



## THE APPLICATION OF ICHNOLOGY TO PALAEOENVIRONMENTAL AND STRATIGRAPHIC ANALYSIS

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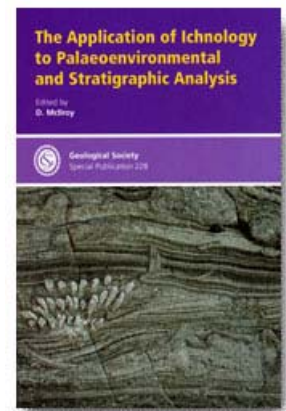
### INTRODUCTION

Fossils are among the most important tools for the interpretation of ancient depositional environments. Historically focus has been placed largely on body fossils, the skeletal remains of past life, but increasingly emphasis has been placed on trace fossils: borings, burrows, tracks, and trails. *The Application of Ichnology to Palaeoenvironmental and Stratigraphic Analysis* attempts to balance the scales by highlighting the value of ichnofossils in the interpretation of the stratigraphic record.

A product of the 2003 Lyell Meeting, this volume includes contributions from numerous trace fossil specialists. It consists of 20 chapters, including the introduction (Table 1), and is roughly organized into three parts. The first section (chs. 2-6) includes conceptual and methodological treatments of ichnofossils in laboratory and field settings in addition to taxonomic and distributional studies of Recent trace makers. The second section (chs. 7-16) treats ancient depositional environments, generally arranged from offshore to onshore settings, and the third section (chs. 17-20) addresses temporal changes in trace fossil diversity.

As stated on the back cover, "This volume aims to provide an analytical review of the ichnology of all major depositional environments and the use of ichnology in biostratigraphic and sequence stratigraphic analysis." Furthermore, it claims that the "comprehensive coverage of ancient depositional environments means that the book will be of use as a course text for undergraduates as well as

an invaluable reference text for all students of ichnology whether they are ichnologists, sedimentologists, or petroleum geologists by trade." One may ask: How well does this book live up to these goals? I would argue not as advertised, but before addressing the shortcomings, I highlight the volume's many positive aspects.



### BOOK FOR A BURGEONING FIELD

Despite an extensive body of descriptive work dating back to at least the 19th century, studies that use trace fossils in stratigraphic analyses and for documenting evolutionary patterns are relatively few. Thus, even first order patterns of morphological and ethological change through the Phanerozoic lag behind those of their skeletal counterparts. From this perspective, trace fossil studies are still in their infancy. Many of the chapters in this volume represent great strides toward the establishment of trace fossil diversity patterns and hypothesis-driven ichnology. For example, Uchman (ch. 7) presents data on the distribution of deep sea trace fossils and plots them alongside Phanerozoic marine diversity, global sea level, and mean global temperature curves. Martin (ch. 8) uses geochemical data as an independent measure of bottom water oxygenation to test oxygen-

related models of trace fossil distribution. And one of the most outstanding chapters is that of Manning (ch. 6), who presents a biomechanical study of vertebrate tracks followed by comparison of experimental and field data. However, the chapters in this volume demonstrate a dearth of clear nomenclatural and morphological standards for ichnology. Some of these issues are presented in the subsequent discussion of the book's core themes.

*Ichnotaxonomy.* The second chapter (by McIlroy) is a fine review of ichnology past and present and includes suggestions for classification, methodology, and future directions. In general, this chapter serves as a springboard for the rest of the volume. A question that arises here and elsewhere relates to the taxonomic treatment of trace fossils. Some have suggested a taxonomic code independent of the ICZN, which currently straps the ichnological community with two rules that are apparently ignored by many workers: (1) trace fossil names must be accompanied by a statement identifying the trace-making animal; and (2) Recent traces cannot be named using standard binomial nomenclature. The first rule seems particularly absurd when considering that different organisms may be responsible for similar traces through space and time, not to mention the obvious difficulty in confirming an organism-trace relationship by observing a body fossil "dead in its tracks." Glaub defends the second rule by suggesting that Recent traces (microborings) should not be used to establish ichnotaxa because such a practice, coupled with the identification of the living trace maker, would result in a "parallel taxonomy." In fact, the so-called "parallel taxonomy" problem is an artifact of trying to shoehorn dissimilar objects into the same classification system. The nature of ichnofossils as forms produced by organisms, but not as organisms themselves, invites an independent naming system: one for the trace and another for its maker. Just as you wouldn't classify your home as *Homo*; a prawn's burrow isn't *Callinassa*. Nevertheless, Glaub (ch. 4, p. 65) violates the second rule for the sensible reason that "if a modern trace and a fossil trace are identical, it is consistent to give them both the same name," thereby avoiding awkward terminology such as "*Skolithos*-like burrow" when referring to Recent traces.

*Ichnofacies, Ichnofabrics, and Ichnocoenoses.* A more common thread streaming through the book is the establishment and utility of ichnofacies, packages of strata characterized by similar trace fossil assemblages. Though ichnofacies continue to be added, refined, and applied, the contributions in this volume indicate that ichnofacies are being replaced by more detailed analyses

and methods for teasing data from the trace fossil record. Certainly, the authors who weighed in on the matter agreed that ichnofacies are not indicative of simple bathymetric trends in trace fossil distribution as often portrayed, but are controlled by myriad environmental and sedimentological variables that may or may not be controlled by depth. Indeed, McIlroy (ch. 2, p.9) laments, "It is regrettable that most sedimentology textbooks focus on Seilacherian ichnofacies, rather than on the more flexible ichnofabric/ichnocoenosis approach." The approach to which he refers involves careful analysis of trace fossils and their spatial relationships with the aim of defining ichnocoenoses that generally approximate the traces of a single community. Although in this volume McIlroy (chs. 2, 12) appears to be the only author who adopts this approach, it is clear that other contributors bypass ichnofacies in favor of more detailed treatments of the ichnological record.

*Ichnostratigraphy and Temporal Trends.* Because trace fossils reflect ethology more than morphology, and because similar traces are likely produced by myriad species through time, ichnofossils generally have less biostratigraphic utility than body fossils. Nevertheless, several contributions in this volume demonstrate the value of trace fossil distributions for stratigraphic correlation and studies of evolution and extinction. In fact, as mentioned by Twitchett and Barras (ch. 18), an ichnofossil, *Treptichnus pedum*, defines the base of the Cambrian. The same authors present data on trace fossil distributions through mass extinctions that demonstrate notable radiations following extinction events. Uchman (ch. 7) plots a diversity curve for deep sea trace fossils based on over 150 flysch deposits that roughly mirrors Phanerozoic diversity curves for marine invertebrates, and Bromley (ch. 20) presents the stratigraphic distribution of bioerosive ichnotaxa that also shows a temporal increase in trace fossil diversity. Genise (ch. 19) presents data on the stratigraphic ranges of insect ichnotaxa in paleosols that are similar to the body fossil records of bees, beetles, ants, and termites. Finally, Pemberton et al (ch. 3) and Buatois and Mangano (ch. 14) address the application of ichnofossils to marine and terrestrial sequence stratigraphy, respectively. These studies demonstrate that ichnologists have begun to release the potential of trace fossils for stratigraphy, evolution, and ecology.

## NOT FOR THE UNINITIATED

Let's now return to the question of how well the book lives up to its advertised "comprehensive

coverage” of depositional environments and its suitability as a “course text for undergraduates.” Although the book offers an extensive treatment of terrestrial and marine siliciclastic environments, carbonates are largely ignored. Furthermore, many of the chapters represent myopic treatments of their respective depositional settings and are not well enough integrated to facilitate clear understanding of the ichnological differences between paleoenvironments. Don’t let the running heads fool you – if you’re expecting an overview of “ichnology in lacustrine deltas” – you won’t get it, but a case study (albeit a good one) from a spatiotemporal speck. Another factor that limits the accessibility of this book to those who lack experience in ichnology is the copious references to ichnotaxa without accompanying illustrations. Although the figures in some chapters are outstanding, others fail to provide a single trace fossil illustration, even in contributions that are largely taxonomic.

Many of the abovementioned shortcomings are symptoms of the multi-author nature of this book and other volumes that are compiled from the contributions of specialists who embrace independent styles and conventions. Examples of author-independent styles that pervade the book include

the inconsistent italicization of facies names (e.g. Skolithos vs. *Skolithos* ichnofacies) and the ever persistent interpretive vs. descriptive naming of lithofacies (e.g. estuarine vs. burrowed mudstone facies). Instead of a well integrated and comprehensive review of ichnology, this volume is better viewed as a loosely organized compilation of ichnologists’ current work.

In several ways these problems can be viewed as strengths. As a collection of contributions from specialists, the volume provides a superb treatment of the current state of the field – and the prognostication is a good one. Inconsistencies in nomenclature, methodology, and interpretation of trace fossil data among various authors not only provide a source for generating new ideas and research directions, but they demonstrate that ichnology is a blossoming field with a clear course for future study. Ichnologists are poised for testing hypotheses of evolution, ecology, and extinction and for refining stratigraphic and paleoenvironmental models that can be applied in academia and industry alike. Careful study and discussion of this volume is sure to draw new blood to the field and encourage students and professionals to make new trails of their own.

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