Annales Societatis Geologorum Poloniae (2015), vol. 85: 453–455. doi: http://dx.doi.org/10.14241/asgp.2015.033

BIOEROSIONAL ICHNOTAXA AND THE FOSSILIZATION BARRIER

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Bromley, R. G. & Nielsen, K. S. S., 2015. Bioerosional ichnotaxa and the fossilization barrier. *Annales Societatis Geologorum Poloniae*, 85: 453–455.

Abstract: For the establishment of a new ichnogenus or ichnospecies, the type material shall be fossil, not unfossilized material. This is not always possible, because the transition between the two states, the fossilization barrier, is extremely vague defined. In most fossil material, this is not a problem. However, in the case of bioerosion structures (borings, rasping traces, attachment scars in hard substrates), the problem is serious. For example, when does a sponge boring in an oyster shell become fossilized? The question arises when Recent and sub-Recent materials are considered. Two examples are discussed. (1) Microborings are described and named in foraminifera dredged from the sea floor. In this material, it is not possible to distinguish between "fossilized" and "unfossilized" foraminifera. Bioturbation and other processes may have mixed recently dead, Pleistocene and older foraminifera in the sea-floor sediments. (2) Small, characteristic borings are made by slipper limpets in pagurized gastropod shells. The structures would constitute a new ichnospecies of *Oichnus*, but these borings have not been found in "fossilized material" and the borings therefore remain nameless. Because bioerosion structures constitute "ready-made fossils", it is suggested that the onset of fossilization be equated with the death of the bioeroding tracemaker.

Key words: Fossilized, unfossilized, bioerosion, trace fossils, microborings.

Manuscript received 21 October 2014; accepted 11 September 2015

INTRODUCTION

Since its second edition, the International Code of Zoological Nomenclature has only allowed the use of names for modern traces established prior to 1931 (Stoll *et al.*, 1964; Ride *et al.*, 1999, Art. 1.2.1). The nomenclatural restriction of Art 1.2.1 in the ICZN applies for the establishment of new names only, i.e., for the establishment of a new ichnogenus or ichnospecies, the type material shall be fossilized, not unfossilized material. Even so, Bertling *et al.* (2006) recommended the use of existing and well defined trace fossil names (based on fossil material) for "modern" traces, following Bromley and Fürsich (1980) and Bromley (1990). Hence, it is up to the research community to accept naming of modern traces within already existing trace fossil names.

The reason for excluding unfossilized traces is that tracemakers make traces in a wide variety of substrates, ranging from unpreservable *via* rarely preservable to eminently preservable. Birds disturb air and fish water in ways comparable to the disturbance a rabbit produces in sand. Naming unpreservable structures would produce a plethora of useless names (Seilacher, 1953).

THE FOSSILIZATION BARRIER

The above situation appears to be clear and straight-forward, but in fact contains a serious flaw: it is impossible to define the fossilization barrier. Different dictionaries define "fossil" in very vague terms, emphasizing different aspects: "usually prehistoric" (McIntosh & Friedrichsen, 1971), "before the beginning of historic time" (Bates and Jackson, 1984), "dug out of superficial deposits" (Tweney and Hughes 1968), "whether consolidated or not" (Nelson and Nelson, 1967). "Fossil" and the fossilization barrier remain undefined (see Bromley 1990 for further discussion).

ICHNOTAXA FOR BIOEROSION TRACE FOSSILS

In one group of trace fossils, those resulting from the bioerosion of lithic and skeletal substrates, the fossilization barrier problem may be solvable. The tracemakers include producers of borings into the substrate, or raspers scratching it surficially, or attaching organisms etching the surface. The problem is solvable here, because the substrate, being already hard, has a high preservation potential. When the boring tracemaker has finished its bioerosion, little or no change may occur after intermittent or final burial. Modern and Mesozoic bioerosion can show extremely similar modes of preservation. It may be considered that the fossilization barrier coincides with the death of the bioeroder. Bertling *et al.* (2006) mentioned this possibility, but expressed doubts about its usefulness. Nevertheless, two ex-

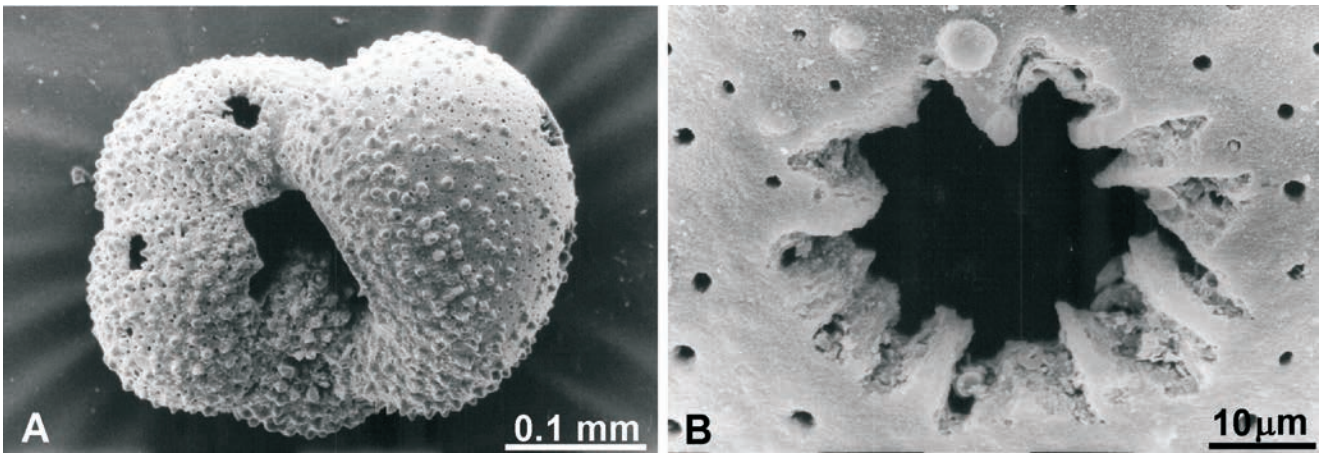

Fig. 1. Bioerosional traces occurring in planktonic foraminifera. **A.** General view. **B.** *Stellatichnus radiatus* Nielsen & Nielsen, 2001.

amples of bioerosion studies are provided here to show how this consideration would greatly benefit bioerosion studies.

EXAMPLES OF BIOEROSION NOMENCLATURE

Microborings in foraminifera in seafloor sediments

Quaternary sediments from a number of localities, both on shore and from the sea floor, have yielded a surprisingly varied series of bioerosion traces within the tests of foraminifera. These have been treated ichnotaxonomically (Fig. 1; Nielsen 1998, 1999; Nielsen and Nielsen 2001; Nielsen *et al.*, 2002, 2003). The problem is that, in the seafloor material, the ages of individual dead foraminifera are not known. In most forms of these borings, the structure is regarded as predatory, and so was produced during the life of the foraminifer; but at what time was that?

Obviously, it would be counterproductive to leave these varied structures unnamed, because their status relative to the fossilization barrier is unknown. But if the death of the borer and/or the prey is regarded as the moment of fossilization, this difficulty is overcome.

Small slits bored in pagurized gastropod shells

In coastal waters of the Aegean Sea, Greece, gastropod shells containing hermit crabs are commonly inhabited by the small slipper limpet, *Crepidula unguiformis* Lamarck. The *Crepidula* lives sedentarily in the space within the shell, behind the crab. The limpet bores a single slit-shaped hole to the exterior (Fig. 2) at its anterior end, providing

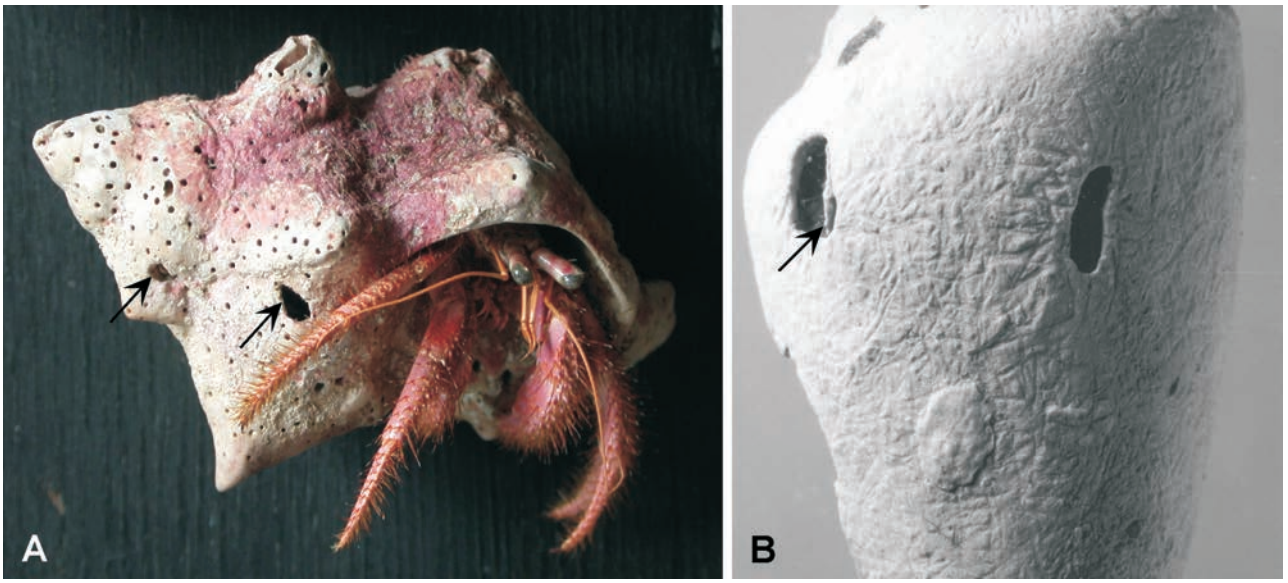

Fig. 2. *Crepidula unguiformis* borings. **A.** *Crepidula unguiformis* borings (arrows) in a pagurized shell, *Hexaplex trunculus* containing the hermit crab *Paguristes oculatus*. The smaller borings are *Entobia* isp., the work of a boring sponge. **B.** Two borings of *Crepidula unguiformis* in the shell of *Strombus decorus*. In the left boring, the edge of the shell of the tracemaker is in a characteristic position (arrow). Note the heavy scraping of the substrate by hungry echinoids, producing the trace fossil *Gnathichnus pentax*.

both safety and access to water. A single pagurized shell may contain numerous individuals of these slipper limpets.

The boring can be referred to *Oichnus* isp. However, it has to remain lacking an ichnospecies designation, because it has not been found in fossil material, despite much searching. It will be regrettable, if the boring cannot be given a trivial name, as it represents an *Oichnus* with a unique function and therefore merits further research. However, if the shell is regarded as becoming fossilized on the death of the *Crepidula*, e.g., when it is collected, then the problem vanishes.

CONCLUSIONS

Trace fossils may be named only on the basis of fossilized type material. However, this is not very satisfactory, as the fossilization barrier is not definable. Nevertheless, there is a possible way out of this problem for bioerosional trace fossils in lithic and hard skeletal substrates. In these hard substrates, little preservational change takes place with burial and time. As a consequence, traces in woody substrate should be excluded. Borings in modern shells resemble those in Cenozoic and even earlier fossil substrates. Thus it is suggested that the fossilization barrier on trace fossils in lithic and hard skeletal substrates may be defined as the death of the borer.

In bioerosion studies using modern seafloor sediments, the age of foraminifera, the substrates for microborings, is not known. Yet the mode of preservation is closely similar to that of Cenozoic material, so in order that the microborings can be named, the dead material is considered to be fossilized.

In the case of small borings, referable to *Oichnus* isp. and made by slipper limpets in modern pagurized shells, it is clear that they are not fossilized, so providing them with an ichnospecies name is prohibited. A search of Pleistocene material has not yielded fossilized borings of this type. However, if the fossilization barrier is taken at the death of the borer, the problem is solved.

Acknowledgments

The authors are indebted to Alfred Uchman and Frank Simpson for helpful suggestions. Further, Emma Ruggiero, Jordi Martinell and Max Wisshak for their helpful suggestion and critical review of the manuscript

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