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SOIL PEDOLOGY AND FORMATION REGIME OF THE NORTH-EAST DESERT HINTERLAND OF EL- FAYOUM GOVERNORATE

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ABSTRACT: *The current investigation was carried out to identify and study the physiographic units of the desert hinterland north-east El-Fayoum Governorate using Landsat Thermatic Mapper (ETM 7). Soil characteristics, classification, deposition mode and sand mineralogy assemblage of the studied area were also performed. For these purposes, ten soil profiles were chosen representing the physiographic units. Site and soil profiles were morphologically described and samples were collected according to soil vertical variations. These samples were used for physical, chemical and mineralogical analysis.*

According to the interpretation of the Landsat Thermatic Mapper (ETM 7) using GIS, seven physiographic units were identified in the studied area. These units are the young alluvial terraces, denuded rock land, rough cobbly- stony hilly rock land, wadi bottom, river terraces, dissected plateau remnants rock land and not dissected to moderately dissected plateau remnants rock land. The characteristics of the representative soil profiles were used for classifying the studied soils according to USDA (2010) up to family level. These soils were affiliated to Entisols or Aridisols.

The statistical size parameters of sand fraction indicated that soil materials were poorly sorted and mostly transported and deposited under water action. The deposition environment was fluvial (deltaic) and the hydro-dynamic conditions were rolling and suspension.

Quartz is the predominant light mineral followed by feldspars and calcite and non-opaque minerals dominated heavy minerals of sand fraction (0.125-0.063 mm). The mineralogical assemblies of sand fraction in the studied soils and their ratios reveals that soils are recent or immature and of multi- origin and/ or multi depositional regimes.

Key words: *GIS, physiographic units, Landsat Thermatic Mapper (ETM 7), light minerals, heavy minerals.*

INTRODUCTION

Reclamation and utilization of the Egyptian desert areas is one of the most important hopes for the overcoming the agricultural needs.

Satellite images proved to be useful tool of reconnaissance inventories for large area of many types of landscapes. Also, Landsat Imagery has been widely accepted as a basis for soil survey at small scales. Furthermore, its use has been successfully demonstrated in delineating soil associations on the landscape (Westin and Frazee, 1976 and Worcester and Moore, 1978). Siegal and Abrams (1976) concluded that Landsat data were useful for mapping major geomorphic units.

El Fayoum Governorate occupies a circular depression in the Eocene Limestone Plateau at the northern part of the Western Desert of Egypt. It is located at about 90 km. to the south west of Cairo. It is divided into six districts, namely; Tamia, Senours, Ibshoway, El Fayoum, Yousef El- Sadie and Itsa.

The North – East desert hinterland of El-Fayoum Depression, adjacent to both sides of Cairo- El–Fayoum desert road is considered a promising area for agricultural utilization.

According to UNDP/FAO (1966) and the geological map of El-Fayoum (Conoco, 1987), particularly characteristic of the narrow divide between El Fayoum depression and the Nile valley are a number of high hills or ridges of Pliocene age. It was a gully in the lower middle Eocene formation during the Pliocene, subsequently filled with rubble and boulders of Oligocene age. However, the continued erosion of the surrounding softer middle Eocene strata, predominantly by wind, has left the more resistant fill of the former gullies standing out high in the terrain as hills.

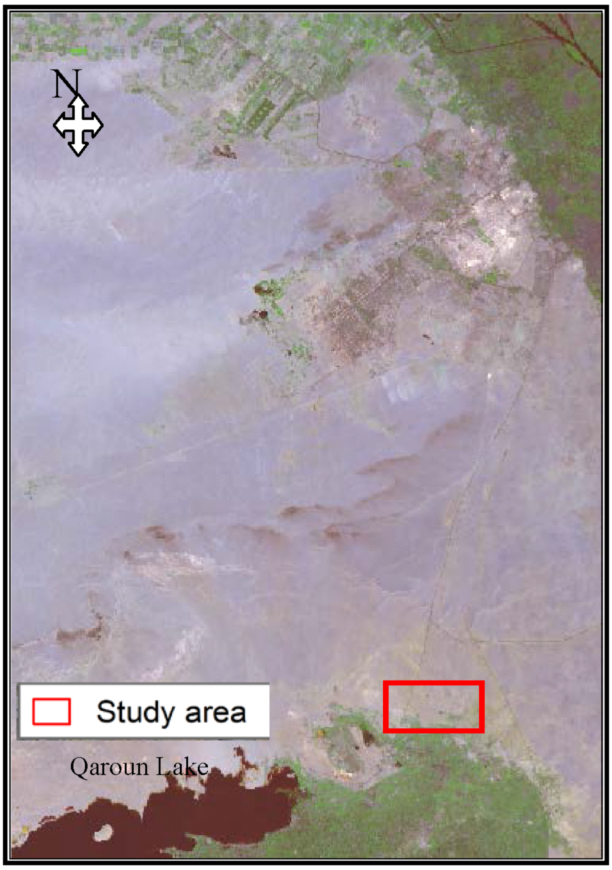
Beadnell (1909) distinguished the Ravine Beds in the middle Eocene, which consist of white clays and shales, marls, Limestones and silt stones, some of them highly gypsiferous.

The meteorological data of the studied area indicated that the mean annual temperature ranges from 21.4 to 28° C. The maximum annual temperature differs from 28.8 to 29.5° C and the minimum from 13.6 to 15.6° C. El Fayoum receives a very low amount of rainfall where average rate is between 9-17 mm/year. The mean annual relative humidity ranges from 28 to 67% (CALC, 2010). According to (USDA, 2010) the soil moisture regime is “Torric” and the temperature regime is "Hyperthermic".

The aim of this study was to identify the physiographic units of the north-east desert hinterland of El- Fayoum depression using Landsat Thermatic Mapper (ETM 7). Moreover, soil characteristics, classification, deposition mode and mineralogy of studied area are also studied.

MATERIALS AND METHODS

The studied area is located in the North-East desert hinterland of El-Fayoum Depression that lies between latitudes 29° 34^{-} to 29° 45^{-} North and longitudes 30° 50^{-} to 31° to 00^{-} East (image, 1).



Study area

Image (1): Location of the studied area

Landsat Image composite of Enhanced Thermatic Mapper (ETM7) with bands 2, 3 and 4 was used to add an extra landscape assessment to the photo-interpretation map. Space image interpretation performed using the physiographic analysis as proposed by Burnigh (1960) and Gosssen (1967). The preliminary image interpretation map was checked in the field to emphasize the boundaries of the physiographic units. Ten soil profiles were dug deep to 150 cm or lithic contact to represent the predominant characteristics of the identified physiographic units of the studied area. Soil profiles were described in the field according to FAO (2006). Soil color is defined according to the Munsel Color (2009).

Soil samples were collected, air dried, crushed and sieved through 2- mm sieve and subjected to physical, chemical and mineralogical analysis. Gravel contents were determined as a percent by volume. Particle size distribution, soil pH in (1:2.5) soil extract, total salinity (EC_e) and soluble cations and anions in saturated paste extract were determined according to methods described by Black (1982).

The studied soils were classified up to the family level according to USDA (2010).

Cumulative percentages were plotted against phi- diameter on an arithmetic probability paper and eight percentiles; Φ1, Φ5, Φ16, Φ25,Φ 50, Φ75,Φ 84 and Φ95 were estimated according to Griffiths (1967).

The statistical grain size parameters were then determined according to the formula of Folk and Ward (1957). The depositional environment of sediments is calculated according to Sahu (1964) and hydro-dynamic conditions according to from Passega (1957 and 1964).

Mineralogy of sand fraction:

Heavy and light minerals of the sand fraction (0.125 – 0.063 mm.) are separated by means of the Bromoform according to El – Hinawi (1966). The systematic identification of the light and heavy minerals was carried out using the polarizing microscope as principles reported by Kerr (1959) and Milner (1962).

RESULTS AND DISCUSSION

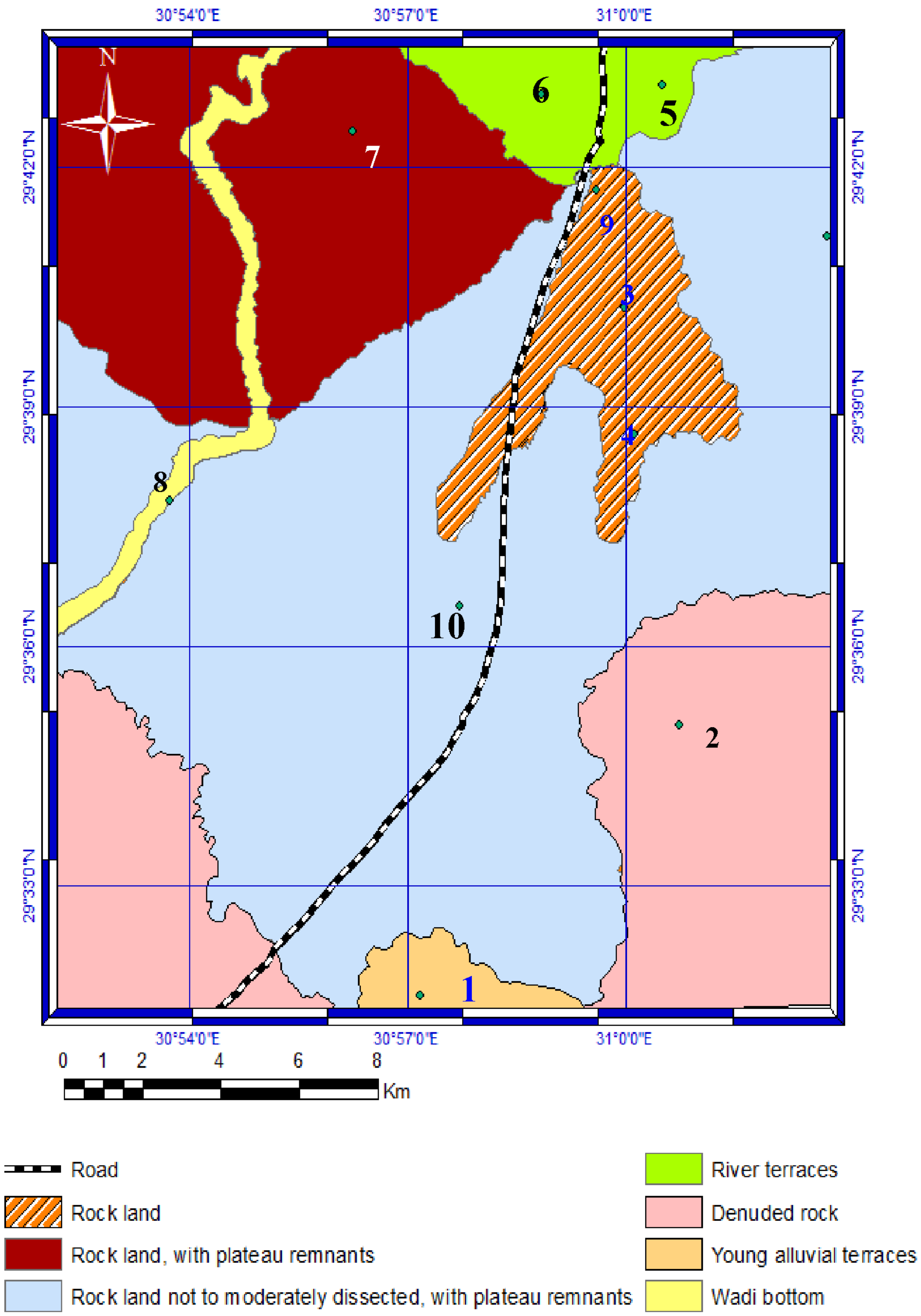
Seven physiographic units are identified using the Landsat Thermatic Image (ETM 7). These units are the young alluvial terraces, denuded rock land, rough cobbly-stony hilly rock land, wadi bottom, river terraces, dissected plateau remnants rock land and not dissected to moderately dissected plateau remnants rock land. Ten soil profiles were chosen represented these units. Data of morphological description, physical properties and chemical analysis are illustrated in Tables 1, 2 and 3 respectively. The distribution of the physiographic units and representative profiles are shown in Map (1).

Generally, the main landscape of the studied area is denuded rock with narrow strips of terrace adjoining the valley. There are many river terraces of different ages prevailing the northwards of El Ate canal. The main characteristics of the studied area are as follows:

Young alluvial terraces:

The youngest terrace soils are generally still less gravelly, and more sandy. Gypsum pseudo- sand is also an important constituent, but locally these youngest river deposits tent to be loamy. These soils occur along the former lake beaches of the Fayoum depression (UNDP/FAO, 1966). These unit soils are represented by profile, 1. These soils are characterized by gently sloping, very pale brown color in surface and reddish yellow to pink in subsurface layers (dry), sandy loam to sandy clay loam texture, 1.09 to 7.50 % gypsum contents, 1.58 to 3.37% lime contents, 7.6 to 7.9 soil pH, 6.24 to 11.75 ds/m EC, 9.75 to 11.50% ESP and have a Gypsic horizon.

These soils are classified according to USDA (2010) as: Typic Haplogypsids, fine loamy, mixed hyperthermic.



Map (1): Location of studied soil profiles and physiographic units.

Table (1): Morphological features of the studied soil profiles.

Physiographic unit	Profile No.	Slope gradient	Depth (cm)	Soil colour		Texture class	Soil structure	Soil consistency	Boundary
				Moist	Dry				
Young Alluvial Terraces	1	Gently sloping	0-30 30-75 75-100 100-150	10YR7/4 5YR6/6 5YR6/4 5YR7/6	10YR8/4 5YR7/6 5YR7/4 5YR7/6	SL SCL SL SCL	Massive Massive Massive Massive	Soft Friable Friable Friable	CS CS GS
Denuded Rock	2	Nearly level	0-50 50-90 90-150	10YR6/6 10YR6/4 10YR6/4	10YR7/6 10YR7/4 10YR7/4	LS SL SCL	Massive Massive Massive	Slightly hard Friable Friable	GS GS
Rock land	3	Gently Sloping	0-50 50-110 110-150	10YR6/4 10YR7/4 10YR6/4	10YR7/4 10YR8/4 10YR7/4	SCL	Massive Massive Massive	Hard Friable Friable	GS GS
	4	Sloping	0-40 40-75 75-150	10YR8/4 10YR6/6 10YR6/6	10YR7/4 10YR7/6 10YR7/6	SL SL SCL	Massive Massive Massive	Loose Friable Friable	CS CS
	9	Gently sloping	0-30 30-100 100-150	10YR6/6 10YR7/4 10YR6/6	10YR7/4 10YR8/4 10YR7/6	SCL	Massive Massive Massive	Friable Friable Firm	GS CS
River Terraces	5	Nearly level	0-15 15-70 70-110	5YR7/4 5YR6/6 5YR6/8	5YR8/4 5YR7/6 5YR6/6	SL LS LS	Massive Single grain Single grain	Slightly hard Loose Loose	CS GS
	6		0-35 35-75	2.5YR6/6 2.5YR7/4	2.5YR7/6 2.5YR8/4	LS SL	Single grain Massive	Loose Friable	CS
Rock outcrops	7	Sloping	0-40 40-90	10YR6/6 10YR6/8	10YR7/6 10YR6/6	SCL C	Massive Massive	Friable Firm	CS
Wadi bottom	8	Nearly level	0-25 25-100 100-150	10YR6/6 10YR6/6 10YR7/4	10YR7/6 10YR7/6 10YR8/4	LS LS SL	Single grain Massive Massive	Loose V. friable Friable	CS GS
Moderately High Terraces	10	Gently sloping	0-25 25-90 90-130	10YR6/6 10YR7/4 10YR6/6	10YR7/6 10YR8/4 10YR7/6	SL SCL SL	Massive Massive Massive	Friable Friable Friable	CS CS

Where:- Boundary: CS= Clear smooth GS= Gradual smooth
Texture: SL= sandy loam SCL =sandy clay loam LS= loamy sand C= clay

Table (2): Some main physico-chemical properties of the studied soil profiles.

Physiographic unit	Profile No.	Soil depth (cm)	Gravel %	Particle size distribution %				Texture class*	Organic matter %	$CaCO_3$ %	Gypsum %	CEC, (Cmolc kg^{-1})
				Coarse sand	Fine sand	Silt	Clay					
Young Alluvial Terraces	1	0-30	--	41.75	28.17	6.00	24.08	SL	0.19	3.37	1.09	16.88
		30-75	--	43.66	21.75	11.22	23.37	SCL	0.15	1.58	7.50	15.53
		75-100	--	45.95	17.86	22.75	13.44	SL	0.11	1.85	2.37	8.56
		100-150	--	51.17	14.87	10.65	23.31	SCL	0.09	1.58	1.90	15.50
Denuded Rock	2	0-50	--	59.91	17.88	13.98	8.23	LS	0.23	10.34	6.74	5.96
		50-90	--	53.65	14.37	17.31	14.67	SL	0.14	12.97	6.63	9.18
		90-150	--	41.99	23.68	11.47	22.86	SCL	0.10	18.55	2.86	15.77
Rock land	3	0-50	--	39.88	26.59	12.55	20.98	SCL	0.13	4.85	4.26	14.33
		50-110	--	45.44	19.99	13.23	21.34		0.08	7.07	3.21	13.51
		110-150	--	41.91	23.97	11.99	22.13		0.06	7.80	3.48	15.91
	4	0-40	--	44.57	19.68	21.91	13.84	SL	0.15	9.39	7.33	8.76
		40-75	--	41.88	21.64	19.99	16.49		0.13	6.96	3.53	10.09
		75-150	--	49.29	15.55	12.98	22.18	SCL	0.11	6.22	1.39	15.93
	9	0-30	--	15.38	31.22	25.87	27.53	SCL	0.21	1.58	4.95	19.61
		30-100	--	55.88	12.55	9.99	21.58		0.18	1.05	7.21	14.63
		100-150	--	51.75	16.70	9.15	22.40		0.14	1.00	16.18	15.04
River Terraces	5	0-25	28	49.58	21.87	17.89	10.66	G SL	0.09	3.80	3.49	7.17
		25-85	22	66.58	14.25	10.20	8.97	G LS	0.08	3.59	3.24	6.33
		85-110	9	65.58	14.35	11.58	8.49	SG LS	0.05	2.43	2.38	6.09
	6	0-60	30	66.89	16.57	9.55	6.99	G LS	0.10	4.85	6.84	5.34
		60-75	10	27.23	40.35	20.16	12.26	SG SL	0.07	1.32	4.36	10.97
Rock outcrops	7	0-40	18	49.88	13.35	11.17	25.60	G SCL	0.22	1.05	2.35	17.64
		40-90	--	21.04	9.86	23.15	46.63	C	0.37	0.95	3.12	35.16
Wadi bottom	8	0-25	--	70.98	14.21	6.88	7.93	LS	0.24	3.95	12.55	5.81
		25-100	--	67.25	16.00	6.12	10.63	LS	0.16	4.06	10.33	7.16
		100-150	--	45.99	21.48	27.09	5.44	SL	0.14	5.22	5.32	4.56
Moderately High Terraces	10	0-25	--	44.35	25.55	19.97	10.13	SL	0.17	4.22	9.01	6.91
		25-90	--	46.88	17.88	13.26	21.98	SCL	0.13	2.64	12.63	14.83
		90-130	--	49.68	21.88	17.28	11.16	SL	0.09	1.58	17.07	7.42

Fine earth: LS=Loamy sand, SL=Sandy loam, SCL=Sandy clay loam, C=Clay Gravel: SG=Slight gravelly G=Gravelly

Table (3): Chemical analysis of soil paste extract for the studied soil profiles.

Physiographic unit	Profile No.	Soil depth (cm)	ESP	pH (1:2.5)	ECe, dS/m	Cations (mmolc L^{-1})				Anions (mmolc L^{-1})		
						Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{--}
Young Alluvial Terraces	1	0-30	9.75	7.74	11.75	24.77	17.68	85.34	0.23	3.20	86.70	38.11
		30-75	11.47	7.60	6.24	15.78	10.12	43.29	0.11	4.88	36.76	25.67
		75-100	10.88	7.75	10.26	28.35	8.10	70.50	0.26	4.75	60.18	42.27
		60-150	11.50	7.90	7.95	27.92	5.52	50.68	0.19	3.56	45.90	34.85
Denuded Rock	2	0-50	9.84	7.45	41.08	181.68	29.20	294.92	0.65	4.99	387.60	113.86
		50-90	10.02	7.50	44.02	151.95	42.37	319.55	0.48	4.63	291.70	218.04
		90-150	9.55	8.15	42.81	143.74	31.57	310.83	0.51	3.26	272.30	211.10
Rock land	3	0-50	11.67	7.65	26.05	86.97	14.65	181.89	0.22	3.25	200.88	80.59
		50-100	10.56	7.70	16.64	52.88	11.60	120.78	0.21	3.88	137.68	43.92
		100-150	8.94	7.80	44.53	154.87	18.69	323.29	0.47	3.00	296.76	197.56
	4	0-40	6.22	7.90	8.21	22.67	11.13	55.61	0.11	3.38	66.3	19.85
		40-75	7.84	7.78	22.14	75.35	13.15	160.71	0.34	4.50	144.84	100.21
		75-150	8.07	7.75	31.49	127.90	23.24	228.61	0.38	3.56	229.50	147.06
	9	0-30	9.44	7.55	74.75	217.09	103.73	542.50	0.88	3.25	578.20	282.75
		30-100	11.07	7.45	103.99	293.76	178.29	798.50	0.95	3.50	727.24	540.76
		100-150	10.61	7.35	148.01	647.12	238.67	1074.50	1.80	3.13	1116.88	840.09
River Terraces	5	0-25	9.56	7.54	14.18	50.05	13.15	102.97	0.21	4.88	119.34	42.16
		25-85	6.11	7.60	3.57	27.90	4.07	25.91	0.13	4.13	18.36	35.53
		85-110	5.34	7.65	4.28	33.22	6.04	31.08	0.10	3.75	16.32	50.37
	6	0-35	7.13	7.50	11.08	43.74	14.65	80.42	0.18	4.25	88.72	46.01
		35-75	9.37	7.79	86.83	228.55	217.93	830.50	0.86	3.50	713.84	560.20
Rock outcrops	7	0-40	12.15	7.45	40.76	135.75	19.20	295.88	0.51	3.75	325.32	122.2
		40-90	13.39	7.52	67.18	145.83	63.08	487.74	0.70	3.00	522.18	172.17
Wadi bottom	8	0-25	10.57	7.35	39.90	130.58	44.45	289.65	0.35	3.50	390.64	70.89
		25-100	9.67	7.40	51.65	123.80	85.90	374.99	0.65	3.75	537.54	44.05
		100-150	11.74	7.56	18.12	54.59	14.65	131.58	0.23	3.63	163.16	34.24
Moderately High Terraces	10	0-25	11.08	7.49	75.33	214.08	96.03	546.90	0.89	3.75	588.48	265.67
		25-90	9.82	7.43	44.96	195.67	14.65	326.40	0.62	3.38	327.38	206.60
		90-130	10.01	7.30	42.14	123.45	44.84	305.91	0.58	3.00	334.38	137.40

Denuded rock land:

The denuded rock land type is important for potential irrigated agriculture, because it was developed from the Ravine Beds of the middle Eocene as " white clays, marly limestones and mud stones, some of the beds highly charged with gypsum", Beadnell (1905). These materials, once exposed to weathering are strongly subjected to erosion, particularly by the wind. The denudation of the geological formation has resulted in a land type of rather smooth topography. These unit soils are represented by profile, 2 and characterized by nearly level, yellow to very pale brown, loamy sand to sandy clay loam, 2.86 to 6.74% gypsum contents, 10.45 to 18.55 % lime contents, 7.45 to 8.15 soil pH, 41.08 to 44.02 ds/m soil salinity, 9.55 to 10.02 % ESP and have a gypsic horizon. These soils are classified according to USDA (2010) as: Leptic Haplogypsids, coarse loamy, mixed, hyperthermic.

Rock land (rough cobbly- stony hilly land):

This unit is presented by profiles, 3, 4 and 9. The soils of this unit have loamy white clay, marl and mud stones parent materials, with very bad permeability and have high salts content. There are clear aspects of physical weathering by wind erosion. These soils are characterized by gently sloping and sloping topography, yellow to very pale brown color (dry), sandy loam to sandy clay loam texture, 1.39 to 16.18 % gypsum contents, 1.0 to 9.39 % lime contents, 7.35 to 7.90 pH, 8.21 to 148.01 ds/m EC, 6.22 to 11.67 % ESP. Soils of profile,9 have a salic horizon , while soils of profiles, 4 and 9 have gypsic horizon. These soils are classified according to USDA (2010) as:

Soils of profile, 3: Typic Torriorthents, fine loamy, mixed hyperthermic

Soils of profile, 4: Leptic Haplogypsids, coarse loamy, mixed, hyperthermic

Soils of profile, 9: Gypsic Haplosalids, fine loamy, mixed, hyperthermic

Wadi bottom:

This unit is presented by profile, 8. These soils are characterized by nearly level topography, very pale brown to brownish yellow color (dry), loamy sand to sandy loam texture, 5.32 to 12.55 % gypsum contents, 3.95 to 5.22 % lime contents, 7.35 to 7.56 soil pH values, 18.12 to 51.65 ds/m EC, 9.6 to 11.74 % ESP and have a Gypsic horizon.

These soils are classified according to USDA (2010) as: Leptic Haplogypsids, sandy, mixed, hyperthermic.

Soils of river terraces:

This unit is presented by profiles, 5 and 6. These soils have oldest river terraces landform, dominantly gravelly sediments, with a gravelly pavement surface, gypsum crystals and lime spots. These soils are characterized by nearly level topography, yellow to very pale brown color (dry), gravelly loamy sand to gravelly sandy texture, 2.38 to 6.84 % gypsum contents, 1.32 to 4.85 % total carbonate, 0.05 to 0.10 % organic matter, 7.5 and 7.79 pH, 3.57 to 86.83 ds/m EC and ESP 5.34 to 9.56 %.

These soils are classified according to USDA (2010) as:

Soils of profile, 5: Typic Torriorthents, sandy, mixed, hyperthermic

Soils of profile, 6: Typic Haplogypsids, sandy, mixed, hyperthermic

Rock land, with plateau remnants:

This land type has a dissected plateau shape as a result of the exposure of hard horizontal upper Eocene starter with the Oligocene gravels in the northern escarpment of Fayoum depression. This unit is represented by profile 7. The soils are characterized by sloping topography, gravelly sandy clay loam to clay texture class, yellow to yellowish brown color (dry), 18.4 % gravel content in the surface layer, 2.35 to 3.12 % gypsum contents, 0.95 to 1.05 % lime contents, 0.22 to 0.37 % organic matter contents, 7.45 to 7.54 pH, 30,76 to 67.18 ds/m EC and 12.15 to 13.39 % ESP. These soils are classified according to USDA (2010) as: Typic Torriorthents, clayey, mixed, hyperthermic.

Rock land, with not dissected to moderately dissected plateau remnants:

This land type has undissected to moderately dissected plateau rock land. This unit is represented by profile 10. The soils are characterized by sloping topography, very pale brown to yellow color (dry), sandy loam to sandy clay loam texture, 9.0 to 17.07 % gypsum contents, 1.58 to 4.22 % lime contents, 0.09 to 0.l7 % organic matter contents, 7.3 to 7.49 pH, 42.14 to 75.33 ds/m EC and 9.82 to 11.08 % ESP. These soils are classified according to USDA (2010) as: Leptic Haplogypsids, fine loamy, mixed, hyperthermic.

Deposition mode of studied soils:

Particle size distribution of sand fractions is shown in Table (4).The statistical size parameters namely mean size (Mz) sorting (ծ1), Skeweness and kurtosis (KG) of the studied soils are given in table (5). Data in Table (5) showed that the (MZ) varied between 0.73 and 2.92 Ф which indicate that the predominant particle size is medium sand with the presence of fine and coarse sand. The inclusive graphic standard deviation ($ծ^2$) is used as a measure of sorting (ծ1). Values of sorting are from 1.02 to 1.77 Ф, which indicate poorly sorted soil materials that mostly transported and deposited under water action (Inman, 1952). The surface layer of profile 5 has moderately sorted (0.99 Ф), which indicate that wind and water are responsible of transportation and depositional of these materials. Skewness (Ski) data indicate the symmetrical distribution of 95 % of the grains around the mean size (Mz). Studied soils have not any specific distribution trend with depth. They range between strongly coarse skewed to strongly fine skewed. Kurtosis (KG) is a measure for the peakedness of the frequency distribution curve, i.e. the ratios of sorting in the extremes, or the two tail of distribution curve as compared with the sorting in the central part. Data in Table (5) designate lepto, very lepto and extremely leptokurtic classes, which reveal a very energy environment and very low modification of grain size. Furthermore, the data of statistical size parameters reveal that the studied soils are of non-uniform parent materials.

Environment of deposition:

The calculated and determined environments of deposition by applying the discriminant function of Sahu (1964) are given in Table (6). Data in Table (6) indicated that the different layers of the representative soil profiles have fluvial (deltic) deposition environment. The results could designate that the studied soil materials are mostly deposited under aqueous environments.

Hydro- dynamic conditions:

The data in Table (6) are used for concluding the hydro-dynamic conditions (C-M pattern) according to Passega (1957 and 1964). The concluded C-m patterns are illustrated in Table (6) and Fig (1). The results indicated that the mechanism of transportation of different layers of most of studied soils is rolling and suspension (O – p segment). The deepest layers of profiles 6 and 7 and the subsurface layer of profiles 2 and 5 are belong to N-O segments indicating that soil materials are transported and deposited by rolling. The surface layer of profile 4 corresponds to Q-R segment that indicates that its materials are transported and deposited under graded suspension.

Table (4): Particle size distribution of sand fractions of the studied soil profiles.

Physiographic unit	Profile No.,	Depth	No.,	Sand fractions %								total/ %
				>4	>2	>1	>500	>250	>125	>63	<63	
Young Alluvial Terraces	1	0-30	1	0.00	0.85	21.21	14.03	10.12	23.21	23.06	7.52	100.00
		30-75	2	0.00	0.80	25.76	15.50	10.10	15.10	23.76	8.99	100.00
		75-100	3	0.00	0.81	22.81	14.86	9.57	19.09	24.66	8.19	100.00
		100-150	4	0.00	1.09	23.86	14.07	8.74	16.59	27.11	8.56	100.00
Denuded Rock	2	0-50	5	0.00	0.60	17.35	21.70	23.17	15.87	16.44	4.88	100.00
		50-90	6	0.00	0.66	10.26	32.40	35.27	13.52	6.46	1.44	100.00
		90-150	7	0.00	0.62	20.85	24.20	28.55	15.18	8.62	2.01	100.00
Rock land	3	0-50	8	0.00	0.65	10.96	20.66	32.29	20.17	11.37	3.91	100.00
		50-110	9	0.00	0.66	4.19	16.00	33.29	27.11	16.31	2.46	100.00
		110-150	10	0.00	0.65	18.46	25.44	27.05	17.37	8.94	2.10	100.00
	4	0-40	11	0.00	0.52	7.96	9.41	23.18	29.33	23.50	6.10	100.00
		40-100	12	0.00	0.65	7.58	12.11	26.59	32.02	19.08	1.99	100.00
		100-150	13	0.00	0.65	5.54	10.61	22.98	36.06	20.48	3.70	100.00
	9	0-30	24	0.00	0.59	11.02	20.33	19.07	19.89	19.69	9.41	100.00
		30-100	25	0.00	0.66	16.36	20.70	11.88	23.66	17.29	9.46	100.00
		100-150	26	0.00	0.63	14.72	18.47	19.65	31.45	12.54	2.55	100.00
River Terraces	5	0-15	14	0.00	0.63	4.92	13.78	45.23	27.38	6.90	1.16	100.00
		15-85	15	0.00	0.59	25.53	18.18	30.81	18.41	5.60	0.88	100.00
		85-150	16	0.00	0.60	14.82	17.49	37.50	22.30	6.20	1.09	100.00
	6	0-65	17	0.00	0.67	17.32	21.15	30.86	20.70	7.92	1.39	100.00
		65-150	18	0.00	1.33	41.54	24.63	15.37	10.04	5.24	1.87	100.00
Rock outcrops	7	0-45	19	0.00	0.72	10.87	16.28	34.37	20.54	13.92	3.31	100.00
		45-150	20	0.00	2.73	37.62	22.33	14.97	9.96	7.07	5.32	100.00
Wadi bottom	8	0-20	21	0.00	0.72	18.66	28.37	29.31	13.48	6.64	2.84	100.00
		20-110	22	0.00	0.59	19.90	32.35	30.29	11.17	4.30	1.41	100.00
		110-150	23	0.00	0.56	20.08	27.52	29.01	16.38	5.34	1.12	100.00
Moderately High Terraces	10	0-25	27	0.00	0.59	17.91	20.66	19.46	20.51	15.20	5.66	100.00
		25-90	28	0.00	0.63	22.01	24.31	23.71	17.80	9.14	2.41	100.00
		90-130	29	0.00	0.56	20.46	20.97	15.51	13.11	14.16	15.25	100.00

Table (5): Statistical size parameters, for grain size distribution of the five sand fractions of the studied soils.

Physiographic unit	Profile No.	Depth	No.	Mean size (MZ)	Sorting (σ)		Skewness (Sk)		Kurtosis (KG)	
					σ	class	Sk1	class	KG	*class*
Young Alluvial Terraces	1	0-30	1	1.85	1.63	poorly sorted	-0.25	Coarse skewed	0.66	*Very leptokurtic*
		30-75	2	1.75	1.66	poorly sorted	0.09	Nearly Symmetrical	0.57	*Leptokurti*
		75-100	3	1.88	1.61	poorly sorted	-0.13	Coarse skewed	0.89	*Extremely Leptokurtic*
		100-150	4	1.97	1.54	poorly sorted	-0.17	Coarse skewed	0.63	*Very leptokurtic*
Denuded Rock	2	0-50	5	1.63	1.44	poorly sorted	0.01	Nearly Symmetrical	0.72	*Very leptokurtic*
		50-90	6	1.02	1.19	poorly sorted	0.82	Strongly fine skewed	0.95	*Extremely Leptokurtic*
		90-150	7	1.23	1.33	poorly sorted	0.06	Nearly Symmetrical	0.92	*Extremely Leptokurtic*
Rock land	3	0-50	8	1.63	1.38	poorly sorted	0.02	Nearly Symmetrical	1.08	*Extremely Leptokurtic*
		50-110	9	2.05	1.02	poorly sorted	0.14	Fine skewed	0.95	*Extremely Leptokurtic*
		110-150	10	1.45	1.47	poorly sorted	0.13	Fine skewed	0.79	*Extremely Leptokurtic*
	4	0-40	11	2.47	1.30	poorly sorted	-0.82	Strongly coares skewed	1.01	*Extremely Leptokurtic*
		40-100	12	1.98	1.26	poorly sorted	-0.19	Coarse skewed	0.88	*Extremely Leptokurtic*
		100-150	13	2.13	1.26	poorly sorted	-0.19	Coarse skewed	0.98	*Extremely Leptokurtic*
	9	0-30	27	1.90	1.46	poorly sorted	-0.03	Nearly Symmetrical	0.80	*Extremely Leptokurtic*
		30-100	28	1.28	1.46	poorly sorted	0.39	Strongly fine skewed	1.37	*Extremely Leptokurtic*
		100-150	29	1.63	1.32	poorly sorted	-0.14	Coarse skewed	0.78	*Extremely Leptokurtic*

Table (5): Con.,

Physiographic unit	Profile No.	Depth	No.	Mean size	sorting		skewness		kurtosis	
					σ	class	Sk1	class	KG	*class*
River Terraces	5	0-15	14	1.73	0.99	moderately sorted	-0.03	Nearly Symmetrical	1.23	*Extremely Leptokurtic*
		15-85	15	0.97	1.02	poorly sorted	1.14	Strongly fine skewed	0.58	*Leptokurti*
		85-150	16	1.40	1.18	poorly sorted	0.20	Fine skewed	1.00	*Extremely Leptokurtic*
	6	0-65	17	1.38	1.40	poorly sorted	0.07	Nearly Symmetrical	0.85	*Extremely Leptokurtic*
		65-150	18	0.73	1.29	poorly sorted	0.48	Strongly fine skewed	1.00	*Extremely Leptokurtic*
Rock outcrops	7	0-45	19	1.70	1.29	poorly sorted	0.03	Nearly Symmetrical	1.11	*Extremely Leptokurtic*
		45-150	20	0.95	1.65	poorly sorted	0.47	Strongly fine skewed	1.64	*Extremely Leptokurtic*
Wadi bottom	8	0-20	21	1.23	1.29	poorly sorted	0.15	Fine skewed	0.90	*Extremely Leptokurtic*
		20-110	22	0.98	1.09	poorly sorted	0.15	Fine skewed	0.96	*Extremely Leptokurtic*
		110-150	23	1.12	1.17	poorly sorted	0.13	Fine skewed	0.81	*Extremely Leptokurtic*
Moderately High Terraces	10	0-25	30	1.65	1.47	poorly sorted	0.14	Fine skewed	0.75	*Extremely Leptokurtic*
		25-90	31	1.37	1.41	poorly sorted	0.21	Fine skewed	0.82	*Extremely Leptokurtic*
		90-130	32	1.85	1.77	poorly sorted	0.21	Fine skewed	0.66	*Very leptokurtic*

Table (6): Environment of deposition and hydrodynamic of sedimentation

Profile No.	Depth	σ^2	Sahu (1964)				*Passega(1964)*
			Y1	Y2	Y3	Y4	*C-M Pattern*
1	0-30	2.657	5.796	211.261	-21.572	2.088	*O - P*
	30-75	2.756	5.532	220.510	-24.098	3.734	*O - P*
	75-100	2.592	5.905	213.986	-21.597	4.174	*O - P*
	100-150	2.372	4.090	195.160	-19.393	2.634	*O - P*
2	0-50	2.074	4.065	175.313	-17.783	4.217	*O - P*
	50-90	1.416	2.851	141.438	-16.198	10.731	*N - O*
	90-150	1.769	4.895	153.673	-15.478	5.455	*O - P*
3	0-50	1.904	4.561	171.102	-16.357	6.272	*O - P*
	50-110	1.040	-0.795	120.605	-9.264	7.042	*O - P*
	110-150	2.161	5.011	181.759	-19.209	5.265	*O - P*
4	0-40	1.690	2.311	153.523	-10.131	0.927	*Q- R*
	40-100	1.588	1.922	148.146	-12.455	4.151	*O - P*
	100-150	1.588	1.695	152.363	-12.423	4.796	*O - P*
9	0-30	2.132	3.676	184.001	-18.001	4.517	*O - P*
	30-100	2.132	6.764	192.642	-20.296	9.968	*O - P*
	100-150	1.742	3.340	151.986	-14.156	3.671	*O - P*

Table (6): Con.,

Profile No.	Depth	σ²	Sahu (1964)				Passega(1964)
			Y1	Y2	Y3	Y4	C-M Pattern
5	0-15	0.980	1.328	113.779	-8.014	7.174	*O - P*
	15-85	1.040	-0.156	115.018	-14.465	11.071	*N - O*
	85-150	1.392	2.831	135.534	-12.849	7.095	*O - P*
6	0-65	1.960	4.820	167.454	-17.161	5.182	*O - P*
	65-150	1.664	5.669	147.958	-16.747	8.358	*N - O*
7	0-45	1.664	3.474	156.992	-14.298	6.620	*O - P*
	45-150	2.723	10.810	232.652	-25.970	11.444	*N - O*
8	0-20	1.664	4.241	148.066	-15.019	6.009	*O - P*
	20-110	1.188	3.561	114.034	-10.928	6.354	*O - P*
	110-150	1.369	3.337	124.684	-12.332	5.386	*O - P*
10	0-25	2.161	4.164	184.217	-19.170	5.223	*O - P*
	25-90	1.988	4.594	171.028	-18.102	5.947	*O - P*
	90-130	3.133	6.619	250.781	-27.963	4.959	*O - P*

O – P = Transportation by rolling and suspension
N - O= Transportation by rolling
Q- R= Transportation by graded suspension
Y1= -3.688Mz +3.7016 σ -2.0766 Sk +3.1135 KG
Y1< -2.7411 indicates Aeolian deposition
Y1> - 2.7411 indicates beach deposition
Y2= 15.6334Mz +65.7091 σ +18.1071 Sk +18.5043 KG
Y2< 65.365 indicates beach deposition
Y2> 65.365 indicates shallow agitated marine
Y3= 0.2852Mz -8.7604 σ -4.8932 Sk +0.0482 KG
Y3< -7.419 indicates deltaic deposition
Y3> - 7.419 indicates shallow agitated marine
Y4= 0.7215Mz +0.403 σ +6.7322 Sk +5.2927 KG
Y4< 9.8433 indicates turbidity current deposition
Y4> 9.8433 indicates deltaic deposition

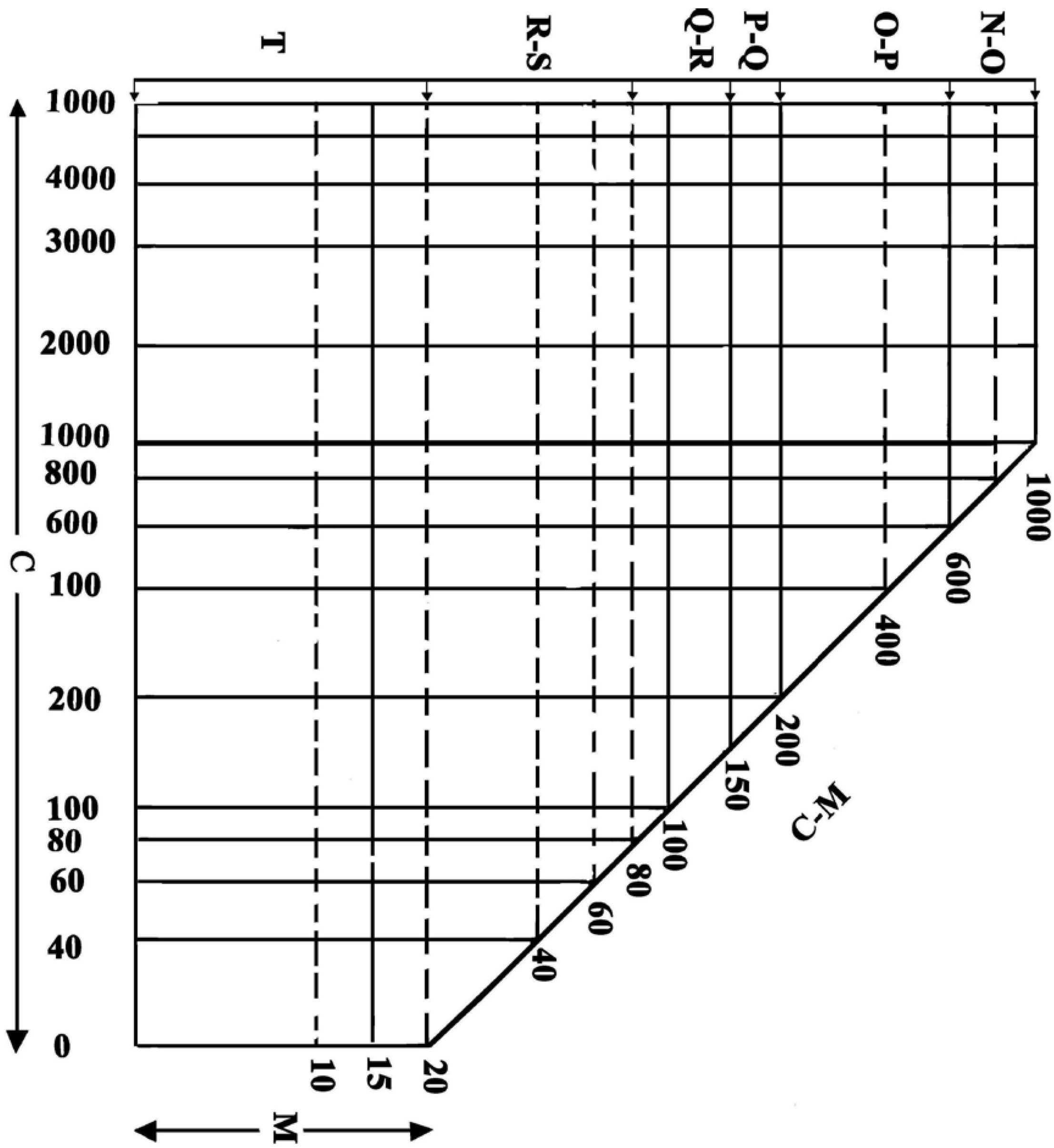


Fig (1) C-M pattern diagram of the studied soils

Mineralogical composition of sand fraction:

Light minerals:

Light minerals have specific gravity less than 2.85 g/cm^3. Data of light minerals analyzed in studied soils sand fraction are given in Table (8). The data in Table (8) indicated that quartz is the predominant mineral and varies between 75.3 and 85.0 % of the light minerals. Soils of denuded rock have higher contents of quartz. Feldspars (orthoclase, plagioclase and muscovite) are found in amounts between 7.5 and 16.7 % of the light minerals. Soils of rock land, with not to moderately dissected plateau remnants have relatively higher contents of feldspars. Calcite is a lower content and varies between 5.3 and 12.2 % of light minerals. Soils of river terraces have higher contents of calcite. Quartz is the only chemically and physically durable mineral constituent of plutonic rocks common enough to accumulate in great volume. Therefore, it is expressed maturity of sand by quartz content. Because most of the quartz was originally associated with feldspars, the maturity may also be expressed by the disappearance of feldspars (Pettijohn, 1984). Contents of feldspars reveal to immature or recent.

Heavy minerals:

Heavy minerals have specific gravity more than 2.85 g/cm^3. The heavy minerals content is a useful guide to the type of source rock, which the sand has derived (Boswell, 1933) and could be used as a tool to evaluate soil profile uniformity and its development (Bear, 1964 and Mitchell, 1975).

Data in Table (7) indicated that, the non – opaque minerals dominate heavy minerals. Opaque minerals content ranged between 17.3 and 42.5 % and their higher contents are found in river terraces. Amphiboles ranged from 10.26 to 26.41 % and pyroxenes from 15.60 to 22.29 % of the heavy minerals content and dominates non-opaque minerals followed by epidotes 6.82 to 19.41 %, and Biotite from 4.81 to 15.17 %. Zircon from 2.40 to 9.53 % dominates the resistant minerals followed by rutile and tourmaline. Andalusite, Staurolite, silimonite, garnet, kyanite, chlorite, olivine and apatite are also found in few a amounts.

Uniformity of soil materials

The mineral assemblage as well as the ratios of Z/R, Z/T, Z/R+T, P+A/Z+R and B/Z+R and their distribution pattern with depth are taken as a criteria for profile uniformity as recommended by Brewer (1964).

Haseman and Marshall (1945) recommended the ratios of zircon / Tourmaline, zircon/ Rutile and zircon/ Rutile + Tourmaline which are taken as criteria for investigating profiles uniformity. While amphibole / zircon + tourmaline, amphibole + pyroxene / zircon + tourmaline and Biotite / zircon + tourmaline are taken as criteria for investigating soil development. Data of uniformity and weathering ratios calculated for studied soils listed in Table (9). The results indicated that the studied soils are heterogeneous either due to their multi-origin or to the subsequent variations along the course of sedimentation. Therefore, these soils are considered young from the pedological point of view.

Table (7): Frequency distribution of heavy minerals in the sand fraction (0.125- 0.063 mm)

physiography	Profile No.,	Depth Cm	Opaques %	Non-opaques %															
				Amphiboles	Pyroxenes	Epidotes	Biotite	Zircon	Rutile	Tourmaline	Silimonite	Andalusite	Staurolite	Garnet	kyanite	Chlorite	Olivine	Apatite	Others
Young Alluvial Terraces	1	0-30	19.60	21.80	17.40	14.30	7.60	9.11	6.19	4.20	1.91	2.70	3.29	3.40	1.09	2.70	1.19	1.31	1.81
		30-75	23.30	24.09	18.30	15.20	6.41	8.21	6.60	3.80	0.70	3.49	2.70	2.20	0.70	2.20	1.70	1.20	2.50
		75-100	21.20	22.59	17.74	14.91	7.31	7.11	5.91	4.71	1.21	4.40	1.60	1.91	0.80	3.40	0.80	0.70	4.90
		100-150	21.40	23.29	18.29	14.60	6.89	7.90	6.20	3.90	1.30	2.30	3.21	3.30	1.12	2.90	0.30	0.90	3.60
Denuded Rock	2	0-50	25.60	17.22	24.39	11.69	12.21	4.40	3.41	2.31	0.70	2.09	5.29	4.50	0.0	1.80	0.20	2.20	7.59
		50-90	21.70	10.29	20.89	18.31	10.61	7.51	4.49	6.19	1.21	1.90	4.49	4.71	0.0	3.20	1.70	2.80	1.70
		90-150	34.20	20.40	27.12	14.19	8.69	3.91	2.71	1.90	0.0	4.19	2.90	3.69	0.0	2.60	2.20	2.60	2.90
Rock land	3	0-50	37.00	10.69	25.22	20.79	12.52	5.22	1.79	3.10	0.0	5.52	4.70	0.90	0.21	2.24	3.70	1.40	2.00
		50-110	40.90	14.23	25.09	16.70	11.30	2.40	4.096	4.91	0.0	5.70	5.30	1.79	0.90	0.80	2.99	2.50	1.30
		110-150	25.60	18.30	22.40	23.35	9.39	4.42	2.59	2.59	0.0	4.60	5.20	0.70	0.75	1.21	2.06	0.75	1.69
	4	0-40	27.50	23.60	21.98	15.98	9.57	5.80	2.29	2.54	1.32	1.99	2.79	2.88	1.08	1.17	1.53	1.08	4.40
		40-100	30.40	24.80	21.09	9.80	12.40	7.80	2.90	3.41	2.10	3.51	1.90	2.10	0.60	1.01	0.83	2.10	3.65
		100-150	28.70	20.70	24.10	10.29	10.50	7.41	3.10	3.71	2.00	2.20	4.31	4.19	0.80	1.89	0.60	3.00	1.21
	9	0-30	21.10	20.99	21.78	17.01	7.82	3.22	3.22	5.28	2.43	2.60	4.52	1.99	1.00	3.89	1.68	0.0	2.43
		30-100	25.60	18.43	22.29	15.99	9.20	4.44	2.49	5.88	1.87	0.91	4.02	2.49	1.35	2.49	2.49	3.51	2.13
		100-150	27.30	16.23	18.48	22.28	8.57	4.73	3.92	4.73	1.42	0.79	4.07	3.41	1.55	2.24	2.24	2.91	2.24
River terraces	5	0-15	38.30	26.41	22.40	13.91	4.81	6.69	2.71	4.29	1.20	1.80	1.10	3.31	1.39	2.50	0.79	0.79	5.90
		15-85	36.40	28.10	15.60	18.81	13.81	5.80	3.30	3.51	1.49	3.69	2.50	2.70	0.80	3.69	0.20	0.20	7.70
		85-150	42.50	18.90	17.20	17.21	7.81	6.30	2.61	4.61	0.90	3.20	1.60	2.76	0.70	1.50	0.0	0.0	5.50
	6	0-65	37.70	17.92	16.53	11.92	7.37	3.32	2.56	6.95	2.27	1.46	6.46	4.99	0.0	2.53	1.34	4.65	9.70
		65-150	39.10	18.55	13.36	17.15	5.02	5.37	4.83	8.50	2.03	1.92	4.76	4.20	0.0	3.00	2.69	3.82	4.79
Rock outcrops	7	0-45	17.30	15.93	15.24	18.63	12.20	3.66	3.78	7.46	1.36	1.00	5.87	4.35	0.0	4.14	0.0	0.0	6.38
		45-150	42.20	18.20	14.97	20.76	7.39	5.22	5.93	7.89	1.31	0.47	5.25	3.36	0.0	3.86	0.0	0.0	5.39
Wadi bottom	8	0-20	29.80	16.09	17.87	15.89	13.61	5.35	2.62	5.03	0.0	3.44	4.90	3.41	3.45	1.89	0.23	3.66	2.55
		20-110	22.40	18.29	16.51	12.04	11.68	4.53	3.34	7.31	0.0	2.59	8.47	1.98	2.43	2.53	0.76	2.12	5.41
		110-150	26.70	18.87	17.40	17.40	12.06	6.48	2.73	5.86	0.0	2.19	5.67	0.67	2.18	2.73	1.92	3.17	0.67
Moderately High Terraces	10	0-25	28.10	19.02	21.75	17.03	14.10	4.44	1.69	2.26	0.75	2.26	3.23	2.26	0.75	3.74	4.11	0.34	2.26
		25-90	31.10	21.47	16.49	13.58	9.46	9.53	3.80	3.80	1.60	2.06	1.60	3.80	0.85	2.40	3.06	0.85	5.64
		90-130	30.60	19.90	17.16	15.92	15.17	4.54	1.77	3.20	1.46	4.23	3.92	3.20	0.67	1.03	3.20	1.46	3.20

Table (8): Frequency distribution of light minerals in the sand fraction (0.125- 0.063 mm)

physiography	Profile No.,	Depth cm	Quartz %	Feldspars%			Calcite %
				Orthoclase	Plagioclase	Muscovite	
Young Alluvial Terraces	1	0-30	78.40	4.40	6.30	2.20	8.70
		30-75	78.20	3.70	4.30	3.70	10.10
		75-100	76.10	4.50	4.10	4.80	10.50
		100-150	77.70	4.30	5.30	3.50	9.20
Denuded Rock	2	0-50	82.30	3.40	3.8	3.00	7.50
		50-90	81.20	4.10	3.30	2.70	8.70
		90-150	85.00	2.30	3.10	3.20	6.40
Rock land	3	0-50	82.40	3.40	3.20	3.10	7.90
		50-110	78.30	3.10	4.90	2.30	11.40
		110-150	81.70	2.70	4.20	1.50	9.90
	4	0-40	81.20	2.10	3.10	1.30	11.30
		40-100	82.40	2.20	4.60	1.80	9.00
		100-150	82.60	3.70	2.70	2.90	8.10
	9	0-30	81.30	4.60	3.30	3.40	7.40
		30-100	82.20	4.40	2.60	3.40	7.40
		100-150	83.00	6.30	3.10	2.30	5.30
River terraces	5	0-15	79.60	3.60	3.60	3.90	9.30
		15-85	78.00	4.20	3.80	4.40	10.60
		85-150	77.30	5.30	3.40	4.40	9.60
	6	0-65	75.30	5.30	4.20	4.00	11.20
		65-150	76.20	4.40	4.80	5.50	10.10
Rock outcrops	7	0-45	76.70	6.30	4.20	3.10	9.70
		45-150	84.20	4.20	3.40	0.90	7.30
Wadi bottom	8	0-20	83.30	4.30	3.20	2.20	7.00
		20-110	79.80	3.30	3.40	1.30	12.20
		110-150	82.70	3.40	3.40	1.90	8.60
Moderately High Terraces	10	0-25	77.60	8.30	5.10	3.30	5.70
		25-90	76.40	7.80	5.30	2.10	8.40
		90-130	81.10	4.30	3.20	2.60	8.80

Table (9): Uniformity and weathering ratios of the studied soils.

Physiographic unit	*Profile No.*	*Depth (cm)*	*Uniformity ratios*			*Weathering ratios*		
			Z/T	Z/R	Z/T+R	Wr1 (A/Z+T)	Wr2 (A+P/Z+T)	Wr3 (B/Z+T)
Young Alluvial Terraces	1	0-30	2.17	1.47	0.88	1.64	2.95	0.57
		30-75	2.16	1.24	0.79	2.01	3.53	0.53
		75-100	1.51	1.20	0.67	1.92	3.42	0.62
		100-150	2.03	1.27	0.78	1.97	3.52	0.58
Denuded Rock	2	0-50	1.91	1.29	0.77	2.57	6.21	1.82
		50-90	1.21	1.67	0.70	0.75	2.28	0.77
		90-150	2.05	1.44	0.85	3.52	8.19	1.50
Rock land	3	0-50	1.68	2.89	1.06	1.28	4.31	1.51
		50-110	0.49	0.59	0.27	1.95	5.38	1.55
		110-150	1.69	1.69	0.85	2.59	5.77	1.34
	4	0-40	2.28	2.59	1.21	2.84	5.44	1.12
		40-100	2.29	2.69	1.24	2.18	4.05	1.11
		100-150	2.00	2.39	1.09	1.86	4.04	0.95
	9	0-30	0.63	1.06	0.39	2.44	4.97	0.91
		30-100	0.76	1.74	0.53	1.78	3.94	0.89
		100-150	0.99	1.20	0.54	1.71	3.66	0.90
River Terraces	5	0-15	1.56	2.48	0.96	2.49	4.54	0.45
		15-85	1.66	1.76	0.85	2.00	3.63	1.45
		85-150	1.37	2.42	0.88	2.60	4.22	0.72
	6	0-65	0.48	1.30	0.35	1.74	3.35	0.72
		65-150	0.63	1.11	0.40	1.34	2.30	0.36
Rock outcrops	7	0-45	0.49	0.97	0.33	1.43	2.80	1.10
		45-150	0.66	0.88	0.38	1.39	2.53	0.56
Wadi button	8	0-20	1.06	2.04	0.70	1.55	3.27	1.31
		20-110	0.62	1.36	0.43	1.54	2.94	0.99
		110-150	1.11	2.29	0.75	1.53	2.94	0.98
Moderately High Terraces	10	0-25	2.01	2.62	1.14	2.86	6.14	2.12
		25-90	2.59	2.43	1.25	1.62	2.87	0.72
		90-130	1.42	2.55	0.91	2.57	4.79	1.96

Where: Z= zircon
T= tourmaline
R= rutile
B= biotite
P= pyroxenes
A= amphiboles

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بيدولوجيا وظروف تكوين أراضي الوحدات الفيزيوجرافية للظهير الصحراوي شمال – شرق محافظة الفيوم

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الملخص العربي

اجري هذا البحث للتعرف علي الوحدات الفيزيوجرافية المميزة للظهير الصحراوي شمال شرق محافظة الفيوم وذلك للتعرفعلي خصائص وتقسيم وظروف الترسيب والتركيب المعدني لاراضي هذه المنطقة.

ولهذه الاغراض اختيرت عشر قطاعات أرضية لتمثل هذه الوحدات ووصفت المظاهر المورفولوجية للمنطقة والقطاعات الارضية وجمعت منها عينات أرضية طبقا للاختلافات داخل القطاعات الارضية واجريت عليها التحليلات الطبيعية والكيميائية والمعدنية .

وطبقا لتفسير صور الاقمار الصناعية للمنطقة باستخدام تكنولوجيا نظم المعلومات الجغرافية تم التعرف علي سبع وحدات ارضية هي الشرفات الحديثة ،اراضي الصخور المعراة،الاراضي الحصوية،قاع الوادي ، الشرفات النهرية ، بقية أراضي الهضبة المتشققه ،وبقية اراضي الهضبة الصخرية الغير متشققه ،ولقد استخدمت خصائص الاراضي المدروسة في تقسيمها طبقا للتقسيم الامريكي الحديث حتي مستوي العائلة تحت رتبة الاراضي الحديثة او الاراضي الصحراويه .

وقد اظهرت نتائج دراسة التوزيع الحجمي لحبيبات مجموعة الرمل وتحليلاتها الاحصائية ان معامل الفرز لمواد التربة رديء مما يدل علي ان المياه هي غالبا المسئولة عن نقل وترسيب هذه الحبيبات ،وتبين ان ميكانيكة انتقالها كان بين التدحرج والمعلق .

ولقد أوضح التركيب المعدني لمجموعة الرمل سيادة الكوارتز للمعادن الخفيفه يليه الفلسبارات والكالسيت، كما تسود المعادن المعتمة مجموعة المعادن الثقيلة وتدل نتائج دراسة توزيع المعادن الثقيلة والمقاومة للتجوية ونسبها الي ان هذه الاراضي غير ناضجة ومادة اصلها غير متجانسة نشأت من مواد وتحت ظروف متعددة .

وبدراسة التركيب المعدني لمكونات الرمل وجد ان المعادن الخفيفة تتميزبسيادة الكوارتز مع وجود كميات قليلة من الاوثوكلايز والبالجيوكلايز والمسكوفيت، اما بالنسبة للمعادن الثقيلة فيسود فيها المعادن الغير معتمة مع كميات متناقصة من البيروكسين والامفيبول والزركون والروتيل والتورمالين والابيدوت وكميات قليلة جدا من الجارنت والكيانيت والسليمنيت والكلوريت والاولفين.

وتشير نتائج دراسة توزيع المعادن الثقيلة والمقاومة للتجوية ونسب التجوية الي عدم وجود تجانس بين طبقات القطاعات تحت الدراسة وان الاراضي غير متجانسة وقد فسر ذلك علي اساس الاختلافات في مادة الاصل او ظروف الترسيب.

River Terraces	6	0-65	0.48	1.30	0.35	1.74	3.35	0.72
		65-150	0.63	1.11	0.40	1.34	2.30	0.36
Rock outcrops	7	0-45	0.49	0.97	0.33	1.43	2.80	1.10
		45-150	0.66	0.88	0.38	1.39	2.53	0.56
Wadi button	8	0-20	1.06	2.04	0.70	1.55	3.27	1.31
		20-110	0.62	1.36	0.43	1.54	2.94	0.99

		110-150	1.11	2.29	0.75	1.53	2.94	0.98
Rock land	9	0-30	0.63	1.06	0.39	2.44	4.97	0.91
		30-100	0.76	1.74	0.53	1.78	3.94	0.89
		100-150	0.99	1.20	0.54	1.71	3.66	0.90
Moderately High Terraces	10	0-25	2.01	2.62	1.14	2.86	6.14	2.12
		25-90	2.59	2.43	1.25	1.62	2.87	0.72
		90-130	1.42	2.55	0.91	2.57	4.79	1.96

Table (1): Morphological features of the studied soil profiles.

Physiographic unit	Profile No.	Slope gradient	Depth (cm)	Soil colour		Texture class	Soil structure	Soil consistency	Boundary
				Moist	Dry				
Young Alluvial Terraces	1	Gently sloping	0-30	10YR7/4	10YR8/4	SL	Massive	Soft	CS
			30-75	5YR6/6	5YR7/6	SCL	Massive	Friable	CS
			75-100	5YR6/4	5YR7/4	SL	Massive	Friable	GS
			100-150	5YR7/6	5YR7/6	SCL	Massive	Friable	
Denuded Rock	2	Nearly level	0-50	10YR6/6	10YR7/6	LS	Massive	Slightly hard	GS
			50-90	10YR6/4	10YR7/4	SL	Massive	Friable	GS
			90-150	10YR6/4	10YR7/4	SCL	Massive	Friable	
Rock land	3	Gently Sloping	0-50	10YR6/4	10YR7/4		Massive	Hard	GS
			50-110	10YR7/4	10YR8/4	SCL	Massive	Friable	GS
			110-150	10YR6/4	10YR7/4		Massive	Friable	
	4	Sloping	0-40	10YR8/4	10YR7/4	SL	Massive	Loose	CS
			40-75	10YR6/6	10YR7/6	SL	Massive	Friable	CS
			75-150	10YR6/6	10YR7/6	SCL	Massive	Friable	
	9	Gently sloping	0-30	10YR6/6	10YR7/4		Massive	Friable	GS
			30-100	10YR7/4	10YR8/4	SCL	Massive	Friable	CS
			100-150	10YR6/6	10YR7/6		Massive	Firm	
River Terraces	5	Nearly level	0-15	5YR7/4	5YR8/4	SL	Massive	Slightly hard	CS
			15-70	5YR6/6	5YR7/6	LS	Single grain	Loose	GS
			70-110	5YR6/8	5YR6/6	LS	Single grain	Loose	
	6		0-35	2.5YR6/6	2.5YR7/6	LS	Single grain	Loose	CS
			35-75	2.5YR7/4	2.5YR8/4	SL	Massive	Friable	
Rock outcrops	7	Sloping	0-40	10YR6/6	10YR7/6	SCL	Massive	Friable	CS
			40-90	10YR6/8	10YR6/6	C	Massive	Firm	
Wadi bottom	8	Nearly level	0-25	10YR6/6	10YR7/6	LS	Single grain	Loose	CS
			25-100	10YR6/6	10YR7/6	LS	Massive	V. friable	GS
			100-150	10YR7/4	10YR8/4	SL	Massive	Friable	
Moderately High Terraces	10	Gently sloping	0-25	10YR6/6	10YR7/6	SL	Massive	Friable	CS
			25-90	10YR7/4	10YR8/4	SCL	Massive	Friable	CS
			90-130	10YR6/6	10YR7/6	SL	Massive	Friable	

Where:- Boundary: CS= Clear smooth GS= Gradual smooth

Texture: SL= sandy loam SCL =sandy clay loam LS= loamy sand C= clay

Table (2): Some main physico-chemical properties of the studied soil profiles.

Physiographic unit	Profile No.	Soil depth (cm)	Gravel %	Particle size distribution %				Texture class*	Organic matter %	$CaCO_3$ %	Gypsum %	CEC, (Cmolc kg^{-1})
				Coarse sand	Fine sand	Silt	Clay					
Young Alluvial Terraces	1	0-30	--	41.75	28.17	6.00	24.08	SL	0.19	3.37	1.09	16.88
		30-75	--	43.66	21.75	11.22	23.37	SCL	0.15	1.58	7.50	15.53
		75-100	--	45.95	17.86	22.75	13.44	SL	0.11	1.85	2.37	8.56
		100-150	--	51.17	14.87	10.65	23.31	SCL	0.09	1.58	1.90	15.50
Denuded Rock	2	0-50	--	59.91	17.88	13.98	8.23	LS	0.23	10.34	6.74	5.96
		50-90	--	53.65	14.37	17.31	14.67	SL	0.14	12.97	6.63	9.18
		90-150	--	41.99	23.68	11.47	22.86	SCL	0.10	18.55	2.86	15.77
Rock land	3	0-50	--	39.88	26.59	12.55	20.98	SCL	0.13	4.85	4.26	14.33
		50-110	--	45.44	19.99	13.23	21.34		0.08	7.07	3.21	13.51
		110-150	--	41.91	23.97	11.99	22.13		0.06	7.80	3.48	15.91
	4	0-40	--	44.57	19.68	21.91	13.84	SL	0.15	9.39	7.33	8.76
		40-75	--	41.88	21.64	19.99	16.49		0.13	6.96	3.53	10.09
		75-150	--	49.29	15.55	12.98	22.18	SCL	0.11	6.22	1.39	15.93
	9	0-30	--	15.38	31.22	25.87	27.53	SCL	0.21	1.58	4.95	19.61
		30-100	--	55.88	12.55	9.99	21.58		0.18	1.05	7.21	14.63
		100-150	--	51.75	16.70	9.15	22.40		0.14	1.00	16.18	15.04
River Terraces	5	0-25	28	49.58	21.87	17.89	10.66	G SL	0.09	3.80	3.49	7.17
		25-85	22	66.58	14.25	10.20	8.97	G LS	0.08	3.59	3.24	6.33
		85-110	9	65.58	14.35	11.58	8.49	SG LS	0.05	2.43	2.38	6.09
	6	0-60	30	66.89	16.57	9.55	6.99	G LS	0.10	4.85	6.84	5.34
		60-75	10	27.23	40.35	20.16	12.26	SG SL	0.07	1.32	4.36	10.97
Rock outcrops	7	0-40	18	49.88	13.35	11.17	25.60	G SCL	0.22	1.05	2.35	17.64
		40-90	--	21.04	9.86	23.15	46.63	C	0.37	0.95	3.12	35.16
Wadi bottom	8	0-25	--	70.98	14.21	6.88	7.93	LS	0.24	3.95	12.55	5.81
		25-100	--	67.25	16.00	6.12	10.63	LS	0.16	4.06	10.33	7.16
		100-150	--	45.99	21.48	27.09	5.44	SL	0.14	5.22	5.32	4.56
Moderately High Terraces	10	0-25	--	44.35	25.55	19.97	10.13	SL	0.17	4.22	9.01	6.91
		25-90	--	46.88	17.88	13.26	21.98	SCL	0.13	2.64	12.63	14.83
		90-130	--	49.68	21.88	17.28	11.16	SL	0.09	1.58	17.07	7.42

**Fine earth:* LS=Loamy sand, SL=Sandy loam, SCL=Sandy clay loam, C=Clay Gravel: SG=Slight gravelly G=Gravelly

Table (3): Chemical analysis of soil paste extract for the studied soil profiles.

Physiographic unit	Profile No.	Soil depth (cm)	ESP	pH (1:2.5)	ECe, dS/m	Cations (mmolc L^{-1})				Anions (mmolc L^{-1})		
						Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{--}
Young Alluvial Terraces	1	0-30	9.75	7.74	11.75	24.77	17.68	85.34	0.23	3.20	86.70	38.11
		30-75	11.47	7.60	6.24	15.78	10.12	43.29	0.11	4.88	36.76	25.67
		75-100	10.88	7.75	10.26	28.35	8.10	70.50	0.26	4.75	60.18	42.27
		60-150	11.50	7.90	7.95	27.92	5.52	50.68	0.19	3.56	45.90	34.85
Denuded Rock	2	0-50	9.84	7.45	41.08	181.68	29.20	294.92	0.65	4.99	387.60	113.86
		50-90	10.02	7.50	44.02	151.95	42.37	319.55	0.48	4.63	291.70	218.04
		90-150	9.55	8.15	42.81	143.74	31.57	310.83	0.51	3.26	272.30	211.10
Rock land	3	0-50	11.67	7.65	26.05	86.97	14.65	181.89	0.22	3.25	200.88	80.59
		50-100	10.56	7.70	16.64	52.88	11.60	120.78	0.21	3.88	137.68	43.92
		100-150	8.94	7.80	44.53	154.87	18.69	323.29	0.47	3.00	296.76	197.56
	4	0-40	6.22	7.90	8.21	22.67	11.13	55.61	0.11	3.38	66.3	19.85
		40-75	7.84	7.78	22.14	75.35	13.15	160.71	0.34	4.50	144.84	100.21
		75-150	8.07	7.75	31.49	127.90	23.24	228.61	0.38	3.56	229.50	147.06
	9	0-30	9.44	7.55	74.75	217.09	103.73	542.50	0.88	3.25	578.20	282.75
		30-100	11.07	7.45	103.99	293.76	178.29	798.50	0.95	3.50	727.24	540.76
		100-150	10.61	7.35	148.01	647.12	238.67	1074.50	1.80	3.13	1116.88	840.09
River Terraces	5	0-25	9.56	7.54	14.18	50.05	13.15	102.97	0.21	4.88	119.34	42.16
		25-85	6.11	7.60	3.57	27.90	4.07	25.91	0.13	4.13	18.36	35.53
		85-110	5.34	7.65	4.28	33.22	6.04	31.08	0.10	3.75	16.32	50.37
	6	0-35	7.13	7.50	11.08	43.74	14.65	80.42	0.18	4.25	88.72	46.01
		35-75	9.37	7.79	86.83	228.55	217.93	830.50	0.86	3.50	713.84	560.20
Rock outcrops	7	0-40	12.15	7.45	40.76	135.75	19.20	295.88	0.51	3.75	325.32	122.27
		40-90	13.39	7.52	67.18	145.83	63.08	487.74	0.70	3.00	522.18	172.17
Wadi bottom	8	0-25	10.57	7.35	39.90	130.58	44.45	289.65	0.35	3.50	390.64	70.89
		25-100	9.67	7.40	51.65	123.80	85.90	374.99	0.65	3.75	537.54	44.05
		100-150	11.74	7.56	18.12	54.59	14.65	131.58	0.23	3.63	163.16	34.24
Moderately High Terraces	10	0-25	11.08	7.49	75.33	214.08	96.03	546.90	0.89	3.75	588.48	265.67
		25-90	9.82	7.43	44.96	195.67	14.65	326.40	0.62	3.38	327.38	206.60
		90-130	10.01	7.30	42.14	123.45	44.84	305.91	0.58	3.00	334.38	137.40

Table (4) Particle size distribution of sand fractions of the studied soil profiles.

Physiographic unit	Profile No.,	Depth	No.,	Sand fractions %								total/ %
				>4	>2	>1	>500	>250	>125	>63	<63	
Young Alluvial Terraces	1	0-30	1	0.00	0.85	21.21	14.03	10.12	23.21	*23.06*	*7.52*	*100.00*
		30-75	2	0.00	0.80	25.76	15.50	10.10	15.10	*23.76*	*8.99*	*100.00*
		75-100	3	0.00	0.81	22.81	14.86	9.57	19.09	*24.66*	*8.19*	*100.00*
		100-150	4	0.00	1.09	23.86	14.07	8.74	16.59	*27.11*	*8.56*	*100.00*
Denuded Rock	2	0-50	5	0.00	0.60	17.35	21.70	23.17	15.87	*16.44*	*4.88*	*100.00*
		50-90	6	0.00	0.66	10.26	32.40	35.27	13.52	*6.46*	*1.44*	*100.00*
		90-150	7	0.00	0.62	20.85	24.20	28.55	15.18	*8.62*	*2.01*	*100.00*
Rock land	3	0-50	8	0.00	0.65	10.96	20.66	32.29	20.17	*11.37*	*3.91*	*100.00*
		50-110	9	0.00	0.66	4.19	16.00	33.29	27.11	*16.31*	*2.46*	*100.00*
		110-150	10	0.00	0.65	18.46	25.44	27.05	17.37	*8.94*	*2.10*	*100.00*
	4	0-40	11	0.00	0.52	7.96	9.41	23.18	29.33	*23.50*	*6.10*	*100.00*
		40-100	12	0.00	0.65	7.58	12.11	26.59	32.02	*19.08*	*1.99*	*100.00*
		100-150	13	0.00	0.65	5.54	10.61	22.98	36.06	*20.48*	*3.70*	*100.00*
	9	0-30	24	0.00	0.59	11.02	20.33	19.07	19.89	*19.69*	*9.41*	*100.00*
		30-100	25	0.00	0.66	16.36	20.70	11.88	23.66	*17.29*	*9.46*	*100.00*
		100-150	26	0.00	0.63	14.72	18.47	19.65	31.45	*12.54*	*2.55*	*100.00*
River Terraces	5	0-15	14	0.00	0.63	4.92	13.78	45.23	27.38	*6.90*	*1.16*	*100.00*
		15-85	15	0.00	0.59	25.53	18.18	30.81	18.41	*5.60*	*0.88*	*100.00*
		85-150	16	0.00	0.60	14.82	17.49	37.50	22.30	*6.20*	*1.09*	*100.00*
	6	0-65	17	0.00	0.67	17.32	21.15	30.86	20.70	*7.92*	*1.39*	*100.00*
		65-150	18	0.00	1.33	41.54	24.63	15.37	10.04	*5.24*	*1.87*	*100.00*
Rock outcrops	7	0-45	19	0.00	0.72	10.87	16.28	34.37	20.54	*13.92*	*3.31*	*100.00*
		45-150	20	0.00	2.73	37.62	22.33	14.97	9.96	*7.07*	*5.32*	*100.00*
Wadi bottom	8	0-20	21	0.00	0.72	18.66	28.37	29.31	13.48	*6.64*	*2.84*	*100.00*
		20-110	22	0.00	0.59	19.90	32.35	30.29	11.17	*4.30*	*1.41*	*100.00*
		110-150	23	0.00	0.56	20.08	27.52	29.01	16.38	*5.34*	*1.12*	*100.00*
Moderately High Terraces	10	0-25	27	0.00	0.59	17.91	20.66	19.46	20.51	*15.20*	*5.66*	*100.00*
		25-90	28	0.00	0.63	22.01	24.31	23.71	17.80	*9.14*	*2.41*	*100.00*
		90-130	29	0.00	0.56	20.46	20.97	15.51	13.11	*14.16*	*15.25*	*100.00*

Table (5) Statistical size parameters, for grain size distribution of the five sand fractions of the studied soils.

Physiographic unit	Profile No.	Depth	No.	Mean size (MZ)	Sorting (σ)		Skewness (Sk)		Kurtosis (KG)	
					σ	class	Sk1	class	KG	*class*
Young Alluvial Terraces	1	0-30	1	1.85	1.63	poorly sorted	-0.25	Coarse skewed	0.66	*Very leptokurtic*
		30-75	2	1.75	1.66	poorly sorted	0.09	Nearly Symmetrical	0.57	*Leptokurti*
		75-100	3	1.88	1.61	poorly sorted	-0.13	Coarse skewed	0.89	*Extremely Leptokurtic*
		100-150	4	1.97	1.54	poorly sorted	-0.17	Coarse skewed	0.63	*Very leptokurtic*
Denuded Rock	2	0-50	5	1.63	1.44	poorly sorted	0.01	Nearly Symmetrical	0.72	*Very leptokurtic*
		50-90	6	1.02	1.19	poorly sorted	0.82	Strongly fine skewed	0.95	*Extremely Leptokurtic*
		90-150	7	1.23	1.33	poorly sorted	0.06	Nearly Symmetrical	0.92	*Extremely Leptokurtic*
Rock land	3	0-50	8	1.63	1.38	poorly sorted	0.02	Nearly Symmetrical	1.08	*Extremely Leptokurtic*
		50-110	9	2.05	1.02	poorly sorted	0.14	Fine skewed	0.95	*Extremely Leptokurtic*
		110-150	10	1.45	1.47	poorly sorted	0.13	Fine skewed	0.79	*Extremely Leptokurtic*
	4	0-40	11	2.47	1.30	poorly sorted	-0.82	Strongly coares skewed	1.01	*Extremely Leptokurtic*
		40-100	12	1.98	1.26	poorly sorted	-0.19	Coarse skewed	0.88	*Extremely Leptokurtic*
		100-150	13	2.13	1.26	poorly sorted	-0.19	Coarse skewed	0.98	*Extremely Leptokurtic*
	9	0-30	27	1.90	1.46	poorly sorted	-0.03	Nearly Symmetrical	0.80	*Extremely Leptokurtic*
		30-100	28	1.28	1.46	poorly sorted	0.39	Strongly fine skewed	1.37	*Extremely Leptokurtic*
		100-150	29	1.63	1.32	poorly sorted	-0.14	Coarse skewed	0.78	*Extremely Leptokurtic*

Table (5): Con.,

	Profile No.	Depth	No.	Mean size	sorting		skewness		kurtosis	
					σ	class	Sk1	class	KG	*class*
River Terraces	5	0-15	14	1.73	0.99	moderately sorted	-0.03	Nearly Symmetrical	1.23	*Extremely Leptokurtic*
		15-85	15	0.97	1.02	poorly sorted	1.14	Strongly fine skewed	0.58	*Leptokurti*
		85-150	16	1.40	1.18	poorly sorted	0.20	Fine skewed	1.00	*Extremely Leptokurtic*
	6	0-65	17	1.38	1.40	poorly sorted	0.07	Nearly Symmetrical	0.85	*Extremely Leptokurtic*
		65-150	18	0.73	1.29	poorly sorted	0.48	Strongly fine skewed	1.00	*Extremely Leptokurtic*
Rock outcrops	7	0-45	19	1.70	1.29	poorly sorted	0.03	Nearly Symmetrical	1.11	*Extremely Leptokurtic*
		45-150	20	0.95	1.65	poorly sorted	0.47	Strongly fine skewed	1.64	*Extremely Leptokurtic*
Wadi bottom	8	0-20	21	1.23	1.29	poorly sorted	0.15	Fine skewed	0.90	*Extremely Leptokurtic*
		20-110	22	0.98	1.09	poorly sorted	0.15	Fine skewed	0.96	*Extremely Leptokurtic*
		110-150	23	1.12	1.17	poorly sorted	0.13	Fine skewed	0.81	*Extremely Leptokurtic*
Moderately High Terraces	10	0-25	30	1.65	1.47	poorly sorted	0.14	Fine skewed	0.75	*Extremely Leptokurtic*
		25-90	31	1.37	1.41	poorly sorted	0.21	Fine skewed	0.82	*Extremely Leptokurtic*
		90-130	32	1.85	1.77	poorly sorted	0.21	Fine skewed	0.66	*Very leptokurtic*

Table (6) Environment of deposition and hydrodynamic of sedimentation

Profile No.	Depth	σ^2	Sahu (1964)				*Passega(1964)*
			Y1	Y2	Y3	Y4	*C-M Pattern*
1	0-30	2.657	5.796	211.261	-21.572	2.088	*O - P*
	30-75	2.756	5.532	220.510	-24.098	3.734	*O - P*
	75-100	2.592	5.905	213.986	-21.597	4.174	*O - P*
	100-150	2.372	4.090	195.160	-19.393	2.634	*O - P*
2	0-50	2.074	4.065	175.313	-17.783	4.217	*O - P*
	50-90	1.416	2.851	141.438	-16.198	10.731	*N - O*
	90-150	1.769	4.895	153.673	-15.478	5.455	*O - P*
3	0-50	1.904	4.561	171.102	-16.357	6.272	*O - P*
	50-110	1.040	-0.795	120.605	-9.264	7.042	*O - P*
	110-150	2.161	5.011	181.759	-19.209	5.265	*O - P*
4	0-40	1.690	2.311	153.523	-10.131	0.927	*Q- R*
	40-100	1.588	1.922	148.146	-12.455	4.151	*O - P*
	100-150	1.588	1.695	152.363	-12.423	4.796	*O - P*
9	0-30	2.132	3.676	184.001	-18.001	4.517	*O - P*
	30-100	2.132	6.764	192.642	-20.296	9.968	*O - P*
	100-150	1.742	3.340	151.986	-14.156	3.671	*O - P*

Table (6): Con.,

Profile No.	Depth	σ^2	Sahu (1964)				Passega(1964)
			Y1	Y2	Y3	Y4	C-M Pattern
5	0-15	0.980	1.328	113.779	-8.014	7.174	*O - P*
	15-85	1.040	-0.156	115.018	-14.465	11.071	*N - O*
	85-150	1.392	2.831	135.534	-12.849	7.095	*O - P*
6	0-65	1.960	4.820	167.454	-17.161	5.182	*O - P*
	65-150	1.664	5.669	147.958	-16.747	8.358	*N - O*
7	0-45	1.664	3.474	156.992	-14.298	6.620	*O - P*
	45-150	2.723	10.810	232.652	-25.970	11.444	*N - O*
8	0-20	1.664	4.241	148.066	-15.019	6.009	*O - P*
	20-110	1.188	3.561	114.034	-10.928	6.354	*O - P*
	110-150	1.369	3.337	124.684	-12.332	5.386	*O - P*
10	0-25	2.161	4.164	184.217	-19.170	5.223	*O - P*
	25-90	1.988	4.594	171.028	-18.102	5.947	*O - P*
	90-130	3.133	6.619	250.781	-27.963	4.959	*O - P*

O – P = Transportation by rolling and suspension
N - O= Transportation by rolling
Q- R= Transportation by graded suspension

Y1= -3.688Mz +3.7016 σ -2.0766 Sk +3.1135 KG

Y1< -2.7411 indicates Aeolian deposition
Y1> - 2.7411 indicates beach deposition

Y2= 15.6334Mz +65.7091 σ +18.1071 Sk +18.5043 KG

Y2< 65.365 indicates beach deposition
Y2> 65.365 indicates shallow agitated marine

Y3= 0.2852Mz -8.7604 σ -4.8932 Sk +0.0482 KG

Y3< -7.419 indicates deltaic deposition
Y3> - 7.419 indicates shallow agitated marine

Y4= 0.7215Mz +0.403 σ +6.7322 Sk +5.2927 KG

Y4< 9.8433 indicates turbidity current deposition
Y4> 9.8433 indicates deltaic deposition

Table (7) Frequency distribution of heavy minerals in the sand fraction (0.125- 0.063 mm)

physiography	Profile No.,	Depth Cm	Opaques %	Non-opaques %															
				Amphiboles	Pyroxenes	Epidotes	Biotite	Zircon	Rutile	Tourmaline	Silimonite	Andalusite	Staurolite	Garnet	kyanite	Chlorite	Olivine	Apatite	Others
Young Alluvial Terraces	1	0-30	19.60	21.80	17.40	14.30	7.60	9.11	6.19	4.20	1.91	2.70	3.29	3.40	1.09	2.70	1.19	1.31	1.81
		30-75	23.30	24.09	18.30	15.20	6.41	8.21	6.60	3.80	0.70	3.49	2.70	2.20	0.70	2.20	1.70	1.20	2.50
		75-100	21.20	22.59	17.74	14.91	7.31	7.11	5.91	4.71	1.21	4.40	1.60	1.91	0.80	3.40	0.80	0.70	4.90
		100-150	21.40	23.29	18.29	14.60	6.89	7.90	6.20	3.90	1.30	2.30	3.21	3.30	1.12	2.90	0.30	0.90	3.60
Denuded Rock	2	0-50	25.60	17.22	24.39	11.69	12.21	4.40	3.41	2.31	0.70	2.09	5.29	4.50	0.0	1.80	0.20	2.20	7.59
		50-90	21.70	10.29	20.89	18.31	10.61	7.51	4.49	6.19	1.21	1.90	4.49	4.71	0.0	3.20	1.70	2.80	1.70
		90-150	34.20	20.40	27.12	14.19	8.69	3.91	2.71	1.90	0.0	4.19	2.90	3.69	0.0	2.60	2.20	2.60	2.90
Rock land	3	0-50	37.00	10.69	25.22	20.79	12.52	5.22	1.79	3.10	0.0	5.52	4.70	0.90	0.21	2.24	3.70	1.40	2.00
		50-110	40.90	14.23	25.09	16.70	11.30	2.40	4.096	4.91	0.0	5.70	5.30	1.79	0.90	0.80	2.99	2.50	1.30
		110-150	25.60	18.30	22.40	23.35	9.39	4.42	2.59	2.59	0.0	4.60	5.20	0.70	0.75	1.21	2.06	0.75	1.69
	4	0-40	27.50	23.60	21.98	15.98	9.57	5.80	2.29	2.54	1.32	1.99	2.79	2.88	1.08	1.17	1.53	1.08	4.40
		40-100	30.40	24.80	21.09	9.80	12.40	7.80	2.90	3.41	2.10	3.51	1.90	2.10	0.60	1.01	0.83	2.10	3.65
		100-150	28.70	20.70	24.10	10.29	10.50	7.41	3.10	3.71	2.00	2.20	4.31	4.19	0.80	1.89	0.60	3.00	1.21
	9	0-30	21.10	20.99	21.78	17.01	7.82	3.22	3.22	5.28	2.43	2.60	4.52	1.99	1.00	3.89	1.68	0.0	2.43
		30-100	25.60	18.43	22.29	15.99	9.20	4.44	2.49	5.88	1.87	0.91	4.02	2.49	1.35	2.49	2.49	3.51	2.13
		100-150	27.30	16.23	18.48	22.28	8.57	4.73	3.92	4.73	1.42	0.79	4.07	3.41	1.55	2.24	2.24	2.91	2.24
River terraces	5	0-15	38.30	26.41	22.40	13.91	4.81	6.69	2.71	4.29	1.20	1.80	1.10	3.31	1.39	2.50	0.79	0.79	5.90
		15-85	36.40	28.10	15.60	18.81	13.81	5.80	3.30	3.51	1.49	3.69	2.50	2.70	0.80	3.69	0.20	0.20	7.70
		85-150	42.50	18.90	17.20	17.21	7.81	6.30	2.61	4.61	0.90	3.20	1.60	2.76	0.70	1.50	0.0	0.0	5.50
	6	0-65	37.70	17.92	16.53	11.92	7.37	3.32	2.56	6.95	2.27	1.46	6.46	4.99	0.0	2.53	1.34	4.65	9.70
		65-150	39.10	18.55	13.36	17.15	5.02	5.37	4.83	8.50	2.03	1.92	4.76	4.20	0.0	3.00	2.69	3.82	4.79
Rock outcrops	7	0-45	17.30	15.93	15.24	18.63	12.20	3.66	3.78	7.46	1.36	1.00	5.87	4.35	0.0	4.14	0.0	0.0	6.38
		45-150	42.20	18.20	14.97	20.76	7.39	5.22	5.93	7.89	1.31	0.47	5.25	3.36	0.0	3.86	0.0	0.0	5.39
Wadi bottom	8	0-20	29.80	16.09	17.87	15.89	13.61	5.35	2.62	5.03	0.0	3.44	4.90	3.41	3.45	1.89	0.23	3.66	2.55
		20-110	22.40	18.29	16.51	12.04	11.68	4.53	3.34	7.31	0.0	2.59	8.47	1.98	2.43	2.53	0.76	2.12	5.41
		110-150	26.70	18.87	17.40	17.40	12.06	6.48	2.73	5.86	0.0	2.19	5.67	0.67	2.18	2.73	1.92	3.17	0.67
Moderately High Terraces	10	0-25	28.10	19.02	21.75	17.03	14.10	4.44	1.69	2.26	0.75	2.26	3.23	2.26	0.75	3.74	4.11	0.34	2.26
		25-90	31.10	21.47	16.49	13.58	9.46	9.53	3.80	3.80	1.60	2.06	1.60	3.80	0.85	2.40	3.06	0.85	5.64
		90-130	30.60	19.90	17.16	15.92	15.17	4.54	1.77	3.20	1.46	4.23	3.92	3.20	0.67	1.03	3.20	1.46	3.20

Table (8) Frequency distribution of light minerals in the sand fraction (0.125- 0.063 mm)

physiography	Profile No.,	Depth cm	Quartz %	Feldspars%			Calcite %
				Orthoclase	Plagioclase	Muscovite	
Young Alluvial Terraces	1	0-30	78.40	4.40	6.30	2.20	8.70
		30-75	78.20	3.70	4.30	3.70	10.10
		75-100	76.10	4.50	4.10	4.80	10.50
		100-150	77.70	4.30	5.30	3.50	9.20
Denuded Rock	2	0-50	82.30	3.40	3.8	3.00	7.50
		50-90	81.20	4.10	3.30	2.70	8.70
		90-150	85.00	2.30	3.10	3.20	6.40
Rock land	3	0-50	82.40	3.40	3.20	3.10	7.90
		50-110	78.30	3.10	4.90	2.30	11.40
		110-150	81.70	2.70	4.20	1.50	9.90
	4	0-40	81.20	2.10	3.10	1.30	11.30
		40-100	82.40	2.20	4.60	1.80	9.00
		100-150	82.60	3.70	2.70	2.90	8.10
	9	0-30	81.30	4.60	3.30	3.40	7.40
		30-100	82.20	4.40	2.60	3.40	7.40
		100-150	83.00	6.30	3.10	2.30	5.30
River terraces	5	0-15	79.60	3.60	3.60	3.90	9.30
		15-85	78.00	4.20	3.80	4.40	10.60
		85-150	77.30	5.30	3.40	4.40	9.60
	6	0-65	75.30	5.30	4.20	4.00	11.20
		65-150	76.20	4.40	4.80	5.50	10.10
Rock outcrops	7	0-45	76.70	6.30	4.20	3.10	9.70
		45-150	84.20	4.20	3.40	0.90	7.30
Wadi bottom	8	0-20	83.30	4.30	3.20	2.20	7.00
		20-110	79.80	3.30	3.40	1.30	12.20
		110-150	82.70	3.40	3.40	1.90	8.60
Moderately High Terraces	10	0-25	77.60	8.30	5.10	3.30	5.70
		25-90	76.40	7.80	5.30	2.10	8.40
		90-130	81.10	4.30	3.20	2.60	8.80

Table (9) Uniformity and weathering ratios of the studied soils.

Physiographic unit	Profile No.	Depth (cm)	Uniformity ratios			Weathering ratios		
			Z/T	Z/R	Z/T+R	Wr1 (A/Z+T)	Wr2 (A+P/Z+T)	Wr3 (B/Z+T)
Young Alluvial Terraces	1	0-30	2.17	1.47	0.88	1.64	2.95	0.57
		30-75	2.16	1.24	0.79	2.01	3.53	0.53
		75-100	1.51	1.20	0.67	1.92	3.42	0.62
		100-150	2.03	1.27	0.78	1.97	3.52	0.58
Denuded Rock	2	0-50	1.91	1.29	0.77	2.57	6.21	1.82
		50-90	1.21	1.67	0.70	0.75	2.28	0.77
		90-150	2.05	1.44	0.85	3.52	8.19	1.50
Rock land	3	0-50	1.68	2.89	1.06	1.28	4.31	1.51
		50-110	0.49	0.59	0.27	1.95	5.38	1.55
		110-150	1.69	1.69	0.85	2.59	5.77	1.34
	4	0-40	2.28	2.59	1.21	2.84	5.44	1.12
		40-100	2.29	2.69	1.24	2.18	4.05	1.11
		100-150	2.00	2.39	1.09	1.86	4.04	0.95
	9	0-30	0.63	1.06	0.39	2.44	4.97	0.91
		30-100	0.76	1.74	0.53	1.78	3.94	0.89
		100-150	0.99	1.20	0.54	1.71	3.66	0.90
River Terraces	5	0-15	1.56	2.48	0.96	2.49	4.54	0.45
		15-85	1.66	1.76	0.85	2.00	3.63	1.45
		85-150	1.37	2.42	0.88	2.60	4.22	0.72
	6	0-65	0.48	1.30	0.35	1.74	3.35	0.72
		65-150	0.63	1.11	0.40	1.34	2.30	0.36
Rock outcrops	7	0-45	0.49	0.97	0.33	1.43	2.80	1.10
		45-150	0.66	0.88	0.38	1.39	2.53	0.56
Wadi button	8	0-20	1.06	2.04	0.70	1.55	3.27	1.31
		20-110	0.62	1.36	0.43	1.54	2.94	0.99
		110-150	1.11	2.29	0.75	1.53	2.94	0.98
Moderately High Terraces	10	0-25	2.01	2.62	1.14	2.86	6.14	2.12
		25-90	2.59	2.43	1.25	1.62	2.87	0.72
		90-130	1.42	2.55	0.91	2.57	4.79	1.96

Where: Z= zircon
T= tourmaline
R= rutile
B= biotite
P= pyroxenes
A= amphiboles

River Terraces	6	0-65	0.48	1.30	0.35	1.74	3.35	0.72
		65-150	0.63	1.11	0.40	1.34	2.30	0.36
Rock outcrops	7	0-45	0.49	0.97	0.33	1.43	2.80	1.10
		45-150	0.66	0.88	0.38	1.39	2.53	0.56
Wadi button	8	0-20	1.06	2.04	0.70	1.55	3.27	1.31
		20-110	0.62	1.36	0.43	1.54	2.94	0.99
		110-150	1.11	2.29	0.75	1.53	2.94	0.98
Rock land	9	0-30	0.63	1.06	0.39	2.44	4.97	0.91
		30-100	0.76	1.74	0.53	1.78	3.94	0.89
		100-150	0.99	1.20	0.54	1.71	3.66	0.90
Moderately High Terraces	10	0-25	2.01	2.62	1.14	2.86	6.14	2.12
		25-90	2.59	2.43	1.25	1.62	2.87	0.72
		90-130	1.42	2.55	0.91	2.57	4.79	1.96