Book Reviews / Critique

Book Reviews

Coccolithophores

Edited by Amos Winter and
William G. Siesser
Cambridge University Press
1994, 242 p., US$150.00

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In my office, I have numerous microfossils displayed around the walls. Much to my chagrin, I can predict that visitors will be excited more by the coccoliths than by my cherished foraminifera. I am forced to admit that, at least among non-foraminiferologists, these incredibly intricate, overdesigned, gear-like skeletons (coccoliths), only microns in size, do in fact perk people's casual curiosity more than foraminifera. This book on living coccolithophores continues to rub salt in the wound. It was assembled with the goal of being a multidisciplinary book on coccolithophores and it succeeds as a high quality, comprehensive treatment of these fascinatingly elaborate and important marine organisms. The book consists of 11 chapters which cover history, ultrastructure, ecology, morphology, function, classification, biogeography, oceanography, sedimentation, and isotope geochemistry of coccolithophores. At the heart of this book is a well illustrated atlas-style chapter showing 140 modern species which account for 70% of all living species. The SEM micrographs are generally superb. For those with appreciation for historical background, the book begins with an interesting account of scientific progress and improvements in technology that led to our present day understanding of coccolithophores.

As the editors point out, coccolithophores have been the focus of much study in recent years because they are a major component in many of the Earth's biogeochemical systems. Their huge biomass with rapid turnover capability makes them critical elements for understanding global climatic change and the biogenic carbonate flux. Coccolithophores, for example, produce dimethyl sulphide which is a nucleation molecule for cloud formation. They are abundant in the centres of warm, nutrient-poor, subtropical oceanic gyres, but they are productive and diverse at higher latitudes, as satellite photographs of the oceans have shown highly reflective white plumes caused by coccolithophore blooms. They reach extremely high abundances in these blooms, estimated at 10 million specimens per litre. Of interest to geologists and paleontologists is the process of coccolith calcification, which results in coccoliths contributing 20% to 40% of all biogenic calcium carbonate.

One of the most intriguing aspects of coccoliths is their morphology. The descriptive morphology of coccoliths is treated in a clear and straightforward manner, but I understand that coccolith structure and crystallography has been revised thoroughly in recent years through the activities of the International Nannoplankton Association. There is still great deal of speculation over the fundamental purpose of the intricate coccolith morphology. Most theories centre around protection and flotation regulation. From my perspective, coccoliths appear to be shaped like turbine vanes or water wheels with surface area maximized. Could this form have the function of catching water currents and tumbling the organisms through water masses, thus keeping them afloat in search of nutrients? For a more expert examination of the functional morphology of coccoliths, Chapter 5 is highly recommended.

The surface area of the coccolithophore relative to its mass is so great that it takes tens of years for one to settle to ocean floor. We know that coccolith sedimentation follows biogeographic distributions and therefore settling rates must be relatively rapid, in part to avoid dissolution. The answer to this dilemma lies in the fact that coccoliths settle mostly in faecal pellets from copepods and other suspension feeders, and are preserved only in certain anoxic and low oxygen zones. As anyone familiar with the white speckled shales of the Western Interior Cretaceous knows, this is how coccoliths are preserved as valuable components of the geological record.

Coccolithophores is of obvious use to paleontologists and paleoceanographers. It also merits the attention of sedimentary geologists, particularly since coccolith-stuffed faecal pellets are a major component of petroleum source rocks of Jurassic and Cretaceous age.

Sequence Stratigraphy of Foreland Basin Deposits

Edited by J.C. Van Wagoner and
G.T. Bertram
American Association of
Petroleum Geologists
Memoir 64
1995, 487 p., US$120.00 (member)
US$180.00 (non-member)

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AAPG *Memoir 64* is different from many of its predecessors about sequence stratigraphy. There is more of a focus on data and examples, and less on terminology and definitions. Many arguments for and against sequence stratigraphy during the

past 10 years focussed on the significance of eustasy relative to the formation of sequences, and whether or not concepts formulated from passive continental margins were transferable to other basins. Additionally, more attention seemed to be given to bounding surfaces than to the rocks with the bounding surfaces in many of these earlier publications.

Memoir 64 corrects some of these past shortcomings in focussing on a variety of outcrop and subsurface examples from the foreland basin of western North America. While there is still the litany of definitions and terminology, as with many new concepts, the reader does have a choice. One can choose to get caught up in the debate about terminology and its application, or one can look at the rock descriptions and interpretations, and draw one's own conclusions. Depending on which choice is made, you may have a different opinion about the merits of *Memoir 64*.

The memoir is an outgrowth of an AAPG-sponsored field trip associated with the 1991 AAPG annual meeting in Denver, and which was led principally by Exxon people. Given the Exxon influence, it may be surprising that any individuality remains between chapters. The blend of papers from other organisations helps, but the variety of interpretations in the memoir also indicates that there has been some evolution of thought within Exxon.

Chapter lengths vary from 10 to almost 90 pages (average about 30 pages) with numerous fold-out cross sections, maps, diagrams, and photographic images. With one exception, each chapter focusses on the real basis of sequence stratigraphy; the rocks together with their bounding surfaces.

The organization of the contents is somewhat eclectic. There are four chapters dealing with the Book Cliffs and which are in no apparent order, and in their midst are several unrelated chapters from different geographic areas. The last chapter by Pemberton and MacEachern, which deals with the application of ichnology to sequence stratigraphy in foreland basin deposits, seems like an afterthought.

The first chapter, by Milton and Bertram, presents an interesting conceptual discussion about play types and controls on topset formation which is linked to topset area, rate of relative sea level change and sediment supply. Unfortunately, it does not fit with the memoir's titled theme, "outcrop and subsurface examples."

A chapter by Krystinik and DeJarnett examines several sequences and sequence boundaries from the Western Interior Seaway within a chronostratigraphic framework for the Upper Cretaceous (Campanian–lower Westphalian), and challenges the regional implication of sequence boundary continuity. They note that there are a variety of stratal stacking patterns along strike within time equivalent deposits, and that sequence boundaries are not regionally correlative. They conclude that while some parts of the Western Interior Seaway parallel global sea level variations, other parts are tectonically overprinted, thus explaining the regional differences.

Of the four chapters devoted to the Book Cliffs, three examine the facies architecture of different wave-dominated shorefaces within the Blackhawk Formation. Kamola and Van Wagoner detail the conceptual nature of parasequence architecture and bounding surfaces. Taylor and Lovell review the depositional environments and paleogeographic distribution of the Kenilworth within a sequence stratigraphic framework. O'Byrne and Flint discuss their recognition of a hierarchy of three previously unrecorded unconformities and other bounding surfaces within the Grassy Member, with their associated incised valleys and subaerially exposed interfluves. They go on to discuss prediction of stacking patterns, and types of shale permeability barriers for the selection and use of analog outcrops for subsurface modelling.

Van Wagoner has a very long chapter devoted to the Desert Member (Blackhawk Formation) and the Castlegate Sandstone, detailing the impact of two hierarchies of sequence boundaries (regional versus more local) on stratal architecture, and proximal/distal variations within the rocks and their bounding surfaces. What stands out in this chapter is the unique and peculiar interpretation of a terminal fan with anastomosed splays for the distal end of the Castlegate Sandstone, with no evidence of a lowstand shoreline for such a depositionally significant stratigraphic unit. This interpretation is bound to generate much debate!

Scwhans reviews the stratal stacking of fluvial to shallow marine sequences from the Cretaceous of west-central Utah. Of particular note is his interpretation of the impact of structural-tectonic factors on sequence development, stratigraphic stacking patterns and the character of bounding surfaces depending on their proximal-distal position to the thrust-front and times of tectonic activity.

Shanely and McCabe examine the sequence stratigraphic framework of Upper Cretaceous rocks (Turonian-Campanian) of the Kaiparowits Plateau. The key product from their study is a conceptual and predictive stratigraphic framework which can be linked to adjacent regions, and more specifically, can be used to understand regional stacking patterns in similar basins elsewhere, for hydrocarbon exploration and development.

Three chapters deal with strata within San Juan Basin, New Mexico. Nummedal and Molenaar discuss the Gallup Sandstone (late Turonian-early Coniacian), deposited in a strandplain setting during a long-term relative sea-level rise that was punctuated by several relative falls or stillstands in sea level. Jennette and Jones, and Valasek discuss the sequence stratigraphy of the Tocito Sandstone (early to middle Coniacian). Jennette and Jones outline the stratal architecture of four high-frequency sequences, focussing on the fluvio-estuarine nature of the lowstands and the control exerted by tectonically reactivated basement faults. Valasek examines the basis for identifying small-scale sequences within coeval shelf to continental deposits and the limited preservation potential of lowstand systems tracts in ramp settings.

From the Powder River Basin (Wyoming), Larue looks at the impact of basement structure which controlled the stacking patterns of depositional facies of fluvial valley-fills and associated sequence boundaries at the base of and within the Niobrara Sandstone. Donovan redefines a previously interpreted stratigraphic framework for the Muddy Sandstone, identifying a key sequence boundary which helps to explain the overall geometry and extent of hydrocarbons in the Hilight Field. He concludes that the Muddy Sandstone is an erosional remnant of an originally more widespread incised valley and younger shoreline deposits above the upper unconformity.

The Memoir has two negative points: 1) the poor quality of the black and white photographs makes it impossible to see detail being described by the authors; and 2) some of the chapters are too long. One could argue that the Memoir is too heavy on definitions and terminology, but it is good to see the authors defining their own particular use of terms. Lastly, the price will discourage casual readers, and students, from buying their own copy of the Memoir.

Memoir 64 is largely based on rocks and examples, and should be of interest

to readers with a particular interest in foreland basin deposits, and/or sequence stratigraphic concepts in such settings. Others who should find the Memoir interesting are those who want some specific outcrop and subsurface examples of sequence stratigraphy from foreland basins for teaching, or for use in their own work, and those who want further elaboration of some of the basic concepts and application of sequence stratigraphy in general.

Fractography: Fracture Topography as a Tool in Fracture Mechanics and Stress Analysis

Edited by M. S. Ameen
Geological Society of London
Special Publication No. 92
1995, 240 p., US$48.00 (member)
US$93.00.00 (non-member)

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Despite being first applied to rocks in 1979, "fractography" is a new term to most earth scientists; new enough anyway to require partial definition in the title of this book. On this basis, I opened the volume with misgivings. As I suspected, the good ship *Fracture Morphology* is sailing under a new flag. And she is well-rigged. On page 3, I learned that "all fractures develop fractographic features" ;what a surprise! To be fair, the Introduction also contains thoughtful commentaries on the 11 papers in the volume.

Fractures are understudied today, although they are known to provide significant insights at low cost. Their analyses have traditionally had one of three objectives: to flesh out the structural history of a region (paleostress reconstructions), to describe fractured reservoirs, or to establish contemporary *in situ* stress axes. None can be accomplished effectively without reference to fracture morpholgy.

The opening two papers describe methods for recording the roughness of fracture surfaces, mechanically and photogrammetrically. Neither study offers significant insights beyond methodology. P. and E. Bankowitz, however, use surface features to show that drilling effects have induced discing fractures in cores recovered from the German Kontinentales Tiefbohr-programm (KTB) borehole. Core orientations being known, the saddle and trough geometry of these fractures, plus other morphologic features, can be used to define the axes of the horizontal principal stresses compressing the rocks around the hole. Their results are impressively consistent over several hundred metres and agree with other indicators. Conclusions like this depend on laboratory studies of fracture evolution. B.R. Kulander and S.L. Dean created artificial fractures and tracked the development of surface features so as to document fracture propagation dynamics. Many of these features are ubiquitous in rocks and are noteworthy because they are primary structures that are diagnostic of brittle failure. By implication, slickensides and solution features, often cited as diagnostic of primary shear failure, are likely to be secondary structures superimposed on former brittle fractures.

M.S. Ameen has characterized fractures in outcropping Permo–Triassic sandstones and underlying basement rocks in northern England. Cross-cutting and abutting relationships enabled him to determine the relative age of different fracture sets and the study was areally extensive enough to allow evolving configurations of horizontal paleostress trajectories to be mapped. Direct dating of the phases of fracturing was not feasible, so established northwest European geotectonic events were invoked to provide a chronology. Equally interesting is another study by Ameen in which he employs fracture surface morphology in Cretaceous chalk to elaborate the Late Mesozoic and Tertiary structural evolution of the Thanet monocline in southeastern England. In both papers, fieldwork methods are extensively illustrated with photographs and diagrams. J.C. Roberts also uses fracture surface markings in Jurassic limestone in south Wales to infer paleostress orientations.

The final three papers in the volume consider joint patterns rather than fracture morphology.

J.W. Cosgrove addresses the conditions under which natural hydraulic fractures occur. A.M. Goodwin mapped lateral changes in the joint geometry in chalk and proposes that this may reflect variations in differential stress and/or rock strength across the area. Photographs suggest that the outcrops are good candidates for reservoir characterisation. Lastly, M.R. Gross *et al.* revisit geomechanical controls on fracture spacing in a paper that has economic implications which they do not explore.

In my opinion, approximately half of these papers are likely to be reasonably widely cited. Some of the material has appeared elsewhere, so one has to question publishing this particular collection in a hardback volume. I have no criticism of the editing, page design, photo reproduction, and diagram clarity. All are excellent and the volume is most attractively produced.

The Origin and Evolution of Birds

By Alan Feduccia
Yale University Press, 1996, 432 p.
US$55.00

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Since Feduccia's 1980 book *The Age of Birds*, there has been no broad, detailed overview of avian evolution accessible to the non-specialist. In succeeding decades dinosaur theorists have adopted birds, many new bird fossils have been described from around the world; new techniques and models have achieved widespread acceptance, and much older work has been reviewed. To resynthesize this heady mixture of fact, theory and interpretation into an essentially new view of avian evolution is a formidable challenge, and this new book is of great importance to all interested in birds and dinosaurs.

Although less popular than his earlier work, much of the book is readable for a non-specialist. Although birds are front and centre, Feduccia's broad perspective provides fascinating reading. Paleo-ecology and comparative anatomy illuminate many questions: flight in *Archaeopteryx* is supported by the presence of trees; flamingos are presented in the context of filter feeding in sharks, whales and the "flamingo pterosaur" *Pterodaustro*, the grasping feet of swifts are compared with those of chameleons and koalas. Glimpses of scientific history and current controversy provide context.

Canadians will find that they have not

been ignored, and Canadian fossils discussed include *Caenagnathus, Ichthyornis* and *Diatryma.* The work of such Canadian Paleontologists as Currie, Fox, McGowan and Dale Russel is cited.

The first third of the book discusses the origin of birds and their flight. Feduccia attacks the dinosaur specialists from a perspective in avian paleontology, in a section that is as much about "dinosaurs" as it is about "birds". Seven *Archaeopteryx* specimens, along with new Jurassic and Cretaceous birds, are used to attack the new orthodoxy, that birds may be descended from dinosaurs. Birds (he argues) are *not* descended from dinosaurs, but are descended from pre-dinosaurian thecodont reptiles; flight arose in the trees, feathers evolved for flight; dinosaurs were not hot-blooded and certainly not feathered. Along the way he attacks what he considers overly rigid cladistic interpretations and reminds us to the power of convergence.

The rest of the book has more revelations. Chapter 4 argues that most Cretaceous birds belong to a distinct group of "opposite birds" (enantionithines). Most Cretaceous birds became extinct with the dinosaurs; a few "transitional shorebirds" carried on the torch, and Tertiary adaptive radiations took place in parallel with those of mammals.

Chapter 5 discusses flamingos, ducks and long-legged waders, and presents a detailed view of the avian missing link *Presbyornis*, a "shorebird-duck mosaic". Chapter 6 discusses the always fascinating flightless birds, providing a wonderful example of the speed of evolution with a flightless rail on 1.5 m.y. old Ascension Island.

Chapter 7 presents birds of prey, including the spectacular teratorn form Argentina, the largest known flying bird with a wingspan up to 7.5 metres. Chapter 8 discusses the complex rise of land birds, including the passerines, where the lack of fossils constitutes "one of the great voids in avian paleontology." The book concludes with 33 pages of references, and a substantial index.

It would be unreasonable to expect such a large and complex book to be totally objective. Feduccia dismisses the more extreme views of other theorists as "bluster"or "wild speculations", yet he cheerfully postulates that *Hesperornis* could have borne live young at sea! He criticizes scientists who give names to scraps of bone, yet accepts a family diagnosis from "a fragment of a coracoid". Feduccia feels that the "ground up" theory of flight origins is "counter-intuitive", yet surely such advances in science as evolution and drifting continents have been so to their opponents. Although occasional invective keeps the reader alert, the main arguments are very lucidly presented and there is enough hard evidence to make everyone think again.

Extensive illustration includes cladograms, maps, drawings of bones (many without a scale), and even cartoons. Many photographs (often poorly reproduced) illustrate birds, fossil sites, and bones. The excellent bird drawings are by George Miksch Sutton. One painting by John P. O'Neill is reproduced in color on the jacket; sadly his other paintings appear in monochrome.

Such minor weaknesses apart, this is a remarkable synthesis of abundant and very diverse data, which splendidly summarizes 20th century understanding of bird evolution as Newtons' great *Dictionary of Birds* summarized 19th century progress in ornithology.

The Petroleum Geology of Ireland's Offshore Basins

Edited by P.F. Crocker and P.M. Shannon
Geological Society of London
Special Publication No. 93
1995, 498 p., US$65.00 (member)
US$117.00 (non-member)

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The Petroleum Geology of Ireland's Offshore Basins contains up-to-date geological data and interpretations on most of the prospective sedimentary basins that surround Ireland. This Special Publication is the proceedings of the April 1994 conference convened in Dublin by the Department of Transport, Energy and Communications, the Institute of Petroleum, and the Irish Offshore Operator's Group. The date of publication coincides with the 25th anniversary of the first exploration well drilled off Ireland, in 1970.

The book is indispensable for companies and individuals involved in petroleum exploration and development in this area. As well, government departments and universities will find in it a wealth of sedimentological and stratigraphic information. It contains 36 papers and an introduction. The papers are arranged roughly by age of the prospective rocks: the five Upper Paleozoic basins are described first, followed by 14 papers encompassing the Celtic Sea basins south and southeast of Ireland. The troughs and basins of the eastern Atlantic on the west side of Ireland are described last.

The book contains a wealth of data on structures, reservoir beds, seals, porosity and permeability for all basins. Many articles supply drill stem test results. In some cases, calculations of the oil or gas in place are provided. Seismic lines are well illustrated. Petroleum source bed analyses and interpretation are provided for almost all regions. There is, however, a complete lack of any petroleum assessment of any of the basins. This is unfortunate because most explorers want some numerical indication of how much petroleum is present and can be produced, or how impoverished or prolific a basin might turn out to be.

This Special Publication could have been improved if a comprehensive sedimentary and stratigraphic column were provided. Stratigraphic colloquialisms are the rule throughout the book, and this is tough going for geologists not thoroughly aquainted with the detailed geology of the region. Likewise, it is a pity that a comprehensive map of the locations of all the basins is lacking. The map in the Introduction gives some idea of the general position of about half of the basins and sub-basins. This handicap makes for slow going. Jumping from article to article to learn of the age of formations or the location of oil fields is time consuming and in some cases unproductive. For example, the Douglas oil field, although discussed in the text, is not recorded on any map. The reader would benefit from a more comprehensive Index.

The papers are easy to read. Eight of the articles are only one or two pages long, thus resembling abstracts or expanded abstracts. There are practically no spelling mistakes. Diagrams are clear. It is a pleasure to read such a book, which contains a minimum of acronyms and no forced use of sequence stratigraphy.

The Petroleum Geology of Ireland's Offshore Basins is timely, and brimming over with data brought together in one place.