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# BOOK REVIEWS

## Folds and fractures

Ramsay, J. G. and Huber, M. I. 1987. *The Techniques of Modern Structural Geology. Volume 2: Folds and Fractures*. Academic Press, London. 381 pp. Price: £17.50, $34.50.

Those who already have Volume 1 of this series will have been waiting, like me, for Volume 2. They will get 381 pages for the relatively modest price of £17.50 and I think this is good value for money. Like Volume 1, Volume 2 contains many facts, definitions, explanations, exercises and illustrations, organized in a very practical way. The book should be ideal for students who want to learn techniques of structural geology by themselves or for teachers who are too busy or too lazy to put together practical exercises.

It took me a long time to digest the book and write this review. There are eight sessions on folds and five on fractures, plus three Appendices. Perhaps the relative emphasis on folds is a measure of the authors' own interest in these structures. Certainly this part is more complete than the one on fractures. Some of the material on folds is an updated version of Ramsay's first book (1967), but the illustrations are mostly new and they are excellent. The first four sessions deal with geometric aspects of folds. The approach is delightfully practical and simple, with that lack of pretentiousness that seems to mark John Ramsay's style. Session 15 (Fold Morphology) introduces simple definitions of features of a single folded surface, mainly those based on curvature. It might have been useful here to define curvature mathematically and to give some examples (some confusion may be created by the reader being told that curvature can be positive or negative, whereas standard mathematical textbooks proclaim curvature to be a positive quantity; but this should not have serious practical consequences). Fold forms are mainly analysed using Fourier series. In these days when computers and programming languages seem to become obsolete as fast as one learns to use them, it is comforting to be reminded that there are simple visual methods of harmonic analysis. In contrast, Session 16 (Fold Orientations: Projection Techniques) might have made some concession towards Fisher statistics and numerical contouring procedures, instead of relying only on stereonets and manual counters. Session 17 (Fold Classification), deals in fact with folded layers. The reader is reminded of the classifications of Ramsay (1962, 1967) and is given examples and exercises. Session 18 (Fold Sections and Profiles) is an eminently geological discussion of how to draw fold profiles and reconstruct them from surface data. This is the kind of practical session that is so often missing from standard textbooks, whereas it is truly basic training for any geologist.

The next two sessions deal with aspects of fold mechanics. Anyone who has tried to assimilate and compare the works of Ramberg, Biot, Johnson, Fletcher, Smith and others, will know that this is a difficult subject. The mathematics are heavy and the results controversial, even for very early stages of folding. In Session 19 (Fold Mechanics: 1. Single Layers), Ramsay and Huber take the easy way out and quote formulae for buckle wavelengths without deriving them, or even properly explaining them; although, to do the authors justice, they promise better in Volume 3. The discussion on fold shapes is also a little mystical, with no reference, for example, to the computer modelling of Dieterich, or Williams. This deficiency is even more obvious in Session 20 (Fold Mechanics: 2. Multilayers) where many of the statements (Models A–E, p. 418) seem to be articles of faith, with little reference to relevant experiments or numerical calculations. I do, however, like the geological illustrations and also the section on chevron and kink folds, where simple geometrical principles give good results.

Sessions 21 and 22 cover subjects that John Ramsay has always been specially interested in. Session 21 (Strain and Small-scale Structures in Folds) makes abundant use of simple geometrical fold models (flexural slip, flexural flow, tangential longitudinal strain) and their combinations, either amongst themselves, or with various initial (pre-fold) strain states. The resulting strain patterns are compared with those in real rocks; but not with those in experimental or computer models, which would have made the subject more complete. Finally, to finish the discussion of folds, Section 22 (Superposed Folding) is a good summary of our current understanding of successive fold phases and their interference. The approach is almost purely geometric, with emphasis on shear folding, which indeed seems to provide a reasonable approximation to what is observed, at least in highly ductile rocks. The authors make the valid point that we know little about the mechanics of such processes.

To summarize, this first part on folds (Sessions 15–22) is dominantly geometric and phenomenological. The approach has many advantages, including a very important one for this kind of book: simple mathematical exercises are easy to devise. In general, I find that the topics in these sessions have been comprehensively covered. On the other hand, there is little explanation as to why the topics were chosen or why they may be important. In fact, I am left wondering if some of them are important at all! What is the use, I ask myself, of studying folds in great detail? If it is to get an idea of more regional kinematics, then it is a shame that nothing much is said about the old problem of extension parallel to fold axes, nor about fold development in wrench zones.

The five sessions on faults I find easier to justify and even novel in some respects. Session 23 (Fault Geometry and Morphology) deals with the basics, in a practical way. It also begins to consider (without really saying so) the very important problem of how regional deformation can accumulate to a finite degree by slip on various fault systems. In Session 24 (Faults and the Construction of Balanced Cross-sections) the reader gets a good introduction to section balancing and restoration, although I find the list of 10 references somewhat incomplete (I searched in vain here for a reference to Butler, although there are two in the source list at the end of the book). Session 25 (Mechanical Analysis of Fractures) goes through the usual analyses of stress, simple elasticity, failure criteria and Mohr envelopes, but does so in a refreshingly simple way, uncluttered with excess mathematics. There are also pleasing digressions into such subjects as fault-plane solutions, shatter cones and vein formation. A section on the products of rock fracturing would have been better if there were descriptions of experimental rock products. Session 26 (Ductile and Brittle Shear Zones) contains a good summary of John Ramsay's mathematical analyses of ductile shear zones. It would have been more useful with adequate referencing of work by Coward, Kligfield, Schwerdtner and others, on strain factorization. I also missed a reference to Bell in connection with conjugate shear zones and strain patterns. On the other hand, I like the discussion of brittle–ductile shear zones and the excellent illustrations of en échelon vein systems. The session ends with a woefully short and inadequately referenced section on shear sense indicators (where are Lister and Snoke?), which is surely one of the most important topics in structural analysis, but gets less than 2 pages of text (and 4½ pages of good illustrations to make some amends).

Finally, Session 27 (Joints) contains basic descriptions and some good examples, but little to convince the reader that joints are worth spending time on.

Amongst the Appendices, the one on stress is straightforward and to be found in many books; but the one on geological mapping contains many useful hints and two examples of John Ramsay's field maps which set remarkably high standards (the originals will probably become collectors' items).

In general, this book is very good in terms of illustrations, simple mathematical exercises, kinematics of folds and fault patterns, and practical hints for the field geologist. On the other hand, some key aspects of structural geology are missing (perhaps they will be in later volumes) and so too are many important references. The book is hardly an inspiration for new research; but then it was probably not meant to be so. On balance, I think most of us will be very glad to own a copy, especially for teaching or for learning the techniques of structural geology.

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## Laboratory course in structural geology

Rowland, S. M. 1986. *Structural Analysis and Synthesis: A Laboratory Course in Structural Geology*. Blackwell Scientific, Palo Alto. 224 pp. Price $26.95 paperback.

Laboratory exercises using progressively more complicated geologic maps of mythical terrains have been a feature of my introductory