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SEASONAL VARIATIONS IN CHEMICAL AND MINERALOGICAL PROPERTIES OF QARUN LAKE SEDIMENTS

BY

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Key Words : Chemical, Mineralogical and Sediments.

ABSTRACT

Values of pH , salinity (as EC) calcium and magnesium (Mg^{+2}) were increased westwards in the bottom sediments of the investigated Lake . The highest pH values were recorded in the Spring and the lowest in Summer ,while the highest values of EC , Mg^{+2} , Chloride (Cl^{-1}) and Sulphate($SO4^{-2}$) were recorded in Summer . Soluble ($SO4^{-2}$) and Cl^{-1} in the western sector were higher than those of the eastern side. Lake sediment samples were rich in organic matter content attaining relatively high value in Spring, except for the middle sector, where the highest values were recorded in Summer.

Montmorillonite was the dominant clay mineral (31-69%), however it decreased westwards. Vermiculite, Illite and Kaolinite were also found but with a less occurrence . Calcite, Quartz and Feldspars were dominant among the non-clay minerals.

INTRODUCTION

The Fayoum Governorate is a circular depression in the limestone plateau of the northern part of the Western Desert In Egypt, It lies at about 90 Km southwest of Cairo. Lake Qarun is situated between 30° 25' - 30° 49' E and 29° 25' - 29° 34' N. It has an area of about 226 km^2 (22000 hectares) with a maximum depth of 8.0 m, and mean depth of 4 m. It is considered as closed shallow basin.

Most of the previous investigations carried out on Lake Qarun included some ecological, productivity and water quality studies regardless of the effect of bottom soil properties, Siliem (1993). The geological picture of El-Fayoum Depression was studied by a number of workers. Abd El-Aal (1971) found that, the parent material is the most important soil forming factor. In course of time, a proper pond soil is formed on the primary soils as a result of constant sedimentation of suspension and their mixing with organic matter and precipitated mineral compounds. Rabie and El-Araby (1979) mentioned that, the mineralogical composition of clays is one of the most important factors affecting physical and chemical properties of soils which reflects the fertility conditions of soils. Taking into consideration the origin and soil uniformity of sediments in Fayoum area, Kassem and Elwan (1980) showed that, the soil properties of the area are developed under a stratified condition or under multidepositional regime. Moreover, they mentioned that the origin of the soils could be related to lacustrine as well as to post lower Paleolithic Nile deposit.

The soils of the Fayoum could be classified into the following sub-units:

- Nile alluvium soils (heavy to light textured soils),
- Fluvio-lacustrine soils (saline soils)
- and desert fringe soils (calcareous soils), Hammad et al (1983).

Hamdi (1961) reported that, prolonged contact of soils with sea water rich in Mg-ions as well as the continuos leaching of soils with water containing carbonic acid leads to the transformation of hydrous Mica into Montmorillonite. More Sunil *et al.,* (1983) found that, soil pH, under submergence conditions, was stabilized around neutrality (whereas the values of electrical conductivity was almost doubled). On the other hand, Banerjee *et al.*, (1976) noted that soil and water ponds lose salinity in course of time. Jones et al., (1971), Islam and Islam (1973) and Rahmatullah et.al. (1976) found that, soil submergence increased its level of soluble K, Ca and Mg ions.

This investigation was carried out for studying the seasonal variations in some properties and the mineral composition of Qarun lake sediments.

MATERIALS AND METHODS

Lake Qarun has an area of about (226 Km^2) 22000 hectares, it is a relatively shallow closed basin. In the present study, sediment samples were taken at a regular seasonal intervals during the period extends from January to October, 1993. Twenty two stations were selected to cover the different ecological and geological areas of the lake. Sediment samples were dredged from the stations in January, April, July and October 1993. These stations were divided into 3 sectors (i.e. the eastern sector of the lake includes stations No. 1 - 7, the middle sector consists of stations No. 8 - 16 while the western sector comprises stations No. 16 - 22).

Mineral composition of clay fraction was determined in three stations, where each station represents specific sector. The samples were air dried, ground and passed through a 2 mm sieve for the chemical analysis. Mineralogical analysis was undertaken for some samples, properties of the studied soils are shown in Table (1).

Particle size distribution was carried out using the pipette method according to Kilmer and Alexander (1949). Soil pH was determined in 1:2.5 soil suspension using pH meter, Electrical conductivity (as sign of the soil salinity) was determined by conductivity meter, Jackson (1967).

Soluble cations and anions in soil water extract were carried out according to the standard methods described by Jackson (1967) as follows: Calcium and Magnesium were determined by titration with Sodium -EDTA solution. Chloride was determined by titration against $AgNO_3$ c. Sulphate was determined as Barium Sulphate. Organic matter percentage was determined according to Walkely and Black method outlined in Jackson (1967). Clay fraction was separated by sedimentation procedure using NaCl for dispersion. Carbonates were dissolved using 1 N NaOAc - HOAc at pH 5, then the samples were treated with 20% H_2O_2 followed by the citric Dithonite for the free ion oxides removed. The mineralogical analysis was conducted using Mg saturated, glycerol solvated and K heated to 550 °C for 4 hr. X-ray diffraction pattern were obtained using PW 1050 Philips X-ray diffractometer with Ni- filtered and Cu-X-radiation at 36 KV and 16 MA potential, (Jackson, 1969).

Table (1) : Mechanical analysis and soil chemical properties of Lake Qarun sediment.

Station	Particle Size Distribution %				O.M	Soil	Soluble Ions < m.e./100 g					EC	Sediment
	Clay	Silt	F.Sand	C.Sand	.%	pH	SO4	Cl	HCO_3	Ca	Mg	mmhos/Cm at 20°C	.type
1	29.15	31.57	4.19	35.09	2.79	8.97	8.25	38.7	1.2	3.2	9.8	7.8	C.L.
2	25.46	33.10	7.45	33.99	3.35	8.76	11.00	46.8	0.8	6.8	5.6	9.1	C.L.
3	8.04	5.37	25.89	60.70	0.67	8.99	10.50	27.0	2.0	2.2	5.4	5.5	S.
4	37.82	28.37	15.37	18.44	4.99	8.79	10.00	68.4	1.2	8.4	8.8	12.0	C.L.
5	30.02	30.02	15.70	24.26	6.29	8.83	10.00	90.0	1.6	10.8	14.0	16.0	C.L.
6	28.06	30.61	16.58	24.75	4.02	8.93	10.00	76.5	1.4	10.2	11.6	13.9	C.L.
7	20.54	30.81	21.18	27.47	3.35	8.92	10.50	64.8	0.8	9	10.2	12.0	L.
8	19.96	22.81	20.67	36.56	5.03	8.94	13.00	72.0	1.2	11	9.8	13.7	S.L.
9	15.11	32.72	10.51	41.66	2.35	8.95	9.25	44.1	0.8	5.8	4.8	8.7	S.L.
10	16.05	16.06	11.98	55.91	4.56	8.96	11.00	63.9	1.2	9	9.4	12.1	S.L.
11	16.45	19.16	27.52	36.84	4.62	8.96	9.00	73.8	1.2	13	9.0	13.5	S.L.
12	---	---	---	---	0.80	8.95	9.50	19.2	0.8	1.8	4.6	4.5	---
13	33.84	33.83	30.38	1.95	7.52	8.77	7.50	77.4	1.6	6.6	11.8	15.7	C.L.
14	29.75	27.28	41.48	1.47	6.17	8.83	10.00	72.0	1.2	7.4	9.0	14.1	C.L.
15	10.4	22.88	49.56	17.16	0.67	9.00	9.50	30.6	1.2	2.4	3.8	6.1	S.L.
16	18.76	35.17	39.51	6.57	3.99	8.88	9.50	63.9	1.6	6.6	8.4	12.0	L.
17	29.41	26.96	36.77	6.86	5.76	8.92	8.50	82.8	1.4	8	13.0	16.9	C.L.
18	10.95	35.05	29.79	24.21	2.53	8.94	9.50	54.9	1.2	7	7.4	11.9	S.L.
19	29.05	27.85	28.57	14.53	3.70	8.86	8.00	77.4	1.4	7	12.2	15.1	C.L.
20	19.91	22.12	30.09	27.88	2.23	9.08	10.00	54.0	1.2	6	6.6	11.1	S.L.
21	24.99	23.95	30.24	20.82	3.70	8.98	11.50	98.1	1.6	10	15.4	18.8	S.L.
22	9.88	15.82	22.99	51.31	4.64	8.98	9.50	50.4	1.2	6.8	5.6	10.5	S.L.
El-Bats	2.28	6.85	73.42	17.45	0.29	8.85	7.50	6.3	0.8	0.6	0.8	0.7	S.
El-Wadi	30.64	33.00	33.53	2.83	1.00	8.75	7.00	8.1	1.8	1.6	1.4	1.1	C.L.

C.L. = Clay loam, S.L. Sandy loam soil
S. = Sandy Soil, L. loam soil

RESULTS AND DISCUSSION

Sediment pH:

pH values of Lake Qarun sediment increased gradually towards the western part of the lake, whereas, these values increased from 8.88 at the eastern sector to 8.93 at the western part of the lake in Winter season. Results recorded in Table (2) and Figs. (1, 2) show that pH of the eastern sector ranges between 8.76 - 8.99, 9.09 - 9.40, 7.80 - 8.10 and from 8.45 - 8.80 with an average of 8.88, 9.17, 7.94 and 8.62 in Winter, Spring, Summer and Autumn seasons respectively. The gradual decrease in pH towards the eastern sector may be correlated with the decrease in the pH of the water discharged from El-Bats drain. This result agrees with Siliem's 1993 who found that the pH of Lake Qarun water ranged between 8.39 and 8.93 in the western direction. The middle part of the lake has maximum pH values in Summer and Autumn, this increase may be due to the decrease in O.M% through this period (Table 2).

The seasonal variations in pH, show that the highest values were recorded in the Spring while the lowest were achieved in the Summer. The increase in pH is usually correlated to the photosynthetic activity or may be due to the increase in bicarbonate concentration (Smith, 1940). On the other hand, the decrease in pH (in Summer) may follow the increase in organic matter content as shown in the same table, whereas the maximum O.M% was noticed during Summer. These results agree with that of Saad (1973) and Nashy (1991) who correlated the decrease in soil pH with the increase in O.M%. Simple correlation shows that there are a negative correlation between soil pH and O.M% (r= 0.40).

Organic matter percentage (O.M%):

Lake Qarun sediments are rich in their organic matter content. Its percentage ranged between 2.2 and 7.5%. Results of Table (2) and Figs. (1,3) show that organic matter content in the northern part was higher than that of southern part of the lake. The results indicate that, organic matter content in the seven stations of the eastern sector increases towards the West, Fig. (3).

Organic matter values of the bosediments at the eastern sector of the lake increase gradually in Summer to reach their highest values in Spring, Fig. (1). The same trend was noticed in the western section whereas no remarkable

Table (2) : **Seasonal variation in chemical properties of Lake Qarun bottom sediments.**

Parameter	*Winter*			*Spring*			*Summer*			*Autumn*		
	Eastern X ± SE	Middle X ± SE	Western X ± SE	Eastern X ± SE	Middle X ± SE	Western X ± SE	Eastern X ± SE	Middle X ± SE	Western X ± SE	Eastern X ± SE	Middle X ± SE	Western X ± SE
pH*	8.88 ± 0.16	8.92 ± 0.14	8.93 ± 0.16	9.17 ± 0.18	9.29 ± 0.19	9.17 ± 0.26	7.94 ± 0.17	8.01 ± 0.18	7.93 ± 0.13	8.62 ± 0.12	8.74 ± 0.23	8.68 ± 0.25
OM%	3.63 ± 0.71	3.97 ± 0.84	3.79 ± 0.59	4.02 ± 0.69	3.93 ± 0.70	4.10 ± 0.55	3.11 ± 0.53	3.96 ± 0.59	3.87 ± 0.57	3.18 ± 0.59	3.45 ± 0.58	3.50 ± 0.49
EC**	10.90 ± 1.02	11.05 ± 1.01	13.76 ± 0.96	12.77 ± 1.20	13.21 ± 1.03	13.50 ± 0.82	11.59 ± 1.17	11.56 ± 1.16	15.93 ± 0.95	12.31 ± 1.03	11.69 ± 1.02	11.23 ± 0.73
SO4	9.61 ± 0.64	9.84 ± 0.63	9.43 ± 0.60	7.17 ± 0.41	8.00 ± 0.38	7.21 ± 0.69	9.23 ± 0.38	9.68 ± 0.39	9.17 ± 0.48	7.89 ± 0.34	8.08 ± 0.53	7.49 ± 0.47
Cl	58.89 ± 2.52	56.63 ± 2.36	68.79 ±2.25	51.63 ± 2.58	51.83 ± 2.16	49.00 ± 1.77	45.64 ± 2.68	53.81 ± 2.09	64.07 ± 2.35	28.77 ± 1.64	25.08 ± 1.67	28.00 ± 1.47
Ca+2	7.23 ± 0.98	7.13 ± 0.98	7.34 ± 0.61	6.86 ± 0.85	7.08 ± 0.81	6.63 ± 0.62	4.31 ± 0.76	5.68 ± 0.71	5.46 ± 0.60	4.19 ± 0.65	3.78 ± 0.64	3.64 ± 0.62
Mg+2	9.34 ± 0.94	7.78 ± 0.86	9.80 ± 1.03	8.20 ± 1.13	7.45 ± 1.02	5.51 ± 0.81	8.46 ± 1.29	10.95 ± 1.10	13.34 ± 1.17	5.96 ± 0.86	5.26 ± 0.85	5.13 ± 0.76

Soluble Ions were determined in 1:5 soil water extract and calculated as (m.e./100 g).
*** pH was determined in 1:2.5 soil suspension.**
**** EC was calculated as mmhos/cm at 25°C.**

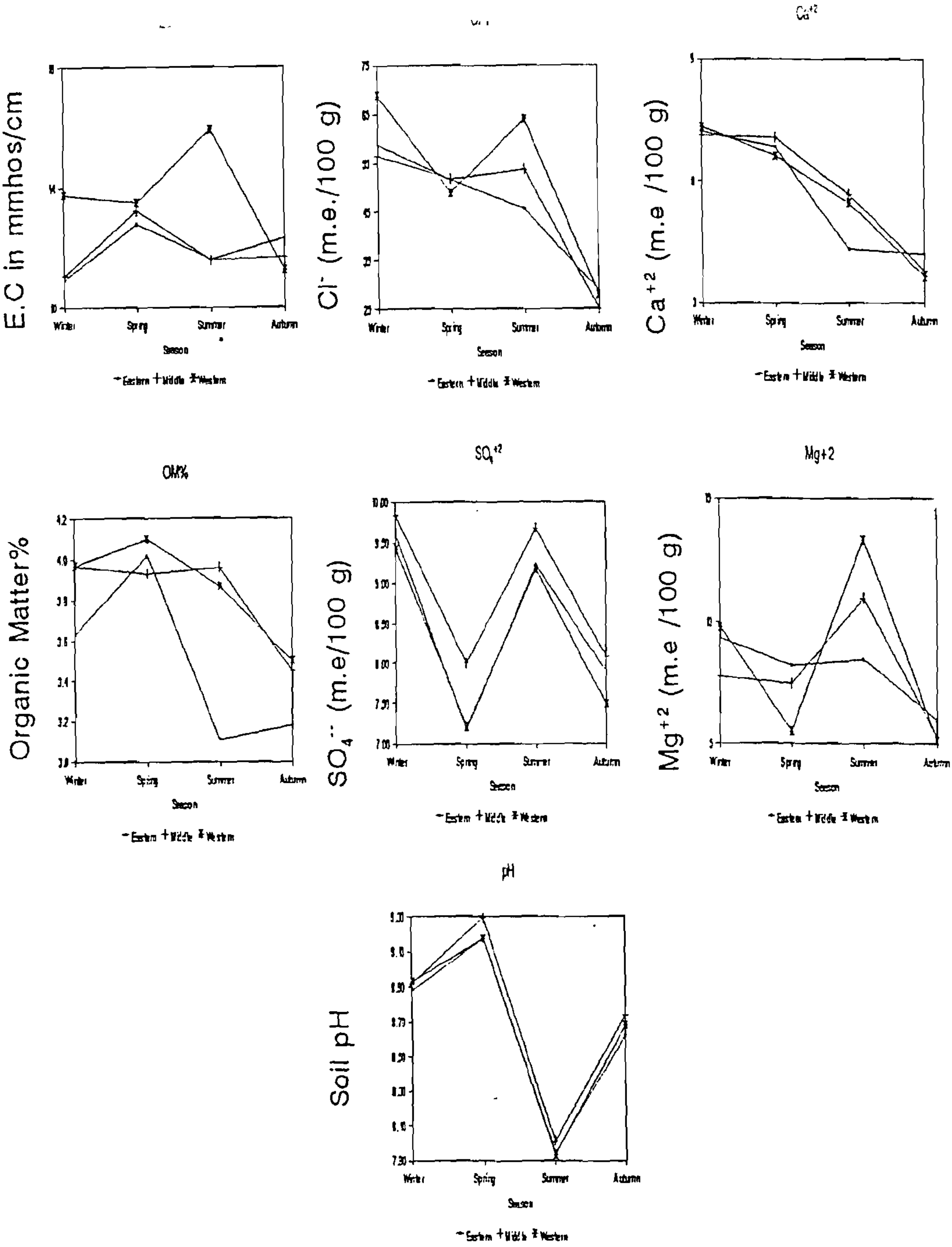

Fig.(1): Seasonal variation in soil chemical properties of Lake Qarun.

change in O.M% was observed in the middle sector. The highest O.M% was recorded during the Summer. This may be due to the increase in water temperature and the increase in detritus material. Statistical analysis shows that, soil O.M was negatively correlated with soil pH (r= 0.40).

Salinity of sediments:-

The electrical conductivity of soil water extract was determined as a measure of soil salinity. Results showed that soil salinity of the lake gradually increased at the West direction all year round, whereas the opposite occurs in Winter. Soil salinity increases gradually from Winter up to Summer 1993 in stations located at the middle of the lake (stations 4, 9, 11 and 12). This increase may be correlated with the increase in the evaporation rate as a result of the rise in air temperature. The opposite trend was remarked in stations 6 and 19 during the same period. Fig. (4) shows that, electrical conductivity of some stations near the source of drainage water decreases with increasing of the quantity of discharged water. The same Figure reveals that EC. increases toward the north direction.

The seasonal variations in soil salinity (expressed as mmhos/cm at 25 °C) at the eastern sector, showed values increasing from 10.9 (in Winter) to 12.77 (in Spring), then decreasing to 11.6 (during Summer) and again increasing to reach 12.3 mmhos/Cm (in Autumn). The same trend was noticed at the middle sector. On the other hand, EC values of the western section gradually increased with increasing water temperature. These results are in agreement with those of Siliem (1993). Statistical analysis reveals that soil salinity is correlated with the soluble Sulphate and Chloride, It attains its highest value with Chloride where the determined values were 0.13 and 0.574 respectively.

Sulphate (SO_4^{-2}).

Sulphate ions in Lake Qarun sediment gradually increases in the middle sector Fig. (5), They reach its maximum in stations 8, 14 and 15 in the middle sector. This result agrees with those of Siliem (1993) who found that the Sulphate content of Lake Qarun water are high at western basin compared with eastern one. Data in Table (2) indicates that, SO_4^{-2} values at the eastern part of the lake are 9.61, 9.84 and 9.43 in Winter, then they decreases to 7.17, 8.00 and 7.21 m.e./100 g soil in the Spring. These values increases during Summer attaining its highest value. The increase in soluble SO_4^{-2} may be correlated

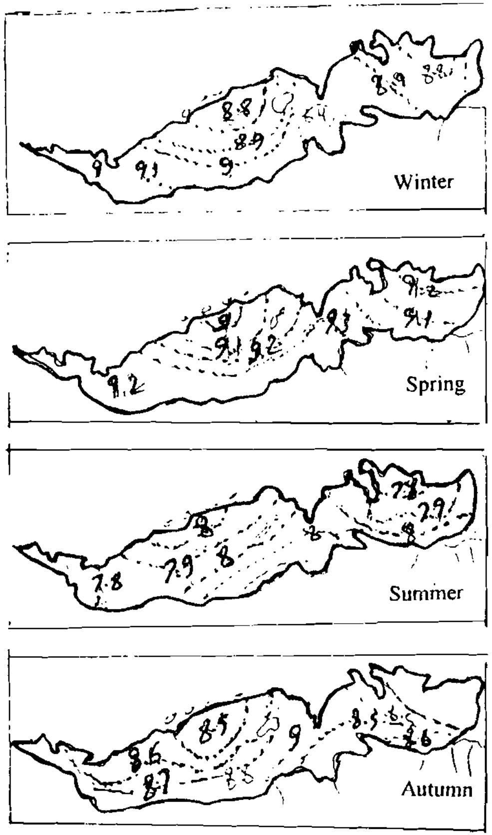

Fig.(2): Seasonal variations and Horizontal distribution in soil pH in Qarun Lake.

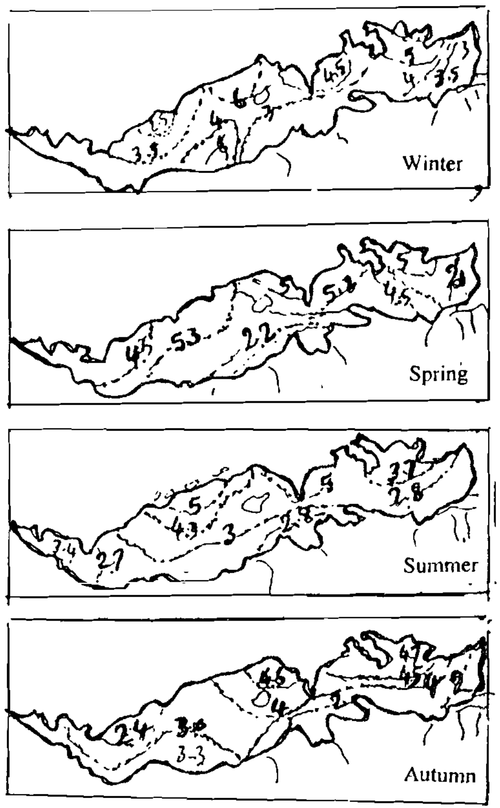

Fig.(3): Seasonal variations and horizontal distribution in 0.M% in Qarun Lake.

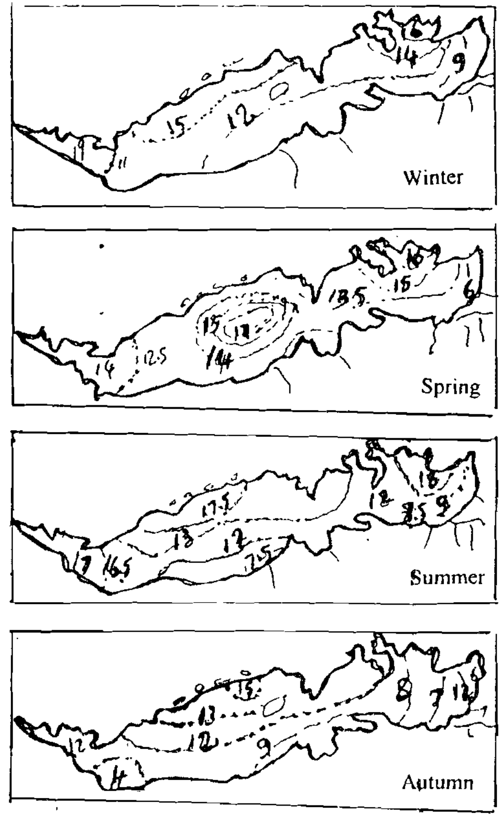

Fig.(4): Seasonal variations and horizontal distribution in electrical conductivity in Qarun Lake.

with increasing soil salinity. On the other hand, the remarkable decrease in SO_4^{-2} level during Autumn is correlated with the increase in soluble chloride during this period as well as the decrease in soluble magnesium. Statistical analysis show a positive correlation between both soluble Sulphate and both calcium and magnesium. R were 0.26 and 0.57 respectively.

Chlorides:-

Chloride ions concentration is considered as one of the most important factors affecting either directly on the survival and distribution of fish at different stages of their life cycle; or indirectly by affecting the amount of plankton which represent the main food of early larval stages of fishes. Chloride level at the western basin is slightly higher than that of the eastern sector (Fig. 1).

This phenomenon may be due to reduction of SO_4^{-2} in the water discharged from El-Bats drains. Results in Table (2) indicate that Cl^{-1} concentration gradually decreased from Winter to reach its lowest value in Autumn in the stations 5, 6 and 7 at the eastern sector. The decrease in Cl^{-1} level agrees with observation and results of Pratt (1978) and Nashy (1986) who found that soluble Cl^{-1} in soils decreases as time of leaching goes on, or may be due to its low concentration of El-Bats and El-Wadi water (Siliem, 1993). Data show also that, Cl^{-1} increases during Autumn up to Spring in stations 10, 14 and 15 and up to the Summer in stations 14 and 16 at the middle sector.

Calcium and Magnesium:

The results indicate that soluble calcium gradually decreases from Winter to reach its lowest values in Autumn .Magnesium follows a contrary pattern within the same period . On the other hand, Soluble Ca^{+2} increases from Winter up to the Spring, then decreases in some stations. Moreover, soluble Ca^{+2} increased at eastern sector in Winter but decreased in the Spring. Generally, the soluble Ca^{+2} increases at the middle then it decreases in the west direction. Fig. (7) show that soluble Ca^{+2} in the north part of the lake is higher than those of the south part. The increase in Cl^{-1} was associated to the increase in soil calcium content. Statistical analysis shows a highly positively correlation between Cl^{-1} and Ca^{+2} in the sediment soil.

The regression equation is : $Cl^{-1} = 8.347 + 6.972\ Ca$ $(r = 0.822)$

Soil soluble magnesium increases from Winter up to Summer then decreases in Autumn at the stations 4, 5 and 10. On the other hand, their values decreases from Winter up to Spring, then increases at most stations of the lake. There is a positively correlation between Ca^{+2} and Cl^- in soil Fig. (7) : Seasonal variation in soluble Cl^- in Lake Qarun sediment (r = 0.822). Fig. (8) indicates that, soluble magnesium increases towards the north direction.

Mineralogical analysis:
X-ray analysis:

Results of the X-ray diffraction analysis, Table (4) show that the clay fraction of the investigated samples is formed of the following minerals:-

1- Montomorillonite:- Montomorillonite is indicated by its basal reflection at 14.73 - 15.78 A° (Jones and Brown, 1959).
2- Illite : This mineral is identified by the spacing at 9.9 - 10.2 A° which is not affected by glycerol or heating the K- saturated samples.
3- Kaolinite : This mineral is indicated by its basal reflections (001 and 002) at about 7.13 - 7.31 and 3.57 - 3.60 A° respectively. Thermal treatment to 550 °C resulted in the disappearance of these reflection. The non-clay minerals are Calcite, Quartz and Feldspars were detected as follows:

a- Calcite : Calcite is identified by its basal reflection at 3.03 and 3.06 A°.
b-Quartz : This mineral is identified by its strong line at 3.34 - 3.36 A°, also by the lines at 4.22 A°.
c-Feldspars : Feldspars were distinguished by the characteristic reflection at 6.24 - 6.42 A° and 3.18 - 3.24 A°.

Data in Table (3) show that clay minerals form about 40% , 55% and 55% of clay fraction at the eastern, middle and western sectors of Lake Qarun soils respectively. The non-clay minerals including Calcite, Quartz and Feldspars are present in proportions varying from 10-2 0% , 11-2 2% and 14-2 0% respectively.

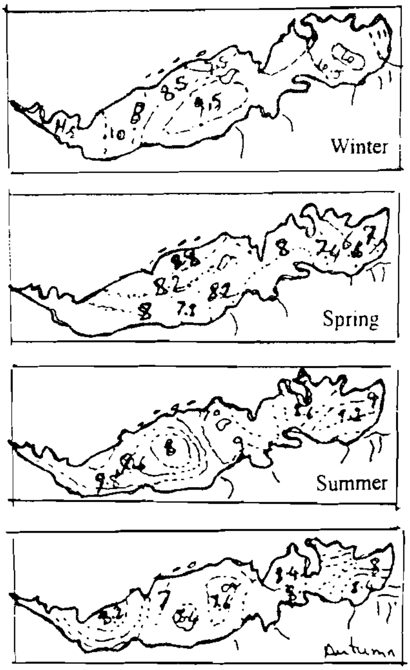

Fig. (5): Soluble sulphate ($SO_4^{=}$)

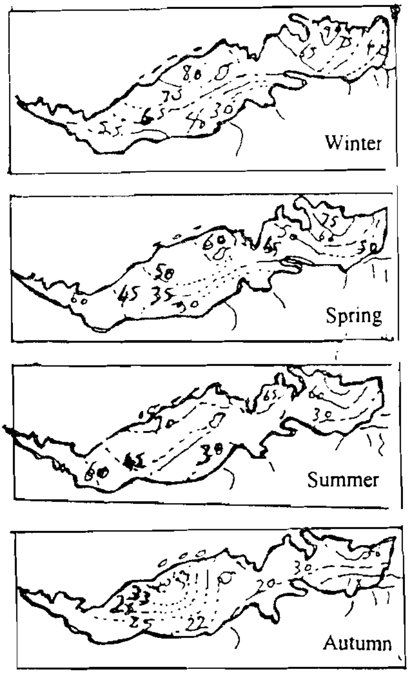

Fig. (6): Soluble Chloride (Cl^{-})

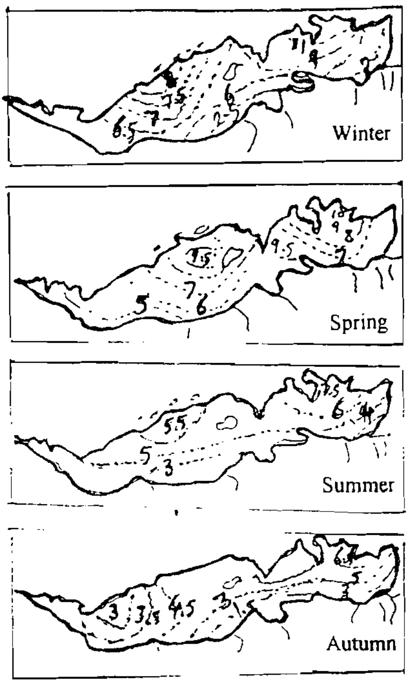

Fig. (7): Soluble Calcium (Ca^{++})

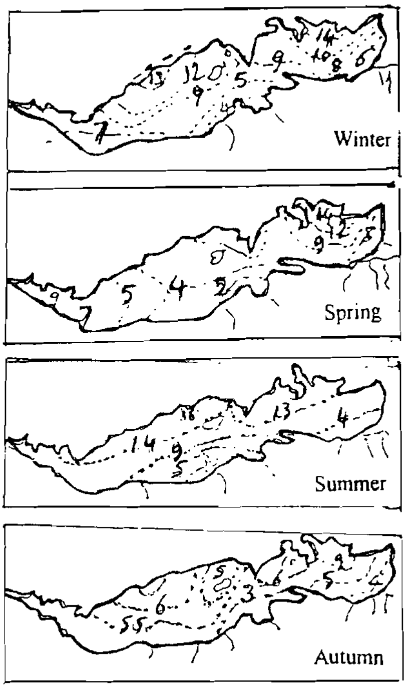

Fig. (8): Soluble Magnesium (Mg^{++})

Figure (5-8): Seasonal variation and horizontal distribution in soluble ions in Qarun Lake.

Table (3): Semi-quantitative clay and non-clay minerals compositions of clay fraction of Lake Qarun soil.

Location	Sampling data	Clay minerals				Non-clay minerals		
		montmorillonite	Vermiculite	Illite	Kaolinite	Quartz	Calcite	Feldspar
Eastern Sector	Jan. 93 Oct. 93	12.47 10.51	10.45 8.44	5.10 5.64	11.61 9.05	22.07 19.15	17.56 20.72	20.74 26.49
Middle Sector	Jan. 93 July 93 Oct. 93	37.85 21.59 22.89	5.75 12.24 19.25	4.82 3.42 1.64	6.35 10.17 11.19	13.60 18.93 15.50	14.79 17.11 19.20	16.84 16.54 10.33
Western Sector	Jan. 93 Oct. 93	32.42 29.36	7.46 18.03	7.51 2.46	7.31 10.00	11.28 14.68	15.51 10.99	18.51 14.48

Table (4): X-ray diffraction of the clay fraction of Lake Qarun soil.

Location	Sampling data	Montmorillonite	Vermiculite	Illite	Kaolinite
Eastern Sector	Jan. 93 Oct. 93	31.47 31.24	26.36 25.10	12.88 16.77	29.29 26.89
Middle Sector	Jan. 93 July 93 Oct. 93	69.11 45.53 41.64	10.50 25.81 35.02	8.80 7.20 2.98	11.59 21.46 20.36
Western Sector	Jan. 93 Oct. 93	59.27 49.05	13.64 30.12	13.72 4.12	13.37 16.71

For studying the seasonal variations in clay minerals, results in Table (3) and Fig. (9-11): indicate that Montmorillonite decreases from 69.1 to 41.6% and from 59.3 to 49.1% in both the middle and western sectors. But there is no remarkable change at the eastern section. The decrease in Montomrillonite may be due to its transformation into other mineral. Vermiculite increases from 10.5 to 35.0% and from 13.6 to 30.1% at the middle and western sectors respectively. These results agree with Naga Et al., (1981) who reported that the clay fraction of Fayoum soils is mainly Montmorillonite (50-70%), and Kalonite (10-15%). As well as the results agree with those of Hamdi (1961) who indicated that prolonged contact osoils with sea water leads to the transformation of hydrous mica into Montmorillonite.

Percentage of the Illite minerals increases from 12.8 to 16.8% at the eastern sector, while the opposite occurs at the middle and western sectors. The Percentage of Kaolinite decreases from 29.2 to 26.9% at eastern sector but it increases from 11.6 to 20.4% and from 13.4 to 16.7% in both the middle and western sectors, respectively. This result agrees with Nage et al., (1981). With regard to the non-clay mineral distribution, results indicates that calcite (11 - 20%), quartz (11 - 22%) and feldspars (10 - 26%) were the non-clay minerals in the area of investigation. Data also showed that, there is no remarkable changes in percentage of quartz. On the other hand, Calcite and Feldspars increased in both the eastern and middle sectors but there percentage decreases at the western part of the lake. The change in calcite percentage may be correlated with the changes in calcium content in the soil sediments.

CONCLUSION

From the previous results, it can be said that:

1- Lake Qarun can be considered as one of the most suitable ecological medium for rearing different fish species which prefer the natural feed such as *Mugil sp.* and *Tilapia sp.* The middle part of the lake is the best for this purpose.

2- Discharging of the drainage water into the lake should be increased for decreasing its salinity and increasing its content of organic matter.

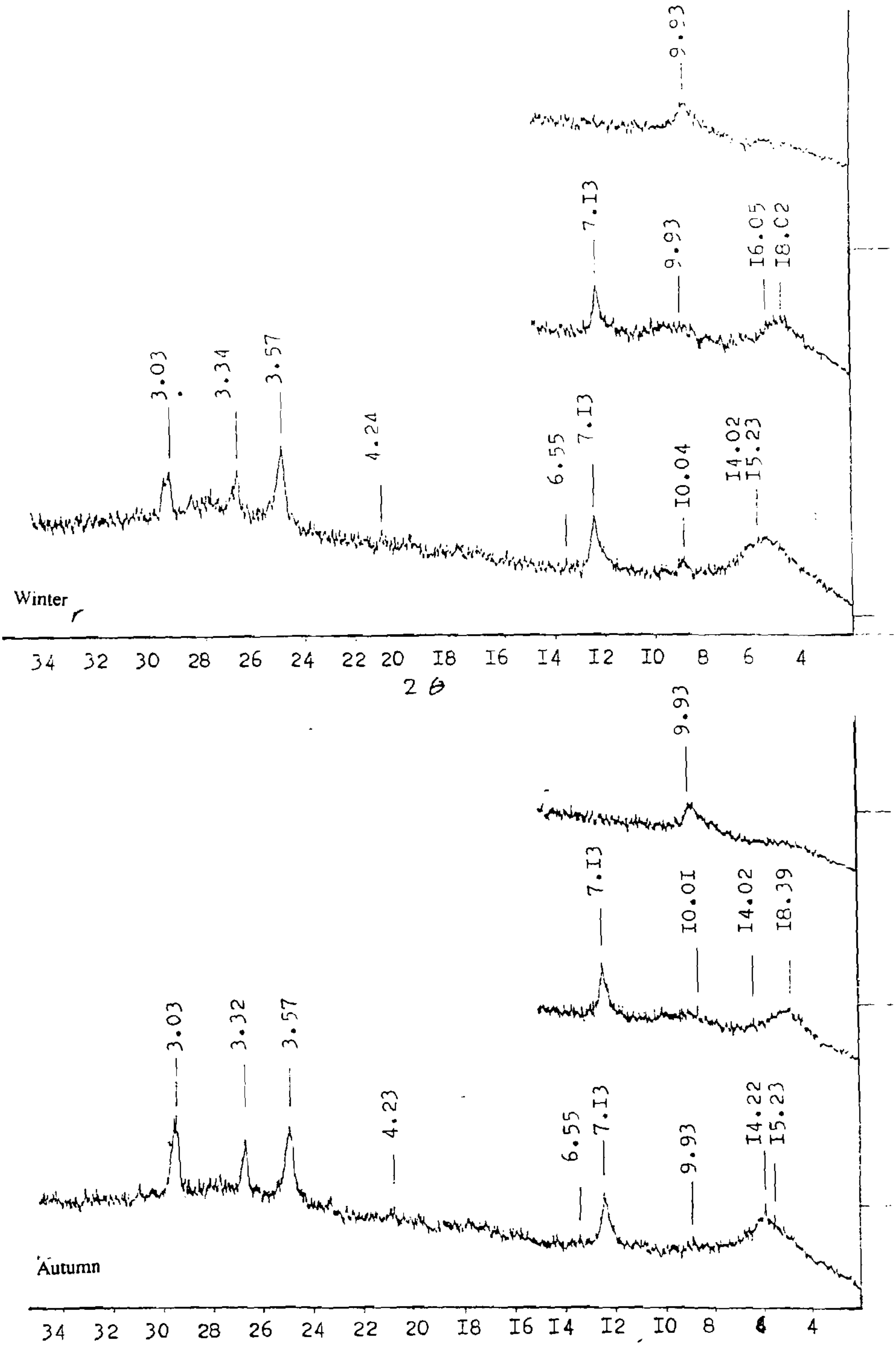

Figure (9): Xray diffraction of clay fraction of the eastern sector of Qarun Lake.

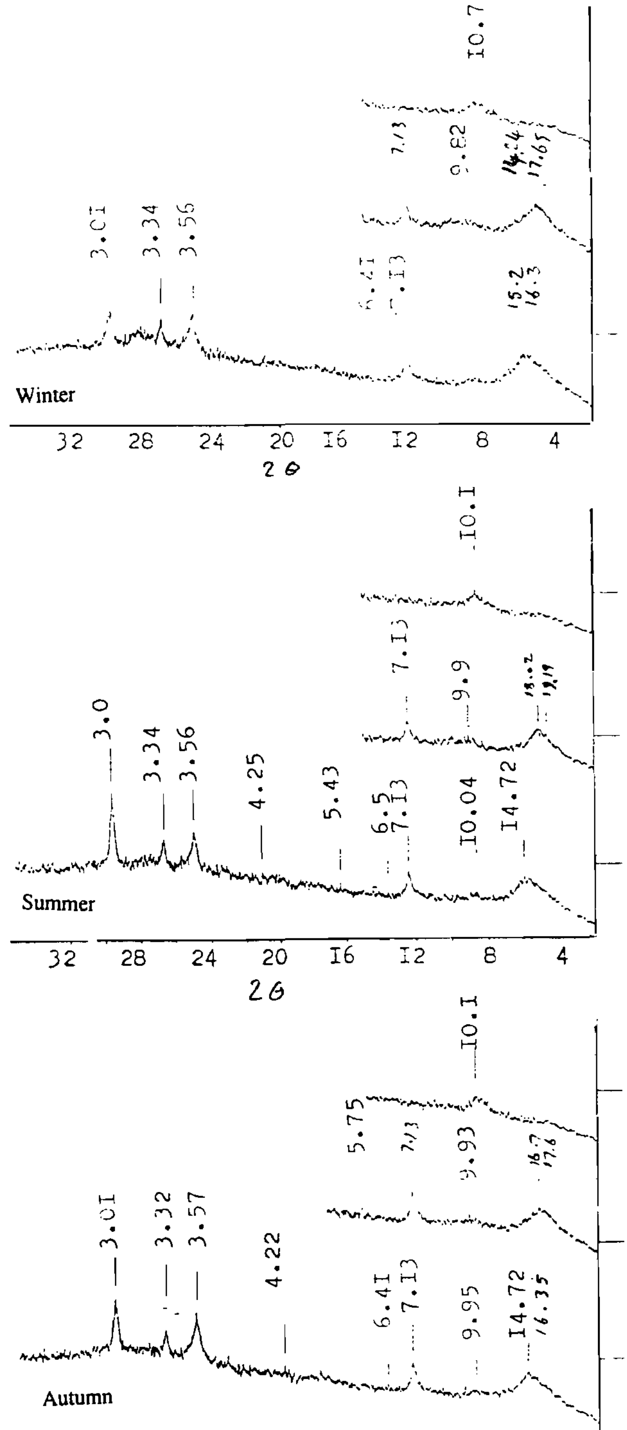

Figure (10): X-ray diffraction of clay fraction of the middle sector of Qarun Lake.

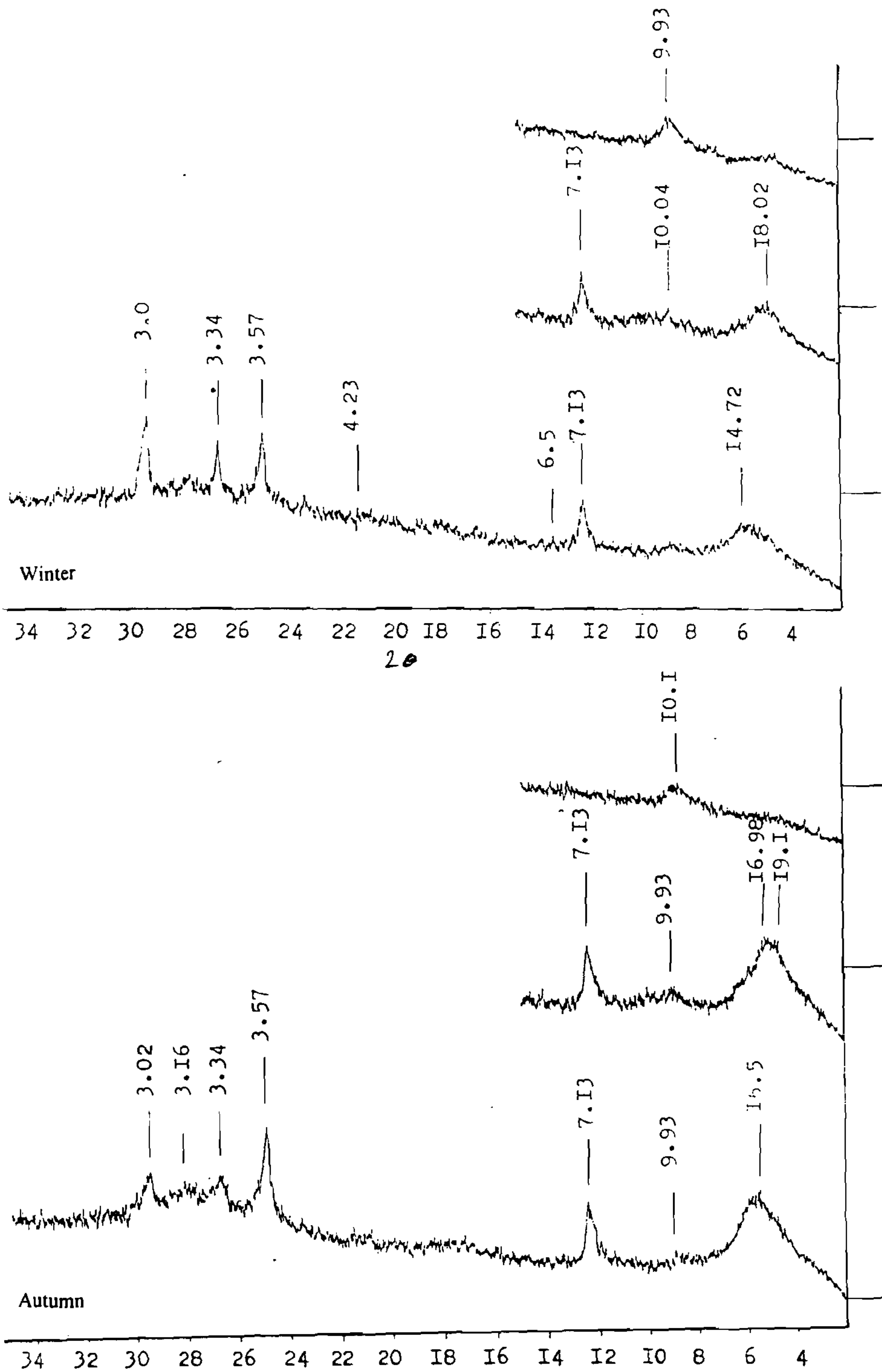

Figure (11): X-ray diffraction of clay fraction of the western sector of Qarun Lake.

3- Montmorillonite is dominant and represents the main mineral in Lake Qarun soil. The Vermiculite and Koalinite are in the second and third order respectively. Moreover, the soil contained non-clay minerals such as Calcite, Quartz and Feldspars. Some minerals transformation were happened.

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