

MINERALOGICAL AND CHEMICAL COMPOSITIONS AS CRITERIA FOR THE DIFFERENTIAL
ORIGIN OF THE BOTTOM SEDIMENTS OF MERSA EL-AT, RED SEA, EGYPT

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Key Words: Mineralogy, Chemical Composition, Sediments, Red Sea.

ABSTRACT

A study of mineralogical & chemical compositions of the bottom sediments at Mersa El At embayment was conducted in favour of investigating the effect of both the terrestrial and marine environments upon the embayment; considering the assumption that the terrestrial environment is responsible for silicates and the marine environment for carbonate minerals. Both mineralogical and chemical compositions reveal the presence of carbonate and silicate mineral associations.

The relative abundance of the carbonate minerals is affected greatly by the biogenic constituents and shows no evidence of diagenetic processes. Bottom sediments showed a predominance of carbonate minerals while beach sediments showed a prevalence of silicates. The action of each environment was found to interfere with the effect of the other.

INTRODUCTION

For many decades, the Red Sea has attracted the attention of scientists. Bair and Grossland (1939) presented a description of reefal formation and outlined the topographic nature of the Red Sea. Subsequent studies have been made by Shukri and Higazy (1944 a,b); Mohamed (1949); Said (1950, 1951) and Shukri (1953). Recent studies have been confined to the Red Sea coral reefs and their depositional environment (Friedman, 1965, 1968, Loya and Slobodkin 1971).

El-Sayed (1984) presented an account on the mineralogy and chemistry of the back-reef sediments in a limited area at Hurgada. In his study, Ayalon (1976) divided the west coast of the Gulf of Aqaba according to heavy mineral distributions into four provinces. The distribution patterns and trends of heavy mineral assemblages are correlated with the mineralogy of source rocks. The origin, genesis and nature of the reef sediments of the northern Red sea was studied by El-Samak (1992).

A geochemical study of the bottom and beach sediments of Jubal area was made by El-Askry, et al (1988). Sedimentological and mineralogical composition of unconsolidated sediments in the Jubal strait region were studied by Moussa, et al (1991).

Concerning the study area, Goldberg (1970) and Friedman (1972) discussed the origin and the historical of development of Mersa El-At embayment. Nawar (1989), and Nawar and Deghedy (1989) studied the texture, mineralogy and the carbonate content of Mersa El-At nearshore sediments, while Nawar and Shata (1989) studied the geochemistry of the carbonate fraction of these sediments.

The present work aims to define the differential origin of the bottom sediments of the investigated area in accordance with both mineralogical and chemical compositions.

Geological, Hydrographical and Climate Setting:

Suez and Aqaba Gulfs are two large elongated embayments which are a part of the rift system dividing the African and European plates. The Gulf of Aqaba is about 1800 m deep and occupies the full width of the latest phase of rifting.

According to Wecht et al (1992), there is an annual cycle that develops in a continuous manner in the Gulf of Aqaba, where the water column reaches vertical homogeneity in February and the new thermo-cline begins to develop in March. Both the upper water ($T=21-26^{\circ}\text{C}$, $S=40.3 - 40.8\%$) and deep water ($T=21^{\circ}\text{C}$, $S=40.7\%$) of the Gulf are colder and generally saltier than the corresponding Red Sea water mass. A summary of earlier studies of the region is given by Reiss and Hottinger (1984).

Climate conditions in the region involve high radiation, high evaporation (1cm day^{-1} , Assaf and Kessler 1976). The average annual rainfall ranges from 5 to 25 mm, the majority of which falls in winter within few days (Friedman, 1968).

Study Area:

Mersa El- At embayment lies on the southwestern side of the Gulf of Aqaba. Its position makes it a special case for the study of the effect of the two environments; marine and terrestrial, upon its sediments (Fig.1). The nearshore

MINERALOGICAL AND CHEMICAL COMPOSITIONS OF SEDIMENTS OF MERSA EL-AT.

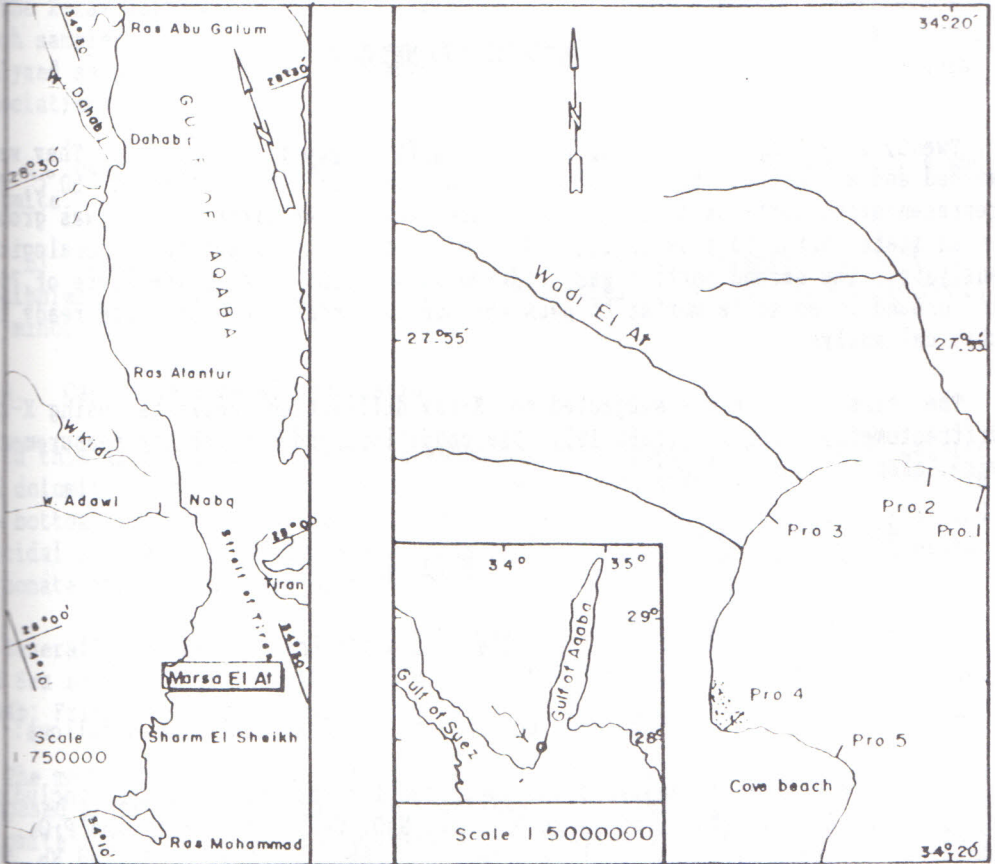


Figure 1: Outline map of Mersa El- At embayment showing locations of sampled profiles.

portion of the embayment has a crescent shape that extends northeast-southwest. Its northern and southern ends are directly fringed seawards with living coral reef terraces, and bordered landwards by quaternary coralline limestone terraces. In the middle part of the embayment, the living reefs are relatively faraway from the shore line compared to the flanks.

MATERIAL AND METHODS

Twenty five samples were collected along five profiles Fig. (1). They were washed and air dried, then redried in an oven at temperature of 50°C. Two representative portions of each sample were taken. The first portion was ground in an agate mortar to pass through 44 u mesh sieve and ready for mineralogical analysis. The second portion was redried in an oven at a temperature of 70°C and ground in an agate mortar to pass through 60 u mesh sieve and made ready for chemical analysis.

The first portion was subjected to X-ray diffraction analysis using X-ray diffractometry, Philips (1060/180). The conditions under which the measurements were taken, are as follows:

Wave length Cu K = 1.54050 Å
 Anode/strain/Cathode/Current = 45KV/25 mA¹
 Filter - nickel
 Sensitivity = 4 x 100 and 10³ counts/second
 Measurements range (2 θ°) = 4-60°

The second portion was subjected to complete chemical analysis as follows:-

The complete chemical analysis was conducted for the major oxides, including SiO₂, TiO₂, Al₂O₃, total iron as Fe₂O₃, MnO, MgO, CaO, Na₂O, K₂O, and P₂O₅, in addition to trace elements including Ba, Zn, Rb, Sr, Ga, Y, Zr and Nb. The analysis was carried out using X-ray florescence. The major oxides were determined in fused tablets by X-ray spectrometric system (Philips Pw 1400) and the trace elements were determined using pressed powder discs.

The samples were mixed in a platinum crucible with di-lithium metaborate spectormelt (Al₂) in a ratio of 1:4 (w/w) and fused in high frequency oven at 1400°C for about 10 min until miscibly homogenous fluid is formed and put in the oven for another 10 min to produce fused tablets. Standardization was based on the U.S.G.S. natural reef standards, G.2, GSP.1, AGV-1, JB-1 and BIR for sandstone, limestone, shale, clay and calcareous reef, respectively.

Both chemical and mineralogical analyses were carried out in Central Laboratory of Karlsruhe University, Germany.

RESULTS AND DISCUSSION

I. Mineralogical composition

The X-ray diffraction pattern of Fig. (2a-c) for the offshore, nearshore and beach samples respectively, indicate well crystalized mineral matrices in all analyzed samples. From the diffractograms, it is noted that the present mineral associations belong to;

a) carbonate mineral association (i.e. aragonite, calcite, Mg-calcite and dolomite).

b) Silicate mineral association (i.e. quartz, feldspars), Table (1). Amphiboles and evaporites appear in some localities, i.e. Cove beach sediments as minor constituent.

A. Carbonate mineral association:

In this association the relative abundance of aragonite, Mg-calcite, calcite and dolomite vary. Dolomite appears in some localities as minor constituent in the bottom sediments. El-Sayed (1984) has studied some of the intertidal and subtidal sediments from Hurgada and has shown that aragonite is the dominant carbonate mineral followed by high Mg-calcite.

Generally, the reefal and carbonate sediments in the different areas of the Red Sea show more or less the same mineralogical assemblages (Shukri and Higazy, 1944b; Friedman, 1968; Behairy, 1980; Behairy, et al, 1983 and Rao, 1983).

The marine bottom sediments in the area of investigation Profile (1) were composed principally of aragonite, followed by high Mg-calcite, calcite and dolomite (Table 1). This table reveals the relative abundance of the carbonate minerals. The relative distribution of the carbonate minerals can be ascribed to the disintegration of coral terraces in this area.

According to El-Sayed (1984) aragonite is produced originally from corals and fragments of carbonate-producing green algae, e.g. Halimeda species as well as from inorganic carbonate precipitation. Mg-calcite is produced mostly from the rigid framework of reef building coralline algae and molluscs along with aragonite.

In Profile (2), with decreasing water depth, it is observed that calcite and Mg-calcite constitute the major part followed by aragonite and traces of dolomite (averages 20, 16, 12 and 2%), respectively. Such variation in the relative abundance of the carbonate minerals can be related to the dominance of algal fragments which are composed mainly of Mg-calcite.

Table (1): Relative Abundance of the Different Minerals in the Sediment of Mersa El At.

Prof. No.	S.No.	Arag%	Cal%	Mg-Cal%	Dolomite%	Mole% of MgCO ₃ in HMg	Quartz	Orthoclase
1	1	20.3	17.6	26.5	4.4	18.00	15.8	9.2
	2	2.2	11.9	2.9	1.9	22.00	46.0	19.8
	3	39.7	10.8	32.6	3.3	18.00	6.8	3.2
	4	39.0	11.5	36.5	-	22.00	6.6	2.2
	Average	25.3	13.0	24.6	2.4	20.0	18.8	8.6
2	5	11.0	17.2	9.8	2.1	8.00	34.4	17.3
	6	10.66	19.5	10.1	2.3	22.00	33.3	16.3
	7	8.5	21.8	12.3	2.1	12.00	29.0	18.5
	8	3.1	28.7	24.7	1.4	33.00*	21.0	14.3
	9	18.20	20.2	19.5	1.7	18.00	20.5	13.4
	10	22.6	12.9	19.9	1.2	12	21.5	13.3
Average	12.3	20.1	16.1	1.8	21.0	26.6	15.5	
3	11	7.7	13.4	3.5	3.1	14.0	36.4	19.4
	12	4.0	3.9	3.7	1.6	12.00	46.2	28.9
	13	3.5	7.5	2.6	1.5	22.00	47.0	24.2
	14	10.0	4.5	5.7	1.4	12.0	40.66	25.1
	Average	6.3	7.3	3.9	1.9	15.0	42.6	24.4
4	15	3.6	2.4	1.0	1.4	22.0	46.8	31.3
	16	4.8	4.8	3.5	2.5	12.0	44.3	24.8
	17	6.00	4.7	3.1	2.1	19.0	43.2	25.9
	Average	4.8	4.00	2.5	2.00	18.0	44.8	27.3
5	18	5.9	3.3	5.3	2.6	12.00	44.5	24.3
	19	-	4.4	2.3	1.7	18.00	50.0	28.8
	20	10.8	3.6	2.6	3.8	18.00	39.4	19.4
	21	-	2.3	3.00	2.2	11.0	52.5	29.0
	22	3.9	3.9	2.9	-	12	47.3	27.1
	23	-	4.8	-	3.8	-	47.0	25.4
	24	-	4.9	-	2.4	-	51.4	30.0
	25	-	2.2	2.7	1.8	22.0	53.2	28.8
	Average	1	4.7	2.8	2.0	12	48.1	26.6

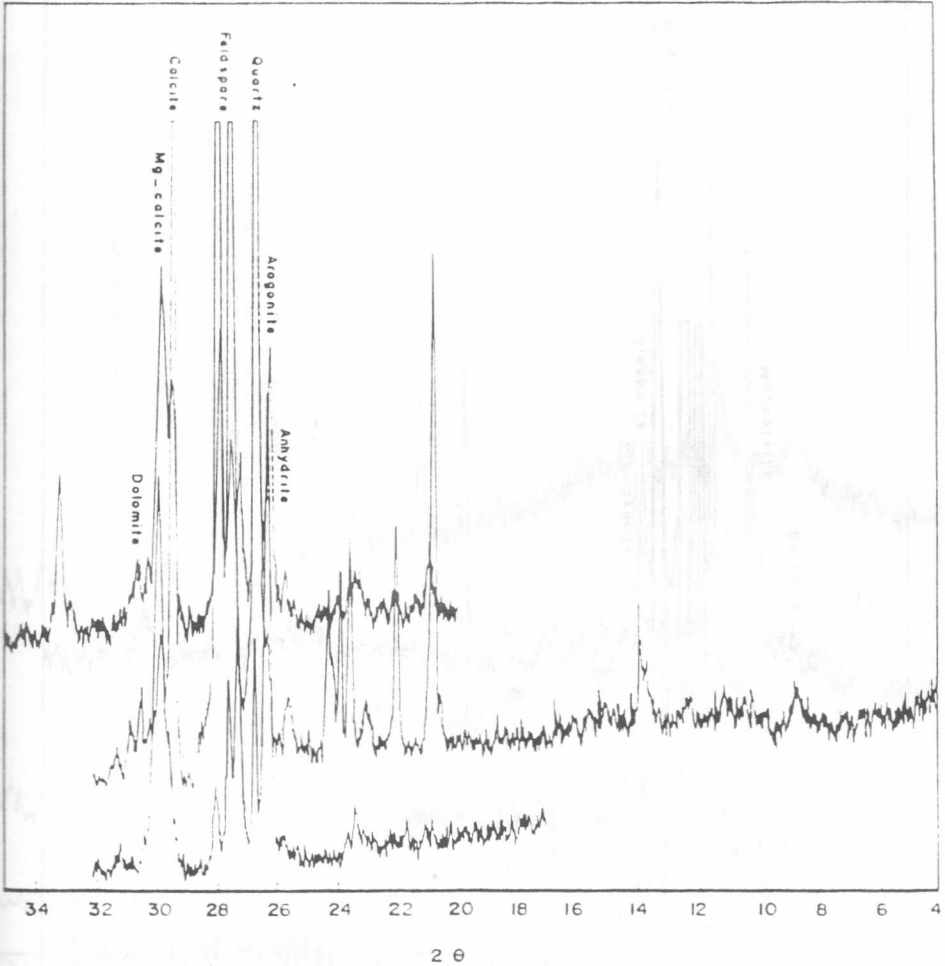


Figure 2a: X - ray diffraction patterns of offshore sediments.

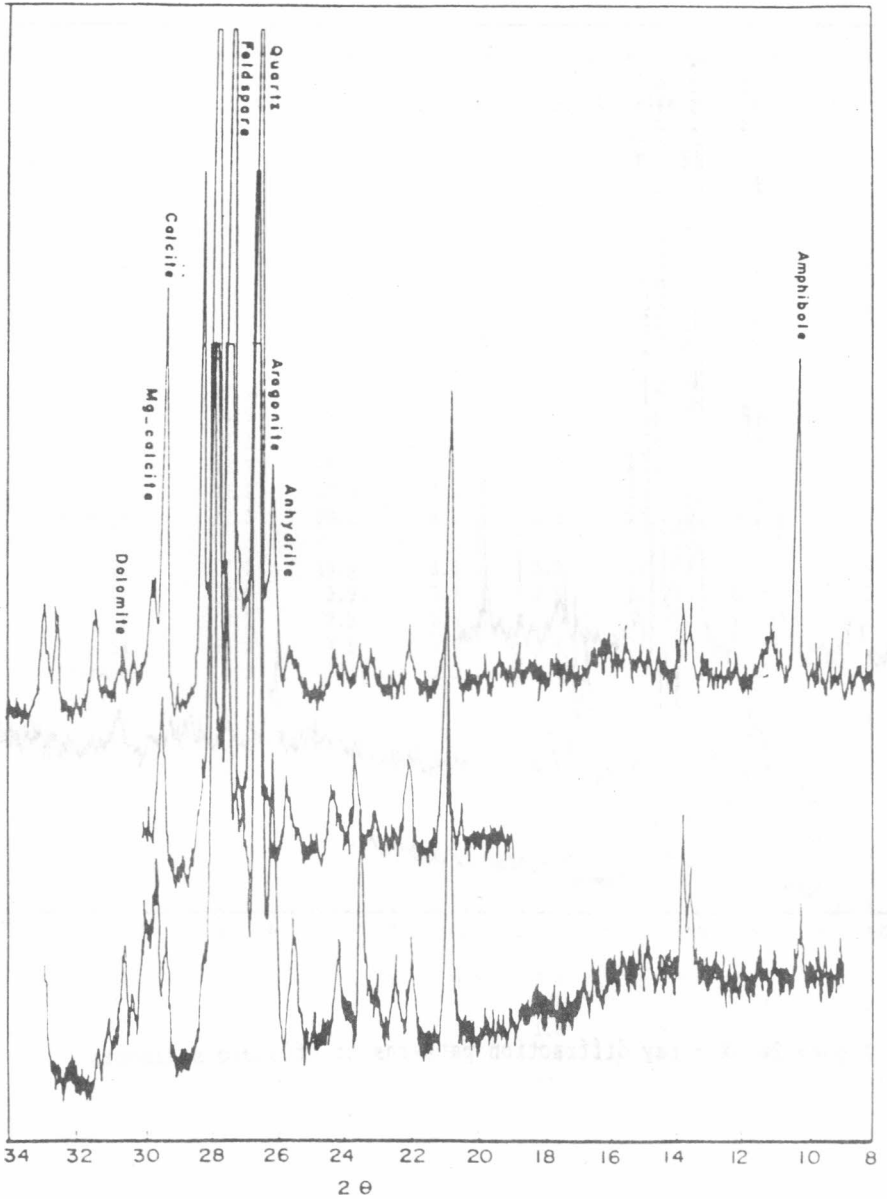


Figure 2b: X - ray diffraction patterns of nearshore sediments.

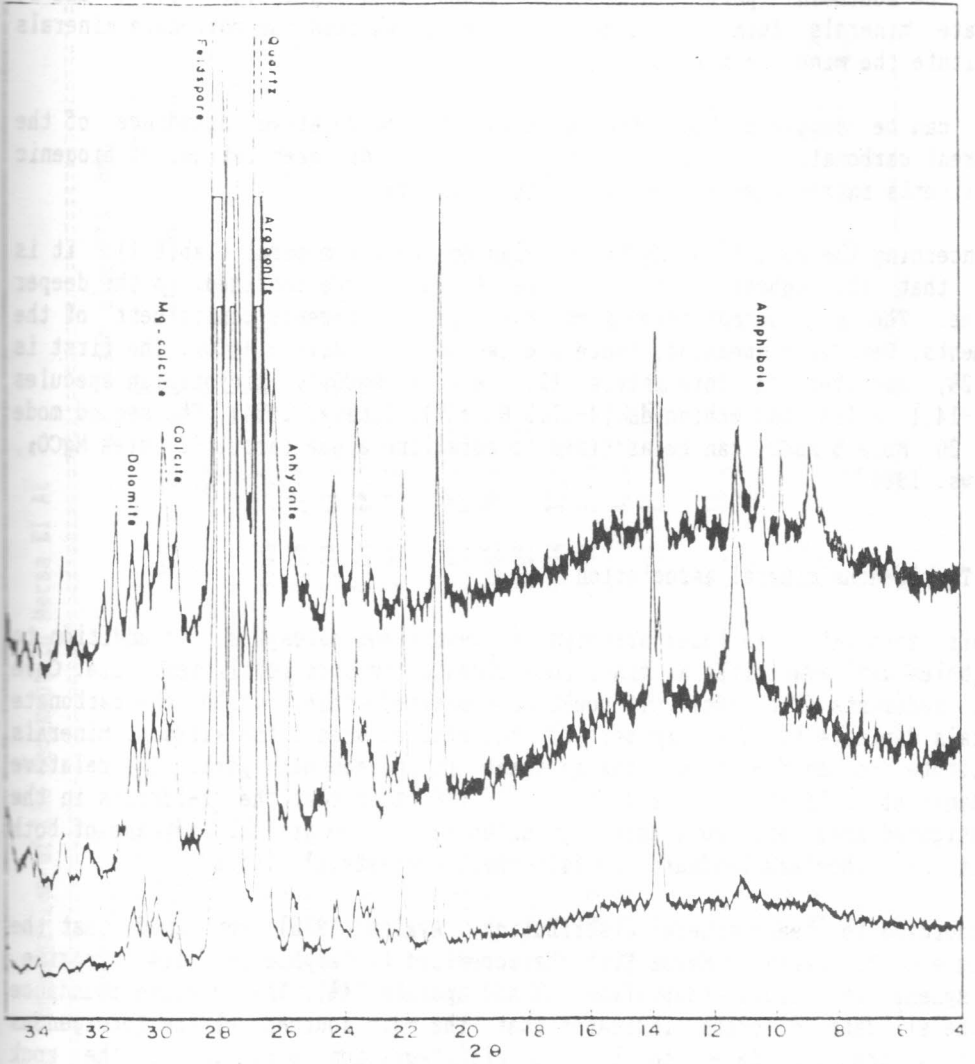


Figure 2c: X - ray diffraction patterns of cove beach sediments.

In the southern part of the investigated area (profiles; 3, 4 and 5) silicate minerals form the major constituent; whereas the carbonate minerals constitute the minor constituent.

It can be suggested that the variation in the relative abundance of the different carbonate minerals is attributed to the differentiation of biogenic constituents rather than to the diagenetic processes.

Concerning the Mole % of $MgCO_3$ in high Mg-calcite mineral (Table 1), it is found that the highest values of Mole % $MgCO_3$ are confined to the deeper samples. The Mg content depends on the type of biogenic constituent of the sediments. Generally speaking, there are two modes of Mole % $MgCO_3$. The first is at 12%, ascribed to foraminifera (12.7 Mole % $MgCO_3$), Alcyonarian specules (11.2-14.1 Mole% and echinoids (4-11.5 Mole %), (Chave, 1954). The second mode is at 20 Mole % $MgCO_3$; can be ascribed to coralline algae (about 22 Mole% $MgCO_3$, Mathews, 1966).

B. Terrigenous mineral association

This association includes principally quartz and feldspars, in addition to amphiboles and evaporites as minor constituents in some localities, i.e. Cove beach sediments (Fig. 2c). It could be observed that, while the carbonate minerals dominate the northern part of the studied area, the silicate minerals constitute the major part of the sediment in the southern part. The relative abundance of silicate minerals (Table 1) indicates that the feldspars in the investigated area are represented by orthoclase. The gradual increase of both quartz and orthoclase landwards reveals their terrestrial origin.

According to heavy mineral distribution, Ayalon (1976) mentioned that the province of Ras Barka to Mersa Elat characterized by (amphibole, 18%; pyroxine, 12%; sphene, 8%; zircon, tourmaline, 4% and apatite, 4%). The relative abundance of the silicate minerals indicates that the main sources of the terrigenous materials are considered to be the disintegration products of the rock fragments. Nawar (1988) mentioned that the sands of Cove province are in fact, products of Sharm El-Sheikh sandstones conglomerates and breccia filling deposits of Pre-Pleistocene age and quaternary coralline limestones.

II. Chemical Compositions

Table (2) illustrates the distribution of major and trace elements in bottom sediments of Mersa El- At embayment. Similar to the analysis in mineral association terms (carbonate and silicate associations), it is preferable to divide chemically the measured elements into:

- a) carbonate associated elements, and
- b) silicate associated elements.

Table (2): Complete Chemical Composition of the Sediment in Mersa El At

Prof No.	St. No.	Depth m	Major elements %										Trace elements (ppm)									
			CaO	MgO	SrO	SiO ₂	Al ₂ O ₃	Na ₂ O	K ₂ O	Fe ₂ O ₃	TiO ₂	P ₂ O ₅	I.l ppm	Mn	Zn	Ba	Ga	Rb	Y	Zr	Nb	
1	1	5.0	39.3	2.4	0.4	15.1	2.4	1.1	1.1	0.4	0.10	0.05	36.5	128.0	45	104	0.0	31	17	0.00	14	
	2	6.5	12.1	1.6	0.1	56.1	9.8	3.6	2.6	3.1	0.10	0.06	10.4	27.0	85	320	7.0	77	34	344	25	
	3	10.0	46.3	1.9	0.5	5.6	0.6	0.6	0.4	0.2	0.05	0.04	43.2	401.0	41	51	0.0	11	10	0.00	4	
	4	10.0	45.5	1.8	0.6	4.9	0.4	0.7	0.3	0.2	0.05	0.05	44.9	27.0	45	51	0.0	6	9	0.00	6	
	Average			35.8	1.9	0.4	20.4	3.3	1.5	1.1	1.0	0.08	0.05	33.8	146.0	54	132	1.8	31	18.0	86	12
2	5	B.	26.9	1.4	0.3	36.2	5.4	1.7	2.3	0.7	0.14	0.05	23.8	300.0	48	189	0.0	66	17	00	14	
	6	0.5	28.4	1.5	-	34.7	5.0	1.6	2.2	0.7	0.14	0.05	24.2	-	-	-	-	-	-	-	-	
	7	5.0	29.3	1.8	0.2	32.1	5.5	1.7	2.6	0.5	0.07	0.05	25.9	449.0	50	248	0.0	67	11	0.0	9	
	8	5.0	35.4	1.9	0.3	21.5	3.9	1.4	1.8	0.3	0.06	0.04	32.6	27.4	43	153	0.0	53	11	0.00	10	
	9	5.0	36.4	1.9	0.1	20.7	3.5	1.3	1.7	0.3	0.05	0.04	32.3									
2	10	9.0	35.8	1.6	0.4	21.5	3.8	1.7	1.6	0.5	0.10	0.05	32.6	19.5	45	145	0.0	46	14	0.00	9	
	Average			32.0	1.7	0.3	27.8	4.5	1.6	2.0	0.5	0.10	0.05	28.6	199.0	47	184	0.0	58	13	0.00	11
	3	11	B.	19.9	1.1	0.3	41.1	7.6	2.6	2.5	6.0	1.40	0.11	16.2	16.0	126	228	1	74	79	1021	71
		12	B.	10.5	0.5	0.1	59.3	10.6	3.0	4.5	0.9	0.20	0.04	8.7	305.0	56	356	14	131	19	169	16
		13	2.0	7.7	1.7	0.6	59.4	11.0	2.8	3.4	4.2	0.80	0.20	7.3	70.0	107	373	12	103	50	1254	38
14		3.0	16.4	0.8	0.2	49.1	9.4	2.8	3.6	1.9	0.30	0.07	14.0	7.0	68	295	4	104	29	222	23	
Average			13.6	1.0	0.3	52.2	9.7	2.8	3.5	3.2	0.67	0.10	11.6	115.0	89	313	8	103	44	667	37	

Table (2) cont.

Prof No.	St. No.	Depth m	Major elements %										Trace elements (ppm)									
			CaO	MgO	SrO	SiO ₂	Al ₂ O ₃	Na ₂ O	K ₂ O	Fe ₂ O ₃	TiO ₂	P ₂ O ₅	I.l ppm	Mn	Zn	Ba	Ga	Rb	Y	Zr	Nb	
4	15	0	6.9	0.4	0.1	63.5	12.5	3.6	5.0	0.8	0.10	0.04	5.9	67.0	53	381	20	104	17	95	15	
	16	23.0	10.6	1.1	0.1	55.1	11.0	3.2	3.4	4.1	0.70	0.13	9.1	108.0	100	341	16	109	37	656	28	
4	17	5.0	11.7	0.9	0.2	54.9	11.3	3.5	3.6	2.4	0.41	0.10	8.0	28.7	83	319	15	108	31	230	24	
	Average		9.7	0.8	0.13	57.8	11.6	3.4	4.0	2.4	0.40	0.09	77.0	68.0	79	347	17	107	28	327	22	
5	18	-	12.4	1.0	0.1	55.4	10.8	3.2	3.4	2.5	0.45	0.13	11.1	132.0	89	308	13.0	95	33	327	24	
	19	-	6.7	0.4	0.1	64.9	11.7	3.3	4.4	1.3	0.18	0.06	5.5	194.0	62	357	17.0	128	22	180	17	
	20	-	14.3	1.1	0.2	45.2	8.6	2.7	2.4	10.5	2.30	0.16	11.5	272.0	165	206	6.0	70	128	1793	112	
	21	-	5.4	0.5	0.05	68.1	10.7	2.9	4.8	0.8	0.12	0.04	5.2	328.0	52	430	10.0	123	17	147	14	
	22	-	8.3	0.6	0.1	61.8	12.0	3.7	4.0	2.0	0.32	0.08	6.8	250.0	72	348	14.0	110	33	229	24	
	23	-	8.6	0.7	0.1	59.2	11.0	3.2	3.7	4.6	0.90	0.08	61.0	344.0	91	350	14.0	105	53	734	54	
	24	-	5.5	0.4	0.05	68	11.3	3.0	4.9	0.7	0.11	0.04	4.9	221.0	50	439	15.0	126	15	134	12	
	25	-	2.7	0.3	0.04	71.5	12.5	3.4	4.8	1.5	0.24	0.06	2.2	768.0	61	430	19.0	132	23	224	21	
	Average		8.0	0.6	0.1	61.8	11.1	3.2	4.1	3.0	0.58	0.08	6.7	314.0	80	359	13.5	111	40.5	471	35	

Il = ignition loss

B. = Beach

Table (2): Complete Chemical Composition of the Sediment in Mersa El At

		Major elements %											Trace elements (ppm)									
Prof No.	St. No.	Depth m	CaO	MgO	SrO	SiO2	Al2O3	Na2O	K2O	Fe2O3	TiO2	P2O5	I.l ppm	Mn	Zn	Ba	Ga	Rb	Y	Zr	Nb	
1	1	5.0	39.3	2.4	0.4	15.1	2.4	1.1	1.1	0.4	0.10	0.05	36.5	128.0	45	104	0.0	31	17	0.00	14	
	2	6.5	12.1	1.6	0.1	56.1	9.8	3.6	2.6	3.1	0.10	0.06	10.4	27.0	85	320	7.0	77	34	344	25	
	3	10.0	46.3	1.9	0.5	5.6	0.6	0.6	0.4	0.2	0.05	0.04	43.2	401.0	41	51	0.0	11	10	0.00	4	
	4	10.0	45.5	1.8	0.6	4.9	0.4	0.7	0.3	0.2	0.05	0.05	44.9	27.0	45	51	0.0	6	9	0.00	6	
	Average			35.8	1.9	0.4	20.4	3.3	1.5	1.1	1.0	0.08	0.05	33.8	146.0	54	132	1.8	31	18.0	86	12
2	5	B.	26.9	1.4	0.3	36.2	5.4	1.7	2.3	0.7	0.14	0.05	23.8	300.0	48	189	0.0	66	17	00	14	
	6	0.5	28.4	1.5	-	34.7	5.0	1.6	2.2	0.7	0.14	0.05	24.2	-	-	-	-	-	-	-	-	
	7	5.0	29.3	1.8	0.2	32.1	5.5	1.7	2.6	0.5	0.07	0.05	25.9	449.0	50	248	0.0	67	11	0.0	9	
	8	5.0	35.4	1.9	0.3	21.5	3.9	1.4	1.8	0.3	0.06	0.04	32.6	27.4	43	153	0.0	53	11	0.00	10	
	9	5.0	36.4	1.9	0.1	20.7	3.5	1.3	1.7	0.3	0.05	0.04	32.3									
2	10	9.0	35.8	1.6	0.4	21.5	3.8	1.7	1.6	0.5	0.10	0.05	32.6	19.5	45	145	0.0	46	14	0.00	9	
	Average			32.0	1.7	0.3	27.8	4.5	1.6	2.0	0.5	0.10	0.05	28.6	199.0	47	184	0.0	58	13	0.00	11
	3	11	B.	19.9	1.1	0.3	41.1	7.6	2.6	2.5	6.0	1.40	0.11	16.2	16.0	126	228	1	74	79	1021	71
		12	B.	10.5	0.5	0.1	59.3	10.6	3.0	4.5	0.9	0.20	0.04	8.7	305.0	56	356	14	131	19	169	16
		13	2.0	7.7	1.7	0.6	59.4	11.0	2.8	3.4	4.2	0.80	0.20	7.3	70.0	107	373	12	103	50	1254	38
14		3.0	16.4	0.8	0.2	49.1	9.4	2.8	3.6	1.9	0.30	0.07	14.0	7.0	68	295	4	104	29	222	23	
Average			13.6	1.0	0.3	52.2	9.7	2.8	3.5	3.2	0.67	0.10	11.6	115.0	89	313	8	103	44	667	37	

Table (2) cont.

Prof No.	St. No.	Depth m	Major elements %										Trace elements (ppm)									
			CaO	MgO	SrO	SiO ₂	Al ₂ O ₃	Na ₂ O	K ₂ O	Fe ₂ O ₃	TiO ₂	P ₂ O ₅	I.I ppm	Mn	Zn	Ba	Ga	Rb	Y	Zr	Nb	
4	15	0	6.9	0.4	0.1	63.5	12.5	3.6	5.0	0.8	0.10	0.04	5.9	67.0	53	381	20	104	17	95	15	
	16	23.0	10.6	1.1	0.1	55.1	11.0	3.2	3.4	4.1	0.70	0.13	9.1	108.0	100	341	16	109	37	656	28	
4	17	5.0	11.7	0.9	0.2	54.9	11.3	3.5	3.6	2.4	0.41	0.10	8.0	28.7	83	319	15	108	31	230	24	
	Average		9.7	0.8	0.13	57.8	11.6	3.4	4.0	2.4	0.40	0.09	77.0	68.0	79	347	17	107	28	327	22	
5	18	-	12.4	1.0	0.1	55.4	10.8	3.2	3.4	2.5	0.45	0.13	11.1	132.0	89	308	13.0	95	33	327	24	
	19	-	6.7	0.4	0.1	64.9	11.7	3.3	4.4	1.3	0.18	0.06	5.5	194.0	62	357	17.0	128	22	180	17	
	20	-	14.3	1.1	0.2	45.2	8.6	2.7	2.4	10.5	2.30	0.16	11.5	272.0	165	206	6.0	70	128	1793	112	
	21	-	5.4	0.5	0.05	68.1	10.7	2.9	4.8	0.8	0.12	0.04	5.2	328.0	52	430	10.0	123	17	147	14	
	22	-	8.3	0.6	0.1	61.8	12.0	3.7	4.0	2.0	0.32	0.08	6.8	250.0	72	348	14.0	110	33	229	24	
	23	-	8.6	0.7	0.1	59.2	11.0	3.2	3.7	4.6	0.90	0.08	61.0	344.0	91	350	14.0	105	53	734	54	
	24	-	5.5	0.4	0.05	68	11.3	3.0	4.9	0.7	0.11	0.04	4.9	221.0	50	439	15.0	126	15	134	12	
	25	-	2.7	0.3	0.04	71.5	12.5	3.4	4.8	1.5	0.24	0.06	2.2	768.0	61	430	19.0	132	23	224	21	
	Average		8.0	0.6	0.1	61.8	11.1	3.2	4.1	3.0	0.58	0.08	6.7	314.0	80	359	13.5	111	40.5	471	35	

II = ignition loss

B. = Beach

A. Carbonate associated elements:

They are also referred to as biogenic elements, including Ca, Mg, Sr and probably Mn.

It is observed that CaO % attains its maximum value, 46.3%, in the northern profile (No. 1), then gradually decreases to the minimum (2.7%) at the southern profile (NO. 5). This gradual decrease in CaO% can be attributed to the variation of the sediment-type along the embayment. Moreover, water depth is considered as a controlling factor.

Similarly, MgO shows the same pattern of distribution as CaO, whereas it shows its maximum value (2.4%) at profile No.1 and attains its minimum (0.3%) at profile No. 5. The variation in MgO content related ultimately to the present carbonate mineral form which can be attributed either to the biogenic constituent or to the physico-chemical transformation. In the area of investigation, the variation in MgO reveals the relative abundance of different biogenic constituents of the sediments.

SrO% ranges from 0.7% at the northern profile (No.1) to 0.04% in profile No. 4. The significantly high concentrations of strontium content in the carbonate sediments has been discussed by several authors as Sigel (1961) and Stehli and Hower (1961). The latter reported several 1000 ppm of strontium in recent carbonate sediments. Strontium variations depend to a large extent on the relative abundance of aragonite.

Manganese attains its maximum concentrations (768 ppm) at the southern part of the investigated area and records its lowest (16 ppm) in the northern part. This distribution pattern reveals that Mn is not linked with the carbonate minerals but with silicates. It may be adsorbed onto the surface of feldspars.

B. Silicate associated elements:

They are also referred to as terrigenous elements including SiO₂, Al₂O₃, K₂O, Na₂O, TiO₂ and Fe₂O₃. In contrast to CaO, it has been found that SiO₂ increases gradually from northern to the southern part of the investigated area suggesting presence of two sediment types, carbonates and silicates. SiO₂ ranges from 4.9% in the northern part to 71.5% in the southern part.

Al₂O₃ follows the same distribution pattern of SiO₂. It varies from minimum values (0.4%) in profile 1 to maximum value (12.5%) in Profile 5. K₂O and Na₂O also show the same pattern of distribution as SiO₂ and Al₂O₃, suggesting their share in building of the present feldspar, i.e. orthoclase.

Fe_2O_3 distribution reveals an irregular variation. It is dependent neither on carbonate, nor on silicate associated elements. The high concentrations of iron in the southern part of the investigated area can be attributed mostly to the contribution of terrigenous fragments.

TiO_2 attains its maximum value 2.3% at profile No. 5. The variation of TiO_2 linked with that of Fe_2O_3 reflects the coexistence of magnetite and rutile, Fig. (3), which are in fact, products of disintegration of the source rock in the area of investigation.

In general, the measured trace elements attains their maximum values in the southern part of the area of investigation, which may suggest that the mineralization processes predominated in this part of the study area.

Correlation analysis:

The correlation analysis was run to illustrate the different links of the mineral associations. It reveals that Ca, Mg and Sr are incorporated in the crystal lattice of carbonate minerals (Fig.4a-c), while K, Na,Al with Si form the present type of feldspar, i.e. orthoclase (Fig.5a-c). Ba links in its presence with the silicate and it seems to be adsorbed onto the surface of feldspar (Fig. 6a-c).

Concerning the trace elements, strong correlations between Zn, Zr, Nb, Y and Fe were observed suggesting their coexistence with magnetite (Fig. 7a-d). Rb reveals its adsorption on the surface of the feldspars (Fig. 8a-b).

The correlation between the biogenic and terrestrial elements reflects the presence of two different sources of the sediments in the area of investigation, namely; marine and terrestrial.

CONCLUSION

Both mineralogical and chemical analyses reveal the presence of an inverse relationship between carbonate and silicate mineral associations. This illustrates that there are two environments affecting the dominant sediment types:

a) marine environment, which is responsible for the predominance of carbonate minerals in the bottom sediments; and

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b) terrestrial environment, that is acting for the dominance of terrigenous material in the Cove beach sediments. The action of both environments are interfering together. There is no evidence for the diagenetic processes, but the mineralogical composition is greatly affected by carbonate/terrigenous contribution.

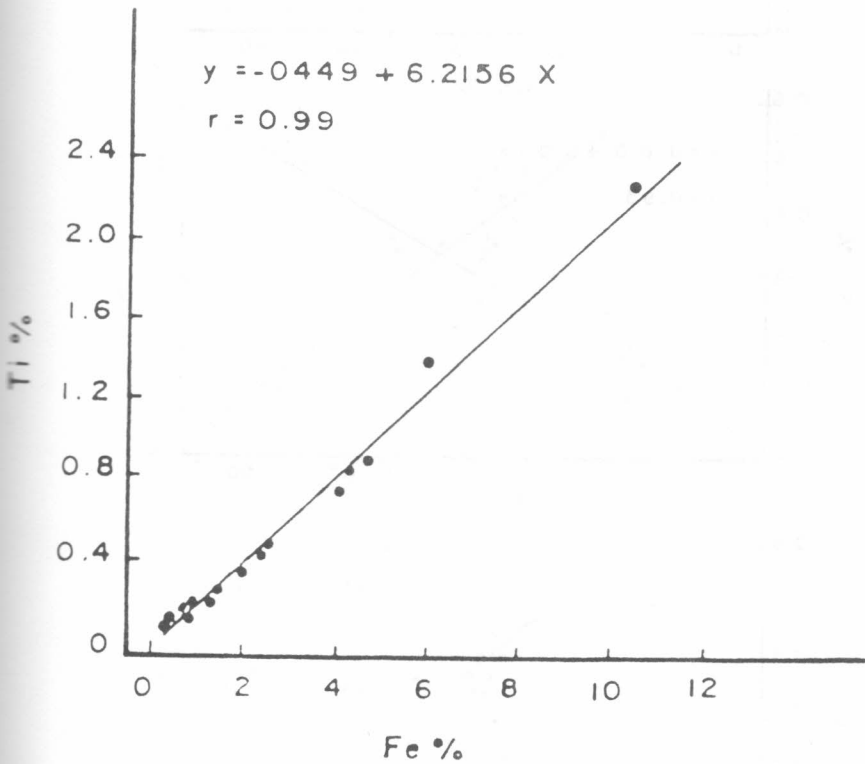


Figure 3: Iron versus Titanium in the bottom sediments of the studied area.

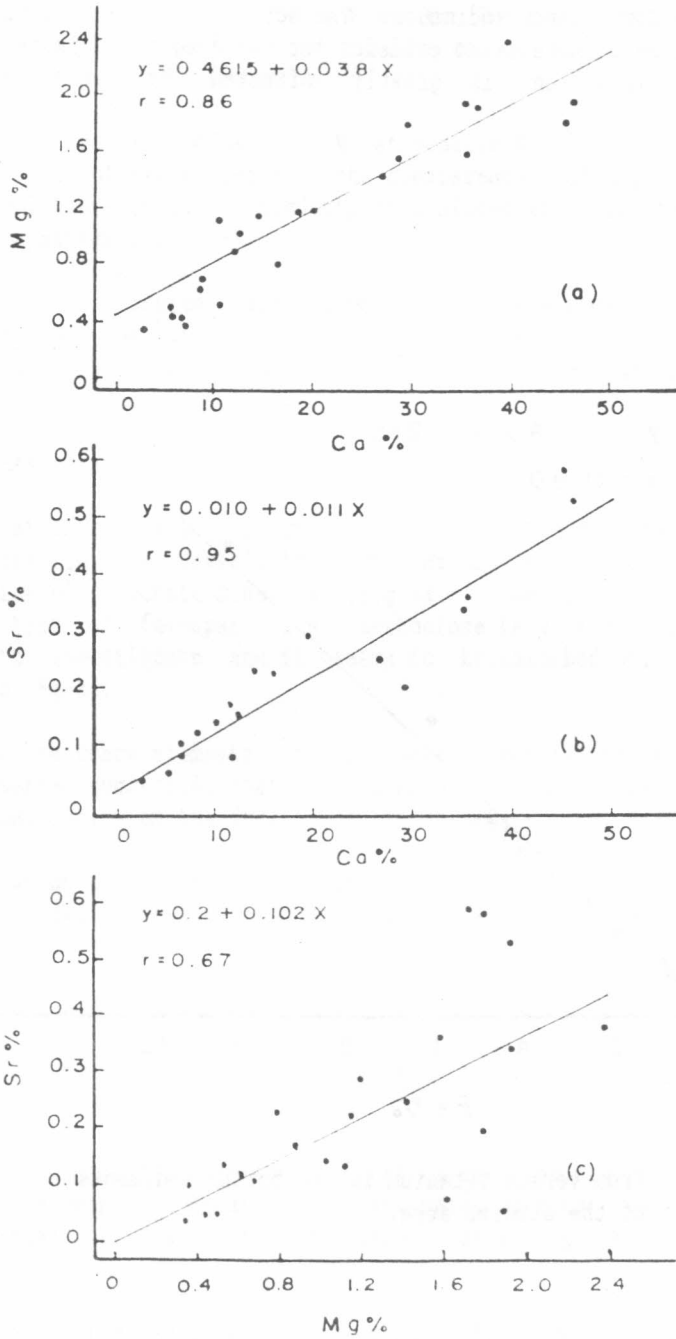


Figure (4 a-c): Biogenic elements interrelations in the bottom sediments of the studied area.

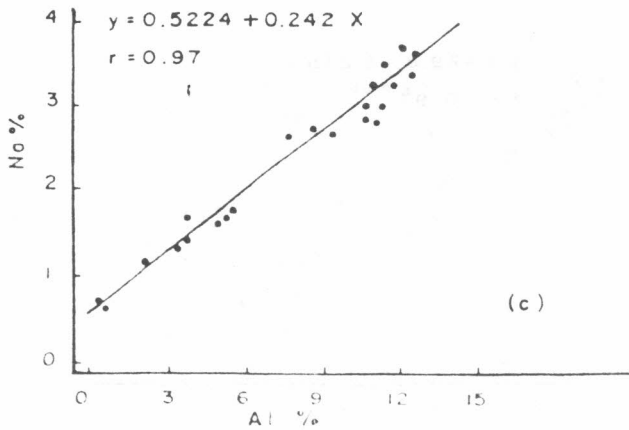
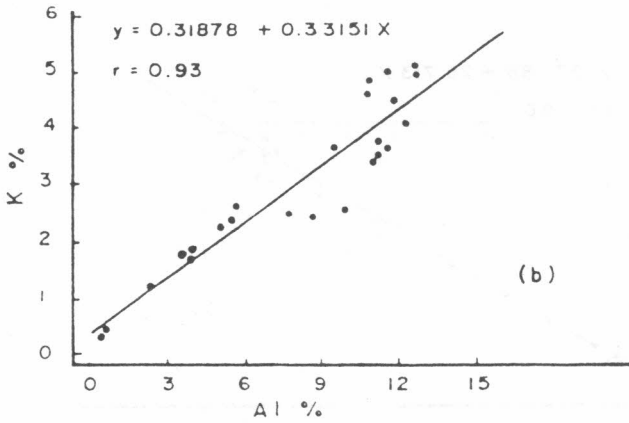
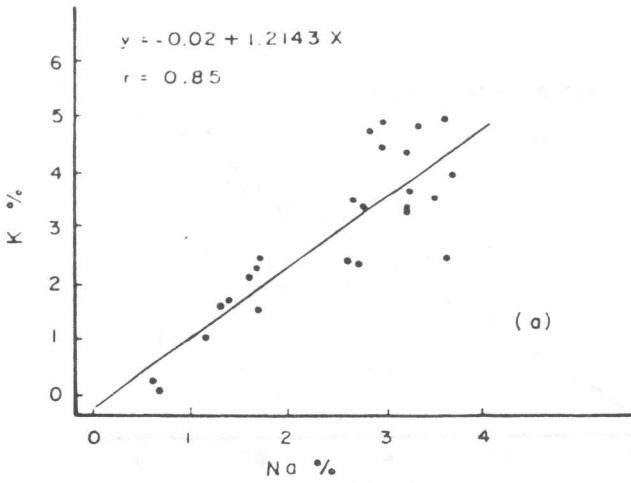


Figure (5 a-c): Terrigenous elements interrelations.

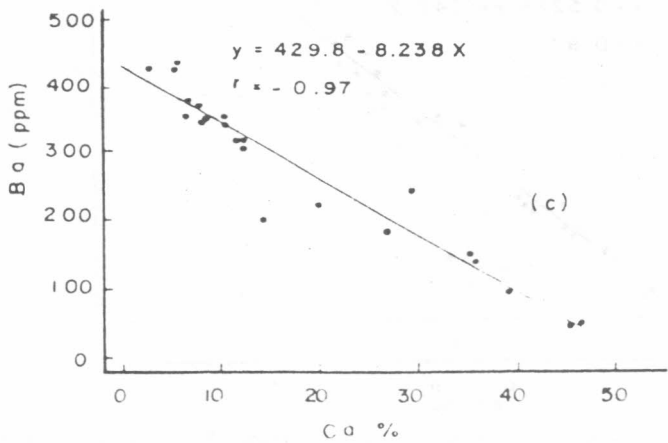
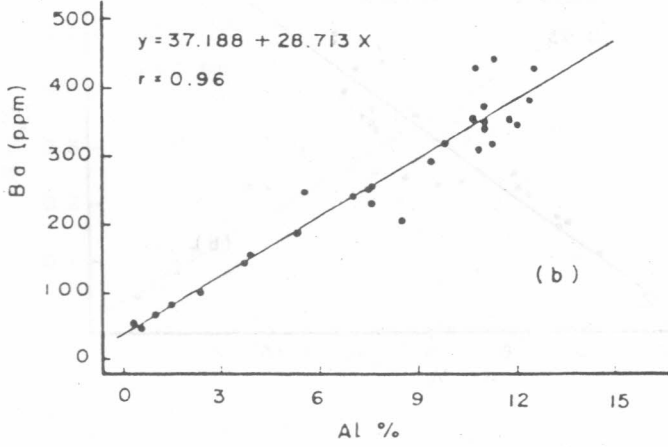
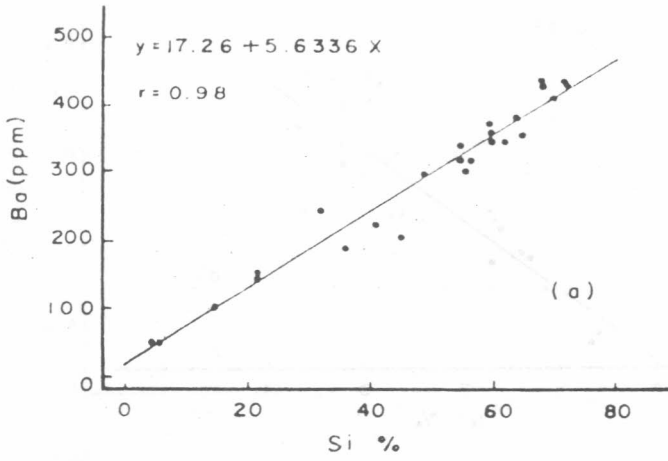


Figure (6 a-c): Barium - Carbonates and Silicates relations.

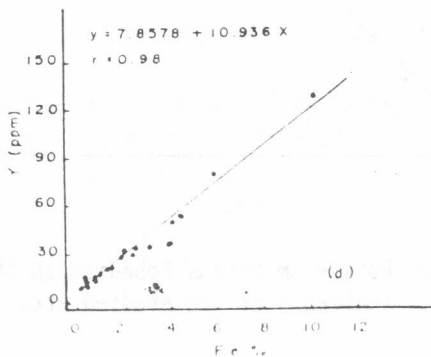
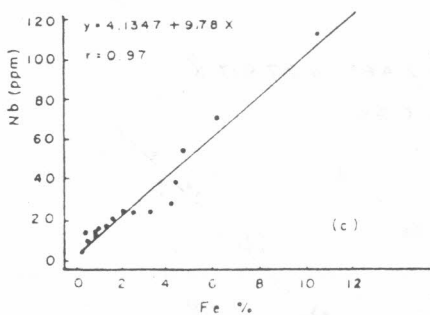
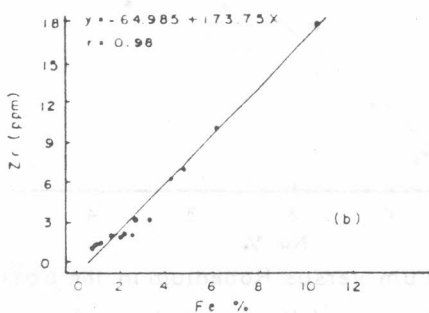
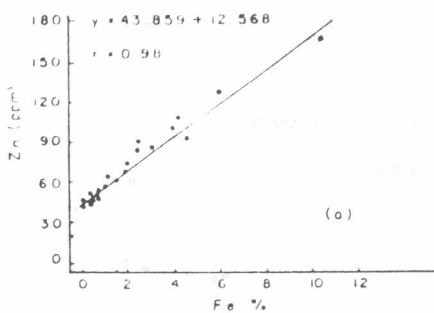


Figure (7 a-d): Trace elements - Iron relations.

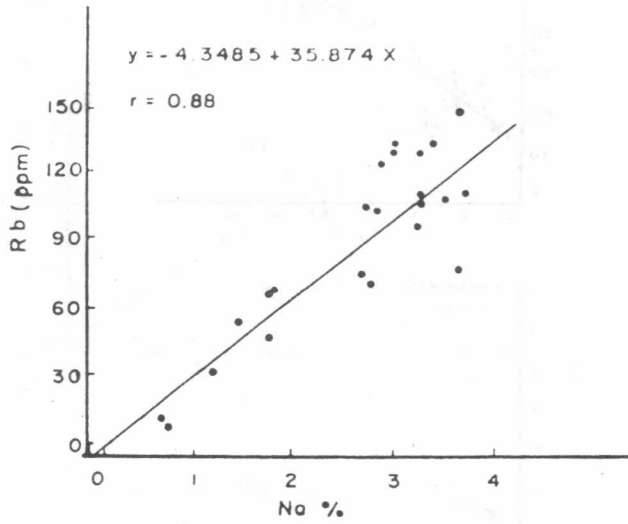


Fig.8a: Sodium versus Roberidium in the bottom sediments of the studied area.

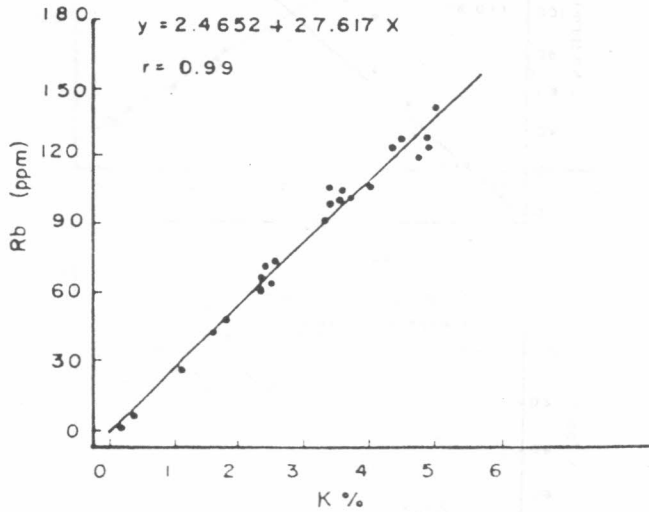


Figure (8 b: Potassium versus Roberidium in the bottom sediments of the studied area.

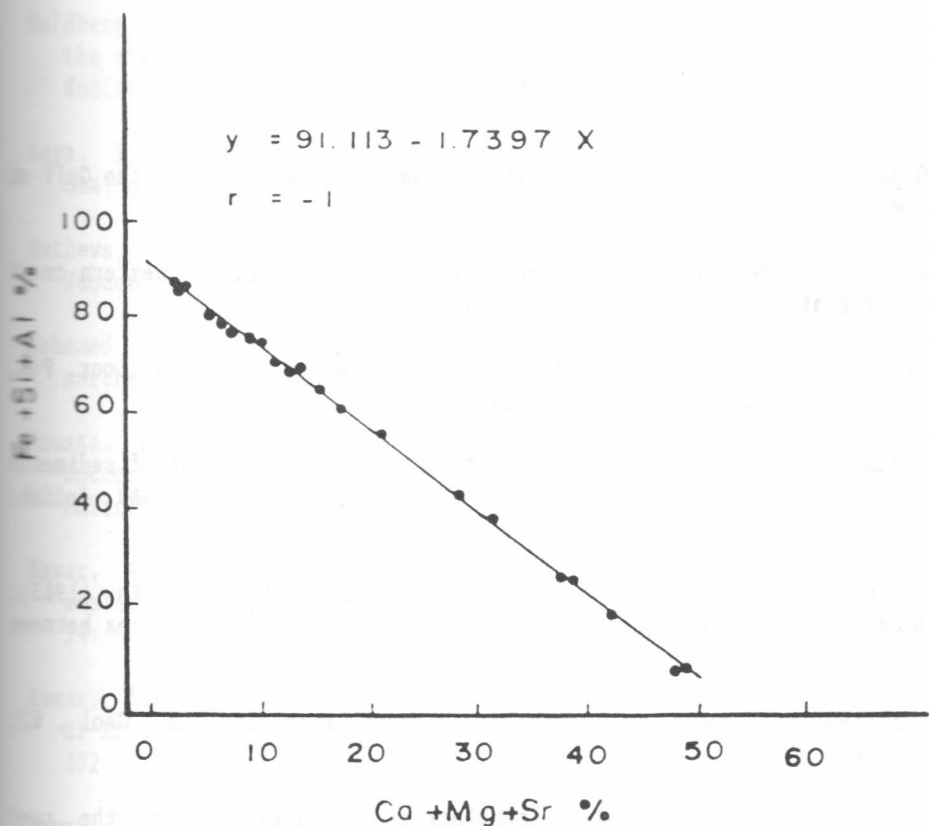


Figure 9: Biogenic elements versus terrestrial elements in the bottom sediments of the studied area.

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