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Soil Genesis and Uniformity of Wadi Al-Queh, Al-Quseir, Red Sea Coast, Egypt

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ABSTRACT

Red Sea coastal zone within the "Golden Triangle" national project is brought out as promising agrarian expansion. Wadi Al-Queh is one of the drainage basins located east of Red Sea Mountains with buoyancy water and soil resources. Current study aimed at investigating soils of wadi Al-Queh with respect to their genesis and degree of homogeneity based on the mineralogical analysis. Four landforms were recognized running east to west namely; bajada plain, wadi terraces, mid-stream wadi course and piedmont plain. Twenty nine soil samples were selected representing eight georeferenced profiles to embody all variations in the different landforms. To recognize the prevailing depositional environmental conditions, samples were subjected to granulometric analysis for the sand fraction. Heavy and light minerals of fine sand fraction were estimated. The uniformity ratios among resistance minerals of zircon, rutile, and tourmaline were calculated. Weathering ratios (Wr1, Wr2, and Wr3) between the non-resistance and resistance minerals were used as criteria for investigating parent materials uniformity and consequently the degree of soil development. Obtained results revealed the dominance of quartz with 89.15- 98.85% of the total light minerals. Opaque minerals are composed essentially by iron oxides in the range 37.75-71.25% of the total heavy minerals. Frequencies of transparent minerals indicate the contribution of igneous, metamorphic and sedimentary sources in soil derivation at whole landforms. They were mostly derived from Nubian sandstone, limestone, conglomerate, breccia, granite, basalt, and schist during Tertiary to Recent ages. Obvious heterogeneous distribution of calculated weathering and uniformity ratios with depth depicted that most of the studied soils were poorly sorted, poorly developed and mostly composed of more than one parent material under multi-depositional environments conditions with non-uniform in nature. Water as the major erosional agent contributes in rifting the wadi paths between mountainous blocks towards east direction. Weathered materials from igneous, sedimentary and metamorphic sources were deposited to form a great outwash plain in which the soils under consideration were stratified. In conclusion, it is quite clear that soils of wadi Al-Queh represented an apparent discontinuity or a type of irregular interstratifications due to geogenetic weathering, mostly related to a multi-origin and/or multi depositional regime.

Key words: Soil origin, Parent material uniformity, Soil mineralogy, Wadi Al-Queh, Red Sea coast.

INTRODUCTION

The Eastern Desert of Egypt extends from the latitude of Cairo at the north to the southern border of Egypt with Sudan within an area of about 224,000 km^2. This desert consists mainly of high and very rugged mountains running parallel to the Red Sea coast and comprises Precambrian crystalline igneous and metamorphic rocks. Sedimentary rocks occur mainly at the northern (mainly limestone) and southern (mainly sandstone) fringes of the desert. The mountains in the Eastern Desert are dissected by well developed drainage systems ending either at the Red Sea or at the Nile Valley. The dissection of this desert by dense networks of valleys and ravines indicates that wet climate had prevailed in the region in the past (Hereher and El-Ezaby, 2012). World soil map (FAO/UNESCO, 1973) mostly classified the Eastern Desert of Egypt as Lithosols (soils of rocky origin).

Soil forming factors dominating the coastal zone of the Red Sea are generally similar. These factors include: igneous parent materials rich in silica; hot and arid climate; lack of vegetation cover; sloping topography; and relatively low maturity. Soil profiles indicate that they are just accumulations of sand and rock debris piled from adjacent weathered rocks. There are no developed surface or subsurface diagnostic horizons, such as clay skins or calcareous accumulations. Soil profiles are dominated by shallow to moderately deep depth with rock fragments (pebbles) significantly occur at all sites. Soils have only one horizon, arbitrarily termed ‘A’ horizon forming recent soils "Entisols" and lying over a rocky basement. Texture analysis reveals their sandy nature with high water permeability, hence they are classified as *Psamments* (Vogg and Wehmeier, 1985).

Promising wadis of the Egyptian Eastern Desert have special significance for agriculture expansion due to their lands and water resources potentialities. The area between Safaga and Al-Quseir districts within the Red Sea Agroecological Zone got a special importance in the national income. It represents one of the most promising areas for different developments along the Red Sea coast. Nowadays, the Egyptian government is going to implement a mega project in that region between Qena, Safaga, and Al-Quseir, which called "The Golden Triangle Project". Lots of targets are aimed to establish new industrial areas as well as tourism, mining, and trade that represent a major development in Upper Egypt. Besides, agricultural activities have planned to take place for comprehensively sustainable development of this area.

In doing so, wadi Al-Queh is considered one of the most promising drainage basins in the Golden Triangle of the Eastern Desert. Due to its superior potentiality of water resources, that wadi is selected in the present study. Agriculture activities in this wadi are very limited. However, few scattered parts near few wells are under cultivation using ground water as the main water source.

Mineralogical investigations are essential tool for studying soil genesis. They clarify the origin and uniformity of soil parent materials in terms of the degree of minerals weathering, losses and gains of soil matrix according to involved processes (Brewer, 1964). Moreover, the use of index minerals and its ratios have proven successfulness for a long time in evaluating uniformity and origin of parent material (Lotti and Averna, 1986). Several attempts have been carried out to study the Egyptian soils in terms of their origin and development (Elwan *et. al.*, 1980; Kassim and Abd El-Rahman, 1981; Gewaifel *et. al*., 1981; Kassim *et. al.*, 1989).

The main objective of the current investigation is to search for quantitative evidence indicating the origin and uniformity of wadi Al-Queh soils based on the mineralogical analysis.

STUDY AREA

Current study was conducted in wadi-Al-Queh which is located along the Red Sea coastal line at 32 Km away north of Al-Quseir city. Geographically, studied wadi is located in the area extending from 26° 11' to 26° 25' N and 33° 53' to 34° 11' E (map 1). According to Gomaa (1992), Al-Queh catchment basin covering an area of about 432000 feddan and the longest flow pathway extends along 67.5 Km from west to east. It is stretched from SW to NE direction and accessible by a paved road connecting the area with Al-Quseir town.

Wadi Al-Queh lies within the Golden Triangle project which has nowadays special governmental focus to establish new urban communities that represent a major development in Red Sea coastal region and Upper Egypt. It could be considered one of the most promising wadis for agricultural expansion along the Red Sea coast. In particular, studied part of Wadi Al-Queh was delineated and used as base map for current investigation. It covers an area of about 10963 feddan with length reached to 37.5 Km from west to east.

Climatological data from 1995 to 2015 (20 years period) were obtained from the Egyptian Meteorological Authority (2016) through Climatic Atlas of Egypt. Considered area lied within the desert climate belt (hyper arid conditions), where it was characterized by hot dry summer and warm rainless winter. The annual mean values of minimum and maximum air temperatures were 20.5°C and 27.5°C, respectively. The minimum and maximum mean of evaporation rates were 5.94 and 9.01 mm/day, recorded in December and July months, respectively. The annual mean of the relative humidity was 51.69%. The annual average wind speed was 25.30 km/h in period of windy months which starts by March and ends by May.

The geological aspects of the area in which Wadi Al-Queh is located were outlined by many investigators, among them Said (1990), Abdel Razik (1972), MPGAP (1990), Misak and Abd Elbaki (1990) and Gomaa (1992). They conclude that rock exposures and formations in the area had a wide range of geologic times varied from Precambrian to Quaternary ages. The Precambrian age was represented by igneous and metamorphic rocks, with the dominance of granite and basalt rocks. Sedimentary rocks belonging to the Tertiary and Quaternary periods dominated the upper layers of Wadi Al-Queh. Sediments during these ages were deposited in synclinal fold within the basement complex. Tertiary period includes Upper Cretaceous, Paleocene, Lower and Middle Eocene, Oligocene, Middle Miocene and Pliocene ages. The study area was affected by numerous types of faults. The folded Cretaceous – Eocene sediments were observed along the study area and deposited in hollows within the basement complex. Meanwhile, Quaternary period includes the Pleistocene and Holocene ages that are represented by wadi deposits, playa and mud pans, sabkha, and old gravel and sand.

Information extracted from interpreted remotely sensed data, DEM analyses, and other auxiliary ground truth sources were used to identify the landscapes and landforms in study area. In the vicinities of Wadi Al-Queh, the area is characterized by conspicuous types of geomorphological units, which are (a) Coastal plain, (b) Hilly terrain, (c) Mountainous belts, and (d) Hydrographic basins, (map 2). The coastal plain extended parallel to Red Sea shore line and exhibited the landforms of wet sabkhas and alluvial fans (bajada plain). Watershed area includes: (1) Red Sea mountainous terrain which was cut eastward by many drainage system from which wadi Al-Queh, (2) hilly terrain which was divided into coastal (wadi terraces) and inland hills, (3) water collectors which were divided into morphotectonic depressions (i.e. El-Sakia depression in Wadi Al-Queh) and hydrographic basins (Al-Queh basin) (Aggour, 1997). According to Gomaa (1992), wadi Al-Queh cuts its course in tectonic depression, which stretches in a SW-NE direction.

Morphological features of soils were greatly influenced by topographic situation of landforms. Varysized surface coarse fragments (coarse gravels to boulders with the dominance of stones) were noticed over most of the upper and middle portions soils of the wadi. The study area soils were prone to erosion due to excessive water runoff of flooding hazards. The landform of the area was characterized by an obvious gentle slope generally towards the east direction. The slopes were nearly level to gently sloping as varied from 0.75% to 4.75%, where the dominant aspect was west-north to east. Elevations above sea level were varied from 193 m at upstream to 9 m at downstream portion.

MATERIALS AND METHODS

Field studies were carried out of the area under consideration using thirteen representative soil profiles. Locations of studied profiles were spatially chosen as a transect representing whole achieved landforms in the studied wadi (map 3). Profiles Nos. 1, 2, 3, and 4 were distributed on the alluvial fan (bajada plain), covered an area of 3127.3 feddan (28.52% of sampled area). Meanwhile, profiles Nos. 5, 6, 7, and 8 were chosen on wadi terraces and interfluves occupying an area about 2658.7 feddan (24.25%). The midstream of wadi course covered an area of 1761.4 feddan (16.07%) and sampled by two profiles Nos. 9 and 10. The piedmont soils had an area of 3415.5 feddan (31.15%) and were represented by three profiles Nos. 11, 12 and 13, (map 3). The morpho-pedological features of the sites and profiles were described and characterized as per the standards procedures given by Soil Survey Staff (1996), USDA-NRSC (2002), and FAO (2006).

Observation sites were georeferenced using UTM coordination system and geolocated for mapping using ARC GIS software 10.1 (ESRI, 2012).

Only 8 profiles were chosen for present study resultant in 29 soil samples. Selected soil samples were air dried, ground, and passed through a 2 mm sieve. After pretreatment, soil samples were analyzed as per the standard procedures and methods given by Mani *et al.,* (2007) to determine the mechanical analysis. Fine sand fraction (250-63 µm) was obtained by dry sieving, then the heavy and light mineral fractions were separated using bromoform (sp. Gr. 2.84). Both of heavy and light mineral grains were mounted over Epoxy material and visualized by electron microscopic scanner (EMS) according to Duncan *et. al.* (2004).

Soil genesis and profile uniformity or discontinuity were evaluated based on calculated ratios of Z/R, Z/T and Z/R+T (Haseman and Marshall, 1954), and according to the weathering ratios Wr1, Wr2, and Wr3 stated by Hammad (1968).

RESULTS AND DISSCUSION

Studied soils were formed and developed under desert climatic environment. Thus, active physical weathering had prevailed soil derivation. In contrast, low magnitude of chemical weathering is expected and may result in little variations among soils. However, soils of Wadi Al-Queh are the results of interplay of aeolian fluvial and marine influx of sedimentary materials.

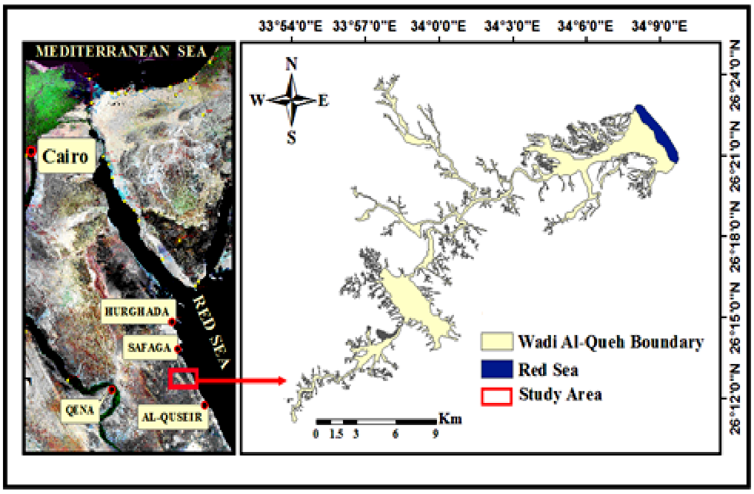
(1) Mineralogy of the light sand fraction

Examination of the light sand fraction revealed the dominance of quartz which ranged between 89.15% and 98.85% of the total light minerals (table 1). Obviously, percentages of quartz found to be higher in elevated landforms including both of midstream wadi course and piedmont soils (96.35-98.85%), than those being in the lower ones belong to terraces and bajada soils (89.15-93.85%). This is may be attributed to the relative mobility forces of eroded sediments between lower and higher landforms.

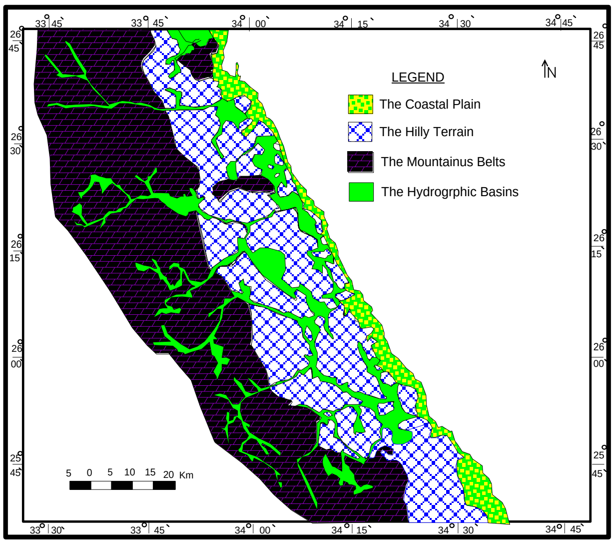
Normal quartz is commonly present, as well as undulose quartz is also detected which indicates the contribution of metamorphic sources in soil derivation. It is commonly present as sub-rounded to angular grains. Regarding Feldspars, the total contents ranged between 1.15 and 10.85% of the light fraction. They mainly represented by potash feldspars as orthoclase (0.35-5.25%) and microcline (0.10-2.50%), in addition to calcium rich feldspar, known as plagioclase (0.15-4.75%). The vertical distributions of detected light minerals have no regular trends (table 1).

(2) Mineralogy of the heavy sand fraction

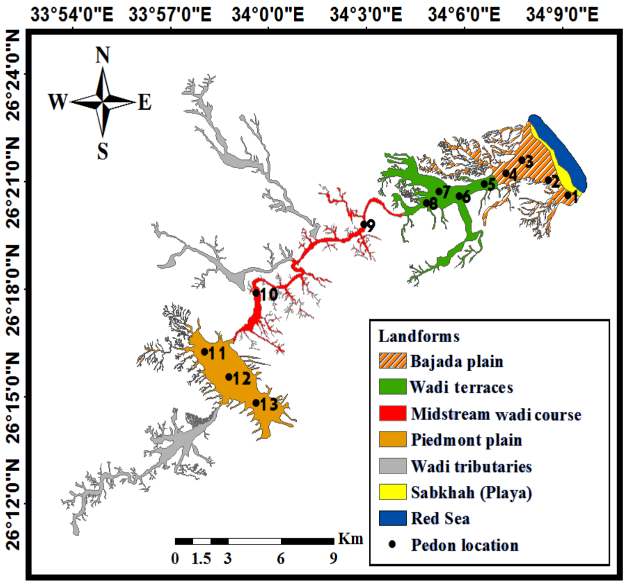
Heavy minerals are generally studied in terms of opaque and non-opaque minerals. Results given in table (2) showed that opaque minerals and apatite are the most abundant minerals over whole landforms. They are followed by zircon, pyroxene and sometimes epidotes at bajada plain and wadi terraces, while followed by zircon and hornblend at mid-stream wadi course. Pyroxene, hornblend and sometimes zircon and epidotes are in subordinate amount at piedmont plain. In general, garnite, tourmaline and rutile are found in relatively low amounts, whereas kyanite and sturolite are detected as trace.



Map 1: Location of Wadi Al-Queh, Red Sea coast, Eastern Desert of Egypt.



Map 2: Main geomorphic units of the studied area at Red Sea coast region.



Map 3: Locations of the studied profiles at Wadi Al-Queh landforms.

Table 1: Mechanical analysis and frequency distribution of light minerals in fine sand fraction (0.063-0.25 mm) of Wadi Al-Queh soils.

Land form	Profile No.	Depth (cm)	Particle size distribution				Light minerals			
							Quartz	Feldspars		
			Clay	Silt	Sand	Texture class		Orth.	Plag.	Mic.
Bajada plain	1	0-25	3.50	5.20	91.30	S	90.25	4.20	3.05	2.50
		25-55	4.25	3.50	92.25		91.05	3.85	2.75	2.35
		55-90	2.50	7.25	90.25		92.15	3.55	2.35	1.95
		90-130	4.75	4.15	91.10		93.45	2.70	2.10	1.75
	2	0-30	5.55	6.50	87.95	S	91.45	3.20	3.50	1.85
		30-60	4.25	5.50	90.25		92.15	2.35	3.75	1.75
		60-105	3.75	7.50	88.75		91.45	3.15	4.75	0.65
		105-120	3.50	3.50	93.00		90.05	4.50	4.00	1.45
Wadi terraces	6	0-10	6.75	3.15	90.10	S	89.15	5.25	3.65	1.95
		10--35	6.65	3.75	89.60		89.95	4.15	3.85	2.05
		35-70	5.25	4.00	90.75		90.55	5.35	2.25	1.85
		70-130	5.05	5.10	89.85		90.75	3.85	2.9	2.5
	7	0-15	9.65	2.25	88.10	LS	91.45	3.85	3.35	1.35
		15-35	8.90	3.15	87.95		92.15	4.50	1.60	1.75
		35-75	8.25	3.30	88.45		92.75	3.65	1.93	1.67
		75-105	9.10	4.00	86.90		93.85	3.95	1.55	0.65
Mid-stream wadi course	9	0-8	3.15	3.30	93.55	S	98.70	0.75	0.25	0.30
		8--24	4.05	3.75	92.20		97.25	1.15	1.00	0.60
		24-46	4.35	2.45	93.20		96.85	1.30	0.90	0.95
	10	0-27	2.25	3.50	94.25	S	96.35	2.15	0.80	0.70
		27-45	3.00	4.00	93.00		97.25	1.85	0.35	0.55
		45-55	3.15	4.15	92.70		98.35	1.25	0.30	0.10
Piedmont plain	11	0-20	2.15	2.10	95.75	S	97.25	1.50	0.70	0.55
		20-45	2.05	2.75	95.20		97.50	1.80	0.45	0.25
		45-80	2.55	3.10	94.35		97.95	1.55	0.15	0.35
		80-115	3.40	3.55	93.05		98.40	1.05	0.25	0.30
	13	0-25	1.50	1.55	96.95	S	97.75	1.05	0.95	0.25
		25-40	1.75	2.15	96.10		98.10	0.95	0.80	0.15
		40-75	1.15	2.50	96.35		98.85	0.35	0.55	0.25

Orth. = Orthoclase Plag. = Plagioclase (Ca-rich) Mic. = Microcline
S = Sand LS = Loamy sand

Opaque minerals are composed essentially by iron oxides (e.g., hematite and goethite) in the range of 37.75-71.25%. The non-opaque minerals showed distinctly the variation among investigated soils as they differ in age and origin. Soils of wadi course and piedmont landforms contains the highest percentage of the non-opaque minerals within the range of 42.55-62.25%, whereas, soils of bajada and wadi terraces come next with range of 28.45-53.80%.

The non-opaque minerals comprise the following types:

Pyroxenes were detected in the light fraction include augite and hyperthene with a majority of the former. Augite was relatively high and varies in the range 11.05-24.15% at whole achieved landforms except wadi course, where it ranged between 4.35 and 9.85%. No regularity was noticed for pyroxenes distribution with depth.

Amphiboles were the most common minerals identified in the non-opaque. They were recorded in all samples, represented by diopside, actinolite and hornblende. Green hornblende was the most frequent amphibole mineral where it constitutes more than 70% of the total amphiboles. Its proportion found in two different levels, low to moderate at wadi terraces where they varied from 3.15 to 10.05%, whereas, being moderate to high within the range 9.25-19.25% at wadi course and piedmont soils.

Zircon was achieved in whole analyzed samples with different frequency ranges. Low range was detected between 2.10-12.50% at piedmont soils, while moderate quantity was found at bajada landform where zircon varied from 9.75 to 15.45%. High concentration of zircon ranged between 10.80 and 29.30% associated with wadi course and terraces soils. Most of zircon grains found to be colorless and prismatic with clear surfaces.

Rutile was recorded in low percentage with frequency ranged between 0.15 and 5.55% for whole studied samples. Reddish and rounded grains were the most abundant of rutile.

Tourmaline was found in low to moderate frequency between 0.95 and 9.30% over all landforms. It occurs in rounded grains mostly in brown, yellowish brown and colorless varieties.

Epidote was represented by sub round grains having interference colors. It was recorded within wide range of moderate quantity between 12.05 and 1.9% at bajada and piedmont soils, respectively. Meanwhile, its frequency was within low records as varied between 0.25 and 6.55% at both of wadi course and terraces soils. Generally, epidote have distributed with no specific trends with depth.

Garnet occurred in colorless forms having different frequencies in relation to landforms. High proportions found in bajada and wadi course soils as its values were between 4.5 and 9.15%, while being moderate at wadi terraces, where concentrations varied from 0.95 to 4.20%. Soil samples of piedmont plain have a wide range of garnet records as they ranged between 0.0 and 9.2%, where surface soils have the highest values.

Staurolite grains were presented in golden yellow color with short prismatic form, having a frequency varying between 1.1 and 6.45% for all studied landforms.

Biotite known as black mica, it was detected in rounded grains forms with low frequency values as they ranged between 1.0 and 6.5% for all landforms.

Regarding the origin of the studied soils, according to (Victor and Gujar, 1995) the mineralogy of transparent heavy fraction has been used as guide to provenance. Amphiboles, pyroxene and plagioclase indicate soil derivation from igneous rocks of basic to intermediate provenance, while epidote, zircon and rutile indicate acid to intermediate igneous rocks. Rutile, biotite and orthoclase derived from acidic igneous rock like granite. Zircon, amphiboles, staurolite and garnet are indicating soil derivation from metamorphic rocks. Olivine emphasized on soil formation from acidic and basic igneous rocks as well as metamorphic ones. The general abundant of hornblende (unstable heavy minerals) indicate of immature conditions or recent sediments.

Results indicate different frequencies of plagioclase, hornblende and biotite with the fact of quartz dominancy in whole soils of achieved landforms, which prove the contribution of granite as an acidic igneous rock in soil derivation. Meanwhile, the existing of olivine, pyroxene and hornblende in all studied soil profiles refer to soil derivation partially from basalt as a basic igneous rock. In conclusion, soils of the studied landforms were assumed to be formed partially of weathered materials from Precambrian to Upper cretaceous igneous sources. The existing of undulose quartz, garnet and staurolite in the heavy fraction of the studied soil samples lead to the metamorphic rocks as additional source rocks for the sediment under consideration.

Structurally, the Red Sea Mountains as the main watershed in the area were dissected by numerous Eocene and Miocene valleys through existing faults. Water as the major erosional agent contributes in rifting the wadi paths between mountainous blocks towards east direction. Weathered materials from igneous, sedimentary and/or metamorphic sources were deposited to form a great outwash plain in which the soils under consideration were stratified. Fig. No. 1 shows a satellite image of Wadi Al-Queh with the fronts of some studied pedons representing achieved landforms soils. Obviously, the image illustrates the contribution possibility of sedimentary and igneous sources in soil derivation. Pedon No. 11 is located at interfering zone between igneous and sedimentary rocks of the piedmont. Thus, it contained common weathered rock grits from different sources representing translocated alluvium soils. Sloppy alluvium soils presented by profile No. 9 were recognized as water laid igneous parent materials in wadi course. However, volcanic deposits were registered only over limited sites of the study area. Meanwhile, pedon No. 7 models the wadi terraces soils which derived mainly from aeolian deposits in addition to volcanic ones. In-situ formed soils were found only as a residuum in bajada plain as represented by pedon No. 2.

Gomaa (1992) mentioned that sedimentary rocks in the area under consideration have great contribution in soil derivation with several contents of fine sand minerals during three stages between Tertiary and Holocene periods. These are: (1) Soils of piedmont plain and hilly landforms were formed partially during Pre-Miocene (from Upper Cretaceous to Oligocene) from Nubian sandstone, siltstone and evaporates (shall and limestone). (2) Soils of wadi terraces and interfluves were formed mainly during Miocene and derived from limestone, sandstone, breccia and conglomerate parent materials. (3) Soils of wadi course and bajada (alluvial fans of outwash plain up to 200 m above sea level) were formed during Post Miocene (from Pliocene to Holocene) from weathered sediments of coarse sand and gravels.

Table 2: Frequency distribution of heavy minerals in the fine sand fraction (0.063-0.25 mm) of Wadi Al-Queh soils

Land form	Ped. No.	Depth (cm)	Light min. (%)	Heavy min. (%)	Opaque min.	Non opaque minerals													
						Pyroboles min.					Para metamorphic minerals			Ubiquitous minerals			Epidotic min.	Others	
						Pyroxenes			Amphiboles										
						Aug.	Hp.	Diops.	Horn.	Act	Gr.	Sta.	Ky.	Zir.	Tor.	Rut	Epid.	Bio.	Apat.
Bajada plain	1	0-25	95.34	4.66	45.45	15.25	3.50	2.55	7.65	3.25	7.35	5.30	0.25	13.75	5.15	3.10	10.15	5.25	17.50
		25-55	94.33	5.67	37.75	18.15	5.80	3.15	6.15	1.75	5.05	3.15	1.15	10.55	3.45	4.35	12.05	4.15	21.10
		55-90	93.53	6.47	39.35	20.75	3.25	3.50	5.75	2.10	4.90	2.50	1.35	15.45	3.15	5.05	4.25	4.75	23.25
		90-130	94.12	5.88	41.15	22.50	6.95	4.15	5.10	2.35	4.50	1.10	0.65	14.05	5.20	3.15	4.20	1.35	24.75
	2	0-30	91.33	8.67	48.50	23.15	3.45	2.55	4.25	3.35	8.20	1.30	0.25	5.15	4.75	3.15	7.45	5.75	27.25
		30-60	94.24	5.76	41.15	17.15	5.75	3.25	8.25	1.45	5.85	3.05	0.15	13.75	3.15	4.30	9.75	1.00	23.15
		60-105	93.22	6.78	40.15	20.75	4.25	1.50	9.85	0.95	4.90	5.50	2.50	11.75	0.95	1.45	4.20	4.15	27.30
		105-120	96.32	3.68	39.75	20.25	2.75	2.45	9.05	4.25	6.50	2.35	0.65	9.75	2.85	0.15	9.20	1.55	28.25
Wadi terraces	6	0-10	91.85	8.15	40.50	13.45	5.25	2.30	7.45	2.55	3.45	3.55	0.75	19.50	2.95	1.95	3.45	2.15	41.25
		10--35	91.50	8.50	43.50	11.05	4.65	3.25	5.45	2.15	2.45	2.05	1.05	17.35	0.95	0.65	6.55	3.15	39.25
		35-70	90.85	9.15	43.75	17.45	2.95	4.05	3.15	3.05	0.95	1.65	1.65	19.75	7.65	1.05	2.05	2.15	42.45
		70-130	90.50	9.50	45.15	10.65	4.25	3.05	4.65	1.55	1.25	3.45	2.55	23.05	1.05	0.65	5.65	2.55	35.65
	7	0-15	90.37	9.63	43.65	11.55	4.20	3.05	5.95	3.15	1.65	5.05	2.05	15.65	2.25	1.65	4.10	5.55	34.15
		15-35	85.75	14.25	45.05	12.65	2.15	3.65	7.45	1.95	4.20	6.15	1.50	13.25	1.95	1.05	2.25	6.35	33.45
		35-75	82.11	17.89	42.45	20.30	4.35	4.10	6.40	4.55	1.20	3.35	1.20	11.15	1.25	0.75	5.20	3.15	33.05
		75-105	87.23	12.77	57.45	14.25	4.00	3.55	10.05	1.05	3.25	2.25	3.65	10.80	0.95	0.25	6.25	3.25	35.45

Ped = Profile
min = minerals

Aug = Augite
Hp = Hyperthene
Diobs = Diopside
Horn = Hornblende
Act = Actinolite

Gr = Garnet
Sta = Staurolite
Ky = Kyanite

Zir = Zircon
Tor = Tourmaline
Rut = Rutile

Epid = Epidotes
Bio = Biotite
Apa = Apatite

Table 2: Continued.

Land form	Ped. No.	Depth (cm)	Light min. (%)	Heavy min (%)	Opa que min.	Non opaque minerals													
						Pyroboles min.					Para metamorphic minerals			Ubiquitous minerals			Epidotic min.	Others	
						Pyroxene		Amphiboles											
						Aug.	Hp.	Dips.	Horn	Act	Gr.	Sta.	Ky.	Zir.	Tor.	Rut	Epid.	Bio.	Apat.
Mid-stream wadi course	9	0-8	83.65	16.35	63.55	4.35	0.75	3.05	14.75	5.90	7.40	5.55	5.15	18.30	6.50	5.55	2.35	5.25	15.15
		8--24	82.36	17.64	67.65	7.55	1.85	3.65	15.25	9.45	9.15	2.65	3.85	17.60	5.45	2.35	0.25	6.20	14.75
		24-46	81.45	18.55	56.35	5.75	6.15	4.45	19.25	11.15	4.25	5.35	4.35	11.25	4.05	1.75	1.80	6.50	17.95
	10	0-27	85.33	14.67	63.65	8.65	3.45	5.25	13.25	1.35	3.05	3.15	2.15	29.30	8.20	3.65	0.55	6.25	11.75
		27-45	84.24	15.76	64.15	9.85	2.45	6.35	12.50	0.70	5.25	1.90	4.40	27.75	7.25	3.40	1.35	3.20	13.65
		45-55	83.22	16.78	68.50	5.35	2.95	7.10	11.15	2.25	4.00	0.75	9.55	21.05	4.50	2.30	0.25	4.65	15.15
Pied-mont plain	11	0-20	90.75	9.25	63.25	24.15	4.90	1.55	9.25	1.75	9.20	5.35	1.85	2.10	1.25	2.15	5.35	1.40	29.75
		20-45	89.25	10.75	65.50	19.25	2.60	2.15	11.50	3.25	1.15	1.30	0.45	9.20	4.50	5.40	10.00	4.00	25.25
		45-80	88.85	11.15	70.75	23.15	3.95	3.45	12.35	2.40	5.75	1.95	0.85	7.30	3.55	0.05	3.35	3.20	28.75
		80-115	88.50	11.50	71.25	18.30	3.45	2.90	14.10	1.35	0.00	3.40	2.15	10.35	3.30	3.20	3.50	1.75	32.25
	13	0-25	85.88	14.12	56.85	13.25	2.05	0.25	11.45	4.10	6.90	6.45	2.45	11.85	9.30	4.00	1.90	5.50	20.55
		25-40	83.36	16.64	50.70	15.15	5.80	1.65	18.45	0.35	2.80	4.25	1.10	12.50	5.45	3.25	2.35	5.15	21.75
		40-75	81.44	18.56	46.20	17.45	6.75	2.45	10.40	3.95	3.20	2.90	4.25	9.65	8.35	2.30	1.95	4.25	23.15

Ped = Profile
min = minerals

Aug = Augite
Hp = Hyperthene
Diobs = Diopside
Hom = Hornblend
Act = Actinolite

Gr = Garnet
Sta = Staurolite
Ky = Kyanite

Zir = Zircon
Tor = Tourmaline
Rut = Rutile

Epid = Epidotes
Bio = Biotite
Apa = Apatite

Further, the assumption reported by Brewer (1964) denoted that iron-ores, zircon, rutile and tourmaline minerals are abundant in the Nubian sandstone from which the soils under studying were derived during the Pre-Miocene time.

Accordingly, the obtained results of the petrographic analysis for the studied profiles lead to the fact that the possible source rocks may be granite, basalt, limestone, Nubian sandstone, conglomerate, breccia and schist that form the investigated soils.

(3) Uniformity of soil materials

The evaluation of homogeneity or heterogeneity of a soil parent material by mineralogical analysis could be achieved by the assumption that certain minerals are most resistant to weathering. Thus, resistant minerals were diminished during the course of soil development (Brewer, 1964). Application of Z/R, Z/T, and Z/R+T ratios for studied soils revealed as shown in table (3) that whole soils are of the multi-origin or formed under multi-depositional regimes as indicated through the patterns of frequency distribution. Absence of any specific pattern of these ratios distributions with depth have proven that most of the studied soils are of heterogeneity nature. Such conclusion is confirmed further by weathering ratios.

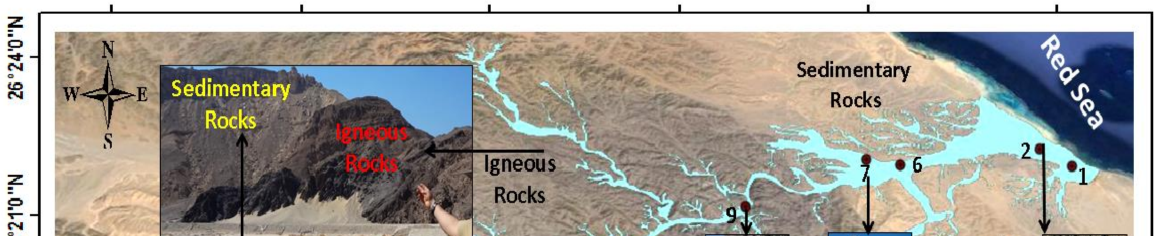
Values of weathering ratios Wr1, Wr2 and Wr3 were calculated as shown in table (3). Results indicate a case of heterogeneity occur in all studied soils. Bajada soils express higher values at surface layers and then decrease irregularly with depth, except for Wr1 and Wr2 in profiles Nos. 1 and 2, respectively, where inverse cases were detected. This may be attributed to the variable balance between heavy minerals.

Table 3: Ratios of resistant minerals and weathering ratios of the separated sand fraction at Wadi Al-Queh.

Land form	Profile No.	Depth (cm)	Z/R	Z/T	Z/R+T	Weathering indices	
						Wr1	Wr2
Bajada plain	1	0-25	4.44	2.67	1.67	1.76	0.45
		25-55	2.43	3.06	1.35	2.14	0.41
		55-90	3.06	4.90	1.88	1.55	0.28
		90-130	4.46	2.70	1.68	2.15	0.30
	2	0-30	1.63	1.08	0.65	4.12	0.51
		30-60	3.20	4.37	1.85	1.81	0.46
		60-105	8.10	12.37	4.90	2.71	0.75
		105-120	65.00	3.42	3.25	3.67	0.91
Wadi terraces	6	0-10	4.87	3.22	1.94	2.51	0.65
		10--35	26.69	18.26	10.84	1.29	0.30
		35-70	18.81	2.58	2.27	0.80	0.15
		70-130	35.46	21.95	13.56	0.89	0.20
	7	0-15	9.48	6.96	4.01	1.44	0.34
		15-35	12.62	6.79	4.42	1.69	0.52
		35-75	14.87	8.92	5.58	2.99	0.54
		75-105	43.20	11.37	9.00	2.66	0.91
Mid-stream wadi course	9	0-8	3.30	2.82	1.52	0.62	0.22
		8--24	7.49	3.23	2.26	0.76	0.31
		24-46	4.14	1.79	1.25	2.14	0.72
	10	0-27	8.03	3.57	2.47	0.81	0.40
		27-45	8.16	3.83	2.61	0.82	0.40
		45-55	9.15	4.68	3.10	1.36	0.48
Piedmont plain	11	0-20	9.56	1.83	1.54	9.42	2.18
		20-45	5.76	1.64	1.27	2.51	0.79
		45-80	4.56	1.47	1.11	5.73	1.69
		80-115	4.63	1.52	1.15	2.75	1.04
	13	0-25	2.96	1.27	0.89	1.95	0.72
		25-40	3.85	2.29	1.44	2.52	1.17
		40-75	4.20	1.16	0.91	3.23	0.87

Wr1 = (Pyroxenes + Amphiboles) / (Zircon + Tourmaline).
Wr2 = Horn /(Zircon + Tourmaline).
Wr3 = Biotite / (Zircon + Tourmaline).

Z = Zircon
T = Tourmaline
R = Rutile



Where, soils having higher rations indicate superiority of pyroxenes and amphiboles vs. resistant minerals including zircon, rutile and tourmaline.

Profiles Nos. 6 and 7 representing wadi terraces and Profiles Nos. 11 and 13 representing piedmont soils are expressing a similar manner. Weathering ratios are higher at the surface of profile 6 and 11 while being higher in contrast at the deepest layers of profile 7 and 13, with irregular increments. Mid-stream wadi course soils convey different pattern, where weathering ratios have the highest values at bottom layers. An explanation of this could be driven on the premise that pyroboles (pyroxenes and amphiboles) constitute higher content of the mineral assemblage of sub-surface soils. Meanwhile, zircon, rutile and tourmaline are relatively of lower content.

In general, higher value of weathering ratios could be due to the possible contamination with other sediments of different origin-enriched in pyroxenes and amphiboles. On the other hand, low values of Wr1, Wr2 and Wr3 may be connected to inheritance from parent materials enriched originally in resistant minerals like zircon, rutile and tourmaline.

Quantities as well as vertical distribution of the resistant minerals are used as indication of parent material origin and degree of soil development. Fig. (1) present the distribution of total resistant minerals with depth in the studied soil profiles. Resistant minerals of bajada soils (profiles 1 & 2) were about 13-23% with altering increase or decrease of their concentrations with depth, which indicate irregular variation manner between topsoil and sub-surface layers. Terraces soils show an obvious contrast between included profiles (profile 6 & 7) with general heterogeneity status. Their resistant minerals varied between 12-28% with steady slightly decreases in depth (profile 6) or aggressively increase at soil surface and sub-surface layers followed by moderate decreasing towards the bottom.

With regard to soils of wadi course, they show general decreasing of resistant minerals with depth within wide range from 13-41%. Resistant minerals quantity at the surface layer of profile No. 9 is 32% decreasing slightly in subsoil to 25% and sharply to about 13% in the deepest layer. Concerning soils of piedmont (profile 11) they have 7% of resistant minerals in the surface layer as the lowest value among studied soils; followed by moderate increases as 13% and 22% at sub- surface and deepest layers, respectively. However, they have 7-25% of resistant minerals for all representative profile. Generally, low contents of resistant minerals in some layers may indicate soil formation during recent periods from alluvium sediments, whereas, soils having high contents of resistant minerals indicate soil derivation from Pre-Cambrian – Upper cretaceous sources. Moreover, gained date show that there is apparent discontinuity or a type of stratification for the sediments of Al-Queh wadi, associated to the assumption that different origins and ages contribute in soil formation.

In conclusion, it is quite clear that the soils under study at wadi Al-Queh represent an apparent discontinuity or a type of irregular interstratifications due to geogenetic weathering, mostly related to a multi-origin and/or multi depositional regime. Results illustrate how most of soils under study have a state of stratification and heterogeneity of their parent materials.

Obtained distribution data of analyzed minerals exhibit a pattern mostly inherited from the parent material and partially was modified by the environments prevailing during transportation and sedimentation. Furthermore, the main action of water agent dominated the watershed system of the area under consideration play a key control of most sediments degradation or aggregation.

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الملخص العربى

أصل وتجانس التربة بوادى القويح، القُصير، ساحل البحر الأحمر، مصر

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تعد أراضى إقليم ساحل البحر الأحمر والتى تنتمى للمشروع القومى "المثلث الذهبى" من المناطق الواعدة والتى أدرجت مؤخرا من قبل الدولة ضمن خطة التنمية الزراعية بالصحراء الشرقية. أختير وادى القويح فى الدراسة الحالية والذى يقع شمال مدينة القصير بحوالى ٣٢ كم كأحد أهم أحواض المجارى المائية والتى تنحدر فى إتجاة الشرق من سلاسل جبال البحر الأحمر نحو الساحل، والذى يزخر بإمكانياته المائية والأرضية. وتهدف الدراسة إلى تقييم أصل ودرجة تطور الأراضى بوادى القويح بناءا على الدراسات المعدنية.

تم تحديد أربعة أشكال جيومورفولوجية بالمنطقة وهى سهل البهادا، المصاطب النهرية، المجرى الأوسط للوادى، السهل البدمونتى(التحاتى)، تم تمثيلها بعدد ٨ قطاعات أرضية تم تحديد إحداثياتها الجغرافية لتشمل كافة الإختلافات الطبوغرافية للأشكال الأرضية بمنطقة الدراسة. الدراسة الحقلية شملت وصف المنطقة Landscape وصفا مورفولوجياً والتعرف على العوامل النشطة لتكوين الأراضى، بالاضافة إلى حفر القطاعات الأرضية عند المواقع الممثلة للوحدات الأرضية المختلفة ووصفها وصفاً مورفوبيدولوجياً، مع تجميع عينات التربة بإجمالى عدد ٢٩ عينة لتمثيل للتتابع الطبقى للقطاعات المدروسة تمهيداً للتحليل المعملى. ولدراسة تطور قطاع التربة من خلال التعرف على مواد الأصل التى تكونت ونشأت منها أراضى وادى القويح، تم إجراء التحليل المعدنى لآفاق القطاعات الارضية الممثلة من خلال تحديد التوزيع الحجمى للحبيبات Particle size distribution وفصل مكون الرمل الناعم (٠.٢٥– ٠.٠٦٣ مم) وتقدير المعادن الثقيلة والخفيفة light and heavy minerals بواسطة الفحص الميكروسكوبى. إشتملت الدراسة على تحديد العلاقة بين مجاميع المعادن الثقيلة Heavy minerals من خلال حساب نسب التجانس Uniformity ratios بين المعادن المقاومة للتجوية Weathering resistant minerals وهى: الزركون والتورمالين Zr/T ، والزركون والروتيل Zr/R ، وكذا الزركون إلى الروتيل والتورمالين Zr/R+T كمقياس لمدى تجانس مادة الأصل بالإضافة إلى حساب نسب المعادن الثقيلة المقاومة للتجوية إلى الغير مقاومة Weathering ratios كمعيار لتجانس وتطور القطاع الأرضى.

أكدت نتائج الدراسة على سيادة معدن الكوارتز بنسبة تراوحت بين ٨٩.١٥–٩٨.٨٥٪ من إجمالى المعادن الخفيفة. وتراوحت نسب المعادن المعتمة بين ٣٧.٧٥–٧١.٢٥٪ من إجمالى المعادن الثقيلة. ودلل توزيع نسب المعادن الثقيلة الشفافة على مشاركة كل من الصخور النارية(قاعدية وحامضية) والرسوبية والمتحولة فى تكوين تربة منطقة الدراسة، والتى تمثلت فى العموم من صخور الحجر الرملى النوبى، الحجر الجيرى، الكنجلوميرات، البريشيا، الجرانيت، البازلت، النيس، وذلك خلال الأزمنة الثلاثى والرباعى والحديث. أوضحت الدراسة غياب التجانس فى توزيع نسب التجانس والتعرية تماما مع العمق بكافة قطاعات التربة موضع الدراسة مما أكد على أن التربة ضعيفة التصنيف والتطور قد تكونت فى الغالب من مواد أصل متعددة فى ظل ظروف ترسيب بيئية متباينة. وأشارت الدراسة على أن المياة هى العامل المؤثر فى تجوية ونقل وإرساب الفتات الصخرى بالمنطقة لتكوين أراضى وادى القويح الغير متجانسة فى أصولها والغير منتظمة فى تكوين طبقات قطاعاتها والمتباينة فى نظم ترسيبها.