Clay Minerals in Lake Mobutu Sese Seko (Lake Albert) — Their Diagenetic Changes As An Indicator of the Paleoclimate

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With 9 figures and 4 tables

Zusammenfassung

Sedimentkerne aus dem Albert-See wurden mineralogisch untersucht. C^{14}-Datierungen ergaben für das Kernende des längsten Kerns ein Alter von 28 000 Jahren v. h. Die Tonfraktion enthält Smektit (S), Illit (I), Kaolinit (K) und Wechsellagerungsmineralien (I—S). Der Anteil der einzelnen Mineralien ändert sich zyklisch mit der Tiefe. Vom Hangenden zum Liegenden läßt sich folgende Abfolge beobachten:
S (I+K) → I—S (S, + I, + K) → I (I—S, +(K)) → I—S (I, + S, +K) → S (I+K).

Diese Abfolge steht im Zusammenhang mit der Pleistozänen Entwicklung des Albert-Sees. Das Auftreten von Illit wird als diagenetische Umwandlung aus Smektit erklärt. Zum Zeitpunkt der Illitbildung (> 12 500 v. h.) war der Albert-See abflußlos und hochkonzentriert. Diese Tatsache wird unterstrichen durch die Vergesellschaftung von Illit mit den Zeolithen Phillipsit und Chabasit. Das gleichzeitige Auftreten von protodolomitischen Oolithen zeigt, daß der Seespiegel wesentlich tiefer als heute lag.

Abstract

The mineralogy and chemistry of cores from Lake Mobutu Sese Seko (East Africa) were studied. The base of the longest core was ^{14}C-dated at 28,000 years B.P. The clay fraction contains smectite (S), illite (I), kaolinite (K) and interstratified illite-smectite (I—S). These clays vary in a cyclic pattern. The following sequence was observed in the longest core from top to bottom:
S (I+K) → I—S (S, + I, + K) → I (I—S, +(K)) → I—S (I, + S, +K) → S (I+K).

This sequence is related to the Pleistocene evolution of Lake Mobutu Sese Seko. The occurrence of illite is explained as a diagenetic transformation of smectite into illite. During the illite formation (> 12,500 years B.P.) the lake was in a closed basin stage, a conclusion supported by the presence of phillipsite and chabazite zeolites and the occurrence of protodolomitic oolites together with the illite.

Résumé

Des carrottes de sondage provenant du Lac Albert ont fait l'objet d'études minéralogiques. L'extrémité inférieure des carrottes les plus longues ont, datées par le C^{14}, un âge de 28.000 années. La fraction argileuse comprend de la smectite (S), de l'illite (I), de la kaolinite (K), et des minéraux à feuillets (I—S). La proportion des minéraux change cycliquement avec la profondeur. Du haut vers le bas, on observe la suite suivante:
S (I+K) → I—S (S, + I, + K) → I (I—S, +(K)) → I—S (I, + S, +K) → S (I+K).
Cette suite est en liaison étroite avec le développement du Lac Albert au Pléistocène. La présence d'illite s'explique par la transformation diagénétique à partir de la smectite. Au moment de la formation de l'illite (> 12.5000), le Lac Albert était sans écoulement et était marqué par une forte concentration. Ce fait est souligné par l'association d'illite

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avec les zéolites, la philippsite et la chabasite. La présence simultanée d'oolites protodolomitiques montre que le niveau du lac était nettement plus bas qu'ajourd'hui.

Краткое содержание

Провели минералогическое исследование кернов озера Альберта — озеро Мобуту Сесе Секо — восточная Африка. Возраст основания наиболее длинного керна равен 28 000 годам. Глинистая фракция содержит смектит (S), иллит (И), каолинит (K) и перемежающиеся прослойки иллита и смектита (I—S). Количество каждого минерала изменяется циклически. От кровли до подошвы наблюдают следующую последовательность:
S (I + K) ——————— I — S ($S_1 + I_1 + K_1$) ——————— I (I — S + [K]) ———————
——————— I — S (I + S + K) ——————— S (I + K).

Такая последовательность связана с историей развития озера Альберта в плейстоцене. Иллит рассматривают, как диагенетическое преобразование смектита. Во время образования иллита (12600 лет тому назад) озеро Альберта не имело выходя и содержало большое количество солей. Это подчеркивает и ассоциация иллита с цеолитным филлипситом и хабазитом. Одновременное образование протодоломитных оолитов указывает на то, что уровень воды тогда был значительно ниже сегодняшнего.

Introduction

The lakes of East Africa have fascinated scientists for a long time due to their tropical location, their great variety in water chemistry, and their unique ecology (e. g., Capart, 1952; Verbeke, 1957; Coulter, 1963; Talling, 1963; Talling and Talling, 1965; Kilham, 1972). Moreover, many of these lakes are old and their basins contain abundant information concerning the Pleistocene climatic history of East Africa (Livingstone, 1965, 1975; Kendall, 1969; Grove and Goudie, 1971; Richardson and Richardson, 1972; Gasse, 1977; Street and Grove, 1976).

Until now, the lakes of East Africa have received greater attention by paleohistorians and paleoecologists than by geologists. Fairly recently, however, this trend has changed. In the last 10 years, several expeditions to the large East African Rift lakes have recovered a suite of long cores containing a wealth of information (Degens et al., 1971; Degens et al., 1973; Hecky and Degens, 1973; Müller and Förstner, 1973; Stoffers and Fischbeck, 1974; Degens and Stoffers, 1976).

Studies of these cores revealed that, in addition to the standard methods of pollen and diatom analyses, certain authigenic or diagenetic minerals such as carbonates, zeolites, feldspars, and evaporites can be used for paleolimnological interpretation (Stoffers and Holdship, 1974; Stoffers, 1975; Stoffers and Hecky, 1978).

In the present paper mineralogical and chemical data obtained from two cores (A 1 and A 3) taken from Lake Mobutu Sese Seko (formerly Lake Albert) will be discussed. Based on these data, and in particular on the diagenetic changes of the clay minerals, a reconstruction of the history of the lake for the past 28,000 years is attempted.

Lake Mobutu Sese Seko is the northernmost lake in the Western Rift Valley (Figure 1). It has a surface area of approximately 5300 km^2 and is located at an altitude of 619 m above sea level. The maximum water depth is 58 meters. Semliki and Victoria Nile Rivers are the principal rivers draining into Lake Mobutu Sese Seko. The Semliki River connects Lake Edward with Lake Mobutu Sese Seko. The effluent from the lake is the White Nile. The present water chemistry is given in Table 1. Most striking are the high phosphate and low silica contents. The major constituents are similar in proportion to Lake Edward which suggests that the water chemistry of Lake Mobutu Sese Seko is mainly determined by the inflowing Semliki River.

Due to the shallow water depth the lake is normally well mixed. However, thermal stratification can occur, with oxygen depletion in water below 35 meters approximate water depth (TALLING, 1963).

Core A 1 was collected in 1971 by the Department of Zoology of Duke University, Durham, North Carolina from a water depth of 46 m and was studied for diatoms by HARVEY (1976). Core A 3 was raised in 47 m water depth by the Woods Hole Oceanographic Institution in 1972. The core locations are depicted in Figure 2.

Methods

Grain size analyses were made using standard sieve and Atterberg settling tube techniques.

Carbonate content was measured gasometrically.

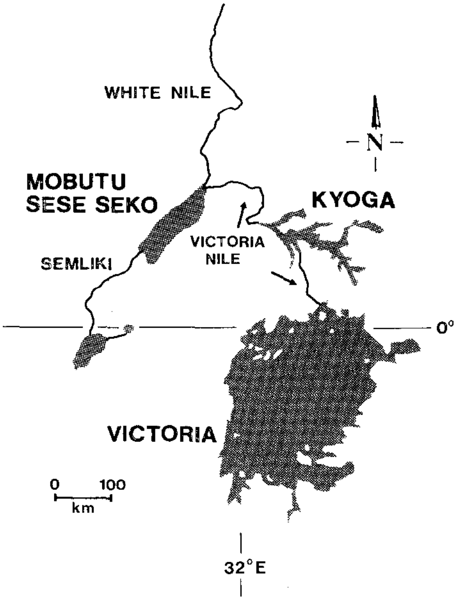


Fig. 1. Lake Mobutu Sese Seko in relation to Lakes Victoria and Edward.

Na mg/l	K mg/l	Ca mg/l	Mg mg/l	Cl mg/l	SO_4 mg/l	HCO_3 mg/l	SiO_2 mg/l	total P µg/l	pH	Date
91	65	9.8	32.1	33	36.5	447.3	0.04-1.1	120-170	9.0	Febr. 61

Table 1. Chemical composition of surface water, Lake Mobuto Sese Seko (TALLING, 1963; TALLING and TALLING, 1965).

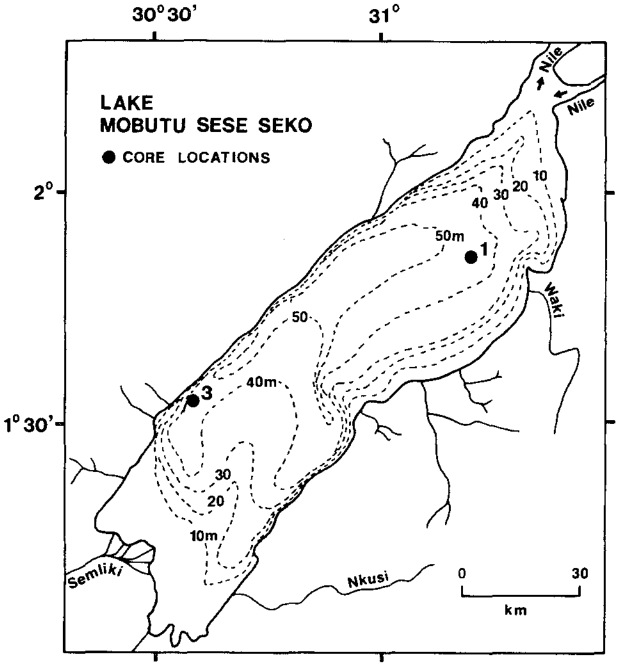


Fig. 2. Bathymetric chart of Lake Mobutu Sese Seko, after Capart (Verbeke, 1957) and core locations.

Mineral content was determined by X-ray powder diffraction analyses using a Phillips diffractometer with nickel-filtered Cu Kα radiation. Samples for clay mineral analyses were first treated with 10 % hydrogen peroxide to remove organic matter, and then with diluted acetic acid to dissolve the carbonates. Separation of the individual clay fractions was done by applying the centrifuge method. Clay smears were made on glass slides and the analyses were made according to the methods described by Hathaway (1956). Quantitative chemical analyses of the clay fraction were made using atomic absorption spectrophotometry after a combined HF-$HClO_4$-HNO_3 digestion.

Organic carbon was determined with a Leco-carbon analyzer.

Electron microscope studies of selected samples were performed with a Cambridge stereoscan S 4 and a Siemens electron microscope (Elmiskope 100).

Results

Lithology

From the top of core A 3 to 185 cm the sediment is a dark grey to black finegrained mud, and from 185 cm to 460 cm there is a change to a uniform light grey color. The lowermost 21 cm of the core are very sandy and the core terminates in a dry, brittle material at 481 cm. A similar layer was also encountered in core A 1 at around 660 cm core depth. Below this coarse textured interval down to the bottom of core A 1 at 1060 cm, greenish-grey, finegrained muds predominate.

Age

Seven core intervals of core A 1 were radiocarbon dated. An age of 28,180 ± 860 years B. P. was found for the base of the core (HARVEY, 1976). The coarse-grained interval present in the two cores revealed a carbon date of 12,500 ± 190 years B. P. Sedimentation rates were quite varied and ranged between 0.13 mm and 0.33 mm per year with lower rates at station A 3.

Diatoms

The diatoms of core A 1 were studied in detail by HARVEY (1976). According to his diatom analyses, the core can be subdivided in the following manner:

IV	The Stephanodiscus-Nitzschia portion	0— 90 cm
III	The Upper Stephanodiscus-Melosira portion	100— 645 cm
II	The portion with few or no diatoms	650— 930 cm
I	The lower Stephanodiscus-Melosira portion	940—1060 cm

Mineralogy

Apart from the layer silicates which are dominant constituents, carbonates, quartz, and feldspars were detected by X-ray diffraction analyses.

In Fig. 3 the diatom distribution is shown in relation to the total carbonate

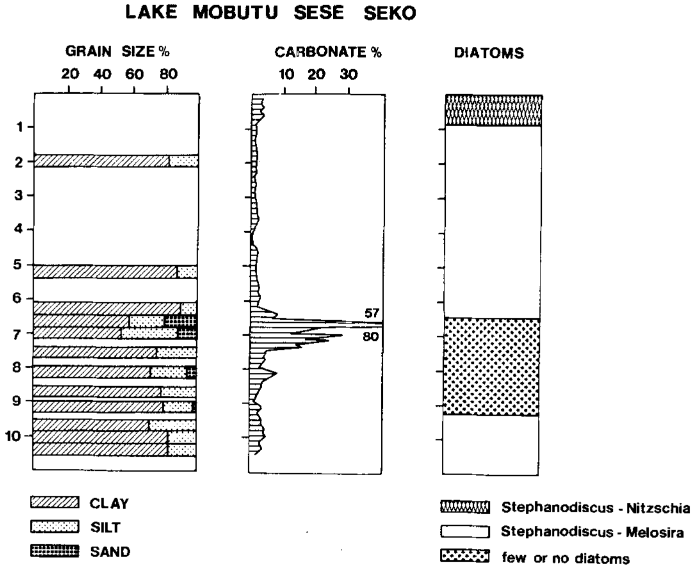


Fig. 3. Grain size, carbonate content and diatom distribution in core A 1. Diatom data are from HARVEY (1976).

content and the grain-size distribution of core A 1. As can be seen, the carbonates are an insignificant sedimentary component. In general, the content varies between 0 and 5 % with the exception of the coarse-grained interval of the two cores where carbonate exceeds 10 %. The highest value with 80 % was found at 660 cm in core A 1. This carbonate interval correlates with the core portion with few or no diatoms and compared with the grain size distribution, it is the sediment sequence with the highest sand and silt portions. In the coarse-grained intervals, proto-dolomitic oolites are the main components (Figs. 4 a, b; 5 e, f). A number of larger concretions are present consisting of incrustated ostracods and fish vertebrae.

Scanning microscope studies reveal that the oolites are generally composed of angular particles (Fig. 5 c) although microsized rhombs can be detected in some oolites (Fig. 5 d). In thin sections a slight indication of a gravitational cement was observed in some of the oolites. The proto-dolomite is a $Mg_{35}\,Ca_{65}\,(CO_3)_2$ dolomite as shown by X-ray diffraction.

At Station A 3 the carbonate content increases in the upper core section.

Together with the oolites, the zeolites phillipsite (Fig. 5 a) and chabazite (Fig. 5 b) are present in the silt fraction of core A 1. The chabazite is a potassium-rich variety as indicated by X-ray energy dispersive analyses.

Clay Mineralogy

In core A 3, smectite, kaolinite, and illite are present in the clay fraction. Smectite is by far the dominant clay mineral. In the carbonate-rich sandy layer at the bottom of the core, interstratified illite-smectite becomes more abundant.

The clay fractions of core A 1 contain illite, smectite, interstratifieds, and kaolinite. These clays vary in a cyclic pattern:

A. Upper Cycle. Down to about 665 cm core depth dioctahedral smectite dominates, followed by illite, some kaolinite, and traces of quartz. At 660 cm depth interstratified illite-smectite and smectite dominate, accompanied by considerable illite, some kaolinite, and traces of quartz. From 670 cm depth to about 770 cm illite is most abundant, accompanied by some interstratifieds, some kaolinite, and traces of quartz. In downward direction, the upper cycle thus consists of:

$$S\,(I + K) \longrightarrow I - S\,(S, + I, + K) \longrightarrow I\,(I - S, + (K)).$$

B. Lower Cycle. As stated above, from 670 cm sediment depth to about 770 cm illite is most abundant, accompanied by some interstratifieds, some kaolinite, and some quartz.

At 800 cm depth, a transition commences towards interstratifieds which are most abundant at 849 cm core depth. These are accompanied by some illite, smectite, kaolinite, and traces of quartz.

At 1040 cm depth in the lowermost sample smectite is dominant, accompanied by some illite, kaolinite, and traces of quartz. In a downward direction the lower cycle can be represented in the following way:

$$I\,(I - S, + (K)) \longrightarrow I - S\,(I, + S, + K) \longrightarrow S\,(I + K)$$

Representative glycolated clay patterns of the two cycles are shown in Figure 6. In addition, the potassium contents of the clay samples are presented. There is a

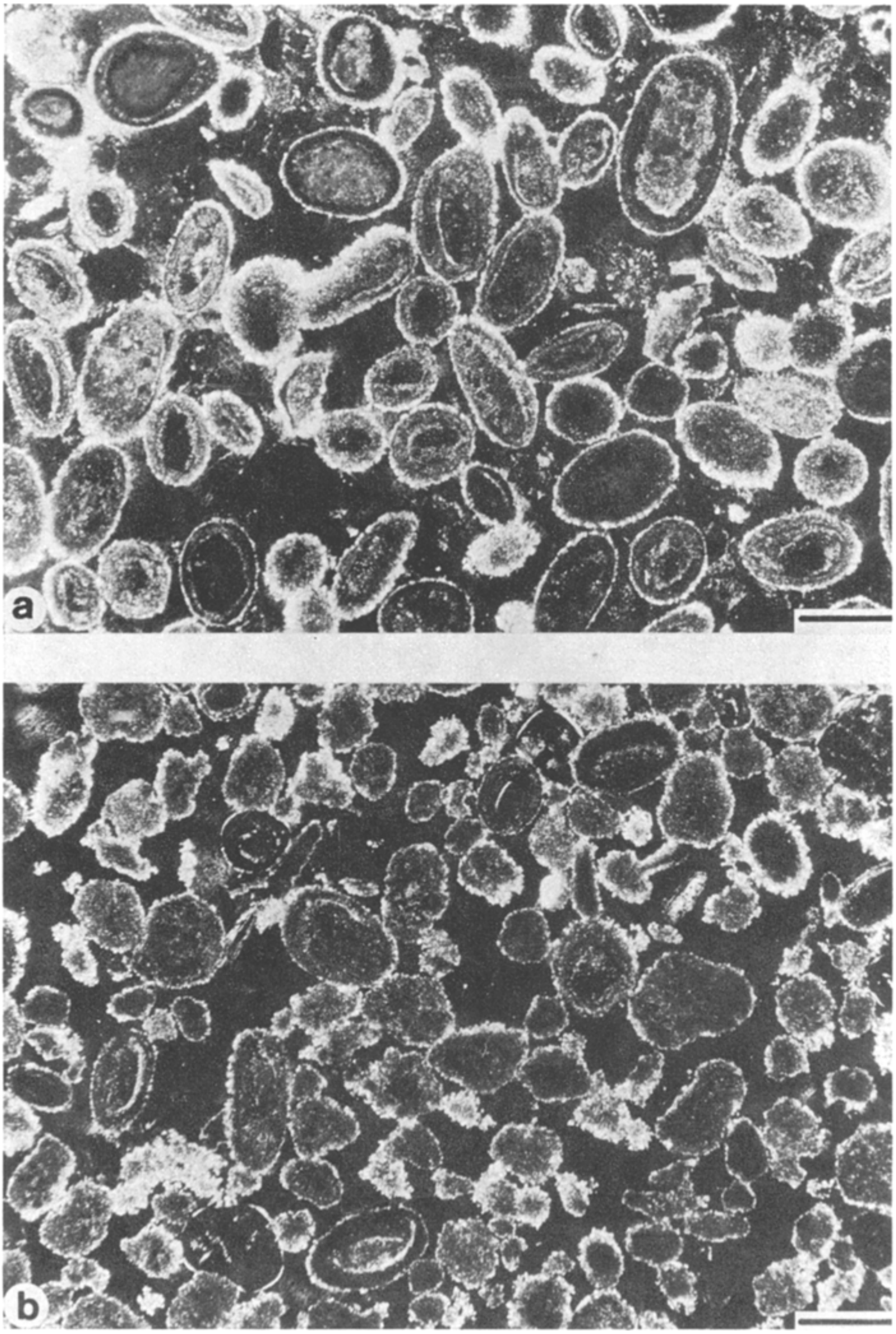


Fig. 4. a, b Thin section of coarse grained mainly oolitic material present in cores A 1 and A 3. Crossed nicols. Scale bar is 400 μm

a) Station A 1

b) Station A 3.

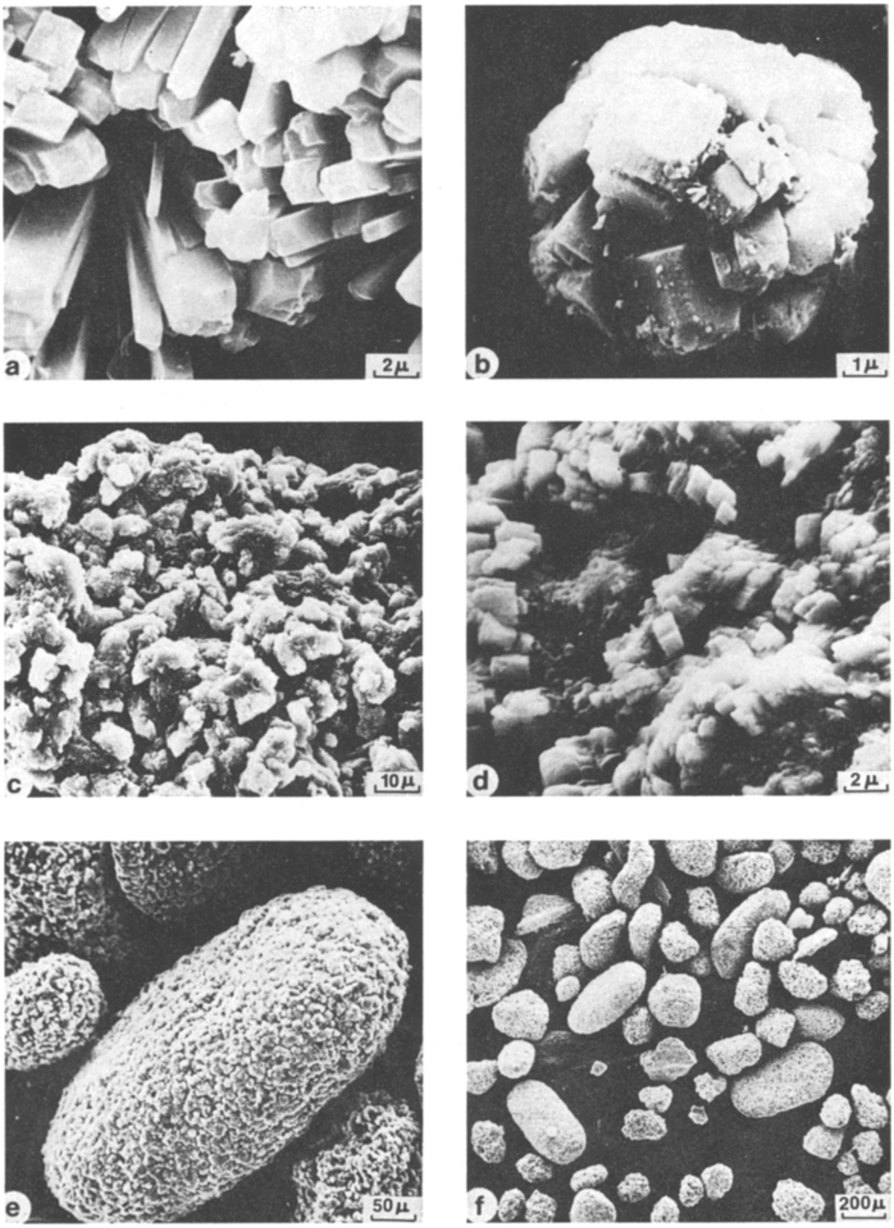
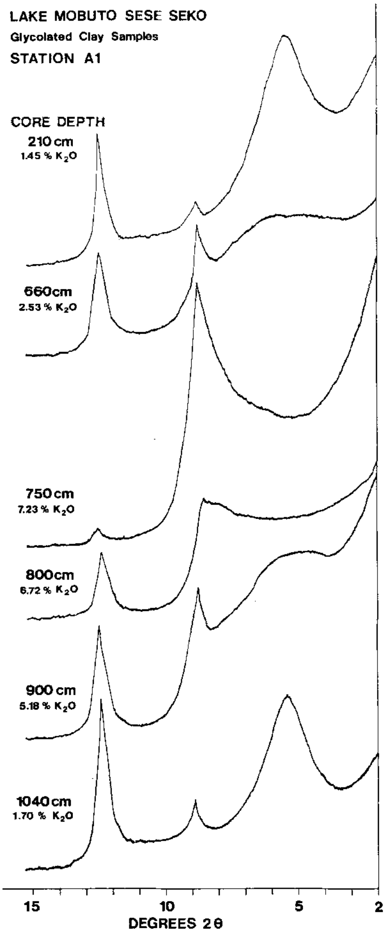


Fig. 5. Scanning electron micrographs of sediment samples from the illite interval (660—$\sim$ 760 cm core depth) of core A 1

a) Phillipsite
b) Chabazite
c) surface of protodolomitic oolites revealing small angular particles
d) surface of protodolomitic oolites with small dolomitic rhombs
e) protodolomitic oolites
f) coarse fraction showing abundant protodolomitic oolites and dolomitized shell material



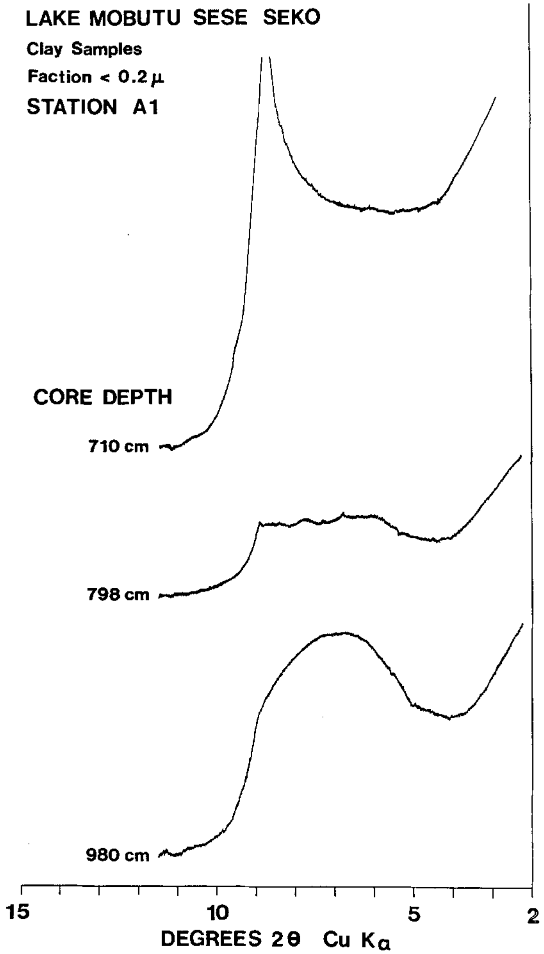


Fig. 6. x-ray diffractograms of selected glycolated clay samples (fraction < 2 μm) from core A 1

Fig. 7. x-ray diffractograms of selected clay samples (fraction < 0,2 μm) from core A 1

clear relation between the dominance of smectite and low potassium values, whereas in the illitic interval the potassium content is highest.

X-ray diffractograms of the clay fractions from 3 samples that were separated into fine (< 0.2 μm) and coarse (0.2 μm—2.0 μm) clay indicate that illite dominates in the coarse sized clay of all samples, whereas in the fine clay illite dominates only at 750 cm depth. At 800 cm depth interstratifieds occur and at 980 cm depth smectite is most abundant in the fine fraction (Fig. 7).

Electron Microscope Studies

Electron micrographs of all clay samples show essentially three types of particles:

a) large, semi-euhedral particles

b) small, euhedral to semi-euhedral particles

c) large, anhedral, sheet-like, folding particles.

a) The large, plate-like particles often exhibit semi-hexagonal shapes and are masked by MOIRÉ patterns (Fig. 8 a, b, c). At the edges the sequential ordering of individual sheets can be observed. These particles, which appear at all sediment depths, suggest detrital biotite or illite.

b) In all samples, small to medium-sized particles are prominent. The particles are selectively thin. Frequently their outlines are relatively sharp and they exhibit a semi-euhedral (hexagonal) shape (Fig. 8 d, e). They are particularly abundant between 700 and 800 cm depth. Sometimes these particles have less well-defined outlines and their shape is rather anhedral (Fig. 8 f). In this form the particles suggest the identification of smectite. They are particularly abundant in the lowermost sample at 10.40 m depth.

c) In all samples a few large particles are present that have a sheet-like, folding shape, with a turbostratic piling of sheets or tactoids (Fig. 8 g, h). The particles are relatively rare and appear in insignificant amounts only in the upper core interval, and they probably represent smectite. In the lowermost sample at 10.4 m depth large sheet-like (but not folding) particles also appear, suggesting degraded illite-smectite.

Chemistry

The chemistry of core A 3 and some selected samples from core A 1 is given in Table 2 and 3.

Potassium, magnesium, and calcium are all enriched in the illitic interval of core A 1. Magnesium and strontium are especially high in the protodolomitic layer present in the two cores. Most striking are the manganese fluctuations, which range from 700 up to 12,500 ppm, with the highest values in the near-shore core A 3. In this core the large-scale fluctuations are present only in the lower core portion, whereas a rather uniform manganese content of about 2,000 ppm is found in the upper two meters. Organic carbon ranges from 1.4 % to 4.4 %, with the highest values in the upper two meters.

Discussion

The changes in the clay mineralogy, sediment chemistry, and diatom assemblage provide a detailed picture of the lake level oscillations, which in turn allow the reconstruction of climatic events in tropical Africa. Based on the data obtained from the two cores, the history of Lake Mobutu Sese Seko is depicted in Fig. 9 for the last 28,000 years. In the sediments deposited between 28,000 and 25,000 years B. P., detrital smectite and kaolinite are the dominant sediment constituents. Apart from layer silicates, the diatiom genera Stephanodiscus and Melosira are present. The diatom studies by HARVEY (1976) indicate that Lake Mobutu Sese Seko was open during this time period with lower dissolved ionic concentrations than those prevailing today. The lake level was probably higher than present and temporary stratification seems likely. These limnologic conditions are reflected in the fluctuating manganese values. When manganese was high, the lake was well mixed and oxidized, whereas the low concentrations indicate stratifications and sufficiently low Eh values that liberate manganese from the sediment.

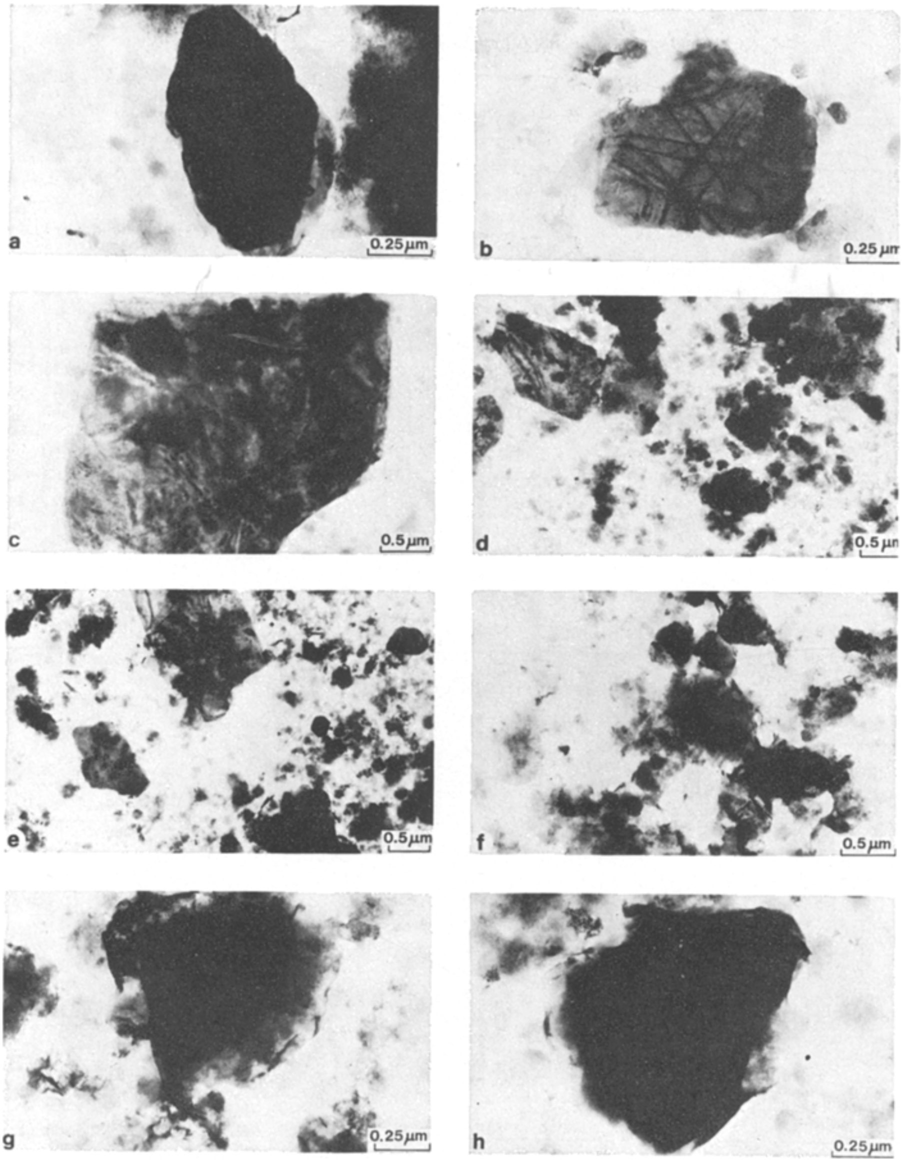


Fig. 8. Transmission electron micrographs of typical clay samples from core A 1
a) semi-euhedral crystal of illite
b) semi-euhedral crystal of illite with Moiré pattern
c) illite
d) large illite crystallites and smaller semi-euhedral interlayer — or illite crystallites
e) same as d), at center right kaolinite crystallite
f) smectite or interstratified particles
g) typical smectite particles
h) same as g)

Station A 3
Bulk Sample

core depth (cm)	Org. C %	Fe_2O_3 %	Mn ppm	CaO %	MgO %	Sr ppm
0	3.5	8.4	1870	2.2	1.4	250
20	3.2	8.4	2000	3.2	3.4	335
45	3.5	8.5	1900	3.5	2.5	372
60	3.4	8.4	1940	3.6	2.5	350
75	3.2	8.4	2150	3.6	3.0	420
90	3.4	8.3	2150	2.3	3.0	300
105	3.6	8.4	2300	2.5	3.0	415
130	4.4	8.5	2400	1.5	3.2	400
145	4.2	8.5	2270	3.0	3.4	315
160	3.7	8.4	2280	2.7	3.0	340
200	1.7	10.2	2300	0.4	2.1	320
225	1.7	10.4	8600	0.5	1.8	105
250	1.4	10.2	4900	0.5	1.8	95
275	1.7	10.3	7400	0.6	1.8	115
300	1.7	10.3	4130	0.6	1.7	110
325	1.8	10.3	3420	0.6	1.8	115
350	2.1	10.3	2140	0.7	1.8	115
375	2.7	13.5	2560	1.1	2.2	132
400	2.9	9.2	3800	1.1	2.0	130
425	2.5	12.0	1350	0.7	2.0	135
450	2.5	9.0	4780	5.7	4.5	610
460	2.8	6.2	12500	25.0	15.5	2000

Table 2. Geochemistry of bulk sediments station A 3.

STATION A 1 clay-samples core depth (cm)	Fe_2O_3 %	K_2O %	MgO %	CaO %	Mn ppm
201-202	7.58	1.44	1.49	0.63	900
502-503	6.72	2.58	1.83	0.78	1650
655	6.29	2.52	3.98	2.13	2020
660	6.43	2.52	6.64	2.69	2575
710	7.58	5.52	5.76	11.90	2562
750	8.94	7.20	4.90	2.59	2612
798	8.52	6.70	2.79	1.11	958
849	8.39	6.42	2.41	1.43	700
900	6.84	5.16	2.07	1.46	556
950	7.29	5.82	2.46	2.24	2219
980	7.69	6.00	2.35	2.41	2710
1045	8.72	2.04	1.58	0.70	750

Table 3. Geochemistry of selected clay samples Station A 1.

From 25,000 to about 16,000 years B. P. interstratified illite-smectite are most abundant. Diatoms are generally absent with the exception of a few layers (Harvey, 1976). Thus this interval is likely to represent lower lake levels and closed basin conditions for the lake during a more concentrated water stage than today. The few diatom layers suggest some alternations between open and closed conditions. The sampling made in this study, however, was not closely spaced enough to detect these changes in the mineralogy of the sediments.

The most striking evidence of a closed basin period is from the time interval between 16,000 and 12,5000 B. P. Illite is the most dominant sediment constituent. The occurrence of illite is explained as a diagenetic transformation of detrital smectite into illite in highly concentrated waters. Illite is most abundant in the fine fraction ($< 0.2\ \mu m$), which indicates that the diagenetic transitions take place mainly in the fine fractions of the clay minerals. Together with the diagenetic illite, protodolomitic oolites occur. These oolites reveal that the water level of the lake dropped significantly. The lake level was probably at least 40 meters lower than today. The gravitational cement, which was observed in a few oolites, even suggests subaerial exposure. Under the very saline and alkaline conditions during this time period volcanic glass is altered to a potassium-rich chabazite and phillipsite. These reactions are well documented from other East African alkaline lakes (Hay, 1963, 1966; Eugster, 1969; Surdam and Eugster, 1976).

For this closed basin stage only traces of kaolinite could be detected in the sediments suggesting that the supply of kaolinite from the Semliki River and the Victoria Nile as the main source for kaolinite was basically stopped.

As shown by theoretical considerations, closure of Lake Mobutu Sese Seko could

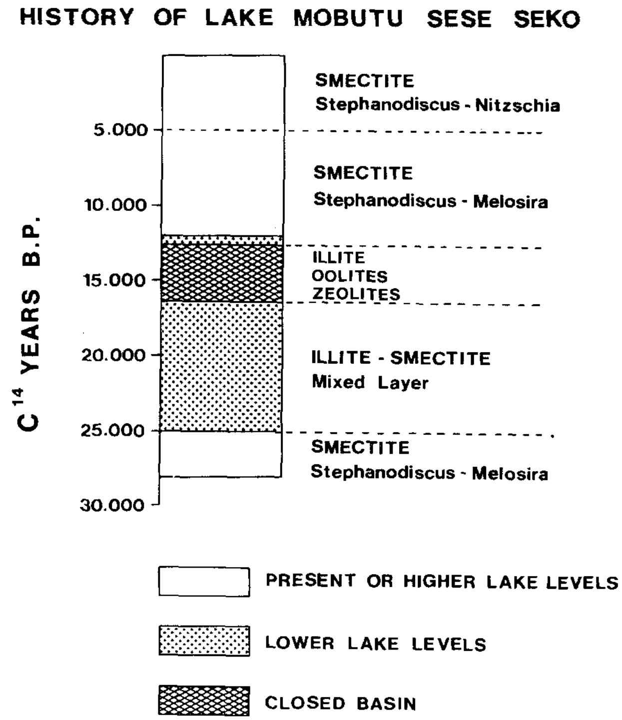


Fig. 9. History of Lake Mobutu Sese Seko for the last 28,000 years B.P. as deduced from mineralogical and diatom data

only be achieved if the regional climate were 5° C cooler than present and the regional precipitation were reduced by about 29 % (Harvey, 1976).

After 12,500 B. P. the lake level rose very quickly. The cool, dry climate which prevailed before changed into a warmer and more humid climate. The transition from diagenetic illite to interstratified illite-smectite and finally to smectite is very short, the latter remaining the dominant clay mineral since 12,500 B. P., when kaolinite again becomes more important. The inflow of the Victoria Nile and the Semliki River is indicated. As a consequence of the dilute water conditions of the lake, diatoms occur. The genera Stephanodiscus and Melosira again imply lower dissolved ionic concentrations than prevail today. The greater tributary inflow led to higher lake levels than at present (Harvey, 1976).

At 5,000 B. P., the lake's diatom plankton changed from the genera Stephanodiscus and Melosira to the genera Stephanodiscus and Nitzschia, which are now dominant in the modern lake. During the last 5,000 years the lake has been in essentially its modern state. At station 3, located near the western shore of Lake Mobutu Sese Seko, the carbonate and organic carbon contents increase around 5,000 years B. P., which may reflect higher productivity in the near-shore areas where nutrient input and regeneration are greatest. The higher organic carbon content caused the sediments to become slightly reducing. The manganese fluctuations which were noted earlier ceased after 5,000 years B. P.

Correlation with other East African lakes

The mineralogical, geochemical, and diatom data of the Lake Mobutu Sese Seko cores provide insight into the interaction of climate and geology over the last 28,000 years. The climatic interpretation obtained can be more or less correlated to other East African data. As can be seen from Table 4, the period of high and dilute water in postglacial time, in particular from 12,500 to about 5,000 years B. P., is confirmed in Lake Manyara (Stoffers and Holdship, 1974) in Lake Victoria (Kendall, 1969), and in Lake Naivasha (Richardson and Richardson, 1972). Also other lakes situated close to the equator, such as Lakes Magadi and Nakuru (Butzer et al., 1972) demonstrate that the last major wet period in East Africa was in postglacial time. It is interesting to note that lakes well north of the equator (e. g., Lake Rudolf, Galla Lakes in Ethiopia) reveal a similar postglacial history; however, instead of the unimodal pluvial of the equator lakes, these lakes record a bimodal pluvial period with two major rainfall peaks centered around 10,000 and 6,000 years B. P. (Butzer et al., 1969, 1972; Grove and Goudie, 1971; Grove et al., 1975).

The dry period with low lake levels present in Lake Mobutu Sese Seko before 12,500 years B. P. correlates well with the climatic picture obtained from other East African lakes (see Tab. 4). The few older data available from Pleistocene sequences in East Africa also provide some striking parallels. The early open period of Lake Mobutu Sese Seko can be correlated to the 29,000 to 24,500 years B. P. humid phase at Lake Manyara, and also Manyara's 19,000 to 16,000 years B. P. moist episode bears some resemblance to moister periods at Lake Mobutu Sese Seko as suggested by the diatom data (Harvey, 1976).

The stratigraphy of Lake Mobutu Sese Seko generally agrees with the emerging pattern of a dry ice age and wet postglacial periods at low latitudes.

Lake Mobutu Sese Seko[1]	Lake Manyara[2]	Lake Victoria[3]	Lake Naivasha[4]
present	present	present	present
similar climate as today	approx. the same climate as today	climate interp. uncertain	climate similar to present
5,000	5,200	3,000	3,000
fluctuating wet period moister than today	fluctuating wet period moister than today	somewhat drier	drier than today
12,500	12,500	6,500	4,000
generally dry with short moister intercalations	dry	second pluvial peak, wetter	climate becomming drier
25,000	16,000	9,500	5,000
wet period	moderately wet	moderately dry	Gamblian pluvial
>28,000	19,400	10,500	>9,200
	dry	first pluvial peak moderately wet	
	26,500	12,500	
	moderately wet	dry	
	27,500	>14,500	
	dry		
	47,200		
	moderately wet		
	48,200		
	dry		
	>55,000		

Table 4. Climatic history of different East African lakes. Sources of data (1) this report and Harvey (1976); (2) Stoffers and Holdship (1975); (3) Kendall (1969); (4) Richardson and Richardson (1972).

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