Journal of Structural Geology, Vol. 13, No. 10, pp. 1197 to 1199, 1991
Pergamon Press plc. Printed in Great Britain

BOOK REVIEWS

Deformation and tectonics—a birthday dedication to H. J. Zwart

Knipe, R. J. and Rutter, E. H. (editors) 1990. *Deformation Mechanisms, Rheology and Tectonics*. Geological Society Special Publication No. 54. The Geological Society, London, U.K. Price £85, $142.

Volume 54 of The Geological Society of London Special Publications addresses a broad range of issues in rock deformation. The editors R. J. Knipe and E. H. Rutter ought to be congratulated for a thorough job in selecting a group of competent authors, choosing outstanding papers and molding manuscripts into a uniform frame. Throughout, the scientific and technical quality is excellent and many contributions will become classics which will be quoted for years to come. An extensive subject index helps to identify topic of interest. The volume is an outgrowth of an international conference on tectonics and microstructures which was held at the University of Leeds in March 1989.

The 47 papers from 90 authors are divided into eight groups: (1) The role of water (such as hydraulic fracturing, changes in pressure during seismic faulting, and alteration); (2) Fracture and faulting (the influence of heterogeneities, mineralization and strain rate); (3) Instabilities and localization (again emphasizing the heterogeneous nature of deformation and its causes at different levels from mantle phase transformations to stylolites in limestones); (4) Flow mechanisms and flow laws (dealing mainly through experiments with ductile deformation of single and polycrystals); (5) Rock fabrics (a pot-pourri of papers among which modelling of recrystallization of quartz could lead to a new approach to texture analysis); (6) Deformation of weak sediments (field observations are interpreted relying on mechanical principles); (7) Experimental modelling using analogue materials (closely related to the previous chapter but with an experimental approach); and finally (8) Deformation mechanisms and tectonics (with attempts to interpret microstructural observations on a larger scale). The spread of topics is very wide and so is the scale which ranges from the submicroscopic (e.g. high-resolution electron microscopy of dislocation cores) to the tectonic. In all sections there is an excellent mix of experimentation, modelling and natural observations. The volume emphasizes brittle and low-temperature deformation, which distinguishes it from other deformation volumes published in recent years. Curiously though, the successful brittle–ductile fault stress analysis of the French school is absent among the topics. However there is an impressive section on instabilities which provides access to phenomena which are of crucial importance to structural geology. Contributions on low-temperature deformation, fracture, faulting, pressure solution and mechanical properties of soft sediments dominate, and papers on intracrystalline ductile flow appear a bit misplaced; in a journal they may have received a wider exposure. But it is excellent to bring both groups together and personally—with my research interests more in the ductile regime—I found the book to open new perspectives and provide fascinating reading. I have been surprised to see how little contact there seems to be between geotechnical engineering/rock mechanics and geologists. In ductile deformation there is much more awareness of research in materials science.

Most contributions are research papers; some sections are introduced by reviews. The research papers are more impressive and it is amazing how many superb contributions this volume contains. Admittedly a few have been published in similar form elsewhere but several long-awaited and carefully prepared computations of new experimental results (including valuable data) and interpretations (for example on halite and calcite rocks and crystals) are finally complete. The volume ranks on a similar level as the famous Memoir 79 of the Geological Society of America and is highly recommended to those interested in the quantitative and mainly microstructural effects of deformation. At a list price of $142 it may not find its way onto many personal bookshelves but is essential for libraries where ever there is a Geology Department. One may also consider becoming a Fellow of the Geological Society of London and receive it at a bargain price of $68.

The volume is dedicated to the work of Hendrik Jan Zwart of the University of Utrecht on the occasion of his 65th birthday. His contributions to metamorphic and structural geology, particularly in the orogenic belts of the Pyrenees, the Caledonides and the Alps have indeed been monumental. Curiously this volume does not deal with any of the issues which brought Professor Zwart his reputation (except perhaps the last paper on Alpine deformation on Naxos) and in none of the 47 articles is there a single reference to Zwart's work. To remedy that it would have been nice to have the Preface of Emile den Tex followed by a list of Zwart's publications.

H.-R. Wenk

Berkeley, U.S.A.

Seismology for physicists

Gubbins, D. 1990. *Seismology and Plate Tectonics*. Cambridge University Press, Cambridge, U.K. 339 pp. Price $59.50 (hardback), $27.95 (paperback).

This is a well-written textbook for final-year undergraduate physics students, based on a course taught by the author and Dan McKenzie at Cambridge University. The Preface states that the main aim of the course is to give physics and mathematics students a broad but quantitative exposure to one aspect of modern geophysics, seismology.

The first chapter introduces the reader to earthquakes, seismic waves and a layered Earth with an outermost shell of plates responding to internal convection and conduction. The second chapter rapidly covers the mathematical background for elastic waves, deformation, strain, gravitation, stress, energy, heat conduction and density in the Earth. Exercises (a total of 68), guides to further reading, and a useful summary end this and succeeding chapters.

The next four chapters form the core of the book. Elastic waves (P, S, Raleigh and Love)—their reflection, refraction, dispersion and polarization (Chap. 3); travel-time tables and curves, velocity determinations including inversion methods, and specific methods for the location of earthquake epicenters and focal depths (Chap. 4); free oscillations, spherical and torsional oscillation modes of the Earth (Chap. 5); the earthquake source: seismic moment, the double-couple force system, fault-plane solutions, and synthetic seismograms (Chap. 6).

The final chapter introduces the physics student to plate tectonics. It briefly describes basic plate theory and its historical development, then presents plate movements and poles of relative motion, marine magnetic anomalies, cooling and sinking of oceanic lithosphere, subduction depths, and triple junctions. The plate history of the northeastern Pacific is given as an example.

The book shows well many connections between seismology and plate tectonics. It has many good, clear illustrations and examples. I especially liked the five long practical problems (102 pages, 30% of the book). Working through the practicals gives the reader an appreciation of the techniques used in studying dispersion and free oscillations in surface waves, locating an earthquake, performing a fault-plane solution, and calculating movements of triple junctions and plates through time. All or portions of 80 seismograms are included in the book, for use in the practicals, but some are too poorly reproduced to be usable. Stereo- and equal-area-nets (figs. 4.24 and 6.10) are included for the practicals, but they are printed sideways (east to top!) and reduced 50% (which is alright but the equations on pp. 130–131 must be changed because R is changed).

There are too many other drafting, lettering, caption or printing errors in the figures (1.1, 1.6, 3.2, 4.18, 6.7b, 7.1, 7.22, 7.24 (2), 7.28). Equation (4.5) has the ratio of shell radii inverted. I found a small number of other text misprints.

I read this book as a structural geologist interested in seismology as it applies to tectonics. I learned many interesting aspects of seismology from the book, but I did find it hard going in several places, forcing me to refer to Aki and Richards (*Quantitative Seismology,* published by W. H. Freeman, San Francisco, 1980) and Ruth Simon (*Earthquake Interpretation,* published by William Kaufmann, Los Altos, California, 1981) extensively. Gubbins lists these and other resources. In other words, the book by Gubbins does not stand alone; this should not be a problem in most university settings.

The book's title suggests that it includes somewhat more on plate tectonics than it actually does. There is nothing wrong with the plate tectonics chapter: it gives a good basic grounding, but only in the practical (finding the movement patterns of the Erratic, Beatific, Nasty and Joker's plates) does anything of interest develop (to me). Hot spots, apparent polar wandering and paleomagnetic pole determinations are geophysical aspects of plate tectonics of current interest, barely covered or not covered at all.

I enjoyed the book, and I am still working on the practical problems. Would I use it as text for a basic geophysics course? Probably not, unless the student could afford a comparable book covering magnetism, gravity and electricity in their 'geo-' forms. As a basic seismology text it would need backup by Aki & Richards (1980) or Bullen & Bolt (1985). It does have practical information and procedures in seismology not easily found elsewhere; the practical exercises are valuable. The paperback price is quite reasonable (for the 1990s), and the blue and red cover map is handsome; a final challenge to the reader is to explain the two colors of fault solutions on the cover map.

Peter H. Mattson

New York, U.S.A.

Petroleum basins at passive margins

Edwards, J. D. and Santogrossi, P. A. (editors) 1990. *Divergent/Passive Margin Basins.* American Association of Petroleum Geologists Memoir 48. The American Association of Petroleum Geologists, Tulsa, Oklahoma, U.S.A. Price $102 hardcover. AAPG members $68.

This Memoir is the third in a planned series of five volumes which together comprise AAPG's World Petroleum Basins project (Cratonic Basins; Interior Rift Basins; Divergent/Passive Margin Basins; Active Margin Basins; Foreland Basins and Foldbelts). The stated aim was to aid explorationists by supplying "a broad, comparable base of data and concepts to improve their forecasts through analogue techniques"; to provide usable analogues for frontier basins, not just descriptions for posterity. I have reviewed it in this context; but feel bound to emphasize the special nature of the volume, to pre-empt any disappointment by readers expecting a follow-up to the excellent Continental Margin Memoirs 29 and 34.

Memoirs 29 and 34 (and other well-known AAPG and SEPM products such as the Seismic Stratigraphy Volumes 26 and 42) contained a large number of fairly short, state-of-the-art papers. There was something for everyone, and the less dedicated reader could dip into the book and get a flavour of recent and current advances. In contrast, Memoir 48 contains four review papers on individual basins: the Campos (Brazil), the Northwest Shelf of Australia, the Gabon Basin and the Niger Delta. These range in length from less than 40 to more than 80 pages, and are augmented by short introductory and concluding sections by the editors. Apart from some good-quality seismic and geological cross-sections, there is little here for the casual reader—a significant investment of time is required to get much out of the volume.

In fairness to the series editors this is exactly what they set out to do—to describe in detail a few carefully selected 'type' or 'model' basins. The recent entry of smaller and independent oil companies (American not stated, but implied) into international exploration is cited as one reason for the timeliness of this series.

The editors' Introduction is very short (2 pages) and contains nothing which readers of this Journal will find new or surprising. Although they permit themselves more space in the Summary and Conclusions, I feel that the Introduction could usefully have been extended, especially as the chapter authors display some inconsistency in terminology.

The Campos Basin, described by L. R. Guardo, L.A.P. Gamboa and C. F. Lucchesi of Petrobras, seems to have been selected as 'the' model basin and justifiably so. It was on everyone's lips following Petrobras' deep-water successes and has provided encouragement elsewhere, particularly in West Africa. It would have been easy to choose the shallow-water Niger or Mississippi Delta, but perhaps somewhat backward-looking as few such plays remain unexplored.

The authors begin with a straightforward geological description of the basin, which displays a classic three-fold rift-to-passive-margin evolution. Non-marine syn-rift sediments of Early Cretaceous age are succeeded by an Aptian evaporite sequence associated with the transition to drifting. Drifting continued to the present day, allowing development of an open marine shelf which evolved from carbonate-dominated in the Late Cretaceous to clastic-dominated in the Tertiary. Of particular interest is the prolific syn-rift lacustrine source rock which has fed reservoirs of all ages: I suspect that most explorers would express initial scepticism over its regional charging capabilities. Reservoirs are typically turbidite fans associated with sea-level low-stands and range from Cretaceous to Oligocene in age. Giant fields are developed with turbiditic sands up to 150 m thick. The chapter concludes with descriptions of half-a-dozen fields with contrasting reservoirs: Badejo (Cretaceous, lacustrine coquina); Pampo (neritic Albian carbonates); Namorodo (Cenomanian/Turonian turbidite sandstones; Enchovas/Bonita (Eocene turbidites); Marlim (Palaeogene basin-floor fans with a component of stratigraphic trapping).

This chapter is a good summary, both for explorers and for land-biased structural geologists who wish to know what a passive margin is really like. It includes some very nice seismic sections (the best in the book), although unfortunately no uninterpreted versions are provided. However, the structural geological content is minimal and the geodynamic treatment unsophisticated—for example, backstripping or decompaction of the sediments is not touched upon and neither is McKenzie's model nor its successors. Salt tectonics scarcely rates a mention, despite its importance in generating many of the known hydrocarbon traps. The source reference list dates to about 1988, and includes many in Portuguese or in publications which would not appear in the average oil company library. It is certainly the most accessible treatment of the Campos Basin I have come across.

The next chapter on the Northwest Shelf of Australia (principally the Barrow-Dampier Basin) is much shorter at 35 pages. It is written by B. P. Butcher of Woodside Petroleum, operators of the Goodwyn–Rankin liquefied natural gas project. The author admits at the outset that much of what he writes has been superseded since the paper was prepared in 1985. In particular, a major conference volume was published in 1988 (Purcell, P. G. & Purcell, R. R. (editors), *The Northwest Shelf, Australia: Proceedings of the Petroleum Society of Australia Symposium,* Perth, 651 pp.). I know memoirs take a long time to get from manuscript to public, but it is a pity that the opportunity was not taken to incorporate the salient points arising from this symposium, or at least to point out if any of Butcher's conclusions have proven to be in error.

In contrast to the Campos Basin (but like the North Sea, for example), syn-rift, Early to Mid-Jurassic sediments were largely marine. The Callovian breakup unconformity outlines a pronounced end-rift topography which was infilled by fine-grained marine clastics of the early post-rift. Several largely descriptive pages are devoted to 15 later unconformities and disconformities of supposed eustatic origin. During the Tertiary the passive margin evolved into a broad carbonate shelf. Play types are straightforward: fluvio-deltaic Triassic sands within horsts and extensional tilted fault-blocks were sourced from interbedded or downthrown pre- and syn-rift coals and shales. Around 7 TCF of gas-condensate has been found in the Goodwyn–Rankin trend. Smaller, Jurassic discoveries also occupy structural traps.

Throughout this chapter, coverage of tectonics and structure is very sketchy and simplistic, and the lack of large-scale seismic sections does not help the reader to draw his own conclusions. A couple of other thoughts struck me in comparing this account with other basins and more recent publications: why are substantial Jurassic sandy turbidites not reported, when the tilted fault-blocks contained sandy Triassic sediments ripe for recycling; and what caused the unconformities—eustatic changes or flexural responses to sediment loading or in-plate stress?

The next chapter, on Gabon, occupies 83 pages and so appears to break the series editors' rule of having only one 'type' basin and several shorter accounts per volume. Although it contains no large-format seismic sections, full-page figures make up about half the content. Written by P. Teisserenc and J. Villemin of Elf, it is a very full and thorough description (in excellent English!) of the onshore and offshore Gabon Basin. It makes an interesting counterpoint to the Campos Basin on the other side of the South Atlantic.