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TEXTURAL, MINERALOGICAL AND CHEMICAL CHARACTERISTICS OF BEACH AND COASTAL DUNE SANDS AT ROSETTA WEST, MEDITERRANEAN SEA COAST, EGYPT

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ABSTRACT

The present work deals with a selected locality of black sand deposits occurring as beach deposits and as dunes (West Rosetta) along the Mediterranean Sea Coast. A considerable number of beach as well as dune sand samples have been collected starting from Rosetta outpouring westwards. 42 samples were subjected to grain size analysis to study the textural variation in terms of statistical grain size parameters. For the detected economic heavy minerals, grain size, X-ray diffraction and chemical analyses were made.

The dune deposits appear to have been derived by wind action on the beach deposits. The heavy minerals are concentrated in beach sediments in fine sand grade contrary to that of the dune sediments which concentrate in the very fine sand grade. It seems that the processes of transportation of the beach sands to form local sand dune imparted to the sands of the dunes considerable homogenization regarding their average heavy minerals content.

On the basis of chemical composition variability and during the transition from beach to dune field subenvironments iron is removed from beach magnetite and ilmenite. Two processes occur on the beach, an oxidizing process for ferrous to ferric oxid in the presence of oxygen and water and transportation by wind of oxidized iron. Therefore titanium concentration relative to iron takes place in the dune deposits. The chemical composition of the ilmenite grains, with transition from beach to dune subenvironment, differs with differences in the magnetic susceptibilities and also with differences in the degree of

INTRODUCTION

Large deposits of potentially economic heavy minerals occurs along the Mediterranean Sea Coast, in a zone extending from Rafah to Abu Qir east of Alexandria. The concentration values of heavy minerals are found in beach and coastal dune sands. The present work is the first detailed study to be carried out on a selected locailty of black sand deposits occuring as beach deposits and as dunes along the Mediterranean Sea Coast. This locality is called Rosetta West (Fig.1). The present work deals with textural, mineralogical and chemical characteristics of beach and coastal dune sands.

FIELD INVESTIGATIONS

A considerable number of beach sand as well as dune sand samples have been collected starting from Rosetta outpouring westwards. To estimate beach deposits eleven boreholes were dug, each one penetrating to a depth of one meter, samples were obtained from these boreholes whenever obvious variations in their heavy minerals content have been observed. Normally two samples were collected from each borehole to amount a total number of twenty two samples, within the same site, in ten individual coastal dunes, ten boreholes were dug to one meter depth with a total number of twenty raised samples.

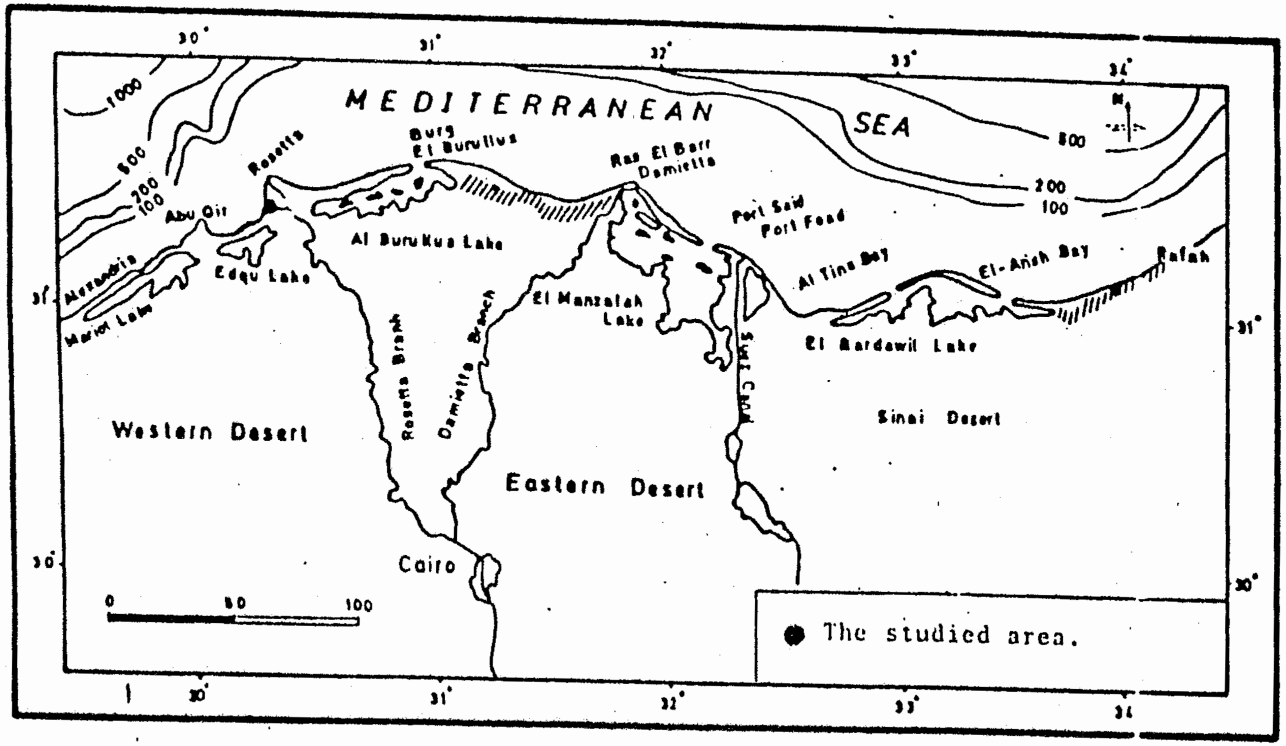

Fig.(1): Map of the northern beaches of Egypt, the sand dune belts, and the location of the studied dunes in west Rosetta.

Table 1: Phi values and statistical grain size parameters of the dune sands

Sample No.	ϕ_5	ϕ_{16}	ϕ_{25}	ϕ_{50}	ϕ_{75}	ϕ_{84}	ϕ_{95}	MZ	σ_1	SK_1	KG
1	2.15	2.30	2.35	2.35	2.15	2.90	3.25	2.58	0.32	+0.21	1.13
2	2.10	2.30	2.40	2.55	2.75	2.93	3.15	2.59	0.32	+0.17	1.23
3	2.13	2.30	2.40	2.65	2.85	3.00	3.33	2.65	0.36	+0.07	1.09
4	2.28	2.48	2.55	2.70	2.83	2.93	3.13	2.70	0.24	+0.02	1.24
5	2.20	2.40	2.45	2.70	2.85	2.93	3.08	2.68	0.26	-0.14	0.90
6	2.10	2.35	2.45	2.60	2.80	2.85	3.20	2.60	0.30	+0.05	1.28
7	2.00	2.20	2.26	2.43	2.68	2.83	3.25	2.49	0.35	+0.29	1.22
8	2.10	2.30	2.45	2.65	2.85	2.95	3.18	2.63	0.32	-0.04	1.21
9	2.00	2.20	2.30	2.45	2.70	2.85	2.25	2.50	0.35	+0.26	1.28
10	1.95	2.20	2.30	2.45	2.75	2.85	3.23	2.50	0.35	+0.22	1.16
11	2.00	2.28	2.38	2.55	2.70	2.80	3.10	2.54	0.30	-0.02	1.41
12	2.00	2.18	2.25	2.40	2.65	2.83	3.05	2.47	0.32	+0.28	1.08
13	1.95	2.20	2.30	2.50	2.70	2.80	3.15	2.50	0.33	+0.04	1.18
14	1.90	2.18	2.25	2.45	2.68	2.80	2.28	2.48	0.36	+0.16	1.31
15	2.00	2.15	2.23	2.40	2.58	2.70	3.15	2.42	0.31	+0.19	1.35
16	1.88	2.05	2.10	2.30	2.55	2.80	3.28	2.38	0.40	+0.37	1.27
17	2.00	2.20	2.30	2.45	2.63	2.83	3.20	2.49	0.34	+0.22	1.49
18	1.80	2.05	2.18	2.48	2.80	3.08	2.55	2.54	0.54	+0.19	1.15
19	2.20	2.43	2.50	2.73	2.85	3.02	3.25	2.73	0.31	-0.01	1.23
20	2.05	2.25	2.30	2.40	2.70	2.90	3.30	2.52	0.35	+0.49	1.28

TECHNIQUE

Grain size analysis was carried out on the collected samples to study the textural variation of dune and beach sand populations. Comparison was made in terms of statistical grain size parameters, mean size, standard deviation, skewness and graphic kurtosis. To evaluate the variability in the general characteristics of heavy mineral assemblages, magnetite was separated by hand magnet. Ilmenite was determined as the sum of a high-iron ilmenite separated magnetically and moderately magnetic ilmenite particles determined by microscopic counting. Monazite was determined by relative radiometric assay. Each of zircon and rutile was estimated as the sum of the normal weakly magnetic ziron and rutile determined by X-ray fluorescence spectroscopy. The magnetic zircon and rutile varieties are microscopically counted in composition variability tube exited fluorescence analyzer (T.E.F.A.) was used.

DISCUSSION OF THE RESULTS

Textural variations of beach and adjacent dune sands (non-gravel fractions) were determined in terms of statistical grain size parameters. Table (1,2). The ranges and averages for these individual parameters are presented in Table (3). From this table discrimination the studied beach and adjacent coastal dune sands

Table 2 : **Phi values and statistical grain size parameters of the beach sands.**

Sample No.	5	16	25	50	75	84	95	MZ	σ_I	SK_I	KG
1	1.10	1.75	1.90	2.30	2.65	2.85	3.20	2.30	0.59	-0.07	1.15
2	1.30	1.75	1.95	2.37	2.70	2.90	3.20	2.34	0.58	-0.10	1.04
3	1.75	1.92	2.05	2.25	2.50	2.72	3.20	2.30	0.41	+0.25	1.32
4	1.75	1.95	2.10	2.20	2.42	2.59	3.05	2.25	0.36	+0.16	1.66
5	1.85	2.00	2.10	2.30	2.45	2.55	2.95	2.32	0.31	+0.59	1.29
6	1.80	2.05	2.12	2.27	2.55	2.75	3.22	2.36	0.40	+0.36	1.35
7	1.70	1.90	2.05	2.20	2.40	2.50	3.10	2.20	0.36	+0.14	1.64
8	1.70	1.90	2.00	2.20	2.40	2.50	2.90	2.20	0.33	+0.08	1.23
9	1.80	2.00	2.10	2.25	2.40	2.45	2.85	2.23	0.27	+0.01	1.43
10	0.37	1.12	1.55	1.95	2.35	2.55	2.95	1.87	0.75	-0.15	1.29
11	0.62	1.45	1.65	2.10	2.45	2.65	3.05	2.07	0.67	-0.15	1.25
12	1.75	1.85	1.90	2.17	2.30	2.38	2.76	2.16	0.28	-0.02	1.03
13	1.44	1.75	1.90	2.15	2.35	2.53	3.15	2.14	0.46	+0.07	1.56
14	1.40	1.75	1.85	2.15	2.38	2.45	3.00	2.12	0.42	-0.04	1.24
15	1.40	1.70	1.85	2.10	2.30	2.40	2.90	2.07	0.41	-0.04	1.37
16	0.20	0.55	0.85	1.55	1.90	2.12	2.62	1.41	0.76	-0.20	0.95
17	1.40	1.65	1.77	2.05	2.20	2.40	2.66	2.03	0.38	-0.05	1.20
18	1.34	1.65	1.75	2.00	2.25	2.38	2.75	2.01	0.39	+0.05	1.16
19	0.80	1.55	1.75	2.12	2.55	2.70	3.12	2.12	0.64	-0.07	1.16
20	1.35	1.65	1.77	2.05	2.33	2.42	2.92	2.04	0.43	+0.01	1.15
21	1.45	1.60	[illegible]	2.15	2.33	2.50	3.15	2.15	0.44	+0.09	1.45
22	0.20	0.50	0.95	1.75	2.20	2.45	2.90	1.57	0.90	-0.22	0.89

Table (3): Ranges and averages of textural parameters values for the studied coastal dune and beach samples.

Parameter	Coastal dune		Adjacent beach	
	Range	Average	Range	Average
Texture:				
Mean Size (MZ)	2.38-2.73 ϕ	2.54 ϕ	1.41-2.36 ϕ	2.10 ϕ
Sand type	F.S. - F.S.	F.S.	M.S. to F.S	F.S
Stand.deviation (σ_1)	0.24-0.54 ϕ	0.34 ϕ	0.27-0.90 ϕ	0.48 ϕ
Sand type	V.W.S.-M.W.S.	V.W.S.	V.W.S. to M.S.	W.S
Skewness (SK_1)	-0.14- +0.49 ϕ	+0.15 ϕ	-0.22 - +0.59 ϕ	+0.03 ϕ
Sand type	C.S. to S.F.S.	F.S.	C.S. to S.F.S.	N.S.
Kurtosis (KG)	0.90 - 1.49 ϕ	1.22 ϕ	0.89 - 1.60 ϕ	1.26 ϕ
Sand type	P.K. - L.K.	L.K	P.K. to V.L.K.	L.K.

by using, mean size (MZ), standard deviation (Q_I) and graphic kurtosis (KG) becomes clear. The grain size parameters recorded a partial sucess in differntiating the two subenvironments. They posses the same mean size, standard deviation and kurtosis but skewness (SK_I) values differ. Coastal dune is fine skewed and beach is near symmetrical. The difference in skewness (SK_I) values of beach and dune sands can be attributed to the great selectivity of wind from beach (near symmetrical) to the coastal dune sands (fine skewed sand), whereas the dune sands tend to be somewhat finer grained than beach sand. This indicates that there is a regional trend of southward reduction in grain size, an observation which is in agreement with El-Fishawi et al. (1975).

To evaluate the variability in the general characteristics of heavy mineral assemblages, the detected heavy minerals were subjected to mechanical analysis. The results of mechanical and mineral analyses of the studied beach and dune sediments are summarized in Tables (4,5,6). From the tables it is clear that in beach sand populations the majority of the economic heavy minerals are concentrated in the fine sand grade contrary to that recorded in the dune sand populations, where the majority of the economic heavy minerals are concentrated in the very fine sand grade. The ranges and average percentages of the

Table 4: Relative heavy minerals distribution in the studied dune samples (in percent).

Sample No.	Magnetite	Ilmenite	Rutile	Garnet	Zircon	Monazite
1	0.41	0 .31	0.20	0.13	0.06	0.001
2	0.70	0.38	0.27	0.03	0.08	0.004
3	0.65	0.58	0.20	0.03	0.07	0.003
4	0.60	1.10	0.23	0.08	0.08	-
5	0.22	0.23	0.20	0.05	0.04	0.001
6	0.33	0.36	0.23	0.04	0.14	0.003
7	0.70	0.27	0.26	0.06	0.08	0.003
8	0.22	0.51	0.20	0.10	0.06	-
9	0.67	1.01	0.25	0.12	0.13	0.004
10	0.61	0.57	0.20	0.05	0.15	-
11	0.27	0.46	0.26	0.04	0.05	0.002
12	0.56	0.69	0.20	0.10	0.06	-
13	0.17	0.21	0.22	0.04	0.14	0.004
14	0.27	0.56	0.15	0.04	0.15	0.001
15	0.10	0.08	0.14	0.03	0.02	0.004
16	0.20	0.67	0.21	0.06	0.03	0.005
17	0.70	0.42	0.28	0.11	0.11	0.004
18	0.70	0.42	0.20	0.05	0.06	0.009
19	0.60	0.26	0.28	0.09	0.16	0.009
20	0.70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 5: Relative heavy minerals distribution in the studied samples of beach sands (in percent).

Sample No.	Magnetite	Ilmenite	Rutile	Garnet	Zircon	Monazite
1	3.24	5.12	0.96	0.35	0.59	0.13
2	3.27	6.03	0.75	0.20	0.67	0.12
3	3.50	6.20	0.83	0.25	0.80	0.007
4	5.36	6.73	0.72	0.35	0.52	0.006
5	3.43	4.12	0.63	0.40	0.60	0.02
6	2.15	4.30	0.78	0.45	0.25	0.05
7	2.20	3.65	0.84	0.04	0.23	0.08
8	8.80	5.12	1.01	0.20	1.00	0.06
9	4.25	5.10	0.65	0.45	0.98	0.08
10	5.43	7.34	0.48	0.14	0.70	0.005
11	5.43	6.65	0.65	0.47	0.58	0.08
12	8.82	9.13	0.72	0.86	0.37	0.09
13	5.32	9.10	0.65	0.14	0.32	0.155
14	3.25	6.82	0.54	0.05	0.79	0.15
15	4.58	5.72	0.46	0.82	0.50	0.03
16	4.60	5.92	0.60	0.25	0.32	0.03
17	4.26	5.80	0.42	0.35	0.15	0.001
18	3.20	4.15	0.35	0.12	0.13	0.005
19	0.25	5.02	0.46	0.03	0.02	0.06
20	0.25	5.10	0.35	0.10	0.01	0.001
21	0.35	0.38	0.25	0.05	0.32	0.065
22	0.30	0.29	0.10	0.47	0.70	0.003

detected heavy minerals are given in Table (7) . The average values beach heavey minerals is 3.74% for magentite, 5.37% for ilmentite, 0.60% for rutile, 0.30% for garnet. 0.48% for zircon and for monazite 0.056%. The average contents of the dune heavy minerals is 0.47% for magentite, 0.49% for ilmenite, 0.22% for rutile, 0.066%, for garnet, 0.09% for zircon and 0.003% for monazite. The differences between the maximum and minimum values of the studied heavy minerals are much smaller in the dune sands as compared to their respective values in the beach sands. However the differences between the maximum and minimum values of the recorded minerals are still notable in the dune sands which reflects in particular the irregularity of the distribution of these minerals when occuring in small concentrations. It appears that the process of transportation of the beach sands to form local sand dune imparted to the sands of the dunes considerable homogenization regarding their average heavy minerals content rather than their recorded individual heavy mineral contents. The physical properties of the recorded heavy minerals though variable due to contribution from different sources, yet they exhibit notable common characteristics. Magnetite is usually subangular and varies in colour from reddish brown to dull balck and some grains show pittings and cavinges. Ilmenite grains have a wide range in their shape from angular to rounded, and vary in colour from

Table 6: Relative distribution of the common economic heavy minerals in different size grades.

Size fraction (mm)	Magnetite		Ilmenite		Rutile		Zircon		Garnet		Monazite	
	Beach	Dune	Beach	Dune	Beach	Dune	Beach	Dune	Beach	Dune	Beach	Dune
> 0.5 mm.	-	-	-	-	-	-	-	-	-	-	-	-
0.5 - 0.25	10.11	-	23.03	-	20.55	-	4.18	-	64.82	-	1.40	-
0.25 - 0.125	63.67	3.01	65.67	7.24	62.14	10.92	65.00	3.74	23.01	11.85	47.65	13.61
0.125 - 0.063	25.92	95.60	10.30	84.44	16.14	87.35	28.57	88.01	10.17	87.03	49.82	85.34
< 0.063	2.30	1.39	1.00	8.32	1.17	1.73	2.25	8.25	2.00	1.12	1.13	1.05

balck to brownish black. Alteration processes partially worked upon the mineral grains causing encrustations, pittings, and converting the surface colours into gray to brownish gray. Rutile grains are prismatic, elongated, tabular and irregular in shape and vary in colour from red to reddish brown. Garnet grains are of the pink variety but some are brownish yellow and colourless and vary in shape from angular to subrounded, and occasionally contain inclusions. Zircon may be found in elongated or broken prisms with common exhibition of zoning and presence of inclusions. Monazite is usually rounded, spherical or elongated and it varies in colour from yellow to yellowish brown to brown.

According to Pettijohn (1957) the stability order of detrital economic heavy minerals identified is as follows: zircon-rutile- garnet-monazite (ultrastable minerals) - magnetite - ilmenite (meta stable minerals). As metastable minerals magnetite and ilmenite are easily weathered and destroyed, they can be considered as indicators for weathering regime. In the present study the variability in the chemical composition of both magnetite and ilmenite was detected. Pure magnetite and ilmenite (three magnetic fractions) samples were chemically analysed and the data obtained are given in Table (8). For both beach and dune

Table 7: Comparative mineralogical composition of the studied coastal dune and beach sand samples.

Minerals detected	Dune		Beach	
	Range	Average	Range	Average
Magnetite	0.10-0.70	0.47	0.25-8.82	3.74
Ilmenite	0.08-1.10	0.49	0.29- 9.13	5.37
Rutile	0.14-0.28	0.22	0.10-1.01	0.60
Garnet	0.03-0.13	0.066	0.03-0.86	0.30
Zircon	0.02-0.16	0.09	0.02-1.00	0.48
Monazite	0.00-0.004	0.003	0.001-0.155	0.056

Table 8: Comparative chemical composition of magnetite and ilmenite recorded in the studied coastal dune and its adjacent beach sands.

Detrital mineral	Sediment	Magnetic fraction	W. Percent							
			SiO_2	Al_2O_3	CaO	Fe_2O_3	Ti_2O	MnO	V_2O_5	Cr_2O_3
Magnetite	Beach	hand magnet	0.033	0.014	0.264	85.864	10.345	0.122	1.932	1.428
	Dune		0.142	0.008	0.934	72.214	24.486	0.430	0.890	0.896
Ilmenite	Beach	Strongly	0.048	0.011	0.417	62.720	34.720	0.495	0.787	1.087
	Dune		0.080	0.002	0.547	60.808	35.543	0.425	0.909	1.186
	Beach	Moderately	0.041	0.011	0.395	58.379	40.141	0.623	0.039	0.370
	Dune		0.065	0.009	0.390	57.314	41.595	0.537	0.835	0.255
	Beach	Weakly	0.034	0.005	0.311	52.984	44.826	0.591	0.079	0.169
	Dune		0.056	0.011	0.558	51.655	46.659	0.627	0.200	0.205

sand populations the chemcial composition of ilmenite grains differes with differences in the magnetic susceptabilities and also with differences in the degree of ilmenite alterations. Whereas the strongly magnetic fraction (fresh ilmenite) is characterized by its lower titanium content relative to iron content and vice versa for the weakly magnetic fraction (altered ilmenite). The main differences recorded between beach and dune magnetite and ilmenite can be attributed to the differences in values of both Ti and Fe contents. Beach magnetite and ilmenite are characterized by their relatively higher Fe content, whereas dune magnetite and ilmenite are characterized by their relatively higher Ti content. Differences in values of Ti and Fe exaplained on the basis of leaching and transportation by wind for iron poorer magnetite and ilmenite to dune field subenvironments.

CONCLUSIONS

The comparison between sedimentlogical, mineralogical and chemical characteristics of both beach sands their coastal dune deposits in Rosetta west, Meditteranean Sea Coast, have been carried out. Textural variations in terms of statistical grain size parameters reveal that the dune deposits appear to have been derived by wind action on the beach deposits. The heavy minerals are concentrated in the dune sediments which are concentrated in the very fine sand grade. It seems that the processes of transportation of the beach sands to form local sand dunes imparted to the

sands of the dunes considerable homogenization regarding their average heavy minerals content rather their contents of the individual heavy minerals recorded.

During transition from beach to dune field subenvironment iron is easily oxidized and the oxidized iron product is transported from beach magnetite and ilmenite under the influence of aeolian processes, causing relative increase in the Ti content on the expense of Fe content. The chemical composition of the ilmenite grains after transition from beach to dune subenvironment have differences in the magnetic susceptibilities and in the degree of alteration.

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