Journal of Structural Geology, Vol. 9, No. 8, pp. 1055 to 1057, 1987
Pergamon Journals Ltd. Printed in Great Britain

BOOK REVIEWS

Deformation of rocks

Nicolas, A. 1987. *Principles of Rock Deformation.* Reidel Publishing Company, Dordrecht, Holland. 208 pp. IBSN 90-277-2368-9 (hbk); Price £43.50 or $59.00. IBSN 90-277-2369-0 (pbk).

Given the scientific hegemony of the English-speaking world, it is good to see translated *Principes de Tectonique* by Adolphe Nicolas. It should perhaps be noted at the outset that the English title gives a much clearer idea of the content to the book, since it is essentially a review of the various processes that are involved in the deformation of rocks, and the geological structures that are formed as a result.

The approach to be adopted by the book is clearly stated in the Foreword. Nicolas begins by saying that there is a critical need in geology as a whole to reduce an often overwhelming mass of field observations to their essentials. Even so, the science still remains in an over-descriptive state. Structural geology does not escape from this stricture, since he argues that there is a profusion of detailed descriptions which are often only of anecdotal interest. He therefore intends to adopt an approach which considers only the essential elements of geological structures, shorn of all their extraneous features, so allowing their physical interpretation to be more easily understood.

Given the analytical strides made by structural geology in the last 25 years or so, such arguments suggest that the book is intended to appeal to a much wider audience within the earth sciences, than might appear at first sight. Indeed, he goes on to argue that such an analytical approach to geological structures and their mechanical interpretation can readily be understood by the non-specialist, since it does not require a mathematical treatment to any great depth. However, such an approach seems to beg a number of questions as far as structural geology is concerned.

There can be no doubt that a thorough understanding of mechanical principles is central to the proper study of geological structures. Ideally, the concepts of stress and strain should be analysed rigorously from first principles as the initial stage in this process. However, it is quite clear that many students who have chosen geology as a subject of academic study find mathematical concepts and physical analysis hard to understand. Faced with this dilemma, we are often forced to adopt a much more qualitative approach to the subject than might otherwise be justified. Although it may be easier for the average student to assimilate and understand, there can be little doubt that this approach leads to a treatment that is essentially superficial. Nicolas has attempted to resolve this difficulty by dealing with the mathematical analysis of stress and strain in two very long appendices, while providing only the most elementary explanation in an introductory chapter to the book. Much of the information contained within these appendices might have more usefully found a place in the main body of the text.

Equally, there can be no doubt that a full appreciation of geological structures requires that their characteristic features are analysed in considerable detail, even if their tectonic setting is ignored. It can be argued that geological structures should first be described, and then their geometrical form and morphological features explained quite separately as resulting from particular mechanisms of deformation. Unfortunately, this approach often proves unsatisfactory at anything beyond the most elementary level. It is my own opinion that factual observations are often closely integrated with their physical explanation in the most successful texts on structural geology. However, this is not an approach much favoured on the continent, and Nicolas proves to be no exception, particularly in dealing with the structures formed as a result of ductile deformation.

Following the introductory chapter on stress and strain, Nicolas first considers the mechanics of fracturing in terms of the Coulomb theory, attaching particular importance to the effects of pore pressure and dilatancy. There is surprisingly little explanation concerning the development of anomalous pore pressures as the result of compaction under gravitational loading, considering its structural significance. The next chapter deals with the mechanisms of plastic deformation, starting with dislocation theory as the basis for a detailed discussion of deformation processes in silicate rocks. This chapter provides a succinct and well-ordered summary of a subject that is too often ignored, or at least glossed over, in the standard texts, particularly when dealing with the processes of creep and recrystallization at a high temperature.

The structures formed as a result of fracturing are next described in a relatively short chapter dealing with joints and stylolites, extension veins and faults. Much of the discussion is concerned with the dynamic analysis of fracture systems, as far as this can be determined from a detailed study of how these various structures are related to one another on a small scale. Regional considerations are almost completely ignored so that there is no discussion of thrust faults as structural duplexes, for example, and even Anderson's theory of faulting is not mentioned.

The remaining chapters of the book are concerned with the structures formed as a result of ductile deformation. The morphological features shown by metamorphic fabrics are first described, along with the various types of linear structure that are commonly found associated with cleavage and foliation in deformed rocks. Problems of terminology and interpretation appear to arise at this point since fracture cleavage is taken as a type of crenulation cleavage, while crenulation cleavage is itself said to evolve into the 'microlayering' that is typical of gneisses. The deformation processes responsible for the development of these fabrics are considered in the next chapter, together with a number of other topics. The foundations for much of this discussion were laid much earlier, and it is perhaps unfortunate that the reader is forced to refer back and forth between different parts of the book as a result.

The final two chapters deal with a variety of structural features, such as pressure shadows, inclusion trails in porphyroblasts, mineral fibres in extension veins, ductile shear zones, boudinage and, most importantly of all, folding. Given the progressive nature of the deformation processes that are involved in their formation, Nicolas has little option but to deal with these structures in a traditional manner, analysing their geometrical form essentially in terms of kinematics. The book ends, apart from the appendices on stress and strain, together with the stereographic projection, with a brief discussion on the nature of superimposed folding.

My main difficulty in reviewing this book lies in separating form and content from one another. I take it to be an attempt to present the non-specialist with the essential elements of deformation processes, without burdening the reader with extraneous details of the geological structures that are the end-result of these processes. Such a general approach to the subject can only be carried so far without any recourse to mathematical analysis. For example, the theory of shear failure does not pose any particular difficulty on this score, unless it is based on the presence of Griffith cracks in the rock. However, the mechanics of overthrust faulting are less accommodating to a non-mathematical treatment, while any realistic account of the buckling process requires quite sophisticated mathematics to do it justice. Nicolas only considers the first-named topic in any detail on account of these difficulties.

The book therefore tends to concentrate on the physical nature of deformation processes taking place in crystalline solids, as might be expected from a structural petrologist. However, this approach encounters its own difficulties when it comes to describing the geological structures that are formed in response to these processes. Often, there is only sufficient space for the briefest of thumb-nail sketches, which hardly provides an adequate picture of the complexity shown by geological structures. For example, in dealing with folds, the dip-isogon method of classifying their shape is not mentioned. I found myself wondering time and again if enough factual information is presented to the reader. Would they understand fully the arguments advanced in this book concerning the contribution that deformation processes make to the evolution of geological structures on a much larger scale?

It seems to me that such an approach would best be integrated into a much more detailed account of structural geology as a whole. As it stands, however, the present book does provide a very useful source of information about deformation processes for the person who has an adequate background to attempt such an integration for themselves.

Of course, I would be the first to admit that my views may be entirely subjective, since I look for a book which does attempt just such an integrated approach to the subject, written from the view-point of a structural geologist. Failing such a book, I would have preferred Nicolas to have written one just on structural petrology.

More objectively, the book can also be criticized on other grounds, which are all too common in scientific writing. Firstly, there is an excessive reliance on a terminology which is often used to state the obvious in the most obscure way possible. I am reminded here of the anecdote about the sociological theory which divides all human relationships into just three categories: mutuality, non-mutuality and pseudo-mutuality. In plain language: some people get on together; some people don't; and some people say they do, but don't. Whether these terms promote any real understanding is a moot point. Equally, to classify folds as an example of continuous but heterogeneous deformation adds little to our understanding of such structures, given their complexity. Many folds are not the result of continuous deformation, if we consider the case of flexural-slip folding, while the deformation might well be considered as homogeneous on a much larger scale than the structures themselves, or if the bedding acts simply as a passive marker. So why not call a fold, just a fold?

Secondly, the use of a complex terminology has a knock-on effect since it almost always results in a book that is very difficult to read, full of sentences with too many nouns and not enough verbs. The present book is no exception. I need take only one example, almost at random. Nicolas writes on p. 103: "In response to an applied stress, a crystal of calcite twins or not depending on its crystallographic orientation in relation to the orientation of this stress". Surely, it would be better to write: "Whether or not a crystal twins in response to an applied stress depends on how its crystallographic axes are orientated in relation to this stress". Two sentences later, he writes: "Only the crystals that are orientated in a favourable direction with respect to the applied stress orientation are twinned", which virtually repeats the first statement, equally clumsily. I spent much time in mentally translating the text into plain English, wondering at the same time how anyone without an adequate background in structural geology could make head or tail of its meaning.

Such deficiencies in the writing are compounded by the production of the book itself. The type-face is poor, and the printing has placed subscripts on the same line as the symbols to which they refer. Obviously, the publisher bears a responsibility for the translation and subsequent production of the book. Even so, it seems likely that the original edition had its deficiencies, since the present edition appears to be almost a literal translation from the French. No doubt, these deficiencies have coloured my reaction to this book, but that's the nature of any market.

J. L. Roberts.

Strathtongue, U.K.

European Dinantian

Miller, J., Adams, A. E. & Wright, V. P. (editors) 1987. *European Dinantian Environments*. John Wiley & Sons, Chichester. Price: £60.00.

This volume contains 18 papers focusing on the Dinantian Subsystem, the lower part of the European Carboniferous broadly equivalent to the Mississippian of North America. The papers are a selection of those presented at a conference in Manchester in April 1984. In the context of both the conference and this volume, the term 'environment' is interpreted widely: "from Europe-wide palaeogeographic reconstructions, through studies of particular sedimentary units to small-scale features such as the ecology of fossil soils". In addition to this variation in scale, there is an attempt to integrate the approaches of different disciplines: sedimentology palaeontology, biostratigraphy, structural geology and geophysics.

Despite this last aim, the volume is written firmly from a sedimentological perspective. Structural and tectonic geology appears in only a minority of the papers. On the largest scale, there are discussions by Leeder and by Bott on the plate tectonic setting of NW Europe in the Dinantian. In particular, did the extensional tectonics in Britain occur in a back-arc setting above a north-dipping subduction zone or in crust attached to a south dipping slab? These authors also discuss crustal scale subsidence mechanisms, particularly the influential 'block and basin' model for the British Dinantian where persistent highs are localized by underlying Caledonian granites. The general applicability of this model is challenged by Grayson and Oldham, who argue for control by fault-bounded tilt-blocks, perhaps in a regional transtensional regime. There are case-studies of individual fault-influenced basins by Black (Clair Basin, West of Shetland), by Gjelberg (Svalbard) and by MacCarthy and Gardiner (Munster basin).

Tectonic control of sedimentary facies is discussed extensively in relation to the Dinantian carbonate/clastic cycles. Leeder and Strudwick argue for a direct link to periodic movement along listric normal faults bounding the basins, and set up testable models to discriminate tectonic, eustatic and sedimentary controls on cyclicity. Walkden discusses cyclicity, particularly in relation to diagenetic histories, and favours a strong eustatic influence. MacCarthy and Gardiner suggest a eustatic control for four of the six cycles in the Munster Basin, with tectonic control of the others.

The remainder of the papers in this volume have a more exclusive sedimentological or palaeontologocal bias and are of less direct interest to structural geologists.

This book is welcome as a timely review of sedimentation in the European Dinantian. Its high price will deter any but specialist Carboniferous workers from buying it, but it can be recommended as an up-to-date reference for anyone needing an overview of tectonic controls on early Carboniferous sedimentation.

Nigel Woodcock.

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Rhenish Massif

Vogel, A., Miller H. & Greiling, R. (editors) 1987. *The Rhenish Massif.* 160 pp. Price: £34.35.

This book represents a selection of papers from a workshop meeting held in Boppard/Rhein in 1984. Anyone interested in Palaeozoic evolution of Europe would be excited by the title and sub-title of this book *The Rhenish Massif: Structure, Evolution, Mineral Deposits and Present Geo-dynamics.* However, your excitement will die away as mine did when you read the editorial. The editors warn the reader from the outset not to expect a comprehensive presentation of the geological evolution of the Rhenish Massif. Instead, a very wide range of different and separate subject areas are covered with only abstracts of interdisciplinary reviews attempting to link them together. This is a pity, since the apparent aim of this international monograph series is to bring together interdisciplinary views on a particular problem or subject area.

Previous monographs have included the much quoted review of the tectonic evolution of the Caledonide–Appalachian Orogen and two modern monographs on earthquake prediction. Unfortunately this particular monograph does not reach the same high standards.

There is a distinct lack of an introductory chapter on the geological history of the Rhenish Massif and therefore this book lacks a unifying theme. The only common linking factor is that most of the nine papers and five abstracts concern themselves with the Rhenish Massif and the along-strike equivalents in the Ardennes and the Bohemian Massif. However, there is no location map or regional geology map where the different study areas can be related.

For the benefit of potential readers, I will now briefly summarize each of the papers and abstracts. H. Arlar describes the lithological and ecological facies development of three Devonian formations in the Ebbe Anticline. Differential subsidence and sedimentation rates are used to explain the facies distribution. L. Lorenz then presents an abstract of his 1984 Tectonophysics paper on late Hercynian plate and interplate processes. This work was recently updated by P. Matte (*Tectonophysics*, 1986, **126**, p. 329). R. Dreesen presents the Upper Devonian event-stratigraphy of the Ardennes Shelf in terms of epeirogeny: for example, oolitic ironstones of the shelf can be correlated with synchronous volcanics and turbidites of the basin. W. Loske and H. Miller have statistically analysed heavy minerals of the Lower Devonian of the Ebbe Anticline and found a correlation between quantity of heavy minerals found and subsidence and sedimentation rates under marine and terrestrial conditions. Three types of zircon population can be recognized, two originating from distal polycyclic–granitic and sedimentary–metamorphic sources and a third from a local volcanic source.

H. Nesbot and H. Flick describe the mineralogy of a spilitized dolerite sill from the Lahn Syncline. The occurrence of albite, aegirine, arfedsonite and stilpnomelene indicate to them that the dolerite is an intraplate alkali basalt although no chemical data are presented. O. Oncken uses coal rank measurements on dispersed vitrinite to evaluate palaeogeothermal aspects of the development of the Rhenish Basin. Comparison of sedimentation rates, subsidence rates and