ISSN 1110-0354
Bull. Nat. Inst. of Oceanogr. & Fish., A.R.E.. 2002. Vol. (28): 367 - 384

STUDIES ON THE PARTICLE SIZE DISTRIBUTION AND BOTH LIGHT AND HEAVY MINERALS OF RECENT SEDIMENTS AT ROSETTA NILE BRANCH (EGYPT)

BY

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Key Words: Sedimentology – Mineralogy – Recent sediments – Rosetta Nile branch

ABSTRACT

The present study deals with the sedimentological and mineralogical investigations of the recent sediments of Rosetta Nile branch, the sediment types change from sand, muddy sand, gravelly sand and gravelly mud to medium fine and very fine sand and muddy sand with variation of depth and location. The sediments represent mostly medium to very fine sand size, well sorted to very poorly sorted, positively to negatively skewed and mostly leptokurtic.

The main minerals present in the sandy size are quartz, feldspar, carbonates and heavy minerals. The distribution vary with location and depth. At Kafr El Zayat and Edfina stations is characterized by the least distinguishing degree of maturity.

The heavy minerals are mainly composed of opaques and then unstable minerals (amphibole and pyroxene). Two associations have been identified as follows: The mixed association (92.59%) and the amphibole-pyroxene association (7.42%). The main source of Rosetta Nile branch sediments is the south Nile sediments. The heavy minerals assemblages appear immature.

INTRODUCTION

The Rosetta Nile branch extends north of El-Khairiya Barrage for about 218 Km along the western boundary of the Nile Delta (Egypt) and it opens finally into Rosetta Estuary through the gates of Edfina Barrage (Fig. 1). It varies in width from 250 to 800 meters with an average of 500 meters. The widest parts lie opposite to Kafr El-Zayat and Dessuq cities. The branch represents a shallow water stream with a depth fluctuating between 4.5 and 16.0 meters in the midstream. The bottom sediments range from sandy-silt in the first half to silty-clay in the northern part (Draz, 1983).

The mineral caposition of the Nile sediments has been discussed (Shukri, 1950; Nakhla, 1959; Zaghloul and Khalel, 1965; Buursink, 1971; El-Massry, 1983; Lotfy, 1997 and Abu El-Enain et al 1997).

The present investigation represents a survey on the regional variation of some physical and mineralogical parameters of the recent Rosetta Nile branch sediments. The work aims to study the sediment type and mineral distribution, to throw some light on bottom lithodynamics the sediment discharge interplay, the heavy mineral associations and the maturity of heavy minerals.

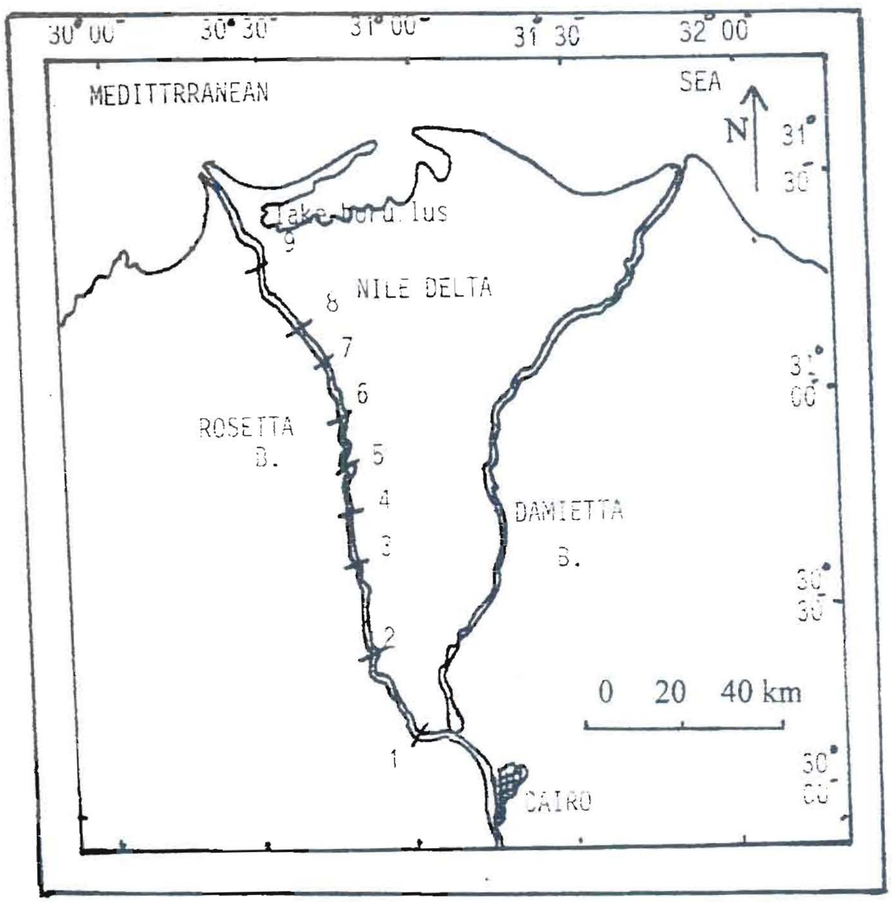


Fig. 1: The Rosetta Nile branch map position of stations

1- Alkanater. 3- El-Khatatba. 5- Kafr El-Zayat.

8- Dessuq. 9- Edfina.

MATERIALS AND METHODS

Sediment samples were collected along a grid profile in order to cover evenly the whole study area. The bottom sediments were collected using a Ekman grab sampler during the period from April to May, 2001.

Nine stations were selected to represent the different habitats (Fig.1). Five samples are collected from each station (Littoral and midstreams sites). Three stations were collected from the beginning of the Rosetta Nile branch at a distance of about 1 Km. north to El-Khairiya Barrage to El-Khatatba City, two from El-Khatatba to Kafr El-Zayat City, Three from Kafr El-Zayat to Dessuq City and one is located just in front of Edfina Barrage.

The samples were subjected to mechanical analysis according to the method described by Folk (1968).

For mineral investigation, very fine sand fractions subjected to heavy minerals separation using bromoform. The light fraction was examined and counted under binocular and transmitted light microscope. The heavy minerals were mounted in canada balsam and counted under the microscope to determine the percent of each heavy mineral. Quantitative determination of the different opaque minerals was carried out using oil immersion under the reflected light.

RESULTS AND DISCUSSION

The data obtained from mechanical analysis showed the percentage of the different fractions and the cummulative percentages. The data are presented on cummulative curves. The average of grain size parameters, mean size (Mz), sorting (δ1), skewness (Sk) and kurtosis (K) are calculated from cummulative curves and given in Table 1 and (Fig. 2).

Mean Size Didribution (Mz):

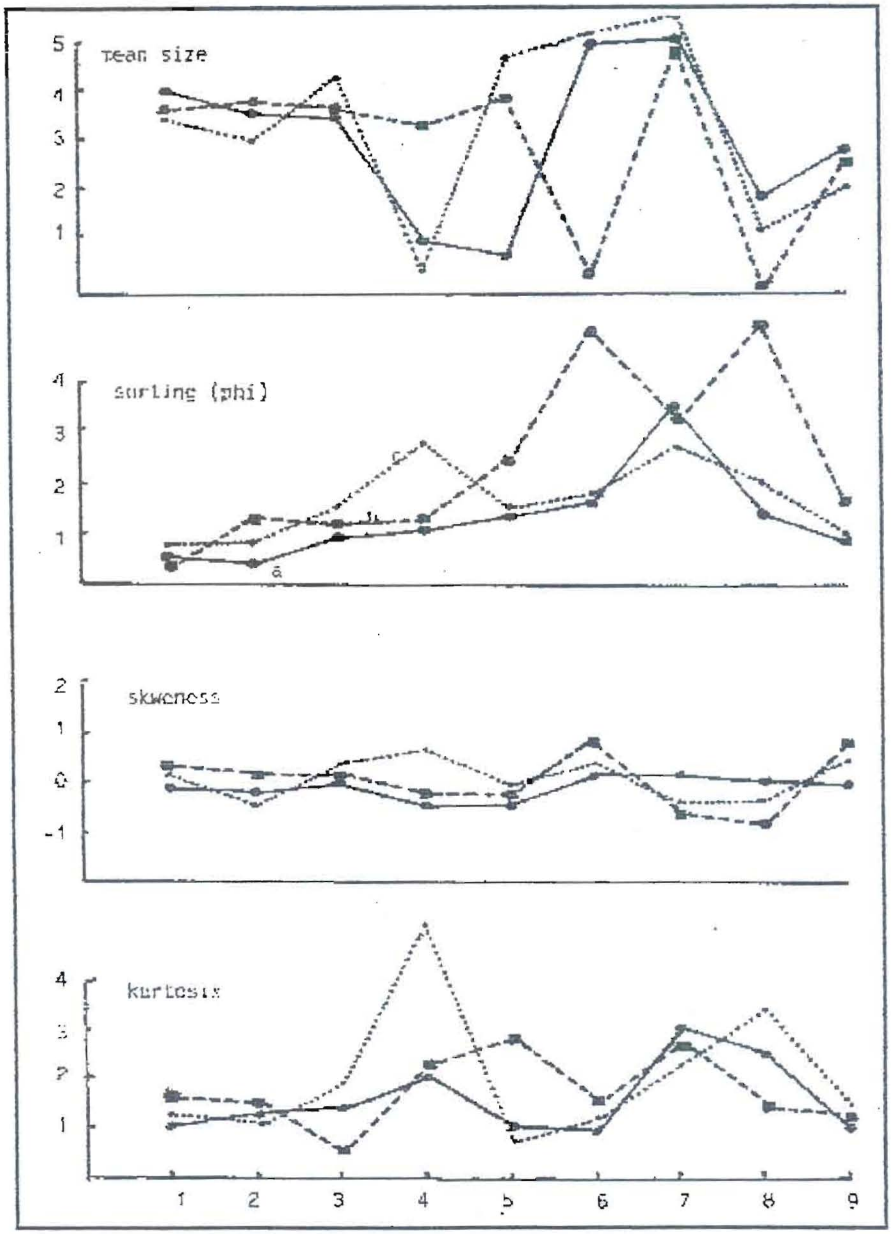
The mean size pattern of Rosetta Nile branch sediments is given in Table (1) and (Fig 2). The average of the mean size of the sediments ranges between 0.27 Φ to 5.13 Φ (i.e. coarse to very fine sediments). According to the distribution of the mean size in the bottom Rosetta Nile branch sediments, at Kafr El-Zayat to Dessuq stations proved to have a very fine sediments, reaching values as high as 5.13 Φ towards the deeper zone. And Edfina station proved to have a very coarse sand size, reaching values as low as 0.27 Φ towards the deep zone, due to the high accumulation of shell fragments.

The gradient of mean size variation in the western and eastern side and middle zone is rather uniform, reaching a minimum valus in the deep zone sediments < 1 m (i.e. coarse sand size) and increasing towards the deep zone (i.e > 1m).

Table (1): percentage of gravel, sand and mud and grain size parameters of Rosetta Nile branch sediments during 2001

Station No.	Water depth	No. of sample	Gravel %	Sand %	Mud %	Type of sediment	Mz		Sk	K
I	<1m	2	—	88.54	11.46	Ms	3.98	0.63	-0.05	1.06
	1-3m	2	—	85.06	14.94	Ms	3.40	0.65	0.03	1.17
	>3m	1	—	87.77	12.23	Ms	3.48	0.55	0.03	1.65
II	<1m	2	0.40	88.48	11.10	Ms	3.50	0.47	-0.06	1.25
	1-3m	2	3.90	90.02	6.08	Ms	2.92	0.83	-0.24	1.13
	>3m	1	0.06	66.95	32.99	Ms	3.50	1.20	0.01	1.45
III	<1m	2	0.40	76.02	23.28	Ms	3.42	0.92	0.08	1.47
	1-3m	2	2.95	52.90	44.14	Ms	4.26	1.54	0.27	1.98
	>3m	1	0.24	76.41	23.39	Ms	3.47	1.02	0.10	0.57
IV	<1m	2	11.66	88.34	—	Gs	0.87	1.16	-0.46	2.03
	1-3m	2	17.09	82.11	0.80	Gs	0.43	2.78	0.75	6.77
	>3m	1	4.64	74.22	21.14	Ms	3.38	1.13	-0.20	2.16
V	<1m	2	12.04	87.66	0.30	Gs	0.63	1.31	-0.20	1.15
	1-3m	2	1.22	43.82	54.96	Sm	4.57	1.36	-0.14	0.88
	>3m	1	10.01	51.82	38.17	Gms	3.82	2.49	-0.18	2.81
VI	<1m	2	1.75	24.65	73.60	Sm	4.90	1.57	0.15	1.00
	1-3m	2	4.07	21.23	74.10	Sm	4.97	1.60	0.20	1.24
	>3m	1	25.09	24.73	50.18	Gms	0.43	6.74	0.73	1.45
VII	<1m	2	6.17	19.70	74.13	Gm	4.98	3.49	0.14	3.04
	1-3m	2	7.53	13.64	78.83	Gm	5.13	2.81	-0.29	2.28
	>3m	1	10.45	28.78	60.77	Gm	4.17	3.42	-0.30	2.67
VIII	<1m	2	6.66	92.22	1.12	S	1.95	1.34	-0.16	2.42
	1-3m	2	12.97	82.71	4.32	Gs	1.13	1.96	-0.38	3.35
	>3m	1	26.78	56.71	16.51	Gms	-0.27	6.01	-0.84	1.45
IX	<1m	2	0.38	97.14	2.48	S	2.83	0.70	-0.18	1.05
	1-3m	2	—	95.72	4.28	S	2.02	0.75	0.24	1.42
	>3m	1	0.28	77.14	22.54	Ms	2.60	0.51	0.50	1.07

G = gravelly g = gravel S = sandy
s = sand M = muddy m = mud



Stations

Fig (2) : Relative frequencies of the grain size fractions of the Rosetta Nile branch sediments.

depth a = < 1m b= 1-3m c=> 3m

From Table (1) and (Fig. 2), the mean size of sediments at Al-Kanater to El-Khatatba are mostly fine sand size, while the mean size at El-Khatatba to Kafr El-Zayat are mostly coarse to fine sand size and also, the mean size sediments at Kafr El-Zayat to Dessuq are mostly of very fine sand size and finally the sediments at Dessuq station to Edfina station are mostly coarse to medium sand size.

Generally, the data from the studied zone show that the sediments of Rosetta Nile branch are mostly of medium to very fine sizes.

Sorting (δ1):

From Table (1) and (Fig. 2), the sorting of the Rosetta Nile branch sediments ranges between 0.47 to 6.74 Φ (i.e. well sorted to very poorly sorted). According to the distribution of the sorting in the bottom Rosetta Nile branch sediments at El-Kanater to El-Khatatba stations proved to have a very well sorted to well sorted (i.e. ranges between 0.47 Φ and 1.54 Φ). At El-Khatatba to Kafr El-Zayat proved to have a well sorted to poorly sorted (i.e. from 1.13 Φ to 2.78 Φ). While at Kafr El-Zayat to Dessuq stations, the sediments proved to have poorly to very poorly sorted (i.e. from 1.57 Φ to 6.74 Φ). And finally, at Dessuq to Edfina stations, the sediments proved to have a well sorted to very poorly sorted (i.e. from 0.70 Φ to 6.01 Φ). From (Fig. 2), the frequency distributions of mean size and sorting show that there is general tendency for sorting to improve with the increase of the graphic mean size values, and the sorting improve towards the beach (i.e. depth < 1m) and southwards.

Skewness (Sk):

The graphic skewness of the Rosetta Nile branch sediments ranges between 0.84 to 0.75 Table (1) and (Fig. 2). About 48.15% of the samples are positively skewed (i.e. finally skewed), while 51.85% of the sediments are negatively skewed (i.e. coarsely skewed). From (Fig. 2), the distribution of skewness shows that the Rosetta Nile branch sediments are mostly near symmetrical to positively skewed at Al-Kanater and Edfina stations and are mostly near symmetrical and negatively skewed at El-Khatatba to Dessuq stations. And related to the depth, the sediments have no distinct distributions (i.e. have a wide range from negatively skewed to positively skewed).

Kurtosis (K):

The kurtosis values of the Rosetta Nile branch sediments ranges between 0.57 Φ and 6.77 Φ Table (1) and (Fig. 2). From (Fig 2), it is possible to conclude that the graphic kurtosis of the Rosetta Nile sediments are mostly leptokurtic and very leptokurtic. At Al-Kanater to El-Khatatba stations and at Edfina stations, the sediments are mostly mesokurtic and leptokurtic, while, from El-Khatatba to Dessuq stations have a wide range from platykurtic to extermlykurtic.

Areal distribution of Gravel, Sand and Mud:

From Table (1) and (Fig. 3), the Rosetta Nile branch sediments are mainly consisted of sand and mud size and very little amount of gravel sizes which vary in percentages and distribution from one station to the other; at Kafr El-Zayat to Dessuq stations, the sediments are dominant by mud and gravel content (i.e. reaches to 74.13% and 26.78% respectively). While at Al-Kanater to El-Khatatba stations and at Edfina stations, the sediments are dominant by medium sand sizes (i.e. sand content reaches to 97.14%).

There is a clear trend for horizontal distribution of the sediments of different grade sizes among the Rosetta Nile branch. i.e. the gravel and mud amount increases at Kafr El-Zayat to Dessuq stations, while the sand amount increases at Al-Kanater and also at Edfina stations.

Generally, from Table 1, the distribution of the gravel, sand and mud sizes show a progressive increase of mud with increasing depth and increase of sand amount southards and at the end of northards.

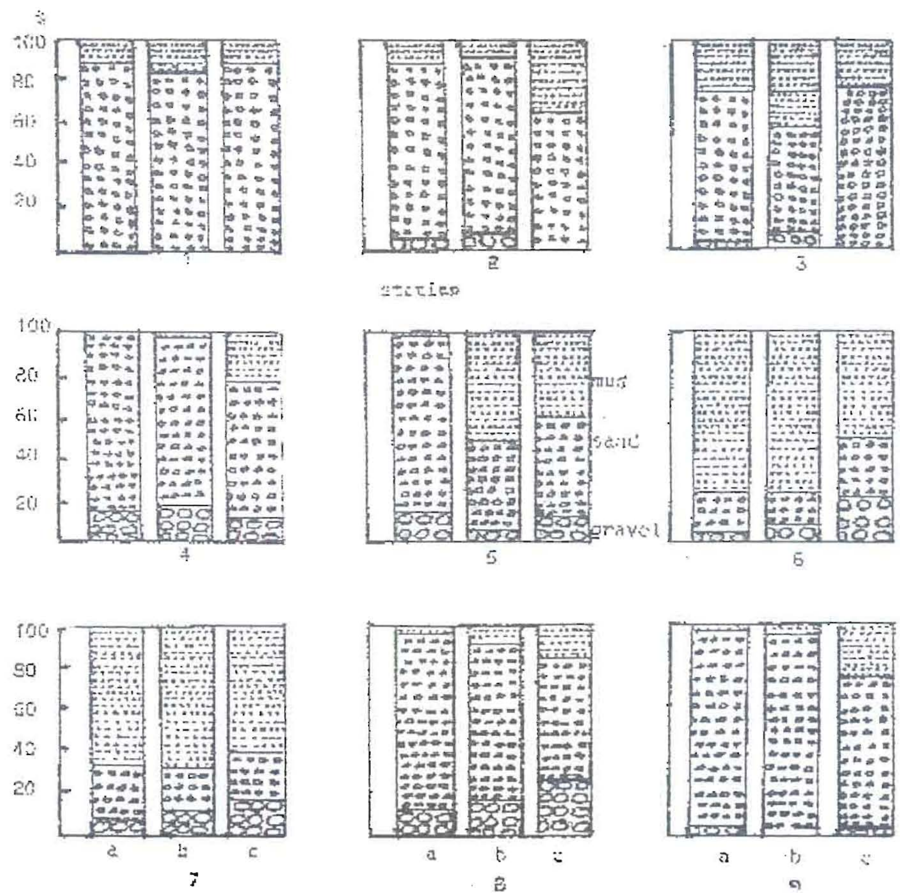


Fig (3) : Histograms for percentages of gravel, sand and mud.
Water depth : 1 =<1 m 2 = 1---3 m 3 =>3 m, Stations (1,2,3,....,9)

Relationship between grain size textural parameters:

The plot of skewness vs. mean size diameter (Fig. 4) can be significant in the separation between dune and beach sands (Friedman, 1961). The application of Friedman's agrument to the sediments under study does not appear to be effective in the separation between sand. All coarse to fine sand sediments are scattered in a narrow range of both mean diameter and skewness.

The plot of kurtosis vs. mean size indicates partly separation between samples of the different meso, and leptokuttic, while the sediments at Al-Kanater to El-Khatatba and Edfina stations are mostly very leptokurtic and extermly kurtic (Fig. 4).

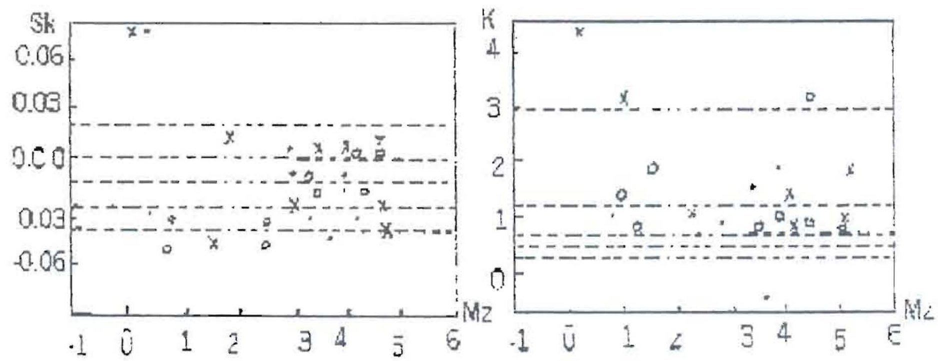


Fig. (4). Relation between Sk, K and Mz. o< 1m x1:3m ->3m

The plot of skewness vs. sorting (Fig. 5) shows that 96.3% of samples fall within the field river environment where they fall on side of the boundary suggested by Friedman (1967) and 85.19% of samples fall on one side of the boundary suggested by Miola and Weiser (1968).

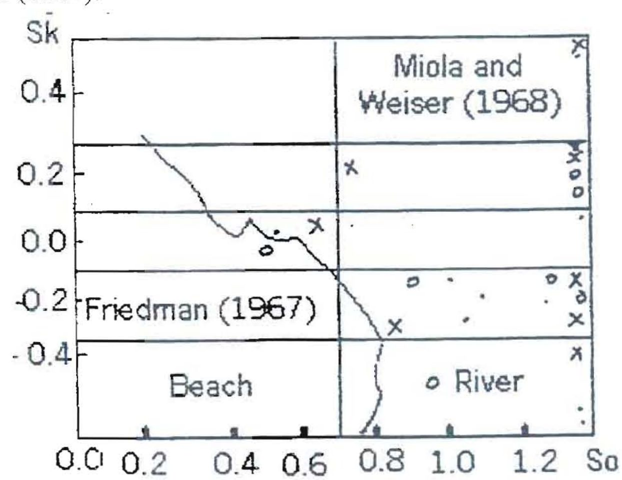


Fig (5): Plot of sorting vs. skewness.

Fig (6) : Plot of sorting vs. mean size.

The grain size analysis data are plotted on Folk's diagram (1968) (Fig. 7). The samples of Rosetta Nile branch sediments were found belong to six textural classes: muddy sand (37.04%), sand (14.81%) gravelly sand (14.81%), gravelly muddy sand (11.11%), gravelly mud (11.11%) and sandy mud (11.11%).

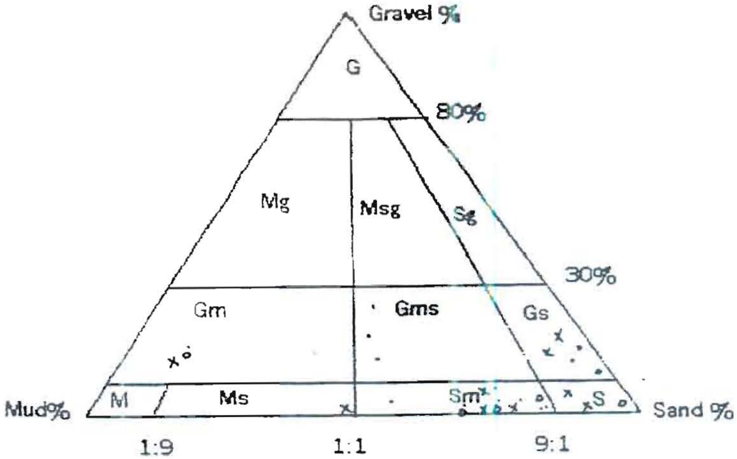


Fig (7) : Sediment type of the reconstucted sedimentary units (Folk, 1968).

Mineral Content:

The mineralogic composition of the Rosetta Nile branch sediments is generally made of quartz (86.96-47.04%), feldspars (6.72-1.94%), carbonate minerals (5.07-0.14%)and heavy minerals (43.1-6.51%).

a- Quartz:

It is found as well developed subrounded to rounded grains, of which very few grains show an evidence of secondary over growth. From Table (2) and (Fig. 8), the maximum content of quartz was observed at Al-Kanater station and reaches to average 74.99% and decreasing northwards until to Dessuq stations (reaches to average 58.66%) and again increasing towards Edfina stations, reaches to average 71.32%.

Generally, the maximum value of quartz in studied area occurs at Al-Kanater stations.

b- Feldspars:

Feldspars (different members of the plagioclase, orthoclase and microcline are rarly present). From Table (2) and (Fig. 8), feldspars content in the Rosetta Nile branch sediments ranges between (6.72-1.94%), and the maximum value appears near Edfina stations reaches to average 6.35% and minimum value appears at El-Khatatba stations (average 3.63%).

The quartz / feldspar ratio (Lotfy, 2001) varies between 18.39 and 10.55% (Table 2). These ratios show that the sediments at Kafr El-Zayat and Edfina stations is characterized by the least distinguishing degree of maturity relative to the other zone.

c- Carbonate Minerals:

The carbonate minerals are mostly fossils and fragments of them of coarser terrigenous clastics, the carbonate minerals phases include aragonite and very minor amount of calcite.

From Table (2) and (Fig. 8), a maximum value of carbonate minerals was observed at El-Khatatba station, where its average 3.19% decreasing northwards and southwards reaches to average 0.95 and 1.43% respectively. From (Fig. 8), the relationship between the distribution feldspar and carbonate minerals appears antipathetic relation.

d- Heavy Minerals:

From Table (2) and (Fig. 8), according to the distribution of heavy minerals and quartz in the Rosetta Nile branch sediments, these distribution proved to have antipathetic relation and near to Dessuq station proved to have a maximum value, reaching values as high as 33.33% (average), decreasing southwards reaches to average 18.51% at Al-Kanater stations.

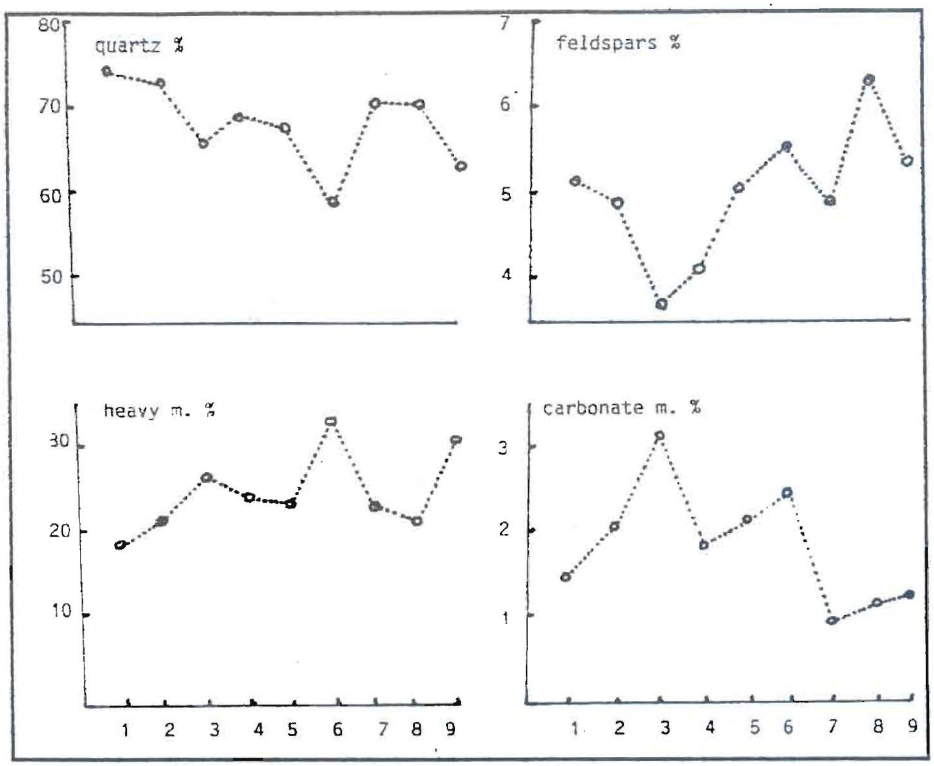
Table (2): average of mineral composition of the recent Rosetta Nile branch sediments in 2001.

Station No.	No. of sample	Quartz %	Feldspars %	Q/F	Carbonate M. %	Heavy M. %
I	5	96.96-67.57	5.37-4.79	14.79	1.80-1.16	26.05-6.51
		74.99	5.07		1.43	18.51
II	5	88.19-64.66	5.56-3.81	15.60	3.16-0.99	29.53-9.09
		73.77	4.73		2.09	21.41
III	5	78.48-55.06	5.32-1.94	18.39	5.07-1.31	41.69-11.13
		66.77	3.63		3.19	26.41
IV	5	73.15-65.31	5.43-2.67	17.07	2.65-1.09	30.93-18.77
		69.23	4.05		1.87	24.85
V	5	77.51-58.12	5.13-4.91	13.55	3.02-1.20	33.95-15.36
		68.02	5.02		2.11	24.86
VI	5	64.66-47.04	6.16-4.81	10.55	4.15-1.32	43.1-27.3
		58.66	5.56		2.45	33.33
VII	5	76.11-67.54	6.48-2.55	15.14	1.07-0.82	29.09-18.08
		71.32	4.71		0.95	23.02
VIII	5	85.65-60.62	6.72-5.66	11.07	2.10-0.13	32.53-7.47
		70.31	6.35		1.15	21.75
IX	5	66.37-60.35	6.72-3.21	11.93	1.61-1.00	35.44-25.3
		63.45	5.32		1.21	30.02

From Fig. (8), there is a clear antipathetic relation between the heavy minerals and either quartz and decreasing southwards.

The heavy minerals suite separated from these sediments arranged in a decreasing order includes the following minerals: opaques, amphibole, pyroxene, epidote, garnet, apatite, rutile, zircon, tourmaline, monazite and staurolite.

Many authors made attempts to group the heavy minerals according to their stability. Folk (1974) grouped the heavy minerals in terms of opaques, micas, ultrastable (zircon, tourmaline and rutile) and metastable (garnet, epidote, apatite and kyanite). He considered pyroxene and amphibole as unstable. Friis (1974) considered pyroxene and amphibole as extremely unstable while epidote and garnet are unstable. The studied heavy minerals are grouped as follows: opaques, unstable (amphibole and pyroxene), metastable (epidote, garnet and apatite) and ultrastable (zircon, rutile and tourmaline). All other heavy minerals are considered as one group.



Stations

Fig (8) : Relative frequencies of minerals in the recent Rosetta Nile branch sediments.

Distribution of heavy minerals: (Table 3 and Fig.9) :

Opaques: The opserved opaque minerals are magnetite, hematite, ilmenite and limonite. Most of the grains are subrounded with lesser amount of rounded and angular grains. The opaques are recorded in all the studied samples, the content ranges between average 39.10 and 27.63%. They show a uniform horizontal variation with slight higher concentration at Al-Kanater to El-Khatatba stations. From Fig. (9), there is a clear antipathetic relation between the opaques and either pyroxene or the amphibole. This is possibly attributed to mineral alteration.

Unstable minerals:

Pyroxenes are represented mainly by augite of greenish yellow to brownish varieties. The rhombic members are enstatite and hypersthene. Pyroxene grains range from rounded to irregular. The pyroxene contents vary from average 25.81 and 28.55%. Amphiboles are first in abundance before pyroxenes. They are represented by hornblende, actinolite and tremolite of prismatic and subrounded forms. Amphibole content ranges between average 27.93 and 34.24%. Pyroxene and amphibole are recorded in all the studied samples and show similar horizontal distribution (Fig. 9), where they generally show gradual increase in abundance northwards. Pyroxenes and amphiboles are similar to the pyroxenes and amphiboles in the recent Nile sediments (Lotfy, 1997), and in the recent Dameitta Nile branch sediments (Lotfy, 1997).

Metastable minerals:

Members of this group, arranged in a decreasing order are: epidote, garnet and apatite. Epidote and garnet are recorded in all the studied medium sand samples. Epidotes are represented by rounded to subrounded grains of pistachite, clinozoisite and rarly zoisite. Their content ranges between average 4.17 and 7.22%. Garnet grains are angular and subangular of pink, rose and colourless varieties. It's average content range between 0.26 and 1.50%.

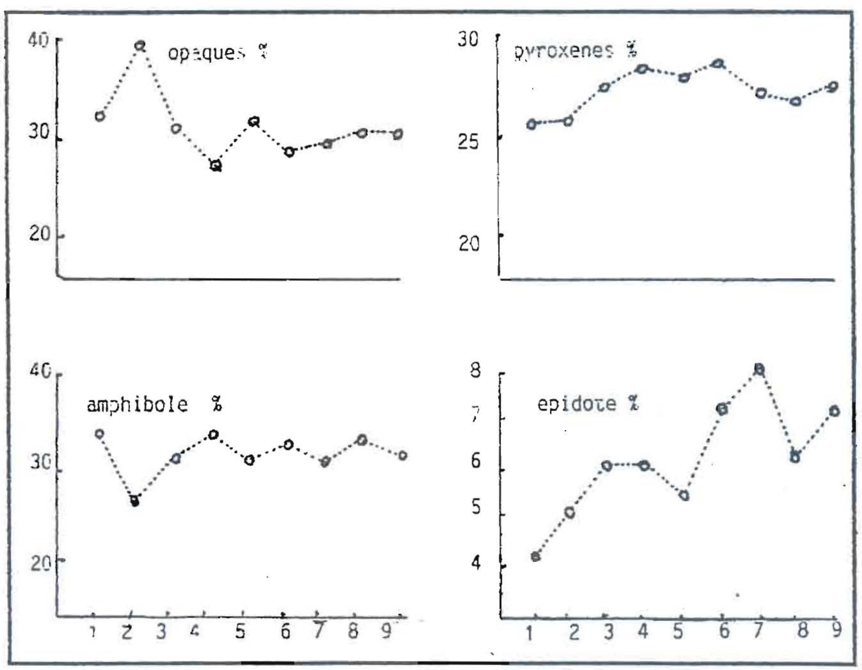


Fig (9) : Relative frequencies of opaques, amphibole, pyroxene and epidote in the Rosetta Nile branch sediments.

Table (3): average percentages of heavy minerals in the recent Rosetta Nile branch sediments

No. of station		I	II	III	IV	V	VI	VII	VIII	IX
No. of samples		5	5	5	5	5	5	5	5	5
Opaques %		32.10	39.10	31.11	27.63	31.01	28.12	29.52	30.52	30.06
Unstable m.	Amp-hibole	33.54	27.93	32.15	34.24	32.68	33.71	31.31	33.57	32.11
	Pyr-oxene	25.81	25.96	27.51	28.55	27.51	28.12	26.61	26.15	27.15
Metastable m	Epido-te	4.17	5.11	6.01	6.18	5.62	7.22	8.11	6.14	7.12
	Gra-rnet	1.50	0.26	0.53	0.31	1.16	0.61	1.13	1.46	0.73
	Epat-ite	0.11	0.30	0.51	0.34	0.22	0.63	0.13	--	0.31
Ultrastable m	Rut-ile	0.62	0.31	--	0.51	0.34	0.22	0.63	0.13	--
	Zir-con	0.55	--	0.81	0.81	0.21	0.91	0.98	0.88	0.65
	Tou-raline	0.93	0.62	0.51	0.72	--	--	0.87	--	0.39
Monozite		0.51	--	0.21	--	--	0.23	--	0.22	0.24
Staurolite		0.08	--	--	0.52	--	0.01	0.41	--	0.06
Others		0.06	0.14	0.42	0.20	1.46	0.57	0.39	0.82	0.51
S/U		0.02	0.02	0.02	0.03	0.01	0.02	0.05	0.02	0.02

S = stable m. U= unstable m.

From Fig. (9) and Table (3), in general, the frequency percent of metastables show a northward increase.

***Ultrastable minerals*:**

These include rutile, zircon and tourmaline and are found as a miner association in some of the studied samples. Rutile is present as reddish brown and yellowish prismatic grains showing fair rounding edges. Zircon is found as colourless small prismatic, bipyramidal or broken grains with rounded edges in some them. Tourmaline displays different pleochroic colours; grey, brown, pink and black in prismatic ovat and rounded grains. Monazite, staurolite and others are rarely and habhazard by recorded in the studied samples. Ternary diagrams were drawn using the constituent minerals; opaques, pyroxene and amphibole and given in Figure (10), modified after Nawar (1987). Two associations have been identified as follow:

The mixed opaques, amphibole and pyroxene association: This association constitutes 92.59%of the examined samples. The amphibole, pyroxene association: It is characterized by the predominance of amphibole over pyroxene. This association constitutes 7.41% of the examined samples.

The maturity of heavy minerals is determined by the following ratio, i.e. weight of stable minerals/weight of unstable minerals (Tucker, 1981). The heavy minerals of Rosetta Nile branch sediments are immature (i.e. S/U ranges between average 0.01 at Kafr El-Zayat station and 0.05 at Dessuq station Table 3).

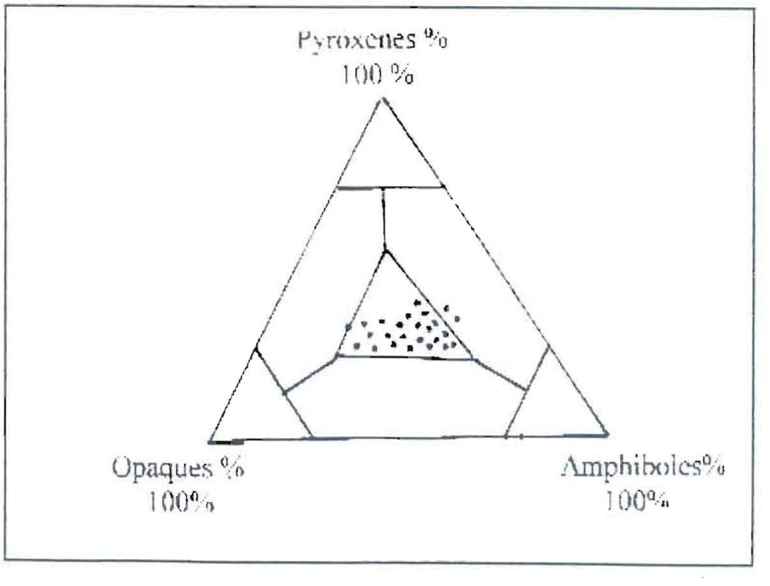


Fig (10) : Diagram shows heavy mineral association.

CONCLUSION

Sedimentological studied on the Rosetta Nile branch sediments show that the mean size of sediments from Al -Kanater to El-Khatatba are mostly medium to fine sand size, to Kafr El-Zayat are mostly coarse to fine sand size, to Dessuq are mostly of very fine sand size and finally to Edfina are coarse to fine sand size. Sorting varies from well sorted to very poorly sorted. Its oscillation reflects the unstable conditions in this part. The sorting improve southwards. The skewness of the sediments shows that the Rosetta Nile branch sediments are mostly near symmetrical to positively skewed at Al-Kanater and Edfina station while at El-Khatatba to Dessuq station are mostly near symmetrically and negatively skewed. Kurtosis are mostly leptokurtic and very leptokurtic and slightly changed to mesokurtic at Al-Kanater and Edfina stations and to have a wide range from platykurtic to extermlykurtic at El-Khatatba to Dessuq stations. The sediment facies change from medium particles-sand at Al-Kanater and Edfina stations and occasionally gravel down with finer-muds predominate at Kafr El-Zayat to Dessuq station. Skewness vs. mean diameter relation gave there relation does not appear to be effective in the separation between sand. The graphic skewness vs. standard deviation relation gave a good separation between beach and river sediments agreement with Friedman (1967). Mean size vs. standard deviation relation proved to give a very good results for environmental interpretations. The sediments were found to belong to six textural classes: muddy sand, sand, gravelly sand, gravelly muddy sand, gravelly mud and sandy mud and vary with location and depth.

The mineral study reveals the presence of light minerals as macro and micro fauna test (Carbonate minerals), quartz and feldspar, and heavy minerals. The distribution of minerals varies with location and depth. At kafr El-Zayat and Edfina stations, the sediment is characterized by the least distingushing degree of maturity relative to the other zones.

The heavy minerals at Dessuq to Edfina stations proved to have a high amount (33.33%). They are composed mainly of opaques, unstable minerals (pyroxene and amphibole), metastable mineral (epidote, garnet and apatite) and ultrastable minerals (rutile, zircon and tourmaline) and others.

Two associations have been identified as follows: The mixed association (92.59%) and the amphibole, pyroxene association (7.41%). There is a clear antipathetic relation between opaques and pyroxene and amphibole and a clear pathetic relation between amphibole and pyroxene. The bottom sediments of the Rosetta Nile branch are rich in pyroxene reflecting an influx of unstable minerals and indicating that the main source of heavy minerals is the south Nile sediments. The heavy minerals assemblages of bottom sediments appear immature due to the predominance of unstable heavy minerals.

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