-40	13.0	110.0	540.0	6.45	Badly-sorted	0.76	-0.12	Ward to coarse
	6	0-20	230.0	470.0	980.0	2.06	Normaly-Sorted	1.01	0.00	Ward to coarse
		20-45	19.0	120.0	530.0	5.28	Badly-sorted	0.84	-0.08	Ward to coarse
		45-150	30.0	160.0	620.0	4.55	Badly-sorted	0.85	-0.07	Ward to coarse
	7	0-20	95.0	370.0	850.0	2.99	Moderately-Sorted	0.77	-0.11	Ward to coarse
		20-75	6.0	24.0	950.0	3.98	Moderately-Sorted	0.99	0.00	Ward to coarse
		75-150	2.8	35.0	120.0	6.55	Badly-sorted	0.52	-0.28	Ward to coarse

Table (23) Statistical size parameters of the soils of Fluvio-lacustrine sediments.

Ph.Unit	profile No.	Depth (cm)	Q_1	Md	Q_3	So	So indicator	Sk	Log Sk	Sk indicator
Fluvio-lacustrine	1	0-25	0.0	20.0	100.0	...	...	...	...	...
		25-80	5.0	62.0	420.0	9.17	Badly-Sorted	0.74	-0.13	Ward to-coarse
		80-150	22.0	130.0	540.0	4.95	Badly-Sorted	0.84	-0.08	Ward to-coarse
	2	0-20	5.5	60.0	320.0	7.63	Badly-Sorted	0.76	-0.15	Ward to-coarse
		20-60	2.5	26.0	180.0	8.49	Badly-Sorted	0.82	-0.09	Ward to-coarse
		60-100	2.1	37.0	140.0	8.16	Badly-Sorted	0.46	-0.34	Ward to-coarse
		100-150	3.7	37.0	160.0	6.58	Badly-Sorted	0.66	-0.18	Ward to-coarse
	4	0-25	25.0	120.0	540.0	4.24	Moderately-Sorted	0.97	-0.01	Ward to-coarse
		25-75	0.0	11.5	150.0	...	...	...	...	...
		75-150	0.0	18.0	340.0	...	...	...	...	...

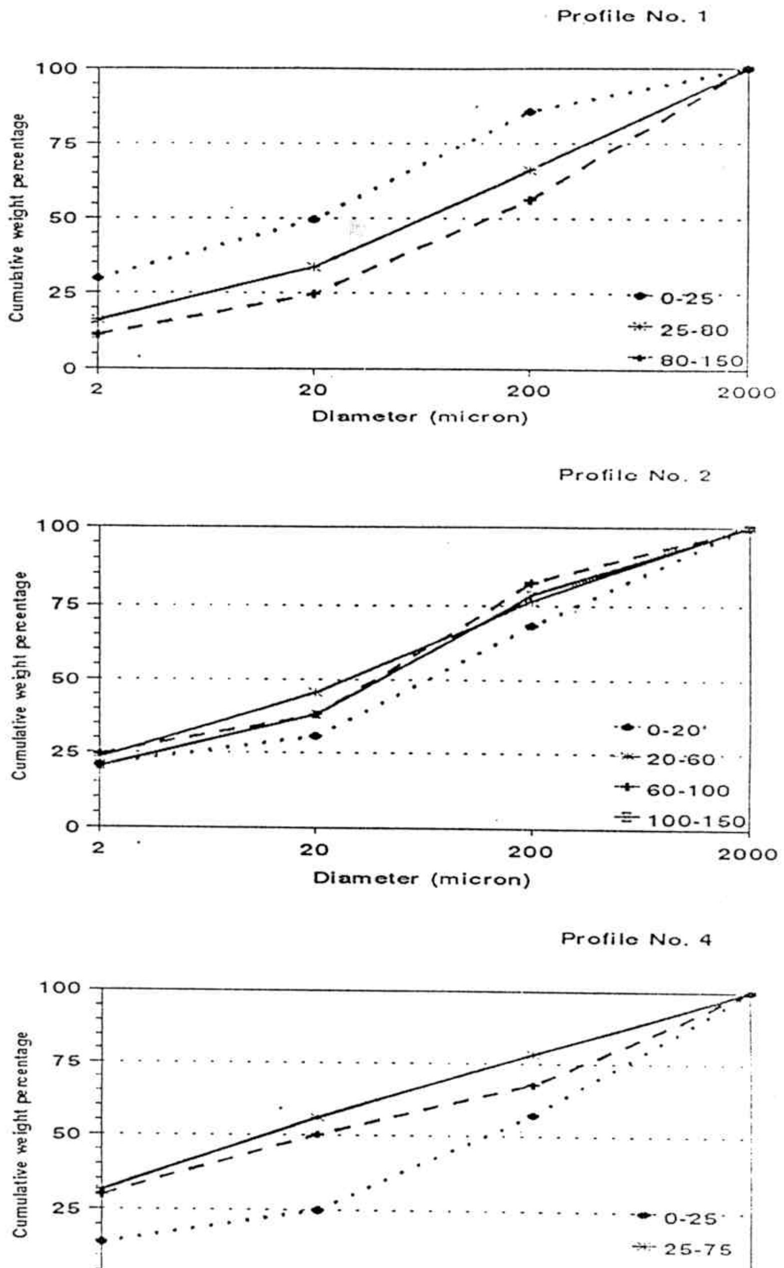


Fig. (14): Cumulative Frequency Curves of the Flvio-
lacustrne soil profiles 1, 2 and 4.

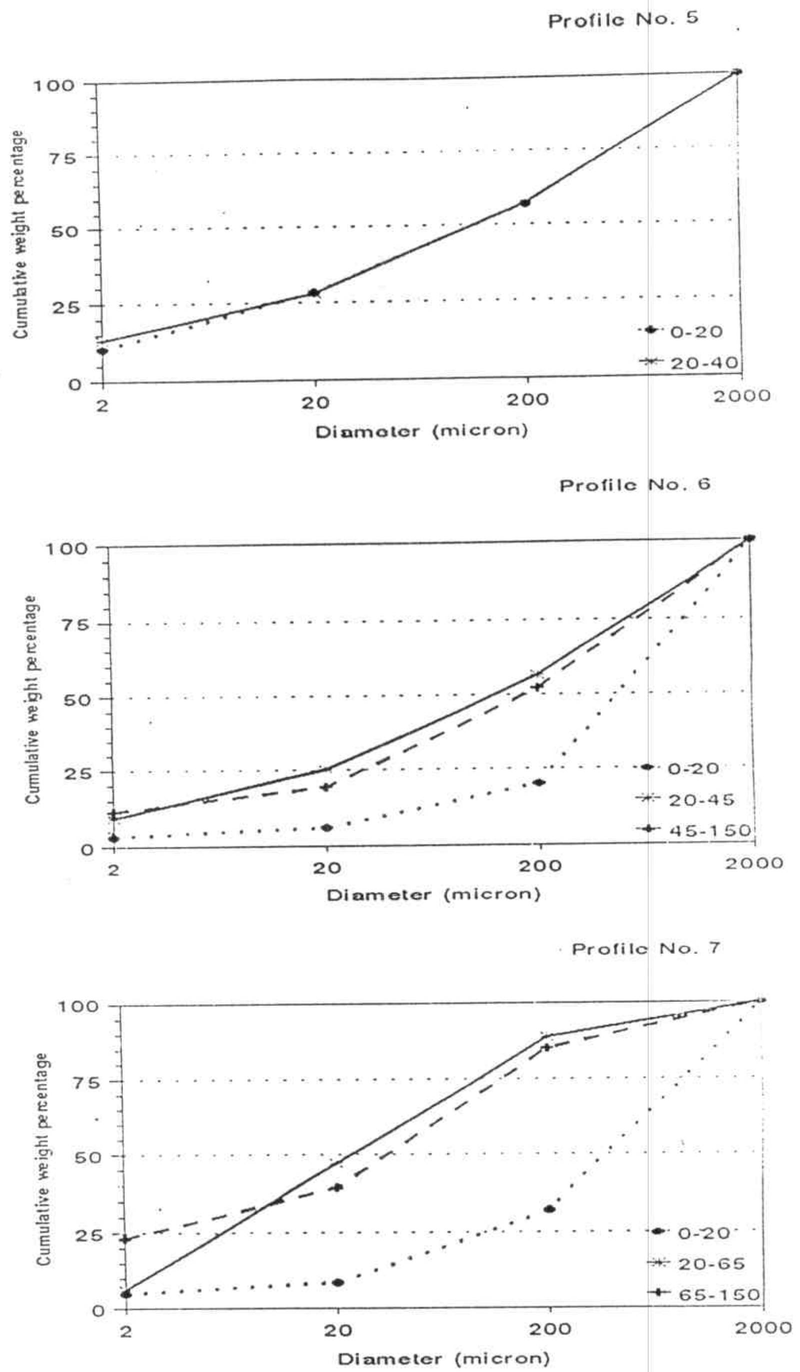


Fig. (15): Cumulative Frequency Curves of the Lacustrine soil profiles 5, 6 and 7.

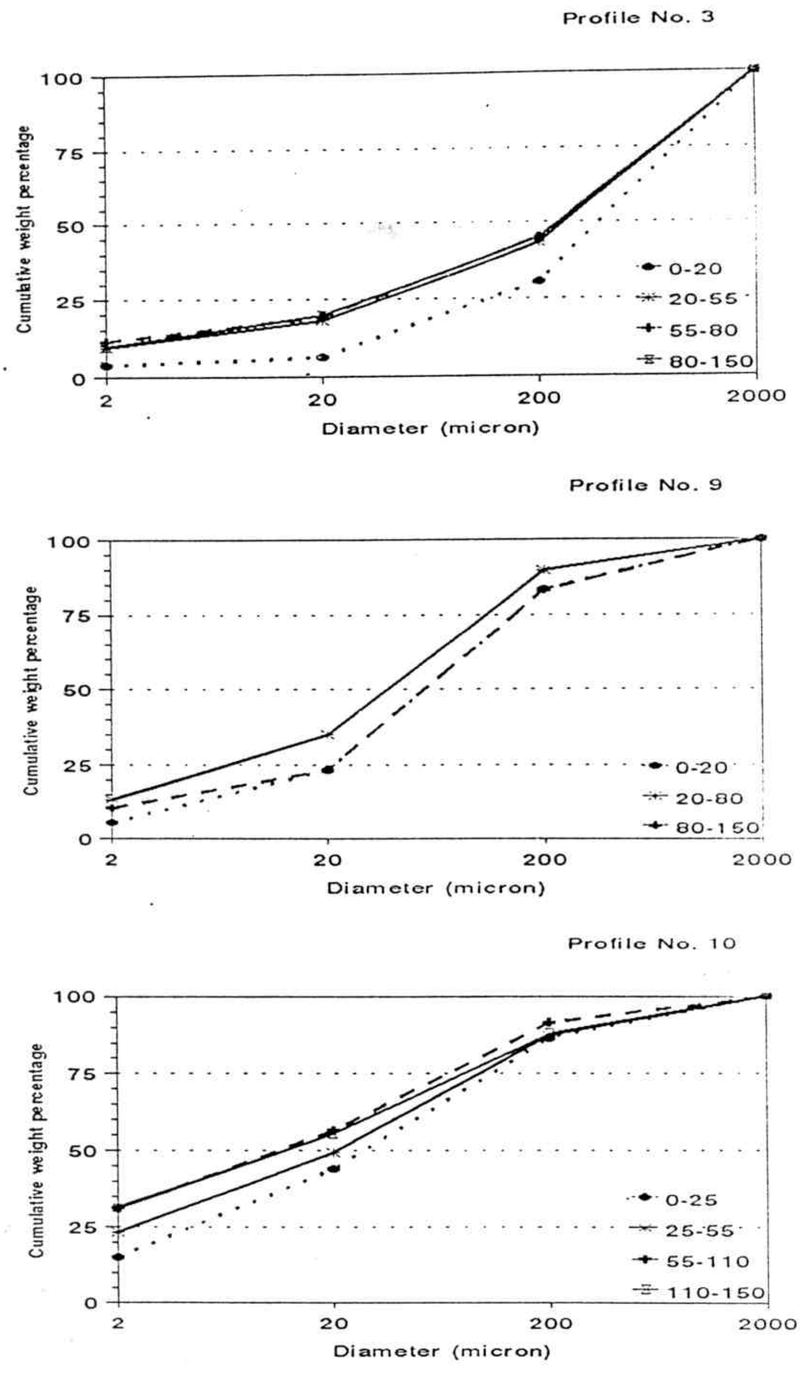


Fig. (16): Cumulative Frequency Curves of the Aeolian plain soil profiles 3, 9 and 10.

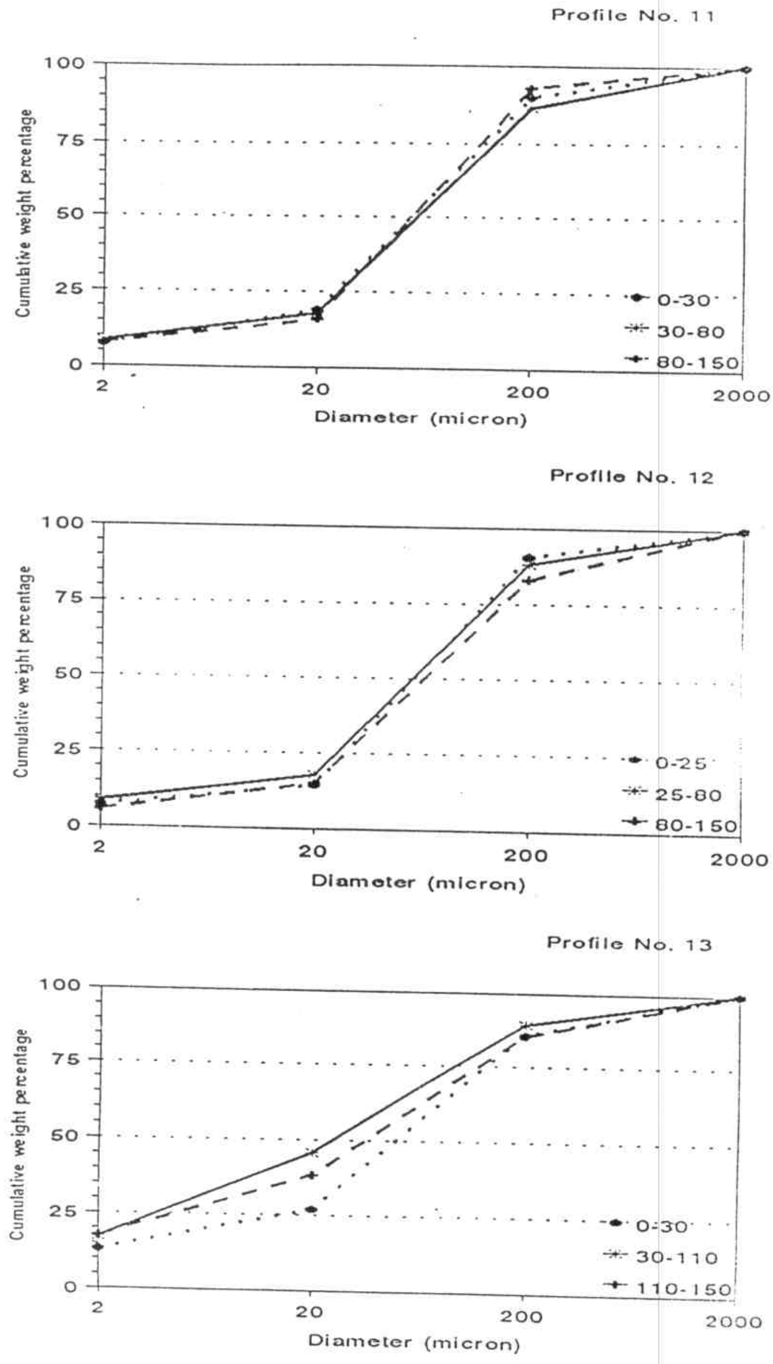
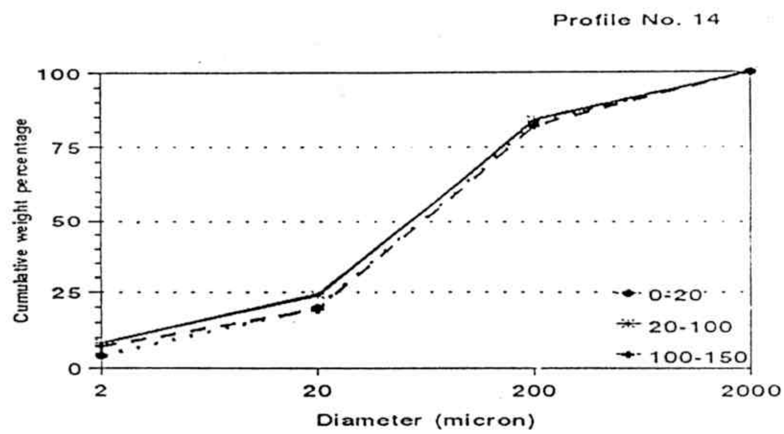


Fig. (17): Cumulative Frequency Curves of the Aeolian plain soil profiles 11, 12 and 13.



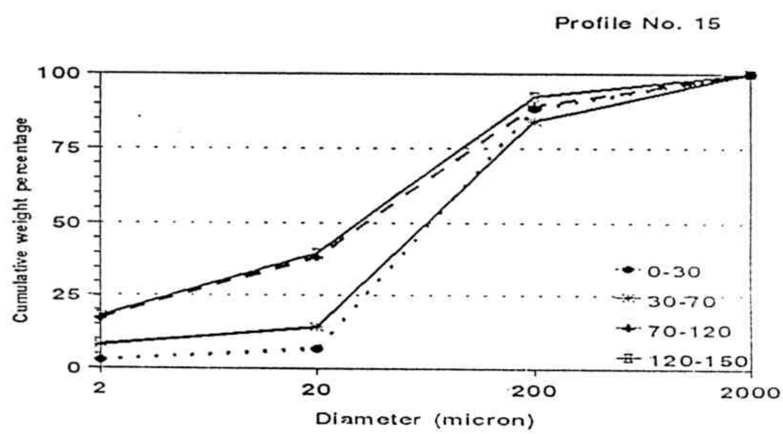


Fig. (18): Cumulative Frequency Curves of the Aeolian plain soil profiles 14 and 15.

4.6.2. WEATHERING RATIO.

The heavy mineral analysis

The mineralogical analysis data of the heavy residue are used for establishing the degree of soil profile uniformity. This is based on the assumption that certain minerals do not undergo any significant change during the course of soil formation. Such minerals are termed the index minerals. If the total percentages of the index mineral or the ratio between any two of them are constant throughout the soil profile, this might suggest one parent material. On the other hand, difference in such trend in the profile marks the location of another parent material. Generally, there is an agreement to consider zircon, tourmaline and rutile as index minerals because of their stability under any weathering condition, ***Barshad (1964)***, and ***Mitchell (1975)***. Evaluating profile uniformity and development in some Egyptian soils using soil mineralogy was carried out by ***El-Demerdashe et al. (1979), Hassona et al. (1995)*** and ***Hassona (1999)***.

In the present investigation, uniformity within the different profiles has been studied by applying different parameters, i.e., index figure (% of heavy minerals), index minerals (percentage of each of zircon, rutile and tourmaline) and ratios of zircon / rutile, zircon / tourmaline and zircon / (rutile + tourmaline) for the different layers within each profile, Table (25). Accordingly one might be able to state the following.

Regarding the soils of marine sediments represented by profiles (8 and 19), Table (25) showed apparent discontinuity of their parent materials, as revealed by the abrupt changes in the distribution of the index figures, index minerals and ratios between them. This confirms the fact of rather discontinuity of soil parent material. Also, soils are enriched in pyroboles rather than zircon, rutile and tourmaline. This suggests that these soils are still developing from the pedological point of view.

Soils of lacustrine sediments which are represented by profile 6 are depicted to be formed of heterogeneous parent materials as indicated by the heavy mineral data, Table (25). The graphic presentation of the particle size distribution and the values of the statistical measures confirm the heterogeneity of the soil material of this profile.

Concerning the soils of fluvio-lacustrine sediments which are represented by profiles 2 and 4, the data in Table (25) reveal that these soils are formed of multi-origin and or / multi depositional regimes, as indicated by irregular trend of the uniformity ratios and the index figures with depth.

Soils of aeolian plain which are represented by profiles 12 and 14, data in Table (25) show that these soils are mostly of similar origin, with local environmental changes throughout the entire depth of profiles. Values of index minerals and uniformity ratios show similarity of the two upper layers of profiles 12 and 14, while its lower layer is quite different, thus discontinuity is clear in these profiles. The results of the granulometric analysis confirmed those of heavy minerals as there are no clear differences in their frequency distribution in the non-clay fractions.

In short, the data of frequency distribution of index figures, resistant minerals and weathering ratios, lead to the conclusion that the soils constituting each profile are heterogeneous either due to their multi-origin or due to the subsequent variations along the course of sedimentation, and therefore, are considered young from the pedological view point.

Table (25) Weathering ratios of the studied soil profiles.

Physiographic units	profile No.	Depth (cm)	Index Figare %	Z / T ratio	Z / R ratio	Z / T+R ratio
Marine	8	0-25	4.10	3.97	3.97	1.98
		25-75	0.90	2.27	3.97	1.43
		75-150	1.90	4.06	5.04	2.25
	19	0-25	9.60	2.06	2.06	1.03
		25-85	7.30	1.87	3.83	1.26
		85-150	7.70	2.94	1.80	1.24
Lacustrine	6	0-20	5.50	2.00	2.53	1.12
		20-45	3.40	0.18	0.18	0.90
		45-150	12.80	1.00	2.56	0.72
Fluvio-lacustrine	2	0-20	5.60	2.43	5.67	1.70
		20-60	32.70	2.36	1.40	0.88
		60-100	10.80	2.92	1.06	0.78
		100-150	4.60	4.75	2.19	1.50
	4	0-25	8.80	2.48	6.61	1.80
		25-75	8.10	1.89	2.97	1.56
		75-150	5.40	3.60	3.60	1.80
Aeolian plain	12	0-25	13.50	5.04	5.04	2.52
		25-80	9.10	5.04	4.00	2.23
		80-150	10.50	2.31	2.85	1.28
	14	0-20	24.60	2.04	2.04	1.02
		20-100	15.30	2.51	5.11	1.68
		100-150	21.80	3.02	5.93	2.00

(Z) = Zircon *(R) = Rutile* *(T) = Tourmaline*

4.7. SOIL CLASSIFICATION

An important aspect of the study is to classify the soils according to ***Soil Taxonomy (Soil Survey Staff 1999).*** This system is based on soil morphology, physical, chemical and mineralogical properties, the presence or absence of diagnostic horizon in addition to the climatic environments of the surroundings. The classification of these soils down to the family level is presented in Table (26). Generally, all the studied profiles are characterized by aridic moisture and thermic temperature regimes, therefore they are classified into two soil orders namely ***Aridisols*** and ***Entisols.***

1. Order: ***Aridisols***

Soils of profiles 1, 2, 4, 5, 6, 7, 16, 17, 18, 19 and 20 are soils that do not have water available to mesophytic plants for long periods. They have one or more pedogenic horizons that may be formed in the present environment (secondary formation). The surface horizon or horizons are normally light in colour and have soft consistence when dry. The pedogenic horizons may be the result of translocation and accumulation of salts, carbonate, gypsum or silicate and of cementation by carbonates, gypsum or silicate. These be only an alteration product of the parent materials without any significant accumulation. The studied soils are placed under two suborders, ***Calcids*** and ***Gypsids***.

The characteristics of those suborders are discussed below:-

a). Sub order ***Calcids***:

Aridisols which have calcic or petrocalcic horizon within 100 cm of the soil surface:

I. Great group "***Haplocalcids***".

Haplocalcids are the calcids that:-

1. Have a calcic horizon but do not have a gypsic or petrogypsic horizon whose upper boundary lies within 100 cm of the surface.
2. Are calcareous in ali parts above the calcic horizon after the upper soil to a depth of 18 cm, has been mixed unless the texture is as course or courser than loamy fine sand.
3. Do not have a duripan whose upper boundary is within 1 m of the soil.
4. Do not have salic horizon above the calcic horizon, and
5. Do not have a petrocalcic horizon whose upper boundary is within 1 m of the soil surface.

1- Subgroup "***Sodic Haplocalcids***"

Haplocalcids that have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 % or more and are dry in all parts of the moisture control section for less than three-fourths of the time.

This subgroup can be classified to one family, Table (26)

* *Sodic Haplocalcids, fine loamy, mixed, hyperthermic* (profiles 6 and 7).

2- Sub group "***Lithic Haplocalcids***"

Haplocalcids that have lithic contact within 50 cm of the soil surface. One family can be identified under this subgroup in the studied area.

* *Lithic Haplocalcids, fine loamy, mixed, hyperthermic* (profile 5).

b). Sub-order ***Gypsids:***

Aridisols which have a gypsic or petrogypsic horizon that has its upper boundary within 100 cm of the soil surface.

Table (26) Calssification of the studied soil profiles

Order	Sub-order	Great group	Sub-group	Family	Representative profiles
Aridisols	*Calcids*	*Haplocalcids*	*Sodic Haplocalcids*	*fine loamy, mixed, hyperthermic*	*6, 7*
			Lithic Haplocalcids	*fine loamy, mixed, hyperthermic*	*5*
	Gypsids	*Haplogypsids*	*Typic Haplogypsids*	*coarse loamy, mixed ,hyperthermic*	*8, 16, 17, 18, 19, 20*
				fine loamy, mixed, hyperthermic	*1, 2, 4*
Entisols	*Orthents*	*Torriorthents*	*Typic Torriorthents*	*sand, mixed, hyperthermic*	*3, 9, 15*
	Psamments	*Torripsamments*	*Typic Torripsamments*	*sand, mixed, hyperthermic*	*10, 11, 12, 13, 14*

According to Soil Taxonommy (1999).

II. Great group "***Haplogypsids***"

Gypsids that doesn't have a petrogypsic, or petrocalcic, a natric, a calcic and an argillic horizons that have its upper boundary within 100 cm of the soil surface.

Subgroup "***Typic Haplogypsids***"

Haplogypsids which have a gypsic horizon that has its upper boundary within 18 cm of the soil surface and do not have a lithic contact within 50 cm of the soil surface. In the studied area; two families can be identified under this subgroup.

1- * *Typic Haplogypsids, coarse loamy, mixed, hyperthermic* (profiles 8, 16, 17, 18, 19 and 20)
2- * *Typic Haplogypsids, fine loamy, mixed, hyperthermic* (profiles 1, 2 and 4)

2. Order ***Entisols***

Entisols are characterized by a mineral nature, they have no evidence of development of pedogenic horizons so that diagnostic horizons are absent. These characteristics qualify them to be classified into the:

a). Suborder ***Orthents***

Soils of this suborder have a particle size class that is loamy or finer in some horizons. Have > 35 percent rock fragments (by volume) with organic carbon content of 0.2 % or less, that decreases regularly with depth.

I. Great group "***Torriorthents***"

Orthents that have a torric moisture regime/ or that have electrical conductivity of the saturation extract that is 2.0 dSm^{-1} or greater at 25 °C in some parts.

One sub-group can be identified under this great group in the studied soils *Typic Torriorthents* while at the family level, they are distinguished into the following.

* *Typic Torriorthents, sand, mixed, hyperthermic* (profiles 3, 9, and 15).

b). Sub-order "***Psamments***"

Entisols that have less than 35 percent (by volume) rock fragments and a texture of loamy fine sand or coarser, in all layers within the control section for the family particle size class.

II. Great group "***Torripsamments***"

Pasamments that have a torric moisture regime.

Sub-group "***Typic Torripsamments***"

Sub-group which represents, central concept of Torripsamments, this subgroup is represented by one family in the studied area.

* *Typic Torripsamments, sand, mixed, hyperthermic* (profiles 10, 11, 12, 13 and 14).

4.8. LAND SUTABILITY CLASSIFICATION FOR AGRICULTURE USE.

From the agriculture point of view, soils of the studied area are considered virgin soils. Evaluating the capability is an essential stage for future practical use. In this respect, many systems have been suggested to evaluate the agriculture limitations affecting land capability under the prevailing conditions. ***Sys system (1985)***, was applied in this work.

Table (27) shows the values that can be used as a guide in rating the soils.

According to ***Storie*** **(1964)** and ***Sys (1991),*** soils are classified following grades:

Grade	Soils	Rate
I	Excellent soils	100 - 80 %
II	Good soils	79 - 60 %
III	Fair soils	59 - 40 %
IV	Poor soils	39 - 20 %
V	Very poor soils	19 - 10 %
VI	Non agricultural soils	Less than 10 %

Table (27) Soil properties rating

Factor	Soil properties				Rating %
A	**Availability and quality of irrigation water**				
	Nile water				100
	Mixed Nile and drains water	1000 ppm.			90
		< 2000 ppm.			80
		2000-4000 ppm.			60
		4000-5000 ppm.			40
		> 5000 ppm.			20
B	**Soil Texture**				
	L., Si.L., S.C.L., S.L., Si.C.L., C.L.				100
	Si.				95-90
	L.S., S.C.				85-80
	F.S., M.S., Si.C., C				75-60
	C.S.				55-40
		Slight. Gr.	**Gravelly**	**Very gr.**	
	L, Si.L., C.L.	80	70	60	
	S.L	70	60	50	
	L.S.	60	50	40	
	S	50	40	30	

Factor	Soil properties	Rating %
C	**Soil profile depth (cm)**	
	>120	100
	120-90	100-
	90-60	90
	60-30	90-70
	<30	70-40
		<40
D	**Wetness (drainage conditions)**	
	Well drained	100
	Moderately drained	95-85
	Imperfectly drained	85-75
	Poorly drained	75-45
	Very poorly drained	45-25
E	**Salinity level (EC dS/m)**	
	<4	100
	4-8	95-85
	8-16	85-45
	>16	<45
F	**Sodicity (ESP)**	
	<10	100
	10-15	95-85
	15-30	85-75
	30-50	75-55
	>50	<55
G	**Carbonate as $CaCO_3$ content %**	
	<5	100
	5-10	95-90
	10-20	90-75
	20-50	75-40
	>50	<40

Factor	Soil properties	Rating %
H	**Gypsum ($CaSO_4$-$2H_2O$) content %**	
	<3	95
	3-10	100
	10-15	95
	15-25	75
I	**Slope %**	
	Flat or Almost flat (0 - 2 %).	100
	Undulating (2 - 8 %).	95-90
	Rolling (8 - 16 %).	90-85
	Hilly (16 - 30 %).	85-70
	Steep (30 - 45 %).	70-35
	Very steep (>45 %).	<35
J	**Erosion**	
	Wind erosion:	
	Non	100
	Slight	95-90
	Moderate	90-75
	Severe	75-20
	Water erosion:	
	Non	100
	Slight	95-90
	Moderate	90-75
	Severe	75-40
	Very Severe	40-10

Applying ***Sys system (1985)*** for the studied soil profiles leads to the data presented in Table (28). The results indicate that the studied soil profiles are placed between (II) and (V) grades as follows:

Table (28): Land capability classification of the studied soil profiles (According to Sys 1985).

Physiographic units	Profile No.	Rating of soil charcteristics %										Capa. rate%	Grade sample	Indication	index sample
		Availability of irrigation water	Textural grade	Profile depth (cm)	Drainage condition wetness	Salinity dSm^{-1}	Sodicity ESP	$CaCO_3$ %	Gypsum %	Slope %	Erosion				
Marine	8	95	92.5	100	100	100	94.5	89.7	95	95	95	63.9	II	Good	S_1
	16	95	93.4	100	100	41.3	75.4	81.5	95	90	95	18.3	V	V.poor	N
	17	95	94.8	100	100	48.8	77.5	76	95	90	95	21	IV	Poor	S_3
	18	95	100	100	100	100	74.6	77.8	95	90	95	44.8	III	Fair	S_2
	19	95	100	100	100	53.1	74.8	86	95	90	95	26.4	IV	Poor	S_3
	20	95	100	100	100	48.8	76.3	90.9	95	90	95	26.1	IV	Poor	S_3
Lacustrine	5	95	90.3	40	60	99.7	93.9	67.5	95	90	95	10.6	V	V.poor	N
	6	95	76.8	100	100	97.3	84.5	80.2	95	95	95	41.3	III	Fair	S_2
	7	95	88.5	100	100	100	80.7	81.9	95	95	95	47.6	III	Fair	S_2
Fluvio-lacustrine	1	95	99.5	100	100	100	86.8	67.7	95	90	95	45.1	III	Fair	S_2
	2	95	80	100	100	100	90.2	75.7	95	100	95	46.8	III	Fair	S_2
	4	95	93.4	100	100	100	90.5	79	95	100	95	57.3	III	Fair	S_2
Aeolian plain	3	95	77.1	100	100	100	100	76.6	95	100	95	50.6	III	Fair	S_2
	9	95	85	100	100	100	79.5	87.8	95	100	95	50.9	III	Fair	S_2
	10	95	82.2	100	100	68.3	79.5	80.9	95	90	95	27.9	IV	Poor	S_3
	11	95	80	100	100	100	74.7	86.6	95	90	95	39.9	III	Fair	S_2
	12	95	75	100	100	100	80.4	88.2	95	90	95	41.4	III	Fair	S_2
	13	95	87.5	100	100	80	80.7	77.7	95	95	95	35.8	IV	Poor	S_3
	14	95	85	100	100	100	79	82.8	95	90	95	42.9	III	Fair	S_2
	15	95	77	100	100	96.2	74	84.3	95	90	95	35.7	IV	Poor	S_3

4.8.1. Soils of grade (II):

The soils of grade II are represented by profile 8 (marine sediments). The soils of this grade are affected by $CaCO_3$ limitation.

4.8.2. Soils of grade (III):

The soils of this grade are represented by eleven soil profiles which belong to the different physiographic units as follows; 18 (marine sediments); 1, 2 and 4 (fluvio-lacustrine sediments) and 3, 9, 11, 12 and 14 (aeolian plain). These soils have moderate limitations which are different in their kind and degree. As a general, three different limitations are recognized. These dominant limitations are $CaCO_3$, texture grade and sodicity (ESP %).

4.8.3. Soils of grade (IV):

The soils of grade IV is represented by soil profiles 10, 13 and 15 (aeolian plain) and profiles 17, 19 and 20 (marine sediments). These soils are affected by moderate to severe limitations. The dominant limitations are $CaCO_3$, sodicity (ESP %), salinity and texture grade.

4.8.4. Soils of grade (V):

The soils of this grade are represented by two profiles which represent the soils of lacustrine sediments (profile 5) and marine sediments (profile 16). These soils are affected by very sever limitations .as salinity, sodicity and $CaCO_3$, while texture grade and soil profile depth are major limitations.

4.9. LAND SUTABILITY CLASSIFICATION FOR DIFFERENT CROPS

According to the value of the suitability index (SI), which is suggested by ***Sys (1991)***, the suitability classes are classified as follows:-

Symbol	Suitability classes	S Index
S1	Very suitable	100 – 75 %
S2	Moderately suitable	75 - 50 %
S3	Marginally suitable	50 - 25%
N	Non suitable	< 25 %

Sys (1993) suggested that the main soil parameters considered in calculating suitability index (SI) for cultivating certain crops are profile depth (A), gravel percent (B), climate (C), slope (D), drainage (E), texture (F), $CaCO_3$ % (G), gypsum content % (H), salinity (I) and alkalinity (J).

The equation used for these calculations is:

SI= A.B.C.D.E.F.G.H.I.J.

The studied crops are:

1- Field crops; alfalfa, barely, cotton, groundnut, onion and wheat.
2- Vegetables; beans, carrots, green pepper, pea, potato and tomato.
3- Fruit; Castor beans, citrus, guava, mango, olives and watermelon.

The studied soil profiles, with capability class of grades (II), (III) and (IV) are evaluated to determine its suitability for growing 18 crops, Table (29).

Table (29) Suitability classification of the studied soil profiles

Physiographic Units	Profile No.	Suitability index for different crops								
		Field Crops	Rate %	SI	Vegetables	Rate %	SI	Fruits	Rate %	SI
Marine sediments	8	Alfalfa	62.70	S2	Beans	25.00	S3	Castor Beans	77.30	S1
		Barley	66.20	S2	Carrots	42.40	S3	Citrus	33.10	S3
		Cotton	75.30	S1	Green pepper	48.50	S3	Guava	66.00	S2
		Groundnut	64.60	S2	Pea	64.90	S2	Mango	40.90	S3
		Onion	51.40	S2	Potato	70.20	S2	Olives	89.80	S1
		Wheat	51.30	S2	Tomato	47.10	S3	Watermelon	76.80	S1
	17	Alfalfa	12.60	N	Beans	0.00	N	Castor Beans	0.00	N
		Barley	28.60	S3	Carrots	0.00	N	Citrus	0.00	N
		Cotton	17.50	N	Green pepper	0.00	N	Guava	0.00	N
		Groundnut	5.50	N	Pea	0.00	N	Mango	0.00	N
		Onion	0.00	N	Potato	0.00	N	Olives	39.90	S3
		Wheat	0.00	N	Tomato	0.00	N	Watermelon	0.00	N
	18	Alfalfa	44.90	S3	Beans	3.50	N	Castor Beans	38.60	S3
		Barley	48.90	S3	Carrots	13.50	N	Citrus	11.40	N
		Cotton	57.60	S2	Green pepper	11.20	N	Guava	39.10	S3
		Groundnut	27.20	S3	Pea	22.30	N	Mango	11.70	N
		Onion	22.10	N	Potato	30.90	S3	Olives	61.70	S2
		Wheat	48.90	S3	Tomato	15.80	N	Watermelon	26.60	S3
	19	Alfalfa	16.30	N	Beans	0.00	N	Castor Beans	0.00	N
		Barley	32.30	S3	Carrots	0.00	N	Citrus	0.00	
		Cotton	25.60	S3	Green pepper	0.00	N	Guava	0.00	N
		Groundnut	5.90	N	Pea	0.00	N	Mango	0.00	N
		Onion	0.00	N	Potato	0.00	N	Olives	37.30	S3
		Wheat	0.00	N	Tomato	0.00	N	Watermelon	0.00	N
	20	Alfalfa	15.50	N	Beans	0.00	N	Castor Beans	0.00	N
		Barley	29.50	S3	Carrots	0.00	N	Citrus	0.00	N
		Cotton	23.20	N	Green pepper	0.00	N	Guava	0.00	N
		Groundnut	5.80	N	Pea	0.00	N	Mango	0.00	N
		Onion	0.00	N	Potato	0.00	N	Olives	37.80	S3
		Wheat	0.00	N	Tomato	0.00	N	Watermelon	0.00	N

Table (29) : Cont.

Physiographic Units	Profile No.	Field Crops	Rate %	SI	Vegetables	Rate %	SI	Fruits	Rate %	SI
Lacustine sediments	6	Alfalfa	42.80	S3	Beans	5.50	N	Castor Beans	51.00	S2
		Barley	32.60	S3	Carrots	26.80	S3	Citrus	8.20	N
		Cotton	58.30	S2	Green pepper	25.20	S3	Guava	33.80	S3
		Groundnut	31.60	S3	Pea	29.60	S3	Mango	17.20	N
		Onion	22.50	N	Potato	28.70	S3	Olives	72.80	S2
		Wheat	29.90	S3	Tomato	21.10	N	Watermelon	62.10	S2
	7	Alfalfa	45.90	S3	Beans	12.10	N	Castor Beans	50.20	S2
		Barley	45.10	S3	Carrots	31.80	S3	Citrus	13.70	N
		Cotton	52.00	S2	Green pepper.	20.40	N	Guava	45.00	S3
		Groundnut	31.40	S3	Pea	31.30	S3	Mango	15.20	N
		Onion	33.60	S3	Potato	39.30	S3	Olives	69.80	S2
		Wheat	42.40	S3	Tomato	24.30	N	Watermelon	45.50	S3
Fluvio-lacustrine	1	Alfalfa	41.10	S3	Beans	4.50	N	Castor Beans	66.50	S2
		Barley	56.30	S2	Carrots	25.90	S3	Citrus	12.40	N
		Cotton	65.50	S2	Green pepper	22.70	N	Guava	57.30	S2
		Groundnut	47.80	S3	Pea	34.40	S3	Mango	23.70	N
		Onion	26.20	S3	Potato	36.70	S3	Olives	85.60	S1
		Wheat	47.80	S3	Tomato	23.00	N	Watermelon	68.70	S2
	2	Alfalfa	41.70	S3	Beans	12.00	N	Castor Beans	61.60	S2
		Barley	49.20	S3	Carrots	26.80	S3	Citrus	19.10	N
		Cotton	61.10	S2	Green pepper	27.10	S3	Guava	57.90	S2
		Groundnut	30.30	S3	Pea	41.50	S3	Mango	26.70	S3
		Onion	28.40	S3	Potato	33.00	S3	Olives	85.60	S1
		Wheat	48.80	S3	Tomato	27.80	S3	Watermelon	60.30	S2
	4	Alfalfa	65.00	S2	Beans	26.00	S3	Castor Beans	79.00	S1
		Barley	62.80	S2	Carrots	40.20	S3	Citrus	25.36	S3
		Cotton	80.70	S1	Green pepper	36.30	S3	Guava	67.80	S2
		Groundnut	54.50	S2	Pea	53.40	S2	Mango	30.40	S3
		Onion	39.30	S3	Potato	53.30	S2	Olives	90.80	S1
		Wheat	63.20	S2	Tomato	35.80	S3	Watermelon	75.70	S1

Suitability index for different crops

Physiographic Units	Profile No.	Suitability index for different crops								
		Field Crops	Rate %	SI	Vegetables	Rate %	SI	Fruits	Rate %	SI
Aeolian plain	3	Alfalfa	33.40	S3	Beans	16.30	N	Castor Beans	65.10	S2
		Barley	25.80	S3	Carrots	40.30	S3	Citrus	21.34	N
		Cotton	59.50	S2	Green pepper	37.40	S3	Guava	49.40	S3
		Groundnut	55.00	S2	Pea	40.10	S3	Mango	22.40	N
		Onion	31.70	S3	Potato	28.00	S3	Olives	66.80	S2
		Wheat	35.90	S3	Tomato	28.10	S3	Watermelon	74.50	S1
	9	Alfalfa	28.50	S3	Beans	12.60	N	Castor Beans	72.50	S2
		Barley	44.80	S3	Carrots	42.20	S3	Citrus	16.60	N
		Cotton	58.60	S2	Green pepper	25.10	S3	Guava	58.80	S2
		Groundnut	35.10	S3	Pea	36.00	S3	Mango	23.90	N
		Onion	35.50	S3	Potato	67.70	S2	Olives	84.50	S1
		Wheat	43.60	S3	Tomato	32.70	S3	Watermelon	56.90	S2
	10	Alfalfa	41.40	S3	Beans	1.70	N	Castor Beans	29.90	S3
		Barley	40.80	S3	Carrots	22.20	N	Citrus	10.40	N
		Cotton	36.00	S3	Green pepper	15.70	N	Guava	30.30	S3
		Groundnut	17.60	N	Pea	23.00	N	Mango	13.70	N
		Onion	8.30	N	Potato	18.90	N	Olives	46.50	S3
		Wheat	29.90	S3	Tomato	14.40	N	Watermelon	26.30	S3
	11	Alfalfa	31.00	S3	Beans	14.00	N	Castor Beans	36.40	S3
		Barley	23.00	N	Carrots	29.60	S3	Citrus	14.10	N
		Cotton	41.20	S3	Green pepper	18.60	N	Guava	31.50	S3
		Groundnut	26.30	S3	Pea	25.80	S3	Mango	16.20	N
		Onion	27.20	S3	Potato	39.60	S3	Olives	62.70	S2
		Wheat	23.70	N	Tomato	18.60	N	Watermelon	34.40	S3
	12	Alfalfa	31.00	S3	Beans	15.60	N	Castor Beans	38.70	S3
		Barley	16.80	N	Carrots	30.70	S3	Citrus	15.00	N
		Cotton	37.20	S3	Green pepper	20.70	N	Guava	37.00	S3
		Groundnut	20.50	N	Pea	25.90	S3	Mango	20.10	N
		Onion	29.90	S3	Potato	39.80	S3	Olives	76.50	S1
		Wheat	15.90	N	Tomato	20.70	N	Water melon	43.50	S3
	13	Alfalfa	29.10	S3	Beans	6.80	N	Castor Beans	31.90	S3
		Barley	14.40	N	Carrots	20.20	N	Citrus	8.70	N
		Cotton	36.20	S3	Green pepper	16.80	N	Guava	29.30	S3
		Groundnut	17.80	N	Pea	21.40	N	Mango	12.90	N
		Onion	19.00	N	Potato	23.80	N	Olives	70.40	S2
		Wheat	21.30	N	Tomato	13.60	N	Watermelon	44.80	S3
	14	Alfalfa	54.20	S2	Beans	13.30	N	Castor Beans	61.90	S2
		Barley	36.00	S3	Carrots	33.90	S3	Citrus	16.40	N
		Cotton	58.80	S2	Green pepper	30.40	S3	Guava	50.30	S2
		Groundnut	46.90	S3	Pea	43.60	S3	Mango	27.30	S3
		Onion	30.90	S3	Potato	43.90	S3	Olives	67.80	S2
		Wheat	36.90	S3	Tomato	27.60	S3	Watermelon	61.50	S2
	15	Alfalfa	28.20	S3	Beans	7.90	N	Castor Beans	26.90	S3
		Barley	16.50	N	Carrots	23.80	N	Citrus	13.40	N
		Cotton	35.60	S3	Green pepper	16.20	N	Guava	22.00	N
		Groundnut	18.60	N	Pea	17.33	N	Mango	18.10	N
		Onion	18.00	N	Potato	21.70	N	Olives	59.00	S2
		Wheat	13.90	N	Tomato	14.30	N	Watermelon	32.40	S3

Data reveal that the studied soil profiles include all the suitable classes (S_1, S_2, S_3, and N). An account on the suitability of the studied soils for different crops is given herafter.

4.9.1. Soils of marine sediments.

The soils represented by profiles 8, 17, 18, 19 and 20 are placed at very suitable (S_1), moderately suitable (S_2) and marginally suitable (S_3) for growing field crops (cotton, alfalfa, barely and groundnut) followed by vegetables (potato, tomato and green pepper) and also fruit trees (olives, guava and castor beans).

4.9.2. Soils of lacustrine sediments

The soils represented by profiles 6 and 7 are placed at moderately suitable (S_2) and marginally suitable (S_3), respectively for growing field crops (cotton, alfalfa, barely, groundnut and wheat) followed by vegetables (green pepper, beans, carrots and tomato) and also fruit trees (castor beans, olives, guava and watermelon).

4.9.3. Soils of fluvio-lacustrine sediments

The soils which are represented by profiles 1, 2 and 4 are placed at very suitable (S_1), moderately suitable (S_2) and marginally suitable (S_3) respectively for growing field crops (cotton, barely, alfalfa, groundnut, onion and wheat) followed by vegetables (potato, pea, carrots and green pepper) and also fruit trees (olives, watermelon, guava, castor beans and mango).

4.9.4. Soils of aeolian plain

The soils represented by profiles 3, 9, 10, 11,12, 13, 14 and 15 are placed at very suitable (S_1), moderately suitable (S_2) and marginally suitable (S3), respectively for growing field crops (alfalfa, groundnut, barely, cotton and onion) followed by vegetables (carrots, green pepper, pea and