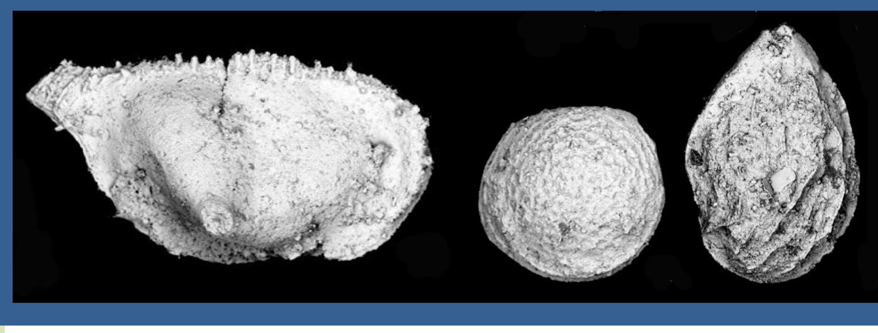
Matrix Reloaded: recovering lost data from fossil marine reptile specimens using micropalaeontological analyses of small amounts of host rock.



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Abstract

Many museums hold palaeontological specimens such as large marine vertebrates of the Mesozoic Era (ichthyosaurs, plesiosaurs, pliosaurs etc) that lack any provenance information, particularly those collected in the 19th and early 20th centuries. This lack of data greatly reduces the usefulness of these fossils to taxonomic studies and other investigations. The specimens may sometimes be tentatively labelled with locations such as ‘Lyme’, ‘Whitby’ or ‘Street’ but not only are these sometimes assumptions added long after collection, rather than known facts, these localities cover a broad range of stratigraphical units. Whilst data such as the name of the collector or the date of collection may not be recoverable, the data that is of greatest use scientifically - the stratigraphical unit or biozone in which the specimen was found – can sometimes be recovered by analysing very small amounts of the matrix of the specimen (as little as 5 to 10 grams) for the purpose of micropalaeontological analyses. The resulting information might also, in some instances, suggest a geographical origin for the specimen.

The authors (with appropriate permission from museum staff) have taken very small samples of host matrix from the rear of several specimens during recent conservation projects where the provenance of the specimen was either totally unknown or was in doubt. The samples were analysed for their calcareous microfossil content, including ostracods and foraminifera. It was found that well-cemented limestones contained little or no recoverable material but softer mudstones have yielded very useful assemblages allowing specific biozones to be attributed to the host specimens, successfully recovering lost data and making the specimens much more useful scientifically. Even when the assemblage of microfauna is found to be poor or absent, some information about the sedimentary conditions of the preservational environment can often be ascertained from the micropalaeontological residues.

Methods and materials

With appropriate permission, small samples of matrix (as little as 5 grams) were removed from the undersides of specimens with scalpels, or by removing loose fragments, during conservation projects. These samples were sent for micropalaeontological analyses.

Samples were disaggregated in ~1% solution of Hydrogen Peroxide for 30 minutes then rinsed, dried, and sorted under a binocular microscope. Microfauna such as ostracods and foraminifera were identified, then photographed using a Scanning Electron Microscope (SEM).

Example 1: **Neonate ichthyosaur skeleton (BU 5289) at the Lapworth Museum of Geology, Birmingham University** (Fig 1)**.** This specimen, about 590mm long, had no provenance data associated with it. A ~12g sample of matrix from the rear of the specimen yielded 110 microfossils: 13 species of foraminifera and 5 species of ostracods. The most abundant species are shown in Fig 2. The occurrence of the particular foraminifera species and subspecies strongly indicates the JF3 Foraminifera Biozone spanning a range from the base of the Complanata-Depressa ammonite Subchronozone to the top of the Conybeari ammonite Subchronozone. The co-occurrence of the foraminifera subspecies *Marginulina prima insignis* and *M. prima incisa* together with the ostracod species *Ogmoconcha hagenowi* and *Ogmoconchella nasuta*, indicates the age of the specimen must be restricted to the very latest Hettangian to very earliest Sinemurian of the Early Jurassic.

During the conservation project this specimen was recognised as a neonate and it turned out to be the only known neonate of this particular species, *Ichthyosaurus communis* – see Lomax et al 2017.

Fig 1

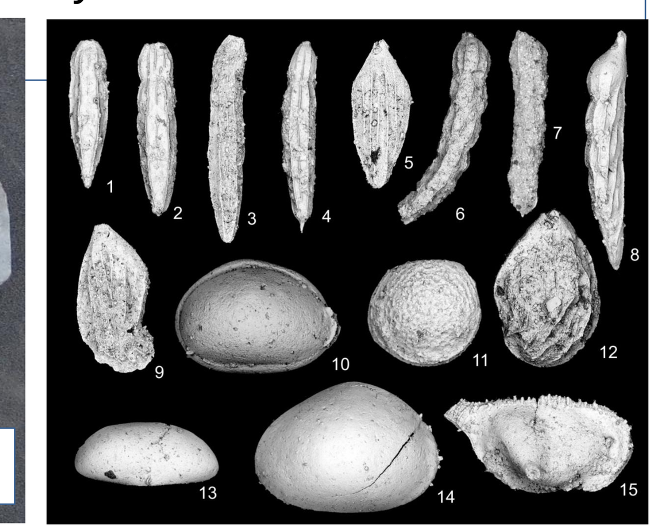


Fig 2>

Example 2: A *Leptonectes ?tenuirostris* skeleton (SHEFM: H93.189) at Sheffield Museum and Galleries (Fig 3). This ichthyosaur was known to have belonged to Thomas Bateman Jnr (1821–1861), a well-known ‘gentleman antiquarian’ in Derbyshire. During a recent development in Sheffield of an exhibition about his work and his collection, the specimen was extensively conserved. However, the fossil had no associated data regarding its original provenance. A sample of ~8 grams of loose matrix yielded microfossils dominated by foraminifera. Although the species generally support a mid-Hettangian to early Sinemurian age, a single ostracod specimen proved crucial, refining the age to an interval Angulata to Bucklandi Chronozone (latest Hettangian-earliest Sinemurian). Fig 4 shows elected calcareous microfossils recovered from this specimen (A-D. foraminifera, E ostracod). A. *Planularia inaequistriata*, B. *Ichthyolaria terquemi*, C. *Mesodentalina matutina*, D. *Paralingulina tenera tenera,* E. *Nanacythere elegans*.

Fig 3

Fig 4

Example 3: *Protoichthyosaurus prostaxalis* skeleton (BMT1955.G35.1) at the Thinktank, Birmingham Science Museum (Fig 5). This 3.2m long ichthyosaur skeleton is the largest known of its species but of much greater importance the skull was preserved in three dimensions, with no hard sediment enclosing the bones – very rare for an ichthyosaur of this age.

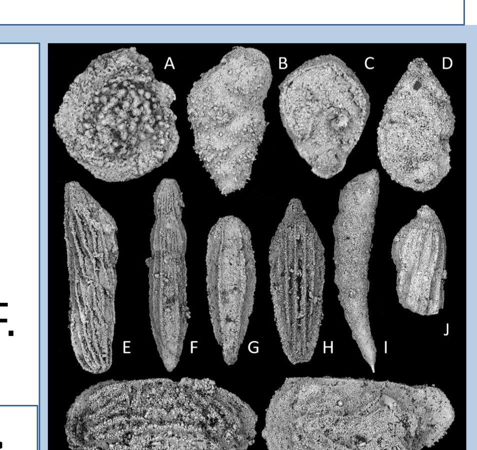
However, the skull had been assembled from the individual bones soon after its excavation in 1955 and in 2015 the skull had to be disassembled and rebuilt to be more anatomically accurate. In the process the postcranial skeleton was rediscovered and an investigation began into the specimen’s origins.

Fig 5

In contrast to the previous two examples, it was known where this ichthyosaur had been found. But very little was known about the age of the sediments from which it had been excavated, nor the geology of the immediate local area and unfortunately all the matrix had been removed from the specimen. However, the exact location of the excavation within a specific field near Shipston-on Stour, Warwickshire, had been well recorded and therefore permission was gained from the landowner to use a mechanical digger to recover some of the sediment in which the specimen had been found (the depth at which the skeleton had been found had also been well recorded).

A sample of ~20 g of matrix provided a diverse assemblage of foraminifera although there were relatively few ostracods. Taken together, the species identified indicate an age equivalent to the latest Angulata to Bucklandi chronozones (late Hettangian to early Sinemurian). Selected calcareous microfossils recovered are shown in Fig 6: (A-J. foraminifera, K-L ostracods). A. *Involutina liassica*, B. *Neobulimina bangae*, C. *Berthelinella involuta involuta*, D. *Planularia protracta*, E. *Astacolus speciosus*, F. *Paralingulina tenera tenera*, G. *Paralingulina tenera substriata*, H. *Ichthyolaria terquemi sulcata*, I. *Prodentalina pseudocommunis*, J. *Mesodentalina matutina*, K. *Nanacythere* sp., L. *Eucytherura* sp

Fig 6>



Discussion & Conclusion

Ostracods and foraminifera are microscopic organisms that mostly live on or within the seabed, whose evolutionary histories stretch far back into the Palaeozoic. Their abundance, ubiquity, high species turnover rate and calcareous body parts that are relatively easily preserved make them interesting in their own right but also this makes them ideal for dating other fossils with which they are found. They are not always preserved in ancient marine sediments (such as in well-cemented limestones), nor are they always preserved well enough to be identified. But when they are recoverable and identifiable, these microfossils have provided very tightly constrained age ranges for fossil marine reptile specimens in museum collections that have lost some or all of the data associated with them.

This method should also work for dating other fossils preserved in marine sediments, not just marine reptiles.

When matrix of a specific age has been identified and is only known to be exposed in only a few outcrops, this can also help to pinpoint the likely geographical source location of the specimen under study.

Furthermore, in one instance during our research, an ostracod was found within the sample that was both modern and marine in habit – indicating that this fossil was likely to have been found at a coastal location.

References

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