BOOK REVIEWS

MARTÍNEZ CATALÁN, J. R., HATCHER, R. D, JR, ARENAS, R. & DÍAZ GARCÍA, F. (eds) 2003. *Variscan–Appalachian Dynamics: The Building of the Late Paleozoic Basement*. Geological Society of America Special Paper no. 364. v + 305 pp. Boulder: Geological Society of America. Price US $64.00 (members), US $80.00 (non-members); paperback. ISBN 0 8137 2364 7.
DOI: 10.1017/S0016756803218835

'The Variscan Belt of Western Europe is part of a large Paleozoic mountain belt 1000 km wide and 8000 km long, that extended in Permian times from the Caucasus and Urals in Europe to the Appalachian and Ouachita mountains in America.' So begins a contribution by Matte to this valuable new volume on Variscan geology, a product resulting from the 15th International Conference on Basement Tectonics held in Galicia in July 2000. Taking the broad view, Matte illustrates how different parts of the Variscan orogen developed in different ways. The central and western European Variscides and the Appalachian–Mauritanian segments provide classic examples of a collisional orogen, built over a >200 Ma history of diachronous collision between Laurentia–Baltica and Gondwana. In contrast, the Urals record a relatively 'soft' arc–continent collision, preserving parts of both the HP–LT accretionary and HT arc complexes.

The book opens with another overview paper, this time by Robardet who emphasizes the role of sedimentological and faunal data in determining Gondwanan palaeogeography and constraining Variscan tectonic models. Such data require just one Variscan oceanic suture (unlike several previous models), running from central Europe to the Lizard in Cornwall, and re-emerging on land as the Ossa Morena–South Portuguese boundary in southern Iberia. Topics covered by other papers taking a similarly broad approach to the Variscan orogen include: the role of transpressional collision and synchronous block rotation ('zipper tectonics') during the Alleghanian convergence of Gondwana and Laurentia in eastern North America (Hatcher); the importance of Carboniferous dextral transcurrent mega-displacements to the assembly of Variscan terranes (Shelley & Bossière); the Palaeozoic evolution of pre-Variscan terranes (Stampfli *et al.*); the relevance of deep seismic reflection profiles to 'thick-' and 'thin-skinned' interpretations of Variscan collisional events (McBride & Knapp); the role of subduction polarity and transform faulting in the creation of zones of opposite vergence in Iberia (Simancas *et al.*).

Interesting and useful as all of the above papers are, however, the true *corazon* of this book lies within the eight detailed studies on different parts of the Variscan orogen in NW Iberia. Specifically, these papers deal with the Alcañices Synform (Clavijo & Martínez Catalán), the Monte Castello gabbro (Andonaegui *et al.*), the Sierra de Careón, Sobrado, Santiago and Malpica–Tui units (Pin *et al.*, Arenas & Martínez Catalán, Rubio Pascual *et al.*, Llana-Fúnez & Marcos), and the Cabo Ortegal and Ordenes complexes (Marcos *et al.*, Martínez Catalán *et al.*). The latter two papers include detailed fold-out colour maps, and, in the case of Martínez Catalán *et al.*, an excellent colour composite diagram of nine cross-sections through the Ordenes Complex. The book is worth obtaining for this last paper alone, a collaborative effort from Salamanca, Madrid and Oviedo.

In addition there is a contribution on the structure of the Iberian pyrite belt (Soriano & Casas), and papers dealing with two Variscan areas in France: high grade metamorphics in the Baie d'Audierne (Lucks *et al.*), and an ultramafic-rich shear zone in the Maures Massif (Bellot *et al.*). Involving nearly 50 geologists, mostly from Spain but also Portugal, France, Germany, Switzerland, USA and New Zealand, this book provides both an update on the 'big picture', as well as a series of detailed studies on the Variscan orogeny. It has been carefully edited, reads well, and is an essential component of any 'Variscan' research collection.

Wes Gibbons

KELLEY, P. H., KOWALEWSKI, M. & HANSEN, T. A. (eds) 2003. *Predator–Prey Interactions in the Fossil Record*. Topics in Geobiology Series Volume 20. xvi + 464 pp. New York, Boston, Dordrecht, London, Moscow: Kluwer Academic/Plenum Publishers. Price Euros 115.00, US $115.00, £74.00 (hard covers). ISBN 0 306 47489 1.
DOI: 10.1017/S0016756803228831

If there was ever a sub-text to the evolutionary process, it is the Tennysonian refrain of 'Nature red in tooth and claw'. In our great museums of natural history the research rooms may be cluttered with dusty fossils presided over by muttering curators, but in the public galleries the scene is very different. Here huge animated dinosaurs wallow in gore, as jaws slobber and teeth grin in reptilian rictus. Nor is there any particular reason to doubt that the common lot of a fossil-to-be was not to end its days on the sandy floor of a tranquil lagoon or flower-bedecked meadow, but more likely to be crushed, harpooned, swallowed, dismembered, or even bored out of existence.

Here eighteen chapters, written by many of the leading experts (and enthusiasts), bring the topic of predation back into focus and also firmly up-to-date. Indeed, its principal strength is as an outstanding literature resource, with not only an impressive catalogue of examples, but also repeated reiterations of some of the major problems in this area. Thus, a number of the authors stress that despite decades of investigation there are many gaps in our knowledge. As a partial remedy several detailed case studies are presented, but these act more as salutary reminders of not only the amount of work still needed but also difficulties in extrapolation to general hypotheses. Indeed, the danger that this could lead to all sorts of unwarranted assumptions is repeatedly stressed. For example, whilst the evidence for both escalation, notably the Mesozoic Marine Revolution (MMR, made famous by Vermeij's seminal contributions) and more generally arms-races (or at least reciprocal changes), is still compelling, a closer reading of the evidence suggests that lurking in the background there may be a considerably more complex picture. What, for example, are we to make of the evidence for fluctuating patterns in drilling intensity on bivalves and gastropods over geological time? As Patricia Kelley and Thor Hansen note in this instance the abiotic influence of major extinctions as a controlling factor to explain such patterns is a serious candidate, but the *de facto* occurrence of biological interactions makes disentangling the various controls almost impossible.

This particular example is just one instance of a fundamental fault line in the study of the evolution of life. Is its history driven more by biological interaction as against response to the demands of the physical environment? For the most part, of course, this book is firmly in the camp of the former school, and the many compelling examples of changes in defensive adaptation are valuable ammunition to those who argue that during geological time the ancient seas became ever more crowded with dangerous animals. Because our sense of defence and attack tends to be rather intuitive, many of these adaptations would benefit from a more rigorous analysis than they have received. A more important, and surprising, oversight is the reluctance to consider the ethology of extinct animals and the real possibility of changing levels of intelligence that might be mediated in part by the evolution of more complex sensory organs, especially olfaction and vision.

This is not to say, however, that some of the current investigators are unaware of some of the subtleties in the investigation of predator–prey interactions. Take the famous case of the platyceratid gastropods and their infestation of mid–Palaeozoic crinoids. As Carlton Brett, in his review of the mid–Palaeozoic equivalent to the MMR, explains, the abrupt increase in crinoid spinosity may be best explained as an *indirect* response to the increasing predation pressure on the snails. Nor is apparently straightforward evidence always so simple. Consider, for example, the classic example of Cretaceous ammonites from the Western Interior of the United States being chomped by mosasaurs, with graphic punch marks inflicted by the teeth of these giant marine lizards. A wonderful story, until it was pointed out that the supposed punch marks are impressions of limpet 'homes'. But the story doesn't stop there. As Mapes & Chaffin explain, in fact the evidence for mosasaur attack still remains strong, and a grisly end in the jaws of these remarkable reptiles is still a real possibility.

This is, therefore, an exceptionally widely ranging book, where the interested reader can learn about the curious asymmetries of wound marks on trilobites (by Loren Babcock), predation on bryozoans (by Ken McKinney and colleagues), and predation by early hominids (by Rick Potts). All provide judicious reviews that are both thoughtful and wide-ranging. The most theoretical chapter, by Mark McMenamin, attempts to introduce the ecological concept of the ecotone, that is where a metaphorical line delimits two distinct systems and can, in certain circumstances, be radically disrupted by an apparently trivial circumstance, in McMenamin's example the introduction of a single species of predator. Whether such re-organizational principles have a relevance to explaining the Cambrian 'explosion' remains to be seen, but his description of such a shift rippling across the Cambrian world is certainly intriguing.

This volume, therefore, is one that will be widely consulted, and will be an essential addition to any library where palaeontology is an active subject. Its steep price, unfortunately, means that it will be beyond the reach of most individuals, but they can at least be encouraged to think carefully as to just how red in tooth and claw nature is in reality.

Simon Conway Morris

GOLDSTEIN, J., NEWBURY, D., JOY, D., LYMAN, C., ECHLIN, P., LIFSHIN, E., SAWYER, L. & MICHAEL, J. 2003. *Scanning Electron Microscopy and X-Ray Microanalysis*, 3rd ed. xix + 689 pp. New York, Boston, Dordrecht, London, Moscow: Kluwer Academic/Plenum Publishers. Price Euros 76.00, US $75.00, £48.00 (hard covers). ISBN 0 306 47292 9.
DOI: 10.1017/S0016756803238838

This is a comprehensive and well-organized guide to scanning electron microscopy (SEM) and X-ray microanalysis. The authors have aimed to keep apace with recent developments in SEM since the publication of the second edition in 1992, and have updated it accordingly, including sections on topics such as variable pressure/environmental SEM, and crystallographic analysis of specimens using electron backscatter diffraction.

The book, complete with CD, sets out the mechanics of the electron microscope, how images are formed and their interpretation, X-ray microanalysis and X-ray production, and the preparation and analysis of samples of differing composition. There are informative summaries on several topics and useful reference lists.

The opening chapter is an introduction to SEM, including the development of different techniques, imaging, structural analysis and elemental analysis. Chapters 2 and 3 discuss the operation of the SEM and electron-beam interactions with the sample. The adjustment of beam current and accelerating voltage are discussed with reference to their impact on image quality, under different operational modes: resolution mode, high-current mode, depth-of-focus mode and low-voltage mode. Simulations of what happens to the beam as it strikes a specimen are described, as are controls on the interaction volume. The nature of and controls on backscattered and secondary imaging signals are detailed.

Chapter 4 discusses image formation and interpretation, including types of electron detector available, and outlines some basic imaging processing techniques. The succeeding chapter, Chapter 5, is set apart for various special topics in SEM, such as surface imaging at low voltages, imaging and X-ray microanalysis using variable pressure and environmental SEM and imaging magnetic materials.

The subject of X-ray microanalysis is covered in chapters 6 through 10, using a similar format to that for the chapters on SEM imaging. Chapters 6 and 7 discuss the generation of X-rays in the SEM specimen, and their detection and measurement using energy dispersive and wavelength-dispersive X-ray spectrometers respectively. Qualitative X-ray analysis is discussed in Chapter 8, and the basic aspects of quantitative X-ray analysis using an ideal specimen, i.e. flat and highly polished, in Chapter 9. The authors detail the X-ray microanalysis of awkward samples with non-ideal geometries in Chapter 10, including thin films on surfaces, particle analysis, rough surfaces, beam-sensitive specimens (e.g. polymers, biological), X-ray mapping, light element analysis and low voltage microanalysis.

Chapters 11 through 14 consider the preparation of a variety of materials for imaging and analysis, including hard materials such as metals, ceramics, geological specimens, microelectronic components, beam-sensitive and relatively soft materials, including polymers and biological samples at ambient temperature, and the preparation of specimens for low-temperature SEM. The use of focused ion beams in specimen preparation is also discussed.

The authors finish off the book by examining the various methods of mitigating charging in non-conducting specimens. Such topics as charging, different coating methods and the materials available for coating are discussed.

Considering the size of the volume, there are few typographical errors. The inclusion of a CD with additional information has obviously expanded the scope and detail that can be included with the publication, although I was surprised to see that model simulation data is only available for Windows 98 and earlier PC operating systems. Overall, the book will be a very useful guide to the subject of SEM for readers new to the subject, and will also be extremely useful as a point of reference for more experienced users.

R. B. Pearce

RAUHUT, O. W. M. 2003. *The Interrelationships and Evolution of Basal Theropod Dinosaurs.* Special Papers in Palaeontology no. 69. 213 pp. London: The Palaeontological Association. Price £60.00 (paperback). ISBN 0 901702 79 X; ISSN 0038-6804.
DOI: 10.1017/S0016756803248834

It sometimes seems that there are more palaeontologists working on theropods (predatory dinosaurs and birds) than on any other group of vertebrates. But while phylogenetic schemes for Coelurosauria (tyrannosaurs, birds and kin) abound, the interelationships of basal theropods (ceratosaurs, megalosaurs, spinosaurs, allosaurs, etc.) have been in need of thorough study. In a major new analysis resulting from first-hand coding of most taxa, Oliver Rauhut has produced what will become a definitive work on basal theropod phylogeny.

Contrary to claims from some corners that theropod phylogeny is a mess, this work highlights the fact that a consensus has emerged. While Rauhut's tree differs in some of its details from others, the general pattern is the same, but this is not to imply that this study is not novel or significant. Characters used to analyse coelurosaur phylogeny have varied considerably, but those employed for basal theropods have not altered a great deal from Gauthier (1986), the first cladistic analysis of Theropoda. Rauhut's approach to character choice is empirical and critical and, consequently, many oft-used characters are discarded or shown to be of dubious value. Of the 224 characters adopted, all are clearly explained and often illustrated.

Two main discoveries result from his analysis. Firstly, paraphyly of Ceratosauria is demonstrated. Monophyly of this group was proposed by Gauthier (1986), and while Rauhut's results were largely novel when first announced (Rauhut, 1998), the topology he proposes has recently been discovered by other authors (Carrano, Sampson & Forster, 2002). This is significant as Rauhut's placement of *Dilophosaurus* outside Coelophysoidea is dependent on his inclusion of the bizarre, edentulous *Shuvosaurus*, a taxon not analysed by Carrano *et al.* (2002). His second main discovery is that spinosauroids ('megalosaurs' plus baryonychids) and allosauroids form a clade, the oldest name for which is of course Carnosauria Huene, 1920. This is surprising given that other recent studies find an allosauroid–coelurosaur clade. However, the characters used to support this latter arrangement are unknown or problematical in non-allosauroid carnosaurs, though homoplasy and a poor Middle Jurassic theropod record do leave room for doubt.

Rauhut ends this work with a discussion of what the analysis means for theropod phylogeny as a whole. Spearman rank correlation and stratigraphic consistency tests indicate that the theropod fossil record is quite good but Gondwanan taxa have ghost lineages almost twice as long as Laurasian taxa. Furthermore, if the Lower Jurassic forms *Cryolophosaurus* and *Eshanosaurus* really are an allosauroid and derived coelurosaur as claimed, then ghost lineage durations across Theropoda will need reappraisal.

A few cited references are not in the bibliography and I disagree with a few of the taxanomic allocations (e.g. *Calamosaurus foxi* is not referable to *Calamospondylus*). Look for the joke in the specimen list of the appendix. At a time when people are becoming increasingly agitated about the PhyloCode, Rauhut simply rejects the application of phylogenetic taxonomy. Given that a published PT definition of Ceratosauria excludes *Ceratosaurus* in Rauhut's phylogeny, I can agree, but others won't be so happy. Furthermore it can be argued that some of the problems created by PT result from poor decisions made by certain authors, and some of these decisions run counter to PhyloCode recommendations.

This work is required reading for anyone working on theropods or with an interest in dinosaur evolution. It provides both a much needed critical approach to character choice, and substantial new data on multiple taxa. The challenge now is to find and describe more key taxa that come from the problem areas on the cladogram.

Darren Naish

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BYRNE, T. B. & LIU, C.-S. (eds) 2002. *Geology and Geophysics of an Arc–Continent Collision, Taiwan.* Geological Society of America Special Paper no. 358. viii + 211 pp. Boulder: Geological Society of America. Price US $80.00; members' price US $64.00 (paperback). ISBN 0 8137 2358 2.
DOI: 10.1017/S0016756803258830

This book developed from a 1997 Tectonics of East Asia Conference in Taiwan, although the introduction alludes to other preceding and subsequent conferences, mainly with Taiwanese, US and French participants, which were concerned principally with the geology of arc–continent collision in Taiwan. The papers in this Geological Society of America Special Paper result partly from the 1997 meeting and cover quite a lot of the geology and geophysics of the Taiwan region. The editors have done their job well and all the papers are written to a high standard, well edited and very well illustrated.

Taiwan is well known as a very young and active collisional orogen, and must now be the best studied arc–continent collision in the world. The thirteen papers in the volume reflect some of the diversity of research in this region. The first three papers (Cho & Yu, Lee *et al.*, Mouthereau *et al.*) focus on the fold and thrust belt and foredeep on the western side of the mountain range. They include detailed cross-sections, partly based on seismic lines, and illustrate well the deformation of the upper few kilometres of the crust.

Cho & Yu show that normal faults previously overlooked or interpreted as rift-related are spatially related to the thrust front, strike parallel to the orogen, and are likely to be due to flexure. Lee *et al.* and Mouthereau *et al.* both conclude that earlier purely thin-skinned tectonic models require modification, show that the present form of the fold and thrust belt is influenced by pre-existing structures, and interpret an important role for thick-skinned thrusting with basement involvement. Hsieh & Knuepfer discuss the complexity of river incision and terrace development in the Western Foothills where very young deformation continues and rates can be measured using radiocarbon dating. Hickman *et al.* link active folding and thrusting to GPS-inferred surface motions, using detailed cross-sections based on oil company exploration. They interpret the GPS measurements in terms of a wedge which has not yet reached a critical state and is deforming internally. Two papers then move deeper into the orogenic belt. These are concerned with metamorphic rocks of the Slate Belt (Fisher *et al.*) and the pre-Tertiary metamorphic rocks (Pulver *et al.*). Both agree that oblique collision of the Philippine Sea plate and the Eurasian margin caused lateral extrusion of the metamorphic rocks, and in both cases it would be interesting to know more about the timing of the structural fabrics which are described, and interpreted as very young.

A number of interesting modelling studies follow. Song & Ma discuss the thermal structure of the orogenic belt and conclude that there is a surprisingly low geothermal gradient of 17°C/km which they explain as the result of cooling due to crustal thickening, and heating due to erosion. They consider that locally much higher and lower values of measured surface heat flow are the result of groundwater circulation. They may well be right, and they do discuss the assumptions in their modelling together with possible independent tests of their results, but some uncertainty remains about how much the results depend on the chosen model. Wang & Hung describe and illustrate simple physical models using layered hydrocarbons deformed in a rectangular box, accompanied by finite element models, and show that syn-orogenic extension occurs in the highest parts of the orogenic belt. Hu *et al.* also use finite element modelling to interpret GPS measurements in north Taiwan where there is a transition from collision to post-collision extension moving offshore into the Okinawa Trough, a puzzling and rapid transition from the elevated island to deep offshore basin. In this paper a few diagrams illustrating the development in time of this complex structure would help the reader unfamiliar with Taiwan to understand their model. Cheng *et al.* discuss seismic tomography of the crust with seismicity and gravity data, and suggest that a strong high velocity anomaly beneath western Taiwan is related to a forearc sliver from the Luzon arc. The termination of this anomaly in north Taiwan raises the question of the former northward continuation of the arc and the three-dimensional geometry of the collision at depth. The final modelling study (Tang *et al.*) also uses the finite element approach to consider the response to subduction of the Philippine Sea plate above an east-dipping subduction zone. In all cases the upper plate fails at the location of the volcanic arc, although failure can occur on trench-ward or arc-ward dipping faults, on either side of the arc, depending on the flexural rigidity and thickness of the continental crust.

The final paper by Malavieille *et al.* brings together some superb images of the seafloor, collected by multibeam swath mapping during French marine cruises, seismic sections, and uses these together with many other data to interpret the evolution of the orogenic belt in the last 3 million years. Although this paper is well illustrated by cross-sections and maps showing the development with time stage by stage, it is still difficult to envisage the development of the orogenic belt in three dimensions with time. What this shows is the need for new approaches to illustration, probably using 3D computer animations which can be rotated in real time on-screen, to show the complexity of the orogenic belt developed in a setting above two subducting lithospheric slabs dipping in opposite directions. Not everything is covered in the 13 papers of this volume; for example there is no account of the arc rocks, the famous melanges, nor the results of seismic tomographic imaging of the mantle. None the less, the papers in this volume give a good and well illustrated review of many aspects of the history of this fascinating orogenic belt.

Robert Hall

Margulis, L. & Dolan, M. F. 2002. *Early Life. Evolution on the Precambrian Earth*, 2nd ed. xxiv + 168 pp. Sudbury, Boston, Toronto, London, Singpore: Jones & Bartlett. Price £21.99 (paperback). ISBN 0 7637 1463 1.
DOI: 10.1017/S0016756803268837

The 1960s and 1970s were exciting times for the study of life on Earth. The discovery of unambiguous microfossils in the Gunflint Chert and Bitter Springs had established, unequivocally, the presence of a significantly pre-Cambrian biosphere. Confirmation of the biogenicity of ancient stromatolites initiated an investigation of their modern equivalents, and played an important role in establishing both microbial ecology and biogeochemistry as worthy scientific disciplines. Major advances were also being made in the understanding of biosynthetic and metabolic pathways, and, as always, the questions of the origin of life and its major divisions loomed large. Among the most provocative of issues of the day was the resurrection of Mereschkowsky's hypothesis that the eukaryotic cell was not so much an individual as a symbiotic consortium of unrelated microbes. Lynn Margulis was of course the champion of the serial endosymbiosis cause and, in classic Kuhnian form, carried the day.

The first edition of this short volume, published in 1983, was Margulis & Dolan's personal take on how these various data interlinked to yield a coherent view of early life on Earth. Idiosyncratic at times, and missing out on whole areas of importance such as plate tectonics, it nevertheless conveyed the excitement of a new endeavour and a genuine expectation of major new insight and discovery. Twenty years on, and the study of early life has more than met this expectation. Revolutionized by new concepts, analytical techniques and data, 'early life' has taken on a life of its own – a bold new scientific discipline with aspirations even to consider the biology of other worlds. Unfortunately, *Early Life II* has fallen well back from the pace, and apart from a few desultory nods to the revolution in molecular biology reads more like history than science. Whittaker's 1959 five-kingdom division of life, for example, continues to be held up as the most useful classification of life (Figure 1-1), and long-ignored terms such as Protoctista and Dinomastigota are dusted off and used as if they were common parlance. The idea that the 'archaeozoa' might be primitive, pre-mitochondrial eukaryotes is well past its due date, as is the possibility that prochlorphyte cyanobacteria might be the source of green-plant plastids; indeed, there is now vanishingly little likelihood that there was more than a single primary endosymbiosis of chlorplasts. At the same time, major new insights into eukaryotic evolution from both the fossil record and molecular biology go entirely unreported. We are told, for example, that eukaryotes evolved somewhere between 2.0 and 0.8 Ga, and that seaweeds make their first positive appearance in the Ordovician, in both cases missing the mark by approximately a billion years. And even where the text has been updated, it is not always consistent: 541 Ma is indeed a reasonable estimate for the base of the Cambrian, but Figure 1-7 still insists it is closer to 580 Ma (and that the base of the Proterozoic is 2600 Ma). The list goes on, but the book, I'm afraid, remains hopelessly mired in the past.

Nick Butterfield

CLIFT, P. D., KROON, D., GAEDICKE, C. & CRAIG, J. (eds) 2002. *The Tectonic and Climatic Evolution of the Arabian Sea Region.* Geological Society Special Publication no. 195. vii + 525 pp. London, Bath: Geological Society of London. Price £120.00, US $200.00; members' price £60.00, US $100.00; AAPG members' price £72.00, US $120.00 (hard covers). ISBN 1 86239 111 4.
DOI: 10.1017/S0016756803278833

The Arabian Sea region is a key area for deciphering plate tectonic reconstructions including the opening of the Red Sea/Gulf of Aden, the northward drift of India, the evolution of the Makran accretionary prism and the geometry and extent of the Indus Fan. It is also a key area for testing models of climatic–tectonic interrelationships, in particular the evolution of the Indian summer monsoon. This volume contains 26 papers documenting plate reconstructions, magnetic and gravity data, seismic surveys, magnetic isochrons, neotectonics and the Pleistocene–Holocene climatic record of the Arabian Sea. It begins with papers that include a new compilation of magnetic and gravity data used to reconstruct the Paleogene plate tectonic evolution of the Arabian Sea and East Somali basin. Multi-channel seismic surveys are used to constrain the sub-surface stratigraphy and structure.

Papers document the onshore geology of the Iranian Zagros belt and Makran accretionary prism, the Kirthar fold belt along western Pakistan and the Ladakh Himalaya. Soon after the initial collision of India and Asia approximately 55–50 Ma ago a molasse basin developed along the suture zone accumulating debris eroded from the southern margin of Asia (Ladakh–Kohistan batholith), as well as the rising Himalaya to the south. The Indus Fan is the depositional repository from the Indus River that drains the entire western Himalaya, Karakoram and southwest Tibetan plateau region. One long paper contains a very useful summary of the geology of the Iranian Makran, an extremely remote and difficult area to work in, that documents years of mapping work at 1:250 000 scale. Large volumes of Paleogene turbidites in Makran may represent palaeo-Indus Fan deposits added to the margin. It is an intriguing possibility that once the volume of the Indus molasse basin in the Himalaya and the Paleogene deposits in the Sulaiman–Kirthar and Makran ranges are added to the volume of the Indus Fan, it may add up to a similar mass volume as the better known Bengal Fan to the east. The Indus–Makran system seems to be a more dominant Paleogene depositional system than the Bengal Fan, reflecting the longer-lasting and older mountain building in the Karakoram and Hindu Kush ranges in the west.

Ocean Drilling Program (ODP) wells off the south Oman continental margin have cored pelagic sediments that reveal a detailed history of upwelling and monsoonal variation. The key evidence for the strengthening of the Indian monsoon system lies in the abundance of *Globigerina bulloides* and similar foraminiferal species associated with the monsoon-induced coastal upwelling in these wells. Detailed studies of the foraminifera-based record on thousand- and hundred-year time scales reveal that models of monsoon upwelling and productivity may not be as simple as has been previously made out. During the glacial times, productivity and upwelling was stronger offshore Somalia during the winter, whereas today production is strongest during the summer SW monsoon. Several papers in this volume are aimed at testing the climatic–tectonic interrelationship, using the Pleistocene–Holocene sedimentation record. The entire Persian–Arabian Gulf was exposed during glacial sea-level lowstand periods, allowing changes in sea level to be quantified. Sea level fell by over 23 m below present level during the Pleistocene glacial period, and peaked during the interglacials at 6 m above present sea level.

Climate change also resulted in the expansion and contraction of deserts. Two wind systems dominated: the northern Shamal winds, strongest during the glacial periods, and the strong SW monsoon winds, strongest during the interglacial periods. Papers record fascinating links using plankton groups as proxies for climatic conditions, using trace element proxies for the oxygen minimum zone, and using nitrogen isotopes as a proxy for upwelling.

The final section of the book has three papers related to neotectonics. Marine terraces along the Makran margin show abundant evidence for coseismic uplift, whereas the south Arabian margin has little neotectonic activity, consistent with it being parallel to a transform fault. The opening of the Red Sea during the Pliocene resulted in faster Arabia–Asia convergence, which caused increased Pliocene deformation along the Zagros Mountains. The uneven thickness of the Hormuz salt and the spectacular intrusion of the numerous salt domes also play a key role in the deformation of SE Iran.

In summary, this book contains a fascinating and extremely useful set of papers on a key area of the planet. It certainly contributes enormously to the dataset needed to unravel the extremely complex nature of the interaction between tectonics and climate, not only for the Arabian Sea region, but beyond. This volume should inspire scientists for the pressing need to drill the Indus Fan. There is one DSDP hole (221) at the southern end of the Fan that has penetrated to the base of the Fan but it was not continuously cored, and another (DSDP site 222) which gets down only as deep as the Upper Miocene, so we still have an incomplete record.

Mike Searle

PROTHERO, D. R., IVANY, L. C. & NESBITT, E. A. (eds) 2003. *From Greenhouse to Icehouse. The Marine Eocene–Oligocene Transition*. Proceedings of the Penrose Conference held 17–22 August 1999 in Olympia, Washington. xiii + 541 pp. New York: Columbia University Press. Price £57.00, US $79.50 (hard covers). ISBN 0 231 12716 2.
DOI: 10.1017/S001675680328883X

Sixty-one authors, 30 chapters and 541 pages of interesting information, ideas, illustrations and interpretations on the marine Eocene–Oligocene transition: this is a substantial piece of work that represents an excellent and up-to-date summary of the Earth's last greenhouse to icehouse transition. Reviews of such weighty works can be either summaries of a book's organization and content or summaries of a book's major findings. When agreeing to review this book, I thought I would attempt the latter review model. But then I read the last chapter of *From Greenhouse to Icehouse* and I found that the editors/authors had already done an excellent job of writing a synthesis of the global changes that took place during this pivotal period of Earth history. So I'll compromise and briefly review both the contents and some of the major findings.

The book itself is organized by geographic region: the Pacific Rim, the Atlantic, Gulf and Caribbean, and the North Sea and Tethys. These three parts are followed by a much shorter fourth, entitled 'Causes and Consequences', that consists of a chapter on Late Eocene impacts and their paleoenvironmental consequences, a chapter on biotic turnovers and the cause of evolutionary change, and the editors' synthesis. The latter summarizes several recurring themes that '... highlight the turning and magnitude of both climatic and biotic change'. The tectonic and palaeogeographic setting of the interval in question, the nature of the shelf deposits (which are the subject of most chapters because that is where most of the macrofossil record is found), boundary recognition and correlation, trends in climatic changes, and patterns and causes of faunal and floral turnover are dealt with in turn. The chapter, and book, concludes with a brief section that suggests the direction that new research might take.

This topical tome, turgid with facts and figures, is the child of a Penrose conference held in Olympia, Washington in August 1999. It is the grandchild of another Penrose conference, held a decade earlier on the same topic. Much new information was accumulated during those ten years and many analytical techniques were refined. The result is a much higher resolution understanding of the climatic and biotic Eocene–Oligocene transition that was first summarized in Prothero & Berggren's 1992 text *Eocene–Oligocene Climatic and Biotic Evolution*.

The book has a few typos (my review copy had an illegible illustration where the page had been folded during printing) but it is quite well priced for its size, and is clearly a valuable contribution to the literature that should be read (or referred to) by all students of Cenozoic climatic and biotic change. It is less than four years since the Penrose conference in question took place but the cited literature shows that the papers in this book are clearly of lesser vintage. So, if an up-to-date understanding of Eocene–Oligocene changes is required, this is the go-to book.

What are the major findings of this text? For me, the revelation of the complexity of biotic turnover patterns from 40 to 34 million years ago stands out. Several turnovers occurred from the middle Eocene and into the Oligocene: in the late middle Eocene, at or near the middle–late Eocene boundary, within the late Eocene, near or shortly after the Eocene–Oligocene boundary, and later into the Oligocene. The turnovers vary in their character from taxonomic group to taxonomic group, from time to time, and from place to place. For example, the Gulf Coast record of molluscan diversity is characterized both by pulses of extinction and origination, the Atlantic Coast record is dominated by extinction, whereas in the Alaskan record origination exceeds extinction. Although very different in character, the turnovers in those three geographic regions were approximately of the same magnitude. Although the biotic changes are pulsed over 15 million years, two intervals of change are most significant, the middle–late Eocene boundary, where diversity loss in Atlantic, Gulf and European molluscs was most significant, and near the Eocene–Oligocene boundary where turnover was dominant.

In comparison to the Atlantic, Gulf and European regions, although northwest Pacific molluscan diversity also drops at the end of the middle Eocene, taxonomic turnover was also significant. This latitudinal contrast hints at the cause of the Eocene–Oligocene biotic changes. Although at least three bolides hit the Earth in the late Eocene, the editors conclude that there is no obvious correlation between impact and extinction. Thus, temperature is left as the major factor involved in biotic turnover. Warm-water molluscs were harder hit than cooler water taxa. Furthermore, correlation of faunal changes from regions as widespread as Australia, the Gulf Coast, Europe and the Pacific strongly suggest that driving forces behind the turnovers were global in nature. Thus the editors succinctly concluded that 'Progressive global cooling and increased seasonality brought on by a combination of tectonic and oceanographic factors led to a series of worldwide pulsed turnovers through the middle Eocene and into the Oligocene'.

Researchers interested in Cenozoic oceanographic and climatic change and their effects on the Earth's biota should refer to this book. It serves as a good investigative model that could be applied to other intervals of environmental and biotic change in the Cenozoic and older geologic record.

Stephen J. Culver

TREWIN, N. H. (ed.) 2002. *The Geology of Scotland*, 4th ed. viii + 576 pp. London, Bath: Geological Society of London. Price £85.00, US $142.00 (hard covers), £29.50, US $46.00 (paperback); GSL member price: £42.50, US $71.00 (hard covers), £22.50, US $37.00 (paperback); AAPG member price: £51.00, US $85.00 (hard covers), £22.50, US $37.00 (paperback). ISBN 1 86239 105 X; 1 86239 126 2 (pb).
DOI: 10.1017/S0016756803298836

Publication of a fourth edition is often indication enough that a book has served and sold well. So it is with *The Geology of Scotland*. Since 1985 it has been a first point of detailed reference on the geology of northern Britain. Well-thumbed copies of one or more of its previous editions must occupy the shelves of most UK geological libraries and of many individual geologists. Should these same users consider buying the new edition?

In a word, yes. The fourth edition is virtually a new book, with three-quarters of the authorship having changed and, more significant, half of the book being set in a completely new structure. Gone is the stratigraphical organization of pre-Caledonian chapters. Instead, this early history is successfully described terrane by terrane, allowing much closer integration of the geology within each terrane. These chapters are preceded by an overall introduction to Scottish geology and a new treatment of the early history of geological investigation in the country. A review of terrane assembly then links the pre-Caledonian and post-Caledonian sections. These Devonian to Quaternary chapters are arranged stratigraphically, with the Jurassic, Cretaceous and Tertiary sediments now each properly receiving a chapter of their own. However, the most important expansion from the third edition is of the former Economic Geology chapter, now meriting five chapters on metalliferous minerals, coal, bulk materials, hydrocarbons and environmental geology.

Within the new structure, most chapters are constructed with a good balance of 'factual' stratigraphy and structure with more interpretative palaeogeographic or tectonic reconstructions. Text mostly dominates figures, but these figures are clear, with a smattering of colour. A block of thirty or more colour plates provides a spectacular advertisement for Scottish geology. Some 65 pages of references underpin the authoritative and up-to-date text.

This is not a book to be read cover-to-cover, nor by those without sound grounding in basic geology. It is essentially a reference book for the the enthusiastic amateur, the inquisitive undergraduate and the busy professional. Yes, it deserves to be used as widely as earlier editions, both in the UK and for those abroad wanting a thorough modern review of the geology of Scotland.

Nigel Woodcock

HENDRIX, M. S. & DAVIS, G. A. (eds) 2001. *Paleozoic and Mesozoic Tectonic Evolution of Central and Eastern Asia: From Continental Assembly to Intracontinental Deformation.* Geological Society of America Memoir no. 194. vi + 447 pp. Boulder: Geological Society of America. Price US $160.00; members' price US $128.00 (hard covers). ISBN 0 8137 1194 0.
DOI: 10.1017/S0016756803308830

Much of central and eastern Asia was assembled by a series of orogenies through the Palaeozoic and Mesozoic, before the Cenozoic India–Asia collision. This book presents 19 papers that describe individual areas or aspects of this vast collage. The papers are grouped thematically. The first seven describe Palaeozoic tectonic events, mainly in Mongolia and northwest China, beginning with a useful regional synthesis by Christoph Heubeck that covers the entire region. Other papers provide details on Tarim, the Tian Shan, much of the Beishan and Inner Mongolia regions, southern Mongolia and the Altun–Qaidam–Qilian regions. This is a good coverage, with little overlap or repetition, and a balanced mix of new datasets and reviews. The next six papers look at Mesozoic orogenies, with a shift in focus to north and east China, and an emphasis on new radiometric ages and fission track studies. If anything, there are too many data and not enough context in the papers in this section. The final papers are studies of tectonic events as recorded in the stratigraphy of the many sedimentary basins. These papers emphasize northwest China and Mongolia again. Individual papers are mainly accounts of the sedimentology of Mesozoic clastic successions, superbly exposed in the arid continental interior. There is an important debt to the active India–Asia convergence, which has produced many of these exposures. At this point I declare an interest, as the co-author of a paper on the Junggar Basin, that relates the stratigraphic patterns to orogenies at the Asian margin. Similar themes are covered in papers on the Qaidam and Turfan basins in China, and several of the basins within Mongolia.

There are a few negative points to make. Many of the figures have reproduced rather poorly, with too much use of subtle grey shades by many authors. It is a shame that there is little correlation with areas in the former Soviet Union, nor are there any papers specifically on such areas. Correlations between China and Mongolia are also weak. Such cross-border studies must be a major direction for the future, and as far I as know there is no recent synthesis of the numerous foreland, strike-slip and rift basins that were active across central and east Asia through the Mesozoic. I would also have liked the editors to present a stronger summary of the main findings and themes in the volume. It's left unclear how the book has challenged or overturned existing large-scale models for the area.

Many of the papers arise out of hydrocarbon industry funding for research into remote basins such as Tarim in the late 1990s; now that the international oil industry has shifted attention away from these areas the pace of international academic involvement may also slow. This is a pity, but makes this volume a timely collection of research from a time of high activity. In the long run it may not matter. There are many Chinese and Mongolian authors to these papers, pointing to the top quality geologists in these countries. They will make increasing contributions to the international literature now that the political doors are open. There is no doubt that this volume will be a very useful resource for anyone studying the areas covered. As a whole, it does not greatly advance our understanding of tectonic or sedimentary processes.

Mark Allen

STEIN, S. & WYSESSION, M. 2003. *An Introduction to Seismology, Earthquakes, and Earth Structure*. xi + 498 pp. Oxford: Blackwell Science. Price £34.95, US $79.95 (paperback). ISBN 0 865 42078 5.
DOI: 10.1017/S0016756803318837

The most detailed knowledge of the interior of Earth and the deformation of the lithospheric plates is provided by seismology. The increased awareness of the need to engineer buildings to withstand earthquakes and plan for natural disasters, the search for natural resources such as hydrocarbons and water, and developments in instrumentation and computing have fuelled a rapid expansion and application of the subject in recent years. Seismology also means different things to different people; most will immediately think of the study of earthquakes or natural seismicity, but much current development in the subject is being driven by the application to natural seismicity of techniques developed in controlled source seismology, where man-made sources are used to generate seismic waves. Consequently, keeping pace with developments in all facets of the subject poses a considerable challenge. Trying to synthesize these developments into one textbook which will stand the test of time must rate as an increasingly impossible task, particularly with the developments in electronic publishing.

In their new textbook Stein & Wysession have attempted to provide an overview of the subject at an intermediate–advanced undergraduate to introductory postgraduate level. This is a difficult level to address, partly because different courses expect different levels of knowledge and it is difficult to ensure that coverage of the subject is to an even standard. However, I believe this book has managed to achieve its objective. The approach taken starts from first principles and relies heavily on mathematics to guide the arguments. This means explanations are well structured and, above all, logical.

It also means that this is not a reference text that one can just dip into for a piece of information. Each chapter repays careful reading. Most chapters begin with an explanation of the relevant theory and then progress to applying that theory to demonstrate how we have arrived at our present state of knowledge. Apart from a good understanding of mathematics, which would be central to any geophysics course, an introductory knowledge of physics and geology is also required to get the most out of this book. There is frequent cross-referencing to later chapters in the book for detailed explanations of some topics which can be avoided by being forearmed with some prior knowledge.

All the main fields of seismology are covered, although the emphasis is on the study of natural seismicity. Controlled source seismology is only briefly, but well, described in the chapter on 'Seismology and Earth Structure'. The seven chapters begin with an introduction followed by 'Basic Seismological Theory', which underpins the rest of the book. Then there are three chapters (Seismology and Earth Structure, Earthquakes and Seismology, and Plate Tectonics), demonstrating how seismology is used to understand the Earth and other planets. These chapters also include welcome diversions into such related subjects as plate vectors, heat flow and SAR interferometry. The book concludes with more theory on processing and modelling seismic signals and data in chapters on 'Seismograms as Signals' and 'Inverse Problems'. Finally there is an appendix covering mathematics requiring more space than there is room for in the main text. At the end of each chapter there are guided suggestions for further reading and a set of numerical/algebraic and computer-based problems. Suggested solutions are supplied to the odd-numbered problems only. There is a good, but not exhaustive, reference list and a useful index which makes cross-referencing between chapters easier. The book is clearly written, very well set out and illustrated throughout with well chosen examples from published work or figures drawn specifically for the book. I found a few typographic errors, although none serious enough to confuse.

In terms of the breadth of coverage and the wealth of information it contains this book should form the basis for most advanced courses in seismology and has to be rated as one of the best seismology texts available. In their preface the authors suggest that the approach of the book is not to focus on the current state of knowledge but instead to demonstrate 'how we seek to find out'. The real measure of whether this book achieves this aim is for how long and how often it continues to be used. It deserves to be around for some time.

Richard England

STANLEY, G. D., Jr. 2001. *The History and Sedimentology of Ancient Reef Systems.* Topics in Geobiology Series Volume 17. xviii + 458 pp. New York, Dordrecht, Boston, London, Moscow: Kluwer Academic/Plenum Publishers. Price Euros 103.55, US $95.00, £65.55 (hard covers). ISBN 0 306 46467 5.
DOI:10.1017/S0016756803328833

Presented in this volume is an eclectic mix detailing current thinking on different aspects of ancient reef systems. Although the reefs described are presented from a geological standpoint, the volume not only covers different aspects of reef evolution and their associated sediments, it also covers how different processes have influenced reefal development. Given the concerns over the current status of reefs at this time of global change, the volume is likely to be of interest to a wide audience, including marine biologists, ecologists and oceanographers, as well as geologists.

The volume contents are roughly arranged in chronological order, with each of the eleven chapters provided by different specialists. The first chapter introduces modern and ancient reef systems, discusses some of the terminology used in their description, and briefly reviews the history of reefs whilst stressing the importance of biological and physical interactions in their development. Some of the subsequent chapters evaluate reefal development during a particular time in geological history, either taking a global perspective (Phanerozoic trends, Precambrian to mid-Paleozoic, Cambrian, Jurassic) or focused on a more localized area (Permian of the Guadalupe Mountains, Triassic of Tethys, Cretaceous of the Caribbean). Other chapters concentrate on the processes of reef development and sedimentation (early calcification of reef organisms, biologically-induced carbonate precipitation, reefal frameworks) or factors influencing reef evolution (global climate and oceanographic change, mass extinctions, nutrients).

There is much to recommend in this volume, since it provides an insight into key questions concerning reefal development through time. In addition to the main themes of the chapters, other topics discussed include the changing role of reefal organisms and their response to local environmental and global change. With contributions from different authors, there is no central thoroughgoing theme to the volume. Instead each chapter allows a foray into different aspects of reef development, and all the elements when taken together give the volume as a whole a broad perspective. There are some drawbacks to the book. In some chapters there is a degree of overlap with topics covered in the Kiessling *et al.* SEPM volume *Phanerozoic Reef Patterns*. For the price of the book, one would expect the presentation and printing to be of high quality, yet many of the diagrams are poorly produced, and in a number of the photographs it is almost impossible to make out the salient features. In summary, although not intended as a textbook, this thought-provoking volume will certainly provide many insights to stimulate anyone with an interest in reefs.

Moyra Wilson

Reference

KIESSLING, W., FLÜGEL, E. & GOLONKA, J. (eds) 2002. *Phanerozoic Reef Patterns*. SEPM Special Publication no. 72. v + 775 pp. Tulsa: Society for Sedimentary Geology (SEPM).

SALTZMAN, B. 2002. *Dynamical Paleoclimatology. Generalized Theory of Global Climate Change.* International Geophysics Series Volume 80. xxix + 354 pp. San Diego: Harcourt–Academic Press (Elsevier Science). Price £46.95 (hard covers). ISBN 0 12 617331 1.
DOI: 10.1017/S001675680333883X

This book aims to take a dynamical systems approach to climate modelling. Instead of modelling global climate as a system in equilibrium, the approach is to allow for the variations in 'boundary conditions' over many different time scales. The relevant boundary conditions include such factors as atmospheric carbon dioxide levels, solar forcing (solar 'constant' changes and Milankovitch cycles), continental positions and elevations as well as sea level. The book considers in three parts: I, the documented nature of climate changes and adoption of a dynamical systems approach; II, the physics behind different parts of the climate system (especially atmospheric CO_2, ice sheets and oceans); and III, dynamical modelling at the time scales of plate tectonics, Milankovitch cycles and millennial-scale cycles.

I found the early section covering documented climate changes rather biased towards the Pleistocene with too much emphasis on ice volume changes as an indication of climate variation. Contradicting the text and a previous figure, Figure 3.2 shows no major glaciation in the Proterozoic or the Cenozoic (i.e. pre-Quaternary). Figure 1.2, a spectral plot of climate variability at scales of less than a day to more than a million years, is used repeatedly to justify treating the climate system behaviour as different at the plate tectonic-, orbital- and millennial-scales. However, though described as 'hypothetical and highly idealised' this plot is misleading. Long records of direct temperature measurements and isotopic records from ice cores and deep-sea sediments do not support the implied variance gaps in the spectrum of climate; rather small spectral peaks denoting periodic and quasi-periodic processes sit on top of dominant 'red noise' at all these scales.

Much of the text in the second part of the book, as well as the figures and equations, is dominated by symbols for processes in the place of words. With eight pages of symbols this makes the book difficult to read unless one is already working in the field. Much of the book involves adding more and more complexity (i.e. adding terms to equations) for each climate system being modelled. Yet there is little attempt to compare the model output when each refinement is added so how can a novice assess the usefulness of the added complexity? I also felt there was far too little comparison of model behaviour with observational data.

The last part of the book provides some very nice insights into modelling the three time scales of climate variability. For example, by treating carbon dioxide levels as decreasing linearly in the Pleistocene it is shown why, once a threshold of 250 ppm is passed, eccentricity forcing becomes important for ice volumes in the latter part of the Pleistocene.

The book is part of the International Geophysics Series and geophysicists would certainly feel more at home with the book than a 'soft-rock' geologist or environmental scientist. This is a pity because more interaction between observers and modellers might well produce less ambitious models. The book provides a comprehensive treatment of past modelling efforts and though I would have preferred a greater use of documented, especially pre-Pleistocene, climate variability, it provides clear indications of the limitations of modelling to date (e.g. the difficulty of estimating global fluxes and imperfect quantitative understanding of the biosphere in terms of the carbon cycle).

Graham P. Weedon