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SEDIMENTOLOGICAL AND MINERALOGICAL SIGNATURE OF WADI EL GEMAL BEACH SEDIMENTS, SOUTHEASTERN DESERT, EGYPT.

A.F. EL HADARY
Nuclear Materials Authority, P.O. Box: 530 El Maadi, Cairo, Egypt.

ABSTRACT

Wadi El Gemal district is located at the southeastern Desert extending for about 30 km and between Latitude 24° 32′ 21" - 24° 41′ 00" and Longitudes 34° 45′ 00" – 35° 07′ 00". The width of Wadi El Gemal opening ranges from one kilometer to 1.5 kilometer. Thirteen spot samples were collected from the back shore area. The grain size ranges from 1.73 to 2.7ϕ, where the grain size increases from south to north. Sorting ranges between 0.33 and 0.53ϕ indicating very well to well sorted sediments. These sediments are reworked for long time with sufficient energy to yield well sorted sediments. The light minerals consist mainly of quartz (37 – 71%). The heavy minerals represented by amphiboles, pyroxenes, with contents range between 26.74% and 48.72%. Epodit, Kyanite, sturolite represent the less common minerals, while minerals as; zircon, rutile, garnet, monazite, sphene and opaque minerals are also encountered. Opaque minerals include magnetite, hematite, goethite, ilmenite and their alteration product, leucoxene. Magnetite has content ranges between 0.31% and 5.54. The ilmenite content ranges between 0.97% and 9.68%. Hematite and goethite present with content ranges between 0.02% and 0.46%. The frequency of zircon in the studied samples ranges between 0.05% and 0.62%. Rutile abundance reaches 0.24%. Leucoxene content ranges between 0.04% and 0.56%. Garnet frquency ranges between 0.05% and 0.95%. Monazite and sphene are very rare in some samples. Mineral chemistry of heavy minerals suggest they were derived from intrusive granitoidic, granitic gneisses and psammitic gneisses origin which are extensively present in Wadi El Gemal tributaries as Wadi Hanglaliya, Wadi Nugrus, Wadi Skiat and Wadi Abu Rushied.

INTRODUCTION

Wadi El Gemal district is located at the South Eastern Desert, extending for about 30 km between the Latitudes 24° 32′ 21"- 24° 45′ 00" and the Longitudes 34° 41′ 00" – 35° 07′ 00". The area is covered by a high to moderate mountains, with rugged topography characteristic of arid and semi arid regions. The temperature in summer ranges from a mean of 12° C at night to more than 45° C day time. Humidity is generally low but increases eastward near the Red Sea coast. Vegetation is generally sparse and rain fall precipitation is very low expect for certain periods, where short but heavy rains from torrents that last for hours to one day. Low water output to the sea leads to decrease the sediments quantity transported to the beach. Wadi El Gemal opening takes delta shape, with about 1.5 km width. The slop in this part is high gradient, reaches 26°. During flash flood, the great slop permits a large volume of sediments to be carried towards the sea. The introduced sediments to the sea help in building Ras Baghdady head. The coastal plain of this area is wide reaching one kilometer at Ras Baghdady and decrease southward to about 200 meters. The coastal plain rises from 3 to 9 m above sea level. It is composed mainly from gravels and sand. The objectives of this paper are to study the sedimentological and mineralogical characteristics of Wadi El Gemal beach sediments.

Wadi El Gemal is composed essentially of basement complexes of igneous and metamorohic rocks dissected by many wadies filled with Quaternary sediments. Some tributaries of Wadi El Gemal are of special importance, such as Wadi Hanglaliya, Wadi Nugrus, Wadi Sikiat and Wadi Abu Rushied. These wadies are a part of the dry drainage system which represents one of the predominant wadies in the Eastern Desert drainage to the Red Sea (Fig. 1).

The psammitic *gneisses* represent the oldest exposure in the area, schists overly concordantly the psammitic *gneisses*. Granitic *gneisses* is conformably overlies the schist. They are also dissected by post granitic pegmatite veins. Basic dikes with different thicknesses are frequently present. Pigmatitic veins of different width cutting all the previous rocks in Wadi El Gemal district (El Shazly & Hassan, 1972). Mineralogical and genetic studies of Wadi Hangaliya area which is one of the most famous occurrences of gold in Egypt, that were carried out by Osman (1989), Khalil and Helba (1998), Surour et al. (1999, 2002) and El Feky (2000). Radiometric and mineralogical investigations of Wadi Abu Rshied were carried out by Abdel Aziz, et al (1967), Hassan, (1964, 1972), Abdel Momem and Harly (1979), Ibrahim et al. (2000), El Ramly et al. (1984), Eid (1986), El Gemmizi (1984) and Hassan and El Gimmizi (1985), where uranium secondary minerals were recorded.

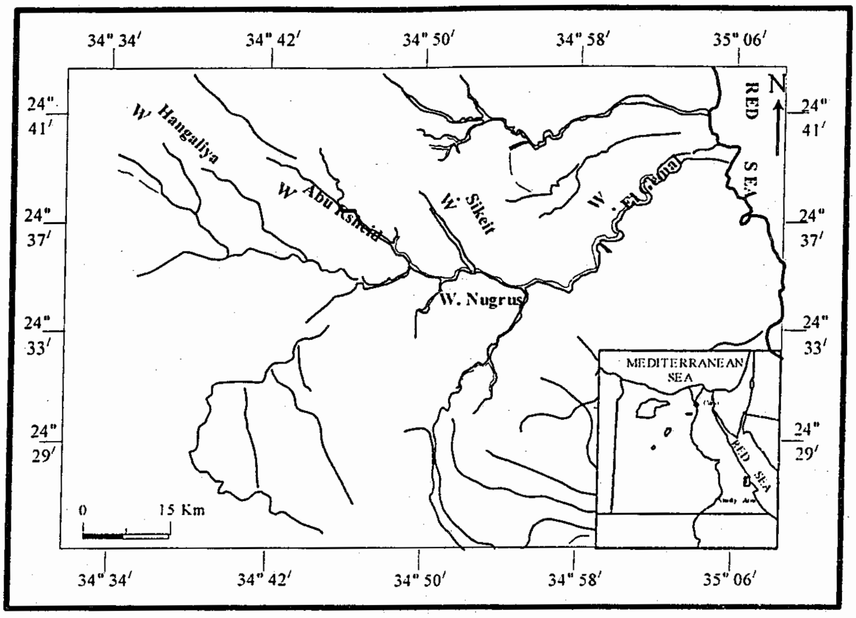


Fig. (1) Location map showing W. El Gemal and its tributaries.

MATERIALS AND TECHNIQUES

Thirteen spot samples at depth of 50 cm, were collected from the backshore area. The samples were taken at about 200 m interval from southwest to northeast respectively, at the southern part of Ras Baghdady (Fig. 2). Each samples weighing about 15 kg. The samples homogenized and quartered using Jhon's Splitter. A representative samples of about 70 gm were subjected to dry sieving analysis. Bromoform and Mthylene Iodide were used to separate the heavy and light fractions. Magnetite contents were separated from the heavy fraction by a hand magnet and the rest of the heavy fraction magnetically fractionated using isodynamic separator at 0.2,0.5,1.0 and 1.5amp. Microscopic examination and counting of the heavy minerals were carried out and the percentages of heavy mineral constituents were determined. The Scanning Microscope (SEM) was used in mineralogical investigation.

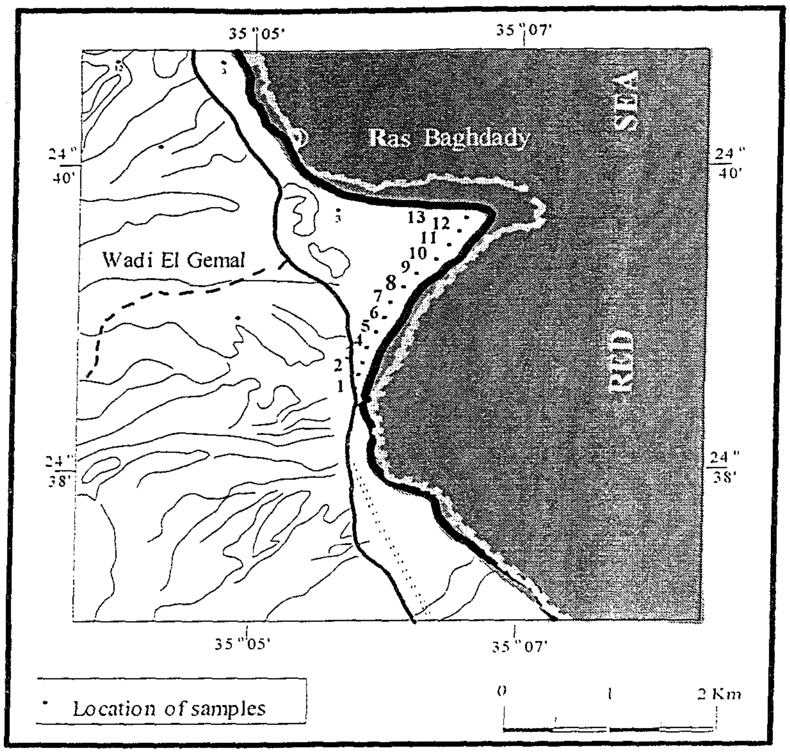


Fig. (2): Map showing location of samples in the study area.

GRAIN SIZE DISTRIBUTION

The grain size distribution was carried out on the collected samples to elucidate the sedimentological processes as transportation and depositional environment. A representative sand sample weights about 70 gm was exposed to dry sieving. The four statistical sedimentological parameters includes the Graphic Mean (Mz), the Inclusive Graphic Standard Deviation (σ_I), the Inclusive Graphic Skewness (Sk_I) and the Graphic Kurtosis (K_G) were calculated (Table, 1). Consequently, it is clear that the studied samples have medium to fine sand grains where M_Z ranges from 1.73 to 2.7ϕ. The sorting ranges between 0.33 and 0.53ϕ indicating very well to well sorted sediments according to Folk and Ward (1957). All samples are platykurtic, where K_G values ranges from 0.2 to 0.44ϕ. The samples have SK_I values between 0.08 and -0.18ϕ, where most of the samples are nearly symmetrical.

The obtained grain size parameters revealed that, these sediments are reworked for long time and transported for long distance in a medium with sufficient energy to yield well sorted sediments (Friedman and Sander, 1978). Grain size distribution along the beach shows general decrease from south to the north. It suggests that these sediments were drifted northward under beach condition (Fig. 3a). The same conclusion could be obtained through Friedman binary diagrams (1961 and 1967). The binary diagrams Mz-Sk_I and σ_I-Sk_I (Fig. 3b and 3c) indicate beach depositional environment. Also C-M diagram proposed by Passega and Byramjee (1969) shows that; these sediments were deposited as rolling and graded suspension in moderate energy medium, Fig. (3d).

MINERALOGY

The study of the heavy minerals gives an indication about their source rocks and the environmental conditions prevailed during their deposition. The heavy and light minerals were examined by Binocular microscope. Frequencies of different minerals were estimated in Table (2). Individual grains of heavy minerals were subjected to Back Scattered Electron (BSE) using the Scanning Electron Microscope. The identified heavy mineral assemblages in the investigated samples can be classified into two main groups. The first group is the opaque iron minerals as; magnetite, ilmenite, hematite, geothite and leucoxene. The non-opaque group includes biotite, pyroxenes, hornblend, epidot, garnet, dolomite, zircon, monazite and rutile.

Light Minerals

Minerals of the light sand fraction consist mainly of quartz and different feldspars minerals (37 – 71%) that are accompanied with less frequent rock fragments and feldspars. Quartz is represented by mono-crystalline grains that are usually rounded to subrounded and less commonly subangular grains. The feldspars are represented by both altered perthitic potash feldspares and sodic plagioclase. Some carbonates uncommonly occur in the light fraction.

Table (1): Statistical parameters of studied samples.

S.No	Mz	Sorting	Sk_I	K_G	S.No	Mz	Sorting	Sk_I	K_G
1	1.73	0.33	0.03	0.20	8	2.44	0.50	-0.11	0.44
2	2.34	0.40	-0.09	0.29	9	2.66	0.39	0.05	0.30
3	2.33	0.53	-0.05	0.44	10	2.46	0.44	0.18	0.36
4	2.45	0.46	-0.09	0.38	11	2.54	0.46	-0.04	0.37
5	2.58	0.43	-0.06	0.35	12	2.55	0.47	-0.09	0.38
6	2.50	0.46	-0.03	0.39	13	2.69	0.43	-0.18	0.34
7	2.70	0.38	0.08	0.26					

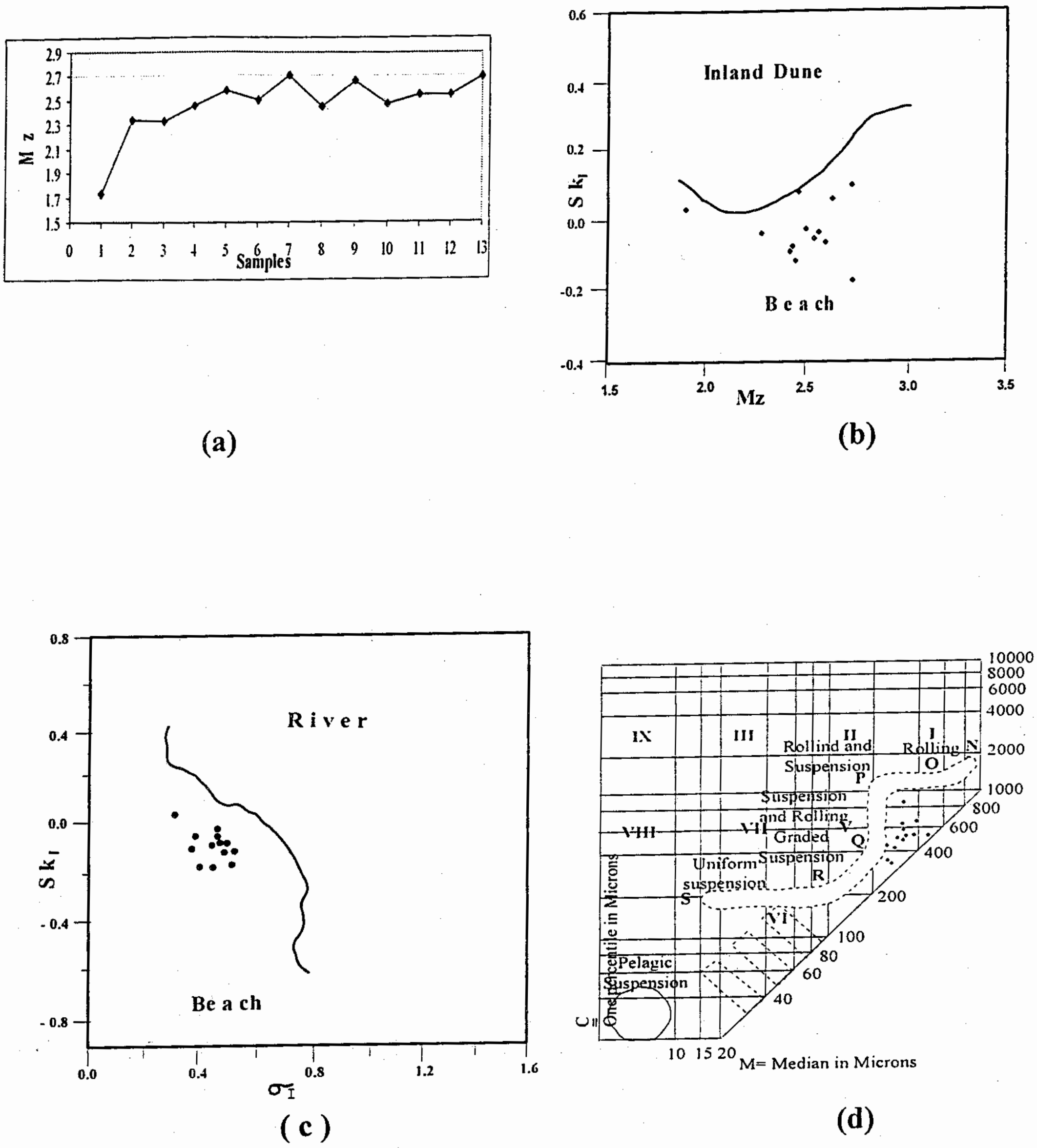


Fig. (3): Showing; a) Distribution of Mz along the shore line from south to north, b) Mz-Sk_I relation. C) σ_I- Sk_I relation. d) C-M diagram of studies samples.

Heavy Minerals

The heavy minerals fraction presents in the studied samples are represented mainly by amphiboles, pyroxenes, according to decreasing order of abundance. Also epodit, Kyanite, sturolite represent the less common minerals, while minerals as; zircon, rutile, garnet, monazite and opaque minerals are also encountered. Opaque minerals include magnetite, hematite, goethite, ilmenite and its alteration product "leucoxene" (Table, 2).

The distribution of amphiboles and pyroxenes among heavy fraction ranges between 26.74% and 48.72% with an average of 36.03%. The pyroxenes are mainly represented by clinopyroxenes especially diopside and augite. They form subrounded to subangular shape, fine to very fine grains. Their color varies from dark green to yellowish green. Hornblend is the most predominant amphibole mineral. It forms subroundd to subangular platy grains and characterized by its brown color. Biotite forms subangular to subrounded grains of dark brown color, with fine to very fine size. Epidot, kyanite and sturolite represent about 1.43% of the sediment. Magnetite content ranges between 0.31% and 5.54% with average 2.27%. Ilmenite frequency ranges between 0.97% and 9.68% with average 5.64%. Hematite and goethite content ranges between 0.02% and 0.46% with average 0.13%. The frequency of zircon ranges between 0.05% and 0.62% with average 0.28%. Rutile abundance reaches 0.24%, where it is absent in some samples, while leucoxene content ranges between 0.04% and 0.56% with an average 0.22%. Garnet frequency ranges between 0.05% and 0.95% with average 0.41%. The average content of economic heavy minerals in the studied sediments is 5.63%, which is economically promising comparing to the black sand of the northern delta beach. The economic heavy minerals content in the different areas of black sand deposits range between 1.76% and 4.54% in Rashied and El Burullus areas respectively (Dabbour, 1995, EL Hadary, 1998 and Bakhit, 2004). But the present work area needs more detailed study to evaluate its economic potentiality.

The content of the total economic heavy minerals along the shoreline (Fig. 4), at meddle and northern part (in the vicinity of the wadi opining) is higher than the southern part. This revealed that the main controlling factor of the heavy minerals content is controlled by the input minerals from Wadi El Gemal.

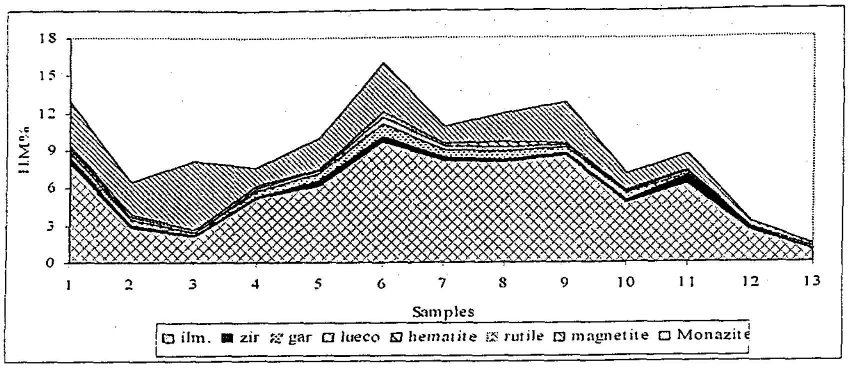


Fig. (4) Distribution of heavy minerals along the beach.

Table (2): Minerals percentages among studied samples.

S.No	Mgt.	Ilm.	Zir.	Gar.	Lue.	Hema.	Rut.	Mgt.	Mon.	Epidt.	Kya.	Stur.	Amph& Pyro.	Qz & Feld
1	3.44	8.05	0.44	0.42	0.34	0.14	0.10	3.44	0.001	0.79	0.34	0.75	47.71	37.4
2	2.52	2.85	0.28	0.39	0.16	0.17	0.15	2.52	0	0.37	0.25	0.77	45.80	46
3	5.54	2.12	0.09	0.17	0.13	0.04	0.05	5.54	0.0005	0.25	0.01	0.10	48.72	42.[illegible]
4	1.43	5.15	0.17	0.34	0.22	0.20	0.11	1.43	0.0003	0.88	0.49	0.49	28.30	62
5	2.46	6.20	0.40	0.51	0.27	0.05	0.06	2.46	0.0001	0.70	0.65	0.34	39.90	48.[illegible]
6	3.89	9.68	0.43	0.95	0.56	0.25	0.24	3.89	0.001	0.86	0.83	0.67	37.00	44.[illegible]
7	1.33	8.14	0.35	0.52	0.29	0.13	0.06	1.33	0	0.75	0.66	0.15	36.74	50.[illegible]
8	2.32	8.00	0.20	0.73	0.30	0.46	0.00	2.32	0.0002	0.51	0.07	0.20	30.02	57.[illegible]
9	3.28	8.52	0.29	0.43	0.23	0.05	0.06	3.28	0	0.74	0.23	0.50	27.54	58.[illegible]
10	1.29	4.87	0.18	0.55	0.15	0.09	0.00	1.29	0	0.67	0.75	0.57	30.00	61.[illegible]
11	1.32	6.26	0.62	0.13	0.22	0.08	0.03	1.32	0.001	0.33	0.64	0.13	32.26	57.[illegible]
12	0.45	2.53	0.08	0.10	0.04	0.08	0.00	0.45	0	0.06	0.12	0.02	37.64	58.[illegible]
13	0.31	0.97	0.05	0.05	0.05	0.02	0.01	0.31	0.0002	0.47	0.12	0.16	26.74	71.[illegible]

Mgt.: Magnetite, Ilm.: Ilmenite, Zir.: Zircon, Gar.: Garnet, Leuc.: Leucoxene, Hema.: Hematite, Rut.: Rutile, Mon.: Monazite Epi.: Epidote Kya.: Kyanite Stur.: Sturolite, Amph: Amphiboles Pyro.: Pyroxene Qz: Quartz, Felds: Feldspare

Binocular microscope and the Scanning Electron Microscope investigation revealed that. the black minerals such as magnetite, ilmenite and geothite consist mainly of fine size with subangular to subrounded grains. Garnet and leucoxene present in medium to fine size with angular to subrounded grains, while zircon and rutile have very fine size.

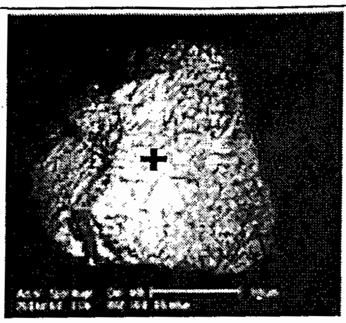
Magnetite

Magnetite has the inverse spinel structure. It occurs naturally as solid solution with many spinel components (Lindsley, 1991). It occurs in the studied samples as angular to subangular, fine grains. The Semi quantitative analyses (EDX) shows tiny microgrooves are common (Fig. 5a). It occurs in sets along dislocation sites (Clemett, et al 2002). Because dislocations can provide fast pathways for exchange that enhance diffusion, especially in very slowly cooled rocks (Sitzman, et al, 2000). Chemical composition of the studied grain shows high iron content with low TiO_2, Cr_2O_3. The low content of chromium, titanium and vanadium suggest intrusive granitoidic origin (Lyakhovich and Lyakhovich, 1983).

Ilmenite

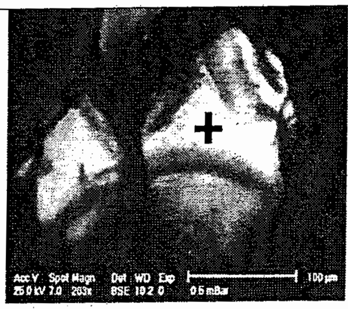
Ilmenite represents the most frequent mineral relative to the heavy economic minerals in the studied sediments. It is rounded to sub-angular black grains with its characteristic purple sub-metallic luster. Two populations of grains are present, where some grains are ferrian ilmenite and others are hydrated, according to Ti/ (Ti + Fe) ratio suggested by Frost et al., (1988). The alteration is low in ferrian ilmenite stage, where the ratio is less than 0.5. The ferrian ilmenite grains are well rounded to ellipsoid shape with smooth surface. These grains are rich in iron content and experienced only slight oxidation and dissolution on grain surfaces, and they persist through the weathering profile (Fig, 5b). Hydrated ilmenite reflects somewhat greater extent of alteration, where different stages of alteration are present in the same grains. Semi quantitative analyses (EDX) of altered ilmenite grain (Fig., 5c) show four zones of alteration. Two set of fractures appear in the core along (1000) plain. The ferran rutile filling these fractures has Fe_2O_3 is about 31.92 and TiO_2 is 59.42. The different zones of ilmenite grain show increase of iron content from the core toward the outer zone. It is proposed two-step reaction mechanism that ilmenite first undergoes a solid-state transformation to pseudorutile via an anodic oxidation mechanism (Paul et al., 2002).

TiO_2	2.82
Fe_2O_3	90.99
SiO2	2.64
Al_2O_3	1.63
CaO	0.21
MnO	0.61
KO_2	0.28
Cr_2O_3	0.15
MgO	0.68



(a)

MgO	0.13
SiO_2	1.47
SO_3	0.08
Cl_2O	0.10
CaO	0.71
TiO_2	42.76
MnO	9.51
Fe_2O_3	45.23



(b)

	Frac. filling	Core	2nd zone	3rd zone	Outer zone
MgO	2.76	0.22	1.31	2.94	5.22
SiO_2	3.87	0.97	1.81	2.9	4.88
CaO	0.27	0.12	0.19	0.17	0.29
TiO_2	59.42	48.16	42.6	18.89	12.81
MnO	1.38	2.72	2.31	1.2	0.61
Fe_2O_3	31.92	47.82	51.78	73.91	76.19
NiO	0.37	----	----	----	----

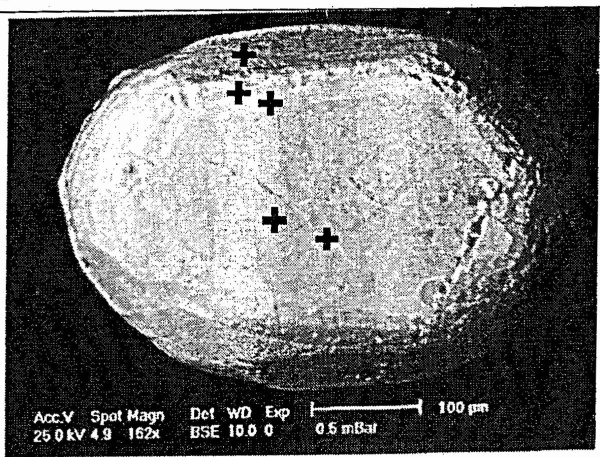


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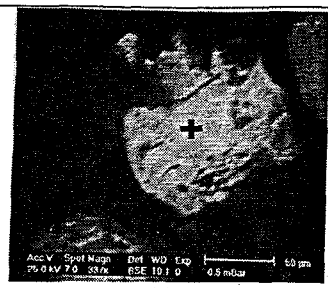
Fig.(5): BES image and chemical composition of a) magnetite b) ferran ilmenite and c) different zones of altered ilmenite.

Hematite and Goethite

Hematite has the trigonal oxid structure forming partial to complete solid solution with other oxides as corundum (Al2O3). eskolaite (Cr2O3) and karelianite (V2O3) (Waychunas 1991), while goethite is the alteration product of hematite. The The Semi quantitative analyses (EDX) show the chemical composition of hematite (Fig. 6a) and goethite (Fig.6b) where Ti, Mn and Th present in hematite and not detected in goethite. They may be leached during hydration processes of hematite to geothite.

	(a)	(b)
SiO2	3.9	4.61
Fe2O3	92.99	92.97
CaO	0.71	0.39
TiO2	1.27	---
MnO	0.36	---
ThO	0.30	---
MgO	---	0.7
Al2O3	---	1.33


(a)

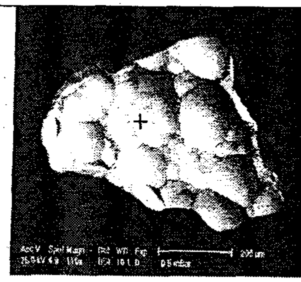

(b)

Fig.(6): BES image and chemical composition of a) hematite and b) Goethite.

Zircon

The zircon grains in the studied samples are concentrated mainly in the very fine size classes. Two types of zircon are present, first one is small short non-presmatic bipyramidal mud type zircon (Fig. 7a) which were recorded previously in Wadi Nugrus (El Gemmizi, 1984), and the second type is prismatic, colorless, yellow and purple with inclusions (Fig. 7b, c, d). Zircon is considered as a "closed system" able to preserve the internal geochemical composition in terms of the source region and evolutionary history of its parent rock (Pidgeon, et al., 1996).

The average (Zr/Hf) ratios in zircon from sedimentary and metasedimentary rocks on one hand and in granitods on the other are extremely similar at 36.3 and 37.3 correspondingly, while the least Hf content occurs in ultrabasic rocks, for instance, (Zr/Hf) = 49.6 in volcanic rocks, and from 55.7 to 76 in basic and ultrabasic rocks (Lyakhvich & Vishnevskiy 1990). Thus, the (Zr/Hf) ratio is a principal indicator of mgmatic differentiation. The Zr and Hf relation is very concomitantly with REEs in response to the genetic geochemical controls of the igneous environment (Younan and El Hadary 2002). Generally, hafnium content increases with the differentiation trend of their igneous parents (Eliwa, et al, 2000). Th/U ratio in zircon is sometimes used to distinguish the origin of zircon, where in igneous rocks it ranges from 0.5 to 1.0, while zircons grown under metamorphic events show lower Th/U (<0.1) (Kinney et al., 1990).

The Semi quantitative analyses (EDX) of the studied zircon grains shows that ZrO_2 range from 56.11 to 67.15% while Hf_2O_3, ranges from 0.94 to 2.22 %. Zr/Hf ratio ranges from 25.86 to 61.66 in different studied grains, indicating ultabasic and granitic origin. ThO_2 and UO_2 content are low reaches up to 0.39 %

and to 0.52% respectively, where the two elements were undedicated in some grains. Th/U ratios of the studied grains range reaches up to 0.75 which indicate the igneous origin.

	(a)	(b)	(c)	(d)
Al_2O_3	----	1.72	2.0	6.46
SiO_2	35.5	27.2	33.1	15.6
Cl_2O	---	0.17	0.08	---
ThO_2	0.27	---	0.39	---
UO_2	0.13	---	0.52	---
K_2O	---	0.18	0.08	2.02
CaO	0.49	2.31	1.32	30.2
Hf_2O_3	1.6	1.27	2.22	---
ZrO_2	61.6	67.1	60.26	18.8
TiO_2	0.27	---	---	0.88
P_2O_5	---	---	---	25.0
Fe_2O_3	---	---	---	1.08

(a) (b&c) (d)

Fig.(7): BES image and chemical composition of zircon: a) Muddy zircon b) Zircon with inclusion, c) Older zircon inclusion and d) apatite inclusion.

Rutile

Rutile is rarely present in the studied samples as very fine prismatic to rounded grains with yellowish brown to deep red color. Rutile is the most dense, high temperature, high pressure polymorph that occurs in both igneous and metamorphic rocks (Haggerty, 1983a). Niobium which may be a major constituent of rutile is not generally abundant in rutile from low pressure environments as cordierite-anthophyllite-garnet gneisses (Dymek, 1983).

Chemical composition of studied rutile grains shows relative high content of Al, P and low Hf and Ca which indicate metamorphic origin (Fig. 8a). It may be derived from schist and psammitic gnesis.

Leucoxene

Leucoxene is the transitional phase during the alteration of ilmenite to the secondary rutile. It is characterized by rough-pitted surface. In the leucoxenation process the ilmenite structure is destroyed and iron ions migrate outside (Dabbour, 1997). Leucoxene is present as fine, rounded grains with yellowish brown to yellowish white. The EDX (Fig. 8b) shows the chemical composition of leucoxene, where TiO_2 content is more than in ilmenite and less than in rutile (Dabbour, 1997). REEs appear as a considerable constituent in the studied grains.

	(a)	(b)
Al2O3	2.4	0.92
SiO2	3.1	4.28
CaO	1.1	0.12
TiO2	90.5	80.1
La2O3	---	6.45
Sm2O3	---	0.06
Nd2O3	---	0.60
Eu2O3	---	1.18
Fe2O3	---	6.44
P2O5	2.7	---
K2O	0.2	---

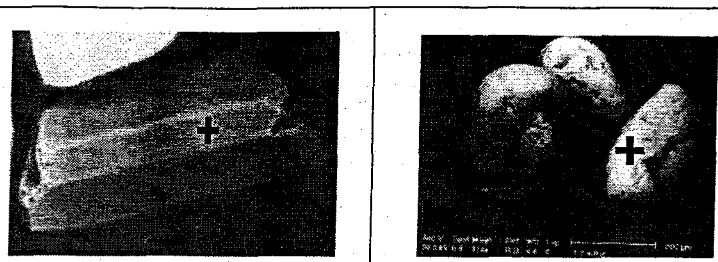


FIG.(8): BES IMAGE AND CHEMICAL COMPOSITION OF A) RUTILE, B) LEUCOXENE GRAINS

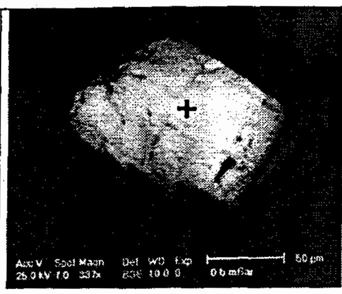
Monazite

Two types of monazite are present; brown angular fragments and rounded small grains with honey yellow colour. It is very rare in some samples and absent in the other samples. The semi-quantitative analysis (EDX) shows the chemical composition of monazite where the main constituent oxides such as P_2O_5, Ce_2O_3 and La_2O_3 are 21.4%, 28.54 % and 15.38 respectively (Fig. 9a). Such monazite grains mostly derived from peraluminous granitoids and gneisses rocks in the area. The LREE-phosphate monazite is widely reported as an accessory mineral in peraluminous granitoids and high-grade metamorphic gneisses (Ayers et al., 1999).

Garnet

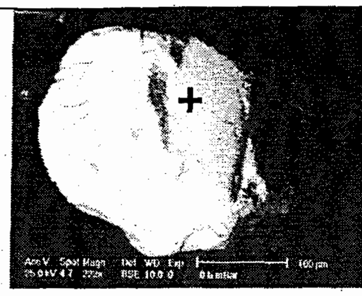
Garnet is a common mineral in metamorphic and high-pressure igneous rocks and a major constituent of the Earth's mantle (Ringwood 1991). Garnet grains in the studied samples are pale pink and colorless varieties with angular to subangular shape. The semi-quantitative analysis (EDX) of garnet grain (Fig. 9b) shows that the average SiO_2 content is 41.63 %, Al_2O_3 is 12.71% and MnO is 0.88 %. It also contains Ca and minor content of Mg and Ti. This composition revealed that, pyrope-almandine-grossular solid-solution is the predominant. The two immiscible garnets can coexist in nature in equilibrium, hence providing a critical constraint for the thermodynamic mixing properties of garnet (Wang, et al 2000, Eric, et al 2000). These garnet grains could be grown in greenschist facies at a pressure of ~20 kbar and above 450°C (Hoisch, et al 2002).

Al_2O_3	0.93
SiO_2	2.98
P_2O_5	21.4
UO_2	1.82
CaO	1.05
La_2O_3	15.38
Ce_2O_3	28.54
Pr_2O_3	3.0
Nd_2O_3	10.61
Sm_2O_3	0.39
Fe_2O_3	0.23
ThO_2	10.01
Y_2O_3	3.67



(a)

MgO	3.66
Al_2O_3	12.71
SiO_2	41.63
K_2O	1.68
CaO	9.85
TiO_2	0.99
MnO	0.88
Fe_2O_3	28.59



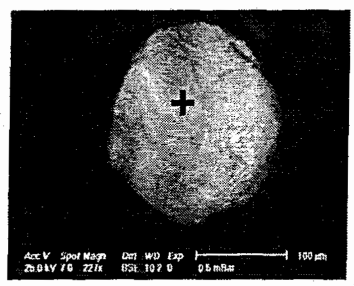
(b)

Fig.(9): BES image and chemical composition a) monazite and b) garnet.

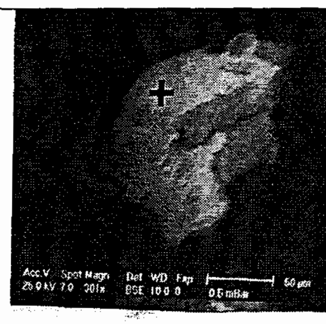
Sphene (Tetanite)

Sephene in Wadi El Gemal beach is very rare, where it identified in one sample only as rounded and angular, brown grains. The semi-quantitative analysis (EDX) of two types (Fig.10 a&b) shows the chemical composition of sphene (titanite), where substitution of Si and Ca by Fe, Cr and K indicating mafic origin of the angular grains (Robinson and Miller, 1999).

	a	b
MgO	1.01	3.64
Al2O3	4.75	6.06
SiO_2	29.38	18.43
Cl_2O	0.17	---
ThO_2	0.85	0.78
CaO	28.56	9.48
TiO_2	32.59	36.10
Fe_2O_3	2.68	22.82
SO_3	---	0.57
K_2O	---	1.02
Cr2O3	---	0.34
MnO	---	0.64



(a)



(b)

Fig.(10): BES image and chemical composition of a) rounded and b) angular sephene .

CONCLUSIONS

1- The grain size studies revealed that, most of these sediments are well sorted where it reworked for a long distance along the beach.
2- The heavy minerals were derived from the nearby area through Wadi El Gemal and its tributaries.
3- The content of total economic heavy minerals along the shoreline is controlled by the input heavy minerals from Wadi El Gemal.
4- The stable minerals only reach the beach, while most of unstable minerals such as uranium minerals, which were recorded in Wadi El Gemal tributaries did not present in the beach sediments. These unstable minerals may be leached or broken down during transportation of these sediments.
5- Economic heavy minerals content in the beach sediments are economically promising, but it needs more detailed study.

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الدلائل الترسيبية والمعدنية للرواسب الشاطئية لوادى الجمال ، جنوب الصحراء الشرقية ، مصر

أحمد فؤاد الحضرى

هيئة المواد النووية ، ص.ب. ٥٣٠ المعادى

يمتاز ساحل وادى الجمال بوجود دلتا يصل عرضها إلى حوالى ١,٥ كم حيث يتكون الساحل من الرمال الشاطئية الناعمة عالية التجانس، وقد تعرضت تلك الرمال للنقل لفترات طويلة ، وترسبت فى بيئة ترسيبية متوسطة القوة ، كما تتواجد بهذه الرمال نسبة كبيرة من المعادن الثقيلة ، وقد أظهرت الدراسة أن تلك الرمال تتكون أساسا من حبيبات معادن الكوارتز والفلسبار بنسبة تتراوح بين ٣٧ و٧١٪ ، أما المعادن الثقيلة فهى عبارة عن معادن الأمفيبول والبيروكسين بنسبة تتراوح بين ٢٦,٧٤ و٤٨,٧٢٪ وكذلك الإبيدوت والكينايت والإشتروليت مع نسب قليلة من الزركون والروتيل والجارنت بنسب تتراوح بين ٠,٠٥ و٠,٦٢٪ للزيركون و٠,٢٤ للروتيل و٠,٠٥ و٠,٩٥٪ للجارنت وبعض المعادن المعتمة مثل الالمنيت والماجنيتيت والهيماتيت والجوثايت والليكوكزين بنسب تتراوح بين ٠,٣١ و٥,٥٤٪ للماجنيتيت و٠,٩٧ و٩,٨٦٪ الالمنيت و٠,٠٢ و٠,٦٤٪ للهيماتيت والجوثايت و٠,٠٤ و٠,٩٥٪ الليكوكزين أما المونازيت والسفيين فيوجدا بصفة نادرة فى بعض العينات. وقد أظهرت التحاليل الكيميائية لحبيبات المعادن الثقيلة أن تلك المعادن قد نتجت عن عمليات تآكل الصخور النارية والمتحولة مثل الجرانيت والنايس المتواجدة فى الوديان المتصلة بوادى الجمال كوادى حنجلالية ووادى أديب ووادى نجروس ووادى سكيت ووادى أبو رشيد .