Menoufia J. Soil Sci., Vol. 5 June (2020): 109 - 131

MINERALOGICAL STUDIES ON CLAY AND SAND FRACTIONS AS WELL AS HOMOGENEITY OF SOILS IN SOUTH TUSHKA AREA, EGYPT

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Received: Feb. 2 , 2019 Accepted: Apr. 29 , 2020

ABSTRACT: ***The present work was carried out to study the mineralogical composition of the clay and sand fractions of some soils located at Tushka area between Latitudes 22^{o} 00$^{\backslash}$ and 23^{o} 28$^{\backslash}$N, and longitudes 30^{o} 00$^{\backslash}$ and 32^{o} 00 E. To fulfill this objective Landsat 8 image and digital elevation model (DEM) of the studied area were used to define the geomorphic units of the studied area. The geomorphic units of the area under consideration could be grouped and described as Young Alluvial Plain, Old alluvial Plains, Pedi Plain, Playa and Aeolian Plain. The different geomorphic units were represented by 26 soil profiles.***

The obtained results indicate that, the studied soils are dominated by Kaolinite clay mineral followed by montmorillonite, interstratified minerals and illites. Also, chlorite minerals are presented in variable frequency depending on the parent material of these soils. The minerals assemblage are interpreted in terms of lithology and depositional environments. The mode of formation of the pre-wet climatic condition is in contrast to the present aridity status.

Mineralogical composition of the sand fraction showed that, light minerals are the major component and mainly dominated by quartz which constitutes more them 89%. Feldspars are depicted with a few amounts not exceed 11% and represented by plagioclase, orthoclase and microcline. On the other hand, heavy minerals are dominated by opaques which constitute from 33% to 60.3%. Non-opaque minerals are dominated by pyroboles (pyroxene + Amphiboles,) followed by very stable minerals (Zircon, rutile and tourmaline). Slightly stable minerals (garnet and epidote) and stable minerals (staurolite, kyanite, silimanite and andalusite) are found in less pronounced amounts.

The frequency distribution of very stable minerals (Zircon, rutile and tourmaline) and weathering ratios lead to conclusion that, the studied soils are heterogeneous either due to their multi-origin and\ or multi-depositional regimes.

Key words: ***Remote Sensing., Clay minerals, Heavy and light minerals, weathering ratios.***

INTRODUCTION

The desert area extends to about 94% of the total area of Egypt. The reminding area is used for agriculture. According to statistics on the annual` increasing of the Egyptian population and their need for food to gotten with reduction in the cultivated lands in valley and delta, due to use agriculture land for building. The government of Egypt decided to get out from the narrow valley and search for other areas for food production.

Tushka area is considered as a depression extended from south of El-Kharga Oasis located in the southern part of the natural eminence of the Egyptian Western Desert. It is situated at the western side of Lake Nasser in the southern, near the Egyptian-Sudan borders between Latitudes 22° and 23° 28\ N and longitudes 30° and 32° oo\ E (Fig 1 a and b). The length of this area is approximately 140 km from east to west, with width of about 100 km.

According to CLAC (2017), the climatic data of the studied area reveal that, the area are falls under arid conditions characterized by a hot rainless summer. The precipitation is quite rare during December, January and February (Winter Season), with high evaporation and low relative humidity.

The geology of the south Western Desert has been studied by several geologists among them, Said (1962 and 1990) and the EGSA (1988). According these studies the studied area is occupied by different types of rocks varying between the Cretaceous and Quaternary. It is mainly composed of marine, fluvio marine and continental deposits.

Geomorphologically, Adel Salam (1965) classified the soils of lower Nubia area on the basis of land forms and geological formation to the following classes:

1- Soils of Flood Plain and Recent Alluvial Deposits.
2- Soils of the Old Alluvial Deposits.
3- Soils of the lower Nubia plain from sandstone.
4- Soils of the lower Nubia plain from granite.
5- Soils of the lower Nubia plain from clay shale.
6- Soils of the lower Nubia plain from limestone.
7- Miscellanies land types.

Abu El-Izz (1971), classified the area located between Wadi Halfa and Aswan into two geomorphic regions namely:

1- The plains of lower Nubia are formed of Nubian Sandstone and dissected by a number of dry wadis and shallow depressions filled partly with deposits of sand and sandy loam.
2- The lower Nubian plateau, which is a limestone plateau with a rugged surface, similar to the "hamada" variety (although it is dotted with outcrops termed" "Khrafish" by the nomads).

The water resources in this South Valley are ground water and Nile water. The ground water is occurred as The Nubian Sandstone aquifer which covers an area exceeds 2 million km^2. It is considered one of the biggest aquifers all over the world (Shehata, 2003). The aquifer occupies the southern east portion of the Nubian sandstone basin (El-Kharga basin) with varied water depth.

The Nile Water Could be used through El-Sheikh Zayed Canal that coming by water upraising station from Nasser Lake north of Khour Tushka with about 10 km. This station consists of 500-meter-long tunnels under the water of Nasser Lake. The pumping station including 20 units and the actual body of the canal is a few hundred Kilometers long four canals allow water to reach the reclaimed soils. The canal could be carrying more than two billion cubic meters of water to the land south west of the High Dam.

Many mineralogical studies have been carried out on the South Western Desert soils of Egypt by Harga *et al* (1983), Abd el Aal *et al* (1984), El-Demerdashe *et al* (1991), and Azzam (2004).

El-Demerdashe *et al* (1991) in their studies of the High Dam Lake. region found that, the clay mineral assemblages are predominantly smectite (nontronite) and or interstratified minerals with less pronounced occurrence of kaolinite, hydrous mica, chlorite and palygorskite, regardless of locality or soil sub-great groups. Accessory minerals however normally dominated by quartz, yet show variations associate with soil sub-great groups.

Fig. (1a): Location Map of the Studied Area (Tushka).

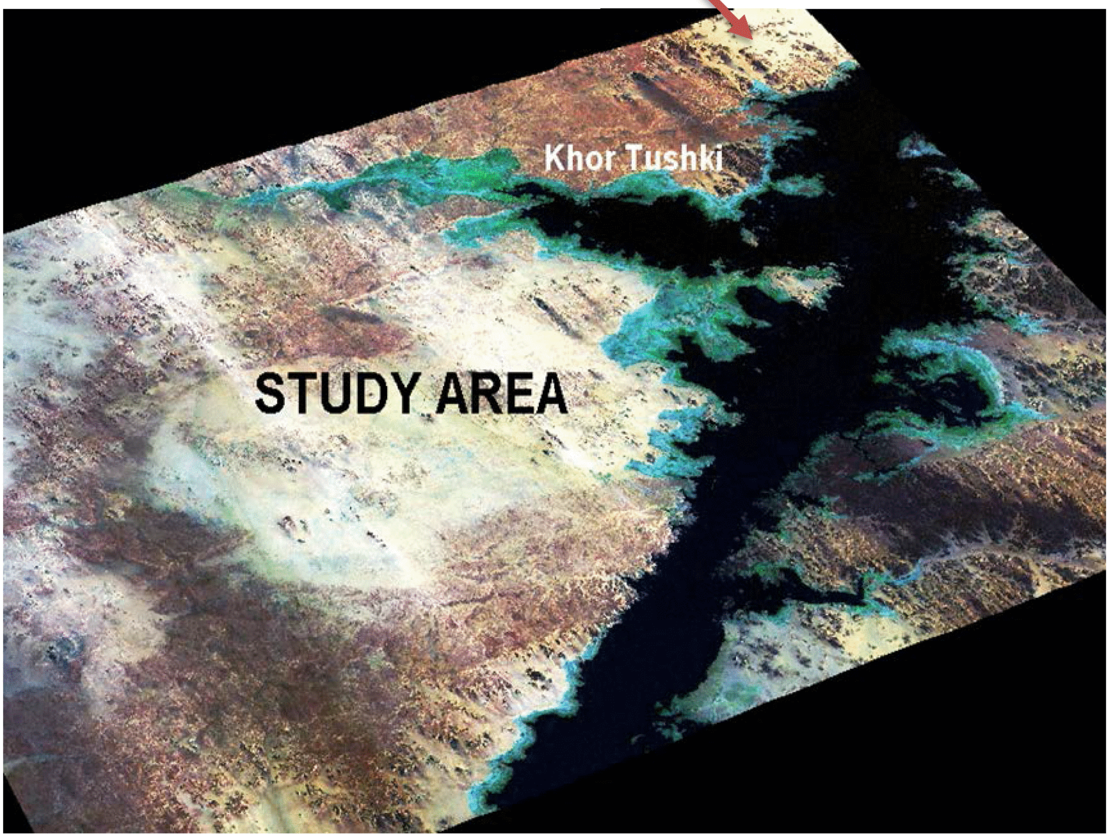

Fig. (1b): LTM Map of the Study Area (Applying Bands 2, 3 and 7).

Azzam (2004) found that, Ca – montmorillonite is generally the dominant clay mineral followed by Kaolinite, vermiculite and illite. The frequency distribution of heavy and clay minerals indicated that the studied soils were derived from multi origin with an effective role for the River Nile sedimentation.

The study of the origin and uniformity of the soils requires the identification of the heavy mineral's domination in the non-clay fraction. This fraction contains relative high percentage of heavy minerals and could therefore, give more reliable data. Heavy minerals are suitable for assessing the origin and uniformity of parent materials because heavy minerals inherited from parent materials or altered during soil formation processes. Their content and distribution are considered among the useful tools in evaluating profile uniformity and development, weathering sequence, losses and gains as well as predicting the processes involved in soil formation, El Demerdashe *et al* (1979), Hassona (1999), Hassanein (2001) and Azzam (2004).

The objectives of current study are to identify the main geomorphic units as well as mineralogical properties of clay and sand fraction, for the soils of the western side of lack Nasser (South Egypt). Genesis and soil formation were also, studied to elucidate its mode of formation, identify minerals within sand sub fraction and their relation to soil development as a degree of parent materials uniformity. The study also aimed to predict the role of environment in the formation of the different clay minerals.

MATERIALS AND METHODS

Remote Sensing and GIS works:

Landsat 8 satellite image path 174 (Rows 44 and 45), path 175 (rows 43, 44 and 45) and path 176 (rows 43, 41 and 45) covering the studied area were acquired on 2017.The images were geometrically corrected and rectification method (image for map) was followed. The geometric model used in the rectification process was second order polynomial and the resampling method is the nearest neighbor method, SRTAM Digital Elevation Model (DEM) was acquired on 2017 and used as the source data for elevation heights of the study area (Fig 2). Geomorphic map was produced using digital image processing of Landsat and DEM using ENVI 5.1 software (III, 2014). The image was stretched smoothly filtered and its histograms were matched for its rectification and restoration according to (Lillesand and Kiefer 2007).

GIS works were performed to produce base, geomorphic map of the studied area using Arc GIS 10.2 software (ESRI, 2014).

Field Work:

The preliminary photo-interpretation map was checked in the field by different ground observation to confirm the boundaries of the geomorphic units or to revise what were shifted. Twenty Six Soil profiles representing different physiographic units of the studies area were taken in sites representing the predominant characteristics of each unit. Soil profiles were dug to a depth of 150 cm or to till the lithic/para-lithic contact (Fig, 2).

Soil samples were collected as representing the different morphological variations through the soil profiles. These Soil samples were air dried, crushed and sieved through a 2 mm sieve. Fine earths (less than 2mm) were kept for different analyses.

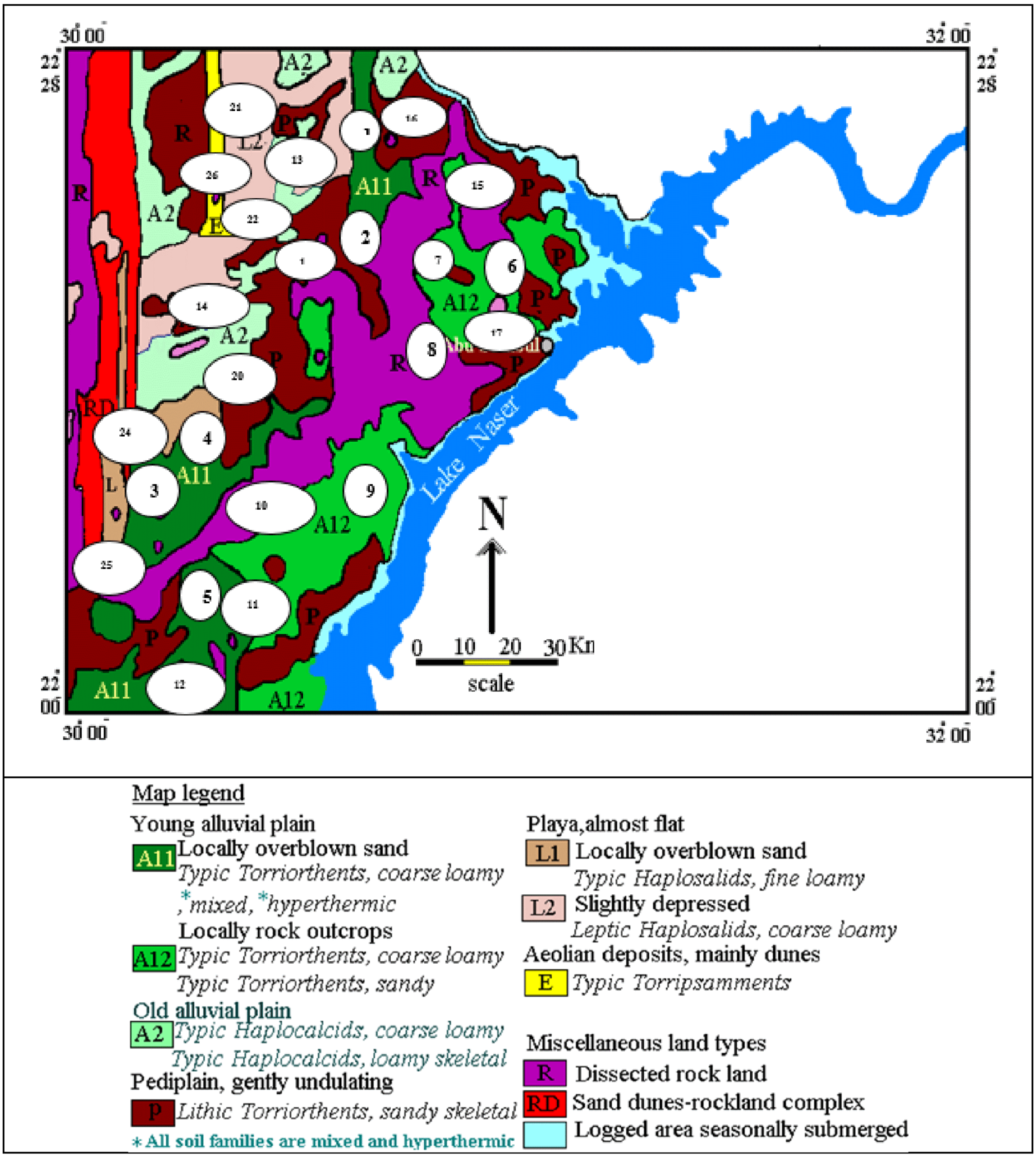

Figure (2): Geomorphic units and location of the chosen soil profiles in the study area.

Separation of Sand and Clay Fractions:

Separation of sand and clay Fractions was undertaken after the essential pretreatment, recommended by Jackson (1969). The samples were then treated with distilled water and diluted Sodium Carbonate Solution (29. L) of pH 9.5 for dispersion of the collided system. Clay fraction of less than 2 um equivalent spherical diameters was then collected after sedimentation of the large, particals, while the sand fraction of (0.125 – 0.063 mm) diameter was separated by sieving.

X-ray analysis of clay minerals:

X-ray diffraction analysis was carried out on the clay fraction less than 2 microns in diameter using Philips PW 1140 / 90, X-ray apparatus, with nickel filter and Cu-radiation. Oriented Clay samples were prepared on glass slides and examined as follows: a) Mg saturated air dried, b) Mg- saturated glycerol solvated and c) K Saturated heated to 550 C for 4 hrs. The X-ray diffractograms were interpreted on the light of tables presented by Brown (1961). Semi-quantitative estimation of the clay minerals proportions was conducted by measuring the peak area as outline by Gjems (1967).

Heavy and Light minerals analysis

Separation of heavy and light minerals of the Sand Fraction (0.125 – 0.063 mm) has been proved to be the most suitable for the microscopic study (El-Hinnawi, 1966). The separation of the aforementioned fractions into heavy (specific gravity > 2.87 g /cm^3) and light minerals (specific gravity < 2.87 g / cm^3) was conducted by means of the bromoform. The light and heavy minerals were collected and washed with alcohol and dried. The index figure was calculated as follows:

$$\text{Index figure} = \frac{\text{Weighted of heavy minerals}}{\text{Weighted of light minerals}} \times 100$$

Mounting of light and heavy fractions was undertaken according to the method of Brewer (1964) in which grains were permanently mounted by Candabalsam. The systematic identification of the light and heavy minerals was carried out using the polarizing microscope principles of identification reported by Kerr (1959) and Milner (1962). The gradual mechanical stage for traverse counts was run as suggested by Milner (1962). Averages of 500 grains were counted as a balance between accuracy and time involved. The percent of different groups of heavy and light minerals was calculated.

RESULTS AND DISCUSSION

Geomorphology of the studied area

The geomorphic analysis technique was carried out to perform the image interpretation based on the knowledge of the relation between geomorphology and Soils as well as the study of the features which are the result of the earth surface process (Sleen, 1984). The studied area included five different geomorphic units (Fig, 2) namely:

I-Alluvial plain (A)

1- Young alluvial plain (A1).
   (A 1.1) locally over blown sand.
   (A 1.2) locally rock outcrops.
2- Old alluvial plain (A2).
   II- Pedi plain, gently undulating "P".
   III- Playa, almost flat "L"
   L.1 – Locally over blown sand.
   L.2 – Slightly depressed.
   IV- Aeolian plain "E"
   V- Miscellaneous land type
   V1- Dissected rock land.
   V2- Sand dunes – rock land complex.
   V3- Logged area seasonally submerged.

Mineralogical Composition of the clay fraction

The clay fraction of the soils plays an important role in determining of the physical, phiso-chemical properties and chemical reaction occurred in Soils. Figs (3 to 9) show the x-ray diffraction patterns of the clay fraction separated from some layers of profiles (1, 4, 13, 18, 21, 22 and 23) represented the soils of different geomorphic units in the Tushka area of Egypt. Semi quantitative estimation of clay minerals for these x-

ray diffractograms are presented in Table (1). The diffraction patterns, revealed that, the clay fraction of the young alluvial plain soils (profiles 1 and 4) is dominated by Kaolinite. Illite and chlorite minerals are detected components. Smectite and interstratified minerals are detected in the layer (10-60) of profile 1 (Figs 3 and 4).

Table (1): Semi-quantitative clay mineral analyses for the clay fraction (< 0.002 mm) of the studied area.

Geomor-phic unit	Profile No.	Depth (cm)	Inter-stratified minerals	Clay minerals				Accessory minerals			
				Kaolinite	Montmori-llonite	Illite	chlorite	Quartz	Feldspars	Calcite	Dolomite
Young Alluvial Plain	1	10-60	-	Dom	-	Few	Trace	Trace	Trace	Trace	-
		60-110	Trace	Dom	-	Trace	Trace	Trace	Trace	Trace	-
	4	25-60	-	Dom	-	Few	-	Mod	Trace	Few	-
		60-90	-	Dom	-	Trace	-	Mod	Few	Trace	-
Old Alluvial Plain	13	20-65	-	Dom	Few	Few	Trace	Mod	Trace	Trace	Trace
		65-90	-	Dom	Few	Few	Trace	Mod	Trace	Trace	Trace
Pedi plain	18	0-25	-	Dom	Trace	Few	Trace	Mod	Trace	Trace	-
		25-45	-	Dom	-	Trace	Trace	Mod	Few	Trace	Trace
Playa	21	30-70	Trace	Few	Trace	Com	Trace	Mod	Few	Trace	-
		70-130	Trace	Few	Trace	Dom	Trace	Mod	Trace	Few	-
	22	25-60	Trace	Mod	-	Com	Trace	Few	Few	-	-
		60-110	-	Com	Few	-	Trace	Com	-	Few	-
	23	25-60	-	Dom	Trace	Few	Trace	Com	Trace	Trace	Trace
		60-90	-	Few	Few	Few	-	Mod	Trace	Trace	Trace

Dom = Dominant > 40 %, Mod = Moderate 15-25%, Com = Common 25-40%, few = 5-15 %, Trace < 5%

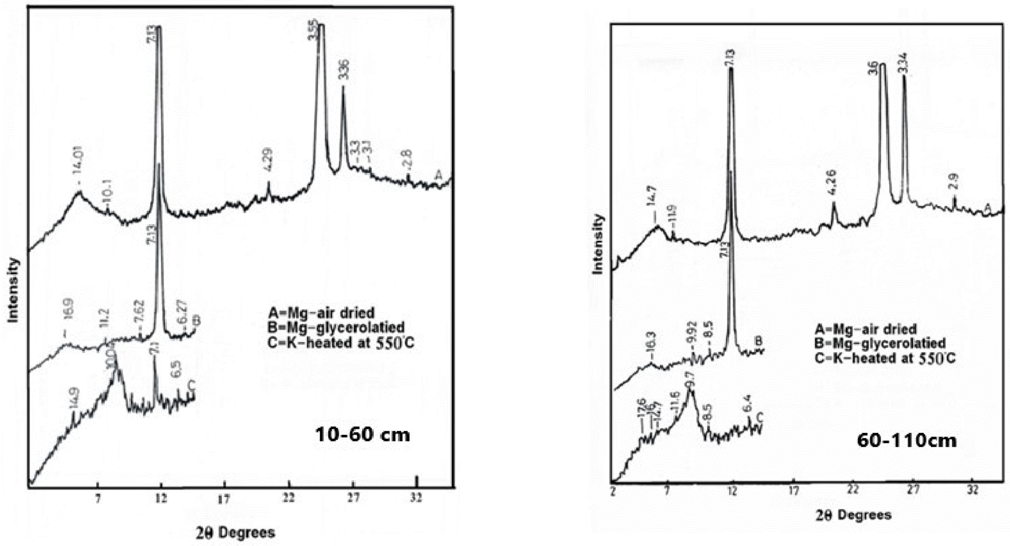

Fig. (3): X-ray diffraction pattern of the clay fraction separated from Young alluvial plain soils (profile 1).

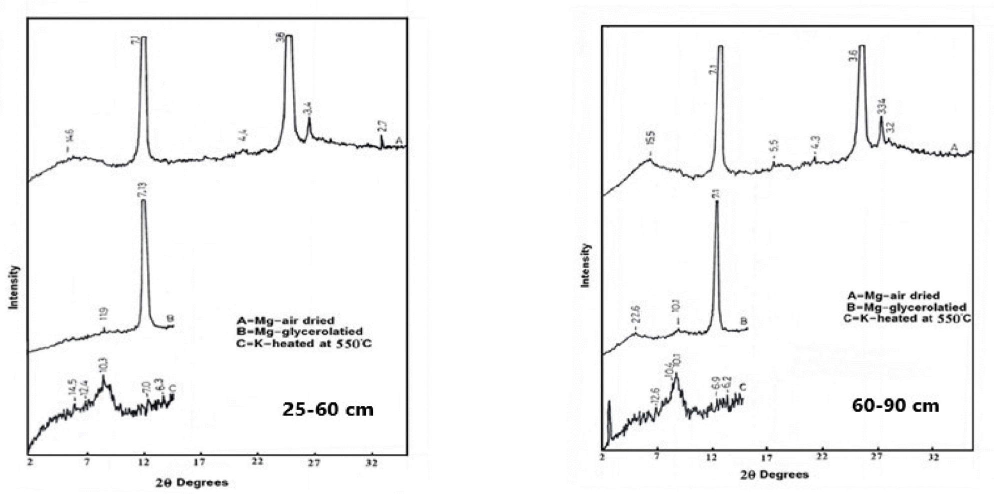

Fig (4): X-ray diffraction pattern of the clay fraction separated from Young alluvial plain soils (profile 4).

Regarding to the old alluvial plain soil (profile 13), data in Table (1) and Fig. (5) showed that, the clay minerals assemblage consists of kaolinite as the major constituent followed by montmorillonite (smectite) and illite. Chlorite is detected in trace amount in the layer (20-65) and the subsoil layers. Interstratified minerals are absent in these soil group.

X-ray diffractograms of the soils of pediplian (profile 18) are depicted in Fig. (6). Data in Table (1) show that, the clay minerals are dominated by Kaolinite followed by illite. Montmorillonite (smectite) and chlorite are detected in traceable amounts, Interstratified minerals are not detected in the soils of this unit.

With regard to the soils of playa (profiles 21, 22 and 23), data in Table (1) and Figs (7, 8 and 9) reveal that, the clay fraction of these soils are dominated by kaolinite followed by montmorillonite (smectite). While in profile 21 illite is the dominant silicate minerals followed by

kaolinite minerals. Chlorite is detected in tracer amounts, while interstratified minerals are found only in the subsurface layers of profiles 21 and 22 in trace amounts.

The accessory minerals in the studied soils are mainly dominated by quartz followed by feldspars, calcite and dolomite.

Relation of Clay minerals to lithology and environments:

The obtained mineralogical composition of the clay fraction indicates that, the soils of the different geomorphic units in the studied area were derived from different parent materials namely sand stone, shall and clay stone therefor their clay minerals are is dominated by Kaolinite.

These minerals are almost inherited from the parent material and affected by pedogenic processes that bed to mineralogical changes this could be indicated by the presence of weatherable minerals such as feldspars. The Kaolinite is perhaps a product of more intensive weathering regime and many have gone through on or more cycles of erosion and sedimentation before deposition in its present pedogenic environments. Montmorillonite coincide with lithology of the parent sediments as well as the enrichment in alkalines and alkaline earth., The presence of quartz and feldspars may be due to physical weathering of the sand and silt fraction under the prevailing arid conditions and remains from the original geological materials, The presence of calcite and dolomite indicate a contribution of calcareous parent materials (calcareous sand stone).

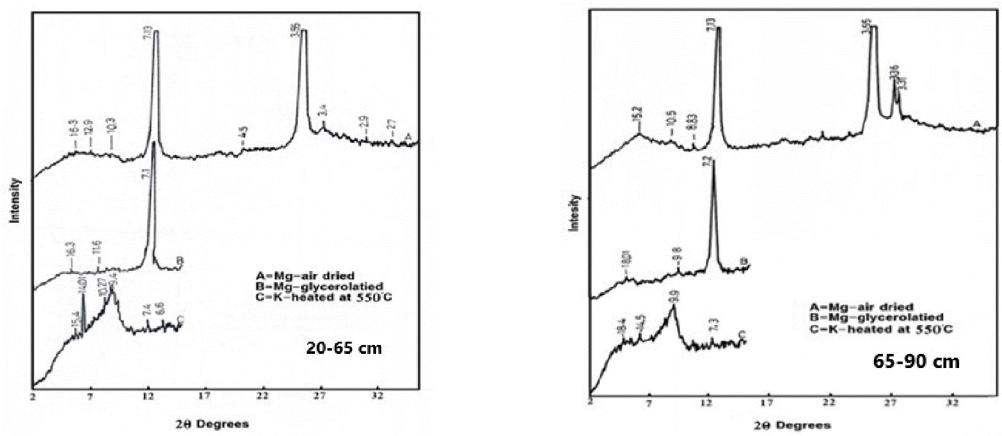

Fig (5): X-ray diffraction pattern of the clay fraction separated from Old alluvial plain soils (profile 13).

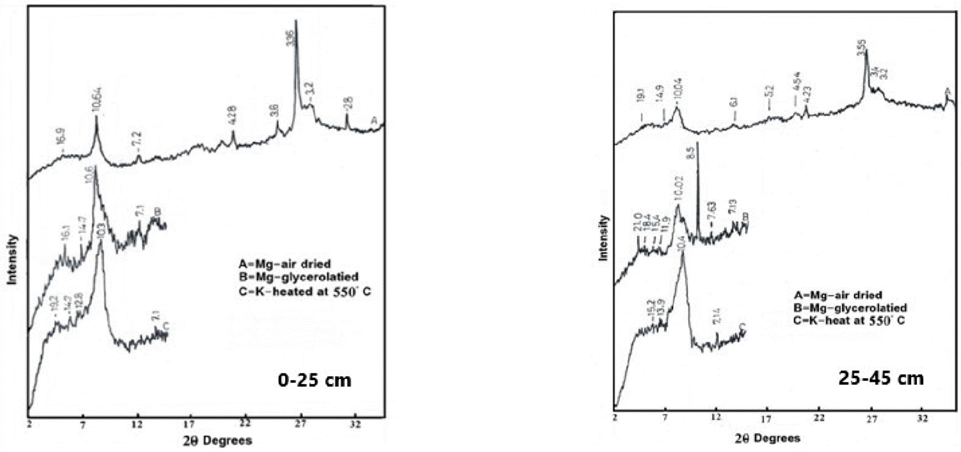

Fig (6): X-ray diffraction pattern of the clay fraction separated from Pediplain soils (profile 18).

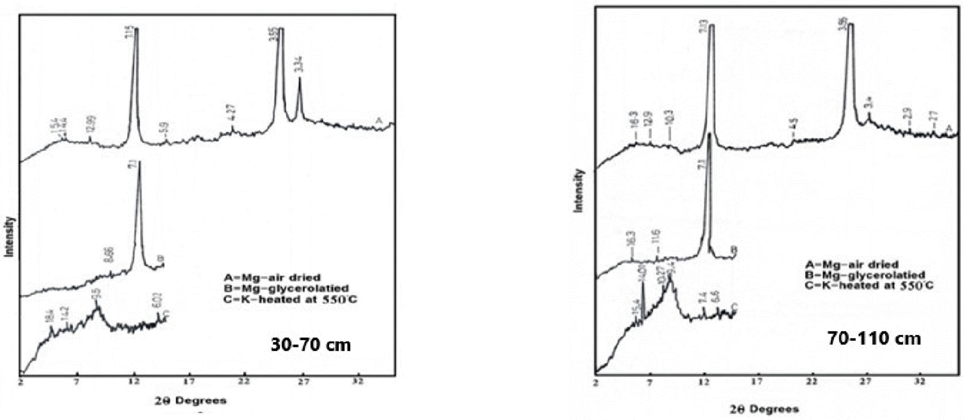

Fig (7): X-ray diffraction pattern of the clay fraction separated from Palya soils (profile 21).

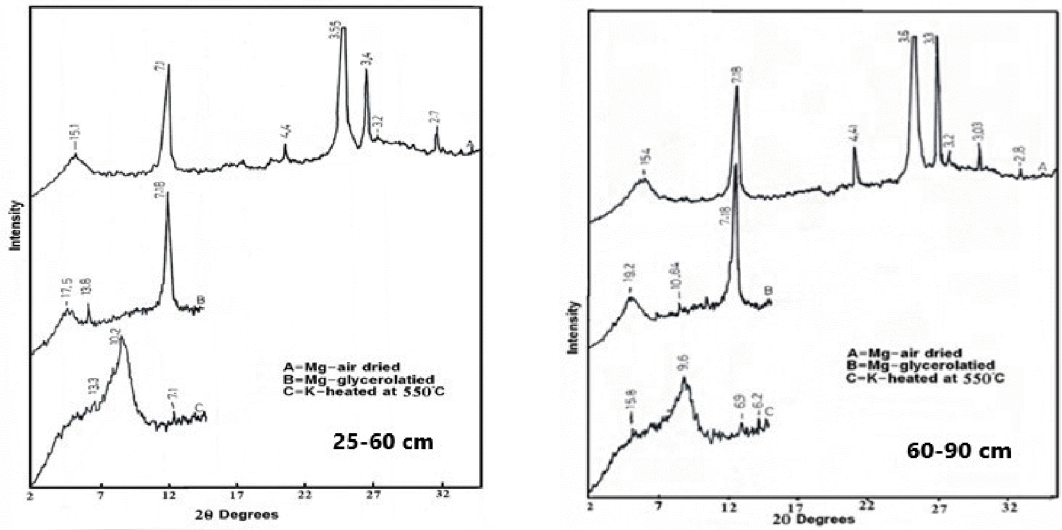

Fig (8): X-ray diffraction pattern of the clay fraction separated from Palya soils (profile 23).

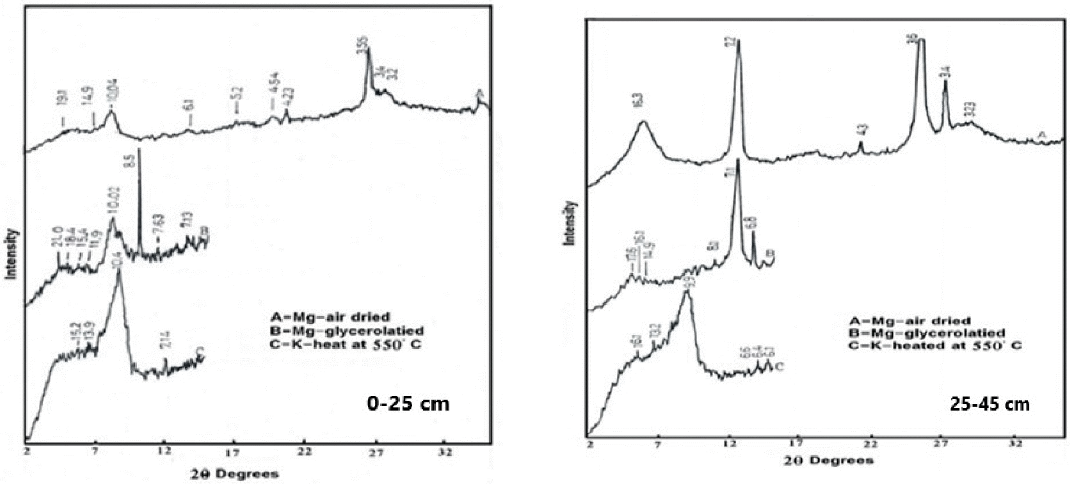

Fig (9): X-ray diffraction pattern of the clay fraction separated from Palya soils (profile 22).

Mineralogy of the sand fraction:

Mineral in the sand fraction are either inherited from the parent material or produced by alteration formation. The origin of the soil is related to the kind and amount of heavy minerals present and that semiquantitative determination of such minerals are usually sufficient to establish soil origin.

(1) Light minerals:

Table (2) shows the distribution of light minerals of the sand fraction in the investigated soil profiles as well as their distribution throughout the entire depth of each profiles.

Data in Table (2) revealed that, the light minerals are composed almost from quartz that constitutes more than 89%. Other associated light minerals are mainly orthoclase, plagioclase and microcline. Quartz grains have common unloose and homogeneous extinction i.e. it is extinguished completely between crossed nichols. Such these grains are thought to be derived from the disintegration of the igneous and metamorphic rocks (Folk, 1968). The dominancy of quartz over other members of the light minerals is mostly related to its resistance to weathering and the disintegration during the multicyclic processes of sedimentation.

Table (2): The distribution of light minerals of the sand fraction in the studied soils.

Geomorphic Unit	Profile No.	Depth (cm)	Quartz %	Feldspars %				Others	Total
				Orth.	Plag.	Micr.	Total		
Young Alluvial Plain	1	0-10	92.5	2.15	2.15	1.05	4.2	2.15	100
		10-60	92.35	2.15	2.2	1.1	5.5	2.1	100
		60-110	93.56	2.1	2.12	1.1	5.3	1.1	100
	2	0-25	92.42	1.08	2.15	2.15	5.4	2.2	100
		25-60	94.66	1.05	2.11	1.08	4.2	1.1	100
		60-90	94.64	1.1	2.11	1.1	4.3	1.1	100
	3	0-25	92.44	1.08	3.23	1.1	5.4	2.15	100
		20-65	94.69	1.05	2.11	1.1	5.3	1.05	100
		65-90	94.69	1.1	2.11	1.1	5.3	1.05	100

	4	0-15	95.84	1.04	1.04	1.04	3.1	1.04	100
		15-40	94.69	1.1	2.11	1.1	4.3	1.05	100
		40-90	92.35	1.1	2.2	2.15	5.5	2.2	100
	5	0-30	95.84	1.04	1.04	1.04	3.1	1.04	100
		30-70	93.69	1.1	3.19	1.1	5.4	1.1	100
	6	0-10	92.47	1.08	3.22	1.08	5.4	2.2	100
		10-50	92.35	1.15	2.2	1.1	5.5	2.2	100
		50-90	94.7	1.05	3.15	1.1	5.3	—	100
	7	0-20	93.62	2.13	2.13	1.06	5.3	1.06	100
		20-45	93.62	1.1	2.13	1.06	4.3	2.13	100
		45-90	95.84	1.04	1.4	1.04	3.1	1.04	100
	8	0-25	93.61	1.06	2.13	1.1	4.3	2.1	100
		25-60	93.61	1.1	2.1	1.06	4.3	2.13	100
		60-90	93.6	1.1	2.1	2.1	5.3	1.1	100
	9	0-30	94.65	1.05	2.1	1.1	4.3	1.1	100
		30-75	93.69	1.1	1.19	1.1	5.4	1.1	100
	10	0-40	93.69	1.1	1.1	3.19	5.4	1.1	100
		40-90	94.65	1.05	2.1	1.1	4.3	1.1	100
	11	0-25	94.7	1.1	2.1	1.05	4.3	1.05	100
		25-60	93.57	1.1	2.13	1.1	4.3	1.1	100
	12	0-25	91.26	2.17	3.3	2.2	7.7	1.09	100
		25-50	93.6	2.1	2.1	1.1	5.3	1.1	100
Old Alluvial Plain	13	0-20	93.6	2.1	2.1	1.1	5.3	1.1	100
		20-40	93.6	1.1	2.1	2.1	5.3	1.1	100
	14	0-30	92.43	1.15	2.15	2.2	6.5	1.07	100
		30-80	92.4	2.2	3.23	1.1	6.5	1.07	100
Pediplain Almost Flat	15	0-20	92.45	1.07	3.23	1.1	5.4	2.15	100
	16	50-40	95.84	1.04	2.08	1.04	4.2	—	100
	17	0-25	93.58	2.13	319	1.1	6.4	—	100
	18	0-25	93.51	1.1	3.19	1.1	4.3	1.1	100
		25-45	93.53	1.1	2.13	1.1	4.3	2.13	100
	19	0-15	93.54	1.1	2.13	2.13	5.4	1.1	100
	20	5-20	94.64	1.05	2.11	1.1	4.3	1.1	100

Table (2): Cont.

Geomorphic unit	Profile No.	Depth (cm)	Quartz %	Feldspars %				Others	Total
				Orth.	Plag.	Micr.	Total		
Playa almost Flat	21	0-30	88.92	1.1	1.1	1.1	3.3	7.87	100
		30-70	91.54	1.1	1.1	1.1	3.3	5.34	100
		70-110	88.92	1.1	1.1	1.1	3.3	7.78	100
	22	0-25	94.64	2.11	1.05	1.1	4.3	1.1	100
		25-60	94.69	1.1	2.11	1.05	4.3	1.05	100
		60-110	93.85	1.06	2.13	2.13	5.3	1.1	100
	23	0-20	94.59	1.1	2.11	1.1	4.3	1.1	100
		20-60	93.63	1.06	3.19	1.06	5.3	1.06	100
		60-90	92.45	2.15	2.15	1.1	5.4	2.15	100
	24	0-10	92.38	2.15	2.2	1.07	5.4	2.2	100
		10-35	92.56	1.06	3.19	1.06	5.3	2.13	100

	25	5-30 30-70	94.64 92.44	1.05 1.08	2.11 3.23	1.1 1.1	3.4 5.4	1.1 2.15	100 100
Aeolian Plain	26	0-30 30-70 70-130	94.95 89.02 90.11	1.05 1.09 1.1	1.1 3.3 1.09	2.1 1.1 1.1	4.3 5.5 3.3	1.1 5.49 6.6	100 100 100

Considering feldspars, it is evident that, these minerals constitute about 3.1 to 7.7% of the light fraction. The members of feldspars can arrange in the order of: Plagioclase > orthoclase > Microcline.

Depth-wise distribution of total feldspar content do not portray any particular pattern with depth indicating uniform distribution of the minerals, except for profiles 1, 2, 3, 4, 14 and 25 which feldspars tend to decrease with depth. The variability encountered in the content of individuals members of feldspars group could be explained on basis of relative resistance of such minerals to different weathering process.

(2) Heavy minerals

Table (3) reveals the distribution trend of heavy minerals in the sand fraction of the soil profiles under considerations as well as their distribution throughout the entire depth of profiles. It is noticed that, opaque and pyroboles (pyroxenes and amphiboles) are the most abundant minerals followed by Zircon, rutile, tourmaline, epidote and garnet in the sub-ordinate minerals. The remaining minerals such as kyanite, staurolite, silimanite, biotite and andalusite are detected in minute amounts.

Index Figure

Date in Table (3) showed that, the index figure values vary widely between 0.12 % and 12%. The lowest and highest values are recoded in the soils of young alluvial plain. The mean values of index figures fluctuated from 1.4% and 8.9% in profiles 23 and 5 respectively.

Differences in index figures of the studied soils may be attributed to the different sources and construction of parent materials and/or depositional process that lead to marked variation in the heavy mineral's constituents (El-Gendy, 1988).

The index figure values in the studied soils revealed that, the high abundant of light minerals in the sand fraction is attributed to these soils are derived from pre-existing Nubian sand stone rocks rich in light minerals (quartz and feldspars).

Table 3

Table 3(2

Table 3(3

Table 3(4

I- Opaque minerals

Opaque minerals are mostly composed of iron ores such as hematite, ilmenite, limonite and pyrite. These minerals are characterized as being isotropic between crossed Nicolls, black colored in plain light, non-pleochroic and generally surrounded to rounded in shape. The highest mean values (60.33 %) is recoded in the young alluvial plain soils (profile 11). While the lowest mean values (33%) is detected in the playa soils (profile 21). The frequency of opaque minerals seems to be related to geographic distribution, wreathing, condition and soil texture.

II- Non-Opaque minerals

Extremely unstable

Amphiboles: **They are the first abundant minerals in all the examined soil profiles and represented by hornblendes, tremolite and actinolite. Hornblende is detected as an abundant member, showing green to dark green varieties with sub angular prismatic to almost rounded grains. The content of**

amphiboles varied widely from soil profile to other. The lowest weighted average content (6.6 %) characterized in the soils of young alluvial plain, whereas the highest content (19%) is detected in the playa soils.

Pyroxenes: are found in all studied soil samples and vary in frequency weighted average from 4.6% to 14.6% of the non-opaque minerals. The lowest value is recorded in the young alluvial plain soils (profile 6), while the highest one is found in pediplian soils (profile 15). Pyroxenes members, Augite, hypersthene and diopside are the most common and present as a yellowish green and greenish yellow varieties and are present as short prismatic, sub angular to sub rounded grains. The presence of pyroboles (pyroxenes + amphiboles) in high percentage can be taken as an indication of the existence of immature conditions or recent depositions.

Slightly Stable:

Garnet: It comprises two varieties a pink dominant variety and of colorless rare one. Garnet is present in subangular to sub rounded grains that display isotropy between crossed nicols. It constitutes ranged from 1.8% of the pediplain soils (profile 19) and 9.96 % of the playa soils (profile 21).

Epidote: Epidote are recorded in all the examined samples. It is generally found in the form of shape angular to sub angular grains and greenish yellow in color, isotropic, high pleochroic and shows parallel extension. Its content ranged from 1.4 to 8.1% and its maximum value is recorded in playa soils (profile 21), while the minimum value is found in the young alluvial plain soils (profile 6).

Stable minerals:

Staurolite: it is identified as a golden yellow colored grain in both plain light and between crossed nicols. It is non pleochroic and sub angular, rarely sub rounded. Staurolite constitutes 2.1% to 11.7% The lowest average values are recorded in the pediplain soils (profile 17), while the highest value is found in the young alluvial plain soils (profile 11).

Kyanite: is detected in colorless varieties, having two perpendicular set of elewage and gives abnormal interference colors between crossed nicols. The mineral grains are generally surrounded in shape. Kyanite constitutes 0.9% to 6.9% of the non-opaque minerals and the low set and highest average values are detected in the soils of pediplain (profiles 16 and 20).

Silimanite: It is found as colorless prismatic or rectangular grain showing vertical striations and parallel extension. It constitutes 0.87% to 4.3% of the non-opaque minerals. The lowest average is recoded in the soils of pediplain (profile 20), while the highest value is detected in the soils of young alluvial plain (profile 8).

Andalusite: This mineral exists as colorless, sub-angular, sub-rounded, more or less irregular and rarely prismatic grains. Its frequency varied widely between 0.9% in the pediplain soils (profile 16) and 4.5% in the young alluvial plain soils (profile 3).

Very stable minerals:

1- **Zircon:** is the most very stable mineral in all the studied soil samples. It is characterized by colorless grain with high relief, The mineral grains have a common prismatic habit and rarely surrounded edges. Zircon percent ranges from 14.8% to 53.63% of the non-opaque minerals. The high average values are detected in the soils of profile (1) (young alluvial plain), whereas the lowest values are found in the soils of profile 21 (playa soils). The vertical distribution of zircon indicates no consistent pattern, thus indicating discontinuity of zircon with depth. The apparent discontinuity in the mineral's distribution could be explained on the premise that the soils studied have multi-origin, i.e. are derived from multi-parent materials and / or show variation associated with depositional regime.

2- Rutile: is the second only to zircon in abundance among the untestable minerals and occurs as variable chapped grains mostly sub angular and sometimes irregular rounded. The mineral color red or reddish brown. The maximum average value (16.5%) is recorded in profile 16 (pediplain), while the minimum average value (8.2 %) is detected in the soils of playa (profile 21), Its distribution does not portray any specific pattern with depth.

3- Tourmaline: is the third abundant very stable minerals and occurs is form of prismatic grain having rounded edges. It is characterized by different colors of which the dominant is pleochroic from reddish violet to dark brown. The maximum (average) value 7.5% is found in profile 23 (playa), while the minimum average value 3.0% is detected in profile 11 (young alluvial plain). The mineral has an irregular pattern of distribution downward the soil profiles.

4- Biotite: Occurs mainly as reddish brown to green flakey variety with sharp edges and common inclusion. Its average amounts range from 9.4% in the soils of playa (profile 21), to 1.1% in the soils of young alluvial plain (profile 6).

Uniformity of soil materials

Many studies about mineralogical investigations of the non-clay fraction in soils established the importance of heavy minerals in evaluating soil origin, genesis uniformity or discontinuity of parent material as well as soil development such as El-Demerdashe *et al* (1979), Hassona *et al.* (1995), Hassona (1999), Abd-El-Razik (2005) and Morsi (2008). According to those authors, the index minerals could be used as bases for evaluation uniformity or heterogeneity of soil material. Moreover, the ratios between two resistant minerals and / or resistant mineral to a mineral susceptible to weathering are also employed either as absolute ratios or as molecular ratios.

Based on the data in Table (4) representing the frequency distributions of uniformity rations of (Zr / T, Zr / R, and Zr / (T + R) for the studied soils could be indicated that these soils are of multi-depositional regime and / or their heterogeneous are due to their multi-origin.

Table (4): Resistance minerals and weathering ratios of the studied soils.

geomorphic unit	Profile no	Depth (cm)	Uniformity ratios			Weathering ratios	
			Z/R	Z/T	Z/(R+T)	Wr1	Wr3
Young alluvial plain	1	0-10	3.6	6.5	2.3	0.27	0.07
		10-60	6.8	11	4.2	0.45	0.028
		60-110	48	9.6	3.2	0.32	0.02
	2	0-25	5.6	11.4	3.8	0.49	0.02
		25-60	5.5	28.2	4.6	0.31	0.08
		60-90	4.5	11.3	3.2	0.46	0.02

	3	0-25	3.1	5	1.9	0.46	0.04
		20-65	4.7	8.3	3	0.52	0.11
		65-90	3.5	6.4	2.2	0.29	0.04
	4	0-15	3.9	6	2.4	0.42	0.014
		15-40	4.8	11.5	3.4	0.33	0.02
		40-90	3.7	6.1	3.5	0.43	0.14
	5	0-30	5	8.9	3.2	0.4	0.04
		30-70	3.7	7.8	2.5	0.24	0.06
	6	0-10	4.5	9	3	0.29	0.02
		10-50	3	5	1.9	0.25	0.02
		50-90	3.9	9.6	2.8	0.26	0.018
	7	0-20	5	9.9	3.3	0.35	0.018
		20-45	2.2	35	2.2	–	0.029
		45-90	4.1	16.7	3.3	0.2	–
	8	0-25	4.3	13	3.3	0.39	0.71
		25-60	4.3	11.8	2.7	0.37	0.041
		60-90	4.6	8.5	2.9	0.37	0.028
	9	0-30	3.7	9	2.6	0.49	0.05
		30-75	3.6	9.9	2.2	0.36	0.14
	10	0-40	4.2	9.4	2.9	0.31	0.054
		40-90	3.3	13.3	2.1	0.3	0.07
	11	0-25	3.7	14.8	2.9	0.44	0.063
		25-60	4.7	12.7	3.4	0.42	0.03
	12	0-25	2.7	6.9	1.9	0.42	0.15
		25-50	4.5	11.7	3.2	0.38	0.093
Old alluvial plain	13	0-20	5	10.1	3.3	0.34	0.071
		20-40	2.5	7.6	1.9	0.67	0.05
	14	0-30	2.9	5.8	1.9	0.36	0.11
		30-80	4.9	12.5	3.6	0.26	0.06

Z = Zircon, Wr1 = (P+A)/(Z+T), R = Rutile, Wr3 = B / (Z+T), A= Amphiboles,
P = Pyroxenes, B = Biotite, T = Tourmaline

Table (4): Cont.

Geomorphic unit	Profile no	Depth (cm)	Uniformity ratios			Uniformity ratios	
			Z/R	Z/R	Z/R	Wr1	Wr1
Pedi plain almost flat	15	0-20	3.9	4.9	1.8	0.71	0.04
	16	50-40	2.5	8.9	1.9	0.42	0.03
	17	0-25	2.5	8.5	2.9	0.4	0.029
	18	0-25	4.5	11.3	3.2	0.39	0.1
		25-45	4.5	9.1	3	0.29	0.04

	19	0-15	3.3	9.9	2.5	0.46	0.04
	20	5-20	3.1	5	1.9	0.53	0.04
Playa almost flat	21	0-30	1.6	2.8	1	1.3	0.42
		30-70	1.7	5	1.3	1.7	0.77
		70-110	2.5	4.9	1.7	1.8	0.3
	22	0-25	2.6	4.5	1.8	0.46	0.63
		25-60	2.9	4.4	0.58	0.24	0.04
		60-110	2.3	5.3	1.6	0.61	0.06
	23	0-20	2.7	4.5	1.6	0.55	0.04
		20-60	3.3	6.7	2.2	0.37	0.02
		60-90	3.3	5.5	2.1	0.48	0.016
	24	0-10	5.5	11	3.7	0.45	0.03
		10-35	3.8	6.4	2.4	0.37	0.06
	25	5-30	5	10	3.4	0.36	0.06
		30-70	0.86	3.7	0.69	0.66	0.1
Aeolian Plain	26	0-30	3.2	5.5	2	0.42	0.04
		30-70	2.5	6.5	1.8	0.45	0.03
		70-130	2.8	6.4	1.9	0.45	0.04

The weathering rations Wr1 and Wr3 calculated for the different layers of each soil profile (Table 4) provided a fairly good confirmation for the results obtained from the studied uniformity rations. These ratios are generally small, this could be explained by two reasons. The first one is that pyroxenes and amphiboles most probably had been derived from recent enrichment arrived from Nile Sediments. The second, the pre-existing rock (Nubian Sandstone) is poor in pyroxenes and amphiboles. Zircon, rutile and tourmaline are relatively high contents.

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دراسات معدنيه لا قسام الطين والرمل وتجانس التربة في منطقه جنوب توشكي – مصر

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الملخص العربي

يهدف هذا البحث إلى دراسة التركيب المنروالوجي لمجاميع الطين والرمل المفصولة من أراضي جنوب توشكي والواقعة بين خطي عرض 55/ 22°، 23/ 28° شمالا وخطي طول 55/ 30°، 55/ 32° شرق، ولتحقيق هذا الهدف استخدمت صور الأقمار الصناعية لاندسات والنظام ثلاثي الأبعاد لمنطقة الدراسة لتحديد الوحدات الجيومورفولوجية والتي اشتملت على السهل الرسوبي الحديث والسهل الرسوبي القديم والسهل التحاتي والبلايا والسهل الهوائي وقد تم تمثيل هذه الوحدات بعدد 26 قطاع أرضي.

وقد أوضحت الدراسة المنرالوجية للطين المفصول من بعض طبقات القطاعات المختارة باستخدام التحليل الطيفي لأشعة أكس إلى سيادة معدن الكاؤلينيت يليه معدن المونتموريلونيت مع وجود المعادن المختلطة وكذلك الأليت والكلوريت بكميات متفاوتة وقليلة وقد اتضح أن هذه المعادن موروثة من مادة الأصل واختلاف بيئة وظروف الترسيب.

ومن الدراسة البتروجرافية لمجموعه الرمل (0,063-0,125 ملم) المفصولة من طبقات القطاعات المختارة وجد أن المعادن الخفيفة تميزت بسيادة معدن الكوارتز والذي تزيد نسبته عن 89% في أغلب الأحيان مع وجود نسبة قليلة من معادن الفلسبارات والتي لم تزيد عن 11% وقد تميزت الفلسبارات بسيادة معدن البلاجيوكليز والأرثوكليز والميكروكلين- أما المعادن الثقيلة فيسود فيها المعادن المعتمة وقد تراوحت نسبتها ما بين 33% إلي 60,3% أما المعادن الغير معتمة فقد تميزت بسيادة معادن البيروبولز(بيروكسين+ أمفيبول)، يليها المعادن المقاومة للتجويه (زركون وروتيل وتورمالين) بينما باقي المعادن مثل الجارنيت - الابيدوت وكذلك معادن الاسترولیت والكيانيت والسلمنيت والاندولوزيت فقد وجدت بكميات قليلة.

وتشير نتائج نسب توزيع المعادن المقاومة للتجوية ونسب التجوية المحسوبة لهذه الاراضي أنها غير متجانسة أما لتعدد مواد الأصل أو لاختلاف ظروف الترسيب.

<u>السادة المحكمين</u>

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Table (3): Frequency distribution of heavy minerals in the sand fraction of the studied soils.

Profile No.	Depth (cm)	Index Figure	Opaque Mineral %	Non-Opaque minerals %															Bio	Oth.
				Extremely unstable			Slightly Stable			Stable					Very stable					
				Pyr.	Am.	Tot.	Gar.	Epi.	Tot.	Stau	Ky	Sill	And.	Tot.	Zir.	Rut	Tou.	Tot.		
Young Alluvial plain																				
1	0-10	5.3	47.1	7.6	12.7	20.3	3.2	2.5	5.5	2.5	0.64	1.9	2.5	7.55	65	18	10	93	5.1	1.9
	10-60	8.1	44.8	10.8	16.2	27	4.1	2.7	6.8	4.1	1.4	1.4	1.4	8.3	45.9	6.8	4.1	56.8	4.1	1.4
	60-110	6.5	49.7	7.4	10.4	17.7	3.1	10	13.14	4.2	1.04	2.1	2.1	9.44	50	10.4	5.2	65.6	1	2.1
	mean	6.2	47.2	6.6	13.1	21.7	3.5	5.1	8.5	3.6	1.03	1.8	2	8.43	53.63	11.73	6.4	68.8	3.4	1.8
2	0-25	1.1	52.5	9.6	13.5	23.1	2.9	1.9	4.8	2.9	0.96	1.9	1.9	7.66	43.3	7.7	3.8	54.8	0.96	1.9
	25-60	2.9	42.9	12.7	4.9	16.7	1.9	2.9	4.8	1.9	0.98	1.9	1.9	4.78	53.9	9.8	1.9	65.6	4.9	1.9
	60-90	7.2	51.3	13.7	10.5	24.2	3.2	4.2	7.4	2.1	1.1	1.1	1.1	5.4	47.4	10.5	4.2	62.1	1.1	1.1
	mean	3.7	48.9	12	9.6	21.6	2.7	3	5.7	2.3	1.01	1.63	1.63	5.95	48.2	9.3	3.3	60.8	1.99	1.6
3	0-25	3.4	53.1	8.7	10.4	19.1	6.9	4.3	11.2	6.9	0.87	2.6	4.3	14.66	34.8	11.3	6.9	53	1.7	2.2
	20-65	3.9	51.8	5.4	15.1	20.5	5.4	3.2	8.6	7.5	1.1	5.4	5.4	19.4	35.5	7.5	4.3	47.3	4.3	4.3
	65-90	3.7	52.3	4.8	9.5	14.3	4.8	2.9	7.7	6.9	1.9	1.9	3.8	14.3	42.9	12.4	6.7	62	1.9	5.4
	mean	3.5	52.4	6.3	11.7	18	5.7	3.5	9.2	7.03	1.29	3.3	4.5	16.12	37.9	10.4	5.97	54.1	2.63	3.96
4	0-15	4.7	53.1	14.2	13.2	27.4	3.8	1.9	5.7	3.8	1.9	2.8	2.8	11.3	65.6	12.2	9.4	80.2	0.94	2.8
	15-40	2.9	51.7	8.03	10.7	18.7	2.7	2.7	5.4	3.6	0.89	1.8	1.8	8.09	51.8	10.7	4.5	67	0.89	1.8
	40-90	3.5	51.3	7.8	9.4	27.2	2.3	2.3	4.6	3.1	1.6	2.3	2.3	9.4	42.9	11.7	7	55.3	7	2.3
	mean	3.7	52.03	10	11.1	21.1	2.9	2.3	5.2	3.5	1.64	2.3	2.3	9.56	50.4	12.2	6.97	67.5	2.9	2.3
5	0-30	12	46.6	14.6	4.9	19.5	4.9	1.9	6.8	4.9	2.9	3.9	2.9	14.6	43.7	8.7	4.9	57.3	1.9	2.9
	30-70	5.7	47.6	4.1	8.3	12.4	4.1	3.3	7.4	5.8	0.83	3.3	2.5	12.4	45.5	12.4	5.8	63.7	3.3	2.5
	mean	8.9	47.1	9.4	6.6	15.9	4.5	2.6	7.1	5.35	1.87	3.6	2.7	13.5	44.6	10.6	5.4	60.5	2.6	2.7
6	0-10	3.5	51.5	5.3	10.6	15.9	5.3	1.1	6.4	4.3	1.1	2.1	4.3	11.8	47.9	10.6	5.3	63.8	1.1	4.3
	10-50	2.8	45.5	4.2	10.4	14.6	5.2	2.1	7.3	3.1	1.04	1.04	3.1	8.28	47.1	15.6	9.4	72.1	1.04	3.1
	50-90	2.2	51.02	4.2	10.4	14.6	5.2	1.04	6.24	5.2	2.1	3.1	3.1	13.5	49.9	12.5	5.2	67.2	1.04	3.1
	mean	2.8	49.3	4.6	10.5	15	5.2	1.4	6.6	4.2	1.4	2.08	3.5	11.1	48.3	12.9	6.6	67.7	1.1	3.5

Pyr = Pyroxene, Am = Amphiboles, Tol = Total, Gar = Garnet, Epi = Epidote, Stau = Staurolite, Sill = Sillimanite
And = Andalusite, Zir = Zircon, Rut = Rutile, Tou = Tourmaline, Bio = Biotite, Ky = Kyanite

Table (3): Cont.

Profile No.	Depth (cm)	Index Figure	Opaque Mineral %	Non-Opaque minerals %															Bio.	Oth.
				Extremely unstable			Slightly Stable			Stable					Very stable					
Young Alluvial plain																				
				Pyr.	Am.	Tot.	Gar.	Epi.	Tot.	Stau	Ky.	Sill.	And.	Tot.	Zir.	Rut	Tou.	Tot.		
7	0-20	2.7	53.3	6.7	11.4	18.1	3.8	1.9	5.7	4.8	1.9	0.95	4.8	12.45	47.6	9.5	4.8	62.3	0.95	4.8
	20-45	0.21	67.8	–	–	–	–	–	–	10.5	–	–	–	10.5	35	15.8	–	50.8	–	–
	45-90	2.5	53.3	6.8	2.7	9.5	5.5	2.7	6.2	4.1	1.4	2.7	1.4	9.6	45.2	10.9	2.7	55.8	1.4	1.4
	mean	1.8	57.8	6.8	7.1	13.8	7.4	2.3	5.95	6.4	1.7	1.8	3.1	11	42.7	12.1	3.8	56.3	1.2	3.1
8	0-25	11.1	49.1	8.9	11.1	20	3.7	3.7	7.4	3.7	1.5	2.2	2.2	6.9	48.1	11.1	3.7	62.9	3.7	2.2
	25-60	7.5	42.2	7.3	10.9	18.2	3.6	2.2	5.8	5.8	1.5	5.8	2.9	16	43.8	10.2	5.1	50.1	0.73	2.9
	60-90	6	48.4	7.8	11.7	19.5	3.9	3.1	7	3.9	0.78	2.3	2.3	9.28	64.9	10.2	5.5	62.6	1.6	2.3
	mean	8.2	46.6	8	11.2	19.2	3.7	3	6.7	4.5	1.3	4.3	2.5	11.6	46.3	10.5	4.8	58.5	2.01	2.5
9	0-30	5	51.9	3.8	10	13.8	3.1	1.5	4.6	5.4	2.3	1.5	2.3	11.5	33.1	14.6	6.2	53.9	2.3	1.8
	30-75	3.1	53	8.1	8.1	16.2	4.1	4.1	8.2	5.7	1.6	3.3	1.6	12.2	40.7	14.6	4.1	59.1	6.1	1.6
	mean	4.05	52.5	6	9	15	3.6	2.8	6.4	5.6	1.95	2.4	1.95	11.9	36.9	14.6	5.2	56.5	4.2	1.7
10	0-40	4.5	55.5	6.5	10.2	16.7	3.9	4.2	8.1	6.4	4.8	4.1	3.8	19.1	48.2	11.6	5.1	64.4	2.9	3.3
	40-90	10.5	56.9	5.5	8.8	14.3	4.4	3.3	7.7	5.5	3.8	3.3	3.3	15.4	43.9	13.2	3.3	60.4	3.3	3.2
	mean	7.5	56.1	6	9.5	15.5	3.4	3.8	7.9	5.95	4.1	3.7	3.6	17.3	46.1	12.4	4.2	62.7	3.1	3.25
11	0-25	11.1	63.5	6.5	8.7	15.2	10.9	2.2	13.1	19.6	2.2	2.2	3.1	27.1	32.6	8.7	2.2	43.5	2.2	3.1
	25-60	5.2	57.1	12.7	8.9	21.6	3.8	1.3	5.1	3.8	1.3	2.5	2.5	10.1	48.1	10.1	3.8	62	1.3	2.5
	mean	8.15	60.3	9.7	8.8	18.4	7.4	1.8	9.1	11.7	1.8	2.4	2.8	18.6	40.1	9.4	3	52.8	1.8	2.8
12	0-25	4.5	52.6	7.8	11.1	18.9	3.3	1.1	4.4	4.4	2.2	2.2	2.2	11	38.9	14.4	5.6	58.9	6.7	2.2
	25-50	5	51.7	6.4	12.4	18.8	2.5	3.5	6	3.2	1.8	1.1	1.1	7.2	45.5	10.2	3.9	59.6	4.6	2.2
	mean	4.75	52.2	7.1	11.8	18.9	2.9	2.3	5.2	3.8	2	1.7	1.7	9.1	42.2	13.2	4.8	59.3	5.7	2.2
Old Alluvial plain																				
13	mean	2.1	53.7	7.1	14.9	22.7	4.3	3.3	7.6	4.3	0.97	1.4	2.4	9.1	42.65	12.1	4.8	59.5	2.9	2.4
14	0-30	7.5	50.7	7.5	8.4	15.9	3.7	4.7	8.4	2.2	1.9	3.7	3.7	11.4	37.4	13.1	6.5	57	4.7	3.7
	30-80	5.1	56.3	7.5	7.5	16	3.2	2.2	5.4	2.2	1.1	3.1	3.2	7.6	53.3	10.8	4.3	68.9	3.2	3.2
	mean	6.3	53.5	7.5	7.9	15.9	3.5	3.5	6.9	2.2	1.5	2.4	3.5	9.5	45.6	11.95	5.4	62.95	3.9	3.5

Table (3): Cont.

Profile No.	Depth (cm)	Index Figure	Opaque Mineral %	Non-Opaque minerals %															Bio.	Oth.
				Extremely unstable			Slightly Stable			Stable					Very stable					
				Pyr.	Am.	Tot.	Gar.	Epi.	Tot.	Stau.	Ky.	Sill.	And.	Tot.	Zir	Rut	Tou.	Tot.		
Pediplain Almost flat																				
15	0-20	1.5	42.2	14.6	11.5	26.1	3.8	7.7	11.5	5.4	1.5	2.3	3.1	10.8	30.8	10.8	6.2	47.8	1.5	0.77
	mean	1.5	42.2	14.6	11.5	26.1	3.8	7.7	11.5	5.4	1.5	2.3	3.1	10.8	30.8	10.8	6.2	47.8	1.5	0.77
16	50-40	1.8	47.8	7.3	11.9	19.2	3.7	3.7	7.4	3.9	0.9	2.8	0.9	8.5	41.2	16.5	4.6	62.3	1.8	0.09
	mean	1.8	47.8	7.3	11.9	19.2	3.7	3.7	7.4	3.9	0.9	2.8	0.9	8.5	41.2	16.5	4.6	62.3	1.8	0.09
17	0-25	1.7	45.1	10.5	7.4	17.9	2.5	1.6	4.1	2.1	0.98	1.1	1.1	5.28	38.5	9.63	3.6	51.7	1.3	–
	mean	1.7	45.1	10.5	7.4	17.9	2.5	1.6	4.1	2.1	0.98	1.1	1.1	5.28	38.5	9.63	3.6	51.7	1.3	–
18	0-25	8.5	45.5	8.3	9.4	17.6	4.6	4.6	9.2	3.7	0.92	4.6	2.8	12.02	41.7	3.9	3.7	54.7	4.6	2.8
	25-45	4.5	52.1	7.9	6.9	14.8	4.9	4.9	9.8	3.9	2.9	3.9	2.9	13.6	44.9	9.9	4.9	59.7	1.9	2.9
	mean	6.5	48.8	8.1	8.1	16.2	4.8	4.8	9.5	3.8	1.9	4.3	4.3	12.81	43.9	9.6	4.3	57.2	3.3	2.9
19	0-15	2.3	54.2	8.8	13.2	22	1.8	2.6	4.4	3.5	1.8	3.5	1.8	10.6	43.9	13.2	4.2	61.5	1.8	3.5
	mean	2.3	54.2	8.8	13.2	22	1.8	2.6	4.4	3.5	1.8	3.5	1.8	10.6	43.9	13.2	4.2	61.5	1.8	3.5
20	5-20	1.5	53.8	8.9	13.3	22.2	6.9	3.4	11.2	6.9	6.9	0.87	4.3	19.97	34.8	11.3	6.9	53	1.7	2.2
	mean	1.5	53.8	8.9	13.3	22.2	6.9	3.4	11.2	6.9	6.9	0.87	4.3	19.97	34.8	11.3	6.9	53	1.7	2.2
Playa almost flat																				
21	0-30	8	33.6	11.8	17.6	29.4	3.3	8.2	11.7	2.4	1.2	2.4	2.4	8.4	16.5	10.6	5.9	41.4	9.4	4.7
	30-70	5.6	27.9	9.7	19.4	29.1	4.9	10.7	14.6	2.9	3.9	1.9	1.9	12.6	16.4	8.7	2.9	38.8	13.5	2.9
	70-110	2.5	37.5	9.3	20	29.3	5.3	5.3	10.6	6.7	2.7	2.7	2.7	14.8	13.3	5.3	2.7	36.1	5.3	2.7
	mean	5.4	33	10.3	19	29.3	9.96	8.1	12.3	3.67	2.6	2.2	2.2	11.9	14.8	8.2	3.9	38.8	9.4	3.4

Table (3): Cont.

Profile No.	Depth (cm)	Index Figure	Opaque Mineral %	Non-Opaque minerals %															Bio.	Oth.
				Extremely unstable			Slightly Stable			Stable					Very stable					
				Pyr.	Am.	Tot.	Gar.	Epi.	Tot.	Stau.	Ky.	Sill.	And.	Tot.	Zir	Rut	Tou.	Tot.		
Playa almost flat																				
22	0-25	2	41.2	10.7	10.1	20.8	2.9	1.2	4.1	4.1	1.8	2.4	2.4	10.7	38.5	14.8	7.1	60.41	2.9	1.2
	25-60	3.8	47.5	5.3	7.4	12.7	4.3	2.1	6.4	4.3	1.1	2.1	2.3	9.8	42.6	14.9	9.6	67.1	2.1	1.1
	60-110	2.5	49.1	8.8	17.5	26.3	2.6	2.6	5.2	4.4	1.6	1.8	1.8	9.6	48.2	13.2	5.3	65.1	2.4	0.77
	mean	2.8	45.9	8.3	11.7	20	3.3	1.96	5.2	4.3	1.5	2.1	2.2	10.03	43.1	14.3	7.3	64.2	2.5	1.02
23	0-20	2.3	47.2	11.6	12.5	24.1	3.6	2.7	6.3	3.6	1.9	0.9	2.7	9.1	35.7	13.4	8	57.1	1.9	0.9
	20-60	1.5	55.3	8.9	10.1	19	4.3	3.4	6.8	2.2	1.1	2.2	1.1	6.6	44.9	13.5	6.7	65.1	1.1	1.1
	60-90	1.3	50.8	6.8	6.4	25	1.7	2.6	4.3	1.7	0.86	0.86	1.7	5.12	43.1	12.9	7.8	63.8	0.86	0.86
	mean	1.4	51.1	9.7	13	22.7	2.9	2.9	5.8	2.5	1.3	1.98	1.8	6.9	41.2	13.3	7.5	62	1.3	0.95
24	0-10	2.9	38	9	15.3	24.3	2.7	2.7	5.4	2.7	–	0.9	0.9	5.4	49.5	9	4.5	63	0.9	0.9
	10-35	2.3	51.7	7.6	11.5	18.1	3.1	3.1	6.2	3.1	1.5	1.5	1.5	7.6	44.3	11.5	6.9	62.7	3.1	0.8
	mean	2.6	44.9	8.3	13.4	212	2.9	2.9	5.8	2.9	1.5	1.2	1.2	6.5	46.9	10.3	5.7	62.9	2	0.85
25	5-30	3.4	49.9	8.8	8.8	17.6	3.5	4.4	7.9	6.2	1.8	2.7	3.5	14.2	44.2	8.8	4.4	57.4	2.7	3.5
	30-70	3.3	48.9	6.8	10.3	17.1	3.4	2.1	5.5	5.5	1.4	2.7	2.7	12.3	20.5	23.9	5.5	49.9	2.7	2.7
	mean	3.4	49.4	7.8	9.6	17.4	3.5	3.3	6.8	5.9	1.6	2.7	3.1	13.25	32.4	16.4	4.95	53.7	2.7	3.1
Aeolian plain																				
26	0-30	8	36.4	6.9	7.6	14.5	9.9	4.6	14.5	8.4	3.1	3.8	3.8	19.1	29	9	5.3	43.3	1.5	3.8
	30-70	7.8	36.7	4.3	14.5	18.8	4.3	1.4	5.7	1.4	–	1.4	2.9	5.7	36.2	14.5	5.6	56.3	1.4	1.4
	70-130	3.5	35.6	5.6	11.2	16.8	4.8	2.1	6.9	1.6	2.9	1.6	3.2	9.3	32.4	11.5	5.1	49.5	1.4	–
	mean	6.3	36.2	5.6	14.5	16.7	6.3	2.7	9.03	3.8	3	2.3	3.3	11.4	32.5	11.7	5.3	49.8	1.4	2.6