JOURNAL OF THE PALAEONTOLOGICAL SOCIETY OF INDIA
VOL. 27, 1982, pp. 64—67

MIDDLE EOCENE OTOLITHS FROM JHADWA, SOUTHWESTERN KUTCH

A. SAHNI[1] AND R. K. SAXENA[2]

1 CENTRE OF ADVANCED STUDIES IN GEOLOGY, PANJAB UNIVERSITY, CHANDIGARH-160 014
2 GEOLOGY DEPARTMENT, LUCKNOW UNIVERSITY, LUCKNOW

ABSTRACT

A diversified otolith assemblage has been recovered from olive clays and brown clayey limestones of the Babia Stage (Lutetian) exposed along the Ratchelo nala section at Jhadwa. The otoliths are associated with cranial and post-cranial isolated skeletal elements mainly of teleost fishes.

The microstructure and ultrastructure of the otoliths has also been investigated.

Presented at VIII Indian Micropalaeontology & Stratigraphy Colloquium held at Baroda, Feb. 1980.

INTRODUCTION

The present paper describes an otolith assemblage recovered from the Lutetian beds outcropping along the Ratchelo Nala, near the village of Jhadwa (23° 30′ 30″ : 68° 36′ 30″) in southwestern Kutch (Fig. 1). The otolith assemblage consists of over twenty two well-preserved specimens and a number of eroded, fragmentary ones which have been grouped into six species representing at least five genera. The otoliths are associated with a foraminiferal assemblage currently being studied by one of us (RKS) and is suggestive of extremely shallow-water conditions.

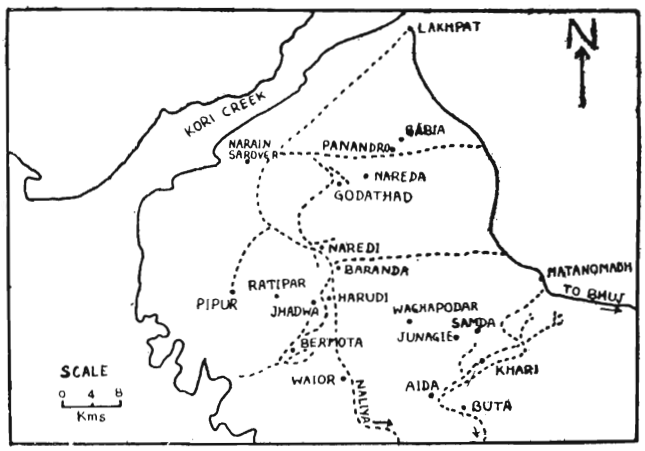


Fig. 1

The study of otoliths is becoming an important micropalaeontological tool not only in throwing light on palaeoecological conditions but also in deciphering evolutionary lineages of fossil fishes (Frizzell 1965, Nolf 1972, Stinton 1976). Of the three types of otolith units which occur in the auditory capsule of teleost fishes, the saccular units (sagitta) are normally of the most common fossil occurrence. The other sets of otoliths such as the lagenar unit (asteriscus) and the utricular (lapillus) are less common except for the lapilli of some large siluroid fishes (Frost 1926, Frizzell 1965, Sahni and Sharma in preparation). In India, fossil otoliths have been described by Gowda (1964, 1966, 1967) from the Odhium Clay of the Uttatur Stage of the Trichinopoly Cenomanian.

In recent years, mainly as a result of the work by Frizzell (1965), Nolf (1972) and others, otolith-based taxa have assumed significance as biostratigraphic markers. This is because evolutionary (temporal) lineages can be deduced from otoliths in the same manner as they can be from complete fish skeletons. Moreover, comprehensive studies of the otoliths of modern fishes makes it possible to identify isolated otoliths at low taxonomic levels. Thus, Frizzell (1965) and others have stressed the fact that otolith-based genera and species can be used for intra and inter-continental correlation of Mesozoic and Tertiary sediments.

In accordance with traditional taxonomic procedures initiated at the turn of the present century, otoliths were grouped under a semi-taxonomic term *Otolithus* with the probable generic name in parenthesis followed by the specific name. During the last two decades, it has been possible to establish the relationship of otoliths with known teleost genera. Hence, in those instances, where the generic identity of the otoliths can be determined with certainty, normal taxonomic procedures (as applicable to fish skeletons) are applied. In some cases, however, where it is not possible to make a generic corres-

pondence of the otolith to the parent teleost, the term *Otolithus* is still retained.

The present otolithassemblage comprising of extremely well-preserved sagitta has been recovered from the *Corbula subexarata* Zone (Tandon 1976). Otoliths, are associated with small-sized lamellibranchs, gastropods foraminifers, ostracodes, holothuids and micro-vertebrate (Fig. 2). This zone is about 4.7m in thickness comprising olive clays and brown clayey limestones with calcareous nodules and exposed about 2.6 km S 15° E of Baranda village in a nala section. It conformably overlies the Unfossiliferous Zone and is underlain by the Dicot Leaf Zone. The associated faunal components include *Meretrix*, *Caridum*, *Mytilus*, *Nucula* (Pelecypoda) ; *Conus*, *Natica* (Gastropoda) ; *Quinqueloculina*, *Triloculina*, *Spiroloculina*, *Discorbis*, *Pararotalia*, *Alfredina* (Foraminifera) ; *Paracypris*, *Cytherella*, *Paijenborchella*, *Alacopocythere* (Ostracoda); *Koteshwaria*, *Feddenella*, *Calclamna*, *Calclamnella*, (Holothuroidea) and micro-remains of fishes including a number of isolated fish teeth, scales, spines, dentaries and cranial fragments. The age of the sequence is under study by one of us (RKS) and on the basis of the microfaunal assemblage is believed to be Lutetian.

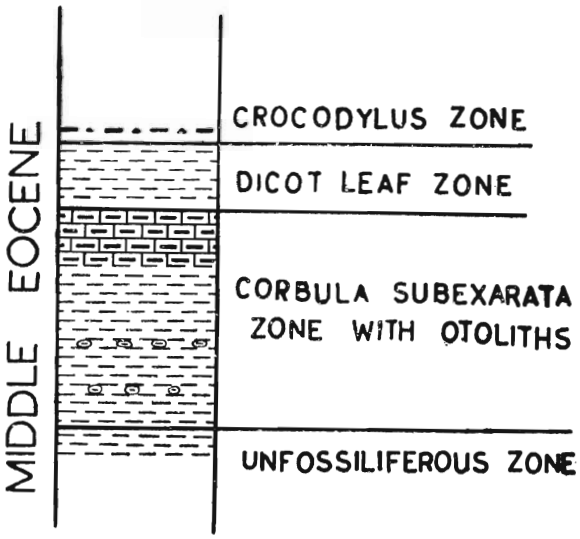


Fig. 2

SYSTEMATICS

The morphology of the otolith sagitta varies considerably in shape, size and orientation of the sulcus which usually occupies the internal face of the otolith. Terminology describing the morphological features of an otolith is to be found in a number of works including those of Frizzell (1961, 1965). Frizzell (1965) has shown that at infra-Familial levels as well diagnostic characters exist for differentiating genera and species. Otolith-based genera are characterised by consistent morphology of the sagitta of their constituent species. Genera are usually differentiated on the basis of the morphology, orientation and length of the sulcus which is found on the internal side of the otolith. Species are based on minor morphological features which include the shape of the otolith, external ornamentation and the relative distinctness of the marginal crenulations.

Pagellus sp. A
(Pl. 1—9, 10, 13-18, 21, 22, 25-28, 33, 34)

By far the most common, this taxa is represented by about 10 well preserved sagitta and a number of eroded and fragmentary ones. In general morphology, specimens resemble *Otolithus* (*Pagellus*) *concavus* described by Frost (1926) in White (1926) from the Eocene of Nigeria. However, the Kutch material is considerably smaller.

Sagittae have a circular outline with marginal crenulations extending on the dorsal and ventral borders. In some instances, the crenulations are very prominent and the troughs separating the marginal crenulations extend towards the centre on the external surface. In most specimens the crenulations are weak. The sulcus is horizontally oriented with prominent ridges or rims delineating the central part of the sulcus. The ostium is shallow and diverges anteriorly. The cauda is horizontal in the central part of the otolith, slightly deflected downwards at the posterior end. The cauda does not reach the posterior margin in any of the specimens. In speci mens referred here to *Pagellus* the posterior margin is bluntly rounded whereas in the majority of the other otoliths in the collection, the posterior extremity represents an angular junction. The internal face of the sagitta is convex while the external is concave, except for the postero-external surface which is convex. Apart from the crenulated margins, there is no surface ornamentation.

Pagellus concavus FROST
(Pl. 1—29, 30)

There is a single sagitta which is nearly 50 percent larger than material referred to *Pagellus* sp. A. Its specific correspondence to *Pagellus concavus* is based on the morphology of the sulcus as well as on its shape. In size, it is somewhat smaller than the specimen ascribed by Frost (1926) to *Pagellus concavus*. It should be noted that the Lutetian marine megavertebrates including fishes, crocodiles and mammals are very similar to those described from the Eocene (Lutetian) of Kutch (Sahni and Mishra 1975) and a similar correspondence can be reasonably expected from the micropalaeontological assemblage.

Dentex ovatus FROST
(Pl. 1—11, 12, 23, 24)

There are three sagitta which resemble *Dentex ovatus* (Nolf 1972). All the specimens are well preserved and are morphologically similar. The otolith is ovate with a posteriorly pointed end. The sulcus is oriented horizontally and has a wide ostium gradually merging with a relatively wide cauda. The sulcus extends to about two-thirds the length of the sagitta. The margins of the otolith are crenulated the dorsal border bears 4 to 6 well marked crenulations with inter-crenulation grooves distinct on both the internal and external surfaces. On the external surface, the anterior region is concave while the posterior is inflated. There appears also to be a distinct depression on the antero-external extremity at the position of the anterior notch marking the position of the ostium. In the smaller specimen, the ostial notch is very prominent and the marginal crenulations are relatively broader.

?Antigonia sp.
(Pl. 1—1-6)

There are three small otoliths which bear resemblance to the sagitta of *Antigonia* described by Nolf (1972). These smooth sagitta are higher than long and possess short and wide sulci. The outline is pentagonal in shape and the posterior margin is straight while the corners are gently rounded. The dorsal margin bears a prominent protuberance. Between this protuberance and the sulcus, is an oval depression. The sulcus of these otoliths appears to be restricted on the internal surface and does not open anteriorly. Its greatest width is in the central portion.

Pristigenys sp.
(Pl. 1—7, 8, 31, 32)

There are two otoliths which can be referred to *Pristigenys*. The ventral area is prominent while the posterior and dorsal margins are rounded.

Otolithus (inc. sed.) sp.
(Pl. 1—19, 20)

There is a very characteristic otolith which cannot as yet be taxonomically assigned to any known teleost taxa. The otolith is ovately cylindrical and a well marked sulcus traverses the internal face of the sagitta terminating in a bulbous, rounded cauda at the posterior end a circular ostium at the anterior end. In some features, such as the orientation of the sulcus and the distinctness of its borders, the specimen bears resemblence to *Otolithus* (*Sciaena*) *simplex* described by Frost (1926) from the Eocene of Nigeria.

MICRO AND ULTRASTRUCTURE

There are relatively few studies on the micro and ultrastructure of fish otoliths. One notable exception is the work of Carlstrom (1963). The internal structure of an otolith affords an interesting study in the process of biomineralization as the chemical composition of these bodies is essentially calcitic in contrast to the rest of the skeletal elements which is apatitic and composed of hydroxy (fluor) apatite. Of the specimens investigated in the present study, the axial view of most otoliths showed palisade calcitic fibres extending towards the outer surface from a central nucleus comprising of very fine grained (at places spherulitic) calcite.

DISCUSSION

Studies on fossil otoliths have so far been confined to Europe and North America and there is little data on the Tertiary and Recent otoliths of the South Asian region. This paper is an attempt to focus attention on otolith studies as these have a significant bearing on the palaeoecological and biostratigraphical investigations of the Mesozoic and Tertiary strata of the Indian subcontinent. Such studies would supplement information obtained from associated micropalaeontological investigations as the recovery techniques for both are the same.

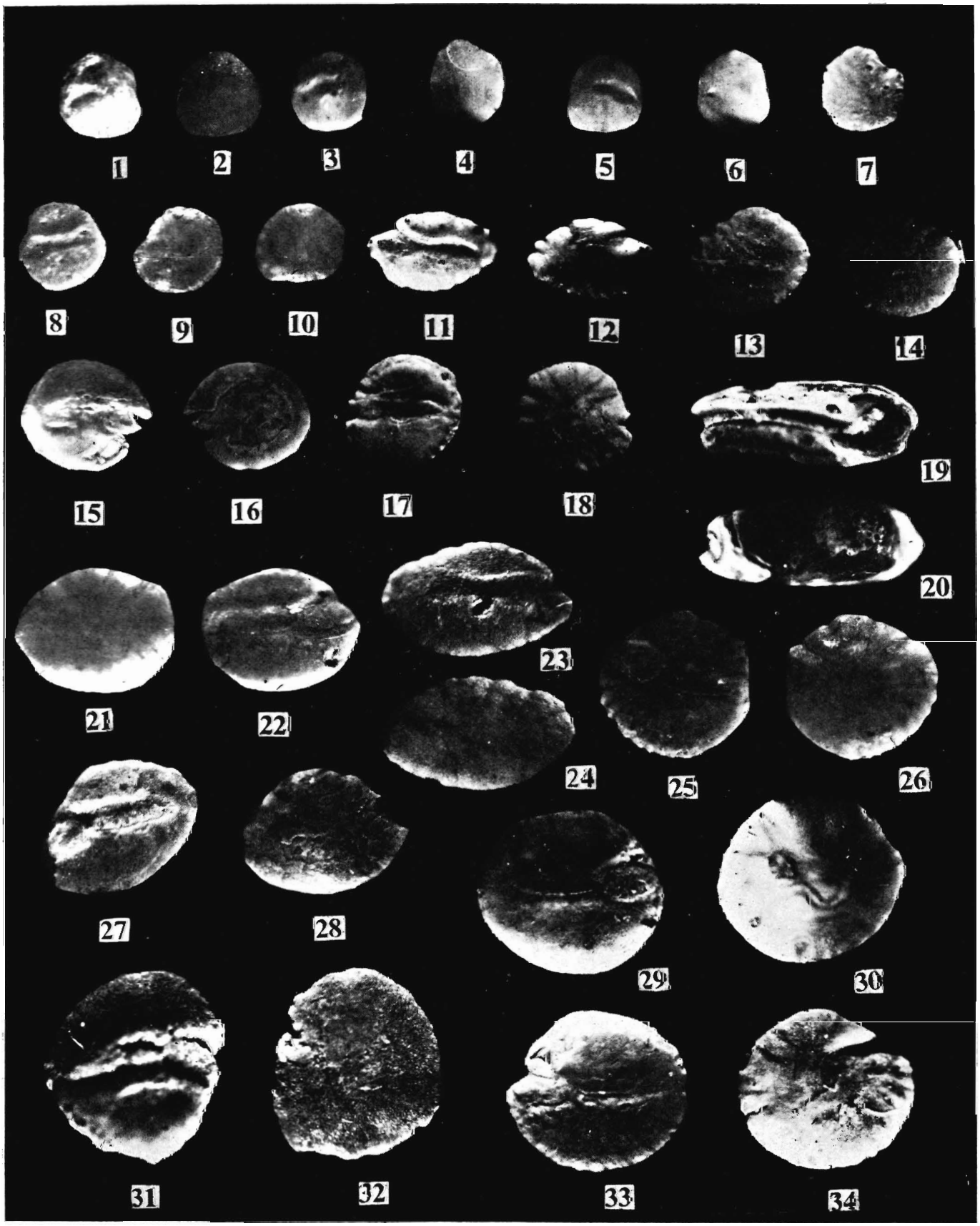
Megavertebrates comprising of gigantic siluroid fishes, turtles, crocodiles and archaeocete cetaceans have been described previously by Sahni and Mishra (1975) from the same location and horizon. Some poorly preserved otoliths can be discerned *in situ* in the skulls of the siluroids but these lack distinguishable morphological details. These large otoliths with diameters of over 1.5 cms are not represented in our otolith collection which comprises of sagitta of less than 1.5 mm in diameters. This discrepancy can reasonably be attributed to the finer-grained sediments which constitute the matrix of the present otoliths.

The megavertebrates and the otolith assemblage indicate very shallow-water marine conditions similar to those prevalent at the time in the Fayum Basin and Mokkattam Hills region in Egypt. In fact, a number of genera are ocmmon to the Kutch Lutetian strata and correlatives from Egypt.

It should be emphasised that the generic and specific identifications of the otolith taxa described here is based on forms described in geographically distant areas such as North America, Europe and Africa. Consequently, it is possible that when the Tertiary teleost faunas of the Indian sub-continent are better known, some taxonomic revision may have to be incorporated. However, in some cases where the genus is represented both by otoliths as well as by teeth and skeletal material as for example in *Dentex*, the presence of the taxa can be firmly established.

REFERENCES

CARLSTROM, D. 1963. A crystallographic study of vertebrate otoliths. *Biol. Bull. Marine Biology Lab.* Woodshole. **125** : 441-463.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34

FRIZZELL, D. L. 1965. Otolith-based genera and lineages of fossil bonefishes (Clupeiformes, Albulidae). *Senck. leth.* Frankfurt. **46a** : 85-110.

FRIZZELL, D. L. AND LAMBER, K. C. 1961. New Genera and Species of Myripristid Fishes, in the Gulf Coast Cenozoic, known from Otoliths (Pisces, Beryciformes). *Bull. School Mines* and *Met.* Univ. Missouri. **100** : 3-25.

FROST, G. A. 1926. Otoliths. In White, E. L. (1926), Eocene Fishes from Nigeria. *Bull. Geol. Surv. Nigeria.* **10** : 84-87.

GOWDA, S.S. 1964. Fossil fish ossiculiths from the Cenomanian of South India. *Eclogae Geol. Hel.* **57** : 743-746.

GOWDA, S. S. 1966. The first fossil otolith from India. *Bull. Geol. Soc. India.* **4** : 15-17.

GOWDA, S. S. 1967. On a new fossil fish known from an otolith from the South Indian Cenomanian. *Jour. Geol. Soc. India.* **8** : 119-129.

NOLF, D. 1972. Les otolithes du Calcaire Grossier a Fercourt (Eocene du Bassin de Paris). *Soc. Belg. Geol. Paleonto. Hydrol. Bull.* **81** : 139-157.

SAHNI, A. AND MISHRA, V. P. 1975. Lower Tertiary vertebrates from western India. *Monograph Pal. Soc. India.* **3** : 1-48.

STINTON, F. C. 1976. Fish otoliths from the English Eocene, pt. 2. *Monograph Palaeontogr. Soc. London.* **130** : 57-126.

TANDON, K. K. 1976. Biostratigraphic classification of the Middle Eocene rocks of a part of southwestern Kutch, India. *Jour. Palaeont. Soc. India.* **19** : 71-88.

WHITE, E. L. 1926. Eocene Fishes from Nigeria. *Bull. Geol. Surv. Nigeria.* **10** : 7-87.

EXPLANATION OF PLATE

PLATE I

All figures approximately ×15, except figures 19 & 20 which are ×20 ; A=internal view, B=external view.

Antigonia sp.
1A, 2B, 3A, 4B—right sagitta
5A, 6B—left sagitta

Pristigenys sp.
7B, 8A—right sagitta
31A, 32B—left sagitta

Pagellus sp. A.
9A, 10B, 13A, 14B, 17A, 18B, 25A, 26B, 27A, 28B, 33A, 34B,—right sagitta
15A, 16B, 21B, 22A—left sagitta

Pagellus concavus
29A, 30B—left sagitta

Dentex ovatus
11A, 12B—right sagitta
23A, 24B—left sagitta

Otolithus sp.
19A, 20B—right sagitta