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MINERALOGICAL AND CHEMICAL CHARACTERS OF THE HEAVY MINERALS OF THE RECENT COASTAL DUNE-SANDS, SOUTHEAST ROSETTA, EGYPT.

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ABSTRACT

The present work deals mainly with the mineralogical and chemical composition of the coastal dune-sands which extend from Edko to southeast Rosetta City. Focusing is made on the chemical composition of each of the economic minerals, in addition to the reflection of the chemical composition on the physical properties of the detected minerals. In order to carry out the present study, 19 boreholes were drilled in the area under consideration by the Nuclear Materials Corporation. 108 samples were raised and subjected to quantitative mineralogical analysis. For the detected economic heavy minerals, grain size analysis, X-ray diffraction and chemical analysis were made.

The mineralogical studies reveal that the dune sand deposits appear to have been derived, by wind action, from the adjacent beach deposits. The conditions of transportation and deposition were rather different in the north than in the south. Southwards from the studied area, there is a slight decrease in heavy mineral contents.

Size analysis for economic minerals indicates that they concentrated mainly in the very fine sand grade, where the average contents of magnetite, hematite, ilmenite, rutile, garnet, zircon and monazite are 0.40%, 0.01%, 0.43%, 0.27%, 0.08%, 0.06% and 0.003% respectively.

Chemical analysis confirmed the X-ray diffraction analysis that the studied heavy minerals appear to have suffered from alteration processes which affected their

INTRODUCTION

The coastal dune belts along the Mediterranean Sea Coast contain valuable economic minerals accumulated and heaped from the Egyptian beach deposits by wind action (El-Gemizi, 1974). Previous studies made on these recent coastal dune-sands did not treat in detail the mineralogical and chemical composition of these deposits (Shukri and Phillip, 1959, Barakat and Imam, 1973; El-Gemizi, 1974; El Fayoumy et al., 1974, El-Fishawi et al., 1975; Sestini, 1975; Kamel et al., 1982 and Misak and Attaia, 1983). Most authors mentioned dealt with the geomorphological characters of these recent coastal dunes.

The present work deals mainly with the mineralogical and chemical composition of the coastal dune-sands which extend from Edko to southeast Rosetta City (Fig. 1).

TECHNIQUE

108 samples were raised from 19 boreholes drilled in the area under consideration by the Nuclear Materials Corporation. These boreholes pierced the crests of each dune up to six meters depth. Samples were taken, as a rule at regular intervals every one meter depth. Mineralogical analysis was made on the collected samples to evaluate the distribution of the recorded heavy minerals

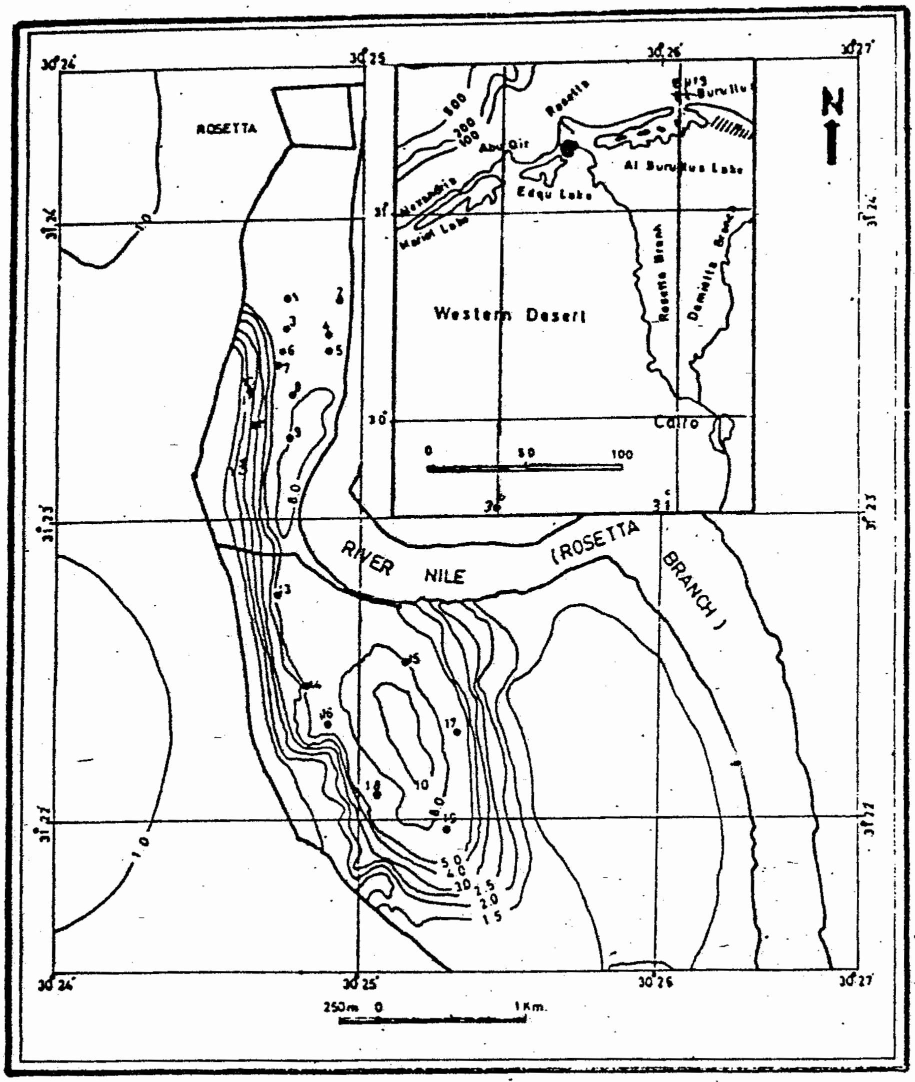

Fig.(1) Location map showing the borehol-- distribution, the studied area and the contou... ies in meters

Table 1; Vertical relative frequencies of the main recorded minerals in five boreholes made in dune sands.

Depth in meter	Magnetite					Heamatite					Ilmenite					Rutile					Garnet				
	1	6	12	14	19	1	6	12	14	19	1	6	12	14	19	1	6	12	14	19	1	6	12	14	19
1	0.60	0.66	0.696	0.31	0.10	0.01	0.01	0.01	0.03	0.005	0.10	0.26	0.68	0.31	0.08	0.23	0.28	0.23	0.20	0.14	0.05	0.09	0.03	0.13	0.03
2	0.18	0.75	0.67	0.19	0.22	0.004	0.005	0.007	0.002	0.01	0.43	0.14	0.77	0.32	0.27	0.21	0.32	0.35	0.15	0.20	0.06	0.03	0.24	0.04	0.10
3	0.20	0.62	0.52	0.16	0.25	0.01	0.01	0.004	0.004	0.02	0.32	0.40	0.48	0.25	0.31	0.25	0.50	0.17	0.17	0.20	0.05	0.16	0.07	0.06	0.07
4	0.37	0.40	0.48	0.39	0.22	0.02	0.009	0.01	0.007	0.004	0.42	0.58	0.42	0.27	0.57	0.34	0.36	0.20	0.26	0.23	0.16	0.11	0.03	0.05	0.15
5	0.17	0.33	0.56	0.27	0.22	0.002	0.017	0.006	0.01	0.005	0.21	0.36	0.69	0.46	0.23	0.22	0.23	0.40	0.26	0.20	0.04	0.04	0.15	0.04	0.03
6	0.19	0.51	-	-	1.05	0.003	0.01	-	-	0.01	0.20	0.98	-	-	0.67	0.17	0.32	-	-	0.49	0.04	0.07	-	-	0.10

Cont.Table 1: Vertical relative frequencies of the main recorded minerals in five boreholes made in dune sands.

Depth in meter	Zircon					Monazite					Strongly magnetic altered silicates					Green silicates					Quartz and feldspars				
	1	6	12	14	19	1	6	12	14	19	1	6	12	14	19	1	6	12	14	19	1	6	12	14	19
1	0.08	0.16	0.14	0.06	0.02	-	0.009	0.002	0.001	0.004	1.44	1.38	1.00	0.52	0.34	3.03	10.86	11.72	9.11	6.48	87.81	85.69	85.09	88.85	92.08
2	0.03	0.08	0.03	0.05	0.01	0.005	0.004	0.004	0.001	-	0.56	1.09	1.23	0.54	0.87	8.90	10.71	10.74	3.32	7.45	88.81	86.24	85.57	94.85	90.23
3	0.03	0.11	0.06	0.02	0.05	0.001	-	0.007	-	0.001	0.58	2.81	0.67	1.35	0.52	11.07	8.99	10.18	8.60	5.93	86.90	87.68	87.16	88.88	91.97
4	0.07	0.04	0.11	0.06	0.04	-	0.003	0.009	0.003	-	1.25	1.07	0.68	0.89	0.77	10.08	3.77	8.48	9.74	5.13	86.65	87.66	87.55	87.75	92.14
5	0.04	0.04	0.04	0.05	0.04	0.004	0.003	-	0.002	0.001	0.78	0.82	0.94	0.82	0.50	4.34	7.71	8.16	9.55	7.93	94.03	89.58	88.26	87.90	89.98
5	0.03	0.04	-	-	0.14	-	0.004	-	-	0.003	1.00	1.18	-	-	0.78	5.80	7.59	-	-	12.30	91.72	88.43	-	-	81.84

both vertically and laterally (Tables 1,2,3). A composit sample (27 kilograms) representing the collected samples was subjected to quantitative mineralogical analysis. Magnetite and the strongly magnetic altered silicates were separated by hand magnet. Monazite was determined by the relative radiometric assay. Zircon and rutile were determined by X-ray fluorescence spectroscopy. Ilmenite, magnetic zircon and rutile, garnet, hematite, lucoxene, coloured and colourless silicates were microscopically counted. The estimated economic minerals are given in table (4). The detected economic mineral grains were subjected to grain size analysis to estimate minerals distribution among the different grain sizes. Each size fraction was subjected to microscopic counting in order to estimate the distribution of each mineral in the different grain sizes. The obtained data are shown in Table (5). Each of the estimated economic mineral was subjected to X-ray diffraction examination to determine and reveal its predominant type, exsolved titaniferrous minerals associated if present, as well as the mineral alteration products (Table 6 and Figs. 2-8). The identification of the recorded minerals was carried out using the A.S.T.M. cards as follows:

Table 2: Average lateral relative frequencies of the main recorded minerals in northern and southern sand dunes.

Direction	Borehole No.	Magnetite	Hematite	Ilmenite	Rutile	Garnet	Zircon	Monazite	Altered silicates	Coloured and colourless silicates	Quartz and feldspars	Clays and fines	Total economic heavy minerals
Northern boreholes	1	0.29	0.008	0.45	0.24	0.07	0.05	0.002	0.94	8.11	89.22	0.59	1.11
	2	0.33	0.01	0.51	0.25	0.03	0.11	0.002	0.83	6.43	90.36	1.13	1.25
	3	0.19	0.002	0.16	0.30	0.05	0.14	-	1.30	9.56	86.51	1.60	0.726
	4	0.27	0.007	0.43	0.19	0.12	0.08	0.002	0.95	8.95	88.25	0.75	1.10
	5	0.34	0.01	0.54	0.34	0.09	0.07	0.002	0.86	8.92	87.23	1.39	1.39
	6	0.55	0.01	0.45	0.34	0.08	0.08	0.004	1.39	8.27	87.55	1.28	1.51
	7	0.53	0.002	0.45	0.27	0.10	0.10	-	1.12	9.52	87.13	0.78	1.45
	8	0.32	0.03	0.57	0.44	0.06	0.06	0.001	1.14	9.61	80.45	1.32	1.48
	9	0.36	0.01	0.44	0.21	0.04	0.05	0.003	1.26	10.35	86.54	0.74	1.11
	10	0.58	0.01	0.31	0.25	0.15	0.08	0.001	1.15	9.80	86.15	1.21	1.39
	11	0.52	0.02	0.53	0.32	0.07	0.08	0.001	1.33	12.11	84.60	0.64	1.32
	12	0.59	0.007	0.61	0.27	0.10	0.08	0.004	0.90	9.86	86.73	0.85	1.66
Southern boreholes	13	0.91	0.03	0.65	0.35	0.06	0.07	0.002	1.61	12.66	78.28	5.58	2.07
	14	0.26	0.01	0.32	0.21	0.06	0.05	0.001	0.82	8.06	89.65	0.56	0.91
	15	0.24	0.008	0.15	0.22	0.04	0.07	0.003	0.82	6.97	91.09	0.11	0.73
	16	0.30	0.01	0.39	0.29	0.10	0.08	0.01	1.27	8.83	87.90	0.82	1.18
	17	0.44	0.004	0.50	0.21	0.05	0.04	0.002	1.15	7.95	88.81	0.86	1.24
	18	0.45	0.03	0.53	0.39	0.13	0.05	0.01	1.15	10.26	85.53	0.66	1.59
	19	0.34	0.01	0.36	0.24	0.08	0.05	0.002	0.63	7.54	89.71	1.04	1.08

Table 3: Range and average frequencies of the main recorded minerals in the studied dune sands.

Direction	Northern boreholes		Southern boreholes	
Mineral	Range	Average	Range	Average
Magnetite	0.17-0.75	0.44	0.10-1.05	0.35
Hematite	0.002-0.03	0.009	0.002-0.03	0.01
Ilmenite	0.14-1.10	0.48	0.08-0.67	0.37
Rutile	0.17-0.50	0.28	0.14-0.49	0.25
Garnet	0.03-0.24	0.08	0.03-0.15	0.07
Zircon	0.03-0.16	0.07	0.01-0.14	0.05
Monazite	0.00-0.009	0.003	0.00-0.01	0.003
Altered silicates	0.56-2.81	1.10	0.34-1.61	0.85
Fresh silicates	3.77-12.11	8.92	3.2-12.66	8.21

1. Magnetite using lines at d=2.53,1.61,1.48,1.85A (A.S.T.M. Card 11.614).
2. Hematite using lines at d=2.69, 2.51, 1.69, 3.68A (A.S.T.M. Card 6.0502).
3. Ilmenite using lines at d=2.74, 1.72, 2.54, 3.73A (A.S.T.M. Card 3.0781).
4. Zircon using lines at d=3.30, 4.43, 2.52, 4.43A (A.S.T.M.Card 11.6.0266)
5. Niobian Rutile using lines at d=3.23, 1.69, 2.48, 3.23A (A.S.T.M. Card 11.396).
6. Almandite garnet using lines at d=2.57, 1.54, 2.87,4.04 (A.S.T.M. Card 9.427).
7. Monazite using lines at d=3.09,2.87,3.30,5.20 (A.S.T.M. Card 11.556).

Representative pure samples for the different detected economic minerals were chemically analysed. The tube existed fluorescence analyszer TEFA was used. The results obtained are shown in Table (7).

RESULTS AND DISCUSSION

The relative frequency distribution of the heavy minerals recorded in the studied area show that ilmenite, magnetite, rutile, garnet, zircon, hematite and monazite exhibit successively decreasing frequencies, yet they show

Table 4: Weight percentage of the main recorded minerals in the studied dune sands.

Minerals	Economic minerals							Gangue minerals		
	Magnetite	Hematite	Ilmenite	Rutile	Garnet	Zircon	Monazite	Coloured altered Silicates	Coloured and colourless minerals	Quartz + Feldspars
Wt.percent	0.40	0.01	0.43	0.27	0.08	0.06	0.003	0.98	8.57	89.20

Coloured gangue minerals: Pyroxenes, amphiboles, tourmaline and staurolite

Colourless gangue minerals: apatite, kyanite

Coloured altered silicate gangue minerals: olivines, pyroxenes and amphiboles.

Table 5: Relative distribution for the detected economic heavy minerals in different size classes.

Size fraction in (mm)	Magne-tite	Ilmenite	Rutile	Zircon	Garnet	Monazite
+ 0.25	-	-	-	-	-	-
-0.25+0.125	3.01	7.24	10.92	3.74	11.85	13.61
-0.125+0.063	95.60	84.43	87.34	88.01	87.03	85.34
-0.063	1.39	8.32	1.73	8.25	1.12	1.05

vertical persistency both qualitative and more or less quantitatively (Table 1). Besides, they show lateral variations which is manifested by slight increase in the heavy mineral contents from south northwards (Tables 2,3).

It is therefore, concluded that the provenance was the same during the time of deposition and this provenance is represented by beach-deposits lying to the north of area under investigation (Atef et al., in press)./ The conditions of transportation and deposition were locally rather different in the northern dunes than in the southern dunes, where southwards there is a slight decrease in heavy mineral contents.

The mineralogical and chemical composition of the detected coastal dune minerals reveal the following:-

a) Economic minerals:

Magnetite: It has an average content of 0.40%, the grains ar generally subangular to subrounded, clustering in the very fine sand-grade (Table 5). X-ray diffraction analysis for magnetite reveals the presence of hematite and ilmenite minerals as exsolved material (Table 6, Fig.2). This indicates that the magnetite suffered from alteration processes. Chemical analysis for pure magnetite samples (Table 7) shows relative high titanium content confirming the X-ray diffraction data that magnetite suffered from

Table 6: Mineral composition of differently magnetic fractions

Minerals analyzed		The detected minerals		Main recorded mineral yarity
Magnetite		Magnetite + Hematite and Ilmenite as exsolved materials		
Ilmenite: Strong.Mag.	0.05amp.	Ilmenite + Hematite + Rutile	Stage (1)	
Ilmenite: Moder.Mag.	0.15amp.	Ilmenite + Hematite		
Ilmenite: Weakly magnetic	0.20 amp.	Ilmenite + Rutile	Stage (2)	
	0.30 amp.	Rutile + Ilmenite		
	0.40 amp.	Rutile + Hematite		
	0.50 amp.	Rutile	Stage (3)	
Rutile		Niobian Rutile + Transluscent (Normal)Rutile + Secondary Rutile		Secondary rutile
Garnet		Alamandite		Almandite
Zircon		Zircon + Hydroxyl apatite.		

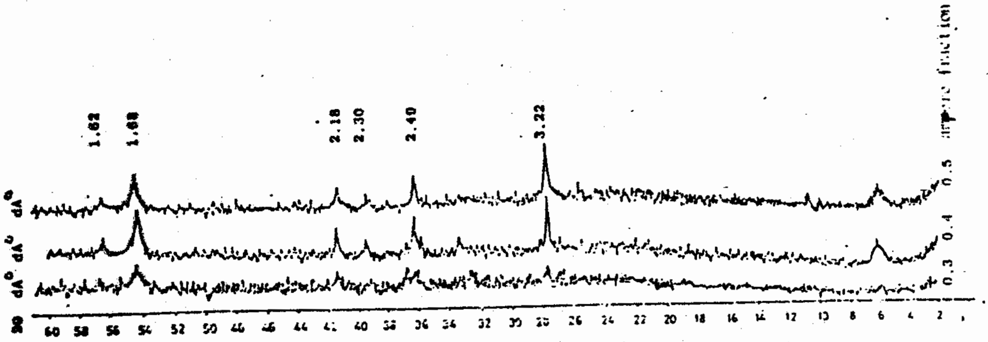

Fig. (4) : X-ray diffraction pattern of the three leucoxenated ilmenite separated at 0.3 amp., 0.4 amp. and 0.5 ampere

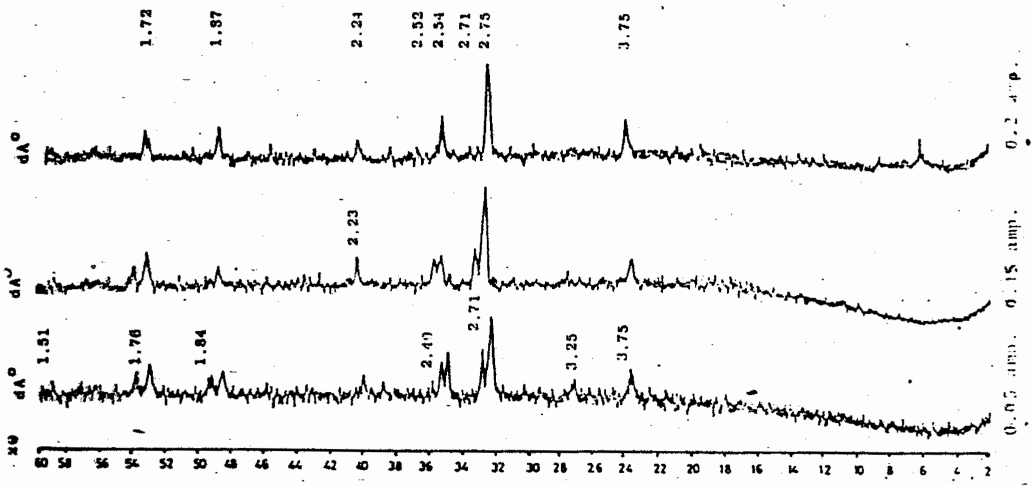

Fig. (3) : X-ray diffraction patterns of the three magnetic fractions of ilmenite separated at 0.05 amp., 0.15 amp. and 0.2 ampere

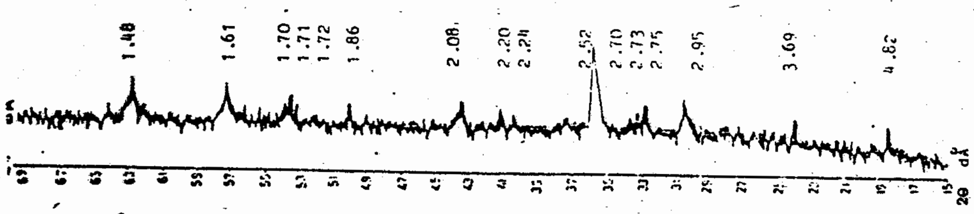

Fig. (2) : X-ray diffraction pattern of magnetite alteration processes, where titanium can enter the magnetite structure and there is a continuous relation between magnetite and the ulvospinel molecule Fe_2TiO_4 (Deer et al., 1979).

Ilmenite: It has an avrage content of 0.43%, the grains are mainly clustered in the very fine sand-grade. To study the alteration of the magnetic ilmenite fractions separated at 0.05 amp., 0.15 amp., 0.20 amp., 0.30 amp., 0.40 amp. and 0.50 amp. (due to magnetic susceptibility), X-ray diffraction patterns of 0.050 amp. and 0.15 amp. reflect to some extent weak lines for ilmenite and detect the presence of the exsolved titani-ferrous magnetite bodies (Fig.3). The intensity lines of ilmenite decrease from moderately magnetic fraction (0.15 amp.) to weakly magnetic fraction (up to 0.30 amp.) in which the crystals of ilmenite is completely destructed as the pattern becomes very close to that of the amorphous state (Stage 2). The line intensities of rutile (Stage 3, as described by Bailey, 1954) get more developed in 0.40 amp., and 0.50 amp. magnetic fractions (Fig.4). Chemical composition for the three strongly, moderately and weakly magnetic fractions of ilmenite reveal differences as the magnetic susceptibilities and the degree of ilmenite alteration differ. The strongly magnetic (fresh ilmenite) is characterized by its low titanium and manganese contents, high iron vanadium and chromium contents and vice-versa for the weakly magnetic fraction (lucoxenated ilmenite).

Rutile: It is recorded in the studied coastal dune sands with an average content of 0.27%. The grains are mainly clusteredin the very fine sand-grade. Mineralogically four varieties are recorded namely. Secondary rutile, niobian rutile ferriferrous rutile and translucent primary (normal) rutile. X-ray diffraction (Figs.5,6) and chemical composition studies show that variations in the physical characteristics of the rutile mineral is due to variations in the chemical composition. Secondary rutile is characterized by its low titanium vanadium and calcium content and relatively high iron and chromium content, contrary to that shown by primary translucent (normal) rutile.

Garnet: It has an average content of 0.08%, the grains are generally subrounded and clustered in the very fine sand-grade. X-ray diffraction pattern illustrates that alamandite is the main garnet variety (Fig.7). Chemical analysis data of the studied dune garnet reveals that the iron content is relatively higher than manganese content confirming X-ray diffraction results.

Zircon: It has an average content of 0.06% and clustered in the very fine sand-grade. The crystals of the

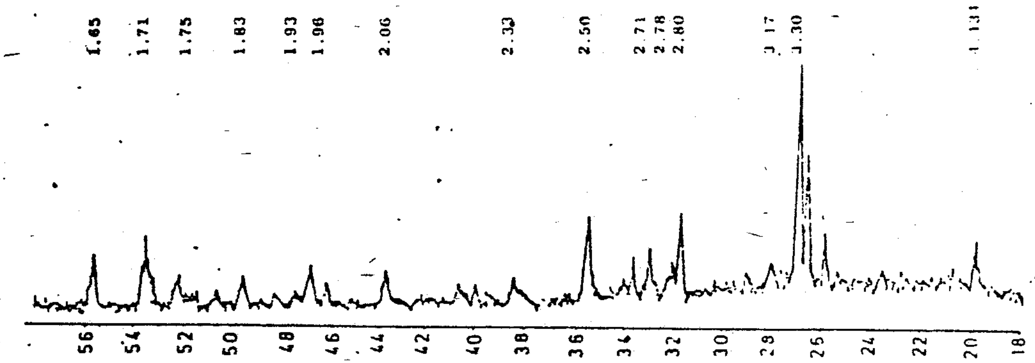

Fig. (8) : X-ray diffraction pattern of zircon concentrate

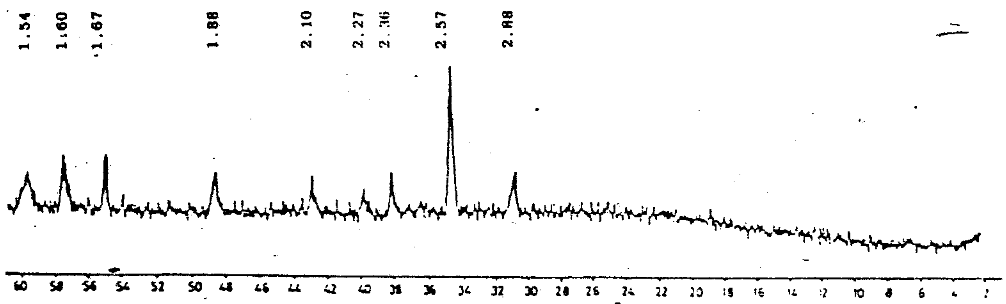

Fig. (7) : X-ray diffraction pattern of Almandite

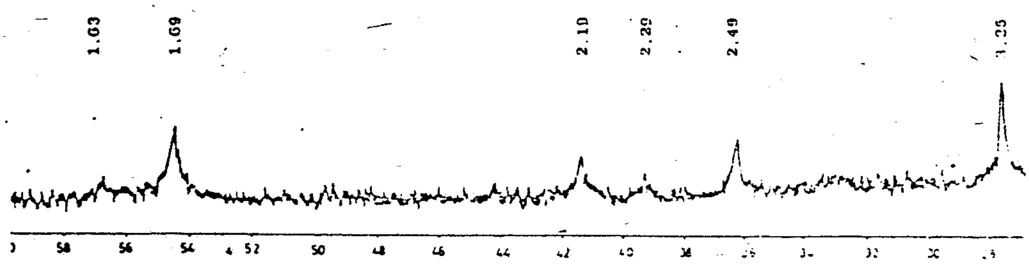

Fig. (6) : X-ray diffraction pattern of normal rutile

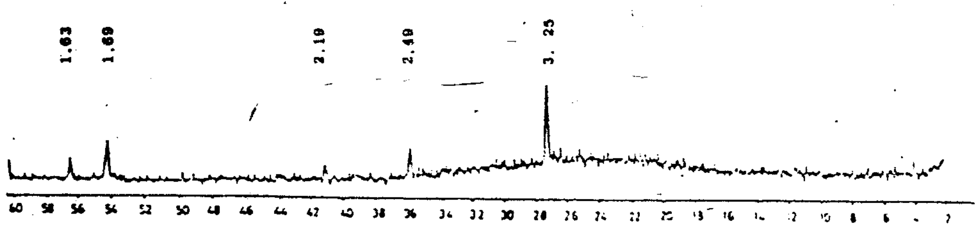

Fig. (5) : X-ray diffraction pattern of secondary rutile

Table 7: Data of spectrographic chemical analysis of the studied economic mineral fractions of coastal dune sands.

Minerals \ Elements		SiO_2	Al_2O_3	CaO	FeO_3	TiO_2	MnO	V_2O_5	Cr_2O_3	K_2O	Cu	Nb	Zr	Hf	U
Magnetite		0.142	0.008	0.934	72.211	24.196	0.430	0.810	0.956	n.d	n.d	n.d	n.d	n.d	n.d
Ilmenite	Strongly magnetic 0.05 amp.	0.080	0.002	0.547	60.808	35.543	0.126	0.909	1.186	n.d	n.d.	n.d.	n.d.	n.d	n.d
	Moderately magn. 0.15 amp.	0.065	0.009	0.390	57.314	41.595	0.537	0.835	0.255	n.d.	n.d	n.d	n.d	n.d	n.d
	Weakly mag. 0.20 amp.	0.086	0.01	0.558	51.655	46.659	0.627	0.200	0.205	n.d.	n.d	n.d	n.d	n.d	n.d
Rutile	Primary	0.064	n.d.	0.691	1.649	96.92	n.d	0.203	n.d	n.d	n.d	n.d	0.185	n.d	n.d
	Secondary	0.292	n.d	0.179	6.670	91.872	n.d	0.137	0.010	n.d.	0.370	0.090	0.350	n.d	n.d
Garnet		42.198	4.427	4.176	31.493	3.085	8.338	2.205	1.271	2.806	n.d	n.d	n.d	n.d	n.d
Zircon		25.26	n.d	1.16	3.29	n.d	0.51	2.36	0.07	n.d.	n.d.	n.d	55.20	4.12	0.42

n.d. not detected .

amber colour zircon variety are well preserved as idiomorphic bipyramid crystals while the other coloured varieties show oval, needle, barrel, subrounded and rounded grains. This phenomenon may be attributed to the ultrastability of amber zircon over the other recorded coloured varieties. Chemical composition confirmed the X-ray diffraction analysis that the orthosilicates of tetravalent zirconium are the main varieties of the zircon group, where the orthosilicates of tetravalent thorium are absent (Fig.8).

Monazite: It is present in a very minor amount. It has average content of 0.003%. The grains are generally rounded to subrounded and mainly clustered in the very fine sand grade.

b) Gangue minerals:

Pyroxenes, amphiboles, tourmaline and staurolite were detected in the studied coastal dune sands and were considered as coloured silicate gangue minerals. Apatite, kyanite, quartz and feldspars are classified as colourless gangue minerals. It is interesting to notice that in the coloured altered iron bearing silicates of olivine, pyroxenes and amphiboles the magnetite was liberated by the action of weathering and alteration composing patches of magnetite inclusions. These inclusions cause an increase in the magnetic susceptibilities of these altered grains to the extent that they can be separated easily with hand magnet.

CONCLUSIONS

The study of the mineralogical characters and chemical composition of the recent coastal dune sands southeast Rosetta city reveals the following:

1. Relative frequencies of the recorded minerals in dune sands reveal that, the conditions of transportation and deposition were locally rather different in the northern dunes than in the southearn dunes, where southwards there is a slight decrease in heavy mineral contents. The dune sand deposits appear to have been derived by wind action from the adjacent beach deposits lying to the north of the studied area.

2. Size analysis for economic minerals indicates that they clustered mainly in the very fine sand grade where the average content of magnetite, hematite, ilmenite, rutile, garnet, zircon and monazite are 0.40%, 0.01%, 0.27%, 0.08%, 0.06% and 0.003% respectively.

3. Chemical analysis confirmed the X-ray diffraction analysis that the studied heavy minerals suffered from alteration processes and variation in physical

characteristics, thus reflecting variation in the chemical composition.

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