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BOOK REVIEWS

ALBARÈDE, F. 2003. *Geochemistry. An Introduction.* xiii + 248 pp. Cambridge, New York, Melbourne: Cambridge University Press. Price £65.00, US $100.00 (hard covers); £24.95, US $50.00 (paperback). ISBN 0 521 81468 5; 0 521 89148 5 (pb).
DOI: 10.1017/S0016756804219173

It is an enormous challenge to write an introduction to geochemistry these days. The discipline has become so diverse that any attempt to be completely comprehensive would yield a massive tome, doubtless beyond the pocket of the student audience at which it is aimed. I suppose that there are two approaches that could be adopted in pursuit of brevity: either skim the surface of the majority of topics and encourage further exploration of specialist texts, or expose the heart of the matter(s) and equip the reader to build outward from there. This book does the latter, quite beautifully. Its forthright numerical approach is refreshing and important. In my experience many students thrive on discursive science, but shy away from the maths. We must take every opportunity to remind them that lurking beneath discussion is unavoidable quantification. That's what science is about.

The book is organized into ten chapters and seven appendices, followed by very useful suggestions for further reading graded according to level of difficulty. The introduction outlines the breadth and complexity of modern geochemistry by giving pen-portraits of Na, Mg and Fe on their travels through the Earth system, an approach usefully reprised in the final chapter. Chapter 1 begins in the obvious and best place, the periodic table, and helpfully refers to high-quality web sites for some heavy-duty chemistry. It moves on to outline chemical bonding, deal with the various geochemical classifications, think a little about reservoirs and introduce radioactivity. From here we move into the general principle of mass conservation (Chapter 2), and see that this may be the key to many seemingly disparate geochemical problems from streamwater chemistry to crystal fractionation in lavas. Elemental and isotopic fractionation are described quantitatively, and the chapter ends with Rayleigh distillation in a nutshell. Already there are examples of what makes the book special (for me) – the insights into controlling details, such as zero-point energy and stable isotope fractionation. Chapter 3 is a short but elegant introduction to geochronology and the principle of radiogenic tracers, a topic returned to later in the book. Element transport is the subject for Chapter 4, advection and diffusion illustrated by reference to closure temperatures, and leading into chromatography theory whose wide application is noted, from mantle magmatism to groundwater flow and oceanography. Chapter 5 gets to the heart of geochemical systems: single then multiple reservoir dynamics and attendant implications for geochemical cycles.

The next three chapters work from surface processes involving the discussion of waters, through metamorphism in all its guises in the context of mineral reactions, to magmatism from the perspective of magma variability and crust–mantle evolution. Chapter 6 begins with a useful summary of fundamental concepts required for solution chemistry, and proceeds to apply them to weathering and erosion, marine chemistry and climate. Chapter 7 outlines diagenesis, hydrothermal reactions and metamorphism, but to my mind doesn't quite convey the wealth of information available on orogenic processes from detailed study of the chemistry of metamorphic minerals. In contrast, Chapter 8 takes a concise but rigorous look at melting in the 'solid' Earth and reviews implications for mantle convection. A challenge is issued to the 'canonical' view of continent growth, by ascribing a dominant role to plume magmatism rather than subduction.

Finally, a couple of side-steps are taken to conclude the book. After reviewing solar element synthesis, Chapter 9 puts the Earth succinctly into its Solar System context, and as mentioned above Chapter 10 takes ten major elements and outlines their geochemistry. The latter will be especially appreciated by students of biogeochemical cycles in which an overview of element behaviour is required. The appendices provide self-contained nuggets of mathematical detail or tabulated fundamental data, except for Appendix F which is a useful overview of analytical techniques (with a cracking aquatic analogy for the principle of isotope dilution!).

To summarize, this is an excellent textbook written by an excellent teacher. His ability to cut through the frightening complexity and breadth of modern geochemistry to the essence of the subject, to outline the underlying mathematics and then provide relevant quantitative examples, is enviable. So, even though the majority of my students may find parts of this book quite difficult, I will recommend it widely – the hardest bits are the most satisfying to understand, and we couldn't want for a more skillful guide.

Mike Fowler

BACON, M., SIMM, R. & REDSHAW, T. 2003. *3-D Seismic Interpretation*. x + 212 pp. Cambridge, New York, Melbourne: Cambridge University Press. Price £80.00 (hard covers). ISBN 0 521 79203 7.
DOI: 10.1017/S001675680422917X

3D seismic data have been referred to as the earth scientists' 'Hubble telescope'. The huge advances made by industry in imaging the subsurface using seismic waves in the last 15 years has meant that we are able to explore the subsurface in unparalleled detail. At one time it was the role of the geologist to take 2D cross-sections constructed from 2D seismic surveys and/or field observations and interpolate between these imperfect interpretations to bring the subsurface to life. Now it is possible to image whole river systems, rift valleys and parts of mountain ranges in three dimensions. The resolution of the data is such that the migration of ancient meandering rivers, the intermittent movement of faults, giant submarine landslides and the topography of ancient landscapes can be accurately mapped through geological time. More recently repeat surveys measuring physical properties over the same location (so-called '4D surveying') have been used to map the migration of fluids in the subsurface.

One of the fundamental paradigms of geology established by Lyell, 'The present is the key to the past', is now verifiable through the application of 3D data. The data show surface processes sculpting the landscape and producing sediment in

the way that has long been inferred. This same paradigm is now being turned into 'The present is the key to the future'. If we wish to know how landscapes can evolve through time there are now few better starting points than looking at the past record through 3D seismic data.

However, as with all techniques, 3D seismic imaging is not without its pitfalls. In their new book, Bacon, Simm & Redshaw begin by taking the reader through the processes of acquiring and interpreting seismic data, and rightly make no apologies for doing so. The key to any accurate, repeatable and verifiable interpretation is fully to appreciate the limitations of the data, the artefacts which provide traps for the ill informed and also the full scope of the information which can be recovered. Whether the reader is interpreting 2D or 3D seismic data there are basic skills and methods which should be learnt before the interesting task of extracting accurate spatial information from the data can begin.

After introducing the essential principles in the first two chapters the third deals with integration of well data with the seismic data. These data provide age and depth constraints on reflectors. Then the basic principles and advantages of computer-based interpretation of seismic data and the tools that are available are covered. Chapter 4 covers geological interpretation of the data. Most users of 3D seismic data could stop at this point; many do. The advantages of 3D imaging over conventional 2D data are sufficient to satisfy most users. However, exploration and particularly production of hydrocarbons makes use of a great deal of the amplitude information embedded in the seismic data. These data can be used to provide constraints on variations in seismic velocity of the subsurface, the fluid content of pore spaces and the elastic properties of the rocks. Armed with a knowledge of these parameters it is possible to 'invert' the data to generate estimates of the rock types (e.g. ratios of sand to shale, bed thicknesses, etc.) which are invaluable in planning a strategy for hydrocarbon extraction or CO_2 sequestration, or simply understanding the subsurface geology. These issues are dealt with in Chapters 5 and 6.

Once all this information is extracted from the data there comes the problem of displaying it. Until recently our view of any seismic data was constrained by the two-dimensionality of the paper plot or computer screen. However, advances in computing have meant that is now possible to view the full three-dimensionality of the data. This subject is reviewed by the authors who resist the temptation to show a range of images – perhaps sensibly since they don't always translate well onto the pages of a book. The real insight is only gained by rotating and viewing the subsurface from a variety of angles on a computer screen or from within a so-called 'HIVE', a full immersive visualization environment – virtual reality but without the virtual – in which the interpreter can literally walk through an image of the ancient subsurface projected within a specially designed room.

The final chapter of the book explains time lapse or 4D seismic surveying. It begins by considering the changes in physical properties of rocks as their fluid pressure or fluid content changes, thus building on the preceding chapters. This technique has not always been successful and the authors address this by reviewing the problems of repeatability in seismic surveying and the specialist processing required to overcome some of these problems. The chapter concludes with a well illustrated successful application of the method.

I found this book very easy to read. Complex concepts are clearly explained and only essential mathematics is included, which can be skipped over. In particular the chapters on amplitudes and inversion were particularly good and have not to my knowledge been adequately covered at the introductory level before. Each chapter concludes with a list of references which can be followed up if the reader requires more detailed information. The book is aimed at geologists and geophysicists who may be new to interpreting seismic data, and although titled *3-D Seismic Interpretation* there is much to be learned from within this volume about interpretation of other forms of seismic data (e.g. 2D and crosshole). At £80.00 this is not an inexpensive book, but for a comprehensive guide to getting the most out of seismic data it has few competitors.

R. W. England

PLADO, J. & PESONEN, L. J. (eds) 2002. *Impacts in Precambrian Shields*. Impact Studies Series. xiii + 336 pp. Berlin, Heidelberg, New York: Springer-Verlag. Price Euros 89.95 (+ VAT at local rate), SFr 149.50, £63.00, US $99.00 (hard covers). ISBN 3 540 43517 4. DOI: 10.1017/S0016756804239176

Around 200 sites where asteroids and comets have collided with the Earth are known on land and beneath the oceans. These impact scars vary in diameter from a few tens of metres to more than 100 km across, and range in age from a few thousands of years to more than 2 billion years old. Most impact sites are now just ghostly circular remnants in ancient eroded rocks, whilst a few are clearly visible as large, deep craters. This surviving record is the hard evidence against which predictions of the environmental effects of potentially catastrophic impact are compared. Estimates of the likelihood, frequency and consequences of impacts are gained from the impact record.

This book (edited by Jüri Plado & Lauri Pesonen) is the fifth publication resulting from the interdisciplinary scientific programme 'Response of the Earth System to Impact Processes' (IMPACT) of the European Science Foundation (ESF). This volume mostly reports significant results from the 4th workshop sponsored by the ESF IMPACT Programme, held in Lappajärvi, Finland in May 2000. From the 43 oral and 31 poster presentations at the workshop, 14 peer-reviewed papers were selected for this volume on the basis of originality and scientific value. The theme of the workshop 'Meteorite Impacts in Precambrian Shields' focused on the characterization of meteorite impact structures of all ages and sizes occurring in Precambrian shields (those stable parts of continents composed of Precambrian rocks with little or no sedimentary cover). Not surprisingly, Precambrian shields, together with platforms (collectively called cratons), are the areas of the world where most of the impact structures on Earth have been found. Because of excellent exposure, and target rocks with similar physical properties, shields allow for a diverse range of impact studies.

Contributions in this volume include detailed studies of the cratering record, particularly, but not exclusively, on the Fennoscandian shield (Abels *et al.*) where nearly 20 % of the world's craters have been identified. Refined considerations of cratering mechanics (Dence) based on field observations, theory and computer modelling are applied to craters on the Canadian shield. Impact-generated hydrothermal systems in the Popigai, Kara and Puchezh–Katunki impact structures are considered (Naumov), along with other detailed studies of the geology, geophysics, petrology and mineralogy of the Popigai impact structure (Masaitis; Pilkington *et al.*; Armstrong *et al.*). A detailed study of Zapadnaya (in the

Ukrainian Shield), another diamond-bearing impact structure, is given by Gurov *et al*. In other contributions, potentially useful tools to the identification and further characterization of impact structures, such as the geochemistry of soils (Boamah & Koeberl) and remote sensing (Wagner *et al.*) are applied to the Bosumtwi (Ghana) impact structure. Among theoretical considerations, numerical modelling of oblique impacts (Artemieva) suggests that tektite production should not be a rare phenomenon. Tektite production increases with low impact angles and increasing projectile velocity. The general absence of tektites in the geological record is attributed to the break-down of glass to clays in < 50 million years. Shuvalov considers modelling the effects of impacts into shallow seas. Sten Suuroja *et al.* study the geology and magnetic signature of the unusual, shallow marine Neugrund structure located in the Gulf of Finland. Tsikalas *et al*. establish a seismic stratigraphy for the impact-related deposits in the Mjølnir (Barents Sea) marine crater, and Kalle Suuroja examines the natural resources associated with the Kärdla (Estonia) impact structure.

Compilations of up-to-date papers focused on a particular subject, such as this, are essential to researchers in the field, and therefore to libraries. I guess you just have to wince at the price and pay it. Each contribution in the volume has a comprehensive list of references. Sadly, as with the previous contribution in the series, no index is provided. This is something that the editors of future publications must address. Or perhaps they are considering providing a series index which would be an excellent solution?

This volume, together with previous publications from the ESF IMPACT Programme, is building into an extremely useful, modern, interdisciplinary library of impact studies. Further volumes are eagerly awaited.

Alex Bevan

YOUNG, T. P., GIBBONS, W. & MCCARROLL, D. 2002. *Geology of the Country around Pwllheli. Memoir for 1:50 000 Geological Sheet 134 (England and Wales).* x + 151 pp. Keyworth: British Geological Survey. Price £35.00 (paperback). ISBN 0 11 884561 6.
DOI: 10.1017/S0016756804249172

Impose a rectangular grid of maps onto a country like Britain and there are bound to be some unlucky areas that contain considerably more sea than land. Such a geological map sheet is Pwllheli, on the south side of the Llŷn peninsula, North Wales. Fortunately this corner of Wales has a geological richness out of all proportion to its size. Precambrian melange and an intrusive complex are cut by the major Llŷn shear zone. Cambrian turbidites are overlain with spectacular unconformity by a near-complete Ordovician sequence comprising sediments and varied Caradoc magmatic rocks. Syngenetic and epigenetic mineralization and a varied Quaternary succession complete the geological picture.

This memoir is one of the last to be published by the British Geological Survey before the switch to briefer sheet explanations. It results from mapping and subsequent analysis not by BGS, but by a contracted team led by Wes Gibbons of Cardiff University. Together with the memoir for the even more thalassic area to the west (Gibbons & McCarroll, 1993), it provides an important transect across the northwestern edge of the Early Palaeozoic Welsh Basin onto the Irish Sea Platform. The quality of the science and its presentation are both high. Libraries with a run of BGS memoirs will want to complete their sets with this significant volume, which will be valued by devotees of Welsh geology.

Nigel Woodcock

Reference

GIBBONS, W. & MCCARROLL, D. 1993. *Geology of the country around Aberdaron, including Bardsey Island. Memoir for 1:50 000 geological sheet 133 (England and Wales).* Keyworth: British Geological Survey.

DOWDESWELL, J. A. & COFAIGH, C. Ó. (eds) 2002. *Glacier-Induced Sedimentation on High-Latitude Continental Margins.* Geological Society Special Publication no. 203. viii + 378 pp. London, Bath: Geological Society of London. Price £85.00, US $142.00; members' price £42.50, US $71.00; AAPG members' price £51.00, US $85.00 (hard covers). ISBN 1 86239 120 3.
DOI: 10.1017/S0016756804259179

The role of marine-terminating ice masses has received considerable attention, as an integral part of modern- and palaeo-oceanographic studies, including the impact of freshwater delivery on thermohaline circulation, processes of continental shelf erosion and supply of sediment to continental shelf, slope and deep marine basin environments.

This volume is a valuable new addition to the Geological Society Special Publication series, with a range of papers concerned with processes of glacier-influenced slope sedimentation, iceberg rafting and the evaluation of geomorphological evidence for reconstructing the dynamics of former ice masses. These are important in gaining a better understanding of contemporary glacier–ocean interactions and reconstructing sedimentation conditions for marine successions preserved in the geological record.

The volume opens with a useful introduction by the editors, highlighting recent advances in glaciomarine studies and providing a brief overview of the papers contained within. Eighteen papers follow which cover different aspects of glaciomarine processes in both hemispheres, although heavily weighted in the favour of the northern. For example, studies are focused on Canada, Alaska, Greenland, the North Atlantic, NW Britain, Norway and the Barents Sea region, while only a couple of papers deal with Antarctica. Given the scope of the topic, perhaps a separate volume more fully addressing southern high latitudes is required?

Having said this, the papers are not limited to studies of contemporary processes, covering a range of geological timescales, including examples from Late Oligocene and early Miocene successions (e.g. Hambrey *et al.*). Most are well illustrated, including some excellent colour figures. Perhaps one of the most striking features of the volume is the variety of methodological techniques referred to, including sequence stratigraphy, application of swath bathymetry and three-dimensional seismic data, geochemistry, high-resolution dating techniques and spectrophotometry. Papers engaging in submarine mass-wasting processes and dynamics (Elverhøi *et al.*) and shear mixing rates and processes (Talling *et al.*) will appeal to those interested in submarine slides and debris flows. Of particular note is the paper presented by Powell & Cooper, which provides a glacial sequence stratigraphic model for temperate glaciated continental shelves. This, along with other papers in the volume (for example those concerned with trough-mouth fans, e.g. Taylor *et al.*) should be of interest for petroleum exploration, as potential analogues for

formulating and testing depositional models for hydrocarbon plays.

Like many texts in the Special Publication series, for the individual the list price is a little expensive, but the members' price is more than acceptable. Overall, this volume should attract a wide readership, being not only of interest to those involved in contemporary glaciomarine research but also the wider geological community.

James Etienne

McCann, T. & Saintot, A. (eds). 2003. *Tracing Tectonic Deformation Using the Sedimentary Record*. Geological Society Special Publication no. 208. vii + 356 pp. London, Bath: Geological Society of London. Price £85.00, US $142.00; GSL member price £42.50, US $71.00; AAPG/SEPM/GSA member price £51.00, US $85.00; hard covers. ISBN 1 86239 129 7.
DOI: 10.1017/S0016756804269175

The sixteen papers in this volume represent a varied collection of studies on the interactions of tectonics and sedimentation in the geological record. It arises out of a session at the EUG meeting in Strasburg on this theme in 2001. Each paper on its own is an interesting case study, taking in Phanerozoic examples from as far apart as Siberia and the Andes. If there is any kind of regional focus, it is on Europe: twelve of the papers cover European basins and mountain ranges, including the Rhine Graben, Pyrenean forelands, the Alps, Apennines and Polish Carpathians. Only the introductory paper by the editors, Tom McCann and Aline Saintot, is a review of the processes involved, and this is mainly at the lithospheric scale of controls on basin formation rather than the details of fold/fault interaction with sedimentation. There is a wide variety of approaches in the other papers, from fairly conventional, fieldwork-based sedimentology and structural geology, to papers that utilize techniques as variable as regional plate reconstructions, subsidence modelling, anisotropy of magnetic susceptibility, geochemical and isotopic provenance signatures, analogue modelling and sequence stratigraphy. In each case, good links are made between the sedimentary record and the regional- or local-scale deformation. I single out the paper by Christophoul *et al*. on the northeast Pyrenees as a neat example of using stratigraphic patterns to infer the deformation record of a foreland basin.

Overall, this diversity is encouraging: there are obviously many ways geologists are tackling the links between tectonics and stratigraphy. But this diversity in areas and techniques covered makes it difficult to recommend paying up to £85 to buy this book, rather than dipping into it when your study area coincides with one of its papers. None of the techniques described seems to be novel, or a radical improvement on established practice. None of the papers is about a Precambrian example, and there is little that links a sedimentary record to hydrocarbon or mineral exploration and production. It has the classic feel of a conference volume: the editors did a great job promoting a useful session at the original meeting, and then received a collection of worthy but fragmented papers from the attendees. All of the papers are sensible lengths, well-illustrated and well-written; the editors may have been lucky with their authors, but I suspect that they have done a great job making sure that every contribution is of a high standard.

It is a shame that none of the contributions is about a tectonically active area. Perhaps the book's scope and title are carefully chosen, to emphasize long-term patterns of sedimentation rather than short-term responses to deformation. But this is surely where great progress is being made, as geomorphologists and seismologists interact with sedimentologists and structural geologists to unravel active examples of tectonics influencing sedimentation – and vice versa. Even allowing that the stated scope is not about neotectonic examples, it is a missed opportunity that there are not more review papers on the tectonic conclusions that can be made from stratigraphy. Perhaps there is an opening for a book that summarizes the stratigraphy of examples of forearc basins, half-grabens, pull-aparts and so on, and highlights the key features that are diagnostic of that particular tectonic setting. This would be similar to the approach of *Tectonics of Sedimentary Basins* eight years ago, but not all of the chapters in that volume described the basin fill in detail.

Mark Allen

Reference

Busby, C. J. & Ingersol, R. V. (eds) 1995. *Tectonics of Sedimentary Basins*. ix + 579 pp. Oxford: Blackwell Science.

Anthony, J. W., Bideaux, R. A., Bladh, K. W. & Nichols, M. C. 2003. *Handbook of Mineralogy. Volume V. Borates, Carbonates, Sulfates*. xi + 813 pp. Tucson: MDP Inc. Price US $130.00 (plus $15 shipping/handling charge in USA, £20 s/h outside the USA); hard covers. ISBN 0 9622097 4 0.
DOI: 10.1017/S0016756804279171

This book is the fifth, and final, volume of this encyclopaedic mineralogy. The first volume was published in 1990, and the subsequent volumes have appeared at regular intervals over the next 12 years. (The third and fourth volumes were recently reviewed in *Geological Magazine*, volume **136**, p. 703, 1999 and volume **138**, p. 223, 2001, respectively.) The final volume follows the same format as the rest of the set: species are arranged alphabetically by mineral name with one species per page. The essential data for each species is set out in a standard format under the following headings: Crystal Data, Physical Properties, Optical Properties, Cell Data, X-ray Powder Pattern, Chemistry, Polymorphism & Series, Occurrence, Association, Distribution, Name, Type Material, References. An account of the crystal structure of each species is not given, although reference to one, where it exists, is included. The locality data is very well researched and up to date, and for the reviewer this aspect of the work is particularly useful. Overall, the *Handbook of Mineralogy*'s format is well suited for uncommon and rare species but less satisfactory for common or important species. There are several shortcomings to the format: specific reference to the data sources is not given nor is there any form of chemical index. There is, however, an index to all species covered in the work at the end of the fifth volume. The *Handbook of Mineralogy* is a very fine reference work printed on high quality acid-free paper and well bound in a strong cloth binding.

The series covers 3613 mineral species arranged in five volumes; it is a testimony to the authors' dedication that they have completed the publication of this enormous task in 13 years. All five volumes are currently in print and a complete set costs US$557, but members of the Mineralogical Society of America can obtain the volumes at a discount though their Society.

Who should buy this set? There are currently three major mineralogical compendia in print: *Dana's New Mineralogy* published in 1997 (reviewed in *Geological Magazine*, volume

135, p. 723, 1998), *Strunz Mineralogical Tables* published in 2001 (reviewed in *Geological Magazine* volume **140**, pp. 368–9, 2003) and the *Handbook of Mineralogy. Dana's New Mineralogy* has the advantage that it is a single-volume work and the treatment of the silicate minerals is particularly fine. The main strength of the *Handbook* is the detailed occurrence data, but this information is mainly of interest to museum curators and advanced amateur collectors. For a research mineralogist, *Strunz*'s crystallographic data and tabular format are very useful, but the lack of physical constants is a drawback. University libraries should consider having *Strunz* and either *Dana's New Mineralogy* or the *Handbook of Mineralogy.*

Allan Pring

References

GAINES, R. V., SKINNER, H. C. W., FOORD, E. E., MASON, B. & ROSENZWEIG, A. 1997. *Dana's New Mineralogy*, 8th ed. xlv + 1819 pp. New York, Chichester: John Wiley & Sons.

STRUNZ, H. & NICKEL, E. H. 2001. *Strunz Mineralogical Tables. Chemical Structural Mineral Classification System*, 9th ed. ix + 870 pp. Stuttgart: E. Schweizerbart'sche Verlagsbuchhandlung.

FORTELIUS, M., KAPPELMAN, J., SEN, S. & BERNOT, R. L. (eds) 2003. *Geology and Paleontology of the Miocene Sinap Formation, Turkey.* xiii + 409 pp. New York: Columbia University Press. Price US $95.00 (hard covers). ISBN 0 231 11358 7.
DOI: 10.1017/S0016756804289178

Book-length treatments of a single formation and its fossils are usually too large and expensive to publish, and don't have enough readers to justify the expense. Such is not the case with this volume, however, which carefully documents a very important unit, the Miocene Sinap Formation of Turkey. Not only is it one of the thickest and most continuous records of the middle and late Miocene from 15 to 5 Ma, but the Sinap Formation is famous for the fabulous mammal fossils that it yields. These include hundreds of specimens from nine orders of mammals, including the Miocene ape *Ankarapithecus*. In addition, the Sinap fauna provides an important link between the handful of well-known Miocene faunas of the Middle East (such as Maragheh in Iran), Greece (the famous Samos fauna), and the well known faunas of the Siwaliks of Pakistan and many localities in the Miocene of Europe. Consequently, Sinap contains both the familiar (rodents, carnivores, horses, rhinos, ruminants, and pigs) and the unfamiliar, such as the Proboscidea and the apes (which migrated out of Africa just before 15 Ma) and the aardvarks (still known from only a handful of fossils), and one of the oldest known Old World camels, which migrated from North America around 6 Ma.

The first two chapters detail the geology and chronology of the formation, including detailed magnetostratigraphic sections and ^{40}Ar–^{39}Ar dates, which give us a high-resolution chronostratigraphy for most of the fossils, and allow precise correlation with the well-dated records in Africa, Pakistan, and Europe. The remaining 14 chapters by a variety of specialists describe the fossil mammals from the Sinap Formation, including a chapter each on insectivores, primates, lagomorphs, carnivores, aardvarks, two chapters on murid, gerbillid, and spalacid rodents, three chapters on the horses and rhinos, and three chapters on artiodactyls (pigs, camels, and ruminants).

In this day and age of declining palaeontology budgets, disappearing positions, reduced access to publications, and inadequate descriptions and illustrations of fossils, it is a pleasure to see that detailed monographic studies like this are still being published. Even if it weren't the bearer of glamorous fossils like *Ankarapithecus* that please the anthropology audience, publication of such detailed studies is still essential if palaeontology is going to have a reliable and well-documented 'data base' for the taxon counters to mine their data and feed their computers. This book is not only important, but it is nicely produced, with a pleasant design and clear illustrations and photographs. In an ideal world, every important fossil-bearing formation would have an up-to-date geology published, and all of its fossils carefully analysed and documented – but we are a long way yet from reaching that ideal world when the barriers to publication are so high. Fortunately, with the publication of this volume, we have detailed documentation of one crucial formation and its faunas that, when combined with the recently published analyses of the Siwaliks, Samos, and western Eurasian mammalian faunas, provides us with a detailed record of faunal and climatic change that will be of interest to geologists, palaeontologists, and anthropologists.

Donald R. Prothero

IKAN, R. (ed.) 2003. *Natural and Laboratory-Simulated Thermal Geochemical Processes*. viii + 398 pp. Dordrecht, Boston, London: Kluwer Academic Publishers. Price Euros 148, US $145, £93 (hard covers). ISBN 1 4020 1344 2.
DOI: 10.1017/S0016756804299174

This book contains ten papers from a range of international contributors covering many aspects of thermal geochemical processes, both in the laboratory and in nature. The papers mainly take the form of reviews, covering the following topics: petroleum in hydrothermal systems, thermal cracking of petroleum, thermochemical reactions of coals, thermal transformation of soil organic matter, pyrolysis of oil shales, formation of young kerogen, geothermal energy, differential thermal analysis, thermal analytical methods in organic geochemistry, and dissipation of thermal energy on the early Earth. The contributions comprise a rather eclectic mix, and are not presented in a logical order. The book would have benefited from an Introduction where the focus of the individual papers could have been broadened out within the overall theme, and links between the chapters highlighted. It is also disappointing to note a number of typographic, labelling and other minor errors that should have been picked up under review or in the editorial process, neither of which appears to have been effective in many cases. In places the figures are extremely poorly reproduced, and the book as a whole gives a very strong impression of variable quality.

The book is targeted at research scientists and students in the field of thermal geochemical processes, but as the ten papers cover a wide range of topics I expect that many of the potential readership may only find one or two contributions to be of direct relevance to their research. Nevertheless, all Earth Scientists will find material of interest in this book, the reviews providing useful entry points into the literature of the individual topics. As such, the book will be a useful addition to many libraries.

Paul Farrimond

KNOLL, A. H. 2003. *Life on a Young Planet. The First Three Billion Years of Evolution on Earth.* x + 277 pp. Princeton, Chichester: Princeton University Press. Price £19.95 (hard covers). ISBN 0 691 00978 3.
DOI: 10.1017/S0016756804309179

Earth history is divided into two great parts: an initial four billion years of 'cryptozoic' pre-Cambrian time, followed by the half billion or so years of the Phanerozoic. With its conspicuous fossil record documenting both time and evolutionary trajectories it is of course the latter bit that attracts the attention of most palaeontologists, but any real understanding of life on Earth requires a substantially longer view. Indeed, the premise of *Life on a Young Planet* is that the Phanerozoic is sufficiently familiar to ignore, at least for the moment. The real question is how our modern world of macroscopic organisms came into being, and why so late in the day?

Life on a Young Planet offers an engaging and authoritative tour of all the big issues in pre-Phanerozoic biology, from the origin of life to the accumulative evolution of eukaryotes, multicellularity and animals, linked together by two overarching and compelling themes. The first is simply that the study of early life is necessarily, and wonderfully, a multidisciplinary pursuit. Fossils offer a glimpse of early organisms, but increasingly the useful data are drawn from the fields of molecular phylogenetics, developmental biology, microbial physiology and isotopic geochemistry. The second is that evolution of life on Earth is linked directly to the nature and evolution of the planet itself – that planetary contingencies have played a significant role in deriving the modern biosphere.

This 'geobiological' approach to understanding evolutionary history is assuredly the way forward. The oxygen-rich makeup of our current atmosphere, for example, is not simply a consequence of oxygenic photosynthesis, but oxygenic photosynthesis combined with the geological means of isolating its two principal products. But do such inter-relationships account for more localized phenomena, in particular those that define the Proterozoic–Phanerozoic boundary? In *Life on a Young Planet* Andy Knoll champions both the general and specific cause, arguing that the age of visible life was induced by a combination of increased oxygen levels, severe glaciation and mass extinction. In this view, bilaterian animals evolved 'early' but were constrained to microscopic dimensions due to limited oxygen availability. Increased tectonic activity through the Neoproterozoic not only supplied the necessary fillip of oxygen (through the enhanced burial of organic carbon), but also the impetus for global glaciation (through the overall drawdown of atmospheric CO_2). Finally, extirpation of the terminal Proterozoic Ediacaran macro-fauna, via some unresolved perturbation, provided the ecological opportunity for the Cambrian explosion of bilaterians.

It's an intriguing story, but far from the final word. Where, for example, are the predicted pre-glacial micro-metazoans? Small size offers no obvious refuge from fossilization – quite the opposite, in fact, as illustrated by the diversity of Neoproterozoic micro-fossil *Lagerstätten*. Moreover, atmospheric oxygen levels appear to have been substantial (as much as 15 % of present values) for the past two billion years, increasing to at least 20 % PAL by *c.* 750 Ma. Irregardless of extensive shallow-water oxygen (and nutrient) oases, such levels are more than enough to support a range of both micro- and macroscopic animals today – why not in the Proterozoic? The oxygen-limitation model further assumes that gas exchange took place solely via integumentary diffusion, but surely even the earliest bilaterians were capable of differentiating basic circulatory systems and/or respiratory organs? Like Knoll, I have also yet to hear a compelling hypothesis for how glaciation might have contributed directly to contemporary evolutionary phenomena, but I am much more skeptical about invoking Ediacaran mass extinction as the final hurdle to the Phanerozoic. Whatever it was that Ediacaran organisms did for a living, they certainly were not holding bilaterians at bay through ecological incumbency or competitive exclusion.

That the Proterozoic–Phanerozoic transition witnessed a remarkable variety of tectonic, climatic, biogeochemical and evolutionary perturbations is not in question, nor indeed the fact that many, even most, of these phenomena are likely to be inter-related. However, I do think it is premature to polarize them all as geological cause and biological effect. Some are no doubt merely coincidental, while others are better interpreted as the *consequences* of evolutionary innovation rather than its cause. In the modern oceans, for example, metazoans comprise some 50 % of marine biomass and have a profound, if poorly understood, impact on biogeochemistry – the evolution of such organisms must have left its mark on contemporary climate and ocean chemistry (Butterfield, 1997). Indeed, the real distinction between the two great parts of Earth history is the degree to which biology controls and defines environment. The eventual triumph of 'progressive' biological environments undeniably owes much to its physical underpinnings, but the proximal cause of the Phanerozoic is most likely to be found among biological contingencies, not least the evolution of bilaterians.

N. J. Butterfield

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BUTTERFIELD, N. J. 1997. Plankton ecology and the Proterozoic–Phanerozoic transition. *Paleobiology* **23**, 247–62.

BARNES, J. W. & LISLE, R. J. 2003. *Basic Geological Mapping*, 4th ed. Geological Field Guide Series. xi + 184 pp. Chichester: John Wiley & Sons. Price £15.99 (paperback). ISBN 0 470 84986 X.
DOI: 10.1017/S0016756804319175

The Geological Field Guide Series has been a reliable and affordable resource for aspiring geological mappers – and more experienced practitioners than might admit so – for more than two decades. Mapping technique evolved fairly slowly during the first three editions of *Basic Geological Mapping* (1981, 1991 and 1995), requiring only modest amendment to this soundly written book. However, since 1995, GPS (Global Positioning System) devices and digital cameras have become more portable and less expensive for field use, and drawing and GIS (Geographic Information Systems) software more widely available for preparing maps and report figures.

John Barnes has wisely enlisted Richard Lisle to help reflect these and other advances (a few traditionalists might prefer to see the last word in quotes). Lisle's influence is also apparent in extra advice on using structure contour to fix contacts, on plotting down-plunge profiles and on cleavage–bedding relationships. There are also some new photos and an extra sample notebook page. Most, though curiously not all, of the text has been recast in gender-neutral language. Many of the diagrams have been allowed more space on the

page but, disappointingly, the quality of the photographs is markedly worse than in the third edition. The page count has increased by 40% for a price comparable to the third edition.

The fourth edition of *Basic Geological Mapping* remains a highly recommended buy for undergraduate geologists and the libraries that cater for them. The new information on the use of GPSs and digital cameras will probably suffice until a fifth edition. I am less confident though that the passing reference to computer-based methods of producing final maps, sections and reports will see the book through another ten years.

Nigel Woodcock

BRANNEY, M. J. & KOKELAAR, P. 2003. *Pyroclastic Density Currents and the Sedimentation of Ignimbrites.* Geological Society Memoir no. 27. viii + 143 pp. London, Bath: Geological Society of London. Price £65.00, US $108.00; GSL member price £32.50, US $54.00; AAPG/SEPM/GSA member price £39.00, US $65.00; hard covers. ISBN 1 86239 124 6.
DOI: 10.1017/S0016756804329171

Ignimbrites are very common in subaerial volcanic successions, both ancient and modern, and are now recognized as the deposits of hot-gas-supported pyroclastic density currents generated by explosive eruptions. They are important not only because they are common – some of the largest must have been generated by eruptions more devastating than any yet witnessed, with worldwide impacts on climate and the environment. The textures and lithofacies characteristics commonly found in ignimbrites are, however, diverse. Precisely what goes on in pyroclastic density currents to produce that diversity has been puzzling volcanologists for decades. *Pyroclastic Density Currents and the Sedimentation of Ignimbrites* explores in detail the physical processes responsible for ignimbrite formation. The authors argue that deposition is primarily controlled by processes that operate in a flow-boundary zone at the base of the pyroclastic density current. This idea was introduced to volcanologists by R. V. Fisher in the 1960s (Fisher, 1966) but received little attention. A similar concept has guided research on turbidity currents and is widely and very effectively used in sedimentology. Michael Branney and Peter Kokelaar have adapted and refined the concept in this memoir, providing a comprehensive, detailed, rigorous explanation that builds on but also goes far beyond Fisher's (1966) original idea.

There are six main chapters. The first chapter defines the aims, gives an overview of relevant recent research and introduces central concepts relating to pyroclastic density currents. The second chapter reviews information on the nature and behaviour of pyroclastic density currents, using scant data gleaned from observations, various numerical models, experiments and analogy with other kinds of density currents. The third chapter focuses on particle support processes likely to be important in pyroclastic density currents. This subject is important and complicated because a very wide range of particle sizes, shapes, densities and temperatures, and an unusual interstital fluid (dusty gas), are involved. In Chapter 4, deposition is considered in detail, dealing with steady, unsteady, and non-uniform currents. The emphasis is on the nature of the flow-boundary zone and how that affects the aggrading deposit. Chapter 5 offers a framework for describing the field characteristics of ignimbrites and interpreting those characteristics in terms of the nature of the flow-boundary zone of the parent current. This chapter is particularly valuable in providing systematic terms and facies codes for common textures found in ignimbrites. The sixth chapter explores the lateral and vertical facies variations in whole ignimbrites in an attempt to reconstruct current dynamics, that is, the spatial and temporal variations in current conditions, and links to deposition, non-deposition, and erosion. Much of this chapter is speculative – the authors have selected common vertical or lateral facies variations, and shown how they could be interpreted in terms of the flow-boundary zone conditions, in many cases as an alternative to other conventional interpretations.

The text is well written and complemented by numerous carefully prepared figures and photographs that greatly enhance its impact. The standards of presentation and editing are extremely high.

This memoir is set to become a benchmark publication in physical volcanology and the starting point for future research on pyroclastic density currents. It will have an important educative role for graduate students and researchers embarking on studies involving ignimbrites, and can serve as an excellent summary of the physical processes relevant to sedimentation from pyroclastic density currents. Perhaps its most valuable contribution is the application of the facies approach to ignimbrites. This approach has been in place in sedimentology for some time and has greatly facilitated description and discussion of textural variations. In my opinion, this memoir is essential reading for anyone serious about explosive eruptions, pyroclastic density currents and ignimbrites.

Jocelyn McPhie

Reference

FISHER, R. V. 1966. Mechanism of deposition from pyroclastic flows. *American Journal of Science* **264**, 350–63.

GLUYAS, J. & SWARBRICK, R. 2003. *Petroleum Geoscience*. xv + 359 pp. Oxford: Blackwell Publishing. Price £37.50 (paperback). ISBN 0 632 03767 9.
DOI: 10.1017/S0016756804339178

Petroleum geoscience is essentially about developing and using technology for competitive advantage in economic decision making, the associated scientific concepts being freely available in the literature (although commonly requiring an imaginative leap in applying their relevance). Utterly critical in this is the ability to acquire and process seismic data of a quality allowing quantitative calibration to attributes of rock properties, pore fill and facies geometry as controlled by well data and basin modelling.

The authors of this imaginative text never really get to grips with this reality. Although the geological concepts are treated adequately (seal integrity, overpressures) to rather well (source rock maturation, reservoir quality), the technologies ('tools') comprise only 12% of the text and receive treatments varying from barely adequate (wireline logs) to totally inadequate (geophysics). In particular, reflection seismic is disposed of in six pages without any references and with precious little physical explanation: the summary of seismic processing gives no reasoning as to *why* such operations are desirable and does not even mention such fundamentals as polarity, phase and the mid-point/depth-point distinction. When, later in the book, readers are introduced to reservoir description from seismic data this means that they encounter amplitude-versus-offset without knowledge of its physical basis, and when they meet the use of porosity/seismic interval

velocity correlation it is without knowledge of how such velocity is derived. Many of the seismic illustrations are dispiritingly poor.

The book is structured to show the use of geoscience at the various sequential stages of exploration, appraisal and production development. The idea makes for a clear business-oriented narrative but results in splitting of the source–reservoir–seal trilogy and some repetitions from the tools chapter (e.g. biostratigraphy). In compensation the presentation of geological concepts and parameters is often succinct, discursive and fully up to date. No topic of consequence is omitted. The link to reservoir engineering is commendable and well handled as is the presentation of risk assessment. Less felicitous is confusion of water depth and relative sea level in the uncritical Exxon-flavoured account of sequence stratigraphy, confusion of closure and trap concepts and failure to set hydrocarbon migration in a rigorous framework of fluid potential.

Value for money on a per page basis is good, probably aided by there being no diagrams in colour. The downside of this is that some greytone figures are poor to unacceptable. There is a full index and a comprehensive list of references which might have benefitted from annotation distinguishing the essential from the supplementary.

Arguably the best parts of the book are the sixteen case histories, making up 27% of the text: concise, very readable and informative explanations of the mind sets and practical realities required to apply concepts and technologies and to recognize their pitfalls in a changing world of politics and economics. They can be strongly recommended to all students considering a career in the petroleum industry, although the concept that Fahud 1 drilled a hanging wall was not the outcome of Fahud 2, but rather the reason for drilling it! Indeed the book might well serve as a primer for aspiring petroleum geoscience managers, but it is not self contained to the point that it will satisfy those with a bent for the technical line. It is likely to prove a uniquely useful supplement for course work and should be available in all good libraries.

David James

AMEEN, M. S. (ed.). 2003. *Fracture and In-Situ Stress Characterization of Hydrocarbon Reservoirs*. Geological Society Special Publication no. 209. vi + 216 pp. London, Bath: Geological Society of London. Price £60.00, US $100.00; GSL member price £30.00, US $50.00; AAPG/SEPM/GSA member price £36.00, US $60.00; hard covers. ISBN 1 86239 130 3.
DOI: 10.1017/S0016756804349174

Fractures play an important role in many hydrocarbon reservoirs. They influence the permeability, porosity and geomechanical properties, and, hence, affect reservoir performance. The realization that the petrophysical properties of a reservoir may be coupled to geomechanics means that reservoir behaviour may be stress sensitive. Few publications discuss this important link and this volume provides a much needed, wide-ranging and up-to-date collection of papers on the subject.

The simplest way to couple fracture behaviour and stress is to calculate the stress on the fracture plane and relate this to conditions for dilation and/or slip. This approach led to the concept of a critically stressed fracture, developed by Mark Zoback, Colleen Barton and colleagues to explain why some fractures flow and others do not. In this volume, Steve Rodgers provides a very clear and concise account of this approach, which he applies to zones of high transmissibility in a borehole from Sellafield, UK. Chanchani, Zoback & Barton provide another good example of the application of this concept to production of a hydrocarbon field in California.

Two sorts of information are required in these applications: (a) fracture distribution, orientation and attributes, and (b) a measure of the *in situ* stress. In a series of papers, forming much of the book, the problem of characterizing fractures from well data, seismic, and regional geological studies is discussed. Wells provide direct information about fractures, but sample only a tiny volume of the reservoir. Hence the need to condition fracture models using available seismic data, either by using seismic attributes to map fracture properties or by correlation of features of seismic horizons, such as curvature, with fracturing. In a neat contribution David Yale points to the important feedback between fracturing and stress: regional stress induces fault slip that, in turn, modifies local stress.

Particularly interesting is the more 'dynamic' approach of using 4-D (multi-temporal) seismics and microseismic activity to monitor changes in the reservoir that may relate to the flow of fluids. Geological evidence for the paths of fluid flow in fractures is discussed by Jolly & Cosgrove.

The recognition of stress-sensitivity of fractured reservoirs raises many challenges in terms of modelling (simulation) of flow and management of hydrocarbon recovery. Smart *et al.* provide a concise review of many of these issues. The problems of translating the complex behaviour of such reservoirs into viable simulations and estimates of uncertainty are discussed and solutions offered to various aspects of these problems. The influence of fractures over a wide range of length scales requires careful treatment in reservoir models, either through effective representation in continuum models or by explicit representation of important conductive features. A key challenge is the development of simulators that are capable of dealing with multiphase flow in fractured reservoirs and that can represent the main features of dispersion and fingering of flow and that, ultimately, will produce reliable history matching to observed production.

This book provides a good summary of the state-of-the-art in the analysis of fractured reservoirs and explores new insights to the issues raised. Understanding of the complex, coupled behaviour of such systems and their response to various production strategies represents a major challenge for the future. Many important 'stepping-stones' to an understanding are explored and the book provides a much needed addition to the literature.

David J. Sanderson

BORLEY, L. (ed.) 2003. *Celebrating the Life and Times of Hugh Miller. Scotland in the Earth 19th Century. Ethnography and Folklore, Geology and Natural History, Church and Society*. 352 pp. Edinburgh: Cromarty Arts Trust and Elphinstone Institute (obtainable from the Cromarty Arts Trust, 4 Belford Place, Edinburgh EH4 3DU, UK). Price £13.50 plus £2.50 p+p in the UK (paperback). ISBN 0 906265 33 9.
DOI: 10.1017/S0016756804359170

This publication is the report of a conference held in 2002 to mark the bicentennial of the birth of Hugh Miller, a native of Cromarty, Scotland. It contains some 26 individual papers gathered under the broad themes of Ethnography

and Folklore, Geology and Natural History, and Church and Society.

Hugh Miller is hopefully a name that is still familiar to most geologists. He is generally portrayed as the self-educated stonemason who, despite being removed from the emerging science of geology by both education and distance, made a number of independent geological and palaeontological discoveries. But in reality it was through his abilities as a campaigning writer that he first came to a wider attention. This growing literary fame led to his move to Edinburgh to become the editor of *The Witness* in which he campaigned against the Church of Scotland and its patronage system. This ultimately led to the establishment of the Free Church. It was during his time in Edinburgh that Miller wrote some very popular geological books, notably *The Old Red Sandstone*.

The first paper in the Geology and Natural History section of the book is by Torrens and discusses the impact that William Smith's ordered geological column for England had on Scottish geology. Miller became part of this debate in discussing how the new stratigraphy explained the failure of attempts to locate coal in both the Old Red Sandstone and Jurassic of Cromarty. This is then followed by a discussion of Hugh Miller's geological collection by Knell & Taylor and its significance to Miller in the context of his times.

We are then treated to two contributions on fossil fish. The first by Trewin discusses the iconic ORS fish *Pterichthyodes* both from Miller's perspective and then a modern treatment of the fossil. The paper by Janvier is equally informative in covering very succinctly the history of our understanding of the fish known to Miller and their significance for evolutionary understanding. We are next taken on a trip to the Isle of Eigg by Hudson and a detailed appraisal of Miller's geological observations as described in *The Cruise of the Betsy*.

The rise of affordable microscopes in the development of geology is the subject of the contribution by Morrison-Low & Nuttall. They discuss Miller's geological use of microscopes, although most geologists would not be impressed by his hand-lens technique (Fig. 1, p. 222). This is followed by a short but useful summary by Collie of Miller's interaction with the geological establishment as represented by Agassiz and Murchison.

The final strictly geological paper is by O'Conner and covers Miller's contribution to the popularization of geology. An interesting concept was the belief that stimulating the working-man with a spectacle would somehow encourage them to swap Chartism (and civil unrest) for an interest in geology and ultimately a bettering of their situation.

However, it must be noted that this book is not a life of Hugh Miller (excellent accounts are written elsewhere) but rather a discussion of the contemporary issues in which he was involved. As such its geological content is provided less for the contemporary geologist, but is of rather more significance for students of early nineteenth century Scotland. However, for anyone interested in the history of geology it is clearly a useful volume and especially so for placing the advances in geological knowledge within an appropriate nineteenth century time context.

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