

# TREATISE ON INVERTEBRATE PALEONTOLOGY

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## Part W MISCELLANEA SUPPLEMENT 1 TRACE FOSSILS AND PROBLEMATICA Second Edition (Revised and Enlarged)

By †WALTER HÄNTZSCHEL

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# TREATISE ON INVERTEBRATE PALEONTOLOGY

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Directed and Edited by CURT TEICHERT

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## PARTS

Parts of the *Treatise* are distinguished by assigned letters with a view to indicating their systematic sequence while allowing publication of units in whatever order each may be made ready for the press. The volumes are cloth-bound with title in gold on the cover. Copies are available on orders sent to the Publication Sales Department, The Geological Society of America, P.O. Box 1719, Boulder, Colorado 80302. The prices quoted very incompletely cover costs of producing and distributing the several volumes, but on receipt of payment the Society will ship copies without additional charge to any address in the world. Special discounts are available to members of sponsoring societies under arrangements made by appropriate officers of these societies, to whom inquiries should be addressed.

## VOLUMES ALREADY PUBLISHED

(Previous to 1975)

- Part C. PROTISTA 2 (Sarcodina, chiefly "Thecamoebians" and Foraminiferida), xxxi+900 p., 5311 fig., 1964.
- Part D. PROTISTA 3 (chiefly Radiolaria, Tintinnina), xii+195 p., 1050 fig., 1954.
- Part E. ARCHAEOCYATHA, PORIFERA, xviii+122 p., 728 fig., 1955.
- Part E, Volume 1. ARCHAEOCYATHA, second edition (revised and enlarged), xxx+158 p., 871 fig., 1972.
- Part F. COELENTERATA, xvii+498 p., 2700 fig., 1956.
- Part G. BRYOZOA, xii+253 p., 2000 fig., 1953.
- Part H. BRACHIOPODA, xxxii+927 p., 5198 fig., 1965.
- Part I. MOLLUSCA 1 (Mollusca General Features, Scaphopoda, Amphineura, Monoplacophora, Gastropoda General Features, Archaeogastropoda, mainly Paleozoic Caenogastropoda and Opisthobranchia), xxiii+351 p., 1732 fig., 1960.
- Part K. MOLLUSCA 3 (Cephalopoda General Features, Endoceratoidea, Actinoceratoidea, Nautiloidea, Bactritoidea), xxviii+519 p., 2382 fig., 1964.
- Part L. MOLLUSCA 4 (Ammonoidea), xxii+490 p., 3800 fig., 1957.
- Part N. MOLLUSCA 6 (Bivalvia), Volumes 1 and 2 (of 3), xxxviii+952 p., 6198 fig., 1969; Volume 3, iv+272 p., 742 fig., 1971.
- Part O. ARTHROPODA 1 (Arthropoda General Features, Protarthropoda, Euarthropoda General Features, Trilobitomorpha), xix+560 p., 2880 fig., 1959.
- Part P. ARTHROPODA 2 (Chelicerata, Pycnogonida, Palaeoisopus), xvii+181 p., 565 fig., 1955.
- Part Q. ARTHROPODA 3 (Crustacea, Ostracoda), xxiii+442 p., 3476 fig., 1961.
- Part R. ARTHROPODA 4 (Crustacea exclusive of Ostracoda, Myriapoda, Hexapoda), Volumes 1 and 2 (of 3), xxxvi+651 p., 1762 fig., 1969.
- Part S. ECHINODERMATA 1 (Echinodermata General Features, Homalozoa, Crinozoa, exclusive of Crinoidea), xxx+650 p., 2868 fig., 1967 [1968].
- Part U. ECHINODERMATA 3 (Asterozoans, Echinozoans), xxx+695 p., 3485 fig., 1966.
- Part V. GRAPTOLITHINA, xvii+101 p., 358 fig., 1955.
- Part V. GRAPTOLITHINA, second edition (revised and enlarged), xxxii+163 p., 507 fig., 1970.

Part W. MISCELLANEA (Conodonts, Conoidal Shells of Uncertain Affinities, Worms, Trace Fossils, Problematica), xxv+259 p., 1058 fig., 1962.

#### THIS VOLUME

Part W. MISCELLANEA (Supplement 1). Trace Fossils, second edition (revised and enlarged), xxi+269 p., 912 fig., 1975.

#### VOLUMES IN PREPARATION (1975)

Part A. INTRODUCTION.

Part B. PROTISTA 1 (Chrysomonadida, Coccolithophorida, Charophyta, Diatomacea, etc.).

Part J. MOLLUSCA 2 (Gastropoda, Streptoneura exclusive of Archaeogastropoda, Euthyneura).

Part M. MOLLUSCA 5 (Coleoidea).

Part R. ARTHROPODA 4, Volume 3 (Hexapoda).

Part T. ECHINODERMATA 2 (Crinoidea).

Part X. ADDENDA, INDEX.

Part E, Volume 2. PORIFERA (revised edition).

Part F. COELENTERATA (supplement) (Anthozoa, Rugosa and Tabulata, revised edition).

Part G. BRYOZOA (revised edition).

Part L. AMMONOIDEA (revised edition).

Part W. MISCELLANEA (Supplement 2) (Conodonts).

### EDITORIAL PREFACE

#### INTRODUCTION

Individual volumes of the *Treatise on Invertebrate Paleontology*, like other similar compilatory works, begin to be out-of-date while they are still in the press. That does not mean that they should not be published, because they incorporate the sum of knowledge at a point in time. Therefore, the idea was developed at an early stage to enhance the value of the *Treatise* as a permanent reference work by publication of revised editions and two such revised editions have already been published. They are of Part V (Graptolithina) by O. M. B. BULMAN, published in 1970, and of Part E, volume 1 (Archaeocyatha), by DOROTHY HILL, published in 1972.

Research on fossil groups summarized in the various published volumes of the *Treatise* progresses at an uneven pace. Therefore, some sections become outdated sooner than others, and some will retain their value as up-to-date sources for many years. The *Treatise* volume with the most heterogeneous content is probably Part W (Miscellanea), published in 1962, which deals with conodonts, tentaculitids, hyolithids, "worms," trace fossils, and problematica.

Among these groups, increase in knowledge and understanding since publication of the volume in 1962 has been most rapid in the field of conodonts and trace fossils, and already in 1966, need was felt for publication of a small paper containing supplemental information accumulated since 1962.<sup>1</sup> Almost half of this paper was taken up by a contribution by WALTER HÄNTZSCHEL, entitled *Recent contributions to knowledge of trace fossils and problematica*.

Two and one-half years later, in December, 1968, Professor HÄNTZSCHEL suggested to me the possibility of publication of a second supplementary paper on trace fossils only, because "new ichnogenera were being established all the time." When this suggestion was discussed in an exchange of letters during 1969, it became apparent that new knowledge was being amassed at such a rapid rate that a "supplement" would soon reach the size of the entire original chapter. Professor HÄNTZSCHEL then offered to completely revise the entire

<sup>1</sup> RHODES, F. H. T., HÄNTZSCHEL, WALTER, MÜLLER, K. J., FISHER, D. W., & TEICHERT, CURT, 1966, *Treatise on Invertebrate Paleontology, Part W, conodonts, conoidal shells, worms, trace fossils: comments and additions*: Univ. Kansas Paleont. Contrib. Paper 9, 17 p., 20 text-fig.

contribution on *Trace fossils and problematica* and it was decided to publish this manuscript as a Supplement to Part W. It was judged that the time was ripe for publication of a comprehensive, thoroughly updated taxonomic text for trace fossils, especially in view of the fairly recent upsurge of interest in this group, particularly in Great Britain and North America, but also in such countries as the Soviet Union, Poland, and France. In Germany, of course, a great volume of work on this group of fossils had been produced at a steady rate since the end of World War II, as is described in the text below.

After his retirement late in 1969, HÄNTZSCHEL spent much of his time on this new task and increased the pace during 1971. He continued to work vigorously up to the beginning of March, 1972, when he suddenly succumbed to an illness from which he did not recover. He died on May 10, 1972.

Fortunately for the work, almost all major problems of policy and general format had been discussed by us before WALTER HÄNTZSCHEL's death and the author's wishes have been persistently respected during the long months of laborious editorial work that followed. Already during the winter 1971-72, HÄNTZSCHEL had submitted long lists of required illustrations, and photography and other art work was proceeding in the editorial office in Lawrence. Also, HÄNTZSCHEL had completed the chapter Introduction, partly in German, and this had been translated. In June, 1972, I spent some days in Hamburg to obtain first-hand knowledge of the degree of completion of the Häntzschel manuscript. Up to that time I could not even be sure that there was enough manuscript or background material available to make it possible for us to complete the job. What I found in Hamburg was a very comprehensive card file, consisting of a separate card for each genus, with descriptions and discussions written for *Treatise*-style publication. On these cards, references to illustrations were only sketchily indicated. Completed, also,

were the introductory parts to individual sections of the manuscript and these were mostly in German. I soon learned that Mrs. MARIANNE HÄNTZSCHEL, Professor HÄNTZSCHEL's widow, was very knowledgeable in her husband's affairs, having assisted him in his work, and she, with great fortitude, guided me in the sifting of these materials.

We were immediately faced with the task of having to prepare captions for nearly 1,000 individual text-figures and integrating these with the descriptive text. Mrs. HÄNTZSCHEL undertook to provide drafts for the captions, working mainly from books and reprints available in her husband's library. Meanwhile, facsimile copies of the entire card file were made and airmailed to the editorial office in Lawrence, where the job of meshing text and figure captions was begun late in 1972. At the same time, photography continued and assembly of illustrations commenced. The bulk of this work was carried out, under my general supervision, by assistant editors LAVON McCORMICK (text) and ROGER B. WILLIAMS (illustrations), ably assisted by special research assistant WILLIAM G. HAKES who was responsible for a great portion of the library research that had to be done and who also made many contributions to the text. All photographic work was done by MICHAEL FREDERICK.

Since Professor HÄNTZSCHEL died before he had completed, or even begun, composition of the manuscript, it was only to be expected that many loose ends would have to be tied up, and such was, in fact, the case. Our greatest headache was references, mainly because the German format of citations differs greatly from the American one, as used in the *Treatise* and other earth science publications in this country. Most Russian references existed only in German, French, or English translation, whereas the *Treatise* requires transliteration of the Russian titles. Innumerable dates, page references, spellings, and occurrence data had to be obtained or verified, some necessitating interlibrary loans, but finally, by the summer of 1973, the first draft of a more

or less complete manuscript could be put together. After another five or six months of checks and rechecks, corrections, changes, and additions, the first portions of the manuscript were finally sent to the press in November, 1973. Completed illustrations were sent to the engraver in December.

Anticipating a long gestation period from the arrival of the cardfile copy from Hamburg in August, 1972, until production of a press-ready manuscript, we continued to incorporate into the manuscript file new information, especially taxonomic, as it came in. Many colleagues assisted us in this task. Their names are mentioned below, but I wish to single out ROBERT W. FREY, University of Georgia, for special acknowledgment. A cutoff date for addition of new information was finally set at about April, 1973, but exceptionally important data, especially new taxa, were incorporated in the text up to the time the manuscript went to press, and some even in galley proof. However, no additional illustrations could be added at that late stage.

A matter of special concern was that of availability of names of trace fossil taxa established after 1930. It was discovered that, apparently due to some oversight of the deliberating body, strict application of the rules of the *International Code of Zoological Nomenclature* adopted by the 15th International Zoological Congress and published in 1961, led to the conclusion that names for trace fossil taxa established before 1931 are available, but those published after 1930 are not. Details are given by WALTER HÄNTZSCHEL below. It was immediately obvious that adherence to such a dichotomy would lead to utter chaos in any monographic treatment of trace fossils. Names of trace fossil taxa published before 1931 would have to be printed in italics and all provisions of the *Code* would have to be applied to them, whereas names published after 1930 would have no standing of any kind and would have to be treated as vernaculars to which the laws of priority and synonymy did not apply.

Professor HÄNTZSCHEL and I, at an early

stage, refused to be faced with such a chaotic situation and agreed on an arbitrary decision to deal with names of trace fossil taxa in such a manner as if all of them—not only those published before 1931—were coming under the provisions of the *International Code of Zoological Nomenclature*. In consequence, in this volume the criteria of availability, the laws of homonymy and synonymy, and all other provisions of the *Code* are applied equally to taxa established before 1931 and after 1930. Suggestions to this effect are the essence of a recommendation to the ICZN made by HÄNTZSCHEL & KRAUS (1972). We have deviated from this recommendation only in setting trace fossil names in italics, partly because Professor HÄNTZSCHEL preferred this style (written communication, March 1, 1971), and partly in order to preserve compatibility with other *Treatise* volumes. In fact, in this volume all taxonomic names are italicized, except those of pseudofossils.

The editorial work on this volume proceeded as part of the larger *Treatise* project, supported by National Science Foundation Grant GB-31331X with payments of \$66,600 in 1972, \$58,900 in 1973, and \$67,100 in 1974. The Geological Society of America supported the editorial office with grants of \$6,000 in 1972, and \$7,000 each in 1973 and 1974. Additional support was received through payment of salaries by the University of Kansas Endowment Association (\$3,230 in 1973, \$1,710 in 1974), and the Wallace Everette Pratt Research Fund in the University of Kansas Department of Geology (\$5,130 in 1972-73).

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It is not possible to indicate in detail for each person the nature of his contribution. Assistance came to the author and later to the editors in the form of gifts of reprints, advance manuscripts, photographs and other illustrative materials; as loans of rare books and reprints; as help in tracing hard-to-find references; in the form of discussions of intricate nomenclatural problems, mostly in correspondence. In a few cases, descriptions of individual genera were supplied and these are acknowledged in appropriate places in the text. Because of Prof. HÄNTZSCHEL'S death, some contributors may have been overlooked, for which we apologize. Our thanks for their cooperation are extended to the following colleagues: H. ALBERTI (Universität, Göttingen), H.-J. ANDERSON (Universität Marburg a.L.), KLAUS BANDEL (Universität, Bonn), K. W. BARTHEL (Technische Universität, Berlin), M. BEAUVAIS (Université de Paris), JAN BERGSTRÖM (Universitet Lund), LASZLÓ BOGSCH (Univ. Budapest), R. G. BROMLEY (Universitet, København), P. BRÖNNIMAN (Université de Genève), GEORGE CALLISON (California State College, Long Beach, Calif.), BARRY CAMERON (Boston University), RAYMOND CASEY (Institute of Geological Sciences, London), C. K. CHAMBERLAIN (Ohio University, Athens, Ohio), T. P. CRIMES (University of Liverpool), L. DANGEARD (Institut Océanographique, Paris), ALFRED EISENACK (Reutlingen), D. W. ELSTON (U. S. Geological Survey, Flagstaff, Ariz.), R. W. FREY (University of Georgia), T. W. GEVERS (University of the Witwatersrand), O. GIROTTI (Università di Roma), M. F. GLAESSNER (University of Adelaide, South Australia),

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## ABBREVIATIONS

Abbreviations used in this division of the *Treatise* are explained in the following alphabetically arranged list.

- Abhandl.**, *Abhandlung(en)*  
**Abt.**, *Abteilung*  
**aff.**, *affinis* (related to)  
**Afr.**, Africa, -an  
**Ala.**, Alabama  
**Alb.**, Albian  
**Alg.**, Algeria  
**Alta.**, Alberta  
**Am.**, America, -n  
**Amtl.**, *Amtlicher*  
**Anatol.**, Anatolia  
**Anis.**, Anisian  
**Ann.**, *Anñaes, Annali, Annal(es), Annuaire*, Annual  
**ant.**, anterior  
**Antarct.**, Antarctic  
**append.**, appendix  
**approx.**, approximately  
**Apt.**, Aptian  
**Arbeit.**, *Arbeit(en)*  
**Arch.**, Archives, *Archivos*  
**Arenig.**, Arenigian  
**Ariz.**, Arizona  
**Ark.**, Arkansas  
**Arg.**, Argentina  
**Årsskr.**, *Årsskrift*  
**art.**, **Art.**, article  
**AsiaM.**, Asia Minor  
**Atl.**, Atlantic  
**auctt.**, *auctorum* (of authors)  
**Aus.**, Austria
- Bajoc.**, Bajocian  
**Barrem.**, Barremian  
**B.C.**, British Columbia  
**Bd.**, *Band*  
**Belg.**, *Belgique*, Belgium  
**Ber.**, *Bericht*  
**Berrias.**, Berriasian  
**Biol.**, Biological, *Biologicheskaya*  
**Birrim.**, Birrimian  
**Biulet.**, *Biuletyn*  
**Bol.**, *Boletim, Boletín*, Bolivia  
**Boll.**, *Bolletino*  
**Briovér.**, Briovérian  
**Brit.**, Britain, British  
**Bull.**, Bulletin
- C.**, Centigrade, Central  
**ca.**, *circa*  
**Calif.**, California  
**Callov.**, Callovian  
**Cam.**, Cambrian  
**Campan.**, Campanian  
**Can.**, Canada  
**Carb.**, Carboniferous
- Carn.**, Carnian  
**Carpath.**, Carpathians  
**cat.**, catalog, catalogue  
**Cenoman.**, Cenomanian  
**Cenoz.**, Cenozoic  
**cf.**, confer (compare)  
**Cincinnati.**, Cincinnati  
**cm.**, centimeter(s)  
**Co.**, County  
**Coll.**, Collection(s)  
**Colo.**, Colorado  
**Colom.**, Colombia  
**Comanch.**, Comanchean  
**commun.**, communication  
**Commun.**, *Comunicações*  
**Comun.**, *Comunicaciones*  
**Conn.**, Connecticut  
**Contrib.**, Contribution(s)  
**cosmop.**, cosmopolitan  
**Cr.**, Creek  
**Cret.**, Cretaceous  
**Czech.**, Czechoslovakia
- Dan.**, Danian  
**Denkschr.**, *Denkschrift(en)*  
**Denm.**, Denmark  
**Dept.**, Department  
**Dev.**, Devonian  
**diag.**, **diagr.**, diagrammatical  
**diam.**, diameter  
**diss.**, dissertation  
**Distr.**, District  
**Dol.**, Dolomite
- E.**, East  
**Ecuad.**, Ecuador  
**ed.**, editor  
**edit.**, edition  
**e.g.**, *exempli gratia* (for example)  
**Eifel.**, Eifelian  
**emend.**, *emendatus(-a)*  
**Ems.**, Emsian  
**Eng.**, England  
**enl.**, enlarged  
**Eoc.**, Eocene  
**Esmark.**, Esmarkian  
**est.**, estimated  
**Est.**, Estonia  
**et al.**, *et alii* (and others, persons)  
**etc.**, *et cetera* (and others, objects)  
**Eu.**, Europe  
**exfol.**, exfoliated  
**expl.**, **explan.**, explanation
- F.**, Formation  
**fam.**, family  
**Festb.**, *Festband*  
**fig.**, figure(s)  
**Finl.**, Finland  
**Förhandl.**, *Förhandling(ar)*  
**Forhandl.**, *Forhandling(er)*
- G.Brit.**, Great Britain  
**Ga.**, Georgia  
**gen.**, genus  
**Geogr.**, Geographical  
**Geol.**, Geological, *Geologicheskikh, Geologische*  
**Ger.**, German, Germany  
**Gotl.**, Gotland  
**Gr.**, Great, Group  
**Greenl.**, Greenland  
**Guatem.**, Guatemala
- Handl.**, *Handling(ar)*  
**Hauteriv.**, Hauterivian  
**Helvet.**, Helvetian  
**Herts.**, Hertfordshire  
**Hettang.**, Hettangian  
**hom.**, homonym  
**horiz.**, horizontal  
**Hung.**, Hungarica, Hungary
- ICZN**, International Commission of Zoological Nomenclature  
**I.G.P.**, *Institut für Geologie und Paläontologie*  
**i.e.**, *id est* (that is)  
**ichnogen.**, ichnogenus  
**ichnosp.**, ichnospecies  
**Ill.**, Illinois  
**illus.**, illustrated, -ions  
**Inaug.**, Inaugural  
**inc.**, **incl.**, including  
**inc. sed.**, *incertae sedis*  
**ind.**, *indeterminata*  
**Ind.O.**, Indian Ocean  
**Ind.**, Indiana  
**Industr.**, Industrial, Industry  
**Inst.**, *Institut*, Institute  
**Internatl.**, International  
**Ire.**, Ireland  
**irreg.**, irregular  
**Is.**, Island(s)
- Jahr.**, *Jahrbuch*  
**Jahresber.**, *Jahresbericht*  
**Jahrg.**, *Jahrgang*  
**Jour.**, Journal  
**jun.**, jr., junior  
**Jur.**, Jurassic

<b>Kans.</b> , Kansas	<b>Naturhist.</b> , <i>Naturhistorische(s)</i>	<b>Penin.</b> , Peninsula
<b>Kimmeridg.</b> , Kimmeridgian	<b>N.B.</b> , New Brunswick	<b>Penn.</b> , Pennsylvanian
<b>km.</b> , kilometer	<b>N.Car.</b> , North Carolina	<b>Perm.</b> , Permian
<b>Ky.</b> , Kentucky	<b>N.Dak.</b> , North Dakota	<b>pers.</b> , personal
	<b>NE.</b> , Northeast	<b>Philos.</b> , Philosophical
<b>L.</b> , Lower	<b>Neocom.</b> , Neocomian	<b>pl.</b> , plate(s), plural
<b>Ladin.</b> , Ladinian	<b>Neth.</b> , Netherlands	<b>Plat.</b> , Platform
<b>lat.</b> , lateral	<b>Nev.</b> , Nevada	<b>Pliensbach.</b> , Pliensbachian
<b>Lias.</b> , Liassic	<b>Newf.</b> , Newfoundland	<b>Pleist.</b> , Pleistocene
<b>loc.</b> , locality, location	<b>n.f.</b> , <i>nova forma</i>	<b>Plio.</b> , Pliocene
<b>long.</b> , longitudinal	<b>N.J.</b> , New Jersey	<b>Pol.</b> , Poland
<b>low.</b> , lower	<b>N.Mex.</b> , New Mexico	<b>Port.</b> , Portugal
<b>Ls.</b> , Limestone	<b>no.</b> , number	<b>Precam.</b> , Precambrian
<b>Ludlov.</b> , Ludlovian	<b>nom. correct.</b> , <i>nomen correctum</i>	<b>prob.</b> , probably
	(corrected or intentionally	<b>Proc.</b> , Proceeding(s)
<b>m.</b> , meter(s)	altered name)	<b>Prof.</b> , Professional
<b>M.</b> , Middle	<b>nom. inval.</b> , <i>nomen invalidum</i>	<b>Proteroz.</b> , Proterozoic
<b>M.</b> , Monotypy	<b>nom. nov.</b> , <i>nomen novum</i>	<b>Prov.</b> , Providence
<b>m.y.</b> , million years	(new name)	<b>pt.</b> , part(s)
<b>Maastricht.</b> , Maastrichtian	<b>nom. nud.</b> , <i>nomen nudum</i>	<b>publ.</b> , publication, published
<b>mag.</b> , magnification	(naked name)	<b>Publ.</b> , <i>Publicacion</i> , Publication
<b>Mass.</b> , Massachusetts	<b>nom. null.</b> , <i>nomen nullum</i>	
<b>max.</b> , maximum	(null, void name)	<b>Quart.</b> , Quarterly
<b>Md.</b> , Maryland	<b>nom. oblit.</b> , <i>nomen oblitum</i>	<b>Que.</b> , Quebec
<b>Medd.</b> , <i>Meddelanden</i> ,	(forgotten name)	
<i>Meddelelser</i>	<b>nom. subst.</b> , <i>nomen substitutum</i>	<b>Rec.</b> , Recent, Record(s)
<b>Meded.</b> , <i>Mededeelingen</i>	(substitute name)	<b>reconstr.</b> , reconstructed, -ion
<b>Medit.</b> , Mediterranean	<b>nom. transl.</b> , <i>nomen translatum</i>	<b>Repos.</b> , Repository
<b>Mem.</b> , Memoir, <i>Memoria</i> , -e	(transferred name)	<b>Rept.</b> , Report
<b>Mém.</b> , <i>Mémoire(s)</i>	<b>nom. van.</b> , <i>nomen vanum</i>	<b>Res.</b> , Research, Resources
<b>Merxem.</b> , Merxemian	(vain, void name)	<b>Rev.</b> , Review, <i>Revista</i> , <i>Revue</i>
<b>Mesoz.</b> , Mesozoic	<b>Nomend.</b> , Nomenclature	<b>Revin.</b> , Revinian
<b>mid.</b> , middle	<b>Nor.</b> , Norian, Norway	<b>Rhaet.</b> , Rhaetian
<b>Mio.</b> , Miocene	<b>Notizbl.</b> , <i>Notizblatt</i>	<b>Rotl.</b> , Rotlandian
<b>Misc.</b> , Miscellaneous	<b>Nouv.</b> , <i>Nouveaux</i> , <i>Nouvelle</i>	<b>Rupel.</b> , Rupelian
<b>Miss.</b> , Mississippi, Mississippian	<b>nov.</b> , <i>novum</i>	<b>Russ.</b> , Russian
<b>Mitteil.</b> , <i>Mitteilungen</i>	<b>N.S.</b> , Nova Scotia	
<b>Mittheil.</b> , <i>Mittheilungen</i>	<b>NW.</b> , Northwest	<b>S.</b> , Sea, South
<b>mm.</b> , millimeter(s)	<b>N.Y.</b> , New York	<b>S.Am.</b> , South America
<b>Mo.</b> , Missouri	<b>N.Z.</b> , New Zealand	<b>Santon.</b> , Santonian
<b>mod.</b> , modified		<b>Sax.</b> , Saxony
<b>Mon.</b> , Monograph,	<b>O.</b> , Ocean	<b>schem.</b> , schematic
<i>Monographia</i> , <i>Monographie</i>	<b>obj.</b> , objective	<b>Schilfsandst.</b> , Schilfsandstein
<b>Mon.</b> , Monument	<b>Occas.</b> , Occasional	<b>Sci.</b> , Science, Scientific
<b>Monatsber.</b> , <i>Monatsberichte</i>	<b>OD</b> , original designation	<b>Scot.</b> , Scotland
<b>Monatsh.</b> , <i>Monatshefte</i>	<b>Okla.</b> , Oklahoma	<b>SD</b> , subsequent designation
<b>Mont.</b> , Montana	<b>Oligo.</b> , Oligocene	<b>S.Dak.</b> , South Dakota
<b>MS.</b> , manuscript	<b>Ont.</b> , Ontario	<b>SE.</b> , Southeast
<b>Mt.</b> , Mount, Mountain	<b>Op.</b> , Opinion	<b>sec.</b> , section(s)
<b>Mts.</b> , Mtns., Mountains	<b>Ord.</b> , Ordovician	<b>Senon.</b> , Senonian
<b>Mus.</b> , Museum	<b>Ore.</b> , Oregon	<b>ser.</b> , serial, series, etc.
	<b>Oxford.</b> , Oxfordian	<b>sér.</b> , <i>séries</i>
<b>n.</b> , new		<b>Sh.</b> , Shale
<b>N.</b> , New, North	<b>p.</b> , page(s)	<b>Sib.</b> , Siberia
<b>Nachricht.</b> , <i>Nachrichten</i>	<b>Pa.</b> , Pennsylvania	<b>Siegen.</b> , Siegenian
<b>N.Afr.</b> , North Africa	<b>Pac.</b> , Pacific	<b>Sil.</b> , Silurian
<b>N.Am.</b> , North America(n)	<b>Pak.</b> , Pakistan	<b>Sinemur.</b> , Sinemurian
<b>Namur.</b> , Namurian	<b>Paleoc.</b> , Paleocene	<b>Sitzungsber.</b> , <i>Sitzungsberichte</i>
<b>Nat.</b> , Natural	<b>Paleont.</b> , Paleontological,	<b>Skript.</b> , <i>Skript(er)</i>
<b>Natl.</b> , National	<i>Paleontologicheskij</i>	

s.l., *sensu lato* (in the wide sense, broadly defined)  
 SM, subsequent monotypy  
 sp., species (spp., plural)  
 spec., special, specimen  
 Spitz., Spitzbergen  
 Ss., Sandstone  
 s.s., s.str., *sensu stricto* (in the strict sense, narrowly defined)  
 St., Saint  
 subg., subgenus  
 subj., subjective  
 SW., Southwest  
 Swed., Sweden  
 Switz., Switzerland  
 Syst., System  
 T, tautonymy  
 tang., tangential  
 Tasm., Tasmania  
 Tenn., Tennessee

Tert., Tertiary  
 Tithon., Tithonian  
 Trans., Transaction(s)  
 transl., translated, -ion  
 transv., transverse  
 Trav., *Travaux*  
 Trias., Triassic  
 Turon., Turonian  
 U., Upper  
 Univ., *Universidad, Università, Universität, Université, Universitet, University*  
 up., upper  
 U.S., United States  
 USA, United States of America  
 USSR, Union of Soviet Socialist Republics  
 v., vol., volume(s)  
 Valang., Valangian  
 var., variety

Vend., Vendian  
 Venez., Venezuela  
 Verhandl., *Verhandlung(en)*  
 vert., vertical  
 Vic., Victoria  
 Vierteljahr., *Vierteljahrsschrift*  
 Volg., Volgian  
 Vt., Vermont  
 W., West  
 Wash., Washington  
 Westphal., Westphalian  
 Wis., Wisconsin  
 W.Va., West Virginia  
 Wyo., Wyoming  
 Ypres., Ypresian  
 Yugosl., Yugoslavia  
 Z., Zone  
 Zeitschr., *Zeitschrift*  
 Zool., Zoological, *Zoologisch*

## REFERENCES TO LITERATURE

Earlier volumes of the *Treatise* were accompanied by selected lists of references to paleontological literature consisting primarily of recent and comprehensive monographs, but also including some older works recognized as outstanding in importance. Publications listed in the *Treatise* were then not regarded as original sources of information concerning taxonomic units, but rather as guides to tell the reader where he may find them.

A departure from this policy occurred with publication of Part C of the *Treatise* in 1964. In these volumes, for the first time, all citations of authors and years in the text were fully documented in the list of references which were well in excess of 2,000. In *Treatise* parts published since 1964 the tendency has been toward fuller bibliographic documentation which is especially evident in Part H, published in 1965, and Part N, published in 1969 and 1971.

Following the wishes of the author, the list of references in the present volume is very comprehensive, comprising 1,720 titles. The editors have endeavored to check the accuracies of all entries, but this proved not to be possible in some cases. Such titles

are indicated by the addition of: [not seen by the editors]. Aiming at something as close to completeness as possible, the author has included in the list a number of references to which no reference is made in the text.

The following is a statement of the full names of serial publications which are cited in abbreviated form in the lists of references in the present volume. The information thus provided should be useful in library research work. The list is alphabetized according to the serial titles which were employed at the time of original publication. Those following in brackets are those under which the publication may be found currently in the *Union List of Serials*, the United States Library of Congress listing, and most library card catalogues. In some instances the current title is followed by the original one in parentheses. The names of serials published in Cyrillic are transliterated; in the reference lists these titles, which may be abbreviated, are accompanied by transliterated authors' names and titles, with English translation of the title. The place of publication is added (if not included in the serial title).

The method of transliterating Cyrillic letters that is adopted as "official" in the *Treatise* is that suggested by the Geographical Society of London and the U. S. Board on Geographic Names. It follows that names of some Russian authors in transliterated form derived in this way differ from other forms, possibly including one used by the author himself. In *Treatise* reference lists the alternative (unaccepted) form is given enclosed by square brackets (e.g., Chernyshev [Tschernyschew], T.N.).

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#### SOURCES OF ILLUSTRATIONS

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## STRATIGRAPHIC DIVISIONS

Classification of rocks forming the geologic column as commonly cited in the *Treatise* in terms of units defined by concepts of time is reasonably uniform and firm throughout most of the world as regards major divisions (e.g., series, systems, and rocks representing eras) but it is variable and unfirm as regards smaller divisions (e.g., substages, stages, and subseries),

which are provincial in application. Users of the *Treatise* have suggested the desirability of publishing reference lists showing the stratigraphic arrangement of at least the most commonly cited divisions. Accordingly, a tabulation of European and North American units, which broadly is applicable also to some other continents, is given here.

### *Generally Recognized Divisions of Geologic Column*

**EUROPE**  
**CAINOZOIC ERATHEM**  
**QUATERNARY SYSTEM**  
 Holocene (Recent) Series  
 Pleistocene Series  
**TERTIARY SYSTEM<sup>1</sup>**  
**Pliocene Series**  
 Astian Stage  
 Pontian Stage  
**Miocene Series**  
 Sarmatian Stage  
 Tortonian Stage  
 Helvetian Stage  
 Burdigalian Stage  
**Oligocene Series**  
 Aquitanian Stage  
 Chattian Stage  
 Rupelian Stage  
 Lattorfian Stage  
**Eocene Series**  
 Ludian Stage  
 Bartonian Stage  
 Auversian Stage  
 Lutetian Stage  
 Ypresian Stage  
**Paleocene Series**  
 Sparnacian Stage  
 Thanetian Stage  
 Montian Stage (includes Danian)

**MESOZOIC ERATHEM**  
**CRETACEOUS SYSTEM**  
**Upper Cretaceous Series**  
 Maastrichtian Stage<sup>3</sup>  
 Campanian Stage<sup>3</sup>  
 Santonian Stage<sup>3</sup>  
 Coniacian Stage<sup>3</sup>  
 Turonian Stage  
 Cenomanian Stage  
**Lower Cretaceous Series**  
 Albian Stage (Gault)  
 Aptian Stage  
 Barremian Stage<sup>4</sup>  
 Hauterivian Stage<sup>4</sup>  
 Valanginian Stage<sup>4</sup>  
 Berriasian Stage<sup>4</sup>

**NORTH AMERICA**  
**CENOZOIC ERATHEM**  
**QUATERNARY SYSTEM**  
 Holocene (Recent) Series  
 Pleistocene Series  
**TERTIARY SYSTEM<sup>1, 2</sup>**  
**Pliocene Series**  
 Foley  
**Miocene Series**  
 Clovelly  
 Duck Lake  
 Napoleonville  
 Anahuac  
**Oligocene Series**  
 Chackasaway  
 Vicksburgian Stage  
**Eocene Series**  
 Jacksonian Stage  
 Claibornian Stage  
 Sabinian Stage  
**Paleocene Series**  
 Midwayan Stage

**MESOZOIC ERATHEM**  
**CRETACEOUS SYSTEM**  
**Gulfian Series (Upper Cretaceous)**  
 Navarroan Stage  
 Tayloran Stage  
 Austinian Stage  
 Eaglefordian Stage  
 Woodbinian (Tuscaloosan) Stage  
**Comanchean Series**  
**(Lower Cretaceous)**  
 Washitan Stage  
 Fredericksburgian Stage  
 Trinitian Stage  
**Coahuilan Series (Lower Cretaceous)**  
 Nuevoleonian Stage  
 Durangoan Stage

**JURASSIC SYSTEM****Upper Jurassic Series**

Tithonian Stage  
 Kimmeridgian Stage  
 Oxfordian Stage

**Middle Jurassic Series**

Callovia Stage<sup>5</sup>  
 Bathonian Stage  
 Bajocian Stage

**Lower Jurassic Series (Liassic)**

Toarcian Stage  
 Pliensbachian Stage  
 Sinemurian Stage  
 Hettangian Stage

**TRIASSIC SYSTEM****Upper Triassic Series**

Rhaetian Stage  
 Norian Stage  
 Carnian Stage

**Middle Triassic Series**

Ladinian Stage  
 Anisian Stage

**Lower Triassic Series**

Scythian Stage

**PALEOZOIC ERATHEM****PERMIAN SYSTEM****Upper Permian Series**

Tatarian Stage<sup>6</sup>  
 Kazanian Stage<sup>7</sup>  
 Kungurian Stage

**Lower Permian Series**

Artinskian Stage<sup>8</sup>  
 Sakmarian Stage  
 Asselian Stage

**CARBONIFEROUS SYSTEM****Upper Carboniferous Series**

Stephanian Stage

Westphalian Stage

Namurian Stage

**Lower Carboniferous Series**

Visean Stage

Tournaisian Stage

**DEVONIAN SYSTEM****Upper Devonian Series**

Famennian Stage

Frasnian Stage

**Middle Devonian Series**

Givetian Stage

Couvinian Stage<sup>9</sup>

**JURASSIC SYSTEM****Upper Jurassic Series**

Portlandian Stage  
 Kimmeridgian Stage  
 Oxfordian Stage

**Middle Jurassic Series**

Callovia Stage<sup>5</sup>  
 Bathonian Stage  
 Bajocian Stage

**Lower Jurassic Series (Liassic)**

Toarcian Stage  
 Pliensbachian Stage  
 Sinemurian Stage  
 Hettangian Stage

**TRIASSIC SYSTEM****Upper Triassic Series**

Rhaetian Stage  
 Norian Stage  
 Carnian Stage

**Middle Triassic Series**

Ladinian Stage  
 Anisian Stage

**Lower Triassic Series**

Scythian Stage

**PALEOZOIC ERATHEM****PERMIAN SYSTEM****Upper Permian Series**

Ochoan Stage  
 Guadalupian Stage

**Lower Permian Series**

Leonardian Stage  
 Wolfcampian Stage

**PENNSYLVANIAN SYSTEM****Upper Pennsylvanian Series**

Virgilian Stage  
 Missourian Stage

**Middle Pennsylvanian Series**

Desmoinesian Stage  
 Atokan Stage

**Lower Pennsylvanian Series**

Morrowan Stage

**MISSISSIPPIAN SYSTEM****Upper Mississippian Series**

Chesteran Stage  
 Meramecian Stage

**Lower Mississippian Series**

Osagian Stage  
 Kinderhookian Stage

**DEVONIAN SYSTEM****Chautauquan Series (Upper Devonian)**

Bradfordian Stage<sup>10</sup>  
 Cassadagan Stage<sup>10</sup>

**Senecan Series (Upper Devonian)**

Chemungian Stage<sup>10</sup>  
 Fingerlakesian Stage<sup>10</sup>

**Erian Series (Middle Devonian)**

Taghanican Stage<sup>10</sup>  
 Tioughniogan Stage<sup>10</sup>  
 Cazenovian Stage<sup>10</sup>

**Lower Devonian Series**

Emsian Stage  
Siegenian Stage  
Gedinnian Stage

**SILURIAN SYSTEM**

**Upper Silurian Series**

Pridolian Stage  
Ludlovian Stage<sup>11</sup>  
Wenlockian Stage<sup>11</sup>

**Lower Silurian Series<sup>11</sup>**

Llandoveryian Stage<sup>11</sup>

**ORDOVICIAN SYSTEM**

**Upper Ordovician Series**

Ashgillian Stage<sup>11</sup>

Caradocian Stage<sup>11</sup>

**Lower Ordovician Series**

Llandeilian Stage<sup>11</sup>  
Llanvirnian Stage<sup>11</sup>  
Arenigian Stage<sup>11</sup>  
Tremadocian Stage<sup>11</sup>

**CAMBRIAN SYSTEM**

**Upper Cambrian Series (Merioneth)**

Middle Cambrian Series (St. David)

Lower Cambrian Series (Comley)

**ROCKS OF PRECAMBRIAN ERAS**

**PROTEROZOIC ERATHEM**

Dalradian, Eocambrian,  
Vendian, Riphean,  
and equivalents

**Ulsterian Series (Lower Devonian)**

Onesquethawan Stage<sup>10</sup>  
Deerparkian Stage<sup>10</sup>  
Helderbergian Stage<sup>10</sup>

**SILURIAN SYSTEM**

Cayugan Series<sup>12</sup> (Upper Silurian)

Niagaran Series<sup>12</sup> (Middle Silurian)

Alexandrian Series<sup>12</sup> (Lower Silurian)

**ORDOVICIAN SYSTEM**

**Cincinnatian Series**

(Upper Ordovician)

Richmondian Stage  
Maysvillian Stage  
Edenian Stage

**Champlainian Series**

(Middle Ordovician)

Mohawkian Stage  
Trentonian Substage  
Blackriveran Substage

Chazyan Stage

Whiterockian Stage

Canadian Series (Lower Ordovician)

**CAMBRIAN SYSTEM**

Croixian Series (Upper Cambrian)

Trempealeauan Stage

Franconian Stage

Dresbachian Stage

Albertan Series (Middle Cambrian)

Waucoban Series (Lower Cambrian)

**ROCKS OF PRECAMBRIAN ERAS**

**PROTEROZOIC ERATHEM**

Algonkian, Beltian,  
Hadrynian, Helikian,  
Aphebian, and equivalents

CURT TEICHERT

<sup>1</sup> For convenience Miocene and Pliocene are often grouped as Neogene, Paleocene, Eocene, and Oligocene as Paleogene subsystems.

<sup>2</sup> Follows essentially Gulf Coast usage.

<sup>3</sup> Classed as division of Senonian Subseries.

<sup>4</sup> Classed as division of Neocomian Subseries.

<sup>5</sup> Included in Upper Jurassic by some authors.

<sup>6</sup> Equivalent to upper Thuringian (Zechstein) deposits.

<sup>7</sup> Equivalent to lower Thuringian (Zechstein) deposits.

<sup>8</sup> Equivalent to upper Autunian and part of Rotliegend deposits.

<sup>9</sup> Also known as Eifelian.

<sup>10</sup> Applies essentially to eastern United States; in western North America European stage terminology is used.

<sup>11</sup> Classified as Series by many English geologists; Tremadocian placed in Cambrian by some authors.

<sup>12</sup> Applies essentially to eastern North America only. BERRY and BOUCOR have advocated use of the English standard scale everywhere in North America (Geol. Soc. America, Spec. Paper 102, 1970).