Journal of Structural Geology, Vol. 10, No. 3, pp. 317 to 320, 1988
Pergamon Press plc. Printed in Great Britain

BOOK REVIEWS

Two books on fracture

Atkinson, B. K. (Editor) 1987. *Fracture Mechanics of Rocks*. Academic Press, London. 534 pp. Price £60.00 (hardback).

Quite simply, this is the best research level geological textbook I personally have seen for many years. It is a veritable *tour-de-force* of both geological and geological-related fracture mechanics, comprising contributions from workers (including the Editor himself) at the forefront of modern research in the subject. The book is divided into 11 chapters, most of which could certainly exist as individual monographs in their own right. However, several of the chapters can also be grouped together into distinct sections based on common themes, such as theory and experiment, field evidence, applications, etc. The Editor himself is responsible (either individually or in partnership) for three of these chapters. Although highly individualistic, the different chapters do fit together into a whole which is a joy and pleasure to read. For this achievement alone the Editor deserves credit. Obviously, there is some repetition between chapters, but this invariably helps to reinforce the points being made and also helps the readability of each chapter by reducing the need for constant reference elsewhere. Each chapter represents the most up-to-date review currently available and many also contain hitherto unpublished work by the individual authors. The book is well illustrated throughout and further benefits from the use of reference lists at the end of each chapter. At £60.00 it is undoubtedly expensive, but it is still a must for any geological library or serious research group.

The first chapter is by the Editor himself and serves a dual purpose: to acquaint the reader (particularly those new to fracture mechanics) with the necessary background to the subject, and as a general introduction to the volume as a whole. It is a marvellously erudite and succinct piece of work and deserves to be read and re-read by all geoscientists. Nevertheless, it is merely an appetizer for what follows.

Perhaps Chapter 2 (T. Engelder), which deals with field evidence on crustal fractures, would have been better positioned somewhat later in the book, but this is only a minor and personal view. The author describes joints and shear fractures on all scales from microcracks to continental strike-slip fault zones, although he restricts discussion to the rupture of intact rock rather than the evolution of fault zones over time. The scope of this chapter is potentially prohibitively large, but the author presents an instructive account, with extensive references for further reading.

Chapters 3 (A. R. Ingraffea) and 4 (B. K. Atkinson & P. G. Meredith) are concerned with the fundamental theories and related experimental results on which the analyses of geological fracture problems are based. The former is concerned with fast fracturing whilst the latter considers slow, stable ("subcritical") crack growth. Both include extensive use of natural data and mathematical models, often originally obtained or derived by the authors themselves. Chapter 4 in particular ideally illustrates the importance of materials science concepts to fracture mechanics.

In Chapter 5 (L. S. Costin), the experimental and theoretical basis provided by the previous two chapters is used to develop a general model for time-dependent deformation and failure. It therefore serves to link the earlier chapters to the later ones (which deal with various applications of fracture mechanics) via the formulation of a rigorous physical model. The information presented in this chapter is relevant to all branches and scales of applied fracture mechanics, and also emphasises the relationship which must exist between fracture and continuum mechanics. Initially the treatment is rather simple but it becomes more complex with realization that failure is ultimately determined by various rate-dependent properties which also result in microstructural changes and material damage.

Chapters 6–9 are concerned with the application of fracture mechanics to a variety of geological problems: hydrofracturing and crustal stress measurements (F. Rummel), geothermal energy exploitation (H. Takahashi & H. Abe), natural fractures (e.g. faults, joints, veins, dykes, etc.) in rocks (D. D. Pollard & P. Segall) and the shear fracture mechanics of earthquake zones (V. C. Li). As such, they are likely to have varying appeals, but I would recommend that they are read on their own merit since they each contain a wealth of information which is potentially much more widely applicable. Personally, I found the chapter by Pollard & Segall particularly stimulating and it clearly indicates how fracture mechanics can be applied to various aspects of structural geology. However, I also realized that the other three chapters contained information relevant to my own research interests. Although individually these four chapters are quite superb, and taken together they are even better, I must make special mention of the chapter by Li since it is arguably the best in the entire book. Considering the overall quality of the book, this represents quite an achievement.

Chapter 10 (D. E. Grady & M. E. Kipp) investigates how a system of cracks responds to different loading configurations and hence affects the mechanical properties of a rock mass. This behaviour (which results in dynamic fragmentation) is much less clearly understood than the behaviour of individual cracks and fractures and hence this chapter is perhaps the most individualistic in the entire volume. Nevertheless, many of the concepts, theories, models and observations described in the previous nine chapters can still be recognized. Several examples of real applications (including enhanced oil–shale seepage and the dynamic stimulation of wellbores) are also given. The relationship between fracture and continuum mechanics is again emphasised, as well as the statistical nature of many natural fracture processes.

The final chapter (B. K. Atkinson & P. G. Meredith) is apparently just a tabulation of experimental fracture mechanics data for different minerals and rocks. However, the 27 pages of data represent the result of years of experimental work by different laboratories and are the accepted values of the parameters needed to apply fracture mechanics to geological problems. The collation of these data in one source will therefore facilitate the future applications of fracture mechanics. The data tabulation is preceded by a sort description of the experimental procedures involved in their determination.

As I said initially, I consider this to be the best geological textbook I have had the pleasure to read for many years. The volume is at the same time both general and specific. It contains simple reviews and also much new and original work. Obviously, one can identify some omissions: from my own interests, I would have liked to have seen some discussion of the microstructures associated with fracture mechanics phenomena, particularly as revealed by electron microscopy. But any omissions are almost certainly a consequence of the current state of the science of fracture mechanics, which is still evolving rapidly particularly with respect to real applications. This book therefore represents our current knowledge of fracture mechanics theories and formulations. As geologists, it is up to ourselves, the readers, to go out and apply them. The geosciences community as a whole owes its thanks to the Editor, Barry Kean Atkinson, for the opportunity to do this via this magnificent text.

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Blès, J. L. & Feuga, B. 1986. *The Fracture of Rocks*. North Oxford Academic, Kogan Page, London. 131 pp. Price £18.50 (hardback).

In my opinion there is no text which provides a properly balanced coverage of the subject of fracture of rocks, and the appearance of an English translation of *The Fracture of Rocks* by Blès and Feuga does nothing to change that situation. Part of the problem may be that the original French language edition first appeared in 1981, whilst the intervening years have seen substantial advances in our understanding of rock fracture. However, the present edition is described as being revised and updated.

The book is structured into two large sections, the first subtitled *Concepts of Rock Mechanics* and the second subtitled *Observation and Interpretation of Natural Fractures*. The first section, which comprises half of the volume, is equally divided into a summary of the theories of stress and strain, and a summary of tensile and compressive failure of rocks, including a consideration of the effects of pre-existing planes of weakness. In this book rocks are always considered to be continuous elastic solids, and thus their granular nature and its consequences are ignored. It is debatable whether it is necessary to repeat stress and