BOOK REVIEWS

How to be right?

SCHUMM, S. A. *To interpret the earth: ten ways to be wrong*. 1991. Cambridge University Press. £20.00 hardback, 133 pp. ISBN 0 521 39507 0.

The title of this book is most arresting. Any geologist is aware that decisions, predictions and interpretations that may have to be based on insufficient information can prove to be wrong. Was this book, therefore, to contain accounts of the various estimates of the age of the Earth, such as Lord Kelvin's reasoned, and wrong, estimate of 20-40 million years, and Dr. John Lightfoot's no doubt equally well reasoned, but ludicrous, assertion that the Earth was created at 9.00 a.m. on October 23rd 4004 BC? Perhaps there would be accounts of real "floaters" such as the dinosaur skeleton unearthed near Tehran in 1930 which, after careful excavation and study, was found to be a hay baling machine that had been caught in a land slip.

None of these accounts are, however, to be found in this book. In fact, it is not a geology book at all, but a book about scientific approach with respect to the earth sciences, particularly geomorphology. The author has published widely on subjects as diverse as hillslope evolution, flood plain construction, large channels on Mars and the geomorphic assessment of uranium mill tailings. In the preface Schumm explains that the basis for the book was an invited lecture on "the validity of the use of analogs in geomorphic interpretation", which was expanded into a series of lectures presented to undergraduates and graduates. The purpose of the lectures was to describe a procedure by which students could conduct research and achieve results. This book stresses an approach rather than a method of investigation, and the ten ways to be wrong are ten specific problems faced by the earth sciences researcher, wary and unwary alike.

The book is divided into four sections. The first section, entitled "To Diagnose the Earth" deals with the nature of earth sciences and the difficulties that researchers have in explaining complex systems, applying simple methods to those systems and extrapolating both into the past and far into the future. As a result, geological predictions can often be seen as being not sufficiently specific. This is because it is often impossible to conduct reproducible experiments, or even any experiments at all, on many geological processes. The result is that people who use the information supplied by the earth scientist, such as civil engineers, employ additional safety factors which reflect the difficulty in determining ground conditions.

The second section is entitled "Scientific Method" and outlines the organisation of scientific method from preparation and data collection through hypothesis generation and analysis to final exploration and acceptance. The importance of multiple working hypotheses is discussed with reference to mortality rates in different divisions of a hospital in 19th century Vienna. Not geomorphology perhaps, but the analogy is valid.

The first two sections discuss different basic scientific problems. Section three, entitled "Problems of explanation and extrapolation" discusses ten specific procedural problems associated with using modern conditions as a basis for extrapolation. The ten problems are time, space, location, convergence, divergence, efficiency, multiplicity, singularity, sensitivity and complexity. This classification sounds rather nebulous at first, but each of the problems is discussed in turn with explanatory examples. For instance, the section on convergence explains that channel incision can be caused by at least four different processes, namely base level lowering, climate change, tectonics and land use change. The discussion of each problem returns to the point that the researcher must not have a blinkered approach and that all possibilities must be considered. Although only a small part of a system may be undergoing investigation, the impact and effect on that part by the rest of the system cannot be ignored.

Section four is entitled "Scientific approach and solutions" and emphasises that the earth scientist cannot adopt a single scientific method but must consider a scientific approach. The approach should be systematic and honest, with no bias or fabrication. Error or fraud will be revealed eventually and this self-correction ensures the advancement of science. The section finishes with one "Final example". It is a complicated example that is personal to the author and concerns changing sediment loads in the Colorado River system. Six hypotheses are advanced to account for the changing sediment loads including sampling technique, land use change including stabilising vegetation and erosion, bank and reservoir construction, drought in high sediment production areas, and varying precipitation. A likely cause is that the decrease in sediment load is a natural result of incised channel evolution since about 1880. Each of the potential causes is discussed in turn, and it is apparent that some of them have more effect than others. Channel incision is (currently) regarded as being the most likely cause but the explanation must be a composite one. It can account for the predominant decrease in sediment load, but decreased flood peaks in some years would explain abrupt decreases and would also allow vegetation to colonise the alluvial deposits thereby possibly accentuating the sediment load decrease.

The book is generally well written and is presented rather in the way that lectures are delivered. It is liberally sprinkled with references should the reader require further information. There are many line diagrams and graphs. A few photographs are included to illustrate examples that could not easily be represented by diagrams. In the preface the author explains that the book ". . . should not be considered as a foray into the philosophy of science. It should only be read by young earth scientists and environmental scientists and students and not by philosophers who would undoubtedly be aggravated by its lack of depth".

Some years ago we were told that we were on the verge of another ice age. Now we are told we are under threat of global warming. Some workers say that sulphur emissions are increasing whilst some research in the Antarctic suggests that atmospheric sulphur dioxide has

not increased in the last million years or so. Some astronomers still propound the impact theory as the cause of the extinction of the dinosaurs whilst ignoring the wealth of geological evidence to the contrary. Others brand *Archaeopteryx* a fake despite the evidence of the fossils themselves. Perhaps in his preface, Schumm should also have included inexperienced researchers, "axe grinders", pseudoscientists, "tunnel vision conservationists" and established scientists who dabble in other peoples' fields along with the young scientists and students who could benefit from reading this book and understanding its conclusions. The underlying message of this book is to beware of the single cause effect. Surely this does not apply solely to geomorphology, but to studies in all disciplines including pure science, environment, nature, investigation of "mystic phenomena", UFO's, history, economics . . . the list goes on. Possibly a 20th century problem in research science is that some of the institutions and companies that fund research want quick and, preferably, favourable, results. Perhaps some researchers do not have the time to be, or are discouraged from being, as thorough as they would like, or ought, to be. If this book makes even one researcher stop and think, it will have been well worth writing. For instance, look how this reviewer's preconceived ideas proved to be inaccurate!

Robert E Brown

The fall and rise of Catastrophism

ALBRITTON, C. C. Jr. *Catastrophic episodes in Earth history*. 1989. Chapman and Hall, London and New York. £13.95 paperback, xvii + 221pp. ISBN 0 412 29200 9.

WARD, P. D. *On Methuselah's trail: living fossils and the great extinctions*. 1991. W. H. Freeman and Company, New York. £14.95 hardback, xii + 212pp. ISBN 0 7167 2203 8.

In 1980, Walter and Luis Alvarez and their research team at the University of California, Berkeley, published their now-famous hypothesis relating the end-Cretaceous mass extinction to the catastrophic impact of an extraterrestrial body. Few scientific papers written this century have generated so much controversy. The ensuing excitement has spawned countless research articles and dozens of reviews and books on the nature of major extinction events. Among them are these two recent books that view the history of extinction from the very different perspectives of their two experienced authors.

Claude Albritton has spent much of his career investigating meteorite craters and "cryptoexplosion structures". From this background, he has prepared an admirable review that begins by chronicling the development of catastrophist theories in the 17th, 18th and 19th centuries, culminating in the uniformitatian counter-arguments of Lyell, Agassiz and Darwin. He then moves on to the history of the discovery and interpretation of meteorite impact craters and assesses the effects that explosive impacts would have on organisms living at the time. This leads him into the "new catastrophism" that has become popular in the wake of Alvarez hypothesis, in which the normal course of Earth history is viewed as having been repeatedly, perhaps periodically, punctuated by relatively brief episodes of very rapid environmental change.

A central area of Albritton's discussion is an evaluation of catastrophic theories for the terminal Cretaceous extinction event, and he documents evidence that has accrued for and against the impact scenario during the last decade. The alternative cases made by other scientists for volcanic activity, climatic controls or sea-level changes as the prime motivators of extinction events are also carefully presented, and Albritton notes that there is currently no scientific consensus regarding the cause or causes of mass extinctions. It is clear, however, that the impact-related theories attract more attention in the scientific and popular literature than do the others, and it may be that a "neo-catastrophic" revolution is under way that is set to become a new paradigm for Earth historians in the 21st century. At the moment, though, the debate still rages, and Albritton rightly does not draw any conclusions. His review details all sides of the question in a full and fair manner and finishes by assessing the state of the discussion. As he quotes from Thomson (1988) "Whatever the outcome of the debate, nobody could ever say it was dull". Nor is Albritton's book.

Peter Ward is a palaeontologist, best known for his work on fossil and living *Nautilus*. His chosen route into the extinction furore is through the survivors. The "Methuselahs" of his title are the "living fossils", organisms of great antiquity that still survive today in much the same form that their ancestors adopted hundreds of millions of years ago. The term "living fossil" was coined by Darwin, who was puzzled by their unchanged existence and who recognised that they provided a cogent weapon for his critics. One of the themes of Ward's book is an examination of why these exceptions did not succumb to the common fate of extinction, but his discourse ranges far more widely than this and develops into a personal view of the history of life in general. His selection of fossils is necessarily subjective, but includes favourites such as the brachiopod *Lingula*, the oysters, the horseshoe crabs, the horsetails and magnolias, the ceolacanth and, of course, the nautilus.

Like Albritton, Ward finds no compelling evidence for a single cause for mass extinctions, while noting that "there is no doubt that catastrophe gets a good press". He also discovers no general reason why particular organisms have been successful survivors, finding rather that each living fossil has its own tale to tell. Some may have found refuges, others may have evolved forms uniquely capable of surviving amid the dramatic changes that have beset the earth, while others may have been simply lucky. Whatever the conclusions, the stories are told in a lively, engaging style in a text liberally laced with personal anecdotes. Unfortunately, a few of the comments and verbal scenarios are rather too fanciful and there are several factual errors, but nonetheless the

book provides a very entertaining read.

In summary, these are two books which in their different ways stand apart from much that has been written on the mass extinction problem. For a balanced review of the concepts and evidence from the birth of scientific geology to the current controversy, read Albritton. For one man's view of the fossil record, read Ward. If you are at all captivated by the mysteries of extinction and survival, you will probably enjoy them both.

Reference

Thompson, K. T., 1988. Anatomy of the extinction debate. *American Scientist*, **76**, (Jan.-Feb.), 59-61.

Richard J. Aldridge

The concrete . . .

PRENTICE, J. E. *Geology of construction materials*. 1990. Chapman and Hall, London and New York. £16.50 paperback, xi + 202pp. ISBN 0 412 29740 X.

Just take a look around yourself. The majority of what you see, the building you're sitting in, the glass in the window, the paint on the wall, even the paper this is printed on, have been produced from, or using industrial rocks and minerals. One part of this field in geology is the world of construction materials. Our dependence on such materials started very early in the history of mankind. Ever since the caveman decided that caves were no longer desirable residences, man has required structures to shelter from the elements.

This book covers the field of construction materials, a discipline in which the geologist plays a major role. As a geologist myself working in this area, I consider that such a book is long overdue. The level at which this book is aimed allows it to be used by professional, student and amateur geologists alike. For the professional and student it offers a broad, but quite detailed overview, enabling readers to move on to more specific texts should they wish. For the amateur this book explains the rock types utilised in this field of applied geology, something that is not usually catered for. In general, if you have any interest in construction materials this book is well worth a read.

The contents are broken down into seven chapters, each, bar the introduction, concentrating on end usage of particular rock types.

Chapter 1. Introduction. A general introduction, covering the history, investigation and quarrying methods of raw materials, and their management.
Chapter 2. Construction Stone. This covers the usage of rocks that require little in the way of processing, such as cut stone, slate, large blocks of hard rock used as sea defences, and fill material.
Chapter 3. Coarse Aggregate. This chapter introduces the usage of processed rocks, in this case the use of crushed rock and coarse sedimentary deposits (gravels).
Chapter 4. Fine Aggregate. This concentrates mainly on sands, including uses, testing, mineralogy, sources, and grain characteristics.
Chapter 5. Structural Clay Products. Moving up the scale of processing, this chapter covers the usage of different types of clays. Concentrating only on the constructional aspects of the clay products market it covers bricks, tiles, pipes and expanded clay products.
Chapter 6. Cement and Concrete. This short chapter just whets the appetite for this field. It concentrates on the production of the cement, a complex procedure using large amounts of raw materials. The second half of the chapter introduces concrete, bringing in one of the uses of the coarse and fine aggregates mentioned in chapters 3 and 4.
Chapter 7. Minor Construction Materials. To round the book off this chapter provides a brief introduction to the production and use of glass, gypsum, insulators and lightweight aggregates, the materials used as the finishing touches of a building.

The chapters consist of quite concise, but detailed descriptions of the rock types in question, the requirements, testing and specifications of the material, and the role that the geologist plays in the overall production of the resource. Where appropriate, real life examples are used to explain aspects of utilisation. The book contains a large number of complementary figures, varying from fairly simple to quite complex in nature. In general these are well explained, though to the layman some may seem a little daunting.

The book is one which I would recommend to students, ranging from A level up to degree level. It is well written, easy to read, something not always found in text books. My only regret is that the price may put people off. As a student once myself I understand the vast cost of scientific literature. £2 or £3 less would be nearer the mark.

Andrew S. Smith

. . . and the clay

MARTILL, D. M. and HUDSON, J. D. (eds.). *Fossils of the Oxford Clay*. 1991. The Palaeontological Association, London. £15.00 paperback, 286pp. ISBN 0 901702 46 3.

This is the fourth in a series of field guides to fossils promoted by the Palaeontological Association. It is the first description of the entire fauna of the Oxford Clay to appear under one cover. Formerly one had to search innumerable papers, monographs, journals and reports in order to find the required information. Here this has been done for you, and in masterly fashion.

The introduction sets the Oxford Clay in the context of geological time and palaeogeography. Depositional facies and palaeoecology are also discussed.

The first seven chapters deal with the invertebrate fauna. Keith Duff has described the rich and diverse bivalve fauna and Neville Hollingworth the gastropods. There is a comprehensive account of the ammonite fauna by Kevin Page, who has also co-operated with Peter Doyle on the belemnites. The rather scanty brachiopod fauna is described by Colin Prosser, and

the remaining groups — crustaceans, worms, echinoderms and microfossils — are dealt with in a single chapter by Dave Martill.

The vertebrate fauna of fish, marine and terrestrial reptiles, is covered in the final four chapters by Dave Martill. These exciting creatures fire the imagination and often attract more attention than the invertebrates. This book presents all the animal groups with equal emphasis. The text is illustrated throughout with superb photography and some excellent line drawings by John Martin.

There are appendices giving a complete faunal list of the Oxford Clay, a list of localities where the clay is exposed, and a list of the main collections of Oxford Clay fossils. The book is thoroughly indexed and there is an extensive bibliography for anyone wishing to delve deeper into any area.

This guide fills a long-standing need for a summary of the faunal diversity of the Oxford Clay. It is a must for anyone interested in the palaeontology of the period, and it should go on every visit to an Oxford Clay exposure.

Alan Dawn

Plate tectonics by numbers

GUBBINS, D. *Seismology and plate tectonics*. 1990. Cambridge University Press. £35.00 hardback, vii + 339pp. ISBN 0 521 37141 4. £13.95 paperback. ISBN 0 521 37995 4.

In the preface Professor Gubbins states how this book grew from a course given to final year physicists at Cambridge University. Inevitably there are dangers in producing a textbook from a successful lecture course. It's rather like the peculiar concept of writing the book of the film; the film may receive rapturous applause but somehow doesn't transfer to paper and ink . . . perhaps it has something to do with the lighting. One can only assume the course was exciting.

For starters the title itself is rather misleading. The vast majority of the book deals with the physics and mathematics of seismology, and then, briefly at the beginning and end the reader is introduced to plate tectonics. The book appears nicely produced — it feels and looks good, yet on closer inspection it yields secrets which really hint at too much haste in the preparatory stages. Apart from inaccuracies, the reproduction quality of many of the seismograms which form the central theme of this volume is often poor.

The book is intended as an introductory text for physicists, mathematicians and geologists. The early chapters outline the principles of elastic wave theory, whilst the middle section considers the interpretation of seismograms, before ending with a final chapter on plate tectonics. The use of mathematics throughout the text directs the book away from the traditional Earth Scientist and towards those wishing to enter the field from one of the other numerate sciences. Yet given this it is still difficult, for example, to appreciate the importance of a phase change from an olivine structure to a spinel structure when discussing the seismic structure of the Earth, without some discussion of mineralogy and crystallography. At one point, the Deep Sea Drilling Project is referred to as a project to drill a large number of shallow sediment holes into the ocean floor with a few into basement. Admittedly all holes drilled into the Earth are shallow when compared with the depths to which seismologists look, but this statement rather overlooks and devalues the exciting science which has issued from both this and the later Ocean Drilling Program, particularly with respect to plate tectonics. It is unfortunate that the book does not have the space for more geological input to back up the extensive introduction to seismology. Plate tectonics, and indeed seismology conjure up exciting images of a dynamic, mobile Earth. They are the very stuff whic have attracted countless students to the Earth Sciences, and are the subjects (other than dinosaurs and their relatives) which attract public attention through picture magazines and the news media. This book, however, somehow doesn't encompass that excitement.

As an introductory text to seismology for physicists and mathematicians the book is a useful course text, accompanying a structured lecture and practical schedule, though students will have to keep their wits about them. For the Earth Scientist the level of mathematics combined with the lack of detailed geological input is unfortunate. The interested amateur, meanwhile, will find little of interest which cannot be gained elsewhere in a more accessible format.

Mike Lovell

Window on the Jurassic world

BARTHEL, K. W., SWINBURNE, N. H. M. and CONWAY MORRIS, S. *Solnhofen: a study in Mesozoic palaeontology*. 1990. Cambridge University Press. £35.00 hardback, ix + 236pp. ISBN 0 521 33344 X.

Wouldn't it be nice, for palaeontologists at least, if there was a rock formation which contained beautifully preserved and rare kinds of fossils, some with their soft tissue impressions; a rock that split easily along perfectly even bedding planes to reveal them. Such a rock formation would have to have been formed under quite exceptional conditions, conditions which might occur only rarely. Fortunately, such rock formations exist. One such formation is the Solnhofen Limestone of Bavaria.

The Solnhofen Limestone is a fine, even-bedded micritic limestone that was deposited in saline lagoons and hollows between coral and sponge/algal reefs during the late Jurassic on the northern continental shelf of the Tethyan Ocean. Fossils are not especially common, but when they do occur, they are often in an excellent state of preservation, and frequently display features of soft tissue anatomy that are not normally found in the fossil record. This fact alone makes the formation of great significance in evolutionary studies. The faunal list is also exceedingly long, and the diversity of

organisms recovered from the numerous quarries in the limestone includes such delights as the earliest bird, one of the world's smallest dinosaurs, coelacanth fishes, and a host of Jurassic seafood, including jellyfish which have no mineralised tissue whatsoever.

One might have imagined that such an important fossil-bearing deposit would have had many books written about it. However, it was only in 1977 that Barthel published in German *Solnhofen: Ein Blick in die Erdgeschichte*. This book provided German speakers with the first general account of the flora, fauna, the palaeoecology and some of the history, scientific and economic, of one of the world's most famous fossil deposits.

English speaking folk have had to wait until now for an opportunity to read between one pair of covers all about this fascinating rock formation. The English version of Barthel's book is not simply a translation, it is also a valuable update, which takes account of a considerable quantity of work that has been devoted to the deposit since its original publication. In this sense the wait was worth it, and Swinburne and Conway Morris (the translator and editor respectively) have done the palaeontological world a great service (sadly Barthel died only one year after the original version was published). Unfortunately, the publishers have not done quite the same good service; at £35 the book will be out of reach of much of its potential audience.

The translation begins with a preface, explaining the historical context of the present edition. The authors have tried to preserve the spirit of the original book, intended for a very general, but motivated audience, but claim that the translation is intended for a more advanced readership. This claim is true for some chapters, but does not follow for others. For example the section on reptiles in chapter seven is extremely basic, whereas in chapter two we are taught how to calculate delta O^{18} values to assess the amount of meteoric water flushed through the system during diagenesis. I would have preferred to have seen all of the chapters brought up to a similar level.

There are seven chapters, each divided into a number of sub-headings. The opening chapter presents a fascinating introduction to the Solnhofen Limestone, and to its exploitation both for fossils and as a building material. The stone was formerly used for making printing plates, hence the name lithographic limestone that is sometimes used for these limestones. These days it is used as roofing slates and for floor tiles, but apparently only a small fraction of the stone quarried is suitable for these purposes. The good thing about its commercial exploitation however, is that there is always a fresh supply of new fossils.

Chapter two places the limestone in its structural, temporal and geographical setting. It is well illustrated with maps and sections, and takes the reader through the evolution of the basin step by step. In chapter three there follows a much closer look at the rock itself, with discussions on the fine structure, the distribution of fossils (they are not common) and on its geochemistry. Chapter four examines the various models put forward to explain how such a rock might have been deposited. The most important feature of the rock is the fine, regular bedding. Several explanations are offered to explain how this might have come about. All require some means for excluding burrowing animals, thus preventing the churning of the sediment. Possible conditions such as high salinity and oxygen depletion are discussed in some detail. In the end it appears that a combination of a number of equally important processes have lead to the formation of this unusual deposit. Chapter five is concerned with palaeoecology. Under this heading the Jurassic palaeoclimate is discussed, although this is also an important part of the sedimentation environment and could equally have been covered in chapter four. Other sections here discuss the life of the lagoon, and of the surrounding reefs and seas, and of nearby landmasses. Apparently, there was little indigenous macroscopic life in the lagoon where the limestones were deposited, but the nearby reefs were teeming with all manner of invertebrates and fish. The only organisms inhabiting the lagoon were surface living animals such as certain fish, but even these suffered from the occasional mass mortality.

Chapter six is on taphonomy (*taphos* Greek = the tomb), the initial processes of fossilization, an altogether absorbing read for those with a sense of the macabre. Here we are treated to sketches of rotting squids, and to photographs of fish which have left traces of their final death throes in the soft mud.

Chapter seven is by far the largest. It is essentially a pictorial atlas of the plant and animal fossils that have been discovered. Just about all the major phyla have been found, as well as several minor groups. The majority of the photographs are of high quality, although one or two lack contrast. Solnhofen fossils look good in colour, a point that the original German version took into account, but which is sadly missed here (for £35 I would have liked at least a few colour plates).

Some fossil groups are discussed but not figured, whereas others are illustrated by several specimens. The world's most famous fossil, *Archaeopteryx*, half bird, half dinosaur, is illustrated by the Eichstatt, Berlin and Solnhofen museum specimens, as well as by a single feather. For such an important species I would also have been inclined to include the London and Tyler museum specimens so that all specimens were easily available for student exercises. An ichthyosaur is figured, but sadly not one of the specimens showing the deeply forked tail. Such a picture would have highlighted how soft tissue outlines lacking skeletal support are also found in this deposit.

An appendix lists all the genera recorded to date, and the bibliography is extensive. All in all, this is an excellent little book. It is a must for all those interested in Mesozic palaeontology. It should prove to be a useful text for students of palaeoecology, as well as to general palaeontologists, not just because of the beautiful fossils, but for its easily readable style. The book will also prove useful to carbonate sedimentologists as a most interesting introduction to a rare and unusual rock type. I heartily recommend it, but I am disappointed that it is so expensive.

David M. Martill