

## REVIEWS

BENTON, M. J. 1997. *Vertebrate Palaeontology*, 2nd ed. xii + 452 pp. London: Chapman & Hall (Thompson Science). Price £24.99 (paperback). ISBN 0 412 73810 4.

Cataloguing the history of vertebrate life is an increasingly difficult task: the number of fossil discoveries increases inexorably, and the interpretation of them expands continually. Al Romer and his various books (notably *The Vertebrate Body* and *Vertebrate Paleontology* was the 'rock' upon which previous generations of vertebrate palaeontologists had stood, and this mantle had been in part inherited by Bob Carroll who provided a new and enlarged edition of Romer's classic *Vertebrate Paleontology* in 1988. Since then the remarkably productive Benton has published an earlier book (1990) with the anglicized spelling of Romer's classic and now this 2nd edition, which is inevitably larger in format and longer, as an update of his earlier effort.

The book is clearly filling a gap. Carroll's book is very large, and hideously expensive, and is only realistically library fodder. Benton's 1990 book was small in format, and very much represented a condensed and slightly updated version of Carroll, at a more affordable price as far as the student was concerned. This second edition is obviously intended to update the subject in the light of progress in the field in recent years, and does so quite effectively. This edition is enlivened by the addition of some of John Sibbick's excellent artwork as restorations of fossil vertebrates.

The format of the book is very similar to that established in the first edition, running more or less in sequence through the major vertebrate groups in form and time, though with some rather odd sequences in places – notably the fossil fish which are separated into chapters that deal with 'early fishes' in chapter 3, but do not consider post-Devonian fish until chapter 7, in between which we are treated to considerations of the origin of tetrapods, amniote evolution and the reptiles of the Triassic. I should perhaps add that a brief comparison with Philippe Janvier's book *Early Vertebrates* (OUP, 1996, reviewed in *Geological Magazine*, vol. 135, 1998, March issue) shows just how superficial the coverage of the fish in Benton really is. Odd though the format may be, each chapter is well organized, and pretty much self-contained, so I will not complain unnecessarily about this; as I said at the outset the field is overloaded with information, and trying to break it into manageable blocks in no easy task.

Each chapter is also supplemented by shorter boxed-in sections of information, in the style of *Nature* 'news and views' reports (a little condensed snippet, chosen for its intrinsic interest). This is where Benton excels: he is good at compiling and summarizing information in a relatively digestible form. In short this book is a very dense, information-packed volume, covering most of the groups in adequate detail, and discussing many interesting and relevant themes of palaeobiological investigation. The structure of each chapter tends to depend upon the cladistic framework that is erected for each of the groups involved and these, unlike the earlier edition, are supported by a suite of node-based characters, which gives a robust and objective setting for the pattern that is portrayed. The narrative style is, I have to say, rather disjointed by the format that has been adopted by the author/editor, and the book does not have the inter-

pretative flow of early volumes such as those by Romer referred to above.

In summary I would say that *Vertebrate Palaeontology* is very much as thorough a compilation of vertebrate facts and figures as anyone could hope or wish for. The information is there, well packaged and the reference section provides more than adequate opportunities for students to supplement the general narrative. As a textbook to support courses in vertebrate palaeontology at undergraduate level it is actually the only one that is both comprehensive and moderately up-to-date and available, so it is the default choice. Mike Benton is to be congratulated on this edition, it is needed, and a great improvement on his first edition. So why am I being a little restrained, rather than overflowing with enthusiasm and praise? The root of this lies in his own observation in the preface, where he ponders with some alarm how quickly this book is likely to become out-dated given the rate at which the subject matter is progressing of late. I believe that in this admission lies the root of its weakness, for me, as a textbook: it simply lacks a sustaining vision or theme – it is just one long compilation of other people's views and work. Therefore the content does (or rather, will) become rapidly outdated.

David Norman

DE WIT, M. & ASHWAL, L. D. 1997. *Greenstone Belts*. Oxford Monographs on Geology and Geophysics No. 35. xxvii + 809 pp. Oxford: Clarendon Press. Price £150.00 (hard covers). ISBN 0 19 854056 6.

Greenstone belts have been defined as 'belt-like areas within Precambrian shields that are characterized by abundant greenstone'. This uninspiring definition belies the importance of greenstone belts, an observation which should also be apparent to any casual observer from the sheer size of this volume. The fact that greenstone belts are both ancient and preserve rocks at a low metamorphic grade means that they contain unique information about the early Earth. Their study is a multidisciplinary task and Maarten De Wit and Lew Ashwal are to be congratulated on bringing together such a comprehensive set of reviews which cover the full range of disciplines necessary to a full understanding of greenstone belts.

Notwithstanding the title, this book is about much more than greenstone belts, for since most greenstone belts formed in the Archaean much of this volume is devoted to a discussion of the rocks which formed and the processes which operated in the early part of Earth history. This book is set therefore to become a major reference work, a source of both data and ideas, on the early history of our planet.

The book is divided into two parts. Part 1 (450 pages) describes the geology of greenstone belts and their surroundings and is a series of invited contributions by prominent scholars. The focus is on recent research, post-1980. This part deals with the essential components of greenstone belts, the external influences on their development and the relationships between greenstone belts and their surrounding rocks. There are comprehensive reviews of the sedimentology, volcanology and geochemistry, structural and

metallogenic aspects of greenstone belt geology. There is a weaker contribution on the metamorphic geology of greenstone belts – reflecting a facet of greenstone belt geology which has received less attention in recent years. There are very useful summaries on the topics of heat flow in the Archaean, mafic and ultramafic magmatism, Archaean fluids and strain in greenstone belts and three different contributions to the subject of Archaean TTG magmatism. The final section of this first part of the book reviews the deep structure of greenstone belts as illuminated by geophysics, the relationship between greenstone belts and their surrounding granitoids, and the tectonic relationships between greenstone belts and their possible granulite-grade equivalents. Two detailed field-based studies from the Yilgarn Craton and Barberton are also included to underline the editors' conviction that critical field areas need to be periodically re-examined in the light of new ideas.

Part 2 (350 pages) reviews the geology of specific cratons. These contributions are written by geoscientists directly involved in the local geology. Each section contains a tabulated compilation of data on the craton reviewed and on the greenstone belts present. These compilations are made to a standard format permitting helpful comparisons between regions. Twenty different contributions review the Archaean greenstone belts of North and South America, Africa, Australia, India, China, Eastern and Western Europe. Six further reviews describe selected examples of Proterozoic greenstone belts and of the Phanerozoic analogues of greenstone belts. The locations of all these areas are summarized on Gondwana and Laurasia maps as the front- and end-papers of the volume. These regional descriptions are very variable both in length and in quality, although the differences chiefly reflect the extent to which the detailed geology is known and understood in the Precambrian cratons described.

This is a monumental book. The volume is well produced and sufficiently sturdy for its size. It contains contributions from almost 100 authors packed into 800 pages of double column text. Contributions to this volume were sought in 1991, the preface written in 1995 but the work not published until early 1997. Sadly this means that this book is not a source for the most up-to-date literature for there are few references post-1994. If it has a bias, it is in the first part and is towards a southern African understanding of greenstone belts, but that is understandable given the location and interests of the editors and also the importance of the Barberton greenstone belt in influencing views on greenstone belt evolution. I have two other criticisms, the first minor, the other less so. Firstly, the mismatch between the text and figures in section 4.1, where colour figures are reproduced in black-and-white which detracts from this chapter. More seriously, the price of this book is a problem. At £150 this places a very important reference work out of the reach of most. It is a must for earth science libraries but it ought to have a place on the shelves of all who work on either the Archaean or on greenstone belts of any age.

Hugh Rollinson

BRETT, C. E. & BAIRD, G. C. (eds) 1997. *Paleontological Events. Stratigraphic, Ecological, and Evolutionary Implications*. xvii + 604 pp. New York: Columbia University Press. Price US \$75.00, £52.00 (hard covers). ISBN 0 231 08250 9.

Ever since the word 'punctuation' was hijacked by those with a nefarious ideological agenda, in making any reference to sudden events in Earth history it has been difficult to avoid

at least oblique reference to the term and thereby conferring upon it a spurious legitimacy. But it was ever the way. So we should be grateful for the appearance of this book because, despite its somewhat prosaic nature, it reviews the evidence for events as discerned in the palaeontological record in terms of exceptional fossil accumulation and intervals of turnover (including epiboles). Each half of the book is introduced by a general review chapter, respectively on fossil Lagerstätten (by Brett, Baird & Speyer) and various bio-events (by Brett & Baird). In between are eighteen other chapters, spanning the geological record but with a firm emphasis on the Palaeozoic. Some of the chapters are of little more than local interest, but others contain points of general relevance. For example Rollins & West (2) discuss the perennial topic of spatial and temporal averaging that surely serve to separate the original communities from the shell-hash available to the palaeontologist. They conclude that all sorts of taphonomic overprint serve to confuse the picture. In the next chapter Miller (3) provides a very detailed investigation of local abundances of Cincinnatian faunas, providing an effective snapshot of the Ordovician seafloor and so allowing a glimpse of the interface where  $\alpha$  and  $\beta$  diversities meet. In a related theme Holland's contribution (12) offers a detailed analysis of on-shore–off-shore distributions, a topic that has received extensive attention. In brief, he finds, albeit with a limited sample, that at the level of genera in brachiopods the overall trend during time towards off-shore habitation as seen at the taxonomic level of family may be confounded. Thus the two genera of Sowerbyellinae moved onshore, *Retrorsirostra* moved in classical fashion off-shore, while *Rhynchotrema* oscillated backwards and forwards. Quite a number of chapters take as their theme the exceptional accumulation of fossils including occurrences of trilobites (Schumacher & Shake (6) and Hickerson (9)) and crinoids (Brett & Taylor (8)). Another useful contribution is by LoDuca & Brett (14) who review the hitherto neglected Lagerstätten of Silurian age in eastern North America, including the 'Gasport Channel'. Together these faunas give us one of our best insights into Silurian marine life that is currently available. A non-uniformitarian theme is tackled by Ausich (19) in his interesting review of encrinites, that is sediments largely composed of crinoidal debris. These accumulations point to vast populations, whose remains controlled lithofacies over substantial areas. Prominent until the Jurassic, they then disappeared for ever. And so it goes with much of this book: nuggets of information that have a bearing on wider issues. For this reason, despite its apparently parochial nature, this book deserves its place in any library with pretensions to completeness.

Simon Conway Morris

HUGGETT, R. J. 1997. *Environmental Change. The Evolving Ecosphere*. xx + 387 pp. London, New York: Routledge. Price £16.99 (paperback). ISBN 0 415 14521 X.

The preparation and publication of any textbook is a personal commitment which demands an immense amount of time. Few people seem to appreciate the effort required, and eventually even the authors themselves forget the pain; yet in a few cutting lines this work is frequently dismissed in book reviews. From my experience of writing three textbooks, I understand the extremes of pain and pleasure that book reviews can cause. At a time when the space for book reviews within many journals is being squeezed, or even lost, it is a sad fact that many reviewers seem more interested in scoring

academic points than in providing a public service. I believe that the true function of a book review is not to score petty points, but to inform people of the contents of a book, of its place within the portfolio of literature on a given subject, and where criticism is to be made then it should be in the light of the aim and audience of a book and not some personal agenda.

It is in this context that I wish to draw the reader's attention to the volume *Environmental Change: The Evolving Ecosphere* by Richard Huggett. This is an impressive and easily accessible volume which integrates a wide range of material and which crosses the traditional subject divides of geology and geography, which hinders all those interested in an holistic understanding of Earth history and the processes which shape it. This novel book provides a process history of the Earth as opposed to a record of events within it, and as such provides an essential complement to more traditional volumes on Earth history and stratigraphy.

The book is organized into nine chapters, each of which has its focus on one aspect or area of Earth evolution. After an initial introduction, setting out the scope, approach, and nature of environmental change the book then deals with the following 'spheres' of interest: 'Cosmosphere', 'Lithosphere and Barysphere', 'Atmosphere', 'Hydrosphere', 'Pedosphere', 'Toposphere', and 'Biosphere and Ecosphere'. In each chapter the dynamic nature of the environment as well as the causes and mechanisms of change are well reviewed with a pleasing emphasis on modern developments and ideas. This builds into a comprehensive understanding of all aspects of the Earth system and is complemented by a final chapter which attempts to identify the common threads and mechanisms within each 'sphere', emphasizing the importance of an evolutionary approach.

As a whole the book works well, is novel in its approach, and is well written. My understanding of the Earth's system was enhanced by reading it and students have much to gain from this volume. In reading the book, however, subject specialists may be concerned about the choice of coverage in certain chapters. For example, as a process geomorphologist I feel that Chapter 7, 'Toposphere', undersells the role of geomorphology, in particular its link with sedimentary processes. However, the book does not aim to provide comprehensive subject reviews, but to simply illustrate *some* of the dynamic and changing aspects of the Earth's surface and in this context the coverage is fine. Specialists may also find some of the definitions and juxtaposition of material challenging. This is particularly true in Chapter 6, 'Pedosphere', which contains material not only on more conventional soil formation but also on sequence stratigraphy. The benefit of this, however, is in breaking down traditional subject divides which we place on material and ultimately hinders the development of an integrative or holistic view of Earth processes. Finally, I have some reservations about the 'trendy' subtitles within many of the chapters, for example 'Watery beginnings', 'A directional world', 'Violent times' and 'Stretch, wobble, roll, and pitch'. These may have an adverse affect on students finding subject specific material quickly; when taken out of the context of the relevant chapter, as above, it is difficult to guess that these subtitles refer to the origins of life, tectonic evolution, extraterrestrial impacts, or Milankovitch cycles respectively.

At the start of this review I suggested that a book review should inform people of the book's contents, its place within the literature, and make any criticisms in the light of the intended aim and audience for the book. To summarize, therefore, the volume *Environmental Change: The Evolving*

*Ecosphere* provides a process history of the Earth and its changing environment. It represents a positive step in the right direction, encouraging a more integrative and cross-disciplinary approach to Earth science, something which is long overdue. It is essential reading for all those undertaking a traditional Earth history or stratigraphy course, as well as providing a foundation for more general courses on earth processes as part of geography and environmental science degrees. It addresses its aims and intended audience well and I am confident that it will be a success with students.

Matthew R. Bennett

GREEN, P. M., KENYON, J. R. & BREWARD, N. 1997. *Discovering Geology: The Lake District*. CD-ROM. Keyworth: Earthwise Publications (British Geological Survey). Price £39.95. PC and Mac compatible.

This production represents one of the first ventures by the British Geological Survey (BGS) into publishing information on CD-ROMs. This medium seems a natural choice for some geological applications, particularly for coloured geological maps, which can be expensive and unwieldy to reproduce in hard copy. So the BGS initiative is very welcome even if, as we shall see, it proves to be not entirely satisfactory.

The CD-ROM arrives with just enough launch instructions for the average user, and with a hard copy of a navigation map through the contents. The major options available from the home menu are Geochemistry, Geophysics, Geology, Landsat images, Photos, References, and Help & Information. There are Introduction and Exit sequences, which can be partially skipped. Most users will probably start with the Geology section, which offers a geological column, geological maps at several levels of detail, and map of mines and minerals. This mining map provides active links to data on each mine. An outline of geological contacts, the fault network, and an array of geographical landmarks can be optionally overlain on most of the maps in the Geology and other sections. Most images can also be supplemented by explanatory text.

The Geophysics section contains gravity and aeromagnetic maps. The Geochemistry section has stream sediment maps for 31 individual elements and for six 3-component combinations, and stream water maps for uranium, fluoride, conductivity, acidity and bicarbonate. By comparison with these and the Geology maps, the Landsat images are more interactive. The user can zoom in on the main image and pan continuously across it, or can select an even higher magnification of six areas of particular interest. These detailed images can be toggled through two choices of orientation. The Photos section offers mostly field and hand-specimen photographs grouped into subsections of minerals, rocks, fossils and scenery, and a further subsection of palaeoenvironmental reconstructions.

Having some prior knowledge of Lake District geology, I much enjoyed browsing through the material on offer here. The geophysical, geochemical and Landsat images are valuable research reference tools, convenient to have packaged together on one disk. However, this CD-ROM is targeted at a much wider audience of school and university students, environmental scientists, planners, and the informed public. I doubt whether it will suit them all. In particular, in common with many educational CD-ROMs, there are no obvious linear routes through the material, which seems organized more for reference than learning. Of course, I realise that some users will be less conditioned than I am by



half a lifetime of reading books, and will be more attuned to the random access structures of CD-ROMs. However, it is undoubtedly true that some routes through educational material are more logical and profitable than others, simply because one area of information is a prerequisite to the understanding of another. The best educational CD-ROMs will be those that signpost the most efficient learning routes for each type of user.

Other reservations about this CD-ROM result as much from the constraints of the medium in general rather than this example in particular. For instance, it is frustrating that there is not enough room on the screen for explanatory text to be placed alongside the map that it describes. As it is the text overprints each map, usually obscuring the features to which it refers. It would help if the text window could be moved and resized, but perhaps this is not possible? Resizing could also avoid the tedious need to scroll through text boxes only a few lines deep. Screen size also prevents displaying two maps side-by-side, and comparison would be easier with the option of a National Grid overlay on each map. The enlarged Landsat images would particularly benefit from this addition, because at present it is not possible to overlay any other locational information on them.

In summary, the compilers of this disk have done an excellent job in blending together BGS material from other formats into a coherent and attractive package. However, the balance of this material is imperfect – why include over thirty esoteric histograms of element abundances but not one simple geological cross-section – and future compilations need to be better planned with specific end-users in mind. However, both users and authors of geological CD-ROMs are in an experimental phase at present and, with constructive feedback, the medium will undoubtedly find its proper role in the information age. BGS have now put down a promising marker in this emerging market, and look well set to develop their CD-ROM skills in the future.

Nigel Woodcock

ZIEGLER, K. TURNER, P. & DAINES, S. R. (eds) 1997. *Petroleum Geology of the Southern North Sea: Future Potential*. Geological Society Special Publication no. 123. v + 209 pp. London, Bath: Geological Society of London. Price £59.00, US \$99.00 (members' price £29.00, US \$48.00); hard covers. ISBN 1 897799 82 9.

To create a hydrocarbon prospect it is necessary first to image a closure and then to argue an acceptable risk for access to charge, viability of reservoir and integrity of seal. This book regrettably ignores such a process. Instead it deals almost exclusively with the distribution of Permian and Carboniferous reservoirs with a little qualitative data and some hypotheses on control of their quality. There is nothing on charge or top seal, nor on pertinent developments in geophysical imaging. Post-Permian hydrocarbon systems are not discussed.

The scene is set by a useful historical review of exploration activity (Glennie) ending with many ideas for future prospectivity which, tantalizingly, are not followed up in later chapters. The next chapter, on recent advances in understanding (also by Glennie), is something of a misnomer; rather than a comprehensive overview it deals mainly with the implications for North Sea structural development of the recently revised Permian stratigraphy of Germany: the impact on prospectivity is less clear.

For me, the meat of the book is provided in two excellent

papers on Rotliegend facies, palaeogeography and chronostratigraphic subdivision by correlation of wet/dry cycles. The first (George & Berry) covers the entire offshore area to the Dutch coast. It is based on examination of 10.7 km of core and 258 wells and gives due recognition to tectono-sedimentary processes. Five major chronostratigraphic divisions are recognized and are well illustrated in detailed palaeogeographic maps. The second (Howell & Mountney) covers only UK waters. It uses 243 wells, many with core, and gives detailed discussion of erg, alluvial fan and lake processes during climatic variation. Twelve climatically-driven cycles (i.e. chronostratigraphic divisions) are recognized and illustrated with five palaeogeographic maps: it is a pity that comparison with the divisions of George & Berry is not more explicit.

Two studies of the Jupiter Fields (Leveille *et al.*) deal with compartmentalization by sealing faults and diagenetic controls on poroperm. Such studies, when expanded to deal with timing of fault seal and impact of early diagenesis in addition to pore occlusion by illite in deep burial, will be useful in developing new plays, e.g. within major flanks. Pre-Permian source rock and reservoir potential (Cameron & Ziegler) is nicely illustrated by (2D) regional seismic in the context of very sparse well control and new ideas are given for both Dinantian and Namurian plays. Westphalian structure (Quirk) and sequence stratigraphy (Quirk & Aitken) also benefit from seismic illustration. The authors argue for a layer-cake stratigraphy, faulted before development of the Saalian unconformity, composed of both reservoir-prone and waste-rock (not seal) prone packages. Modelling of sandstone connectivity is then illustrated for the Schooner field (Mijnssen). The volume concludes with examples of correlation by high frequency Milankovich-based cycles (Yang & Baumfalk), a possibly useful tool in faunally barren sequences without too many faults.

The book is nicely produced but slim for money, particularly at full price. Active explorationists in the area should know much of its contents; for the general sedimentary geologist the book is probably more for selective perusal than for ownership.

David James

WADHAMS, P., DOWDESWELL, J. A. & SCHOFIELD, A. N. (eds) 1996. *The Arctic and Environmental Change*. xi + 193 pp. First published in *Philosophical Transactions of the Royal Society, Series A*, **352**, 197–385. Gordon & Breach. Price not stated (hard covers). ISBN 90 5699 020 9.

This book records current research interests in Arctic climatological and environmental studies, with an emphasis on the physical environment. It is a collection of papers prepared for the Royal Society Discussion Meeting on the Arctic and Environmental Change, held 12–13 October 1994. The book is a reprint of *The Philosophical Transactions of the Royal Society, Series A*, Volume 353, Number 1699, 1995, pp. 197–385.

The 14 chapters discuss modelling climate change; atmospheric circulation and moisture flux; the relationship between fluid dynamics and ozone loss at mid-latitudes and the polar vortex; solar irradiation, air pollution and temperature changes; terrestrial changes in the ecosystem; climatic and biological changes in the Arctic Ocean; thermohaline circulation and ice development in the Arctic Ocean and Greenland Sea; sea ice; how glaciers are affected by environmental changes; measuring the Greenland ice sheet by satellite radar altimetry; geotechnical implications of permafrost

and climatic changes in ice cores in Greenland; and the glaciation history of the Cenozoic Polar Atlantic System.

Each chapter stands on its own with little overlap in content between them, yet they hang together nicely as a compendium under the title. The presentation of an index in this reprinted version is perhaps an attempt to aid the user in finding a common thread between chapters. This attempt is only partially satisfactory, however. For example, both the Greenland Sea and Norwegian Sea are index terms. Yet the chapter by Thiede & Myhre which discusses the Norwegian–Greenland Sea (presented in the text as Norwegian Greenland Sea) is only indexed under Greenland Sea. Information on Greenland Sea drilling is given a greater number of page entries in the index than the word drilling on its own.

Although the Discussion Group was held in 1994, two years before this reprinted edition, the editors have carefully and thoughtfully presented updated information in their preface citing 11 new references. In this way the information lag between original presentation and publication is lessened. The practice of the Royal Society to include some of the discussion that followed the presentation is invaluable in that it allows the non-participant to gain an insight into the clarity and breadth that comes from post-presentation participation.

The final production of the book should have been more carefully executed. There are sudden appearances of bold typeface, and typing errors in both the text (three in the Discussion on page 58 alone) and in the index, and its a pity that the photographs on pages 68 and 69 could not be reproduced in colour.

For those Arctic and environmental researchers and libraries that do not subscribe to the *Philosophical Transactions of the Royal Society, Series A* this book is worth owning. It is informative and scholarly with chapters by some of the foremost researchers in the field.

Eda L. Lesk

CARROLL, R. L. 1997. *Patterns and Processes of Vertebrate Evolution*. Cambridge Paleobiology Series Volume 2. xvi + 448 pp. Cambridge, New York, Port Chester, Melbourne, Sydney: Cambridge University Press. Price £70.00, US \$85.00 (hard covers); £24.95, US \$39.95 (paperback). ISBN 0 521 47232 6; 0 521 47809 X (pb).

Bob Carroll, who has done much to improve our understanding of early tetrapod evolution, was a student of the *eminences grises* of the field of vertebrate palaeontology, and as he happily records shared his time as a student at Harvard with, amongst others, Mayr, Simpson, Romer, Whittington and E.O. Wilson – lucky man! He also stepped into a pair of very large shoes in authoring the new edition of Al Romer's *Vertebrate Paleontology*, which came out in 1988. This latter represents a monumental task of synthesis and compilation, but sadly constitutes a largely unattainable object of desire for the majority of undergraduates who wish to enjoy poring over its contents, so expensive is it.

*Patterns and Processes* represents a completely different approach to the subject, one which is closer to the heart of G. G. Simpson's more synthetic works by emphasizing the true interdisciplinary nature of palaeobiological research, ranging across such fields as genetics, developmental biology, population dynamics, ecology, functional morphology, and (of course) the fossil record. It also resonates with the pattern and process approach which has been at the heart of the writings of Stephen Jay Gould, Niles Eldredge, and others over

the past twenty years. The influence of these workers resulted in an upsurge of interest in palaeobiology (a field which had lain dormant since its origins with Louis Dollo at the beginning of this century) and its potential to influence modern evolutionary thinking was acknowledged by John Maynard Smith in a review article in *Nature* some years ago.

What Carroll sets out to do is to study the process of evolution by reference to one coherent group, the vertebrates. They are, as he acknowledges, clearly recognizable as a natural group (clade), have a pretty passable fossil record and have been the subject of considerable research in the present day laboratory, as well as in the field. But evolutionary research that is carried out on the group as a whole falls into two clear and distinctive camps: on the one hand those who study the fossil record, and on the other those who study vertebrates from a purely modern perspective and, apart from occasional synthetic efforts by the likes of Simpson (1944 – still marvellous but creaking with age), 'never the twain shall meet'. This brings us to the central question being addressed by this book. Charles Darwin assumed, quite logically, that the process of evolution which could be applied through the principle of natural selection as it affects populations and species in the present could, with equal force, be applied to the history of life on Earth: a form of Lyellian uniformitarianism. The fossil history of the vertebrates appears to argue against such uniformity of process and has pushed palaeontologists toward the advocacy of punctuated equilibrium models for large-scale evolutionary change, and to emphasize the importance of mass-extinction events in re-setting the plot of the history of life on Earth; Carroll conjures up a slightly contrived, but very apposite, analogy between this and the original explanatory power of Lyell's Uniformitarianism (of the 1830s) for explaining geological processes in the present day, with the way that plate tectonics in the 1960s has added a radically different component to our understanding of the geological evolution of the Earth over a much longer timescale, one that could not have been possible within the framework of observation and induction from geological processes today.

Throughout this book Carroll grapples with the palaeontological and neontological perspectives on evolution. The first two chapters outline the origin and development of evolutionary thought from Darwin through the eyes of neontologists and palaeontologists, comparing and contrasting their perspectives on the general *modus* of evolution. The bottom line as far as evolutionary biology is concerned is that the punctuational model (arguably, the palaeobiologist's perspective) claims that natural selection is not significant as a mechanism for controlling the pattern and rate of evolution at the level of species. From this starting point Carroll then goes on to examine our understanding of evolution from the study of modern populations, which tends to contradict the punctuationalist view, and from the fossil record (but with emphasis on the limits to our understanding of the fossil record) as a 'high fidelity' record of the timing and circumstance of historical change. This makes interesting, and to some extent sobering, reading, influenced as many of us have been by the exuberance of the Gouldian 'view of life'. The remainder of the book then examines the better documented parts of the fossil record of the vertebrates for patterns which might be illustrative of evolutionary processes (and thereby provide support for, or denial of, the palaeobiological perspective). Examples from the relatively recent (and therefore richest) part of the fossil tend to support Darwinian models of evolution through natural selection.

However, Darwin is not completely vindicated, rates of

morphological change or stasis are far more variable, and factors not considered by Darwin, including continental drift and mass extinctions, are seen to account for patterns of evolution beyond a strictly Darwinian model. The application of phylogenetic systematics also is shown to offer a far more objective way of analysing the pattern of large-scale evolutionary change, and garners support for a punctuational model of change over longer time periods: essentially short periods of intense cladogenesis followed by extended periods of relative stability.

The genetic control of development, genetics, factors limiting or constraining evolutionary change, the physical forces that can affect evolution on a local and global scale, and selected evolutionary transitions among vertebrates all fall under Carroll's remit. This is undoubtedly a *tour de force* by Carroll albeit limited almost exclusively to the vertebrates (he is clearly and obviously favouring his strengths, and I think rightly so). The perspectives taken on Darwinian and punctuational change are in large part shown to be a consequence of the practitioners looking down opposite ends of the same pair of binoculars, magnifying the present or bringing the past into focus. It is undoubtedly the case that palaeobiology has enriched evolutionary studies, and its theoretical basis. Carroll's overview is welcome, well organized, affordable in paperback format and will prove to be a very useful backdrop to undergraduate courses on general evolution, or vertebrate history.

David Norman

#### Reference

SIMPSON, G. G. 1944. *Mode and Tempo in Evolution*. New York: Columbia University Press.

MACLEOD, N. & KELLER, G. (eds) 1996. *Cretaceous–Tertiary Mass Extinctions: Biotic and Environmental Changes*. xiv + 575 pp. New York, London: W. W. Norton. Price £40.00 (hard covers). ISBN 0 393 96657 7.

First, there was Officer & Drake, and now there is Keller & MacLeod. By this I mean that whenever the forces opposed to the hypothesis of a catastrophic mass extinction at the end of the Cretaceous (K/T) need to be invoked, then these are the names to conjure with. The attacks by Officer & Drake, now comprehensively defeated, revolved around how best to interpret the sedimentology and geochemistry of the famous boundary beds. In particular they attempted to explain (away) features such as the shocked mineral grains and iridium in the context of massive volcanism. No-one doubts the reality of the co-eval Deccan eruptions, but the evidence of a bolide impact at Chicxulub (Mexico) is stronger than ever. With the baton of scepticism now in the hands of Keller & MacLeod, the focus has shifted from volcanism to a detailed consideration of the fossil record. Were the extinctions as abrupt as is often claimed, and what is the status of the so-called 'Cretaceous survivors', that is, taxa found in the basal Paleogene? Are they genuine survivors or simple pre-impact faunas that have been reworked into sediments deposited shortly after the catastrophe? Were there regional variations in extinction, and even accepting the evidence for bolide impact why was the recovery period so protracted? The debate has been heated and even virulent, showing not a little of the eternal tension between the 'hard' sciences of physics and chemistry, and the 'soft' science of biology and its handmaiden, palaeontology.

So the debate rumbles on, and this book is a significant

contribution by the anti-catastrophist school. And yet it has its curiosities, not least of which is a question of balance. Thus there are 20 chapters, but almost 40 per cent of the text is written or co-authored by the editors. Their agenda is clear enough, but in places the writing verges on the schizophrenic. One senses that at heart MacLeod & Keller (and their co-writers) secretly wish the bolide hypothesis would silently vanish away; indeed one chapter (by Landis *et al.*) effectively manages to avoid any mention of an impact at all. Elsewhere there is acknowledgement, but it is grudging. Take, for example, the comment by MacLeod: 'The paleontological community has largely accepted the evidence for some type of bolide impact at or near the end of the Cretaceous' (p.128; my emphases). So strong is the evidence of an impact that such statements, and indeed much of the tenor of the book, are simply quaint. MacLeod & Keller seemingly remain unaware that their truculent attitude simply weakens their own position. An impact releasing energy equivalent to  $c.10^8$ – $10^9$  megatons is going to do a great deal of damage, which is clearly encoded in the rock record. Nevertheless, the only reason the K/T impact is of interest is that the bolide must have massively disrupted the biosphere. This response is a problem for biologists. Thus much of what MacLeod & Keller say in this regard is potentially important and deserves attention. And so it would be if they were capable of adopting a balanced viewpoint. It appears, however, that their antagonism to the bolide hypothesis has warped their entire outlook. Thus Pardo, Ortiz & Keller write that 'This low-latitude mass-extinction pattern [that is selective and relatively gradual] was recently confirmed by a blind sample test of the El Kef stratotype section' (p. 140). Hardly. What was 'confirmed' in the final publication (Keller, 1997) was, predictably enough, Keller & MacLeod's view, whereas other groups participating in the blind test came to different conclusions. Thus Canudo (1997) found a pattern of extinction broadly similar to that of Keller's, but nevertheless more dramatic. Two other workers (Olsson, 1997; Orue-Extebarria, 1997) obtained data that pointed even more strongly to a major catastrophe, although Orue-Extebarria (1997) certainly emphasizes the role of 'Cretaceous survivors'. Whether this exercise was in any sense a 'blind test' (see Kouwenhoven, 1997) is less relevant the apparent reluctance to indicate the divergence of views. It is, of course, questionable whether the true course of events will be ever entirely resolved, but a consensus may emerge more effectively by discussion than by what appears, to an outsider, as a polarization.

So what is of value in this book? One chapter, by Gartner, on the extinction of the calcareous nannofossils is unabashed in its support of bolide-driven catastrophe which he described as 'an entirely adequate mechanism' (p. 44). One is almost surprised such a view was permitted to appear here. Other chapters certainly provide valuable new information. MacLeod & Keller are quite right to emphasize the evidence for palaeogeographic variation, and such data as that given on the palynomorphs of Seymour Island by Askin & Jacobsen (Chapter 2) are certainly relevant in this context. Another interesting contribution is by Hollis. He reviews the radiolarian record from New Zealand, an important contribution because hitherto their response to the impact has been uncertain on account of their general rarity and, perhaps, susceptibility to dissolution. Hollis finds little evidence for catastrophe in this higher latitude area, although one wonders whether the dramatic changes in the Paleocene assemblages owe their origin to shifts in ocean circulation, that in turn are ultimately due to the impact. It does seem



that higher latitude sites were in general less affected. Another point that I believe strongly has been unduly neglected is the knock-on effects arising from the impact and presumably the first pulse of extinctions or at least crisis. Surely the initial wave of extinctions triggered further biological disruption? Not only that but recent evidence (D'Hondt, King & Gibson, 1996) suggests that the post-catastrophe ocean experienced marked instability with wild fluctuations of environment. All these can reasonably be attributed, as a final cause, to the impact at Chicxulub, but the aftermath is if anything of greater significance.

Not surprisingly, given the expertise of Keller & MacLeod, the planktonic foraminifera in this book receive close attention. Their points about latitudinal gradients in survivorship as well as selectively of extinctions need to be taken seriously. So too does the suggestion by Keller (p.65) of an ecological reordering emerging as a result of competition in the post-catastrophe oceans. Yet these important points are in part concealed by the prolixity of argument and passages of near-rant which may alienate all but the most sympathetic reader. MacLeod & Keller will no doubt continue to castigate the impact school, and to generate controversy. This need be no bad thing, but perhaps their voices would be listened to more attentively if they accepted the reality of the disaster at Chicxulub and explained that arrival of the comet was only the first step in an immensely complicated story.

Simon Conway Morris

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Applied micropalaeontology is in many respects a mature discipline, since the technique of correlating hydrocarbon exploration boreholes biostratigraphically by means of foraminifera is almost a century old (J. Grzybowski, 1898). The large number of industry-based practitioners attests to the continuing value of microfossil-based zonation and correlation, in tandem with other applications in palaeoenvironmental analysis, sediment and source material provenance, basin thermal history and so on. The recent growth of wellsite work, including the 'biosteering' of deviated wells, is also a reflection of the continuing vigour of the field.

The book, by a very experienced industrial micropalaeontological/biostratigrapher, is logically planned with 160 pages (Chapters 2–6) devoted to the 'tools of the trade', the microfossils available for use, arranged in groups based upon size, composition, and methods of preparation or study. The next 71 pages (Chapters 7–9) concern methodologies and techniques underpinning the application of micro-

fossils, including integrated and quantitative approaches. The final 160 pages (Chapter 10–12) comprise the heart of the book, with case histories in petroleum exploration (Chapter 10 clastic and Chapter 11 carbonate systems) and (Chapter 12, totalling 10 pages) other applications in environmental monitoring, mineral extraction, and engineering. While Chapter 12 is clearly a postscript, and not relevant to the theme of the book, the eight studies in Chapters 10 and 11 are useful compilations of information for major hydrocarbon provinces, with some of which the author has firsthand experience.

The term *compilation* is used advisedly, and the book reflects the advantages and disadvantages of this approach – great range and variety of data but of varying quality, the latter most obvious in the very high proportion of figures derived from published sources, and not always very well reproduced! I found the accounts of microfossil groups with which I am most familiar (ostracods, radiolaria, calcareous nanofossils) to be disappointing and based often upon secondary sources (in some cases an undergraduate text almost two decades old). The brevity of Chapter 9 on the technicalities and difficulties of working with samples derived from drilling (caving, use of 'tops' or First Downhole Occurrences as reliable datum levels, mud contamination, etc.), at the very heart of the application of microfossils in petroleum work, is surprising. I found only four examples (I think) of range charts arranged in species occurrences by tops (FDO) and no discussion of the interpretation of such charts for correlation purposes or in relation to other downhole data.

The book represents a formidable assembly of information by an author with a distinguished record of scholarly achievement outside company time, but it misses its mark in the audience targeted. At £99 students will not buy the book, but they appear to be the most obvious market. The review copy will go into my M.Sc. courseroom.

Alan Lord

- PIFFNER, O. A., LEHNER, P., HEITZMANN, P., MUELLER, ST. & STECK, A. (eds) 1997. *Deep Structure of the Swiss Alps. Results of NRP 20*. xii + 380 pp. Basel, Berlin, Boston: Birkhäuser. Price SFr 188.00, DM 228.00, Ös 1665.00 (hard covers, large format 30 × 43 cm). ISBN 3 7643 5254 X.

Between 1986 and 1995 the Swiss National Science Foundation funded a research programme (NRP20) to investigate the deep structure of the Swiss Alps using integrated geophysical and geological methods. This volume is a compilation of the results of this programme. Much of the research focussed on the acquisition of three deep seismic reflection data sets which traverse the Swiss Alps, the description and interpretation of which form the backbone of this volume. It has been a welcome policy of most deep seismic reflection and wide-angle/refraction research programmes to make the data they acquired easily available in the form of 'atlases'. These have generally taken the form of compilations of the data as paper sections and a brief interpretive description of the data. This volume is more than an atlas. It provides an extremely comprehensive integrated description of the seismic data and available geological data and offers an interpretation of the data, or in some cases interpretations, based on and constrained by surface geology, which builds into a series of detailed cross-sections through the Alps.

The volume consists of 25 chapters, prefaced by a summary

which is an extremely useful aid to searching for relevant data and information. The book begins with a description of the methods of deep seismic reflection and refraction profiling employed in the study, and a section on rock properties. This is followed by two sections which deal with the seismic data and their interpretation. The first deals with sections through the Alpine Foreland and the second with those sections across the mountain belt. It is not clear why this division should have been made, other than because different groups worked on the data and report their findings separately. This has led to differences in interpretations of the data appearing in different sections of the book. The editors have appreciated this and the cross-referencing between chapters is useful and should assist readers to form their own opinion, particularly as observations and interpretations are well separated throughout.

The next section divides the Alps into regions and attempts to explain the evolution of each region using the geophysical data and surface geological information. To do this the authors have drawn on a great deal of existing research and data from surrounding areas, so that this section is not just a description of the Swiss Alps but a comprehensive guide to the geological evolution of the central Alpine orogenic belt in general. A section on the 'Dynamic Alps' focuses on recent crustal movements constrained by seismicity, geodetic surveying and analysis of fission track data.

The final section of the book views the Alps in terms of current plate tectonic theory and examines the evolution of the Alps on a lithospheric scale. This section also draws on data from other research programmes, notably the European Geotraverse. One of the strengths of this volume is that through the multitude of disciplines and range of experience of the 50 or so authors it provides an interpretation of a variety of data which when integrated as well as they are here provides very strong support for the conclusions presented.

This an excellent book for anyone wishing to learn about the geology of the Swiss Alps in particular, and Alpine geology in general. It should also serve as an indication of how deep seismic data can and should be integrated with surface geology. As an example of such an integrated approach the results presented here are second only to the Canadian Lithoprobe studies. The range and scope of the volume is such that it should appeal to geoscientists of all disciplines. Well researched and written chapters are backed up by an excellent reference list, which would form the starting point for further investigation. All the seismic reflection data are presented as large-scale foldouts and the book is superbly illustrated throughout in black and white, with some colour foldouts. However, the format of the book is very large and heavy and this makes it difficult to use without a large desk. It is not for a plane or train journey. It will be a valuable

source of information for teaching, but its main use will be for the continued research which it should stimulate. Considering the wealth of information it contains it is very reasonably priced, and should be on the shelves (suitably spaced and reinforced!) of every library, Alpine researcher and geophysicist working with deep seismic data.

R. W. England

CONDIE, K. C. 1997. *Plate Tectonics and Crustal Evolution*, 4th ed. x + 282 pp. Oxford: Butterworth/Heinemann. Price £24.99 (paperback). ISBN 0 7506 3386 7.

Of all the topics taught to first-year geology classes, it is still the all-encompassing plate tectonic model of the Earth that excites the most interest. Perhaps because of the success of this model in its simplest form, plate tectonics is a topic whose coverage in many 'introductory' texts has changed little over the past twenty-five years, with the same early but inadequate cartoons of the Earth's interior recycled and passed off as new. So it was with some delight that I discovered Condie's *Plate Tectonics and Crustal Evolution* a few years ago, as it seemed to go some way towards filling a void by spanning the gulf between the elementary 'rigid plate' model and the subtleties and exceptions of nature. Now into its fourth edition, and in its twenty-first year, this latest reworking of Condie's book is a thoroughly fresh revision, with a slimmed-down and reorganized content. To cover such a large theme in such a short space has meant that compromises have had to be reached, but Condie's amalgam of large-scale structure and geochemistry works well.

The theme of 'plate tectonics' is introduced in the first chapter. Later sections examine the crust, and tectonic settings. Coverage is occasionally a little curious, with, for example, ocean ridges allowed less than half a page, and a strong emphasis on 'what the setting looks like' rather than 'how it works'. The nature and evolution of the core, mantle, crust and atmosphere occupies the major part of the book, which is rounded off with a brief assessment of the Solar System. Chapters follow a common form throughout. Each is concluded by a list of summary statements and a brief list of suggested further reading, while there is a complete reference list (up to date through 1996) at the end.

Overall, Condie does a good job of piecing the whole tectonic story together. Several topics make challenging but rewarding reading for first or second-year undergraduate students, while most of the book is at an appropriate level for advanced undergraduates – or those who wish to keep one step ahead of their students! In a field with little real competition, this book fills a valuable niche.

David Pyle