

able contribution in its own right. Norman Hughes made important and varied contributions to Cretaceous palynostratigraphy and Mesozoic paleobotany. His first book on this subject, *Palaeobiology of Angiosperm Origins* (1976, Cambridge), played a key role in catalyzing interest in angiosperm origins and in making the fossil record relevant to the debate. Hughes' 1976 book appeared in a critical period in the rehabilitation of angiosperm paleobotany-palynology and Norman Hughes played no small role in this remarkable transformation. *The Enigma of Angiosperm Origins* is readable and certainly presents much that could be the basis for interesting discussion, but I do not feel that it meets the stated goals of the series.

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Stratigraphy

A. Salvador, 1994. *A guide to Stratigraphic Classification, Terminology, and Procedure (International Stratigraphic Guide)* The Geological Society of America, Boulder, USA, XIX + 214 pp. ISBN 0-8137 7401-2

Numbering 214 pages, the book comprises 103 pages of text, a 38 page glossary, 64 pages of bibliography and an 8 page index.

(a) The text is divided into ten chapters: (1) Introduction (5 pages); (2) Principles of stratigraphic classification (5 pp.); (3) Definitions and procedures (12 pp.); (4) Stratotypes and type localities (6 pp.); (5) Lithostratigraphic units (13 pp.); (6) Unconformity-bounded units (7 pp.); (7) Biostratigraphic units (15 pp.); (8) Magnetostratigraphic polarity units (7 pp.); (9) Chronostratigraphic units (22 pp.); (10) Relation between different kinds of stratigraphic units (5 pp.). The illustrations comprise 17 figures and 4 tables, mostly for Chapters 7 and 9.

(b) The glossary lists terms "used in publications dealing with concepts and principles of stratigraphic classification, terminology and procedure," each with generally 1 to 4 short lines of dictionary style text.

(c) The bibliography includes both a 5-page list of what the author calls "National or Regional stratigraphic codes" (which partly reflects his personal judgement on publications, some of which have the same "international" pretensions as the present Guide), and a "comprehensive bibliography" comprising a 57 page list which includes the 2 or 3 previous editions of the same volume by the same author. On account of its volume, the later list (more than 90% references older than 10 years) might have been supposed to be up to date; however with more than 90% of the references older than 10 years, it is mostly a list of historical publications dealing with theoretical principles.

Chapter 1 presents the general background to the philosophy and origin of the volume. Presented as the 2nd edition of an "International Stratigraphic Guide" edited by H.D. Hedberg (1976), the sub-title of this book, "A Guide to stratigraphic classification, terminology, and procedure," more correctly reflects its actual nature. It is the result of a personal synthesis, following many discussions, and represents merely one view amongst others. The author of the volume militates for an "international agreement", i.e. his proposals. The manuscript was openly circulated amongst the community before publication but, at no stage was it submitted to any vote or "international agreement" neither to the Commission of Stratigraphy of the I.U.G.S. nor within the Subcommittee itself, contrary to what is suggested, i.e. p. 2: "recommendations...based on the current consensus of a substantial majority of members of the Subcommittee," or p. 4 "the Subcommittee offers its guide". The previous edition of this Guide had been submitted for a single vote on the desirability of its publication and not on agreement with its content.

The author "gives permission" to use other rules (badly qualified, p. 5, as "more or less conflicting local or national codes"). Commenting on possible alternative views, he regrets not hav-

ing “adequate space” and writes that “it would be unfair to select some views and neglect others.” The volume, however, clearly represents his own personal views, totally respectable and influenced by his own professional experience, scientific background and cultural environment.

Chapter 2 presents general categories of stratigraphic classification. It is devoted to units which are all shown in parallel. One may regret that the precise nature and particular properties of (the tools used to derive) the units is not considered. The Categorisations and definitions used later in the volume would have been better understood (and appropriately qualified) if a clear distinction had been drawn here between descriptive units (mostly lithostratigraphic), correlative and regional units (partly chemo- and biostratigraphic), correlative and global units (magnetostratigraphic and partly other ones), and conventional (integrated approach, chronostratigraphic) units. Interpretative units (sequences) are not recognized.

One may also regret the debatable distinction made between formal units (capitalized: litho-, bio-, chrono-magnetostratigraphic and unconformity-bounded units) and informal ones (non-capitalized: chemostratigraphic or physical, or with a genetic meaning). This is essentially a distinction between those units known from traditional geology and those not yet in common use. Formal and informal units exist, but their main difference is not in the kind of tool used for their characterization but in the extent of knowledge available and their potential identification.

Chapter 3 gives definitions for 13 general terms and explains procedures to define and revise stratigraphic units. Three terms, (geochronology, geochronologic unit and geochronometry) receive special emphasis; but it is not clear whether they concern stratigraphy or not. As the only representative on the Subcommittee on Stratigraphic Classification responsible for that volume, of those scientists who are universally called “geochronologists”, the writer regrets, denies and rejects the choice of the term “geochronometry” to designate a field of scientific study. The study of numerical ages is far from a mere technical exercise (metros $\approx$ measurements); it is a fully scientific study (logos). “Geochronology” is the term

used to designate the subcommission of the International Commission on Stratigraphy dealing with numerical age calibration; international, regional and national meetings for and by those experts are all called congresses of geochronology (it has never been assumed that isotopic dating was the only way to recognize the “sequence of events in the history of the Earth”).

As regards procedures, a consideration of the distinct nature of the different kinds of units would probably have made that point clearer. The rules proposed for naming units are common sense ones, though they sometimes appear trivial (i.e. p. 22: “if there is uncertainty with respect to the assignment of rock bodies to one or the other of two named units, it is always better to express this doubt rather than to make an arbitrary assignment”) but are welcome in general.

Chapter 4 presents the theory of stratotypes, their variety (area, type locality, unit and, boundaries) and general requirements. Following an old fashioned Anglo-Saxon concept, chronostratigraphic units are said to be defined with the emphasis on their lower boundary. Not everyone will agree with this, an important alternative view considers that: i- a unit is primarily defined by its content not by a boundary or point and ii- there is no reason for a boundary to define the base of the next unit without defining exactly equivalently the top of the previous one in a “section representing essentially continuous deposition” (see Chapter 9, p. 90). It appears that two complementary (and physically independent) kinds of information are necessary for the concrete definition of a chronostratigraphic unit: one for the corpus (body of rocks) and one for the boundaries (two points) with adjacent units. For many years, only the bodies of rock (which give the unit its name) were defined and this was sufficient. Nowadays, however, with the need for more precision, the points common to two successive units occupy a special position; the two must be consistent with each other and are necessary to define both a content and precise limits.

Chapter 5 presents units strictly based on the (lithological) nature of their content: nature, definition, kinds and procedures for establishing, correlating, and naming type sections and localities

for stratified and nonstratified rock bodies (igneous and metamorphic).

In contrast to the previous lithostratigraphic, Chapter 6 deals with units defined by the nature of their limits (unconformity). These are descriptive units (no causal or genetic criteria whether orogenic, eustatic or epeirogenic). This is in agreement with the general philosophy of the volume which focuses on the descriptive aspect of stratigraphy. Interpretative units, such as sequences which are also commonly widely bounded by unconformities, are allocated only 8 lines to state that they are excluded from the present category (and the volume). For many geologists this will seem a debatable choice: interpretative units may be accepted as an integral part (result) of stratigraphic studies.

Chapter 7 presents the nature, general definitions, kinds (in detail), and procedures related to biostratigraphic units. Because of the adopted philosophy (i.e. to describe the fossil content of a body of rock and not its significance) several trivial recommendations are made such as p. 54: "fossils that can be identified as reworked should be treated apart from those believed indigenous." This sentence also indicates that purely descriptive theoretical units cannot be practical ones: interpretations (chronologic meaning) and the use of the potential of the human brain are unavoidable in stratigraphy. Systematic categorization not based on practical potential also lead us to lose touch with reality. For example, it is debatable whether boundaries of "lineage biozones" can be equated without proper reservation to surfaces ("biohorizons") when the inherent nature of evolution suggests that the derivation of taxon b from taxon a is not instantaneous (at the present scale of geological knowledge). This requires the concept of an undetermined interval between two successive such units (no matter whether they are litho- or chronologic in nature). The author's adopted philosophy leads him to hide and formally reject the time-correlative meaning in biostratigraphic correlation. The author is however, appropriately, locally lead to consider the time-correlative character (or lack of i.e. ecological dependence) of some of the defined units. Many

readers would have preferred to see this view used throughout.

In spite of the caution taken to remain constantly descriptive, the author cannot restrain himself from "incorrect" (in terms of the philosophy accepted) chronologic interpretations. Without changing the meaning, one may partly quote, pp. 66–67: "codification of biozones by letters or numbers... can be extremely useful... (because it) indicates the sequence and relative positions of the zones". This is incorrect, there are known examples of inadequate sequences and relative positions of perfectly defined (in the sense of the theoretical definitions of this Guide) boundary zones, mostly interval zones (see Guex, 1989, a fundamental reference representing one point of view, or Temple and House, 1991, which represents another one, or other references published in "recognized scientific media").

A few portions of the text are (diplomatically?) cryptic; for example, one would have appreciated to know what is possibly hidden in the sentence, p. 65: "esoteric zonal criteria lose value". Possibly diplomatic too is the fact that the problem of the scales (biozonations) deduced from the biostratigraphic tool are not addressed in this chapter. This universal practice (biozonation) is precisely the time when the theoretical definitions have to be confronted with the actual record and meaning. Finally in the section dealing with procedures the phrase "one or more reference sections" is used (p. 65) instead of "stratotype" possibly to take into account the fact that such "desirable" sections are rarely known. On p. 84, however, the author states that some kinds of biozones "cannot appropriately have a designated stratotype," which makes the situation less rigid and more complex than understood: these biozones do not fulfill the requisite for stratotypes for biostratigraphic units.

Chapter 8 uses the plan common to all other classifications; units are defined as rock bodies. The comment made on the nature of magnetostratigraphic units does not consider the specific causality of the signal compared to other classifications: its instantaneity (at the present scale of knowledge), fundamental global contem-

poraneity, and highly “equivocal” nature. In this manner, the problems of other classifications are simply transferred to one which does not have the same problems (causality) and potential (100% correlative, 0% chronologic). For many readers, it will appear somehow surrealistic to require that magnetostratigraphic units should be defined according to stratotypes (punctual records) when the magnetostratigraphic properties are essentially independent of the locality on the earth (it depends on a physical property of the whole planet).

At this point, one will note that the geochemical approach (chemostratigraphy) and geochronological studies (numerical dating) are not considered sufficiently important to warrant separate chapters. This is possibly because in the logic adopted by the author they do not lead to rock-body units. For other experts, both approaches are able to delineate rock bodies (i.e. oxygen isotopic ratio stages in Recent time; units defined by numerical ages in Precambrian time).

Chapter 9 discusses the nature, definitions and kinds of chronostratigraphic units. It recommends the use of similar rules for Precambrian, and Quaternary times for procedures, and the naming of units. Chronostratigraphic units are bodies of rocks formed during a specified interval of time. In this chapter isochronous validity of biohorizons is locally assumed or understood, something which is inconsistent with the views expressed in Chapter 7. For example, p. 78: chronohorizons (isochronous surfaces) “include many biohorizons”; only some of them are more or less appropriate; or p. 79 “boundary-stratotypes... should be associated with distinct marker horizons (understood to be time-correlative) such as biozone boundaries”. If biostratigraphic zones are defined as bodies of rocks with no time implication for their limits as repeatedly emphasized in chapter 7, this is not valid and boundary-stratotypes should be better associated with more isochronous time significant markers. The ambiguity and considerable distance (and difficulty) between the theoretical exercise in terminology and actual application is well illustrated in this case.

Another case is the question of the Precambrian time scale. After considerable effort and

discussions, the authoritative Precambrian Subcommission has chosen not to define global units in terms of rock-bodies (because of the extreme difficulty in finding appropriate type-sections and subsequent problems of correlation) but in terms of numerical ages. Though obviously more realistic, this approach is rejected here in favour of a recommendation for units similar to Phanerozoic ones. The specific reality of the field and knowledge for Quaternary rocks is similarly considered to be relevant from the same cast (chronostratigraphic units with type sections) as other Phanerozoic rocks.

The potential of some alternative approaches is underestimated in this chapter. For example, p. 97: “Various mineralogical, geochemical... features of rock strata provide means of approximate time-correlation”. Chemostratigraphy does in fact exist and some criteria (iridium anomalies, oceanic fluctuations in relative trace element contents or isotopic ratios) have proved to allow much better time-correlation than some biostratigraphic horizons as defined in this volume. These potentially instantaneous markers, together with magnetic reversals (global and “equivocal”) associated with paleontologic signals (unequivocal but usually less precise), are able to “extend the boundaries of chronostratigraphic units away from their stratotypes” achieving good enough isochroneity”. To write never achieves as on p. 97 is pessimistic as far as geologically significant precision is concerned.

Chapter 10 once again emphasizes the difference in nature of a chronostratigraphic unit versus all other units included in a single group having problems of isochroneity (which is debatable). Another difference (not quoted) is that the former is theoretical (and mostly conventional) and the latter are practical (and mostly factual).

In spite of the debatable character of many of the points discussed in this volume, it is acknowledged that consensus on a single set of rules like the ones presented is impossible. But there are excellent reasons for discussions. In the reviewer’s opinion, at least some attention place should have been given to alternative views if the author wished to give an “international” dimension to his project. In fact, consensus is probably impossi-

ble due to the variety of situations, cultural models (not everyone is cast in the particular American model described), and needs. A unique and rigid set of rules for all stratigraphic tools, for all time periods and for all basins as given in the volume is not attainable. The book has the merit of appearing 20 years after the Hedberg version. It is useful as a basis for reflection; one might have hope for more modern views to have been developed by several experts.

In brief, this is a book on theory; an important reference for a particular school of thought leading to a rigid scheme; a locally old fashioned descriptive view of stratigraphy underestimating some recent knowledge; an impossible task by a single editor. A. Salvador was a main contributor to the Hedberg version (vice chairman of the ISSC 20 years ago) as were some other members of the Subcommittee, which explains why the concepts presented in this book have been so little updated to reflect recent improvements in knowledge.

Experts will no doubt be interested in reading this volume.

References

- Guex, G.J., 1991. *Biochronological Correlations*. Springer, Berlin, 252 pp.
 Temple, J.T. and House, M.R., 1992. Discussion on a guide to stratigraphic procedure. *J. Geol. Soc. London*, 149: 677-678.

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Geological Events

C.B. Officer and J. Page, 1993. *Tales of the Earth, Paroxysms and Perturbations of the Blue Planet*. Oxford University Press, New York. Hardcover, vii + 226 pp. Price: \$24.00 ISBN 0-19-507785-7

James Hutton, the "father of geology", is said to have discovered "deep time", the unimaginable length of geologic time. Then Charles Lyell,

in his classic *Principles of Geology*, used deep time as the basis for arguing that the slow and subtle everyday geologic processes were indeed sufficient to have caused the great geologic changes evidenced in the rock record. Thus, the school of thought called gradualism or uniformitarianism was codified. It is now clear, however, that the natural events that govern geologic processes, e.g., earthquakes, volcanic eruptions, and floods, follow a common fractal pattern-the frequency of occurrence of events is inversely proportional to their magnitude. Minor events, such as rain storms, small earthquakes and low-energy eruptions, make up the normal everyday geologic processes. Major events, such as severe floods, devastating earthquakes, volcanic paroxysms, and asteroid impacts are rare. When this common pattern is taken into consideration, deep time can be interpreted in an altogether different way. Over long intervals of time, rare cataclysmic events become inevitable and it is these events which are likely to have been responsible for major changes in the geologic record.

As Officer and Page observe in their preface, "the key to the future is the past," and the past is a record of paroxysms and perturbations. In this entertaining book, we are treated to a series of tales of some of the major geological events of historic and prehistoric times. We are led through accounts of some of the greatest volcanic eruptions, earthquakes, and floods, visitations by comets and meteors, Ice Ages and times of mass extinctions of life, and for a finale, given a glimpse of human-induced environmental problems. The material is accessible to the nonscientist, but there is enough here to interest even the specialist. Each chapter has the character of a fascinating illustrated lecture on dramatic geologic events and current environmental problems.

After a litany of major terrestrial disasters and their effects, it is somewhat surprising that the chapter on mass extinctions stresses perceived problems with the hypothesis relating extinctions to impacts of large asteroids or comets. But following the new reading of deep time, a connection between the greatest mass die-offs and the most violent events that can affect the biosphere would be quite reasonable.