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# STUDIES ON THE GEOCHEMICAL AND MINERALOGICAL PROPERTIES OF LAKE NUBIA SEDIMENTS

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## ABSTRACT

Twenty three samples from the main channel of Lake Nubia collected during July 1985 were chemically analysed for major chemical constituents, viz: $Al_2 O_3$, $Fe_2 O_3$, Ca O, Mg O, $Ca CO_3$ and for organic matter.

The mineral composition of the sediments was described by studies of the light and heavy minerals. The microscopic investigation of the light fraction indicated that quartz forms up to 97 % while feldspars form up to 2 %. The heavy minerals encountered in the sediments under investigation consist mainly of opaques, iron, tourmaline, rutile, garnet, biotite, hornblend, monazite and others.

## INTRODUCTION

After the construction of the High Dam at Aswan, a very large reservoir was formed. The total reservoir, area is 6276 $Km^2$ at level of 180 m. relative to sea level.

A small area of the reservoir is located in the northerm Mediterranean semi-arid zone, while the major part of the reservoir is in the subtropical zone (El-Ramly, 1973).

The part of the reservoir located in Sudan is called Lake Nubia extends from Adindan in the north to Dal cataract in the south (Fig. 1).

The Aswan High Dam reservoir from a limnological point of view forms one unit. Howevers, the southern part of the reservoir (Lake Nubia) will be directly affected by the flood. Such an area will naturally possess prevailing riverine conditions.

The sediments in the southern region are mainly silt and sand, while those of the northern part are chiefly silt (Fig. 2). The eastern and western sides of this Lake are surrounded by a rocky terraine primarily consisting of piedmont and peneplain sandstones of the Nubia facies.

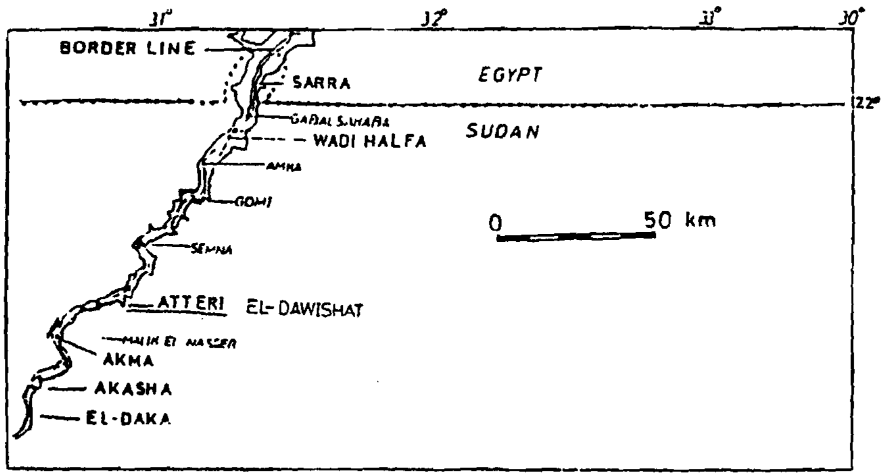


Fig. (1)
Key map showing Lake Nubia.

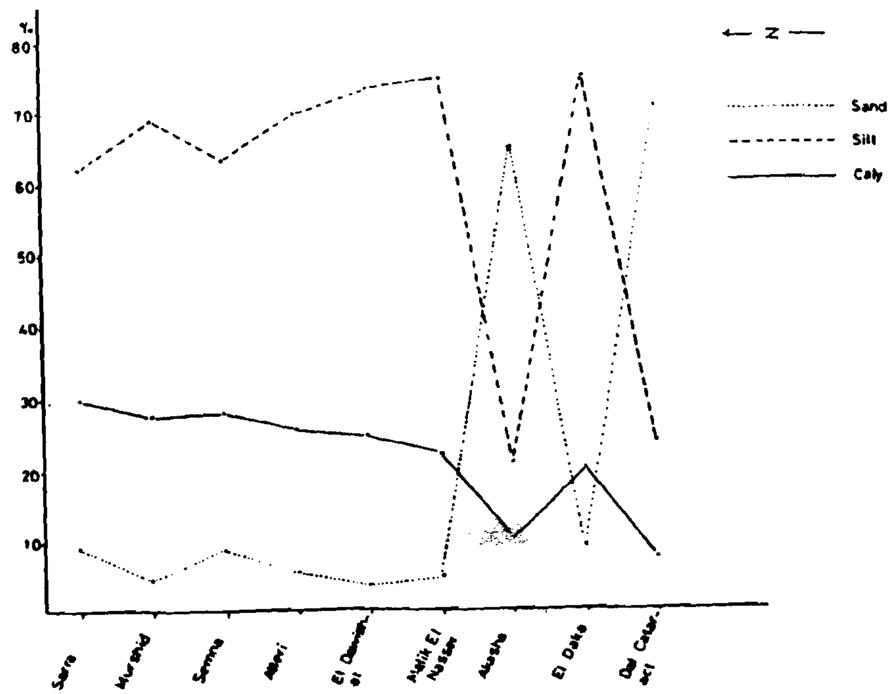


Fig. (2)
Mechanical analysis of the bottom sediments of Lake Nubia.

**General Characteristics of Lake Nubia:**

The amount of total dissolved solids in the Lake is about 210 mg/l at El-Daka (487.5 Km. from High Dam). It decreases to 166 mg/l at El-Dawishat (431 Km. from High Dam).

The thickness of the oxygenated layers varies in the lake at different sites under the effect of the flood. The waters in the gorge region are completely oxygenated from surface to bottom. Generally, the water is saturated during the winter and becomes poorer in the summer season.

The pH value of the surface water is higher than the deeper water during all seasons. The waters are more alkaline in winter and spring than in summer and autumn. The flood causes changes in pH, with a high in the pre-flood period and a decrease during the flood.

The maximal values of electrical conductance (306 umhos) were recorded in Lake Nubia (at Kingarti) and the minimum value was (about 240 µmhos) recorded at Murshid. The E.C. varies with depth, depending on the amount of the suspended materials. In addition the flood water affects the E.C., as it changes depeding on the level of the flood.

## MATERIAL AND METHODS

**a- Sampling :**

The bottom samples were collected by a Petersen dredge from the different locations.

**b- Chemical Analysis :**

$Al_2O_3$ was determined using the complexometric Nafluoride method (Welcher, 1958). Iron Oxide was analysed using the method described by Usatenko and Mikhailova (1956). (Ca) and (Mg) were determined according to the method of Patrovsky and Huka (1958). The Collins calcimeter was used to measure Ca $CO_3$ according to the technique proposed by Jacksons (1958).

For determining the oxidizable or active organic carbon in the sediment, the method of Schollenberager (1927) as described Danna (1965) was followed.

**C- Light and Heavy Minerals**

The size ranges between 3.5 0 to 4.0 0 and between 4.0 0 to 5.0 0 were chosen for the separation of minerals in bromoform. (sp. gr = 2.85).

## RESULTS AND DISCUSSIONS

### 1- Geochemistry :

The values of the chemical constituents analyzed in the bottom sediments of lake Nubia are given in (Table 1).

The distribution of $Al_2O_3$ and $Fe_2O_3$ (Fig. 3) are in general consistent with each other suggesting deposition as hydrolysates, as result of their ionic potlntial (Mason, 1966). The variation in $Al_2O_3$ is partly inverted relative to that of the clay fraction (Fig. 2) perhaps because of the dominant role of aluminum silicate minerals other than the clay (Such as feldspars) (Fig. 3). Aluminum, relains dissolved both in acid solution with pH less

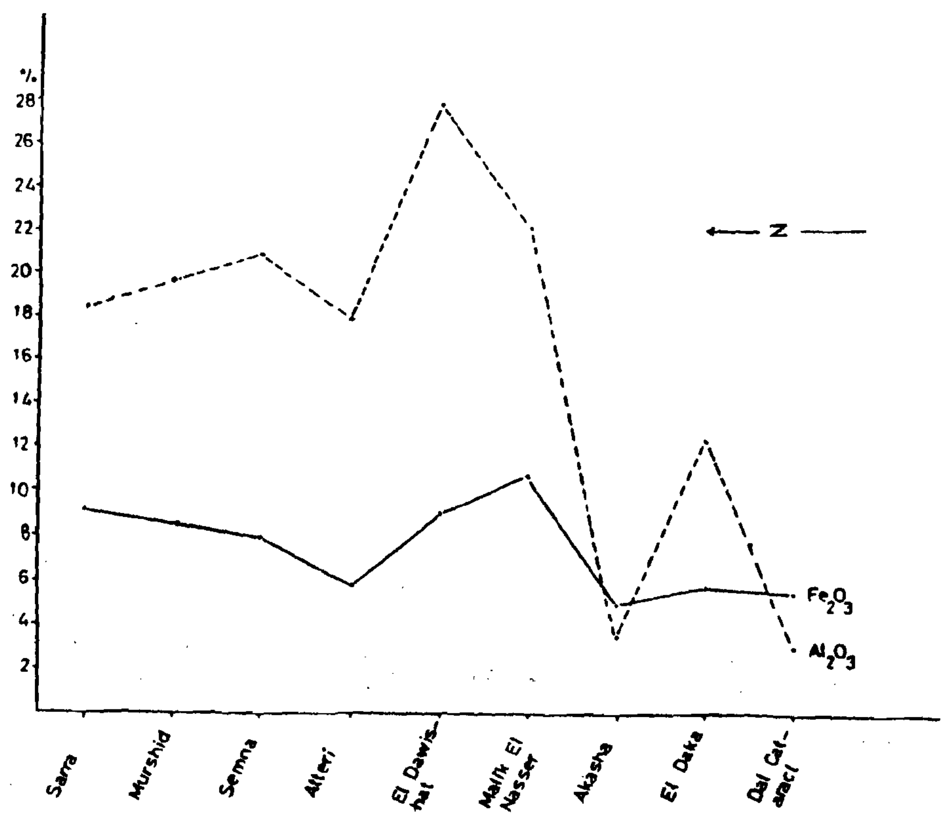


Fig. (3)
Distribution of $Al_2O_3$ and $Fe_2O_3$ in the bottom sediments.

TABLE (1)

The contents of the analysed chemical constituent in Lake Nubia Sediments.

| Sample No. | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $CaCO_3$ | Organic matter | Location | Station | Km/H.D. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.74 | 5.50 | 2.00 | 0.43 | 3.48 | 2.62 | Dal cataract | Middle | 500 |
| 2 | 2.81 | 5.90 | 1.90 | 0.35 | 3.17 | 4.50 | El Daka | East | 487 |
| 3 | 4.53 | 5.5 | 1.76 | 0.27 | 3.00 | 2.62 | El Daka | West | 487 |
| 4 | 2.70 | 7.30 | 1.99 | 0.11 | 2.95 | 2.74 | Akasha | East | 480 |
| 6 | 11.00 | 3.10 | 1.83 | 0.15 | 2.81 | 2.67 | Akasha | Middle | 480 |
| 6 | 10.10 | 3.10 | 1.73 | 0.13 | 2.90 | 2.96 | Akasha | West | 480 |
| 7 | 24.16 | 9.30 | 1.15 | 0.43 | 1.90 | 5.06 | M. El-Nasser | East | 448 |
| 8 | 20.11 | 12.01 | 1.00 | 0.20 | 1.75 | 3.57 | M. El Nasser | West | 448 |
| 9 | 30.60 | 12.10 | 1.90 | 0.19 | 2.79 | 3.39 | El Dawishat | East | 431 |
| 10 | 29.90 | 7.70 | 1.64 | 0.33 | 2.66 | 4.69 | El Dawishat | East | 431 |
| 11 | 21.70 | 6.20 | 1.72 | 0.38 | 2.71 | 3.18 | El Dawishat | West | 431 |
| 12 | 19.51 | 4.60 | 1.03 | 0.17 | 2.41 | 3.18 | Atteri | East | 425 |
| 13 | 18.70 | 8.70 | 1.00 | 0.31 | 2.40 | 3.84 | Atteri | Middle | 415 |
| 14 | 14.13 | 3.50 | 1.05 | 0.21 | 22.40 | 3.60 | Atteri | West | 415 |
| 15 | 16.12 | 9.10 | 1.70 | 0.62 | 2.90 | 3.03 | Semna | East | 403 |
| 16 | 27.60 | 8.20 | 1.75 | 0.66 | 2.85 | 3.60 | Semna | Middle | 403 |
| 17 | 19.10 | 7.10 | 2.00 | 0.47 | 3.10 | 3.74 | Semna | West | 403 |
| 18 | 76.40 | 10.90 | 1.73 | --- | 3.20 | 2.62 | Murshid | East | 378 |
| 19 | 16.80 | 7.80 | 1.52 | 0.10 | 3.14 | 3.25 | Murshid | Middle | 378 |
| 20 | 14.60 | 6.90 | 2.00 | --- | 3.95 | 2.67 | Murshid | West | 378 |
| 21 | 17.00 | 9.20 | 1.50 | 0.49 | 2.10 | 2.65 | Sarra | East | 323 |
| 22 | 20.31 | 10.70 | 1.02 | 0.53 | 1.90 | 2.74 | Sarra | Middle | 323 |
| 23 | 17.5 | 7.3 | 1.00 | 0.37 | 1.95 | 2.81 | Sarra | West | 373 |

than 4 and in alkaling waters in the pH > 9. Aluminum hydroxide precipitates only in the nighborhood of the neutral point, wich is readed in the bottom waters of the Lake Nubia (Fig. 4). Weathering is generally dominant under oxidizing conditions and iron in the oxidized state is highly insoluble in alkaline water. This may explain to the occasionally inconsistent distribution of $Al_2O_3$ and $Fe_2O_3$ in the sediments at some sites in the area under investigation. $Al_2O_3$ versus $Fe_2O_3$ in the bottom sediments. A shart scatter diagram (Fig. 5). A show a positive correlation ($r = 0.58$) between these components.

The variations of CaO and MgO in lake Nubia sediments are partly consistent with each other at some sites; however, they are mostly inconsistent at others (Fig. 6). It is wating that CaO increases at the expuse of MgO (as remark that CaO increases at the expance of NgO) as suggested by their negative correlation ($r = -0.33$) (Fig. 7).

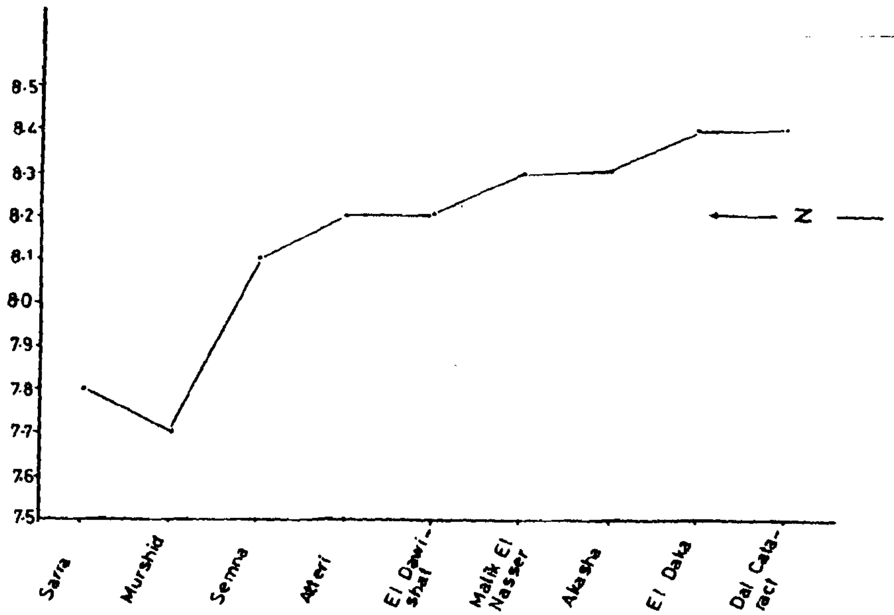


Fig. (4)
pH values of bottom water during July (1985).

The pH values of the bottom water is above 7.7, (Fig. 4), which in on the boundary for Ca $CO_3$ precipitation according to Krumbein and Garrels, (1952).

The maximum value of $CaCO_3$ content of the bottom sediment of the Lake is much lower than that of the shallower more productive natural lakes of Egypt as Lake Marut, where $CaCO_3$ content ranges from 14.82 to 68.84% (El-Wakeel and Wahby, 1970) or that of the natural lakes of colder regions such as lake Michigan where $CaCO_3$ is around 30% (Callender, 1969; Gross et al, 1972) and lake Superior where $CaCO_3$ is more than 40% (Dell, 1971). Serruya (1971) suggested that $CaCO_3$ precipitated is controlled by photosynthesis in Lake Kemert and Lake constance.

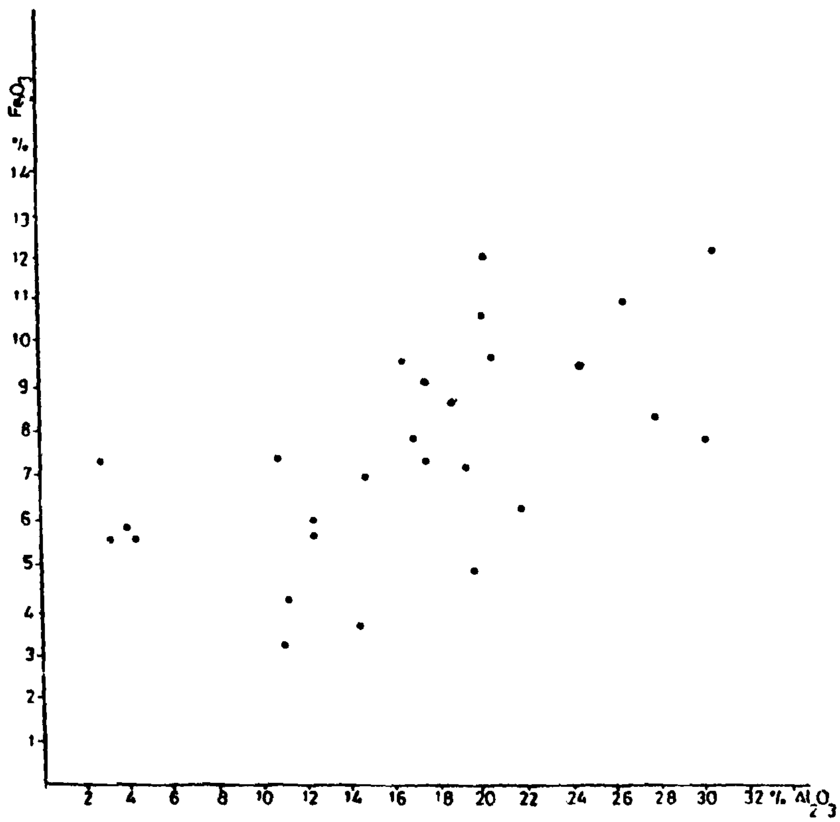


Fig. (5)
$Al_2O_3$ v.s. $Fe_2O_3$ scatter diagram of bottom sediments.

The distributions of $CaCO_3$ in sediments and of pH in Lake Nubia bottom waters are mostly not related, which indicates that the $CaCO_3$ abundance is not affected by the pH values. It can be deduced that the encrusting organisms play the chief role in the lake.

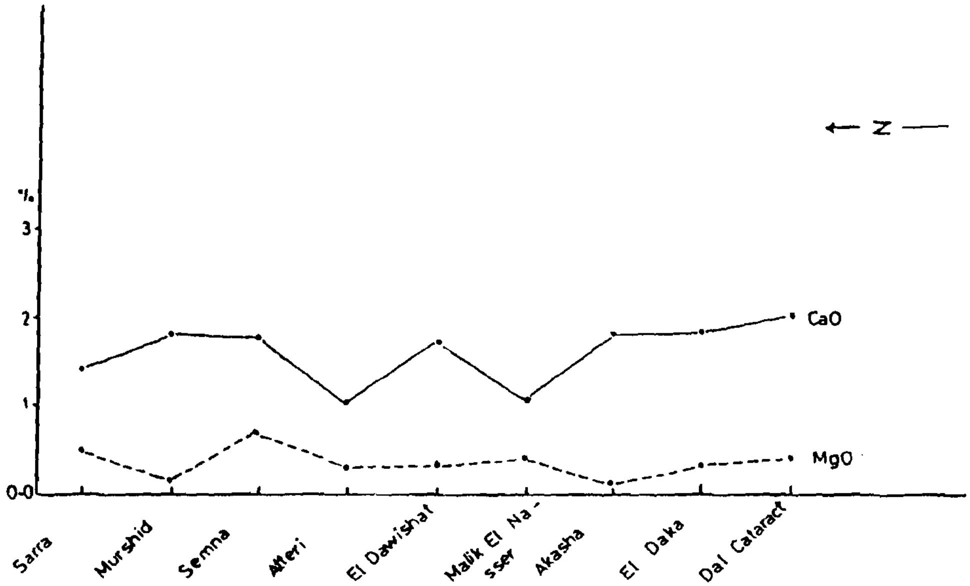


Fig. (6)
Ca O and Mg O concentrations in Lake Nubia sediments.

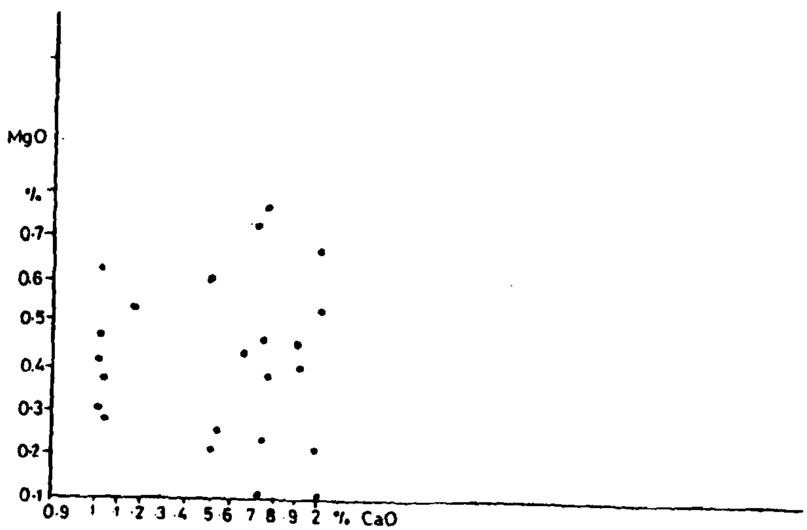


Fig. (7)
Relationship between Ca O and Mg O in the bottom sediments.

$CaCO_3$ and organic matter distributions are also not related to each other, (Fig. 8). This is confirmed by the organic matter vs. $CaCO_3$ scatter diagram (r = -0.10), (Fig. 9). Hassaan et al (1984) studied the sediments of lake Nasser and the northern part of Lake Nubia and reached the same conclusion for both surface and subsurface sediments.

The organic matter provides an indication of the amount and type of food settling to the bottom from the water column.

Table (2) illustrates comparison of average determined chemical composition of Egyptian lakes.

2- Mineralogy:

The mineral composition of the sediments has been discussed by many authors, (Shukri, 1950, 1951 and 1953; Nakhla, 1958; Zagloul and Kalel, 1965; Labib and Sys, 1970; Buursink, 1971; Kamel et al, 1973; Gewaifel et al, 1981 and El-Massry, 1983).

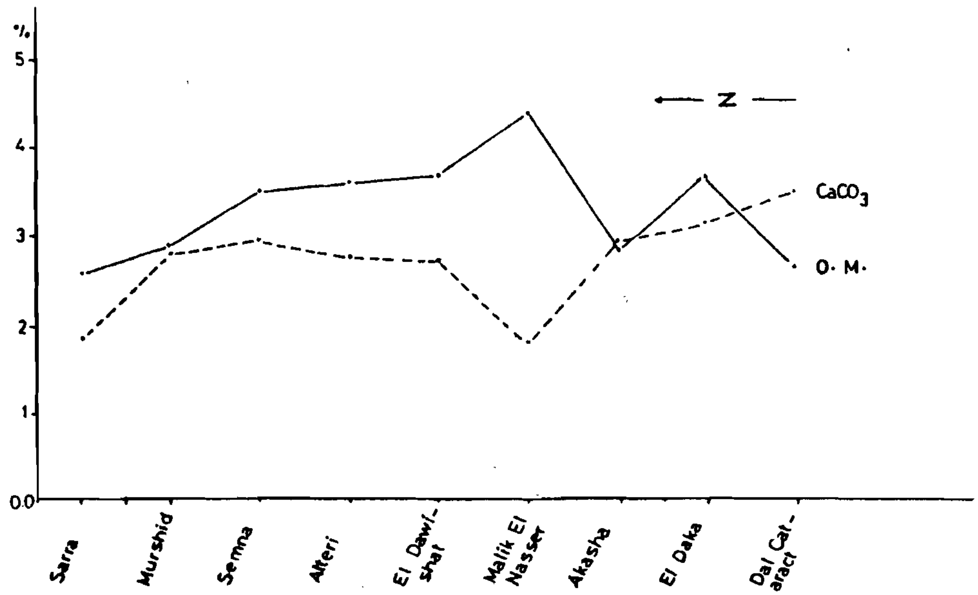


Fig. (8)
Organic matter and Ca $CO_3$ concentrations in Lake Nubia sediments.

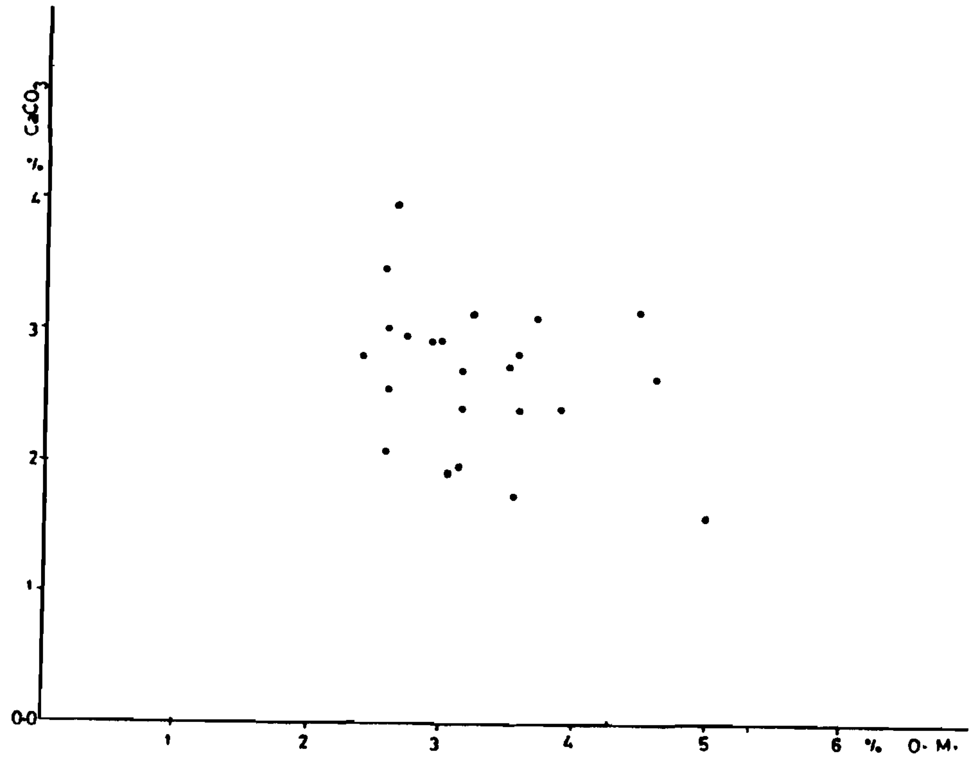


Fig. (9)
Organic matter v.s. Ca $CO_3$ scatter diagram of bottom sediments.

The mineral content of the Aswan Hign Dam reservoir sediments has not been much considered before. Moreover, Hassan et al (1977 a) and Higazi and Elewa (1983) carried out studies of the clay minerals. Phillip et al (1977) provided some insight on the distribution of heavy minerals of Lake Nasser sediments.

In this work, the mineralogical sharacteristics of the light and heavy fractions as constituents of the lake Nubia sediments are studied, in order to elucidate the various types, depositional history and sources of the deposits.

A microscopic investigation of the light fraction indicates that quartz makes up to 97% of it, with feldspar not exceeding 2%. Other minerals as altered feldspars, mica and chalcedony were identified but only as traces. Quartz occurs as colourless to milky grains, which are sometimes stained by iron oxides.

TABLE (2)

Comparison of average determined chemical composition of Lake Marut, Burollus, Qarun, Nasser and Nubia sediments.

| Constituents | Marut (El-Wakeel & Wahby) 1970 | Burollus (Mossoud) 1976 | Qarun (Mossoud) 1976 | Nasser Hassaan et al 1984 | Nubia (the present work) |
|---|---|---|---|---|---|
| $Al_2O_3$ | --- | --- | --- | 6.31-25 | 10.50-30.60 |
| $Fe_2O_3$ | --- | --- | --- | 1.13-17.98 | 3.10-12.10 |
| CaO | --- | --- | --- | 0.26-6.33 | 1-2 |
| MgO | --- | --- | --- | 0.22-1.01 | 0.10-0.66 |
| $CaCO_3$ | 14.80-68.80 | 37.44-51.43 | 39.43-54.15 | 1.44-12.00 | 1.75-3.95 |
| Organic matter | 2.85-22.98 | 13.37-18.75 | 4.46-8.66 | 1.19-5.73 | 2.62-5.06 |

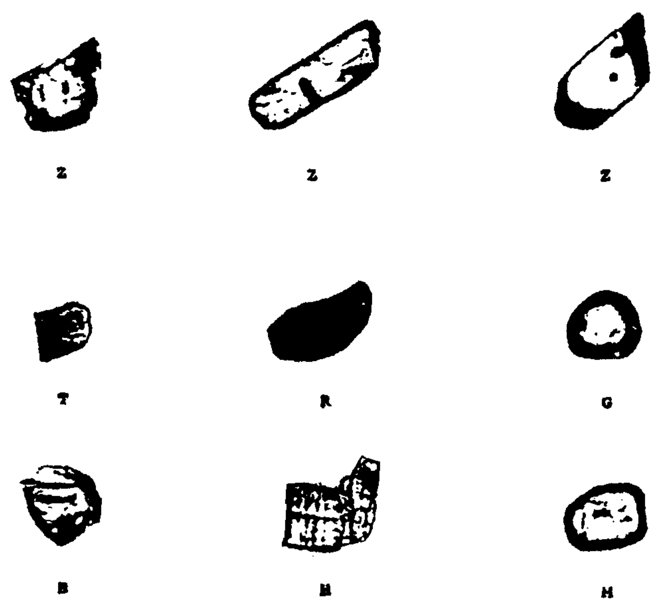


Fig. (10)
Photomicrograph of heavy mineral grains showing zircon (Z), tourmaline (T), rutile (R), granet (G), biotite (B), hornblend (H) and monazite (M).
(PPL. X 60).

TABLE (3)

Percentage of the identified non - opaque minerals.

| S.N | Zircon | Tourmaline | Rutile | Garnet | Biotite | Hornblend | Monazite | Others |
|---|---|---|---|---|---|---|---|---|
| 1 | 37.31 | 10.5 | 15.60 | 9.30 | 17.22 | 7.5 | 1.5 | 1.07 |
| 2 | 35.21 | 21.73 | 12.70 | 7.20 | 14.26 | 8.37 | [illegible] | 0.27 |
| 3 | 33.64 | 19.12 | 14.10 | 7.33 | 12.31 | 11.16 | 1.70 | 0.55 |
| 4 | 58.11 | 16.50 | 9.70 | 9.11 | 18.14 | 3.5 | 0.90 | 1.44 |
| 5 | 45.12 | 17.33 | 16.70 | 7.58 | 9.90 | 2.10 | 0.80 | 0.55 |
| 6 | 59.00 | 7.36 | 17.22 | 8.38 | 3.30 | 1.66 | 0.93 | 1.14 |
| 7 | 33.10 | 32.67 | 7.11 | 15.11 | 4.81 | 5.37 | 0.70 | 1.87 |
| 8 | 40.17 | 30.11 | 6.71 | 12.5 | 3.38 | 4.91 | - | 2.24 |
| 11 | 24.16 | 25.12 | 24.51 | 14.16 | 3.10 | 6.14 | - | 2.81 |
| 12 | 25.60 | 26.13 | 20.70 | 12.11 | 7.81 | 7.22 | - | 0.87 |
| 15 | 54.13 | 20.10 | 14.13 | 2.10 | 4.63 | 3.33 | 0.6 | 1.25 |
| 17 | 56.21 | 17.33 | 17.11 | 3.00 | 2.10 | 2.96 | - | 1.30 |
| 18 | 34.61 | 12.13 | 27.10 | 6.35 | 16.50 | 0.5 | - | 2.81 |
| 20 | 44.30 | 10.50 | 24.12 | 9.20 | 10.11 | 1.11 | - | 0.66 |
| 21 | 50.21 | 12.35 | 22.17 | 3.28 | 9.12 | 1.00 | - | 0.87 |
| 23 | 50.94 | 10.16 | 25.11 | 6.00 | 7.00 | 0.22 | - | 0.57 |

The heavy mineral fraction is less than 5% by weight of each sample. Opaque and non opaque minerals are found, although the opaque minerals form the bulk of the heavy mineral fraction in all samples. These minerals are mainly represented by iron oxides, iron titanium oxides and hydrate iron oxide minerals.

The non-opaque minerals identified in the samples are zircon, tourmaline, rutile, garnet, biotite, hornblende, monazite and some other minerals,(Table 3), (Fig. 10).

Zircon is the most common mineral in the lake sediments. Its frequency ranges between 24.16% and 59%. The most abundant type of zircon is colourless and is found in all samples.

Toutmaline is the second dominant mineral in all the studied sediments, the average frequency of tourmaline ranges between 10.16 and 37.67%. Tourmaline grains are generally prismatic anhedral, subrounded to subangular.

Rutile is found almost in all investigated samples, with frequency ranging between 6.71 and 47.51%. It is represented by reddish-yellow to brown varieties. Generally, rutile grains are subangular to subrounded.

Garnet is recorded in all the samples. Its frequency ranges from 2.1 to 17.22%. Garnet is represented by pink and colourless varieties with subangular to subrounded grains. It sometimes contains inclusions of iron oxide.

The average percentage of biotite ranges between 2.10 and 15.11. Biotite is recorded in the investigated samples as irregular, subangular flakes of brownish and yellowish colours.

Hornblende abundance is low in all the samples, with a range between 0.22 and 11.16%.

Monazite is only observed in the southern part of Lake Nubia. Its frequency range betwen 0.2 and 0.9%. Monazite is recorded as subangular to subrounded.

Other minerals are occasionally present as minor constituents in Lake Nubia sedimetns. These minerals are staurolite, pyroxene, kyanite, epidote, and glauconite.

The heavy minerals in the study area are more or less the same as those recorded in similar Nile sediments at other localities, e.g., the Rosetta area (Zaghloul and Kamel, 1965), Abu Khashaba in (Kamel et al, 1973) in Egypt, as well as Atbra river ,the White and Blue Nile alluvial sediments in Sudan (Gewaifel et al 1977). However, the heavy minerals assemblage studied in the present work (Lake Nubia) indicates more common subangular and subrounded grains.

## CONCLUSIONS

The folwing conclusions can be drawn:

1- The $Al_2O_3$ and $Fe_2O_3$ are deposited simultaneously as hydrolysates, while the CaO and MgO distributions show negative correlation with each other.

2- The amount of organic matter is highly correlated with the amount of silt.

3- The lake sediments are mainly silt, except at the southern part.

4- The light minerals are composed mainly of quartz grains with occasional feldspars.

5- The abundance of the stable heavy minerals are as follows, arranged in decreasing order: zircon, tourmaline and rutile.

6- The most abundant metamorphic minerals are garnet and staurolite.

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