34 Egypt. J. Soil. Sci. Vol. **60**, No. 4, pp. 485-500 (2020)

Egyptian Journal of Soil Science

http://ejss.journals.ekb.eg/

Soil Mineralogy of North Western Desert, Egypt

Abdellatif D. Abdellatif*, **Yousif K. El Ghonamey and Mamdouh K. Abdel Ghaffar**

Soils, Water and Environment Research Institute, ARC, Giza, Egypt

THE PURPOSE of this work is to study the mineralogical characteristics in an area north of the Western Desert, Egypt to give an idea about origin and genesis of soils as well as their uniformity and weathering.The study area divided into four main geomorphological units: terraces, escarpment, structural platform and sand accumulation.The sand fraction consists of light and heavy minerals. The light minerals are the main constituent of sand fraction and consists mainly of quartz (≥ 92 %) 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 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. (c) Metamorphic origin minerals or metastable (index) minerals are detected in considerable portions. The vertical distribution of the index minerals and the uniformity ratio values in the studied soils change irregularly depth wise. This indicates that these soils were formed from materials of multi-origin.The clay minerals could be present as a result of inheritance from parent material by alteration, degradation of primary minerals and addition. The variation in the relative content of the present clay minerals may be attributed mainly to sedimentation regime varieties (e.g., recycling from different sedimentary precursors) and /or to the nature of the source rocks.

Key words: Soil mineralogy, North Western Desert, Egypt

Introduction

Soil mineralogy aims to study and understand the soil mineral phase, which makes up about 90% of the solid volume of mineral soils. This scientific discipline encompasses a diverse range of topics including: i) the occurrence and distribution of soil mineral materials, ii) their chemical composition, and crystallographic properties, iii) the stability, transformations, and interactions of soil minerals in natural environments, and iv) their consequent influence on soil physical and chemical properties and regulating air and water chemistry (Dixon and Schultze, 2002). In addition, heavy mineral assemblages have been deemed as sensitive indicators of sediment source (Garzantiand Vezzoli, 2008 and Yang, et al., 2009). Clay minerals are not only the most reactive inorganic components of soils, largely governing soil behaviors and properties, but they exhibit an extreme degree of both compositional and structural variability that result from intensive pedogenic weathering (Feldman et al., 2008). Bahnasawy (2016) studied the sand mineralogy of North West Wadi El Natroun. The obtained results reveal that light minerals are mainly composed of quartz followed by low amounts of feldspars. Plagioclase and /or microcline predominate in the studied soils. Moreover, orthoclase is commonly the least abundant.

The polarized microscopic examination of the sand fraction in North Western Coast of Egypt showed that light minerals were dominated by

*Corresponding author: E-mail: abdellatifdeyab@yahoo.com
DOI: 10.21608/ejss.2020.48740.1407
Received: 4/11/2020; Accepted: 9/12/2020

quartz then by feldspar minerals. The presence of feldspars indicates that the soils are young from the pedological view point.The predominant minerals in non-opaque minerals were: Pyroxene minerals, Parametamorphic minerals. High-resistance mineral for weathering was predominant with zircon mineral. Distributions of the resistant minerals indicate that the soils are generally of multi-origin and/or multi-depositional regime and are thus young. X-ray diffraction of clay minerals showed the predominance of kaolinite, followed by montmorillonite (Bahnasawy, 2018). Ismail, et al. (2012) studied the mineralogy of the sand fraction in south east of El-Qattara Depression (near the studied area). 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. (c) Metamorphic origin minerals or metastable (index) minerals are detected in considerable portions. The source rocks of sand in the study area are mixture of sedimentary, igneous and metamorphic rocks. 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 aim of this work is to study the mineralogical characteristics in an area north of the Western Desert, Egypt to give an idea about origin and genesis of soils as well as their uniformity and weathering.

Materials and Methods

The study area is located between longitudes °28 ‘58 ‘19.2’ and °29 ‘30 ‘28.8›E and latitudes °28 ‹44 16.8”and °29 ‘1 22.8»N and it extends in the direction northeast-southwest with total area of 945 km^2.The study area occupies a portion of the Western Desert of Egypt (Fig.1). It is located northeast of Bahariya Oasis. It extends in the direction northeast-southwest. The study area takes a pentagonal shape where it is determined by a five lateral sides. The lengths of northeastern, northern, northwestern, southeastern and southwestern borders attain 18.7, 15.6, 32.0, 32.4, 27.5 km, respectively. The area falls under the arid condition as the total rainfall is (3-6) mm/year (Darwish, 2006).

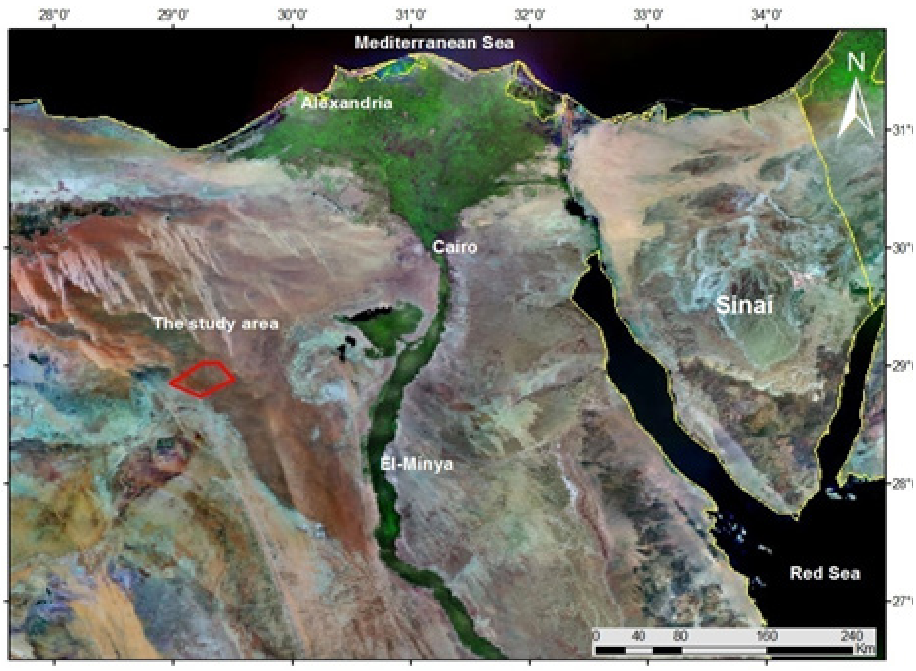

Fig. 1. Location of the study area

Geologically, the study area is covered by extensive exposures of sedimentary successions ranging in age from Eocene to Quaternary. The oldest sedimentary rocks are represented by late folded structure. The surface stratigraphic succession includes sequences of Middle Eocene, Upper Eocene, Lower Miocene, Oligocene and Quaternary sediments. Middle Eocene sequence is represented by Mokattam Group (Hamara Formation) and consists of silty neritic limestone with littoral Oyster beds and thin shale intercalations. Upper Eocene sequence is represented by Qasr El-Sagha Formation and consists of littoral marine to continental clastic sequence with Oyster beds and Coquina layers; intercalations of silt and claystones. Lower Miocene sequence is represented by Moghra Formation and consists of continental to shallow marine clastic sequence including shale and white sandy carbonate beds. Oligocene sequence is represented by Gebel Qatrani Formation and consists of sequence of continental to littoral marine alternating clastics, burrowed siltstone and reddish claystone. Quaternary sediments are represented by small areas of sand accumulations in the western part of the study area (Said,1990).

Geomorphologically, sentinel 2 image taken during the April 2020, triangulated irregular network (TIN map), digital elevation model (DEM map), geological map and data verification by in situ observation were used for delineating the main geomorphologic units. The study area can be divided into four main geomorphlgical units; namely, terraces, escarpment, structural platform and sand accumulation (Fig. 2). Each of these units shows distinct geomorphological features:

1- Terraces unit: The limestone terraces represent the main geomorphological unit where it characterizes the region and covers more than two-thirds of the area. The surface rises above sea level with values reaching its maximum at the northeastern part, where it attains up to 233 m, whereas the lowest is located to the southwest and attains up to 160 m. The terraces can be distinguished into four subunits; high, medium, low and very low terraces. In general, the surface is covered by few to many vary sized gravels, shifting sand and desert pavement interspersed sometimes by rock outcrops, also there are some scattered desert plants. The residual hills (Mesas and Buttes) and drainage lines represent the main erosional landforms on the surface of the terraces.

2- Escarpment unit: At its southwestern portions the terraces is delimited by escarpment extends in a northwest- southeast trend. This escarpment has an elevation ranges from 135 to 150 m (a.s.l) and height ranges between 20 and 40 m. This escarpment distinguishes the area into two parts eastern homogeneous for being belongs to the limestone plateau and western heterogeneous for being belongs to the approaches of Bahariya Oasis.

3- Structural platform unit: The southwestern part of the area represents the approaches of the Bahariya Oasis. From the geomorphological point of view, this part differs from the latter as it shows the relative disturbance, which is, resulted from the impact of the Bahariya Oasis structure, which is considered an anticlinal fold with northeast – southwest axis. The surface in this area reveals a slope in the northwest direction.

4- Sand accumulation unit: Few sand accumulations of aeolian origin occur in the western part of the study area.

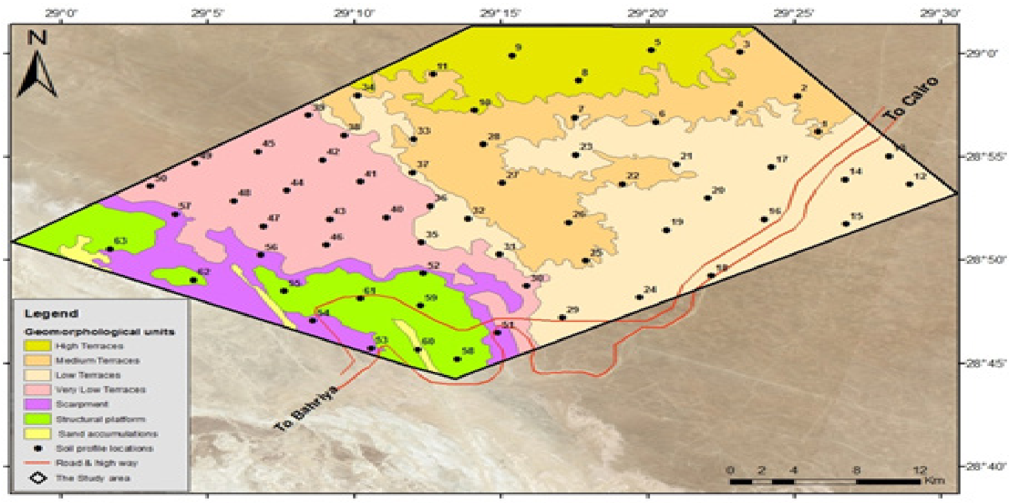

Fig. 2. Geomorphological units and soil profile locations in the study area

Field work

Field investigations were carried out in the study area using geological map (1:100,000), topographic map (1:50,000) and sentinel 2 image were used in this study for geomorphic mapping. Variant geomorphologic units were identified in the study area. Guided by the identified geomorphological units; 63 soil profiles were selected and allocated by the portable global positioning system (GPS). Delegate 176 soil samples have been collected from the troubled soil profiles according to the morphological variations. Government of the spurious soil profiles in the study area is shown in Fig. 2. The expanse of fact-finding in the studied profiles was usually about 150 cm except when met bed rock to locate the type of boundaries and general lithology.

Lab analyses

Particle size distribution using pipette methods, $CaCO_3$, EC, and gypsum content according to (USDA, 2004). Sand fraction: Separation of the light and heavy minerals was carried out for all samples by using bromoform (specific gravity = 2.87) on the very fine sand fraction (0.125-0.063 mm in diameter) according to Mange and Maurer (1992). The light and heavy fractions were weighted and the index figure (I.F) was calculated as follows (El-Demerdash et al. 2000):

$$I.F = \frac{\text{Heavy mineral weighted}}{\text{Light mineral weighted}} \times 100$$

The separated light and heavy grains were permanently mounted on glass slides using Canada balsam. Systematic identification of the heavy minerals (sp. gr. > 2.87) was carried out under the polarizing microscope as described by Mange and Maurer (1992). About 500 grains in random fields were counted for each sample and the percentages of each mineral were calculated.To obtain an integral knowledge on the mineralogical composition of sand fraction, the light minerals (sp. gr. < 2.87) were identified according to the procedure described by Folk (1980).

Clay fraction

The mineralogical analysis of clay fraction (< 2 μ) was carried out on 17 representative soil samples to declare the clay mineral association of different geomorphologic units.Clay fraction was separated by settling technique (Folk, 1980). Duplicate oriented slides were prepared for certain natural clay fraction. The first slide was X-rayed before and after heating to 550° for two hours. The second was X-rayed after the exposure to a saturated glycerol atmosphere at 60°.

The X-ray diffraction analysis (XRD) was carried out for 17 samples using X-ray apparatus (Scintag, Inc., U.S.A, X_1, Advanced Diffraction System with Cu-radiation and Ni filter). The XRD data were interpreted using data published by Brown and Brindly (1980) and schemes adopted by Dixon and Weed (1977). Semi-quantitative (relative proportions) of clay mineral identified were estimated by measuring the peak areas of the first order basal reflection (001) and calculated the percentages of frequency according to methods outlined by Venkatarathnam and Ryan (1971).

Results and Discussion

The soil depths in most of the studied profiles are deep (> 100 cm) with some profiles which are moderate or shallow depth. Soil texture throughout the entire depth of these soil profiles was mostly coarse-textured where the sand fractions more than 85% of the studied samples. According to USDA (2010) the study soils are mainly sand and loamy sand in the different geomorphological units (Table 1). These results consist with the data obtained by El-Naggar (2017).

The mineralogical composition of fine sand and clay sizes and their significance are discussed in the study area as follows:

Mineralogical investigations of sand fraction

The sand mineralogy is commonly used as a tool to evaluate the environmental provenance and soil profile uniformity.

Index Figure (I.F)

The index figures of the examined samples are low and range from 0.1 to 6.7 with an average 2.6. Values of index figures are almost irregular with profiles depth indicating non-uniformity of the layers deposited during the course of soil formation.

Light minerals

The light minerals (sp.gr. < 2.87) of the examined sand fraction are mainly composed of quartz grains (> 90.0%; Table 2). The quartz grains are mostly sub-angular to sub-rounded and stained yellow by ferrugination material. Normal quartz grains with homogenous straight extinction are commonly present as single grains. However, slightly undulose extinction and semi-composite grains are occasionally found. The predominance of quartz over other members of light fraction is mostly related to the primary assemblage of the parent material and its resistance to weathering and disintegration during the multi-cyclic process of sedimentation.

TABLE 1. Minimum, maximum and mean values of some physical and chemical properties in the studied geomorphic units

Ranging values	Soil Depth (cm)	Gravel %	Sand fractions %					Mud %		$CaCO_3$ %	Gypsum %	pH	E.C dS/m
			Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay				
1-High Terraces													
Min.	110	1.0	2.2	5.8	14.2	6.4	1.1	3.8	1.5	3.40	0.10	7.1	3.2
Max.	150	22.5	27.1	41.0	35.1	41.8	15.7	13.1	5.1	23.50	3.20	8.0	47.4
Mean	130	10.2	12.8	17.5	22.5	19.7	7.3	6.9	3.0	12.13	1.78	7.5	24.9
2-MediumTerraces													
Min.	100	1.5	0.9	6.0	11.2	6.0	1.1	3.2	1.2	2.9	0.0	7.2	3.3
Max.	150	21.0	26.0	28.7	41.8	37.8	23.3	16.9	7.1	15.4	6.0	8.3	47.5
Mean	125	7.1	10.2	14.6	22.9	22.9	9.5	9.5	3.4	8.0	1.9	7.7	18.7
3- Low Terraces													
Min.	90	1.0	1.0	4.1	7.3	3.6	0.4	2.7	1.1	2.5	0.0	7.0	3.0
Max.	140	39.5	43.7	30.8	49.9	52.2	18.3	21.9	17.4	20.5	11.9	8.8	62.9
Mean	120	6.9	9.7	15.0	26.1	21.2	7.4	9.8	4.0	8.0	2.5	7.8	20.1
4- Very Low Terraces													
Min.	75	1.0	3.6	6.2	1.2	3.6	0.3	0.3	0.1	2.2	0.0	6.9	3.4
Max.	130	25.5	39.2	54.6	47.9	46.2	30.3	32.8	15.6	60.6	7.9	8.4	69.8
Mean	115	7.6	11.5	16.6	20.3	22.0	9.9	8.3	3.8	8.8	2.1	7.7	20.2
5- Escarpment													
Min.	70	1.50	0.40	2.30	4.40	11.5	3.00	2.40	1.30	4.70	0.30	7.0	4.0
Max.	120	28.5	18.4	16.4	33.5	56.6	32.4	30.3	10.5	43.4	7.2	8.0	107.0
Mean	100	9.5	7.1	9.3	11.8	30.0	18.0	10.8	3.6	11.5	2.7	7.6	121.1
6-Stuctural Platform													
Min.	50	1.0	0.4	3.5	2.7	0.3	0.1	6.7	1.5	8.0	0.1	7.2	3.6
Max.	120	42.5	16.7	57.2	32.3	51.6	30.5	42.1	15.6	58.5	7.2	8.3	60.5
Mean	90	13.5	6.4	18.4	15.5	21.3	9.5	11.8	3.7	21.5	1.4	7.8	20.2

The other members of light minerals are feldspars (orthoclase and plagioclase series). Feldspars are rarely occurred in the studied samples (not exceeding 8%). This could be attributed to the removal of feldspars during weathering processes (Hussien and EI-Araby, 1986). Furthermore, other minerals such as calcite and muscovite are detected and found to be equal or less than 2.0% in this fraction.

The noticeable variations in light mineral assemblage and frequency are mostly attributed to the nature of parent materials from which the soils were derived in conjunction with sedimentation regime. Such criteria can be taken as an indication of the immature soil condition or recent soil deposits (Khater et al, 2008).

Heavy minerals

The heavy minerals (sp.gr.> 2.87) could be used as a tool to evaluate soil profile uniformity (Mitchell, 1975). Several investigators emphasized the importance of heavy minerals in identifying the soil genesis, among them, Mitchell (1975), Folk (1980) and Mange and Maurer (1992). The frequency distribution of the heavy minerals (opaque and non-opaque) will be discussed in the same order as summarized in Table 3 for different geomorphic units.

A) Opaque minerals

Opaque minerals are generally the major heavy fraction constituent in all the examined soils. These minerals are composed essentially of iron oxides minerals (e.g. hematite, magnetite and ilmenite) derived from the adjacent iron-rich rocks. It is ranging from 48.9 to 75.9% with an average of 56.1% that may indicate recycled sedimentary rocks (enriched in iron) to the study area. The weight mean values of opaque minerals range from 51.6 to 65% with high concentration in high terraces unit followed by medium and low terraces units. These results confirm with the data obtained by El-Demerdash et al. (2000).

TABLE 2. Distribution of light minerals (%) in some representative profiles of the studied soils

Geomorphic unit	Profile No.	Depth (cm)	Quartz	Feldspars (Orth.+Plag.)	Others (Mus.+Cal.)
High Terraces	8	0-30	94.5	4.5	1.0
		30-100	92.5	6.0	1.5
		100-150	90.0	6.0	2.0
Medium Terraces	1	0-15	95.0	5.5	1.5
		15-85	92.0	6.5	1.5
		85-150	90.0	8.0	2.0
	4	0-30	94.5	4.5	1.0
		30-85	92.0	6.5	1.5
		85-150	91.0	7.0	2.0
	28	0-20	95.0	4.5	0.5
		20-90	92.0	6.5	1.5
		90-150	91.0	7.0	2.0
Low Terraces	15	0-25	94.0	5.0	1.0
		25-50	91.0	7.0	2.0
		50-150	90.5	7.5	1.0
	20	0-20	94.5	4.5	1.0
		20-85	92.0	6.5	1.5
		85-150	91.0	7.0	2.0
	33	0-15	95.5	3.5	1.0
		15-75	93.0	6.0	1.0
		75-150	91.0	7.5	1.5
Very Low Terraces	42	0-15	94.0	5.5	0.5
		15-75	92.5	6.5	1.0
		75-135	91.0	8.0	1.0
Escarpment	57	0-20	95.0	4.0	1.0
		20-80	92.0	6.5	1.5
		80-150	90.5	7.5	2.0
Structural Platform	61	0-45	94.0	5.0	1.0
		45-110	91.0	8.0	1.0

Note:
Orth. = Orthoclase Plag. = plagioclase
Mus. = Muscovite Cal. = Calcite

B)Non-Opaque minerals

The complementary non-opaque minerals are recalculated to be as 100%. The ultrastable minerals (zircon, rutile and tourmaline) dominant the non-opaque minerals followed by unstable minerals (amphiboles and pyroxenes). However, the metastable minerals (epidotes, garnet, kyanite, staurolite, sillimanite and andalusite) are detected in considerable portions.

To substantiate the frequency distribution of mineral groups and their individual members, the results and discussion are presented under the following subheadings:

1- Ultrastable minerals (Index minerals)

The ultrastable or index minerals (e.g., zircon, rutile & tourmaline) have a wide range of abundance in the study area.

a – Zircon: Zircon is present as colorless, pale gray and has high relief bipyramidal and pyramidal termination with inclusions. However, some sub-rounded grains without inclusions are present. Zircon is regarded as one of the most stable minerals. The mineralogical maturity of heavy mineral assemblages is defined by the zircon-tourmaline-rutile (ZTR) index (Hubert, 1962).

Zircon is the most abundant non-opaque mineral in most of the studied profiles (ranging from 21.2 to 70.1% with an average of 52.7% of the total non-opaques). The weight mean values of zircon range from 33.0 to 63.3%; the highest values occur in the central and western sides of the area which may be more affected by recycling from Nubia Sandstone rocks. The distribution of zircon in all profiles shows irregular abundance throughout the entire depth.

b- Rutile: Rutile grains are mostly deep blood red and brownish red in color with sub rounded to well-rounded form; which indicates recycled sedimentary source rocks (Mange and Maurer, 1992). Rutile is considered as the second abundant ultrastable minerals in most of the studied soil profiles (5.4-28.2% with an average of 12.9% of the total non-opaques). The weight mean values of rutile mineral ranged from 6.9 to 21.2%. The distribution of rutile shows irregular pattern throughout the entire depth.

c- Tourmaline: Tourmaline is represented by varieties of different colors, e.g. pale brown, yellowish brown, green brown, yellowish green and green. However, pale brown and yellowish brown are the most common varieties. It occurs as prismatic grains with sub-rounded edges and characterized by strong pleochroism. Tourmaline represents the third abundant ultrastable minerals in most of the studied samples (0.0-16.7% with an average of 3.6% of the total non-opaques), while the weight mean values ranged from 0.7 to 6.7%. The distribution of tourmaline shows irregular pattern throughout the entire depth.

In conclusion, the occurrence of ultrastable (index) minerals in the heavy suit means either (1) the minerals are being reworked from older sediments or sedimentary rocks (Folk, 1968) e.g. the Pliocene and Miocene sandstone of the study area and/or (2) prolonged abrasion and/or chemical attach has occurred. Physical and chemical weathering processes on multi-sources parent materials lead to the prevalence of immature soil pedons in the study area. This is indicated by the irregular distribution of the ultrastable minerals in the different areas and also by the irregular vertical distribution of such minerals depth wise.

2- Unstable minerals

Pyroxenes and amphiboles constitute the unstable minerals which can be weathered and decay easily than other non-opaque minerals.

TABLE 3. Minimum, maximum and mean values of the heavy minerals distribution in the studied geomorphic units

Ranging values	Opaques %	(Non opaques (recalculated to 100%													Index figure
		Zircon	Rutile	Tourmaline	Amphiboles	Pyroxenes	Epidote	Biotite	Garnet	Kyanite	Andalusite	Sillimanite	Staurolite	Others	
1-High Terraces															
Min.	52.5	39.3	10.2	2.2	5.8	6.7	0.0	0.9	2.3	0.9	0.9	0.9	1.1	0.9	1.1
Max.	69.2	62.2	16.9	2.8	14.6	11.2	0.9	5.6	3.5	1.3	1.8	1.3	3.1	3.4	1.8
Mean	58.1	52.9	13.2	2.5	9.0	9.0	0.6	2.5	2.9	1.1	1.2	1.1	2.4	1.9	1.5
2-Medium Terraces															
Min.	49.5	21.7	8.7	1.6	1.5	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Max.	75.9	70.1	28.2	5.4	48.9	16.3	2.4	14.2	4.6	2.4	4.1	2.0	4.6	3.9	6.7
Mean	58.2	56.3	13.7	3.1	9.2	6.0	0.9	1.2	2.2	1.3	1.6	1.3	2.3	1.3	3.0
Low Terraces 3-															
Min.	40.8	32.8	5.5	1.3	4.1	3.2	0.0	0.0	0.6	0.6	0.6	0.6	1.1	0.8	1.1
Max.	64.7	67.3	20.0	12.6	30.1	16.4	2.8	2.2	4.6	2.9	3.3	2.9	3.7	17.6	5.0
Mean	56.4	54.8	12.5	3.3	11.0	7.9	0.7	0.7	1.9	1.6	1.8	1.6	2.2	2.9	2.5
4- Very Low Terraces															
Min.	48.5	21.2	5.5	2.5	3.3	3.4	0.0	0.0	0.0	0.0	0.5	0.5	1.4	0.0	0.1
Max.	54.7	61.2	56.7	16.7	29.2	12.5	4.7	27.5	27.5	2.4	4.6	3.4	4.9	27.5	6.1
Mean	52.2	50.9	14.4	4.7	13.9	6.7	0.5	2.7	3.8	1.4	1.8	1.5	2.9	3.4	2.4
5-Escarpment															
Min.	49.6	25.3	5.4	1.8	6.0	4.6	0.0	0.0	0.6	0.0	0.6	0.6	0.6	1.5	0.8
.Max	60.1	63.6	13.8	4.7	40.5	19.7	0.0	2.0	3.0	1.8	5.4	3.0	4.2	2.4	6.2
Mean	55.2	45.4	10.2	3.0	20.8	8.5	0.0	1.0	1.7	1.1	2.3	1.5	2.5	1.9	2.3
6-Stuctural Platform															
Min.	50.5	39.5	13.6	2.8	4.5	5.3	0.0	0.0	1.4	0.6	1.4	1.7	2.1	1.1	1.7
Max.	56.1	47.3	16.9	5.9	19.9	13.6	6.8	1.7	2.8	1.7	2.8	5.0	5.5	2.4	3.1
Mean	53.2	43.2	14.7	4.6	13.3	8.0	1.9	1.1	2.1	1.3	2.2	2.7	3.0	1.8	2.3

a) Amphiboles group: Amphiboles are represented mainly by hornblende with less actinolite and glaucophane. The relative high values of amphiboles are recorded in the structural platform, escarpment and low terraces soils. Amphiboles, in general, are recorded with considerable amounts in all the examined samples (ranging from 1.5 to 48.9% with an average of 12.7% of total non-opaque) while the weight mean values ranged from 3.8 to 32.2%.

Three varieties of hornblende were recognized by the microscopic investigation. They show in a descending order: olive green, bluish green and dirty bottle green. Hornblende occurs as prismatic and tabular grains with rounded to sub-rounded edges and mostly displays pleochroism from pale to dark shades with prismatic cleavage. The actinolite was recorded in a fibrous form with faint pleochroism, pale green and pale yellowish green colors. Glaucophane occurs as light pale blue color with cleavage flakes and prismatic form.

b) Pyroxene group: Pyroxenes are commonly associated with amphiboles, having the same mode of distribution in different units but with low quantities (ranging from 1.2 to 19.7% with an average of 7.4%. The weigh average values of pyroxenes ranged from 2.9 to 14.9%. Both the ortho- and clinopyroxene members represent the pyroxenes and the latter being more abundant. The dominant variety in the study area is augite followed by hyperthene and/or dioposide. Augite is present as yellowish green, greenish yellow, prismatic with sub-rounded edges.

In conclusion, amphiboles and pyroxenes are chemically unstable in sediments and they dissolve at an early stage of diagenesis. Therefore, they are found only in either well-sealed ancient sediments or in younger deposits, but in both cases they are valuable indicator of provenance (Mange and Maurer, 1992). From the pedoginic point of view, the presence of amphiboles and pyroxenes in the study area indicate recent and poorly developed soils.

3-Metastable minerals

a) Epidote group: Epidotes are recorded in most of the examined samples (range from 0.0 to 6.8% with an average of 0.8%). The weigh mean values of epidotes range from 0.0 to 5.1% and are mainly represented by pistachite. The pistachite grains are pale green, yellowish green and brownish yellow in color. In addition, the grains are sub-rounded to nearly rounded edges in shape. The distribution of epidotes indicates a metamorphic or hydrothermal source rocks.

b) Garnet minerals occur in most layers of the studied profiles: They are present as brown, colorless, yellow or as yellowish green with rounded to subrounded edges and pitted surface. The weight mean values of garnet ranged from 0.8 to 4.2%.

c) Staurolite is recorded in all the examined soils: It is represented by subhedral or platy golden yellow, brownish yellow or straw yellow. Most of the grains display pleochroism of different intensities, specially the straw-yellow tints. The weight mean values of staurolite ranged from 1.2 to 4.4%.

d) Kyanite is recorded in most of the examined soils: It is represented by prismatic colorless angular to subangular grains and characterized by typical cleavage. The weight mean values of kyanite ranged from 0.5 to 2.4%.

e) Sillimanite is recorded in most of the examined soil profiles: It is recognized as colorless long prismatic or rectangular grains with irregular terminations and distinct vertical striations. The weigh mean values of sillimanite ranged from 0.7 to 3.9%.

f) Andalusite occurs in the most studied soils: It is detected as colorless to faintly yellowish pleochroic sub-angular or prismatic grains with rounded to sub-rounded edges. The weigh mean values of andalusite ranged from 0.7 to 3.4%.

In conclusion, garnet, staurolite, kyanite, sillimanite and andalusite are named as metamorphic minerals and show a wide range in the study soils. The metamorphic minerals, as their name implies, are derived mainly from the metamorphic rocks (e.g. schists, gneisses and metamorphosed argillaceous rocks).

4-Biotite

Biotite occurs mainly as reddish brown, yellowish brown and brown flaky varieties with common opaque minerals inclusions. Biotite is present in many of the examined soil profiles with low quantities (weight mean values ranging from 0.1 to 2.5% of the non-opaque minerals).It is evident from results of this investigation that there is no fundamental mineralogical difference in the studied soil. Indeed, it appears that there is one distinct heavy mineral association characterizing all of these soils. This association is marked by the predominance of opaque minerals, ultrastable minerals, presence of appreciable quantities of unstable minerals, and less frequently metastable minerals. There is a noticeable variation in the quantity of the main heavy minerals in the different soil profiles of the study area.

Environmental provenances 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 provenance, and environment of deposition. The study soils are receiving sediments derived from mixture of two important provenances:

1- The first and the main provenance is dominated by sedimentary rocks (mostly Eocene, Miocene and Oligocene rocks) enriched in ultrastable minerals (zircon, rutile and tourmaline). This provenance is the main source of sands in sediments of the study area.

2- The second provenance is dominated by igneous and metamorphic rocks which contribute more amphiboles, pyroxenes, epidotes and metamorphic minerals. These minerals were transported to the area by water and wind from the basement rocks.

Soil uniformity and weathering

This is based on the assumption that certain minerals are most resistant to weathering during sedimentation development process (Mange and Maurer, 1992). Such minerals are termed as index minerals. Generally, there is an agreement to consider zircon, tourmaline and rutile as index minerals because of their resistance to weathering processes. In this respect, if the total percentages of the index minerals and/or the ratio between any two of them are mostly constant throughout the entire depth of the profile, this might suggest one parent material dominancy and subjected to the same sedimentation cycle. On the other hand, a difference in such trend in the profile marks the existence of parent material heterogeneity and/or many sedimentation cycles.

In the current investigation, uniformity within the different profiles has been indicated by applying different parameters, i.e. index figuresand index minerals (Mitchell, 1975). The uniformity ratios 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 Chapman and Horn (1968).

The data of the current investigation (Table 4) reveal the followings:

1- The vertical distribution of the index minerals and the uniformity ratio values in the soil sediments of the study area change irregularly depth wise. This indicates that these sediments were formed from materials of multi-origin and/or heterogeneity nature.

2- The existence of amphiboles and pyroxenes with considerable amounts indicates that the study soils are young and poorly developed.

3- The ratios between the most susceptible weathered minerals (amphiboles and pyroxenes) and the more resistance ones (zircon and rutile) as formula of A+P/Zr+R are calculated for the assessment of the efficiency of weathering processes throughout the studied soil profiles (Table 4). The results show that the obtained values are high reflecting the effect of weathering processes on these soils due to their relatively low content of less stable minerals of pyroxenes and amphiboles.

4- The variations in uniformity and weathering ratios among the soil profiles and also between the layers in each profile emphasis that these soils are formed from multi-origin and/or due to multi-depositional regimes. These results confirm with those obtained by Noaman et al. (1988).

Clay mineralogy

Knowledge of clay minerals is important in evaluating status of soil fertility, giving a clear indication about weathering processes, and sometimes controlling soil and water pollution (Miller and Donhaue, 1992). Clay fraction is the most active constituent of soils. It determines most soil physical and chemical properties as well as types of reactions that occur in soils (McBride, 1989). The residual minerals, which are either derived from the parent material or altered during the course of soil formation, are considered as one of the useful tools in evaluating profile uniformity or discontinuity. Also, they are essential to calculate processes involved in soil formation (Huang, 1989). Clays add much of the diversity found in soils and the behavior of soil clays is influenced also by the associated minerals in the coarser fractions (Dixon, 1991).

Identification of clay minerals

The clay fraction of soil is commonly composed of a mixture of one or more secondary layer-silicate mineral together with primary minerals inherited

TABLE 4. Uniformity and weathering ratios in some representative profiles

Profile No.	Depth cm	Z/T	Z/R	Z/R+T	(P+A)/(Z+R)
	High Terraces				
8	0-30	28.0	6.1	5.0	0.2
	30-100	25.5	4.6	3.9	0.2
	100-150	17.5	2.3	2.1	0.5
	Medium Tterraces				
1	0-15	18.6	5.2	4.1	0.05
	15-85	16.3	4.8	3.7	0.09
	85-150	30.0	6.0	5.0	0.13
3	0-10	30.0	4.7	4.1	0.06
	10 -75	10.0	1.4	1.2	0.15
	75-130	31.3	4.3	3.8	0.15
4	0-30	14.5	5.2	3.8	0.26
	30-85	27.6	4.2	3.6	0.23
	85-150	43.5	6.2	5.4	0.14
11	0-20	16.4	3.9	3.1	0.31
	20-90	6.7	2.5	1.8	2.14
	90-150	16.7	3.8	3.1	0.60
26	0-20	21.2	5.9	4.6	0.23
	20-50	21.0	3.9	3.3	0.06
	50-110	16.7	4.2	3.3	0.18
28	0-20	14.3	5.0	3.7	0.21
	20-90	11.1	4.2	3.0	0.11
	90-150	25.0	3.7	3.3	0.07
	Low Terraces				
13	0-15	30.0	4.4	3.9	0.15
	15-75	26.3	4.8	4.0	0.31
	75-120	18.1	5.0	3.9	0.23
15	0-25	28.8	5.2	4.4	0.33
	25-50	27.5	4.6	3.9	0.31
	50-150	43.4	5.8	5.8	0.20
17	0-20	27.5	4.4	3.8	0.18
	20-50	20.0	2.3	2.3	0.12
	50-75	24.3	3.4	2.9	0.48
19	0-40	36.5	2.8	2.6	0.32
	40-90	15.7	3.1	2.6	0.40
	90-150	10.7	2.7	2.1	0.63
20	0-20	16.5	4.6	3.6	0.27
	40-85	19.9	7.4	5.4	0.18
	85-150	10.0	4.5	3.1	0.30
23	0-15	17.0	5.2	4.0	0.24
	15-75	21.7	5.0	4.1	0.15
	75-125	14.2	4.3	3.3	0.21
24	0-20	18.7	6.1	4.6	0.23
	20-90	12.0	6.0	4.0	1.21
	90-150	16.2	5.9	4.3	0.55

Profile No.	Depth cm	Z/T	Z/R	Z/R+T	(P+A)/(Z+R)
	Low Terraces				
29	0-20	12.5	3.8	2.9	0.29
	20-90	14.1	5.6	4.0	0.14
32	0-20	14.4	4.6	3.5	0.23
	20-150	18.0	3.9	3.2	0.35
33	0-15	14.2	4.2	3.2	0.52
	15-75	5.3	4.5	2.4	0.16
	75-150	15.0	4.6	3.5	0.11
	Very Low Terraces				
40	0-20	23.8	4.7	4.0	0.15
	20-45	2.7	3.3	1.5	0.18
	45-110	10.5	4.5	3.2	0.52
42	0-15	11.8	9.6	5.3	0.48
	15-35	13.5	5.4	3.9	0.33
	35-75	17.7	5.9	4.4	0.21
	75-135	13.5	5.4	3.9	0.24
46	0-20	16.7	3.6	3.0	0.30
	20-80	16.6	4.0	3.2	0.29
48	0-25	10.8	4.3	3.1	0.31
	25-60	13.8	4.1	3.0	0.17
	60-130	11.0	4.4	3.2	0.29
	Escarpment				
51	0-10	22.0	7.3	5.5	0.22
	10-70	10.9	4.0	2.9	0.33
54	0-35	25.0	5.0	4.2	0.15
	35-95	18.7	3.9	3.3	0.22
56	0-35	14.9	3.9	3.1	0.49
	35-95	9.0	3.8	2.6	1.84
57	0-20	28.2	3.7	3.3	0.28
	20-80	17.9	7.1	5.1	0.87
	80-120	11.1	5.6	3.7	0.91
	Structural Platform				
58	0-20	7.7	2.8	2.1	0.53
	20-60	8.7	2.9	2.0	0.34
61	0-45	16.0	2.7	2.3	0.32
	45-110	8.0	3.2	2.4	0.31
63	0-50	10.0	3.2	2.3	0.38

Note: Z: Zircon R: Rutile T: Tourmaline A: Amphiboles P: Pyroxenes directly from the parent material. Identification of mineral species and quantitative estimation of their properties in such poly-component systems usually require the application of several complementary qualitative and quantitative analyses. One of the most useful methods is X-ray diffraction analysis (XRD). Investigation of the structure, properties, and occurrence of soil clay minerals by X-ray diffraction methods has a major effort in soil science (Page, 1982).

In the present study, the mineral composition of the clay fraction separated from the representative soil samples was carried out by X-ray diffraction analysis which is the essential tool for identification of mineralogical composition of clay. X-ray diffraction analysis was carried out for 17 soil samples representing the studied geomorphic units containing appreciable amounts of clay fraction.

The identification of clay minerals using X-ray diffraction analysis was carried out through the essential principles established by Dixon and Weed (1977) as follows:

1- Smectite minerals are identified by the expansion of the basal reflection (001) from 14-15.8 Ao in the air-dried to about 18.0 Ao upon glycerol salvation and sort of shrinkage (reduction of size) to about 10 Ao in when heated to 550 oC for two hours.

2- Kaolinite mineral is identified by the presence of very sharp peaks at about 7.18 to 7.25 Ao (001) and 3.58 to 3.60 Ao (002) in the air-dried samples. These peaks are not affected by glycerol salvation and they disappear when heated to 550 oC for two hours.

3- Palygorskite mineral is identified by basal reflection ranges from 10.3 to 10.6 Ao which is not affected by the glycerol treatment while it disappears upon heating to 550oC for two hours.

4- Sepiolite mineral is identified by basal reflection ranges from 12.1 to 12.3 Ao which is not affected by the glycerol treatment while it disappears upon heating to 550oC for two hours.

5- Hydrous mica (illite) minerals are detected by the presence of basal reflections at about 9.96 to 10.28 Ao peak upon air-dried which remains constant throughout the different treatments such as glycerol salvation and heating to 550oC for two hours.

6- Non clay minerals: Quartz and feldspars are detected from the existence of 3.37-3.34 Ao and 3.31-3.18 Ao, respectively, throughout the different treatments. Calcite is identified by its characteristic diffraction peaks at 3.08-3.02 Ao. Dolomite is identified by its characteristic diffraction peak at 2.28 Ao.

Clay minerals of the studied soils

Data in Table 5 and Fig. 3 show that the clay minerals of the studied soils are mainly smectite with variable quantities of other minerals. However, kaolinite mineral is subordinate in most of the studied samples. On the other hand, illite, palygorskite and sepiolite minerals are rarely encountered.

In conclusion, gradient variation in the different clay mineral may reflect multi-origin (different source rocks) and multi-environments during the formation of these soils. This is support the previous discussion that the sediments of the study area were not inherited in situ but they were recycled from many sources.

Origin and genesis of clay minerals

The clay minerals are not the same in both the chemical and structural compositions because they were formed by several ways. Keller (1970) pointed out that the clay minerals may be considered, fundamentally, as a product of both the parent materials and the environments. The distribution and genesis of the recognized clay minerals can be discussed as follows:

1- The original formation of smectite from weathering takes place predominantly when the following factors prevail: basic source rocks, poor drainage, low-lying topography, high pH, high silica activity, and abundance of basic cations (Borchardt, 1989).

2- Differences in kaolinite contents of the studied soils are most probably related to the nature of parent material and the content of silica in the source areas. Kaolinite may be formed in source areas by hydrogenation (decomposition) or by selective leaching of alkali feldspars under well aerated conditions and abundant rainfalls (Millot, 1970). The considerable well crystalline kaolinite may also indicate a prolonged intensively weathered product in the source area.

3- Illite is a common detrital mineral inherited from very numerous sediments (Weaver, 1989). The majority of illite in the investigated soil is inherited in a degraded state from muscovite rich sedimentary rocks in the source area.

4- Palygorskite and sepiolite are usually associated with saline media in the highly calcareous soil. It is believed to be pedogenic (diagenitc)

TABLE 5. Semi-quantitative mineralogical composition of the clay fractions separated from representative profiles horizons

Profile No.	Depth cm	Sm	K	I	S	P	Non-clay minerals
3	0-10	Dom.	Few	Few	Trace	Rare	Qz.-Fd.-Ca.-D
8	30-100	Abun.	Few	Rare	Rare	Few	Ca.- Qz.-Fd.- D
11	0-20	Abun.	Few	Rare	Trace	Rare	Qz.-Fd.- Ca
13	15-75	Abun.	Trace	Rare	Trace	Trace	Ca.- Qz.-Fd
19	90-150	Abun.	Mod.	Rare	Trace	Rare	Qz.- Ca.- Fd.- D
20	40-85	Abun.	Trace	Rare	Rare	Mod	Qz.-Fd. -Ca
24	0-20	Abun.	Few	Rare	Trace	Trace	Qz-Ca.-Fd.
28	0-20	Abun.	Few	Rare	Few	Trace	Qz.- Ca.- Fd.- D
33	0-15	Abun.	Trace	Rare	Rare	Rare	Qz.-Fd. -Ca
30	45-90	Abun.	Rare	Rare	Few	Rare	Fd. - Qz.-Ca
40	0-20	Abun.	Few	Trace	Trace	Rare	Qz.-Fd. -Ca
42	35-75	Dom.	Few	Trace	Few	Few	Qz.- Ca.- Fd.- D
48	0-25	Abun.	Mod.	Rare	Trace	Rare	Qz.- Ca.- Fd
51	10-70	Abun.	Few	Rare	Rare	Rare	Qz.-Fd. -Ca
56	0-35	Abun.	Few	Rare	Rare	Rare	Qz.-Fd. -Ca.- D
61	0-45	Abun.	Few	Rare	Rare	Rare	Qz.-Fd. -Ca
63	0-50	Abun.	Few	Rare	Rare	Rare	Ca.- Qz.-Fd

Sm = Smectite
K = Kaolinite
I = Illite
S=Sepiolite
P=Palygorskite

Qz = Quartz
Fd = Feldspar
Ca = Calcite
D = Dolomite

Abundance (Abun.) > 60%
Dominant (Dom.) = 40-60%
Moderate (Mod.) = 20-40%
Few =10-20%
Trace = 3-10%
Rare < 3%

in origin (Millot, et al., 1969). However, the occurrence of palygorskite and sepioloite in the study soils with few amounts may be due to that these soils are recent and poorly developed from the pedogenic point of view.

Further, the genesis of exited non-clay minerals can be briefed as follows:

a) Quartz is inherited mostly from parent materials and transported to the basins of deposition either by streams or wind.

b) Feldspars may be derived from slightly weathered soil developed from highly feldspathic parent materials in the source area. It is worth to mention that the presence of feldspars may support the suggestion of immaturity poorly developed and relatively young age of the study soils.

c) Calcite may be inherited from the limestone parent material in immature soil profiles developed on young geomorphic surfaces.

In conclusion, it is well known that the clay minerals could be present as a result of inheritance from parent material by alteration, degradation of primary minerals and addition. For the present study, the chemical decay is somewhat limited due to the prevalence of aridity, while the mechanical weathering contributes to a great extent. The variation in the relative content of the present clay minerals may be attributed mainly to sedimentation regime varieties (e.g. recycling from different sedimentary precursors) and /or to the nature of the source rocks.

Significance of clay mineral occurrences

The clay content has active effect on chemical, physical and morphological properties of soils as briefed here after:

a) The differences of clay mineral contents contribute to the quality of the soil, so soils that contain simple mineral suite, probably tend to need high levels of management.

b) The relative high clay content (particularly the smectite clay) improves to a great extent the soil water holding capacity and nutrients availability. Furthermore, the clay content give the soils most of their cohesive and adhesive properties. However, the clay content of the study soils is very limited.

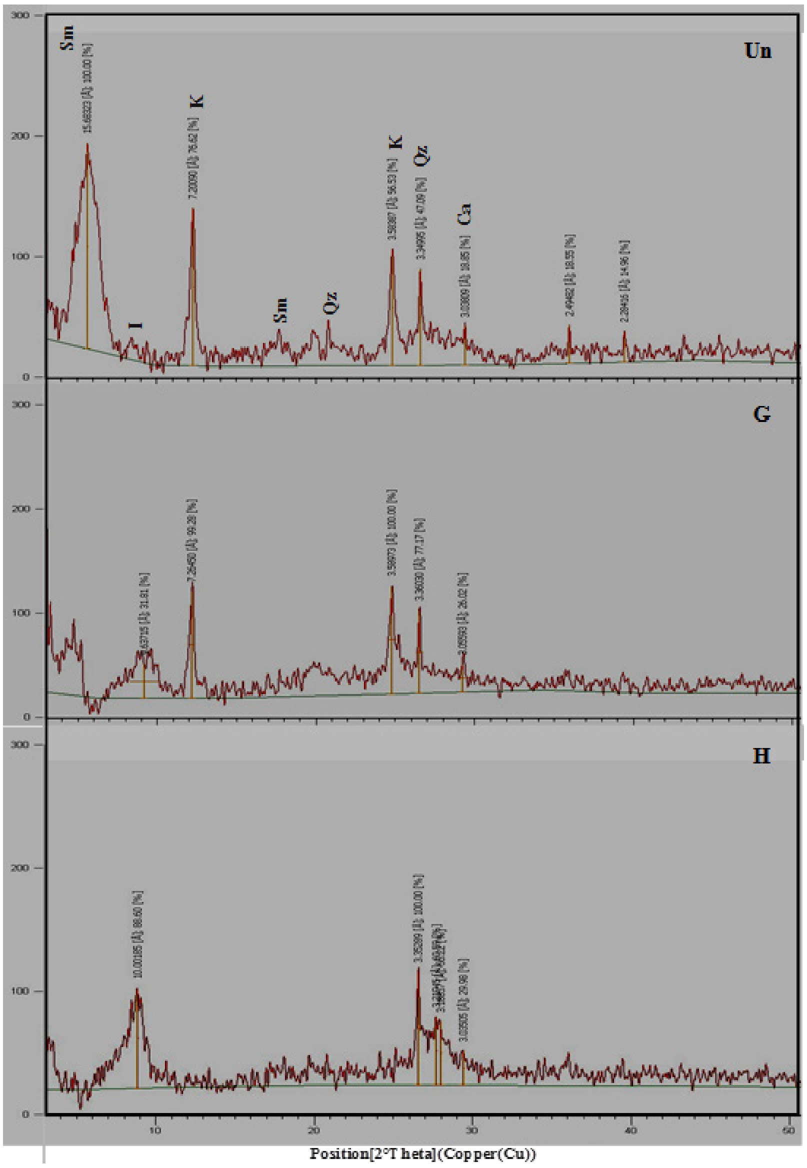

Fig. 3. X-ray differactograms of untreated, gylcerolated and heated clay fraction separated from profile No. 3 (depth 0-10 cm)

c) Soil swelling (by wetting) and shrinkage (by drying) are mainly clay mineral types and contents dependent.

d) The shrinking of soils is credited with forming pressure faces that contribute the boundary of soil structural units (aggregates). The soil structure development is important for aeration improvement. The minute amount of smectite in the study soils hardly can lead to shrinking and swelling damage (destruction effects) as the majority of the soil bulk in the study area is sand. However, smectite effect is magnified with the fine soil texture prevalence.

Conclusion

The difference and random fluctuation in the distribution of heavy mineral associations in the sand fractions are mainly attributed to variations in nature of provenance, and environment of deposition. The study soils are receiving sediments derived from mixture of two important provenances. The first and the main provenance is dominated by sedimentary rocks (mostly Eocene, Miocene and Oligocene rocks) enriched in ultrastable minerals (zircon, rutile and tourmaline). This provenance is the main source of sands in sediments of the study area. The second provenance is dominated by igneous and metamorphic rocks, which contribute more amphiboles, pyroxenes, epidotes and metamorphic minerals. These minerals were transported to the area by water and wind from southern basement rocks. The results show that the obtained values are high reflecting the effect of weathering processes on these soils due to their relatively low content of less stable minerals of pyroxenes and amphiboles. The variations in weathering ratios among the soil profiles and also between the layers in each profile emphasis that these soils are formed from multi-origin and/or due to multi-sedimentation regimes. The clay minerals could be present as a result of inheritance from parent material by alteration, degradation of primary minerals and addition. For the present study, the chemical decay is somewhat limited due to the prevalence of aridity, while the mechanical weathering contributes to a great extent. The variation in the relative content of the present clay minerals may be attributed mainly to sedimentation regime varieties (e.g., recycling from different sedimentary precursors) and /or to the nature of the source rocks.

References

Bahnasawy, N.M. (2016) Sand mineralogy as a criterion for soil uniformity North West Wadi El-Natrun, *Egypt. J. Soil Sci.* **56**, No. 4, 739-759.

Bahnasawy, N. M. (2018) Mineralogical evaluation of some soils representing the geomorphic units in the Northwestern coast of Egypt. *Egypt. J. Soil Sci.* Vol. **58**, No. 4, pp. 383-397.

Borchardt, G. (1989) Smectite minerals in Soil Environments, 2nd edition. Soil science society of America, 675-727.

Brown, G., Brindley, G. W. (1980) Crystal structures of clay minerals and their X-ray Identification. Mineralogical Society, 41 Queen's Gate, London SW7 5HR, 495 pp.

Chapman, S. H., Horn, M. E. (1968) Parent material uniformity and origin of soils in north-west Arkansas based on zirconium-titanium contents. *Soil Sci.Soc. Am. Proc.,* **32**, 265-270.

Darwish, Kh. M. (2006) Soil Salinity Mapping in North and South Bahariya Oasis Using Geostatistics. *Egypt. J. Soil Sci.* **46**, l: 15-2.

Dixon, J. B. (1991) Roles of clays in soils. *Appl., Clay Sci.*, pp. 89-503.

Dixon, J. B., Weed, S. B. (1977) *Minerals in Soil Environments.* Soil Sci. Soc. Amer., Madison, Wisconsin, USA.

Dixon, J.B., Schulze, D.G. (2002) *Soil Mineralogy with Environmental Applications.* Madison, Wisconsin: Soil Science Society of America, 866p.

El-Demerdash, S., Metrvally, M. A., Abdel Rahman, M. E. (2000) Iron Minerals in the Sand Fraction of Some Soils of Bahariya Oasis. *Egypt J. Soil Sci.*, **40**, **4**,513-530.

El-Naggar,A. A. (2017). Development of land capability and suitability maps for Bahariya Oasis, Egypt. *Egypt. J. Soil Sci.* 57, No. 4.

Feldman, S.B., Shang, C., Zelazany,L.W. (2008) Soil mineralogy, P.678-686. In W. Chesworth (Ed.). *Encyclopedia of Soil Science.* Springer, Dordercht, the Netherlands.

Folk, R. L. (1968) Petrology of sedimentary rocks; Sylabus, Univ. of Texas, Hamphill's, Austin, Texas, 170 pp.

Folk, R. L. (1980) Petrology of sedimentary rock; Sylabus, Hamphill's publishing company, Austin, Texas.

Garzanti, E. S., Vezzoli, G. (2008) Settling equivalence of detrital minerals and grain-size dependence of sediment composition. *Earth Planet Sci. Lett.,* **273**,138-151.

Huang, P. M. (1989) Feldspars, olivines, pyroxenes, and amphiboles. *Minerals in Soil Environments,* 2nd edition. Soil Sci. Soc. Am, Madison, Wisconsin, USA, 975-1050.

Hubert, J. F. (1962) A Zircon-Tourmaline-Rutile maturity index and independence of heavy mineral assemblage with gross composition and texture of sandstones. *Journal of Sedimentary Petrology*, **33**, 450-460.

Hussien, S.A., EI-Araby, A.M. (1986) Morphometry and Mineralogy of WadiTomeilat Deposits and Their Evaluation for Desertification Processes. *Egypt J. Soil Sci.* (Special Issue), 1-15.

Ismail M., Azzam, M. A. and Abdel Ghaffar, M. K. (2012) Geomorphology and Genesis of some Soils East and South El Qattara Depression. *Egyptian Journal of Agriculture Research,* **90 3**, 967-989.

Khater, E.A., Mostafa, M.A., Soliman, E.M., Hassona, H.H., Ibrahim, M. S. (2008) Studies on Soil Deposition Mode, Profile Development and Suitability for Specific Crops at El Bahariya Oases, Egypt. *Egypt J. Soil, Sci.* 48, No. **1,** 1-15.

Mange, M. A., Maurer, H. F. (1992) *Heavy Minerals in Colour.* Chapman and Hall, London, **147**.http://

dx.doi.org/10.1007/978-94-011-2308-2.

McBride, M. B. (1989) Surface chemistry of soil minerals. *Minerals in Soil Environments.* 2nd edition soil Sci. Soc., pp.35-88. Am, Madison, Wisconsin, USA.

Miller, R. W., Donhaue, R. L. (1992) *Soils; An Introduction to Soils and Plant Growth.* Prentice-Hall, Inc., Englewood Cliffs, N.J., USA.

Millot, G. (1970) *Geology of Clay.* Chapman and Hall. London, 429 pp.

Millot, G., Paouet, H., Ruellan, A. (1969) Neoformationd'attapulgite dins les sols et carapaces calcaires de la basse Mououya (Maroc Oriental). *C. R. Acad. Sci.Paris* **268**, 77l-774.

Mitchell, W. A. (1975) *Soil Components.* Vol. (2) John, E., Gieseking, New York. American Assoc. Pet. Geologist., **41**, No. 9, 1952 pp.

Noaman, H.I., Hawela, F.M., Khalil, Kh. I. (1988) Genesis and Uniformity of Soils in North and North Western Sinai Peninsula, Egypt. *Egypt. J. Soil Sci* **28 1**,01-74.

Page, A. L. (1982) Methods of soil analysis, part 2. Chemical and microbiological properties. Second edition, Amer. Soc. of Agron., Madison, Wisconsin, USA. 53711.

Said, R. (1990) *The Geology of Egypt,* V.1: Rotterdam, Netherlands, A.A. Balkema Publishers, **734** pp.

USDA (2004) Soil Survey Manual. United State, Department of Agriculture, Handbook 18, U.S. Gov. Print Off., Washington, DC., USA.

USDA (2010) Field Indicator of hydric soils for the United States, Version 7.0.USDA, NRCS, in cooperation with the Natural Technical Committee for Hydric Soils. Washington, DC., USA.

Venkatarathnam, K., Ryan, W. B. F. (1971) Dispersal pattern of clay minerals in the sediments of the Eastern Mediterranean Sea. *Marine Geol.,* **11**:261-282.

Yang, Sh., Wang, Z., Guo, Y., Li, C., Cai, J. (2009) Heavy mineral compositions of the Changjiang (Yangtze River) sediments and their provenance-tracing implication. *J. Asian Earth Sci.*, **35**, 56-65.

دراسة معادن التربة في شمال الصحراء الغربية، مصر

الغرض من هذا البحث هو دراسة الخصائص المعدنية في منطقة شمال الصحراء الغربية بمصر لإعطاء فكرة عن أصل ونشأة التربة بالإضافة إلى معرفة مدى تجانس قطاع التربه وعوامل التجويه. أمكن تقسيم منطقة الدراسة إلى أربع وحدات جيومورفولوجية رئيسية وهي المصاطبTerraces والجرف Scarpmentوالرصيف التركيبى Structural platformوالرمال المتراكمه.Sand Accumulationالجزء الرملى من التربة يتكون من المعادن الخفيفة والثقيلة. المعادن الخفيفة هي المكون الرئيسي للرمل و تتكون أساسا من معدن الكوارتز (< 92 ٪) ، 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 لتربة في منطقة الدراسة هي خليط من الصخور الرسوبية والنارية والمتحولة. وتعتبر الصخور الرسوبية هي المصدر الأول للرمال في رواسب منطقة الدراسه.

كذلك أوضحت قيم التوزيع الرأسي للمعادن الثابتة (index minerals) Ultrastable مع IndexFigure 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.أظهرت النتائج أن القيم التي تم الحصول عليها عالية تعكس تأثير عمليات التجوية على هذه التربة بسبب محتواها المنخفض نسبيًا من المعادن الأقل استقرارًا من البيروكسين والأمفيبولات. الاختلافات في نسب التجوية بين قطاعات التربة وأيضًا بين الطبقات في قطاع تؤكد أن هذه التربة تتكون من منشأ متعدد و/ أو بسبب أنظمة ترسيب متعددة. المكون الأساسى لمعادن الطين فى منطقه الدراسه هو مجموعه معادن السمكتيت مع كميات قليله من معدن الكاولينيت اما معادن الاليت والباليجورسكيت والسيبيوليت فتوجد بكميات ضئيله. يعكس اختلاف التدرج في معادن الطين فى منطقة الدراسه أصولًا متعددة للتربه (صخور مصدر مختلفة) وكذلك بيئات متعددة أثناء تكوين هذه التربة.