

BOOK REVIEWS

Petroleum geology of foreland basins

Macqueen, R. W. and Leckie, D. A. (editors) 1992. *Foreland Basins and Fold Belts*. American Association of Petroleum Geologists Memoir 55. The American Association of Petroleum Geologists, Tulsa, Oklahoma, U.S.A. 460 pp. Price \$110 (hardback. ISBN 0-89181-334-9); AAPG members \$79.

This large volume presents 10 chapters on the Western Canada Foreland Basin, three chapters on other foreland basins on the North American continent (North Slope Foreland Basin, Rocky Mountain Foreland Basin and the Quachita Foredeep Basin) and two chapters on foreland basins from other continents (Venezuela Foreland Basin and the Zagros Basin), together with a Foreword and Introduction, and a summary and conclusions chapter. The chapters were written by a number of authors, some in the form of papers and others appearing as review chapters.

The Foreword to the book explains that the AAPG has decided to publish a series of volumes on world petroleum basins, with each volume being dedicated to one major class of basins. A significant portion of each volume will be devoted to the detailed description of one well-explored 'type' or 'model' basin, while additional summary papers would discuss other basins of similar type. The purpose is to provide a broad-based world-wide data base for geologists exploring for hydrocarbons in frontier provinces to use as analogues to aid assessment.

The introductory chapter of Memoir 55 begins by emphasizing the importance of hydrocarbons to our "Hydrocarbon Society", defines foreland basins and then presents the Western Canada Foreland Basin (WCFB) as a "type example". The reasons given for choosing the WCFB are that it has the attributes of a foreland basin, it is a mature province, and particularly because there exists a wealth of public domain subsurface information "with the notable exception of seismic lines". This introduction then reviews in some detail the contents of the rest of the chapters. The underlying rationale to the book is stated to be to address the question: "Why are some foreland basins so incredibly rich in hydrocarbons, whereas others contain only trivial amounts?"

The first 10 chapters are concerned with the following aspects of the WCFB: Chapter 1—Regional setting, evolution and depositional cycles; Chapter 2—Siliciclastic sequence development in foreland basins with examples from the WCFB; Chapter 3—Tectonics and structure; Chapter 4—Relationships of the stratigraphy of the WCFB to Cordilleran Tectonics: insights from geodynamic models; Chapter 5—Early surface and subsurface investigations; Chapter 6—Conventional hydrocarbon reserves; Chapter 7—Oil and gas plays; Chapter 8—Lithology and diagenesis of sandstones; Chapter 9—Thermal history; and Chapter 10—Petroleum systems (source rocks, geochemistry, hydrocarbon migration).

Chapters 6–10 contain a great deal of information concerning the WCFB. The information is well illustrated with good location and palaeogeographic maps, graphs, diagrams and photographs. There are some excellent tables summarizing the play types, locations of features and source references for the reviews.

Chapter 5 deserves a special mention. Many fine photographs are presented showing the life and times of the WCFB, and these together with the text give a very good idea of just how exciting and 'frontier' this area must have been during early exploration. Of particular interest is the section concerned with "Quacks and Bogus-oil Finding Devices". One of these devices was a cigar-box containing a bullfrog and battery connected to a doorbell. When the box was carried across an 'anticline', the bullfrog was secretly electrocuted by the operator, causing the box to vibrate, the site of the vibration being noted for future drilling.

Apart from Chapter 5, Chapters 1, 3 and 4 are probably of greatest interest to readers of this journal.

Chapter 1 starts by describing the tectonics and the famous terrane accretion story for the west coast of the North American continent. Then, a rather snapshot view of the physiographic features of a typical

foreland basin are reviewed before the history of structural highs in the basin is given. A picture is painted of five major depositional cycles in the WCFB associated with (a) subsidence associated with the accretion of two major terranes onto the western side of the growing Cordillera, and (b) global sea-level changes. It is suggested that a typical foreland basin, i.e. the WCFB can (a) contain depositional hiatuses of >27 Ma, (b) have subsidence pulses driven by accreting terranes that move laterally by hundreds of kilometres to lie adjacent to the foreland basin, and (c) contain several unconformity-bound stratigraphic successions deposited over a time span of ~170 Ma. One wonders how typical this is.

In Chapter 3, the daunting task of reviewing the tectonics and structure of the WCFB and adjacent Canadian Cordillera is attempted. The authors start by describing the structural subdivisions of the area and then review the deformation history, giving details of the timing of deformation. Then a summary of thin-skinned deformation styles is given with pull-out cross-sections included. Hydrocarbon accumulations are discussed in terms of their structural setting. Although most of the information is familiar, this is well written, easy to read and seems, at first sight, to provide a good introduction to the structure and tectonics (see below).

In Chapter 4, geodynamic models are used to address the relationship between the stratigraphy of the WCFB and Cordilleran tectonics. Overthrusting associated with terrane accretion is suggested to produce shallowing-up, unconformity-bounded foreland basin successions "similar to those in European Alpine basins". Successive accretion events are suggested to stack up foreland basin successions, but in some instances, successions appear to correlate in time with postulated eustatic sea-level changes. These conclusions are reached by comparing the Alberta basin with model-generated sequences. A tectonic framework involving the terrane accretion story set out in Chapters 1 and 3 is used. Some terrane-accretion events are deemed too distant to have influenced the foreland basin. This thought-provoking chapter is well-written and accessible, and provides an interesting contrast with the rather dogmatic view of the links between terrane accretion and the stratigraphy of the WCFB in Chapter 1 and the conclusions in Chapter 16. This view reinforces the view expressed in Chapter 3, which, in contrast to Chapters 1 and 16, suggests that the accretion of terranes can only be "loosely linked" with clastic wedge successions in the foreland basin.

If only the links between terrane accretion and foreland basin stratigraphy were as clear as the authors of Chapters 1, 3, 4 and 16 would lead us to believe! Several prominent papers have discussed Cordilleran tectonics in very different terms. It has been suggested that the Insular Superterrane has been linked to the Intermontane Superterrane since the Middle Jurassic, which contrasts with the view presented in Chapters 1, 3, 4 and 16, where the Insular Superterrane is suggested to have collided with Intermontane Superterrane in the Late Cretaceous, driving foreland basin subsidence. Indeed, much of the palaeomagnetic evidence which underpins the terrane/Late Cretaceous collision model has been reinterpreted as evidence of regional tilt rather than large-scale northward transport of terranes. A subduction-based plate tectonic reinterpretation exists, where the Coast Belt Intrusions are suggested to be an Andean-type magmatic arc. This subduction-related interpretation contrasts with the strike-slip terrane accretion interpretation advocated in Chapters 1, 3, 4 and 16. These prominent papers and reinterpretations question the validity of terrane-based models of Cordilleran tectonics. A large part of this reinterpretation was published prior to 1992, so that the editors of this volume were, presumably, aware of these new ideas. However, the controversial nature of Cordilleran tectonics is not stressed in this volume, and some important papers are not cited. As the WCFB is supposed to be a type example for foreland basins, I find it worrying that the reader is not being told the whole story.

On a separate point, the validity of a "type example" of a foreland basin is not justified in the Foreword, and, therefore, open to question. If the WCFB is typical, then where is another basin that is like it? If it is atypical, then why choose it? Really, the WCFB is a well-documented case study rather than an example full of features which typify a foreland basin, some of which may be found in less typical(?) foreland basins!

There are several minor omissions and a few creases that could have been ironed out. For example, in Chapter 1, the Rocky Mountain Foothills and northwestern Alberta (see text) seem to be called the Southern Alberta Foothills and the NorthWest Plains on Enclosure 1(A). Figure 6 is a nice colour pull-out with no explanation of what the colours mean, whilst Figs. 10–11, 14–16 and 18–20 are palaeogeographic maps which contain no key to explain the significance of the ornaments on the map. Amusingly, the Cypress Hills conglomerate was apparently “resedimented by magmatic intrusions”. In Chapter 10, Figs. 15 and 17 have no captions.

In summary, Chapters 1–10 contain a great deal of information about the WCFB; you probably could not do without this book if you were involved in research in this area. Most of it is extremely well presented and fairly accessible to readers unfamiliar with the region, and the authors should be congratulated on bringing together papers on such a wide variety of topics. Make your own mind up about tectonics and regional setting!

The rest of the chapters deal with other (presumably less typical?) foreland basins. In general they deal with the tectonic setting, the structural and sedimentological history, the hydrocarbon reserves, source rocks, reservoir rocks, maturation history and exploration history.

Chapter 11 describes the Zagros Basin, emphasizing the vast hydrocarbon reserves and variety of source rocks of the region. The chapter is very readable and serves as an excellent introduction to the Zagros Basin for those unfamiliar with the region. The chapter also contains a great deal of information. Chapters 12 and 13 are, again, very good introductions to the Venezuela Foreland Basin and North Slope Foreland Basin. Chapter 14 is concerned with the Rocky Mountain Foreland. The border between the Rocky Mountain Foreland and the WCFB is shown in Fig. 1 of the introductory chapter to run roughly along the border between the U.S.A. and Canada. This does not seem to be a very good geological reason for separating these basins. Surely, the Rocky Mountain Foreland is just the southern continuation of the WCFB but with a different structural style? Nevertheless, this chapter is another of the very informative and readable chapters which typify this book. Chapter 15 deals with a foreland basin which is older (Pennsylvanian–Permian) than the other basins described: the Quachita Foredeep.

This is a large book, containing a lot of information. However, not all of the chapters have abstracts, which makes a quick flick through to get the essential information very difficult. The review of the contents of chapters presented in the introductory chapter is rather difficult to take in, as the comments contained are a little out of context.

According to the Foreword, the book is aimed at the explorationist looking for analogues to aid assessment of frontier foreland basins. I will be surprised if many explorationists have the time to consume this much information. Will anyone looking for analogues have time to read the whole of the text concerning the WCFB? What I suspect they need are summaries like the Zagros chapter (Chapter 11), which tells me practically everything I need to know without extending to 10 chapters (cf. WCFB). The summary and conclusions chapter should help in cutting down the time needed to read the book, but I found this chapter disappointing. The emphasis is on facts and figures which, although nicely tabulated, leave it up to the reader to ponder the underlying processes behind the vital statistics of foreland basins. This is symptomatic of the whole volume. The chapters achieve the goal set out in the Foreword and Introduction, that is, to establish a set of analogues. However, very little discussion of the underlying processes in foreland basins occurs either in the individual chapters or as a theme of the book. As the book is really a database of hydrocarbon occurrences in foreland basins rather than being about foreland basins, perhaps the book should have been called *The Petroleum Geology of Foreland Basins*. Should explorationists buy the book? Probably yes. I think they will find the wealth of information of great interest. I am not sure how useful it will be in terms of analogues, as many of the chapters suggest that play types, source and reservoir characteristics and maturation histories vary not only between portion of the foreland basin stratigraphy, but, between the different geographical areas of individual basins! Researchers of any of the areas discussed will benefit from the information presented in chapters. However, if readers are looking for the underlying principles of foreland basin evolution, then they must be prepared to make up their own mind, as these are not stated in this volume. The depth of information contained in the volume will give buyers value for money.

One final criticism is that very little seismic data is contained in this volume. As seismicity is without doubt one of the main exploration tools, the book is crying out for a wealth of seismic lines which illustrate the points made in the text. If no seismic information was available from the WCFB, as suggested in the introductory chapter,

then it must be asked whether it was the best example to pick for a detailed study.

So in summary, I think the volume, with its wealth of information will prompt many people to buy it. However, just imagine the same book with informative abstracts and seismic data from 15 different foreland basins (truly ‘worldwide’) and more discussion of the underlying processes. Now that would be good!

G. P. Roberts

London U.K.

Basin fill and sequence stratigraphy

Williams, G. D. and Dobb, A. (editors) 1993. *Tectonics and Seismic Sequence Stratigraphy*. Special Publications of the Geological Society of London 71. 226 pp. Price £45 (U.K.), \$75 (U.S.) (hardback) (members £21 and \$35).

Sedimentation and tectonics has always been an area popular for geological investigation. Vacant studentships to research on their interactions seem always to attract dozens of well-qualified candidates. There have been countless conferences over the decades. But it always struck me that, until a few years ago, the majority of these studies didn't solve much. The problem is always one of scale. Depositional systems like deltas are large compared with the traditional field areas. Consequently it's rarely possible to isolate, say, those variations in depositional architectures that have been triggered tectonically from those resulting from climatic or eustatic fluctuations. Additionally the tacit confusion between lithostratigraphic and biostratigraphic nomenclature that plagues maps and memoirs even today commonly lead into downward spirals of circular arguments. In the past two decades two linked advances have changed all this.

First, the acquisition of seismic reflection and borehole data through wide swathes of sedimentary basins alleviate the problems of scale. Second, the rediscovery of sound stratigraphic practice and common sense has reinvigorated the regional analysis of sedimentary successions. Peter Vail and colleagues then at Exxon formalized the concepts of sequence stratigraphy and opened the door not only to describing vast tracts of basin fill but also to a hornet's nest of reactionary diatribe! Their early studies related marine depositional architectures directly to changes in relative sea level, then extrapolated these to chart global variations in sea level through geological time. Such a bold attempt at global correlation was bound to attract hostility and since then there's been a tendency to sink the Vail approach merely on this basis. For half of the intervening 15 years the descriptive rigor of the first step in Vail's work has had pretty short shrift. Presumably the traditional standard-bearers of stratigraphic analysis in dusty academic corners didn't like the brash new jargon emanating from oil geologists who use strange things called seismic sections.

More rational criticisms of the Vail approach point out that relative sea-level variations can be induced by tectonics on a variety of scales and so eustatic charts may be ambiguous. Conferences on these aspects tend, even today, to push one way or the other: depositional architectures relate either to eustatic changes or to tectonics. But the common ground is gradually being occupied. *Tectonics and Seismic Sequence Stratigraphy* is a selection of papers resulting from a conference of the same name held in February 1991. The meeting has 21 papers but the editors, Graham Williams and Angela Dobb, acquired just nine contributions for the volume itself. Consequently interested readers would be well advised to seek out other recent works on the subject (MacDonald 1991, Seyfried 1993) to develop a broader base. But what does the Geological Society's volume contain?

The book kicks off with a review by Graham Williams that touches on many of the key topics from the importance of seismic resolution to a reprise of basin fill architectures. The review covers little new ground but provides excellent supplementary reading to support undergraduate courses. There follows a stimulating piece by Jo Cartwright and colleagues on the lateral extent of sequence boundaries. Although not addressing the topic of the book, the article is a clear illustration of the importance of seismic resolution and its potential pitfalls.

Sarah Prosser's article takes the descriptive aspect of sequence stratigraphy and adapts it for rift basins. There are similarities with the preceding contribution: both place great store on likely depositional architectures and their probable seismic signature. These iterations between field-based appreciations of geological complexity and the interpretation of seismic data contrast with the approach of Dave