THE OCCURRENCE OF UPPER LIASSIC OTOLITHS AT HOLWELL, LEICESTERSHIRE

by

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Summary

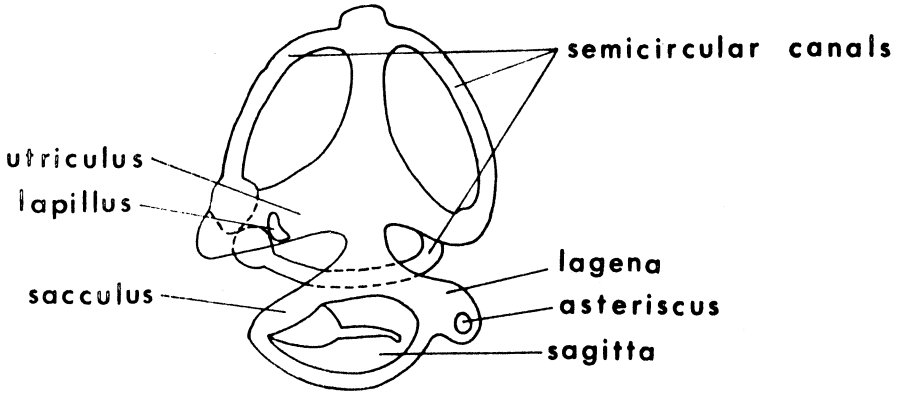
A brief summary of the literature on British Jurassic otoliths is given, together with a list of localities where they have been found. The occurrence of Upper Liassic otoliths at Holwell, Leicestershire, is put on record. Three of the forms are described, one a type of lapillus and two sagittae.

Introduction

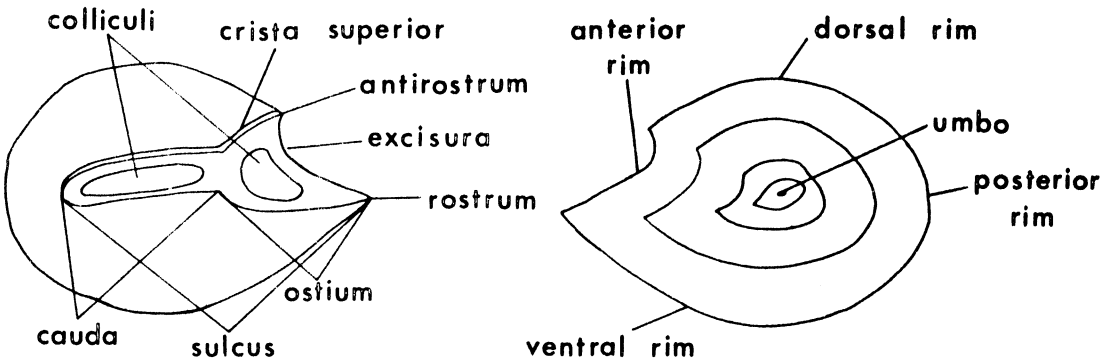
The membraneous labyrinth in Recent Actinopterygian fishes contains three discrete calcium carbonate concretions (otoliths) associated with the auditory nerve and concerned with balance. These otoliths (sagitta, asteriscus and lapillus) occur in three regions (sacculus, lagena and utriculus) of the labyrinth (Text-fig. 1). Also sometimes present in the labyrinth of Recent teleosts are small, probably pathological, calcareous particles usually associated with deformed otoliths (Frizzell and Exline, 1958). In teleost fishes the sagitta is generally the principal otolith. The orientation and terminology used in describing sagittae and lapilli is given in Text-figs. 2 and 3.

Studies on Recent teleosts have shown that the sagitta possesses characters which are relatively constant within any given species and may be used as a means of identification. It has also been found that certain groups of characters may be used in determining genera or even higher taxa. As fossil teleosts usually occur as scattered indeterminate bones, otoliths are often the only means a palaeontologist has of investigating them. This is relatively easy with Tertiary otoliths which may be compared directly with those of Recent fishes, but with Mesozoic forms this becomes hazardous because of the lack of associated otoliths and skeletons. Generic determination of these otoliths is thus rarely possible, although comparison of a contemporary fish fauna (established on skeletal evidence) with their probable Recent descendents can give a rough idea of otolith affinities.

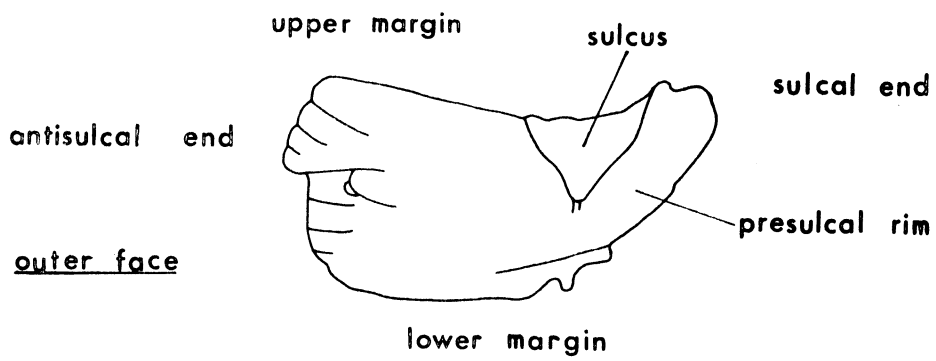
In most fossil deposits where otoliths are encountered, the otoliths are much more frequent than the skeletal remains. This was certainly evidenced in the present study, where no skeletal remains were found although more than a thousand otoliths were recovered. This phenomenon may be caused by bacteria, which are known to be able to live on phosphatic material (e.g. bone) but not on calcium carbonate (S. Rundle, personal communication, 1965).



TEXT-FIG. 1. Diagram showing the location of the otoliths in the membraneous labyrinth.



TEXT-FIG. 2. Diagram of a left sagitta showing terminology.



TEXT-FIG. 3. Diagram of a lapillus showing the terminology given by Frizzell and Dante (1965).

Teleost sagittae are also of use in fisheries research for age determination, done by counting the concentric opaque growth rings (Wimpenny, 1953, pp. 19-21). This is of especial use in studying the plaice (Pleuronectes platessa Linn.), since this fish has scales too small to be readily used and since the otoliths are more convenient than similar annual rings in bones. This is mentioned here because, with the right fossil material, a study of growth rings may be of use in elucidating some details of the ecology of fossil teleosts.

Previous work on British Jurassic otoliths

The earliest record of Jurassic otoliths in this country appears to be that of Woodward (1893, p. 271) who stated that "Otolites of Fishes have also been found" when naming some of the fossils from the Paper Shales (Upper Lias - Tenuicostatum Zone) of Northamptonshire. The next mention they receive is by Frost (1924), who described six species from the Upper Kimmeridgian of Aylesbury and Hartwell in Buckinghamshire, one of these also being recorded from Swindon, Wiltshire. As these otoliths (sagittae) resembled those of the Recent Elopid fishes he assigned them to the "Leptolepididae" which he considered to be their forerunners. In 1926 Frost described a further six species from Hartwell, two based on sagittae and also assigned to the Leptolepidae, and four types of lapilli which he was unable to assign to any group. He also described three species based on "sagittae" of unknown affinity from the Lower Lias of Charmouth, Dorset.

The most recent work is that of Stinton and Torrens (in press), who describe ten species based on sagittae from the Bathonian of Bradford-on-Avon, Wiltshire, and Langton Herring, Dorset. These authors placed seven species into three previously established genera for skeletal remains, by means of comparison between the contemporaneous fish fauna and Recent forms. Thus Leptolepis, the presumed ancestor of the Clupeidae, was used to embrace three of the species (cf. Frost). The general morphology of the otolith was also used in placing two types of subcircular sagittae, usually characteristic of deep-bodied fishes, in the Pycnodontidae.

British Jurassic otolith localities

As otoliths have been found at few Jurassic localities in this country, it would be worthwhile to list those at present known to the author, as a guide to their distribution and to emphasize how much they have been overlooked.

	Horizon	Locality	Source
1.	Lower Lias (Raricostatum Zone)	E. of Charmouth, Dorset	recorded by Frost (1926) (now in B.M. Collections)
2.	Lower Lias (top of Ibex Zone)	E. of Charmouth, Dorset	recorded by Frost (1926) (now in B.M. Collections)
3.	Lower Lias ("Striatum Zone" = Maculatum Subzone of Davoei Zone) (see Dean et al., 1961, p.467)	Napton-on-the-Hill, Stockton, Rugby, Warwickshire	B.M. Collections (P 37658-59). Also probably P 22806
4.	Lower Lias ("Striatum Zone")	Shearn's Quarry, 2 miles S. of Radstock, Somersetshire	B.M. Collections (P 37656)
5.	Lower Lias (Davoei Zone)	2/5 of way between Golden Cap and Seatown, Dorset	Author's personal collection
6.	Lower Lias (Davoei Zone)	Waddington Brick Pit, Waddington, Lincolnshire	Author's personal collection

7.	"Middle" Lias	Aston Magna, Evesham, Worcestershire	B.M. Collections (P 8573)
8.	Upper Lias (Tenuicostatum Zone)	Northamptonshire	recorded by Woodward (1893)
9.	Upper Lias (Cerithium Beds)	Great Brington, Northamptonshire	B.M. Collections (P 37617-23)
10.	Upper Lias (Cerithium Beds)	Berry Wood, W. of Northampton	B.M. Collections (P 37625 - 47)
11.	Bradford Clay (Discus Zone)	Clay Pit, Bradford-on-Avon, Wiltshire	recorded in Stinton and Torrens (in press): now in B.M. Collections (P 47394; 47406; 47800) and Leic. Univ. Mus. Collection (22725-27)
12.	Fullers Earth (clay underlying the Liostrea hebridica lumachelle)	Rodden Hive Point, S.W. of Langton Herring, Dorset	recorded in Stinton and Torrens (in press): now in B.M. Collections (P 47395-402; 47404-05) and Leic. Univ. Mus. Collection (22718-24)
13.	Kimmeridge Clay	Osmington Mills, Dorset	B.M. Collections (P 22766-67; 23607-09)
14.	Kimmeridge Clay	Weymouth, Dorset	B.M. Collections (P 37610-14)
15.	Kimmeridge Clay	Brill, Buckinghamshire	B.M. Collections (P 37673-741)
16.	Kimmeridge Clay	Shotover, Oxfordshire	B.M. Collections (P 37666-68)
17.	Kimmeridge Clay	Aylesbury Brickfield, Buckinghamshire	B.M. Collections (P 12630; 37669-70) (also recorded by Frost(1924)
18.	Upper Kimmeridge Clay (Pallasioides Zone)	Hartwell, Buckinghamshire	recorded by Frost (1924 and 1926): now in B.M. Collections (P 22733-65; 22768-86; 22807; 37671-72)
19.	Upper Kimmeridge Clay (Pallasioides Zone)	Swindon, Wiltshire	recorded by Frost (1924)

Occurrence at Holwell

This paper records the occurrence of abundant otoliths in the Upper Lias (Falcifer Zone) of Holwell, Leicestershire. The exposure in which they were found is at the western end of a large disused ironstone quarry, about half a mile N.E. of Holwell and three miles N. of Melton Mowbray (about SK 744241). The quarry was worked for the Marlstone Ironstone (Middle Lias - Spinatum Zone) which occupies the floor of the quarry. This is overlain in most of the pit by the lowermost Paper Shales (Upper Lias - Tenuicostatum Zone) and Boulder Clay, which yields abundant Lower Lias and Oxford Clay fossils, together with forms from other parts of the Jurassic. In the western end of the quarry the Upper Lias becomes thicker, extending up to the Falcifer Zone, and the Boulder Clay becomes very thin or absent.

Twelve samples of clay were collected at approximately one-foot intervals from a cliff section, on the south side of the end of a roadway into the quarry (built for the removal of the iron ore). The samples were taken from the top of the section down as far as possible, further sampling being prevented by the clay scree slope. If time had permitted it would have been possible to sample a lower sequence about

TABLE 1

Distribution of Otoliths in the section studied at Holwell, Leicestershire

Sample 1 was from the top of the section, each succeeding sample being taken at about one foot intervals downwards. The gypsum present in samples 9, 10 and 11 may have been formed by weathering.

Lithology	Dominant associated fossils	Number of lapilli per kilo	Number of sagittae per kilo	Weight of sample studied
Sample 1 Grey clay made up of unorientated small discrete angular fragments of clearly bedded clay (evidently disturbed.)	No recognisable fossils	0	0	997.7g
Sample 2 Less consolidated layer 4 in. below top of ironstone bed. Contains many flattened calcite ooliths up to 4 mm. Difficult to process, so otoliths may have been missed.	Few fossils (mainly bivalve fragments)	0	0	683.0g
Sample 3 Varies from a non-oolitic grey clay to an oolitic, ferruginous clay	Few associated fossils	1	0	1,109.7g
Sample 4 Similar to Sample 2. Base of ironstone bed	Few fossils	0	0	930.8g
Sample 5 Dark grey oolitic clay with many shell fragments.	Harpoceras falcifer abundant. Bivalves abundant in concentrate	26	33	971.5g
Sample 6 Grey clay with fewer shell fragments	Bivalve fragments abundant in concentrate. Otoliths poorly preserved	21	35	1,202.7g
Sample 7 Dark grey clay with many shell fragments	Brachiopods and molluscs abundant in concentrate	19	72	999.8g
Sample 8 Grey clay with numerous shell fragments and small (? phosphatic) nodules	Concentrate contains abundant bivalves and rather eroded otoliths	24	95	873.4g
Sample 9 Grey mottled clay with many shell fragments and much gypsum	Bivalves abundant in concentrate. Otoliths poorly preserved	25	37	877.2g
Sample 10 Same as Sample 9 but not mottled	Same as Sample 8	20	43	1,090.4g
Sample 11 Same as Sample 8, but with much gypsum	Concentrate contains abundant ophiuroid plates, bivalves and gastropods	18	54	947.3g
Sample 12 Well-bedded grey micaceous clay	Concentrate contains abundant ophiuroid and echinoid plates and various molluscs	45	336	902.4g

fifty yards west of this point.

About a kilo of each sample was thoroughly dried at about 100° C and weighed. Most of the clay was then removed by successively soaking in water, wet sieving through a 30 mesh sieve and redrying, until little clay remained. The residue was finally boiled in dilute sodium carbonate (washing soda) solution and then wet-sieved in water as before. Frizzell (1965) states that sodium carbonate should not be used in the preparation of samples because it causes deterioration of the organic fibres of the otoliths. As this reagent is much used by the author for processing Eocene clays without damage to the otoliths, a few of these Liassic specimens of varying preservation were carefully examined, boiled in a 10% solution of sodium carbonate for an hour, and then re-examined. These specimens remained undamaged, so this treatment was used on all succeeding samples.

The dried, clay-free residues obtained were then graded using a 10 mesh sieve, the coarser fraction being sorted by eye and the finer fraction by means of a binocular microscope on a gridded tray, all the otoliths being removed and eventually counted. All the otoliths were found in the finer fraction, none being large enough to be retained by the 10 mesh sieve.

All the samples examined were from the Falcifer Zone, Harpoceras falcifer (J. Sowerby) being found from the top of the Lias in the section to within three feet of the bottom. No specimens of Harpoceras were found in these lower three feet of section, but the occurrence of H. cf. exaratum (Young & Bird) well below this in the Paper Shales in a nearby section proves them to be within the Falcifer Zone.

It was found that the otoliths were most abundant and better preserved in the lowermost sample studied, becoming increasingly scarce higher up (Table 1). As so few otoliths were found within the ironstone bed, it is presumed that the conditions of its deposition were unfavourable to the fishes yielding them. The sorting action of currents cannot have caused this scarcity, since many of the ooliths present are of similar form and size to the otoliths. Solution and attrition may also be dismissed owing to the reasonably good preservation of the otoliths found.

Taxonomy

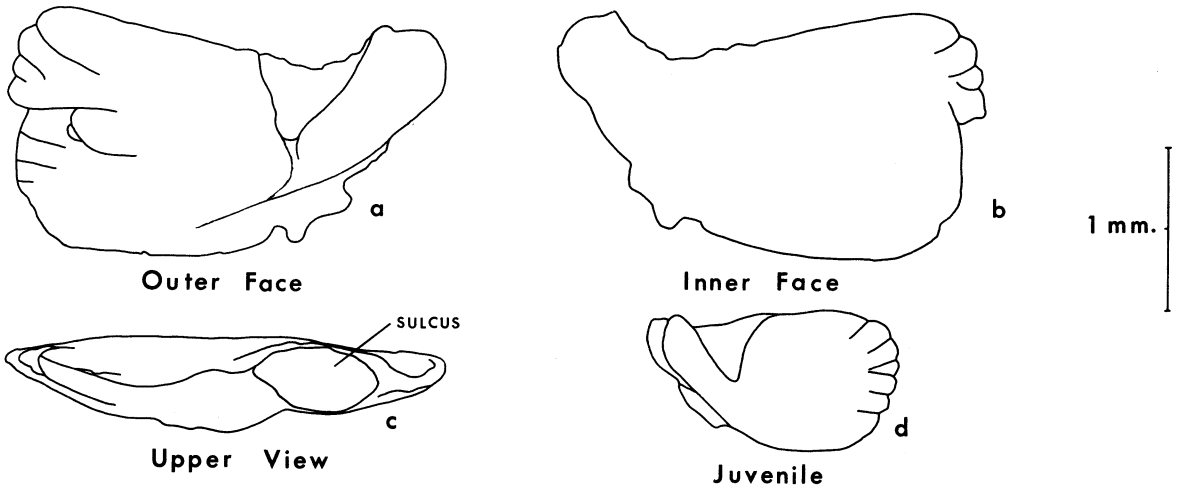
Most works on fossil otoliths have used a trinomial system of nomenclature first established by Koken (1884), in which Otolithus was designated for all fossil otolith-based species. This was followed by a name indicating the probable generic or familial affinities of the species in parenthesis. The use of such a trinomial system is not in accordance with the provisions of the Zoological Code.

An alternative procedure, now adopted by Stinton, Frizzell, and others, is to use conventional generic names where affinities can be demonstrated. There is little difficulty in applying this to Tertiary forms where direct comparision with Recent fishes can usually be made, but with Mesozoic forms this implies a certainty not existing at present and it can therefore be misleading. In cases where the assignment to a genus is somewhat tentative, the insertion of a question mark after the generic name is advisable.

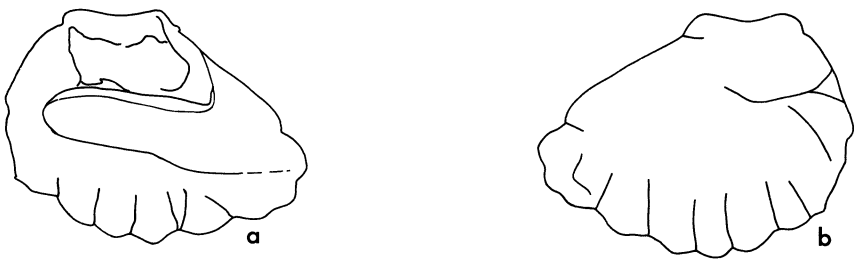
All the lapilli found were of the same type and probably worthy of specific rank; the sagittae, however, belong to many species and would require a great deal of research to elucidate what forms are present and to determine their affinities. It is therefore considered unwise to establish any new species at the present time, but worthwhile to describe the lapilli and two of the sagittae which resemble forms described by Weiler (1953, 1965).

The figured specimens, excepting the sagitta lost in transit, have been deposited in the British Museum (Natural History), the numbers being those of the Department of Palaeontology.

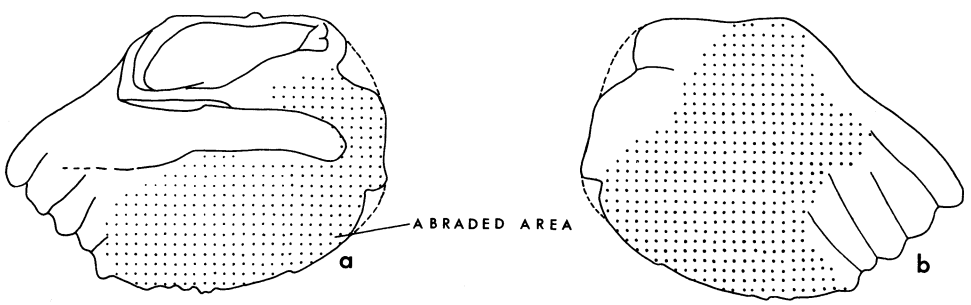
Semionotidae (?) gen. indet.
(Text-figs. 4a, b, c, d)



TEXT-FIG. 4. Semionotidae (?) gen. undet.



TEXT-FIG. 5. cf. Lycopteroidarum? brevis Weiler



TEXT-FIG. 6. cf. Lycopteroidarum? ornatus Weiler

CAMERA LUCIDA DRAWINGS OF UPPER LIASSIC OTOLITHS.

Figured specimens: P 48683 (Text-figs. 4a, b, c): P 48684 (Text-fig. 4d).

Dimensions: P 48683 Length 2.7 mm. Width 1.5 mm. Length/Width 1.8

P 48684 Length 1.5 mm. Width 0.9 mm. Length/Width 1.7

Description: An elongate lapillus with a concave outer face and a convex inner face. Antisulcal half of otolith roughly rectangular, sulcal half tapering towards the sulcal end. Sulcus restricted to triangular region in sulcal half of otolith, opening widely on upper margin and extending half way towards lower margin. Presulcal rim wide and curved outwards. Upper margin relatively smooth, lower margin smooth except for two projections about one third of length from sulcal end, antisulcal end crenulate, divided into two by notch making upper half project over lower half. Outer face smooth.

The juvenile (Text-fig. 4d) differs from the adult in lacking notch on antisulcal margin, although the position where the notch will develop is distinct owing to two crenulation directions, the lower set being approximately horizontal and the upper set directed downwards, as in the adult.

Discussion: These lapilli are referred to the Semionotidae because this order is thought to be the forerunner of Lepisosteus in which the major otolith, the lapillus, is very similar to this form (Stinton, personal communication).

The specimen closely resembles the lapillus from the Lower Lias of Charmouth, Dorset, figured by Frost (1926) as Otolithus (incertae sedis) curvatus. His specimen differs, however, in lacking the crenulate antisulcal margin characteristic of this form. Lapillus Typus a and b figured by Neth and Weiler (1953), although appearing to be somewhat abraded, are also similar to this specimen; Typus a differs in lacking any crenulations and Typus b in that the crenulations present are not divisible into two well defined zones.

cf. Lycopteroidarum? brevis Weiler
(Text-figs. 5a, b)

(The specimen figured here was unfortunately lost in transit.)

Dimensions:- Length 1.9 mm. Width 1.4 mm. Length/Width 1.4

Description: A thin, rather elliptical left sagitta. Dorsal rim horizontal, slightly concave owing to two feeble lobes; rounded, slightly uneven posterior rim; rounded, crenulate ventral rim; and long, oblique, uneven anterior rim. Outer face slightly concave and ornamented with radiating ribs in the ventral and posterior regions. Umbo indistinct, approximately central. Inner face slightly convex, with a medium sulcus opening widely on the anterior rim and terminating near the posterior rim. Sulcus consists of a short, triangular, shallow ostium and a long, wide, slightly curved cauda. Crista superior recurving at the ostial end to form an acute angle and coalescing with the dorsal rim: it is accentuated by a depression above. Marked rostrum; no exisura, antirostrum or colliculi.

Discussion: Stinton (personal communication, 1965) states that he is not in favour of Weiler's group Lycopteroidarum, partly because the genus Lycoptera is freshwater, not marine, and partly owing to the presence of a large asteriscus in this genus, which is presumed to be ancestral to the Cyprinidae whose sagittae do not resemble these.

cf. Lycopteroidarum? ornatus Weiler
(Text-figs. 6a, b)

Figured specimen: P 48685

Dimensions: Length 2.3 mm. Width 1.7 mm. Length/Width 1.35

Description: A thin, rather elliptical right sagitta. Dorsal rim horizontal, slightly concave; posterior rim notched in two places owing to corrosion, probably bevelled; evenly rounded, crenulate ventral rim, corroded posteriorly; and oblique anterior rim. Outer face flat, ornamented with radiating ribs in the ventral region (absent posteriorly due to abrasion). Flat inner face, with a median sulcus opening widely on the anterior rim and terminating near the postero-ventral corner. Sulcus consists of a wide shallow ostium, with an indistinct lower margin, and a long, narrow, relatively deep cauda, slightly downturned near its posterior end. There is an indistinct angle between the ostium and the cauda on the lower rim. Crista superior recurving at the ostial end to form an acute angle and coalescing with the dorsal rim: it is accentuated by a depression above. Marked rostrum and shallow excisura; no antirostrum or colliculi.

Discussion: Although much abraded, most of the diagnostic features are still discernible on this specimen.

Conclusions

It is evident that Jurassic otoliths are not such rare fossils as was previously supposed and, if a careful and systematic search is made in the clay strata at other localities, there is little doubt that otoliths will come to light. The fauna includes a possible Semionotid represented by numerous lapilli, and several forms of sagittae similar to those grouped as Lycopteroidarum? by Weiler, probably not true Lycopterids.

Acknowledgements

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