FOSSIL OSTRACODES FROM LAKE MOBUTU (LAKE ALBERT): PALAEOECOLOGIC AND TAPHONOMIC IMPLICATIONS

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ABSTRACT

Two deep water cores from Lake Mobutu (= Lake Albert) were analyzed for fossil ostracode content to determine palaeohydroclimatic conditions for the lake during the Late Quaternary. Low diversity ostracode assemblages with highly erratic frequency patterns were collected from both cores, spanning a time interval 13 000 BP to the present. Ostracodes dated at approximately 13 000 BP indicate shallow (3-8 m depth), moderately alkaline-saline water conditions at an open lake site currently 47 m deep. Above this horizon, progressive deepening and the establishment of a profundal, fresher water fauna is indicated. Depositional hiatuses, possibly due to deep water erosion, make the dating of this progressive deepening difficult to establish, but it certainly predates 7 500 BP.

Three taphonomic associations are recognized from the ostracode assemblages found. Ostracode sand lag assemblages are life assemblages of un-abraded, articulated fossils formed in relatively shallow water conditions, where fines are winnowed out and refractory organics are oxidized, leaving behind a highly concentrated ostracodal sand. Profundal life assemblages form in deep water, where food availability is low. They are characterized by very low density accumulations of unbroken and often articulated valves, reflecting a lack of transport and low initial population densities. Profundal mixed assemblages are transported admixtures of both shallow and deep water ostracode species, which probably form as a result of bottom current transport. They are recognized by the co-occurrence of species with very different habitat requirements. Fossil material in these assemblages is normally broken or abraded, and valves are mostly disarticulated.

INTRODUCTION

Fossil ostracodes are commonly found in African lacustrine sediments. Previous studies have indicated the utility of these fossils for a wide variety of
palaeoenvironmental interpretations, including (but not restricted to) palaeochemical, palaeodepth and water temperature analyses (Delorme et al. 1977, De Deckker 1983, Forester & Markgraf 1984). Palaeoecological investigations of fossil ostracodes in Africa have primarily been concerned with the development of palaeochemical interpretations of ancient lake sediments, which can then, in some cases, be used for making palaeoclimatic interpretations. To date, most such studies have concentrated on shallow water lake deposits from East Africa (Cohen 1981, Cohen et al. 1983, Carbonel & Peypouquet 1983, Carbonel et al. 1983, Peypouquet et al. 1983, Nielsen 1984). Ostracode standing crops are normally much higher in shallow water lacustrine settings than in deep water, due to considerable differences in food availability between the littoral and profundal zones (Cohen 1984).

In this study, I present preliminary results from the analysis of fossil ostracodes obtained from two cores taken in Lake Mobutu (= Lake Albert of older literature). This study differs from earlier mentioned investigations of fossil African ostracodes in that the cores were derived from relatively deep water (40 and 47 m). Aside from attempting to document the Late Quaternary ostracode faunal history of the lake, a second goal of this study was to determine the origin of deep water ostracode fossil assemblages in lakes. Specifically, are concentrations of ostracode valves found in profundal settings emplaced through in situ burial as life assemblages, or are they primarily death assemblages which have undergone transport and sorting? Such information will be critical in assessing the utility of these types of assemblages for various palaeoecological and evolutionary studies.

MATERIALS AND METHODS

The two cores analyzed in this study were collected by scientists from the Woods Hole Oceanographic Institution (WHOI) during their 1972 expedition to the African Great Lakes. Detailed descriptions and sedimentological interpretations of these cores may be found in Hecky & Degens (1973). The two piston cores, hereafter referred to as Core #2 and Core #3 (Woods Hole Station numbers), were obtained from relatively deep water stations (40 and 47 m respectively) on the Zaire side of the lake (Core #2: lat. 01°29.2'N, long. 30°42.9'E; Core #3: lat. 01°31.2'N, long. 30°34.5'E; see Fig. 1). Total recovered core lengths for Cores #2 and #3 respectively are 532 and 484 cm. The cores are stored and available for subsampling at WHOI.

Ostracode samples were obtained by removing 2-4 g dry mass of sediment from scraped core sample splits. Sample splits were taken every 20 cm for both cores. Sediments were disaggregated by spray washing in warm water. Samples were microscopically examined prior to disaggregation to insure that any breakage of ostracode valves could be ascribed to either original status or damage during preparation.

Samples were sieved in a # 80 US mesh size screen, which insured that all
adults and most juvenile ostracodes would be retained. The coarse terrigenous clastic component (as a fraction of total washed sediment) was calculated by weighing the clastic fraction retained on the screen after sieving.

Washed samples were microscopically examined for ostracode content. Percentages were calculated for each species present. No distinction is made here between adult and juvenile valves. Normally 100 valves were counted, but for many samples with very low ostracode concentrations or predominately broken or unidentifiable valves this was not possible. Such samples are indicated in Figure 2 with an asterisk.

Ostracode abundances were estimated by extrapolation from small (0.01-0.05 g) subsamples. For samples with large numbers of broken ostracodes, abundances were estimated by determining the total mass of ostracodal debris and dividing by the average mass of ostracodes present in that core interval.
Figure 2. Core stratigraphy and ostracode occurrences discussed in this report. 2a. Core No. 2; and 2b. Core No. 3. % CTC is percent coarse terrigenous clastics which equals the proportion of terrigenous clastic grains larger than 2.5 phi (0.177 mm). Tr means CTC are present in trace amounts, less than .001%. Ost. Ab. is ostracode abundance, in # valves per g sediment (dry weight). Ostracode abundance calculations are discussed in the text.

Abbreviations of species present: S.c. – Sclerocypris clavularis, H.i. – Hemicypris intermedia, P.n. – Plesiocypridopsis newtoni, D.s. – Darwinula stevensoni, Cy.sp. – Cypridopsis sp., L.sp. – Illyocypris sp., L.sp. – Limnocythere sp., C.sp. – Chrissa sp.

Percentages refer to total counted valves for that core interval. Asterisks indicate samples for which 100 valves were not available.
CORE STRATIGRAPHY

Stratigraphic columns for the two cores are illustrated in Figure 2. Core #2 consists of diatomaceous muds in the lower portion of the core which gradually coarsen upcore to diatomaceous silts. Near the top of the core sediments become slightly finer but remain diatom-rich. The diatom stratigraphy is discussed by Hecky & Degens (1973).

Core #3, deposited somewhat closer to the modern shoreline, is lithologically more complex. The basal 20 cm consists of a recrystallized ostracode sand. The same unit is rich in angular, 0 phi quartz sand at its base, but
rapidly loses its coarse terrigenous component upsection. From 410-460 cm the core consists of interbedded diatomaceous muds and wispy limonitic silts. These are overlain by muds and diatomaceous muds up to 200 cm. This interval gives way abruptly to an ostracod calcarenite which in turn is overlain by both calcareous and non-calcareous, diatomaceous silts at the top of the core.

Coarse terrigenous clastic material (coarser than 2.5 phi) is very rare in Core # 2, occurring in trace amounts to 0.02% at several core intervals. In Core # 3, coarse clastics occur abundantly at the base of the core but rarely elsewhere.

Two correlated age dates and one radiocarbon date are available for Core # 3 (Hecky & Degens 1973). Correlated ages of 13 000 BP and 7 500 BP for the 480 cm and 340 cm levels respectively were suggested, based on diatom and lithologic corrections with other dated cores. A single radiocarbon date of 2 660 ± 90 BP was obtained by Hecky & Degens (1973) for the 140-180 cm core interval. No previous age estimates or radiocarbon dates are available for Core # 2.

**FOSSIL OSTRACODES**

Low diversity ostracode assemblages were recovered from six sample intervals in Core # 2 and twelve intervals in Core # 3. Of these, three samples in Core # 2 and one sample in Core # 3 consist of unidentifiable fragments only. The occurrence of ostracode material throughout the two cores is extremely erratic with extremely high concentrations at certain horizons which are gounded above and below by barren or low frequency intervals.

With the exception of the 140, 160, 180, 380, 460 and 480 cm samples in Core # 3, all ostracode samples are dominated by angular ostracode fragments. Whole specimens are difficult to obtain, and in some samples are nonexistent. The 140, 160 and 380 cm samples all contain monospecific, very low frequency assemblages of unbroken, unabraded *Scleroocyris clavularis* (Sars), with paired valves present in some specimens. Some of these only occur as internal molds. The 180 cm sample from Core # 3 consists of approximately equal proportions of broken and unbroken specimens, although unbroken valves are never attached, even for species in which strong hinges exist. The 460 and 480 cm samples are highly distinctive in that almost all specimens are found intact, and with attached closed valves.

Preservation of ostracode material consists of original shell material or molds in all cases except the 460 and 480 cm samples. Here the material is heavily recrystallized, and in some cases occurs as internal molds, and elsewhere as indeterminate replacement of original shell material.

The 460 and 480 cm horizons in Core # 3 both contain a distinctive assemblage of ostracodes including *Ilyocypris* sp., *Limnoocythere* sp. and *Cypridopsis* sp. Specific identification for all three taxa at these horizons is
impossible due to the nature of preservation. Charophytes and gastropod shell fragments also occur at these two horizons.

At all other core horizons, the ostracode assemblages consist of five species in variable proportions. *Sclerocypris clavularis* is the most abundant ostracode species, occurring in all but three of the horizons for which identifiable material is available. *Hemicypris intermedia* (Bate) and *Plesiocypridopsis newtoni* (McKenzie) are also quite abundant. Two additional species, *Chriissia* sp. and *Darwinula stevenson* (Brady & Robertson), are much less common in each core, occurring at only a single horizon each. No frequency trends are discernible within the *Sclerocypris clavularis* dominated segments of either core.

**PALAEOECOLOGICAL INTERPRETATIONS**

The ostracodes recovered in this study, while limited in diversity, are nonetheless highly significant for the understanding of environmental conditions in Lake Mobutu during the Late Quaternary. The occurrence of ostracodal sands composed primarily of *Ilyocypris* sp. and *Limnocythere* sp. indicates moderately alkaline, very shallow, lacustrine conditions at the Core # 3 site at 13 000 BP. Similar associations are commonly encountered in modern Lake Turkana, particularly in semirestricted embayments, at water depths of 3-8 m (Cohen 1982). At these depths, ostracodal sands, consisting primarily of ostracode valves and refractory organics from plant debris, accumulate in thin but extensive sheets. They do not form at wave-swept, littoral depths, accumulating instead in the sublittoral zone, below normal daily wave base. The organics quickly oxidize, as observed from examination of short gravity cores. Like the Mobutu core material, ostracode shell assemblages found in this setting at Lake Turkana tend to have a large proportion of intact and connected valves, reflecting their minimal degree of transport. These ostracode concentrations are primarily the consequence of the winnowing of finer material from the site of accumulation. The interpretation of the 460 and 480 cm horizons as being of shallow water origin is further bolstered by the abundant occurrence of unbroken charophytes and coarse quartz sand at these levels.

Unfortunately, the inability to make a specific diagnosis of the taxa present prevents any precise palaeochemical estimates for the lake at this time. However, the assemblage is clearly representative of more saline and more alkaline lake conditions than the remaining assemblage, found at all other productive horizons of Core # 3 and throughout Core # 2.

The *Sclerocypris clavularis-Hemicypris intermedia* assemblage, found elsewhere in the two cores, is typical of profoundal ostracode accumulations in large African lakes. In modern Lake Turkana, these two species form the dominant ostracode association at depths greater than 10 m (Cohen 1982). Thus, the appearance of *S. clavularis* by the 380 cm 1vel of Core # 3, even in
low concentrations, signifies the onset of profoundal conditions in the lake.

Higher levels in Core # 3 and the lower (350-370 cm) ostracode accumulation of Core # 2 contain peculiar admixtures of the S. clavularis-H. intermedi assemblages along with common occurrences of Plesiocypridopsis newtoni and occasional Chriissia sp. Both of these taxa are typical of shallow water and are frequently found around groundwater discharge localities, but rarely occur in the profoundal zone of modern African lakes. Thus, their presence with the deep water species is anomalous for a life assemblage. As noted earlier, a very high proportion of valves in both cores are broken and abraded, suggesting that the fossils may have undergone significant post mortem transport. This interpretation is also supported by the very erratic proportions of various species through the upper interval of Core # 3 and the 350-370 cm interval of Core # 2. Variations like this are extremely uncommon in profound lacustrine ostracode assemblages in the absence of major environmental shifts or the introduction of reworked death assemblages. The sedimentological record does not support an interpretation of major facies changes or sediment accumulation hiatuses at the levels where this sort of change is observed (e.g. Core # 3, between 60 and 100 cm).

The Scleroecypris-Hemicypris assemblage indicates water chemistry conditions similar to those of modern Lake Mobutu. The indicated total alkalinity and salinity for this assemblage is 8-20 meq/l and .8-2 ppt respectively. If Chriissia specimens found with the deep water assemblage are contemporaneous with that assemblage, the hydrochemical conditions for Lake Mobutu for the 180 cm interval of Core # 3 and the 350 cm level of Core # 2 are further constrained. Chriissia is restricted to relatively low alkalinity-salinity water conditions, with maximum alkalinitities of approximately 10 meq/l and salinities of 1 ppt, indicating a relatively narrow range of water chemistries (8-10 meq/l alkalinity and .8-1 ppt salinity). Unfortunately, a species specific identification of the Chriissia material has not yet been possible. Neither Plesiocypridopsis newtoni nor Darwinula stevensonii are particularly informative of hydrochemical conditions as they are both highly generalized in their water chemistry requirements.

DISCUSSION

Hecky & Degens (1973) have reviewed the chemical stratigraphic record for Lake Mobutu based upon their analyses of the WHOI cores. They found that the basal interval of Core # 3 was deposited under low-stand conditions for the lake. A pronounced lake level rise is indicated above the 460 cm horizon of Core # 3 by an abrupt decrease in CaCO3, Mg and Sr content and an increase in clay content. As the authors note, however, the precise timing of this event is difficult to ascertain given the likelihood that the facies change was accompanied by a depositional hiatus.

The upper Core # 3 interval (above 200 cm) again represents an environ-
mental shift, with increasing proportions of CaCO₃, Sr and organic carbon. Mg increases only slightly, and is believed to be concentrated in the montmorillonite clay fraction. Hecky and Degens attribute these changes to a shift towards higher productivity in the lake, as nutrients from the influent Semliki River increased due to increased volcanic and hydrothermal activity in the region (Hecky & Degens 1973: 84-85).

Ostracode taphonomy reflects these environmental shifts in a significant and predictable fashion. Three important taphonomic associations are represented in the Mobutu core material. Together, they illustrate three of the principal mechanisms by which ostracodes are preserved in large African lakes.

The lowest core interval of Core # 3 contains a winnowed ostracode sand lag assemblage. Such lags have been recovered in modern sediments of Lake Turkana (Cohen 1982) and Lake Tanganyika as well as in Plio-Pleistocene sediments of Lakes Malawi and Turkana. They are notably absent from deposits of smaller Pleistocene African lakes (Cohen et al. 1983, Cohen & Nielsen, in press). Where they have been observed in modern lakes, they accumulate at relatively shallow depths (3-8 m) where wave activity has decreased sufficiently to allow coarser organic material to settle, but is still sufficiently strong to remove most fines. Ostracodes are extremely abundant at such depths, which may be littoral (Tanganyika) or sublittoral (Turkana), depending upon wave intensity and water turbidity (Cohen 1984). As sedimentary particles, ostracode valves reach their greatest proportional frequencies at these depths, in some cases comprising up to over 50% of the surface sediment mass in Lake Turkana. Upon burial, oxidation of intermixed organic particles (the other major sedimentary component at burial) reduces their mass in the sediment, thus increasing the proportion of ostracode valves in the sediment. Some Pliocene, shallow-lacustrine calcarenites from East Turkana, Kenya, consist of over 98% ostracode valves by mass.

Fossil ostracodes in these sands, like the modern Lake Turkana accumulations, tend to be unabraded and a large proportion of specimens have paired valves still attached. In both modern Lakes Turkana and Tanganyika, the valve frequencies for species present closely reflect the living ostracode populations of the same areas, indicating that the valves are accumulating as life assemblages.

Ostracode sand lags accumulate as common components of the shallow water deposits of large lakes in Africa. They may be less common in smaller lakes due to the reduced competence of shallow-water wave action in small lakes for winnowing fine particulate matter. Obvious shallow-water life assemblages in the deposits of smaller lakes tend to be associated with abundant clays and silts, preventing the development of calcarenites, even under highly productive situations (Cohen et al. 1983).

Profundal life assemblages appear following the onset of deep-water conditions at the Core # 3 site. They are represented by the monospecific Sclerocypris clavularis assemblages from the 140, 160 and 380 cm samples of Core # 3. Extremely low frequencies, coupled with intact, unabraded speci-
mens typify this kind of assemblage. The presence of paired valves in some specimens of *S. clavularis* from these core intervals is particularly noteworthy, as this species has an extremely weak hinge structure which normally disarticulates shortly after death. Specimens of *Sclerocepis* cannot undergo even brief post mortem transport without their valves being disarticulated.

Population densities of living ostracodes drop off rapidly from the shallow sublittoral to the profundal zone of Lake Turkana (Cohen 1984), due to a severe limitation of food resources in deep water. For profundal ostracodes, which are mostly detritivores, this reduction is also reflected in a decrease in organic carbon content in the sediment. In Core #3, not surprisingly, the low density (profundal) life assemblages are associated with the lowest organic carbon contents in the core, often less than 2.5%.

The remaining ostracode samples from both cores are profundal mixed assemblages, incorporating both local profundal species as well as admixed shallow water taxa. Increase in total abundance for these intervals (80, 100 and 180 cm in Core #3; 50, 350 and 370 cm in Core #2) probably was caused by the post mortem accumulation of valves due to bottom current activity in the lake, perhaps as turbidity currents. Slight increases in coarse terrigenous clastic material, chiefly angular quartz and feldspar grains, are associated with some of these horizons, and both the 160-180 cm interval of Core #3 and the 370-33 cm interval of Core #2 are graded. Hecky & Degens (1973: 23-24) previously noted that the record of depositional hiatuses from Lake Mobutu suggests that vigorous bottom currents have probably been active there during the Holocene. Strong cold water undercurrents, emanating from shallow water regions of the modern lake have been documented by Talling (1969). Such current activity may well be responsible for concentrating the types of mixed shallow-deep water assemblages observed at the previously mentioned core intervals. This would also explain the absence of abundant unbroken and unabraded valves, as well as the erratic species frequency patterns observed at these horizons.

With increasing attention being paid to ostracodes as palaeoecological indicators in African Quaternary strata, it is critical that life assemblages and death assemblages of ostracodes be distinguishable. A better understanding of the mechanisms of transport and burial for these organisms will not only reduce problems of biased palaeoecological and evolutionary interpretations based upon mixed assemblages but may, in the future, provide a new method for evaluating the frequency and nature of subsurface current activity in palaeolakes.

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REFERENCES


