GEOMORPHOLOGY AND GENESIS OF SOME SOILS EAST AND SOUTH El QATTARA DEPRESSION

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Abstract

The aim of the current work is to study the geomorphology and genesis of some soils east and south El Qattara Depression at the north of the Western Desert, Egypt. The study area is located between latitudes 29° 41′ and 30° 30′ N and longitudes 27° 39′ and 28° 43′ E.

The study area can be divided into five geomorphic units namely: Plateau, Pediments, El Qattara Depression, Alluvial plain (western and eastern) and Sand dunes. The soils of these units are mostly sand texture except El Qattara Depression unit which has a sandy loam to clay loam texture. The graphic mean size index is mostly ranging from fine to coarse sand size. The sorting index ranging from moderately well sorted to poorly sorted indicating aeolian and aqueous media of transportation and deposition except the sand dunes unit where the graphic mean size index is fine sand and the sorting index is moderately well sorted indicating aeolian media of transportation and deposition.

The sand fraction consists of light and heavy minerals. The light minerals are the main constituent of sand fraction and consists mainly of quartz (≥ 90 %) followed by feldspars (plagioclase and orthoclase) in addition to muscovite and calcite minerals. The heavy minerals consist of opaques and non-opaques. Opaque minerals are the major heavy fraction constituent in all the examined soils and composed essentially of iron oxide minerals. The complementary non-opaque minerals consist of: (a) Sedimentary origin minerals, which also named ultrastable or index minerals, are mostly dominating the non-opaque minerals. (b) Igneous origin minerals or unstable minerals are the second abundance minerals in the study area. (c) Metamorphic origin minerals or metastable (index) minerals are detected in considerable portions in the study soils.

The source rocks of sand in the study area are mixture of sedimentary, igneous and metamorphic rocks. However, the sedimentary rocks are the first source of sands in western alluvial plain sub unit. The vertical distribution of amphiboles, pyroxenes and index minerals change irregularly depth wise indicating that the study soils are recent, poorly developed and immature from the pedogenic point of view.

The soils of western alluvial plain sub unit are partly affected by Nile sediments than other study units where the Nile sediments during flood periods deposited mostly in the near land south of El Qattara Depression.

INTRODUCTION

El Qattara Depression, which has a nearly triangular shape with a vertex at about 67 km distance from the Mediterranean Sea, is the largest natural closed land depression (19,605 km^2) of the Eastern Sahara. It forms one of the most significant features of the northern part of the Western Desert of Egypt. The depression is a closed inland basin, and the periphery of the depression is usually taken at the present zero Mediterranean Sea level. The lowest point of the depression is 134 m below mean sea level at the western end and its maximum length extends 145 km north-south direction.

El Qattara Depression is cut into horizontal layer of Miocene to Eocene sediments (Said, 1962). Sand and clay layers of Lower Miocene age (Moghra Formation) form the bottom and the surroundings of the north-eastern part of the depression. The northern border is formed by a steep escarpment of white limestone of Middle Miocene (Marmarica Formation). Over large areas of the floor, the bedrock is covered with younger deposits including sand dunes, sabkha and Quaternary evaporite sediments (EGPC/CONCO-Coral, 1987).

The aim of the current work is to study the geomorphology and genesis of some soils east and south El Qattara Depression north of the Western Desert, Egypt.

MATERIALS AND METHODS

The study area lies to the east and south of El Qattara Depression at the north of the Western Desert, Egypt. It is located between latitudes 29° 41′ and 30° 30′ N and longitudes 27° 39′ and 28° 43′ E (Figure 1).

Data:

- Topographic maps (1:100000),
- Geologic map (1:500000),
- Satellite data (ETM^+ with path 178 and rows 39 and 40, acquired in 1998) and the data were analyzed using Arc GIS 9.3 and ERDAS IMAGINE 9.2 software programs.

Field work:

Twenty five soil profiles were selected and allocated by the portable global positioning system (GPS) representing the different geomorphic units in the study area. Eighty two soil samples were collected from these soil profiles.

Laboratory work:

Grain size analysis: The grain size analysis was carried out using the methods of Folk (1968 and 1980). The gravel contents (> 2 mm diameter) were separated from the sample using 2 mm sieve diameter. Sand was separated from Silt and clay by wet sieving using 0.063 mm sieve diameter and fractionated by dry sieving using 2, 1, 0.5, 0.25, 0.125 and 0.063 mm sieves diameter. Silt and clay were determined by the pipette method.

Measure of graphic mean size and sorting: The data of the grain size distribution of the sample were plotted on arithmetic probability graph paper as cumulative curves, where the cumulative percentages were plotted against the phi-diameters (φ) to calculate the grain size parameters for the whole fractions (Folk and Ward, 1957). The graphic mean size (Mz) and inclusive graphic standard deviation (sorting; бI) were calculated by using the following equations:

$Mz = (\varphi_{16} + \varphi_{50} + \varphi_{84}) / 3.$ $бI = (\varphi_{84} - \varphi_{16}) / 4 + (\varphi_{95} - \varphi_{5}) / 6.6.$

Mineralogical analysis of the sand fractions: Separation of the light and heavy minerals was carried out by using bromoform (specific gravity = 2.85 ± 0.02 g/cm^3) on the very fine sand fraction (0.125 - 0.063 mm in diameter) according to Brewer (1964).

The light and heavy fractions were weighted and the index figure (I F.) was calculated as follows:

$$I\ F. = \frac{\text{Heavy mineral weighted}}{\text{Light mineral weighted}}$$

The separated light and heavy grains were permanently mounted on glass slides using Canada balsam. Systematic identification of the minerals was carried out under the polarizing microscope as described by Keer (1959) and Milner (1962). About 500 grains from random fields were counted for each sample and the percentages of each mineral were calculated. Calculations of percentage of heavy minerals were made considering the non-opaque minerals as 100 %; however, the opaque ones were also recorded.

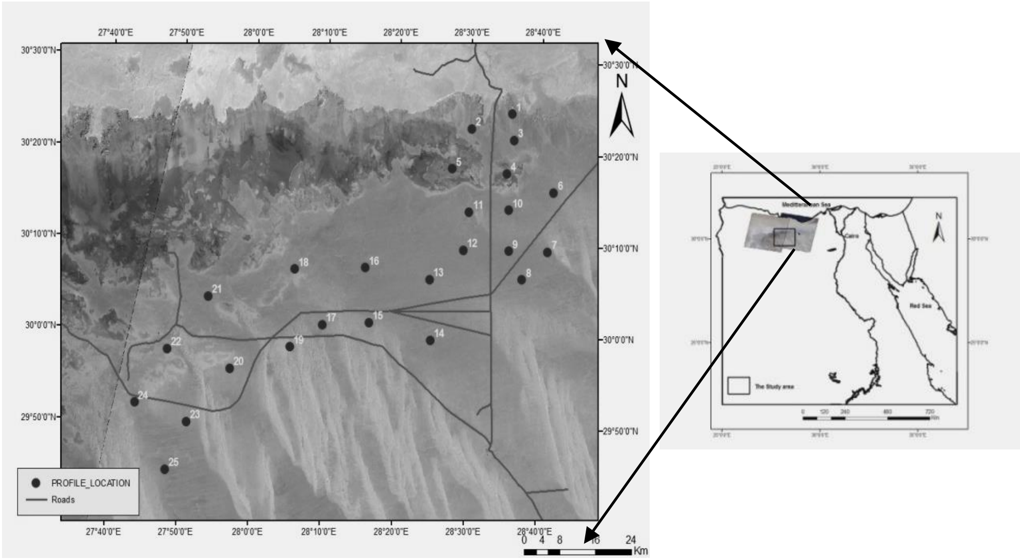


Figure 1. Profile location and roads on a rectified subset ETM$^+$ image (Path 178 - rows 39 and 40) of the study area.

RESULTS AND DISCUSSION

<u>Geomorphic Units</u>:

The main geomorphic units of the study area were identified by using topographic maps (1:100000), geologic map (1:500000), satellite data (ETM$^+$ with path 178 and rows 39 and 40, acquired in 1998) and guided by visual interpretation of Digital Elevation Model (DEM) (Ragab, 2011). These data were analyzed using Arc GIS 9.3 following the geomorphic approach of Dobos *et al.*(2002).The study area is divided into five geomorphic units (Figure 2) namely: Plateau, Pediments, El Qattara Depression, Alluvial plain (Eastern and Western) and Sand dunes.

1-Plateau:

El Qattara Depression is bounded by a steep escarpment along its northern and western side, with an average escarpment elevation of 250 m asl. This northern plateau is covered by the so called Marmarica Formation, a sequence of Middle Miocene mostly calcareous sediments ranging in thickness from a few meters at the depression rim to several hundred meters at the coast, where Pliocene carbonate rocks cover the older formations. Therefore, this unit does not contain any soil profiles.

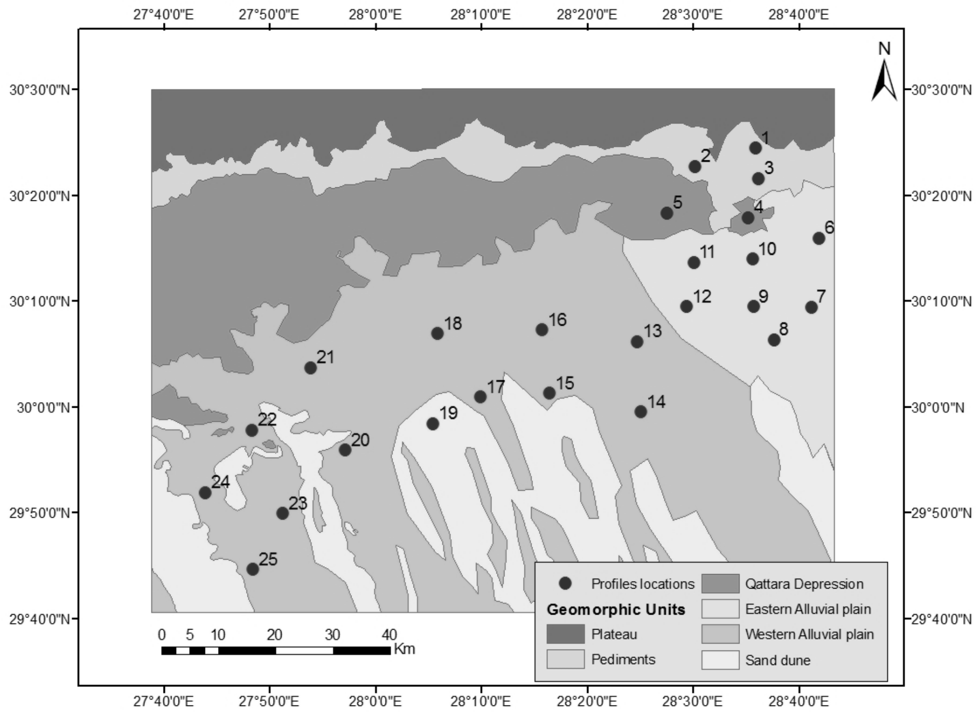


Figure 2. Geomorphic units and profile locations of the study area

2-Pediments:

Pediments is the northern wall of El Qattara Depression that capped by sediments of Middle Miocene age. Its cliffy slopes descend southward to an axial valley. Alluvial fans shapes are mostly present in the foot slopes of the cliffs.

This unit is represented by profiles Nos. 1, 2 and 3. The soils of this unit are mostly sand texture (Table 1) and possess mean size index (Mz) ranging from fine to medium sand size (Table 2). The sorting parameter (*6*I) index ranging from moderately well sorted to poorly sorted (Table 2) deposited by mixture of aeolian and aqueous media of transportation according to the information mentioned by Folk (1968) and Brewer (1964).

3- El Qattara Depression:

The floor of the Quaternary depression below the contour line of 60 m bsl is mainly covered by sabkha and evaporite materials resulting from the evaporation of seeped saline groundwater, while salt-beds cover the western end of the lowest portion of the depression. Within the depression, cones, towers, mushrooms and plateau-like hill landforms, ranging in height from 5 to 30 m, are common, especially near the western scarp of the depression. Sinkholes and caves are development processes, and were further deepened and extend by earth mass wasting, and fluviotile processes (Albritton *et al.,* 1990). It has also been suggested that the depression is of structural control origin (Gindy, 1991). A new theory proposed by Aref *et al.* (2002) is that the high salinity of the near-surface groundwater, and the sodium chloride nature and the high rate of evaporation cause the disintegration of the bedrock.

This unit is represented by profiles Nos. 4 and 5. The soil of this unit is mostly loamy texture and the mean size index (Mz) ranges from coarse silt to medium sand. The sorting index (σI) is poorly sorted indicating aqueous media of transportation.

4-Alluvial plain:

This unit is located in east and south of El Qattara Depression. Alluvial plain is the largest and the most important unit in the study area because it represents the suitable area for agriculture. It is characterized by almost flat to gently sloping land and consists of sand sheet deposits. This unit has abundant impressive fossilized trees indicating present of plant growth in the past geological periods (Albritton *et al.,* 1990).

This unit is classified into two sub units based on the morphological descriptions and the mean size index (Mz):

(a) Eastern sub unit: represented by profiles Nos. 6, 7, 8, 9, 10, 11 and 12. This sub unit is mostly sand texture (Table 1) and possesses mean size index (Mz) ranging from medium to coarse sand size (Table 2).

(b) Western sub unit: represented by profiles Nos. 13, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24 and 25. This sub unit is mostly sand texture and possesses mean size index (Mz) ranges from fine to coarse sand size.

The sorting index (σI) of alluvial plain unit ranges from moderately sorted to very poorly sorted soils deposited by aeolian and aqueous media of transportation.

5-Sand dunes:

The alluvial plain unit that cover most of the study area are associated with longitudinal sand dunes (linear dunes). The dune axes trend north-northwest and south-southeast, parallel with prevailing wind direction.

The dunes are represented by profile No.19 and composed mainly of sand texture. The mean size index (Mz) is fine sand and the sorting index (σI) is moderately well sorted indicating aeolian media of transportation.

Sand Mineralogy:

The sand fraction consists of light and heavy minerals. The light minerals are the main constituent of sand fraction in the study area (≥ 97 %; Table 3). The index figure is distributed irregularly depthwise in the different geomorphic units (Table 3).

1- Light minerals (Sp. Gr. < 2.85 g/cm^3):

They consist mainly of quartz (≥ 90 %) followed by feldspars (plagioclase and orthoclase, from 2 - 5%) in addition to muscovite (≤ 2 %) and calcite (≤ 1 %).

2-Heavy minerals (Sp. Gr. > 2.85 g/cm^3):

The heavy minerals could be used as a tool to evaluate the source rocks, soil profile uniformity, and the state of mineral weathering. The frequency distribution of the heavy minerals (opaques and non-opaques) will be discussed in the same order as given in Table (4).

A-Opaque minerals:

Opaque minerals are generally the major heavy fraction constituent in all the examined soils (from 50.7 to 65.2 %; Table 4). These minerals are composed essentially of iron oxide minerals (e.g. magnetite, illimanite and hematite and other minerals).

Table 1. Grain size distribution and texture classes of studied soil profiles.

Geomorphic Units	Profile No.	Depth (cm)	Sand* (2.0 - 0.063 mm)%					Silt (0.063 - 0.002 mm) %	Clay (< 0.002 mm) %	Textural Classes**
			V.C.S	C.S	M.S	F.S	V.F.S			
Pediments	1	0-20	22.12	21.45	27.04	16.91	4.10	4.38	4.0	S
		20-50	21.89	27.32	29.36	15.77	3.44	1.22	1.0	S
		50-120	17.09	25.00	30.72	19.75	4.49	1.65	1.3	S
	2	0-15	8.06	10.07	40.25	33.43	5.06	2.13	1.0	S
		15-40	1.28	5.93	42.97	44.29	5.08	0.30	0.15	S
		40-120	0.86	5.58	57.66	33.26	2.13	0.31	0.20	S
	3	0 - 15	14.22	14.95	27.11	33.57	6.76	2.29	1.10	S
		15 - 60	1.26	3.24	6.19	54.70	8.35	16.26	10.0	S L
		60-120	1.54	1.89	5.69	66.56	14.47	6.35	3.50	S
El Qattara Depression	4	0-50	1.13	8.68	10.46	10.02	7.66	32.05	30.0	CL
		50-150	0.00	0.51	2.25	28.82	7.72	30.50	30.2	CL
	5	0-20	19.25	14.36	27.74	25.07	6.46	4.00	3.12	S
		20-100	6.68	13.66	23.93	26.07	6.12	12.24	11.3	SL

Alluvial plain	Eastern sub unit	6	0-15	2.63	10.79	28.09	33.11	17.63	4.10	3.65	S
			15-40	7.63	22.89	42.41	18.93	4.65	2.00	1.49	S
			40-80	9.98	22.39	38.91	19.15	5.42	2.15	2.0	S
			80-150	12.64	25.38	38.49	16.24	3.87	2.00	1.38	S
		7	0-15	27.75	46.98	17.70	5.25	2.08	0.14	0.10	S
			15-30	17.26	51.94	19.89	7.23	2.35	0.83	0.50	S
			30-120	11.87	67.09	18.23	1.62	0.36	0.53	0.30	S
		8	0-25	14.08	28.85	26.41	18.68	7.13	2.55	2.30	S
			25-65	19.53	44.61	28.42	5.44	0.96	0.64	0.40	S
			65-150	12.97	39.90	39.68	4.70	0.68	1.27	0.80	S
		9	0-15	8.95	23.51	29.58	28.61	7.09	1.26	1.0	S
			15-120	14.06	46.99	29.08	6.58	0.92	1.27	1.10	S
		10	0-10	8.69	17.99	33.41	27.41	8.77	2.13	1.60	S
			10-30	6.26	31.59	36.28	20.11	4.05	1.00	0.70	S
			30-60	39.00	27.66	16.06	12.18	2.61	1.49	1.00	S
			60-100	6.13	26.55	41.63	19.83	3.38	1.48	1.00	S
		11	0-15	19.78	31.42	31.05	11.84	3.43	1.38	1.10	S
			15-40	19.90	41.73	32.04	4.09	1.04	0.70	0.50	S
			40-90	14.41	33.36	46.29	4.63	0.71	0.40	0.20	S
			90-150	16.33	39.44	39.07	3.87	0.67	0.42	0.20	S
		12	0-10	19.51	30.97	35.34	10.62	2.55	0.71	0.30	S
			10-50	12.19	25.91	43.84	13.03	2.43	1.60	1.00	S
			50-150	14.68	27.83	43.32	10.30	1.25	1.62	1.00	S
	Western sub unit	13	0 - 35	5.59	20.95	42.90	20.61	3.59	4.16	2.20	S
			35 - 75	15.17	35.76	38.24	7.91	0.71	1.21	1.00	S
			75 -150	14.11	33.12	35.19	13.77	2.04	1.17	0.60	S
		14	0 -15	14.97	26.22	18.28	23.23	11.19	4.00	2.11	S
			15 – 40	20.35	42.95	22.05	9.23	2.86	1.56	1.00	S
			40 – 80	37.33	38.50	15.09	5.19	1.63	1.26	1.00	S
			80 -150	25.73	45.71	19.54	5.40	1.60	1.22	0.80	S

***Sand:**

V.C.S: Very coarse sand (2 - 1mm)
C.S: Coarse sand (1 - 0.5mm)
M.S: Medium sand (0.5 - 0.25mm)
F.S: fine sand (0.25 - 0.125mm)
V.F.S: Very fine sand (0.125 - 0.063mm)

****Texture classes:**

S: Sand
LS: loamy sand
SL: Sandy loam
CL: Clay loam
L: Loam

Table 1. Cont.

Geomorphic Units		Prof. No.	Depth (cm)	Sand* (2.0 - 0.063 mm)%					Silt (0.063 - 0.002 mm) %	Clay (< 0.002 mm) %	Textural Classes**
				V.C.S	C.S	M.S	F.S	V.F.S			
Alluvial plain	Western sub unit	15	0 -10	4.56	13.97	18.92	32.92	21.62	5.01	3.00	S
			10 - 30	23.82	25.36	29.29	13.60	4.22	2.21	1.50	S
			30 -70	19.65	22.50	26.78	18.62	7.71	2.74	2.00	S
			70 -130	9.10	16.34	28.88	26.58	13.47	3.43	2.20	S
		16	0 - 20	7.06	8.06	17.80	30.94	23.19	7.45	5.50	LS
			20 - 60	5.11	9.10	12.85	33.02	28.28	6.69	5.00	LS
			60 -150	5.91	10.43	13.68	32.27	25.55	7.16	5.00	LS
		17	0 -15	9.81	14.02	15.49	29.86	23.17	4.45	3.20	S
			15 - 40	6.12	31.82	19.96	12.82	3.28	15.00	11.0	SL
			40 -75	24.47	44.09	23.14	5.92	0.44	1.24	0.70	S
			75 -150	4.22	36.00	48.80	6.98	0.78	2.00	1.22	S
		18	0 - 25	21.42	32.08	20.88	18.09	5.17	1.36	1.00	S
			25 - 80	29.03	40.64	15.03	9.09	3.03	2.00	1.18	S
			80 -150	27.88	42.12	15.13	8.02	2.61	3.00	1.24	S
		20	0 - 20	6.40	19.96	25.38	30.98	8.96	5.32	3.00	S
			20 - 40	10.47	20.38	20.39	26.97	5.55	9.00	7.24	LS
			40 -70	13.91	24.26	22.88	24.48	4.76	5.71	4.00	S
			70 -150	13.94	26.28	24.75	23.38	4.68	4.00	2.97	S
		21	0 -15	23.88	27.03	14.23	20.73	10.35	2.18	1.60	S
			15 - 60	28.21	33.79	14.34	15.59	5.43	1.64	1.00	S
			60 -150	9.58	17.71	19.73	28.11	16.59	5.00	3.28	S
		22	0 - 25	10.33	28.16	25.29	28.18	6.16	1.00	0.88	S
			25 - 90	10.73	25.36	26.85	28.22	6.78	1.06	1.00	S
			90 -150	15.79	26.99	22.05	25.86	6.91	1.40	1.00	S
		23	0 - 30	50.48	20.05	11.75	12.01	3.39	1.32	1.00	S
			30 -70	21.97	18.53	14.91	24.31	14.79	3.39	2.10	S
			70 -150	25.45	21.95	16.27	23.16	10.46	1.61	1.10	S
		24	0 -15	5.83	9.82	26.56	33.96	16.27	4.56	3.00	S
			15 - 50	1.56	5.14	31.48	29.47	7.46	14.69	10.20	SL
			50 - 70	2.00	10.21	56.63	15.23	1.82	9.00	5.11	LS
			70 -150	2.1	2.13	27.25	14.41	3.54	30.57	20.00	L
		25	0 - 15	6.67	6.55	19.96	40.27	18.67	4.78	3.10	S
			15 - 30	22.53	9.96	17.56	28.88	17.13	2.44	1.50	S
			30 - 70	18.19	17.80	17.23	27.96	14.37	2.45	2.00	S
			70 - 90	7.45	16.04	34.14	30.01	7.52	2.54	2.30	S
			90 -150	6.47	6.41	36.89	43.66	3.36	2.00	1.22	S
Sand dunes		19	0 - 20	30.81	24.65	11.16	18.86	11.23	2.29	1.00	S
			20 -150	33.47	36.67	10.22	12.91	6.45	0.18	0.10	S

<u>*Sand:</u>

V.C.S: Very coarse sand (2 - 1mm)
C.S: Coarse sand (1 - 0.5mm)
M.S: Medium sand (0.5 - 0.25mm)
F.S: fine sand (0.25 - 0.125mm)
V.F.S: Very fine sand (0.125 - 0.063mm)

<u>Texture classes:</u>**

S: Sand
LS: loamy sand
SL: Sandy loam
CL: Clay loam
L: Loam

Table 2. Mean size and sorting of the studied soil profiles.

Geomorphic Units		Profile No.	Depth (cm)	Mean size (Mz)	Mean size Index*	Sorting (6I)	Sorting Index**
Pediments		1	0-20	2.37	F.S	1.61	P.S
			20-50	2.10	F.S	1.24	P.S
			50-120	1.27	M.S	1.28	P.S
		2	0-15	1.80	M.S	0.99	M.S
			15-40	2.00	F.S	0.68	M.W.S
			40-120	1.83	M.S	0.56	M.W.S
		3	0-15	1.60	M.S	1.30	P.S
			15-60	3.10	V.F.S	1.33	P.S
			60-120	2.80	F.S	0.86	M.S
El Qattara Depression		4	0-50	3.90	V.F.S	1.88	P.S
			50-150	4.23	C.Si	1.40	P.S
		5	0-20	1.43	M.S	1.64	P.S
			20-100	2.53	F.S	1.80	P.S
Alluvial plain	Eastern sub unit	6	0-15	2.20	F.S	1.15	P.S
			15-40	1.33	M.S	1.04	P.S
			40-80	1.50	M.S	1.25	P.S
			80-150	1.23	M.S	1.17	P.S
		7	0-15	0.07	C.S	0.83	M.S
			15-30	0.30	C.S	0.82	M.S
			30-120	0.57	C.S	0.58	M.W.S
		8	0-25	1.37	M.S	1.32	P.S
			25-65	0.77	C.S	0.94	M.S
			65-150	0.90	C.S	0.84	M.S
		9	0-15	1.60	M.S	1.12	P.S
			15-120	0.93	C.S	0.81	M.S
		10	0-10	1.67	M.S	1.23	P.S
			10-30	1.37	M.S	0.93	M.S
			30-60	0.50	C.S	1.45	P.S
			60-100	1.47	M.S	0.93	M.S
			100-150	0.87	C.S	0.82	M.S
		11	0-15	0.97	C.S	1.45	P.S
			15-40	0.73	C.S	0.85	M.S
			40-90	1.00	M.S	0.81	M.S
			90-150	0.77	C.S	0.82	M.S
	Western sub unit	12	0-10	0.87	C.S	1.11	P.S
			10-50	1.13	M.S	0.99	M.S
			50-150	0.43	C.S	0.78	M.S
		13	0-35	1.67	M.S	1.17	P.S
			35-75	0.97	C.S	0.89	M.S
			75-150	1.13	M.S	1.02	P.S

***Mean Size index**
C.S: Coarse sand
M.S: Medium sand
F.S: Fine sand
V.F.S: Very fine sand
C.Si: Coarse silt

****Sorting Index:**
P.S: Poorly Sorted
V.P.S.: Very Poorly Sorted
M.S.: Moderately Sorted
M.W.S: Moderately Well Sorted

Table 2. Cont.

Geomorphic Units		Profile No.	Depth (cm)	Mean size (Mz)	Mean size Index*	Sorting** (6I)	Sorting Index
Alluvial plain	Western sub unit	14	0-15	1.57	M.S	1.44	P.S
			15-40	0.97	C.S	1.03	P.S
			40-80	0.33	C.S	1.04	P.S
			80-150	0.63	C.S	0.96	M.S
		15	0-10	2.33	F.S	2.33	V. P.S
			10-30	1.00	M.S	1.00	P.S
			30-70	1.23	M.S	1.52	P.S
			70-130	1.93	M.S	1.35	P.S
		16	0-20	2.50	F.S	1.56	P.S
			20-60	2.70	F.S	1.17	P.S
			60-150	2.60	F.S	1.49	P.S
		17	0-15	2.20	F.S	2.20	V. P.S
			15-40	2.33	F.S	2.33	V. P.S
			40-75	0.70	C.S	0.70	M.W.S
			75-150	1.23	M.S	1.23	P.S
		18	0-25	1.03	M.S	1.29	P.S
			25-80	0.70	C.S	1.23	P.S
			80-150	0.70	C.S	1.23	P.S
		20	0-20	2.30	F.S	2.30	V. P.S
			20-40	1.73	M.S	1.73	P.S
			40-70	1.60	M.S	1.60	P.S
			70-150	1.50	M.S	1.50	P.S
		21	0-15	1.13	M.S	1.13	P.S
			15-60	0.93	C.S	0.93	M.S
			60-150	2.03	F.S	2.03	V. P.S
		22	0-25	1.53	M.S	1.38	P.S
			25-90	1.53	M.S	1.38	P.S
			90-150	1.30	M.S	1.30	P.S
		23	0-30	0.27	C.S	1.73	P.S
			30-70	1.53	M.S	1.69	P.S
			70-150	1.17	M.S	1.60	P.S
		24	0-15	2.17	F.S	1.29	P.S
			15-50	2.86	F.S	1.53	P.S
			50-70	2.0	F.S	1.12	P.S
			70-150	3.5	V.F.S	1.56	P.S
		25	0-15	2.4	F.S	1.41	P.S
			15-30	1.57	M.S	1.94	P.S
			30-70	1.47	M.S	1.68	P.S
			70-90	2.0	F.S	1.70	P.S
			90-150	1.97	M.S	1.63	P.S
Sand dunes		19	0-20	0.98	F.S	0.96	M.W.S
			20-150	0.67	F.S	0.67	M.W.S

*__Mean Size index__
C.S: Coarse sand
M.S: Medium sand
F.S: Fine sand
V.F.S: Very fine sand
C.Si: Coarse silt

**__Sorting Index:__
P.S: Poorly Sorted
V.P.S.: Very Poorly Sorted
M.S.: Moderately Sorted
M.W.S: Moderately Well Sorted

B-Non- Opaque minerals:

The complementary non-opaque minerals are recalculated to be as 100 % (Table 4). These minerals consist of:

1-Sedimentary origin minerals:

They are also named ultrastable or index minerals because of their resistance to weathering processes and include zircon, rutile and tourmaline minerals (Folk, 1968). Zircon is the abundant index mineral in the study area. These minerals (zircon, rutile and tourmaline) mostly dominating the non-opaque minerals and high percentages of them are present in western alluvial plains sub unit followed by pediments unit, while the lowest percent is present in eastern alluvial plain sub unit (Table 4).

2- Igneous origin minerals:

The igneous or unstable minerals; amphiboles, pyroxenes and epidotes (Folk, 1968) are the second abundance minerals in the study area (Table 4). The high content of these minerals is present in the eastern alluvial plain sub unit followed by western alluvial plain, while lower content is present in pediments unit.

3-Metamorphic origin minerals:

The metamorphic or metastable minerals (garnet, kyanite, staurolite, sillimanite and andalusite) are detected in considerable portions in the study soils. Pediments unit has the highest percent followed by eastern alluvial plain sub unit, while western alluvial plain sub unit has the lowest content (Table 4).

The metamorphic minerals, as their name implies, that they are derived mainly from the metamorphic rocks (e.g. schists, gneisses and metamorphosed argillaceous rocks) (Folk, 1980).

Origin of sands:

The difference and random fluctuation in the distribution of heavy mineral associations in the sand fractions are mainly attributed to variations in nature of source rocks and environment of deposition. The source rocks of sand in the studied area are mixture of sedimentary, igneous and metamorphic rocks. The sedimentary rocks are the main source of sands especially in western alluvial plain sub unit, while the igneous and metamorphic rocks are the second source of sands especially in eastern alluvial plain sub unit.

Maturity and uniformity of soil profiles:

The occurrence of index minerals (zircon, rutile and tourmaline) in the heavy minerals suit means either (1) the minerals are being reworked from older sediments or sedimentary rocks (e.g. the Miocene deposits of the northern escarpment in the studied area) and/or (2) prolonged abrasion and/or chemical attach has occurred according to Folk (1968). In the studied area, the active physical and inactive chemical weathering processes on multi-sources parent materials lead to the prevalence of immature soil profiles. This is indicated by the irregular distribution of the index minerals in the different units and also by the irregular vertical distribution of such minerals depthwise (Brewer, 1964). Also, the distribution of amphiboles and pyroxenes and index minerals (Table 4) indicate that the study soils are recent, poorly developed and immature from the pedogenic point of view.

The uniformity within the different soil profiles has been indicated by applying different parameters, i.e. index figure and index minerals (Barshed, 1964; El-kady, 1970; and Mitchell, 1975); Tables 3 and 4. The uniformity ratio were also applied i.e. zircon/tourmaline, zircon/rutile, zircon/(rutile + tourmaline) and (pyroxenes + amphiboles)/(zircon + rutile) for different layers of soil profile as suggested by Haseman and Marshall (1945). The vertical distribution of the index figure, the index minerals (Tables 3 and 4) and the uniformity ratio values (Table 5) in the studied soil profiles are changed irregularly depth wise. This indicates that these soils were inherited from multi-sources and/or may subject to different sedimentation cycles.

<u>The relation between the studied soils and Nile deposits:</u>

The presence of pyroxenes and amphiboles are readily susceptible to weathering and decay, thus their frequencies give an indication of the presence of recent deposition. Moreover, Kholief *et al.*, (1969), in their mineralogical studies of sand deposits in the Nile Delta cited a triangle for the comparison of relative frequencies of pyroxenes, amphiboles and epidotes and their distribution after recalculation to one hundred percent. The suggested area inside the triangle represented the mean Nile sediments.

A comparison of relative frequencies of pyroxenes, epidotes and amphiboles recalculated to one hundred percent, for the present studied profiles (Table 6 and Figure 3) and the Nile sediments area (after Kolief *et al.,* 1969), the figure illustrates that the studied soils are characterized by different values of the above three mineral groups, but it is clear that the soils of western alluvial plain sub unit are partly affected by Nile sediments than other units of the studied area where the Nile sediments during flood periods deposited mostly in the near land south of El Qattara Depression.

Table 3. Percent of light and heavy minerals in the studied soil profiles

Geomorphic Units	Profile No.	Depth (cm)	Light minerals %	Heavy mineral %	Index figure	Geomorphic Units	Profile No.	Depth (cm)	Light minerals %	Heavy mineral %	Index figure
Pediments	1	0-20	93.17	6.83	0.073	Alluvial plain, Western sub unit	14	0 - 15	94.00	6.00	0.062
		20-50	94.28	5.72	0.061			15 -40	94.14	5.86	0.053
		50-120	94.71	5.29	0.056			40 - 80	94.92	7.08	0.044
								80 - 150	95.77	4.23	0.080
	2	0-15	96.85	3.15	0.033		15	0 - 10	93.80	6.20	0.066
		15-40	97.87	2.13	0.029			10 - 30	97.22	2.78	0.028
		40-120	93.82	6.18	0.066			30 - 70	94.94	5.06	0.053
								70 - 130	95.24	4.76	0.050
	3	0-15	91.84	8.16	0.089		16	0 - 20	97.20	2.80	0.028
		15-60	91.53	8.47	0.093			20 - 60	98.53	1.47	0.015
		60-120	93.39	6.61	0.071			60 - 150	98.39	1.61	0.016
Qattara Depression	4	0-50	96.77	3.23	0.033		17	0 - 15	93.50	6.50	0.070
		50-150	96.0	4.00	0.042			15 - 40	97.00	3.00	0.032
								40 - 75	94.90	5.10	0.053
								75 - 150	94.10	5.90	0.062
	5	0-20	95.59	4.41	0.046		18	0 - 25	95.40	4.60	0.048
		20-100	97.35	2.65	0.027			25 - 80	94.30	3.70	0.039
								80 - 150	97.60	2.40	0.026
Alluvial plain, Eastern sub unit	6	0-15	95.85	4.15	0.043		20	0 - 20	91.50	8.50	0.088
		15-40	97.00	3.00	0.030			20 - 40	97.40	2.60	0.029
		40-80	97.87	2.13	0.022			40 - 70	94.70	3.30	0.036
		80-150	98.47	1.53	0.020			70 - 150	94.30	3.70	0.040
	7	0-15	97.00	3.00	0.030		21	0 - 15	94.70	5.30	0.056
		15-30	96.63	3.37	0.036			15 - 60	95.50	4.50	0.048
		30-120	95.90	4.10	0.044			60 - 150	96.30	3.70	0.040
	8	0-25	94.54	5.46	0.059		22	0 - 25	96.00	4.00	0.042
		25-65	94.94	5.06	0.056			25 - 90	96.80	3.20	0.035
		65-150	94.40	5.60	0.062			90 - 150	96.40	3.60	0.039
	9	0-15	96.16	3.84	0.044		23	0 - 30	94.00	6.00	0.062
		15-120	92.10	7.90	0.090			30 - 70	95.00	5.00	0.053
								70 - 150	95.90	4.10	0.044
	10	0-10	96.40	5.60	0.060		24	0 - 15	96.00	4.00	0.042
		10-30	94.00	9.00	0.092			15 - 50	97.60	2.40	0.026
		30-60	90.80	9.20	0.095			50 - 70	96.70	3.30	0.036
		60-100	90.50	9.50	0.099			70 - 150	97.20	2.80	0.030
		100-150	92.80	7.20	0.071						

		11	0-15 15-40 40-90 90-150	93.74 93.9 97.86 93.40	6.26 6.10 2.14 6.60	0.062 0.064 0.020 0.069			25	0 – 15 15 - 30 30 - 70 70 - 90 90 - 150	95.00 96.00 93.90 94.60 90.90	5.00 4.00 4.10 3.40 9.10	0.052 0.042 0.043 0.036 0.095
		12	0-10 10-50 50-150	95.69 96.73 96.70	4.31 3.27 3.30	0.045 0.039 0.036	Sand dunes		19	0 - 20 20 - 150	93.40 96.00	8.60 4.00	0.071 0.043
		13	0 - 35 35 - 75 75 - 150	92.15 94.50 96.39	7.85 5.50 3.61	0.085 0.058 0.037							

Table 4. Frequency distribution of the heavy minerals in the recorded soil profiles of the study area.

Geomorphic Units		Profile No.	Depth, cm.	Opaque %	Non-Opaque minerals as 100%														
					Sedimentary (Index) Minerals*				Igneous Minerals**				Metamorphic Minerals***						Others
					Z	R	T	total	A	P	E	total	Gr.	St.	Si.	An.	Ky.	total	
Pediments		1	0-20	63.5	40.4	7.0	1.4	48.8	23.1	5.8	1.4	30.3	3.4	6.3	1.9	4.3	1.0	16.9	4.0
			20-50	58.6	34.4	8.8	0.9	44.1	15.4	7.0	4.4	26.8	4.5	7.9	4.4	7.0	4.0	27.8	1.3
			50-120	59.0	44.0	8.5	1.8	54.3	14.4	4.5	2.3	21.2	5.8	8.1	3.6	4.5	1.4	23.4	1.0
		2	0-15	58.9	42.8	8.1	0.9	51.8	15.8	4.5	0.9	21.1	5.9	6.3	3.2	6.7	2.2	24.3	2.8
			15-40	61.4	40.2	6.9	0.5	47.6	15.7	5.9	1.0	22.6	5.9	6.8	4.4	7.3	2.4	26.8	3.0
			40-120	60.4	46.9	8.2	2.0	57.1	15.3	5.1	1.0	21.4	4.1	4.6	2.3	5.1	2.6	18.7	2.8
		3	0-15	59.0	41.6	10.0	2.1	53.7	12.3	5.3	1.2	19.0	6.1	7.0	4.1	6.2	2.1	25.5	1.8
			15-60	59.5	36.8	7.8	2.5	47.1	15.7	9.8	2.9	28.4	5.4	5.4	3.9	6.4	1.9	23.0	1.5
			60-120	54.3	29.7	9.5	1.7	40.9	17.1	6.9	4.0	28.0	6.0	8.2	4.3	9.5	2.2	30.2	0.9
Qattara Depression		4	0-50	62.5	33.0	8.5	3.7	45.2	11.0	5.5	3.0	19.5	9.4	10.0	3.5	7.4	2.5	32.8	2.5
			50-150	64.3	29.3	7.9	3.0	40.2	11.0	4.8	3.1	18.9	10.4	11.6	4.3	9.2	3.0	38.5	2.4
		5	0-20	63.4	46.9	9.6	2.0	58.5	6.7	2.7	2.0	11.4	5.0	8.0	4.7	8.1	1.3	27.1	3.0
			20-100	61.2	29.2	2.2	-	31.4	40.0	3.2	-	43.2	6.5	3.2	3.3	8.6	2.2	23.8	1.6
Alluvial plain	Eastern sub unit	6	0-15	61.1	51.5	7.8	1.5	60.8	11.8	4.3	2.5	18.6	3.4	3.9	5.4	2.5	1.9	17.1	3.5
			15-40	59.2	46.0	9.4	1.4	56.8	13.6	7.0	2.9	23.5	3.7	3.8	3.3	4.7	1.9	17.4	2.3
			40-80	63.3	38.8	9.2	1.5	49.5	14.3	8.0	3.6	25.9	4.6	6.6	4.6	4.6	3.0	23.4	1.2
			80-150	61.6	36.0	10.1	1.6	47.7	22.2	7.0	2.6	31.8	3.7	5.3	2.6	5.3	2.1	19.0	1.5
		7	0-15	57.5	29.9	8.4	1.7	40.0	24.4	11.3	2.9	38.6	3.4	5.0	2.5	5.0	2.1	18.0	3.4
			15-30	55.1	32.4	7.8	2.5	42.7	28.7	9.8	1.6	40.1	2.9	4.5	2.9	3.7	2.0	16.0	1.2
			30-120	54.4	22.0	6.3	1.5	29.6	31.5	13.0	1.9	46.4	4.1	4.4	3.7	5.6	4.4	22.2	1.8
		8	0-25	59.3	54.6	10.4	1.0	66.0	13.3	4.7	1.0	19.0	2.6	3.6	2.6	3.1	1.6	13.5	1.5
			25-65	58.5	26.4	7.5	1.4	35.3	43.2	7.2	1.9	50.4	1.9	3.3	2.4	3.4	1.9	12.9	1.4
			65-150	53.4	29.6	9.3	2.2	41.1	29.2	8.1	2.2	39.5	3.4	4.1	3.3	3.7	3.0	17.5	1.9
		9	0-15	58.2	39.9	8.4	1.3	49.6	14.7	7.1	2.1	23.9	5.0	6.3	4.2	5.9	5.5	26.9	2.1
			15-120	56.2	26.0	8.0	2.0	36.0	32.0	10.0	1.6	43.6	4.0	5.6	2.8	4.4	1.2	18.0	2.0
		10	0-10	57.7	40.4	9.2	2.1	51.7	20.2	8.4	2.1	30.7	2.1	2.9	2.9	3.5	1.3	15.6	2.0
			10-30	57.5	26.6	7.6	1.5	35.7	28.1	15.2	3.8	47.1	3.0	5.3	1.9	3.8	1.5	15.5	1.7
			30-60	57.4	20.5	6.6	2.0	29.1	32.6	14.4	4.1	51.1	4.9	4.1	2.0	4.1	2.0	17.1	3.0
			60-100	54.8	21.4	11.5	1.8	34.7	30.2	11.5	3.2	44.9	4.1	4.4	3.6	3.6	2.5	18.2	2.2
			100-150	59.4	17.0	7.8	1.8	26.6	33.6	11.5	2.3	47.4	6.0	6.4	4.1	5.5	1.8	23.7	2.3
		11	0-15	59.1	40.5	12.2	1.8	54.5	12.3	5.7	2.3	20.3	5.8	6.3	1.4	5.4	4.5	23.4	1.8
			15-40	56.2	30.8	9.4	1.6	41.8	27.9	8.2	1.6	37.7	4.9	5.4	2.1	3.7	1.6	14.7	2.8
			40-90	56.9	22.5	5.9	1.4	29.8	37.3	11.2	2.3	50.8	4.5	4.0	2.3	3.2	2.7	16.7	2.7
			90-150	54.8	25.2	8.0	1.6	34.8	34.2	9.0	2.8	46.0	3.6	4.0	3.6	4.0	2.8	18.0	4.8
		12	0-10	59.8	50.4	11.5	1.4	63.3	13.9	5.8	1.9	21.6	2.9	3.3	1.4	2.9	1.0	11.5	3.3
			10-50	56.8	41.8	8.8	2.6	53.2	24.2	8.8	1.3	34.3	2.6	3.5	1.8	3.1	0.9	11.9	0.6
			50-150	59.4	36.8	7.7	1.8	46.3	29.0	8.7	1.8	39.5	1.8	2.8	1.8	4.6	1.4	12.4	1.8
	Western sub unit	13	0-35	65.2	60.0	9.2	2.4	70.6	8.8	4.3	3.0	16.1	3.1	3.0	1.2	2.4	1.8	11.5	1.8
			35-75	53.7	39.0	8.2	1.6	48.8	22.6	6.2	2.0	30.8	4.1	4.3	2.9	4.9	2.9	19.1	1.1
			75-150	51.5	43.2	10.6	2.9	56.1	21.1	9.3	1.0	31.4	1.7	2.7	2.6	1.7	0.5	9.2	3.3
		14	0-15	56.2	40.7	10.3	2.1	53.1	20.5	9.8	2.9	33.2	2.9	4.1	2.0	3.3	1.6	13.9	0.8
			15-40	60.8	40.8	10.6	2.4	53.8	18.7	9.1	2.4	30.2	4.3	2.9	3.4	2.4	1.9	14.9	1.1
			40-80	57.3	40.9	7.3	1.3	49.5	25.8	9.9	1.3	37.0	3.4	2.1	1.3	3.0	1.3	11.1	2.4
			80-150	58.5	36.8	12.2	2.4	51.4	20.6	7.4	1.0	29.0	3.4	3.4	2.3	4.9	3.4	17.4	2.2
		15	0-10	60.1	47.0	12.7	2.4	62.1	8.3	4.2	1.4	13.9	3.3	6.1	2.4	6.1	4.7	22.6	1.4
			10-30	61.2	36.8	7.4	1.5	45.7	25.0	14.5	1.5	43.4	2.0	3.4	1.5	2.5	1.5	10.9	-
			30-70	60.9	42.7	10.1	2.0	54.8	25.1	10.1	1.5	36.7	1.0	2.0	1.5	2.0	1.0	7.5	1.0
			70-130	59.6	43.2	9.6	1.9	54.7	25.9	9.1	3.8	38.8	1.4	1.9	1.0	1.0	0.5	5.8	0.8

***Sedimentary minerals**
Z = Zircon
R = Rutile
T = Tourmaline

****Igneous minerals**
A = Amphiboles
P = Pyroxenes
E = Epidotes

***** Metamorphic minerals**
Gr. = Garnet
St. = Staurolite
Si. = Sillimanite
An. = Andalusite
Ky. = kyanite

Table 4. Cont.

Geomorphic Units		Profile No.	Depth, cm.	Opaque %	Non-Opaque minerals as 100%														
					Sedimentary Minerals*				Igneous Minerals**				Metamorphic Minerals***						Others
					Z	R	T	total	A	P	E	total	Gr.	St.	Si.	An.	Ky.	total	
Alluvial plain	Western sub unit	16	0-20	58.4	42.8	10.4	2.3	55.5	17.1	8.1	2.3	27.5	3.6	5.4	2.2	3.2	1.3	15.7	1.3
			20-60	63.3	51.5	10.6	2.8	64.9	14.0	6.7	3.3	24.0	3.4	2.2	0.6	2.2	0.6	10.0	1.1
			60-150	61.2	41.0	12.0	2.0	55.0	16.5	7.0	3.5	27.0	4.0	4.0	2.5	4.5	2.0	17.0	1.0
		17	0-15	62.9	56.0	8.4	2.2	66.6	7.0	6.7	2.8	16.5	3.4	4.5	2.8	2.8	1.7	15.2	1.7
			15-40	56.6	39.0	11.3	3.4	53.7	10.5	10.1	3.8	24.4	3.4	5.5	3.4	5.5	2.5	20.3	1.6
			40-75	57.2	34.4	5.2	1.3	40.9	27.5	15.9	3.4	46.8	3.0	1.7	1.3	3.4	1.3	10.7	1.6
			75-150	61.0	45.8	8.8	2.6	57.2	18.2	9.9	2.6	30.7	2.6	2.6	1.6	2.6	1.6	11.0	1.1
		18	0-25	59.4	37.4	9.7	1.8	48.9	15.8	8.8	4.0	28.6	5.3	6.6	3.1	4.0	1.3	20.3	2.2
			25-80	60.3	46.0	9.2	1.8	57.0	16.1	6.4	2.3	24.8	5.1	3.7	2.8	3.7	1.8	17.1	1.1
			80-150	58.6	37.6	8.1	0.9	46.6	23.0	11.9	2.6	37.5	3.5	4.0	3.1	2.2	1.8	14.6	1.3
		20	0-20	60.7	61.7	5.6	1.2	68.5	7.4	9.3	1.2	17.9	1.9	3.1	2.5	3.7	0.6	11.8	1.8
			20-40	58.7	47.7	8.0	2.6	58.3	5.3	6.9	1.6	13.8	3.7	7.4	3.7	7.3	4.2	26.3	1.6
			40-70	62.6	57.8	10.4	3.0	71.2	4.3	4.3	3.1	11.7	3.1	4.3	2.4	5.5	1.8	17.1	-
			70-150	60.5	50.4	10.1	3.2	63.7	12.0	10.0	2.1	24.1	2.1	2.7	1.6	4.2	1.6	12.2	-
		21	0-15	60.4	49.5	8.7	2.5	60.7	9.7	12.8	1.5	24.0	2.2	2.5	2.5	4.6	2.0	13.8	1.5
			15-60	59.2	39.1	9.9	3.1	52.1	13.0	18.0	1.8	32.8	1.8	2.2	2.2	4.0	4.0	14.2	0.9
			60-150	61.9	50.2	6.5	2.2	58.9	7.0	14.6	2.7	24.3	2.7	3.8	2.7	3.8	2.7	15.7	1.1
		22	0-25	55.0	34.8	11.7	2.1	48.6	17.0	11.3	3.4	31.7	4.2	5.5	2.5	3.8	2.1	18.1	1.6
			25-90	52.3	32.6	14.8	2.6	50.0	13.0	11.1	3.3	27.4	4.4	5.6	3.0	4.4	4.8	22.2	0.4
			90-150	59.7	51.0	4.6	2.6	57.2	15.0	13.8	2.6	31.4	2.0	2.5	1.5	2.6	1.5	10.1	1.3
		23	0-30	54.3	43.7	11.0	1.8	56.5	13.8	6.9	1.8	22.5	4.6	5.0	2.3	4.1	2.3	18.3	2.7
			30-70	53.7	46.6	11.3	3.1	61.0	13.0	6.7	3.1	22.8	3.6	3.2	2.2	4.0	1.4	14.4	1.8
			70-150	50.7	39.5	12.6	3.7	55.8	16.7	10.0	3.3	21.0	5.2	4.4	3.3	4.4	4.4	21.7	1.5
		24	0-15	58.9	49.3	8.7	2.9	60.9	16.2	8.7	2.3	27.2	3.5	3.8	0.6	1.7	0.6	10.2	1.7
			15-50	52.1	43.0	10.8	2.2	56.0	20.6	7.7	0.9	29.2	4.3	4.1	1.7	2.1	1.3	13.5	1.3
			50-70	51.6	39.9	6.3	2.5	48.7	26.3	10.1	2.1	38.5	2.9	2.9	1.3	2.1	0.4	10.8	2.0
			70-150	54.8	39.8	7.2	1.9	48.9	26.4	9.6	2.4	38.4	2.4	2.4	1.4	2.6	1.4	10.2	2.5
		25	0-15	56.9	34.1	12.0	3.2	49.3	24.1	12.0	1.2	37.3	3.2	2.0	1.6	2.4	1.6	10.8	2.6
			15-30	53.0	36.6	10.1	3.0	49.7	23.4	11.1	1.2	35.7	3.8	3.4	2.0	2.0	1.2	12.2	2.4
			30-70	52.4	35.0	10.5	3.0	48.5	21.1	12.2	1.3	34.6	3.8	3.4	2.5	2.9	2.1	14.7	2.2
			70.90	55.6	39.5	9.0	2.5	51.0	22.5	11.5	1.0	35.0	3.0	2.5	2.0	2.5	1.0	11.0	3.0
			90-150	52.7	38.3	7.0	2.3	47.6	25.6	11.2	-	36.8	3.2	3.2	2.3	3.2	1.4	13.3	2.3
Sand dunes		19	0-20	58.0	44.5	9.1	1.9	55.5	16.3	7.2	3.4	26.9	2.4	3.8	2.4	3.8	3.8	16.2	1.4
			20-150	56.2	41.0	10.2	1.2	52.4	14.4	9.8	2.1	26.3	2.5	4.9	3.3	4.5	4.1	19.3	1.2

*__Sedimentary minerals__
Z = Zircon
R = Rutile
T = Tourmaline

**__Igneous minerals__
A = Amphiboles
P = Pyroxenes
E = Epidotes

*** __Metamorphic minerals__
Gr. = Garnet
St. = Staurolite
Si. = Sillimanite
An. = Andalusite
Ky. = kyanite

Table 5. Uniformity ratios of the studied soil profiles*.

Geomorphic Units	Profile No.	Depth (cm)	Z/R	Z/T	Z/ (R+T)	(A+P)/ (Z+R)
Pediments	1	0-20	5.77	28.86	4.81	0.61
		20-50	3.91	38.22	3.55	0.52
		50-120	5.18	24.44	4.27	0.36
	2	0-15	5.28	47.56	4.76	0.40
		15-40	5.83	80.40	5.43	0.46
		40-120	5.72	23.45	4.60	0.37
	3	0-15	4.16	19.81	3.44	0.34
		15-60	4.72	14.72	3.57	0.57
		60-120	3.13	17.47	2.65	0.61
Qattara Depression	4	0-50	3.88	8.92	2.70	0.40
		50-150	3.71	9.77	2.69	0.42
	5	0-20	4.89	23.45	4.04	0.17
		20-100	13.3	0.00	0.00	1.38
Alluvial plain – Eastern sub unit	6	0-15	6.60	34.33	5.54	0.27
		15-40	4.89	32.86	4.26	0.37
		40-80	4.22	25.87	3.63	0.46
		80-150	3.56	22.50	3.08	0.63
	7	0-15	3.56	17.59	2.96	0.93
		15-30	4.15	12.96	3.15	0.96
		30-120	3.49	14.67	2.82	1.57
	8	0-25	5.25	54.60	4.79	0.28
		25-65	3.52	18.86	2.97	1.49
		65-150	3.18	13.45	2.57	0.96

Geomorphic Units	Profile No.	Depth (cm)	Z/R	Z/T	Z/ (R+T)	(A+ P)/ (Z+ R)
Alluvial plain – Western sub unit	14	0 - 15	3.95	19.38	3.28	0.59
		15 -40	3.85	17.00	3.14	0.54
		40 - 80	5.60	31.46	4.76	0.74
		80 - 150	3.02	15.33	2.52	0.57
	15	0 - 10	3.70	19.58	3.11	0.21
		10 - 30	4.97	24.53	4.13	0.89
		30 - 70	4.23	21.35	3.53	0.67
		70 - 130	4.50	22.74	3.76	0.66
	16	0 - 20	4.12	18.61	3.37	0.47
		20 - 60	4.86	18.39	3.84	0.33
		60 - 150	3.42	20.50	2.93	0.44
	17	0 - 15	6.67	25.45	5.28	0.21
		15 - 40	3.45	11.47	2.65	0.41
		40 - 75	6.62	26.46	5.29	1.10
		75 - 150	5.20	17.62	4.02	0.51
	18	0 - 25	3.86	20.78	3.25	0.52
		25 - 80	5.00	25.56	4.18	0.41
		80 - 150	4.64	41.78	4.18	0.76
	20	0 - 20	51.42	51.42	9.07	0.25
		20 - 40	18.35	18.35	4.50	0.22
		40 - 70	19.27	19.27	4.31	0.13
		70 - 150	15.75	15.75	3.79	0.36
	21	0 - 15	19.80	19.80	4.42	0.39
		15 - 60	12.61	12.61	3.01	0.63
		60 - 150	22.82	22.82	5.77	0.38
	22	0 - 25	16.57	16.57	2.52	0.61
		25 - 90	12.54	12.54	1.87	0.51
		90 - 150	19.62	19.62	7.08	0.52

		9	0-15	4.75	30.69	4.11	0.45			23	0 - 30	24.28	24.28	3.41	0.38
			15-120	3.25	13.00	2.60	1.24				30 - 70	15.03	15.03	3.24	0.34
											70 - 150	10.68	10.68	2.42	0.51
		10	0-10	4.39	19.24	3.58	0.58			24	0 - 15	17.00	17.00	4.25	0.43
			10-30	3.50	17.73	2.92	1.27				15 - 50	19.55	19.55	3.31	0.53
			30-60	3.11	10.25	2.38	1.73				50 - 70	15.96	15.96	4.53	0.79
			60-100	1.86	11.89	1.61	1.27				70 - 150	20.95	20.95	4.37	0.77
			100-150	2.18	9.44	1.77	1.82								
		11	0-15	3.32	22.50	2.89	0.34			25	0 – 15	10.66	10.66	2.24	0.78
			15-40	3.28	19.25	2.80	0.90				15 - 30	12.20	12.20	2.79	0.74
			40-90	3.81	16.07	3.08	1.71				30 - 70	11.67	11.67	2.59	0.73
			90-150	3.15	15.75	2.63	1.30				70 - 90	15.80	15.80	3.43	0.70
											90 - 150	16.65	16.65	4.12	0.81
		12	0-10	4.38	36.00	3.91	0.32	Sand dunes		19	0 - 20	23.42	23.42	4.05	12.6
			10-50	4.75	16.08	3.67	0.65				20 - 150	34.17	34.17	3.60	8.00
			50-150	4.78	20.44	3.87	0.85								
		13	0 - 35	6.52	25.00	5.17	0.19								
			35 - 75	4.76	24.38	3.98	0.61								
			75 - 150	4.08	14.90	3.20	0.57								

*

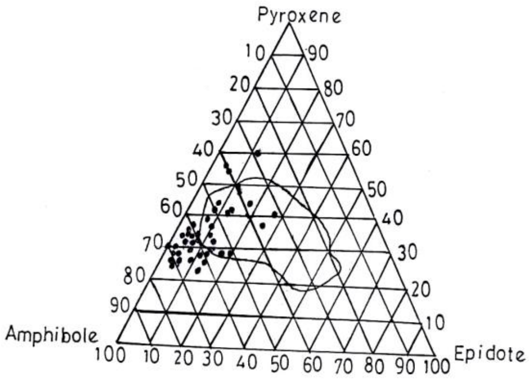
Z = Zircon A = Amphiboles

R = Rutile P = Pyroxenes

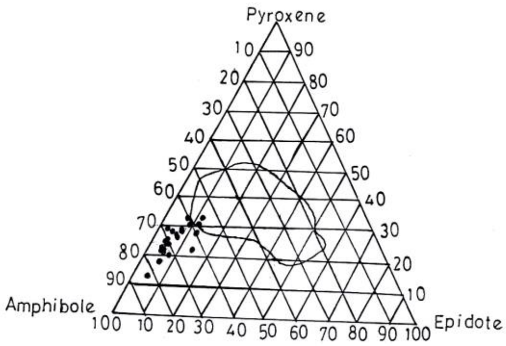
T = tourmaline

Table 6. Amphiboles (A), Pyroxenes (P) and Epidotes (E) relationships in the study area

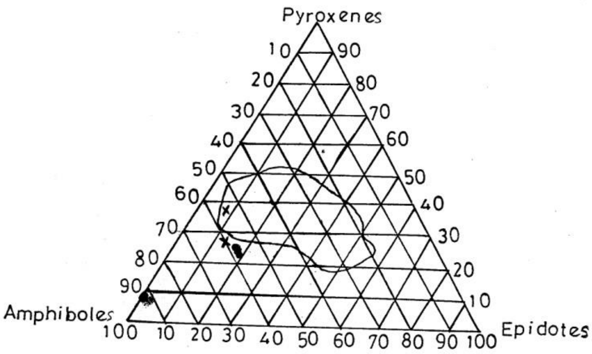
Geomorphic Units		Profile No.	Depth (cm)	A %	P %	E %
Pediments		1	0-20 20-50 50-120	73.9 57.4 67.8	18.5 26.2 21.4	7.6 16.4 10.8
Pediments		2	0-15 15-40 40-120	74.6 69.4 71.4	21.3 26.0 23.8	4.1 4.6 4.8
Pediments		3	0-15 15-60 60-120	65.1 55.2 53.2	28.2 34.4 25.0	6.7 10.4 21.8
Qattara Depression		4	0-50 50-150	58.0 58.0	25.8 25.8	16.2 16.2
Qattara Depression		5	0-20 20-100	58.8 92.5	23.5 7.50	17.7 0.0
Alluvial plain	Eastern sub unit	6	0-15 15-40 40-80 80-150	64.8 58.0 54.9 72.2	21.6 30.0 31.7 19.7	13.6 12.0 13.4 8.1
Alluvial plain	Eastern sub unit	7	0-15 15-30 30-120	63.2 71.1 68.0	29.4 24.5 28.0	7.4 4.1 4.0
Alluvial plain	Eastern sub unit	8	0-25 25-65 65-150	70.0 43.2 72.5	24.4 13.8 20.9	5.6 3.7 6.6
Alluvial plain	Eastern sub unit	9	0-15 15-120	61.3 73.6	29.8 23.0	8.9 3.4
Alluvial plain	Eastern sub unit	10	0-10 10-30 30-60 60-100 100-150	65.8 59.9 64.0 67.2 70.8	27.4 32.1 28.0 25.6 24.3	6.8 8.0 8.0 7.2 4.9
Alluvial plain	Eastern sub unit	11	0-15 15-40 40-90 90-150	60.0 74.1 73.0 75.7	28.0 21.5 22.0 17.8	12.0 4.4 5.0 6.5
Alluvial plain	Eastern sub unit	12	0-10 10-50 50-150	64.4 70.4 73.1	26.6 25.6 22.0	9.0 4.0 4.9
Alluvial plain	Eastern sub unit	13	0 - 35 35 - 75 75 - 150	50.0 73.2 67.5	29.2 20.0 29.7	20.8 6.8 2.8
Alluvial plain	Western sub unit	14	0 - 15 15 -40 40 - 80 80 - 150	60.0 62.4 69.6 70.0	29.0 30.4 26.7 26.3	11.0 7.2 3.7 3.7
Alluvial plain	Western sub unit	15	0 - 10 10 - 30 30 - 70 70 - 130	58.7 62.7 68.5 66.4	31.1 34.2 27.4 23.4	10.2 3.1 4.1 10.2
Alluvial plain	Western sub unit	16	0 - 20 20 - 60 60 - 150	62.3 58.3 61.1	29.5 27.9 25.9	8.2 13.8 13.0
Alluvial plain	Western sub unit	17	0 - 15 15 - 40 40 - 75 75 - 150	39.3 43.2 58.9 59.2	42.8 41.3 34.0 32.1	17.9 15.5 7.1 8.7
Alluvial plain	Western sub unit	18	0 - 25 25 - 80 80 - 150	55.4 64.8 61.4	30.8 25.9 31.9	13.8 9.3 6.7
Alluvial plain	Western sub unit	20	0 - 20 20 - 40 40 - 70 70 - 150	41.4 38.5 36.8 49.9	51.7 50.0 36.8 41.4	6.9 11.5 26.4 8.7
Alluvial plain	Western sub unit	21	0 - 15 15 - 60 60 - 150	40.5 39.7 28.9	53.3 54.8 59.9	6.2 5.5 11.2
Alluvial plain	Western sub unit	22	0 - 25 25 - 90 90 - 150	55.0 47.3 48.3	34.6 40.5 43.5	10.4 12.2 8.2
Alluvial plain	Western sub unit	23	0 - 30 30 - 70 70 - 150	61.2 56.8 55.4	30.6 29.4 33.2	8.2 13.8 11.4
Alluvial plain	Western sub unit	24	0 - 15 15 - 50 50 - 70 70 - 150	60.0 70.6 68.3 68.8	31.5 26.5 26.3 25.0	8.5 2.9 5.4 6.2
Alluvial plain	Western sub unit	25	0 – 15 15 - 30 30 - 70 70 - 90 90 - 150	64.8 66.0 61.0 64.1 70.0	32.8 30.0 35.4 32.9 30.0	3.4 4.0 3.6 3.0 0.0
Sand dunes		19	0 - 20 20 - 150	60.5 54.6	26.9 37.4	12.6 8.0



Western alluvial plain sub unit

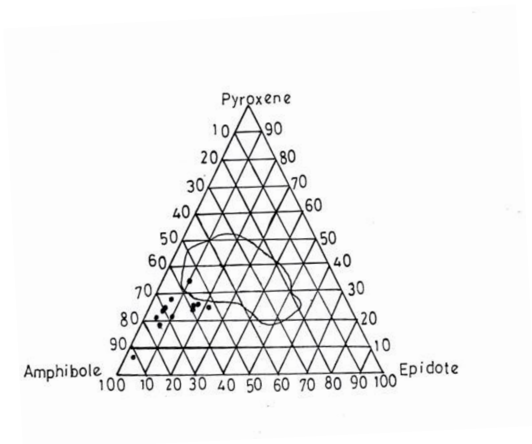


Eastern alluvial plain sub unit



Qattara Depression (.)
and Sand dunes(**x**) units

El



Pediments unit

Figure 3. Distribution of Amphiboles, Pyroxenes and Epidotes minerals in the study area.

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جيومورفولوجية وأصل التربة في بعض أراضى شرق وجنوب منخفض القطارة

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تقع منطقة الدراسة شرق وجنوب منخفض القطارة في شمال الصحراء الغربية ، مصر. وتقع بين خطي العرض 29 ° 41 'و 30 ° 30' شمالا وخطي الطول 27 ° 39 'و 28 ° 43' شرقا. الهدف من البحث هو التعرف على جيومورفولوجية وطريقة الترسيب وأصل التربة في منطقة الدراسة. وتم تقسيم منطقة الدراسة إلى خمس وحدات جيومورفولوجية هي: الهضبة الشمالية Plateau ، السفوح Pediments، منخفض القطارة El Qattara Depression ، اراضى السهول الرسوبية Alluvial plain (شرقية وغربية) والكثبان الرملية Sand dunes. ووجد أن قوام التربة في هذه الوحدات هي في معظمها رملية باستثناء وحدة منخفض القطارة ذات القوام الطميي. كما تبين أن متوسط حجم حبيبات التربة (*MZ*) يتراوح في الغالب من الرمل الناعم إلى الرمل الخشن عدا وحدة الكثبان الرملية حيث وجد ان متوسط حجم حبيبات التربة (*MZ*) هو الرمل الناعم. أما درجة الفرز (*σI*) فهى فى اغلب الوحدات تتراوح بين متوسطة الفرز الجيد الى رديئة الفرز مما يدل على انها ترسبت بواسطة كل من النقل الهوائى والنقل المائي باستثناء وحدة الكثبان الرملية حيث وجد ان درجة الفرز (*σI*) هى متوسطة الفرز الجيد التى تشير الى النقل بواسطة الهواء.

الجزء الرملى من التربة يتكون من المعادن الخفيفة والثقيلة. المعادن الخفيفة هي المكون الرئيسي للرمل و تتكون أساسا من معدن الكوارتز (> 90 ٪) ، يليه مجموعة معادن الفلسبار (بلاجيوكليز وأورثوكليز) بالإضافة إلى معدنى الموسكوفيت والكالسيت. أما المعادن الثقيلة فتتكون من معادن معتمة ومعادن غير معتمة. المعادن المعتمة هى الجزء الأكبر وتتكون أساسا من معادن أكاسيد الحديد (مثل الأليمانيت والهيماتيت). المعادن الغير معتمة تتكون من مجموعات المعادن التالية : (أ) المعادن الرسوبية الأصل التي تسمى أيضا المعادن الثابتة Ultrastable وتشمل معادن الزركون، التورمالين والروتيل (ب) المعادن النارية الأصل وهذه المعادن غير ثابتة وتشمل مجموعة معادن الأمفيبول والبيروكسين والأبيدوت (ج) المعادن المتحولة الأصل وتسمى المعادن الشبه مستقرة Metastable وتشمل معادن الجارنت ، الكيانيت ، الأشتيروليت ، السليمانيت والاندلوسيت.

أظهرت الدراسة أن مصدر التربة في منطقة الدراسة هي خليط من الصخور الرسوبية النارية والمتحولة. الصخور الرسوبية هي المصدر الأول للرمال في رواسب تحت وحدة اراضى السهول الرسوبية الغربية Western Alluvial Plains . كذلك أوضحت قيم التوزيع الرأسي للمعادن الثابتة Ultrastable (index minerals) مع Index Figure وكذلك مجموعة نسب المعادن الثابتة مع معادن الأمفيبول ، والبروكسين أنها تتغيير بشكل غير منتظم مما يدل على ان قطاعات التربة فى منطقة الدراسة غير متطورة وغير ناضجة من وجهة النظر البيدولوجية. ووجد أن تحت وحدة اراضى السهول الغربية تتأثر جزئيا أكثرمن الوحدات الجيومورفولوجية الأخرى برواسب النيل التى ترسبت فى جنوب منخفض القطارة اثناء فترات الفيضان فى العصور القديمة.