

The Study of Trace Fossils

The Study of TRACE FOSSILS

A Synthesis of Principles, Problems
and Procedures in Ichnology

Edited by ROBERT W. FREY



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Robert W. Frey
Department of Geology
University of Georgia
Athens, Georgia 30602

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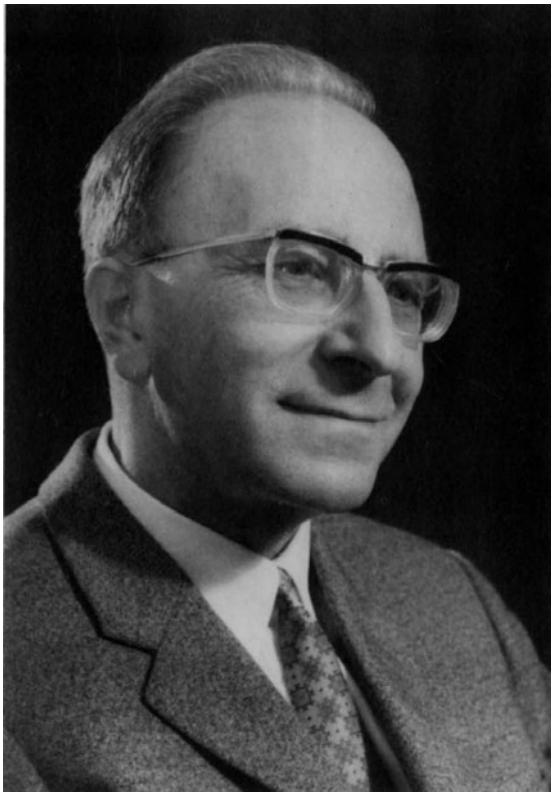
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MEMORIAL

WALTER HÄNTZSCHEL (1904–1972) AND THE FOUNDATION OF MODERN INVERTEBRATE ICHOLOGY

ADOLF SEILACHER

Geologisches-Paläontologisches Institut der Universität Tübingen
Tübingen, West Germany



Walter Häntzschel in 1969.
(*Photo courtesy of Marianne Häntzschel.*)

Walter Häntzschel, whose name is known to every ichnologist, died on May 10th, 1972, following an operation. In appreciation of his fundamental contributions, this book—which summarizes the present status of ichnology—is dedicated to Professor Häntzschel's memory.

Although a more detailed eulogy and a complete list of his publications have already been published (Lehmann, 1972), a few facts must be repeated here because they are essential to appreciate Walter Häntzschel's personality and scientific accomplishments. His life was molded by two world wars and their economic consequences: having grown up in Dresden as the only son of a schoolteacher and as a devoted amateur geologist, he entered the university of his home town at a time of inflation and unemployment. Becoming a scientist at that time would have meant starvation. Therefore, he studied toward an examination for high school teachers. But in order to satisfy his strong scientific interests, he devoted all of his free time as a

volunteer at the local Zwinger Museum, curating paleontological treasures from the Cretaceous of Saxony. He even managed to complete a doctoral dissertation while already engaged in teaching at a local high school. Long before this time he had been in contact with Professor Rudolf Richter (Frankfurt), who by then had opened the new field of “actuopaleontology”—in which fossil phenomena are systematically compared with possible analogs from modern marine environments.

When Richter asked him to take over the new station (“Senckenberg am Meer”) for marine geology and paleontology in Wilhelmshaven, Walter Häntzschel cheerfully accepted. From 1934 to 1938 he spent what was, perhaps, the happiest time of his life, exploring the Wadden Sea tidal flats for sedimentary structures, lebensspuren, and biostratigraphic features that could possibly be applied to the interpretation of ancient sediments (Schäfer, 1964). The results were published in *Senckenbergiana* or *Natur und Volk* and were discussed with students and scientists who visited the station during the summer months in order to see geology in the making. At the same time, however, his duties included consulting for the local port authorities, to whom sedimentation meant not just a scientific problem but also a major threat for an important naval base.

During his Wilhelmshaven time, Walter Häntzschel was well aware that wet-sediment studies should occupy only a limited part of a geologist's life and that the personal experience must sooner or later be referred back to the outcrop. The opportunity came in 1938 with his appointment as a curator at the Dresden Museum, together with the hope for permanence for him and his newly founded family. But the Second World War soon destroyed this hope: he was drafted in 1942 and returned six years later, his health and hopes corroded by three years in a Russian prison camp. He found the city of Dresden and its museum destroyed, and the country divided

by the iron curtain. He searched almost a year before he found a new place for the future: the Geological Institute of Hamburg University, where he stayed until his retirement in 1969.

In Hamburg, his major task was to rebuild the departmental library and collections, both of which were destroyed during the war, in addition to continuing his teaching and administration. Still he found time to publish a considerable number of papers, mostly about trace fossils and other sedimentary structures, and to critically review the complete trace fossil literature for *Zentralblatt für Geologie und Paläontologie*. But there was still another important service to the scientific community that does not appear in official records—Professor Häntzschel's personal messages that he sent out spontaneously whenever he came across some hidden paper that he thought would be of interest to a particular student or colleague, within or outside the country.

This life, without the glamor of an ambitious academic career or of economic success, was the background for the great contribution that will always be connected with Walter Häntzschel's name: the trace fossil volume of the *Treatise on Invertebrate Paleontology* (1962). To appreciate fully the significance of this book, a short review of the history of trace fossil research is necessary. (See also Chapter 1.)

The study of trace fossils had a first culmination in the last century, when most paleontologists were still convinced that they dealt with fossil seaweeds. Accordingly, they described, classified, and named trace fossils along with other fossils. An interesting thought is that Hall's concept of geosynclinal basins, in which sedimentation kept compensating the subsidence, was probably influenced by the “seaweed” theory.

When it gradually became clear that most “fucoids” are caused either by sedimentary processes or by burrowing and crawling creatures, the popularity of these “algal” fossils suddenly decreased. One rea-

son for this indifference was that the sedimentary features could no more be considered as reliable guide fossils or photic-zone indicators. But the other reason was that they now fell into a taxonomic "no-man's-land." They were either omitted from textbooks, or listed under "incertae sedis" or "problematica"—a view that has left its mark even in the *Treatise* arrangement.

Only a few people continued their interest in this field. These were the detectives, fascinated by what they viewed not as novel collector's items but as the record of individual biologic events. Comparison with the tracks and burrows of recent organisms was the obvious starting point, and taxonomic identification of the producers was the primary goal. Modern tidal flats, particularly those of tropical seas, seemed to hold all the clues. But it soon became clear that ancient bedding planes received most of their biogenic markings after the beds were already covered by at least a veneer of subsequent sedimentation. This discovery meant that modern mud surfaces are not the best analogy and that perfectly preserved trace fossils are not an indication of the intertidal zone; they may have formed at any depth.

During this reorientation period, in which trace fossils emerged as a major tool for paleoecology and environmental sedimentology, workers were reluctant to prematurely immobilize this fluctuating field by superimposing a narrow grid of parataxonomy and nomenclature. Walter Häntzschel himself coined very few trace names. But at the same time he felt the need to systematically review all existing knowledge of trace fossil morphology. While others indulged in worldwide field studies and in the discovery of new applications, he chose

the tedious task of accumulating data from a literature scattered widely in history, countries, languages, and disciplines. Only a man of his diligence and modesty could fulfill this task. Tracing dubious names back to their original source and meaning usually requires much more patience and energy than coining new ones. Also required is a basic respect for other scientists' work, regardless of quality and interpretation.

Walter Häntzschel's *Treatise* volume, together with the more extensive bibliography in *Fossilium Catalogus* (1965), was a tremendous milestone in the history of trace fossil research because it provided the first comprehensive reference that was also free enough from interpretation to be accepted by the majority of specialists in the field. In a way, it provided the paradigm—in Kuhn's sense—on which all future research in the field can be based.

The new boom in trace fossil research would have been impossible without Walter Häntzschel's contribution. But with his endowment goes an obligation: in ichnology more than in any other field of paleontology, taxonomic decisions depend on the behavioral and preservational character of the material and on the particular author's interpretation. Also, errors in assigning lower categories cannot be smoothed out on a higher taxonomic level, because hardly any higher category is generally accepted. The alphabetic order of genera still remains best; every new trace fossil name claims equal status, and puts the full load of responsibility on its author.

Out of consideration for Walter Häntzschel, who devoted himself to clearing the nomenclatural jungle, we should not let the weeds grow again!

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- Häntzschel continued his work on a forthcoming revision of the *Treatise* volume.)
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PROLOGUE

In a sense, the field of ichnology is both old and new. Its basic guiding principles were known to a few workers many years ago, and these principles are now being rediscovered by scores of current workers (paleontologists, stratigraphers, sedimentologists, paleoecologists, biologists, and others), who are adding their own bustle, momentum, and refinements to the subdiscipline. As is true in the development of any science, ichnologists have indeed gotten some occasional pebbles mixed in with their snowball; but they have also exposed many misconceptions and have made numerous positive gains.

Ichnology today is rapidly approaching that plateau at which the subdiscipline will settle comfortably into the ever-growing accumulation of “standard” but highly useful methods or procedures in geology. And that fact is perhaps the single most important message of this book: ichnology is not a new “magic wand,” to render sister subdisciplines obsolete; but neither can it be glibly ignored by anyone seriously interested in ancient life or environmental reconstructions.

WHAT IS ICHNOLOGY? HOW EFFECTIVE IS IT?

Numerous authors, myself included, are fond of introducing papers in ichnology with a statement to the effect that “trace fossils are valuable in paleoecology and facies analysis.” No matter how firm our conviction, however, I suspect that we have often been too complacent in explaining it, or at times even in testing it.

Just how useful are trace fossils in paleoecology and environmental reconstructions, or in such “traditional” fields as paleon-

tology, stratigraphy, and sedimentology? More specifically, how do we undertake the study of trace fossils? What kinds of things do we look for? How do we know what we are looking at? What kinds of problems may we expect? Which things are or are not unique about trace fossils? What is a trace fossil?

In effect, this book represents our combined attempt to grapple with such questions. Of course, we did not always agree on the best answer to a given question. But at least we have tried to avoid “fond statements” and “smug answers.” And this leads to what is perhaps the second most important message of the book: ichnology is not a mystical science that provides ready-made, unique answers on instant demand; research in this field requires the same thoroughness and devotion to detail necessary in any other discipline of geology, and involves the same kinds of subjective judgments and logical conclusions. In fact, ichnology represents a mingling of (and draws expertise from) numerous different disciplines — ethology, petrology, geochemistry, oceanography, etc., in addition to the fields already mentioned.

The foregoing also shows that trace fossils, like ripple marks or foraminifers, should not be studied outside of their overall geologic context. Therefore, the third most important message of the book is that we cannot reasonably study trace fossils without paying appropriate regard to other chemical, physical, and biological features contained in the same substrates.

You, the reader and user of this book, will ultimately decide just how effective we have been in demonstrating these three principles and in answering the above questions.

A NOTE ON ORGANIZATION AND CONTENT OF THE BOOK

Broadly speaking, Parts I and II of the book are concerned with the conceptual and material “core” of ichnology: how the science developed historically, and the present “state of the art”; how trace fossils are formed, preserved, sampled, identified, classified, interpreted, and used in other fields of geology; and also how they grade into, or may be confused with, other phenomena. In practice, however, the main emphasis in these two parts is upon biogenic sedimentary structures made by marine invertebrates, the kinds of traces that traditionally have received the most attention from the most people. This traditional but disproportionate emphasis is compensated in the book by Part III, which stresses borings, plant and vertebrate traces, and other occurrences that merit equal study and utilization.

Part IV focuses upon the recent as a

potential key to the past. Aquatic environments are stressed simply because most of the preserved record of ancient traces originated in such environments. Differences in the scope and content of these chapters stem largely from differences in the amount of specific information available from the respective environments.

The objectives of Part V overlap somewhat with those of Part IV, although the main emphasis in Part V is upon methodology and the kinds of results that can be obtained. Borings and plant and vertebrate traces are slighted among the discussions in Parts IV and V, but most of this information may be gleaned from appropriate chapters in Part III.

All in all, we have tried to cover the length, breadth, and depth of ichnology—at least in terms of the information currently available—and we hope that you will find this summary useful.

ROBERT W. FREY

PREFACE

In 1971 I published a review of ichnology (*Houston AAPG: SEPM Trace Fossil Field Trip Guidebook*) that I thought could be expanded rather easily into a worthwhile book on the subject. I probed that possibility for a while, thinking that I would write the book myself. As I began to outline the chapters in more detail, however, it soon became apparent that my personal knowledge of too many facets of ichnology scraped bottom all too soon. I quickly decided that a better book could be produced by soliciting specific contributions from other workers who, collectively, had first-hand experience with virtually every aspect of the field. That became the actual plan, the result of which is this book.

Now, looking over these contributions, I wonder why I ever thought that I *could* write such a book myself. In my humble opinion the contributors have done a commendable job, and I am deeply grateful to them. Significantly, the authors include biologists as well as geologists—a viable combination.

The original outline for the book was essentially my own, a copy sent to each contributor. But the individual authors responded twofold, expanding and refining their parts even more than I had dared hope for. The final product is truly “our” book and not “my” book.

Certain chapters do overlap slightly, as is apparent even from the table of contents; but the intended effect is to enhance continuity. Coherence through the book is especially desirable where the same basic topic is approached from two or more different viewpoints—as by paleontologists and sedimentologists, or by one worker concentrating on diverse traces found in a particular environmental setting and an-

other concentrating only on traces made by a certain group of organisms, regardless of their setting. Nevertheless, needless redundancy has hopefully been eliminated.

Some of the chapters are more specialized than others (because of the nature of particular topics); hence, these may be somewhat less familiar or “comprehensible” than others—depending upon the reader’s own interests and background. Other differences in the scope and content of various chapters stem from the simple fact that a considerably greater backlog of previous work is available in certain facets of ichnology than in others. But we hope that all of the chapters will prove to be useful to anyone wishing to delve into them.

The only parts missing now from the original plan are a chapter on coprolites and one on invertebrate trace fossils in non-marine rocks. Unfortunately but unavoidably, these had to be abandoned during the project. Some of the information, however, has been recouped in other chapters.

Our overall objective has been to produce a comprehensive “textbook” of ichnology, a book that, despite its diverse topics and numerous contributors, is not only thorough in coverage but is also well organized and coherent—not “just another compendium” on the book market. Accordingly, I took considerable liberty in editing the original typescripts, trying to establish a more-or-less uniform style throughout the book and inserting cross-references and other bits of information wherever they seemed to be appropriate. I thank the authors for bearing with me in these alterations, and I hope we attained our objective.

In addition to uniform style and continuity, we tried to arrive at a basic standard in our conventions, classifications, and

terminologies. Considering our diverse personal and scientific backgrounds, I believe that we were largely successful in this effort, especially in matters pertaining strictly to ichnology. One glaring exception, however, is our lack of agreement on a standard terminology for marine bathymetric zones; yet the authors have tried to make their respective meanings clear, and perhaps we may be excused for sidestepping a problem that belongs more to oceanography than to ichnology.

Each chapter was reviewed critically by at least two persons in addition to myself. In most cases the contributors reviewed each other's work, with an admirable display of cooperation. But "outside" reviewers also participated, and I sincerely appreciate their time and interest. Outside reviewers who kindly responded to my requests for the critical reading of various chapters include: D. V. Ager, *University of Wales*; Donald Baird, *Princeton University*; Barry Cameron, *Boston University*; M. R. Carriker, *Woods Hole, Massachusetts*; R. E. Carver, *University of Georgia*; K. E. Caster, *University of Cincinnati*; E. H. Colbert, *Museum of Northern Arizona*; B. R. Erickson, *Science Museum of Minnesota*; J. W. Evans, *Memorial University of Newfoundland*; Laing Ferguson, *Mount Allison University*; D. G. Frey, *Indiana University*; E. I. Friedman, *Florida State University*; Roland Goldring, *University of Reading*; D. E. Hattin, *Indiana University*; H. J. Hofmann, *Université de Montréal*; A. S. Horowitz, *Indiana University*; Wann Lang-

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I am also very grateful to the contributors who relinquished all rights to royalties in order to lower the sales price of this book. The savings to the consumer were substantial.

For the dust-cover design, I am indebted to R. G. Bromley (he will be happy to answer any questions about it).

I must also acknowledge Vedia Vinluan, who skillfully retyped innumerable manuscript pages after I had scribbled all over the originals, and my wife, Sharon, for her considerable patience and understanding during the time that she endured this "book widowhood."

Finally, I can hardly end this preface without mentioning Walter Häntzschel, to whom the book is dedicated. He was one of the original collaborators on this project but was never able to finish the work. He will be missed by all of us.

ROBERT W. FREY
Athens, Georgia

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