BOOK REVIEWS

CARBONATE DEPOSITIONAL ENVIRONMENTS

P.A. Scholle, D.G. Bebout and C.H. Moore (eds.)

American Association of Petroleum Geologists Memoir 33, 708 p., Tulsa, 1983, \$58.00 (\$48.00 to members).

Despite the great progress over the past 30 years in our knowledge of carbonate depositional environments, their characteristic features have not until now been summarized in a single book. Approximately half of this impressive book is made up of over 1300 excellent colour photographs, diagrams and cross-sections, selected to describe characteristic features for non-specialists, principally in the oil and mining industry. This approach enables the reader, with a little imagination, to visit modern carbonate deposition terrains, to snorkel with the authors on the Belize shelf, to bake on tidal flats of the Trucial coast, or to observe from a submersible exposed walls of carbonate cliffs beneath 3.5 km of water. All this in only one day!

The twelve chapters are organized for the most part according to a similar outline and deal with various settings from continental to pelagic. Each depositional environment is defined, and diagnostic criteria are provided for its recognition. Modern examples show physical and biological structures, texture, alteration, regional and tectonic setting. Each chapter also gives examples of ancient environments, lateral facies relationships and diagenesis, and typical sedimentary structures and textures. Each chapter concludes with a brief account of the economic significance of a particular setting for hydrocarbon and base metal accumulations, along with a list of selected references.

The first chapter, on subaerial exposure, by M. Esteban and C.F. Klappa and others, is one of the best written on this subject. The authors discuss the major pathways of evolution of carbonate sediment and rocks when exposed on land, and provide a list of criteria for their recognition in the ancient record.

The increasing success of oil exploration in lake deposits of China, Russia, South America, Africa and the U.S.A., makes the chapter on lacustrine environments, by W.E. Dean and T.D. Fouch of great interest. They present a good, broad overview of lake deposition, though with an over-reliance on North American examples, as is the case for a few other chapters in this book. Because of the lack of modern carbonate lakes in North America, the discussion concentrates on ancient lake deposits, and the presentation of recent settings is weak. In contrast, E.D. McKee and W.C. Ward present a balanced global review of eolian deposits. E.A. Shinn likewise presents a thorough review of tidal flats, with richly illustrated examples of sediment composition, structures and textures in modern and settings well balanced with examples from ancient deposits.

A good overview of carbonate beach environments is provided by R.F. Inden and C.H. Moore. However, this lacks adequate coverage of modern beaches, which are easily studied. Moreover, the treatment of diagenesis and carbonate cements in this chapter is exceptionally brief, despite the fact that one of the authors is a leading authority on this subject.

The "Shelf" heading for the chapter by P. Enos is somewhat misleading, since this succinct discussion is devoted to semi-restricted shelf, lagoon and bay settings, with most modern examples from the Bahamas and Florida Bay. The author stresses the lack of any single criteria diagnostic for environments as diverse as those occurring on restricted carbonate shelves, suggesting that the study of vertical sequences is more useful. According to Enos, the low porosity and permeability of semi-restricted shelf deposits results in their low economic potential. It is a pity that he did not pursue the economic significance of shelves in providing source rocks for hydrocarbon generation. This omission is, however, corrected in part in the very well written and illustrated chapter on middle shelf environments by J.E. Wilson and C. Jordan, who indicate that 0.3 to 3% of organic C is found in lagoonal deposits. These authors suggest that the lower limit for source rocks in carbonates can be as little as 0.25 to 0.3% organic C as compared with 1% for terrigenous sediments.

It is difficult not to use superlatives for the review of reef environments by N.P. James and others, who follow their development from the late Precambrian to Recent. However a discussion of diagenesis, porosity development, reservoirs, and log characteristics should also have been included, since reefs are one of the most prominent hydrocarbon reservoirs, as documented in brief descriptions of Devonian reefs from Alberta and algal mounds from Paradox Basin, Utah.

The regional distribution of shelf margin sands is dealt with in a chapter on bank margins by R.B. Halley, P.M. Harris and A.C. Hine, using spectacular satellite and aerial photography. Since most of the modern examples are from the Bahamas, the coverage of oolite sand dominates over that of skeletal sands. The review of diagenesis in this chapter is the best in the book. The authors selected well-studied Jurassic Smackover oolites to demonstrate hydrocarbon accumulations in ancient high-energy carbonate sands.

Accounts of fore-reef slopes by P. Enos and C.E. Moore and basin margins by H.E. Cook and H.T. Mullins are concerned with slope environments dominated by deposition from suspension and gravity-induced processes. Classification of major submarine mass transport deposit and the criteria for their recognition are summarized by Cook and Mullins, but the predominance of examples of debris flows in this chapter creates the false impression that these deposits are the most common feature of carbonate slopes. The best known example of petroleum production from gravity flow deposits (the Poza Rica trend) is reviewed by Enos and Moore and examples of reservoirs developed in deep water turbidites are given by Cook and Mullins.

The final chapter on pelagic settings by P.A. Scholle, M.A. Arthur and A.A. Ekdale is a comprehensive treatment of the subject. The authors point to the role of biota in the lithologic change of pelagic deposits through the Phanerozoic, with the Palaeozoic dominated by shales and radiolarians and the Mesozoic by carbonates. The authors also refer to the predominance of low-Mg calcite in deep water deposits, which leads to the difference in diagenesis between

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shallow and deep water deposits. Increasing awareness of the significance of pelagic carbonates as hydrocarbon reservoirs in the North Sea, Libya and the Gulf Coast makes recognition of this environment and understanding of its diagenetic processes important for oil exploration and also for the mining industry, in terms of ferromanganese nodules and the occurrence of other deep sea metal deposits.

The editors are to be congratulated on this book which, in terms of design and presentation, is first class and unique in carbonate literature. There are many small errors, such as missing location on colour photographs, wrong citation of figures and improper presentation of some references, and the dark blue background colour to some of the tables makes them difficult to read. It would, however, be churlish to finish on a negative note since this book is possibly as near to being a definitive statement of current knowledge as is reasonable to expect in this fast progressing field. The wealth of data and easily understood presentations will ensure that this volume becomes an important reference book, not only for oil exploration and mining geologists, but also for carbonate geology students. It is a show-piece with colour photography on par with the National Geographic, and the price is a bargain!

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A LAND BETWEEN TWO NILES.

Quaternary and History of the Central Sudan

Martin A.J. Williams and D.A. Adamson (eds.)

A.A. Balkema, Rotterdam, Netherlands; Merrimack Book Service, U.S.A., 1982, \$25.00 (U.S.)

This small but important volume is an interdisciplinary account of the origin and characteristics of the Gezira, a vast alluvial plain which extends south of Khartoum, between the Blue and the White Niles. It is an area of enormous economic importance to modern Sudan, for although occupying only one percent of the total area of Sudan, the Gezira produces sixty percent of the total export revenue. Thus the knowledge of the geological properties of these sediments and the history of their development is of major significance to the entire country.

The book includes papers on such topics as stratigraphy, groundwater geology, soils and vegetation. The most significant contribution is the synthesis of the palaeogeography of Gezira and the lower Blue and White Nile valleys by D.A. Adamson, R. Gillespie and M.A.J. Williams. It is here that most students of the Nile will find the greatest food for thought. The review draws heavily on information from the other papers, with a masterly interplay of sedimentary, biological and archaeological data, so that the book forms a

well integrated regional study. It is indeed a model for this type of report, and in the future it may well be regarded as a classic.

The Quaternary sediments of the Nile Valley have been the subject of intensive study since the 1920s with the pioneer work of K.S. Sandford and W.J. Arkell. More recently, as a result of the international campaign to salvage the archaeological remains in the Aswan Reservoir, there was a resurgence of interest, particularly in the upper portions of this sedimentary sequence. From this work emerged several generally similar syntheses of the Late Quaternary sedimentary history for that portion of the Valley in northern Sudan and southern Egypt.

It became increasingly evident, however, that there was a basic conflict between the Nile sedimentary sequence in Egyptian and Sudanese Nubia and the sequence of climatic events reconstructed from East African lakes that form the headwaters of the Nile and were for most of its history, the major or only source for its water. Some of these differences were resolved when radiocarbon samples from Nubia were re-dated and shown to be significantly different in age from the initial published dates, but there still remain a number of conflicts which have handicapped attempts at an integrated synthesis of the Nile. Unfortunately, most of the critical sections now lie buried below Lake Nasser, or were destroyed by the Kom Ombo reclamation project. The Gezira, lying half-way between the East African highlands and Egyptian Nubia, was therefore an ideal location to re-examine the Nilotic sedimentary sequence.

The Gezira was formed as alluvial fans of the Blue and White Nile rivers. The sands, gravels and clays of these fans are known to be up to 110 m thick, but because of limited exposures only the upper, most recent features have been studied. The earliest of these are of latest Pleistocene age (ca. 20000-12000 B.P.), when both the Blue and White Niles were very different streams from their modern counterparts. East Africa was cold and dry, the eastern Sahara and Sahel were hyper-arid, and the Blue Nile was a braided, shifting stream with many distributaries forming an enormous fan butting against the lower White Nile basin. The White Nile was then at best a highly seasonal river and may have disappeared entirely during much of this interval. A large part of the White Nile trough was choked with dunes. The Gezira owes much of its modern morphology to this period.

Beginning around 12000 years ago, there was a dramatic change in the climate of East Africa with a major increase in rainfall. There was overflow from Lake Victoria into the White Nile, and both the Blue and White Niles (except in the Sudd) became sinuous, stable streams with single main channels, not markedly different from those of today, even though until 5000 years ago there was considerably more rainfall than at present.

This simple scenario of two contrasting river regimes has profound implications for the interpretation of Nilotic history further downstream, traditionally seen as far more complex. The final chapter in this book, on "The Integrated Nile" (D.A. Adamson), attempts to relate the Gezira data with that from upstream in the East African highlands, and from downstream in Nubia and the Mediterranean. The author is reasonably successful in this effort, except with Nubia where he notes several conflicts in the sedimentary sequences.

Unfortunately, Adamson did not appear to be aware that several of the Nubian radiocarbon samples have been re-processed to yield dates significantly different from those originally published. As a consequence, the Nubian sequence

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is now regarded as markedly different from that originally proposed at the close of the Nubian Salvage Campaign. Had he been aware of these revised dates, the author probably could have offered a synthesis with few or no contradictions. Recent work in Egyptian Nubia has confirmed that only a single, almost continuous sedimentary episode is recorded in the Valley from around 21 000 to 12 000 years ago. To this extent it is a direct parallel to the Gezira.

On the other hand, the post-12 000 B.P. sequence in the Gezira is not sufficiently detailed for a comparison with either Nubia or the adjacent eastern Sahara. These more northerly areas record several phases of humid and dry events, and changes in the levels of the Nile, for which there are as yet only hints in the Gezira.

"A Land Between Two Niles" will be of interest to anyone concerned with regional palaeoenvironmental studies or the Quaternary of East Africa. The range of multidisciplinary evidence the contributors bring to bear on this problem, the degree of documentation they offer, the carefully reasoned arguments and the numerous and superbly executed illustrations all combine to make this an impressive, scholarly contribution.

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GEOLOGY OF BURMA

F. Bender, with contributions by D. Bannert, J. Brinckmann, F. Gramann and D. Helmcke

Gebrüder Borntraeger, Berlin, Stuttgart, 1983, 293 p., \$86.24 (U.S.)

The Geology of Burma is an important contribution to the geology of southeast Asia in general and of Burma in particular. Although, as the authors point out, this synthesis is based on data still limited and incomplete, it is much advanced over earlier books by Sir Edwin Pascoe and H.L. Chhibber. The authors review the more recent works of E.L. Searle and Ba Than Haw, R.O. Brunnschweiler, Myint Lwin Thein, Maung Thein, M.S. Garson, B.J. Amos, and A.H.G. Mitchell, as well as the results of German Geological missions which operated in Burma from 1969 to 1982.

Following a general introduction, Chapter Two deals with the regional geological and structural setting of Burma within southeast Asia, based on ground surveys and Landsat imagery. Bender divided the Burmese region into major tectonic domains from west to east: the Arakan Coastal Strip as Foredeep, the Indo-Burman Ranges as Outer Arc, the Western Inner-Burman Tertiary Basin as Inter-Arc Basin or Interdeep, the Central Volcanic Belt as Inner Volcanic-Magmatic Arc, the Eastern Inner-Burman Tertiary Basin as Back-Arc Basin, and the Shan-Tenasserim Massif as Sino-Burman Ranges.

This division is very useful, as it brings the local geology into line with modern nomenclature used widely in the literature of global tectonics. Such a detailed interpretation of structural units in Burma has not been published previously, and it provides a useful overview for dealing with regional geological and structural problems.

The major part of the synthesis, Chapter Three, deals extensively with Burmese stratigraphy, tectonics and magmatism. Unfortunately, the account of the granitoid rocks does not refer to the extensive work carried out at Rangoon University. This suggests that there are at least two granitoid belts in Burma, one subduction-related and the other possibly collision-related, and that many granitoids have been affected by post-intrusive thermal events. For example, K-Ar dating indicates that biotites from the granitoids along the Shan Boundary Fault and in the Sino-Burman Ranges have experienced a significant argon loss due to thermal disturbances in the Tertiary. Likewise a Carboniferous age for the Tawng Peng Granite cited by the authors could be the result of a later thermal event, since a recent radiometric age determination indicates a Cambro-Ordovician age for this body. Similarly a review by the authors of significant metamorphic events such as the high-temperature metamorphism in the Mogok Belt and the high-pressure metamorphism in the Jade mining area would have been useful.

Chapter Four on the palaeogeographic evolution of Burma is rather disappointing in that the geological history from the Precambrian to the Mesozoic is discussed in terms of the Burmese-Malayan Geosyncline, a concept which has now been largely replaced by plate tectonics models. The stratigraphic and tectonic patterns previously recognized in geosynclinal successions can be readily explained in terms of modern tectonic settings, and many eugeosynclinal successions are now readily interpreted as ancient outer arc successions. For example, the existence in northeastern Burma of a subduction zone during the Cambrian is suggested by the presence of the Bawdwin Mine, a rhyolite-hosted massive Pb-Zn-Cu-Ag deposit analogous to the Kuroko deposits of Japan.

The post-Cretaceous geological history of Burma is treated in terms of plate models, though the interpretations are rather generalized. It is hard to visualize, for example, how the Indo-Burman subduction zone moved from a position east of the Andaman island arc to one west of it. The authors do however take into account the Shan Sagaing Boundary (transform) Fault, along which western Burma is thought to have moved about 450 km northwards. This may have originated as early as the Mesozoic; certainly there was significant strike-slip movement in the Late Tertiary (post early Miocene) and there are indications that it is still active.

The final chapter deals with Burma's resources of energy, metallic and non-metallic raw materials, water and soil. It describes the occurrence of hydrocarbons in various structural and stratigraphic traps as well as localities of coal, peat and nuclear fuels. The description of the metallic and non-metallic raw materials of Burma is less detailed than that published in 1978 by P.J. Goossens (in "Geology and Mineral Resources of Southeast Asia", p. 431-492), but the main disappointment is the absence of a discussion of metallogeny in terms of the character of the host rocks and the tectonic evolution of Burma.

Despite these criticism, this book is well illustrated and provides a bibliography of references which will be important to any earth scientist thinking of working in Burma. It is an invaluable source of information for field and research geoscientists working in the region and will eventually become a standard textbook for students learning Burmese stratigraphy.

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