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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

structural geology course for years. I was, therefore, quite intrigued by Stephen Rowlands' laboratory manual that takes this strategy a step further by progressively analyzing a single geologic terrain. Most of the exercises include analyses of various aspects of the structural geology of the mythical Bree Creek Quadrangle, which is included on six separate sheets in the back of the book. This approach is intended to approximate the procedure used by the field structural geologist in the study of a new area.

The book contains 14 chapters that are organized into an orderly sequence of map-related exercises and several exercises that supplement topics which are typically discussed in the lecture portion of a course. The chapter titles are: (1) Attitudes of Lines and Planes, (2) Outcrop Patterns and Structural Contours, (3) Interpretation of Geologic Maps, (4) Geologic Structure Sections, (5) Stereographic Projections, (6) Folds, (7) Stereographic Analysis of Folded Rocks, (8) Parasitic and Superimposed Folds, (9) Faults, (10) Orientation of the Stress Ellipsoid, (11) A Structural Synthesis, (12) Rheological Models, (13) Brittle Failure and (14) Strain Measurement. Five Appendices contain information on: the use of a Brunton compass; trigonometric functions; Greek letter symbols used in the book; determining vertically exaggerated dips; and conversion factors. I cover the topics considered in the last three chapters fairly early in my lectures, but I had no problem moving these exercises in the sequence to coincide with my lectures.

The individual chapters are generally well organized, clearly illustrated and clearly written. A bold-print section at the beginning of each chapter states the objectives of the exercise. Recommendations by the author at various points help the student approach the exercises in an organized manner. The laboratory manual pages are perforated and three-hole punched so they can be taken out and put in a binder along with the exercise answers for easy future reference. Each chapter ends with a brief annotated list of "Further Reading". Typically these references are from other laboratory manuals, structural geology texts, or the *U.S. Journal of Geological Education*. A complete list of references cited is included at the end of the text.

Although most of the book's chapters are fairly standard for laboratory manuals on structural geology, two of the chapters are relatively unique. Chapter 11, A Structural Synthesis, instructs the student in the preparation of an organized report on the structural history of the Bree Creek Quadrangle. The chapter provides organized topic headings and instructions for the presentation of results obtained by the student during the completion of 15 previous problems on the geology of the Bree Creek Quadrangle. The instructions are clear and to the point and even include a brief discussion on how to cite references. Two short sections on Writing Style and Common Errors in Geology Reports help the student through some of the common problems encountered in report writing.

The second unique chapter includes a series of experiments illustrating rheological models using rubber bands, a plastic syringe, a block of wood and Silly Putty. Although the rheological experiments are conceptually useful, even as thought experiments, the geological applications considered in the problems are not equally good illustrations of the application of these processes.

The level of presentation in the text is clearly a compromise between books devoted entirely to map exercises and laboratory manuals that include a more comprehensive and rigorous approach to the techniques of structural analysis. For instance, in the discussion of brittle failure, equations for normal stress and shear stress in terms of the principle stresses and theta are converted to double angle form; however, the author makes no effort to show that these equations are the parametric equations for a circle and form the basis for the Mohr diagram. This same chapter discusses brittle failure in terms of the Mohr envelope and the angle of internal friction (Coulomb coefficient) but makes no mention of the Coulomb criterion or the graphical representation of cohesion on the Mohr diagram. Such criticism could reasonably be dismissed were it not for the erroneous suggestion (pp. 167–168) that cohesionless materials have a Coulomb coefficient of zero and therefore fail at an angle of 45°. I was also disappointed that the author decided that Ramsay's type 1A and 1C folds were not worth mentioning, leaving the student with the impression that all type 1 folds are parallel folds. Through a similar omission, the author implies that all folds with gently dipping axial planes are reclined folds.

Other instructors may find their own pet criticisms of the depth and rigor of the presentation, but the rigor of the presentation can be supplemented as the instructor sees fit. I, nonetheless, appreciate the manual's clearly organized and balanced presentation of topics and its exercises that involve the progressive analysis and written synthesis of a single map area. The text has been popular with my students. I would recommend it to any instructor who emphasizes the interpretation of geologic maps in their introductory structural geology course.

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The Nepal Himalaya

Colchen, M., Le Fort, P. and Pêcher, A. 1986. *Geological Research in the Nepal Himalaya. Annapurna, Manaslu, Ganesh Himal.* Editions du Centre National de la Recherche Scientifique, Paris.

This memoir, by three of the foremost Himalayan workers, covers the central Nepal sector of the mountain range and summarizes over 10 years of field research by the French team. The book is bilingual, the first half in French, the second in English separated by a central section of plates. Thus it appears 'meatier' than it actually is. The English version also suffers from poor translation and the reader is continually puzzling over the meaning of concretized, chemism and other Franglais words.

The text is an updated explanatory paper to accompany the excellent fold-out 1:200,000-scale coloured geological map that was compiled in 1978 and first published in 1980. The map covers the eastern part of the Dhaulagiri Massif, the Kali Gandeki Valley, the Annapurna Massif, the Marsyandi Valley, the Manaslu Massif and the Burhi Gandaki Valley to the western edge of the Ganesh Himal. The lithological-structural map has metamorphic isograds superimposed, and in interpretative cross-section. It is a compilation of many years field studies by the three authors as well as previous mapping by G. Fuchs, P. Bordet and J. Stocklin, and is invaluable to all Himalayan researchers. It seems a pity therefore that the text is only a superficial coverage. The High Himalayan metamorphic rocks and the classic Manaslu granite are described in only 4 pages each and the stratigraphy and tectonic sections are likewise superficial.

There are over 70 black and white photographs some of which, although interesting, are only of limited geological value. The book is well produced by CNRS and has a superb colour photograph of the west face of Machapuchare (6993 m) on the front cover. The area covered is one of the most extensively studied regions of the Himalaya, and this volume can be recommended for all Himalayan researchers.

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Terrane tectonics

Evan C. Leitch & Erwin Scheibner (Editors) 1987. *Terrane Accretion and Orogenic Belts*. American Geophysical Union, Geodynamics Series, Vol. 19. Price $38.

This volume presents a selection of up-dated papers from the Third Circum-Pacific Terrane Conference held in Sydney, Australia, in August 1985. Most of the papers deal with terranes in the Western Pacific margins and there is particular emphasis on Australia and the SW Pacific (220 pages of the 343 page volume). Thus many of the papers deal with pre-Mesozoic terranes in the hinterland of the active Pacific rim. Two earlier volumes dealt mainly with the NW and NE Pacific margins, respectively, while Vol. 18 of the Geodynamics Series also deals with Circum-Pacific orogenic belts and the evolution of the Pacific Basin.

During the last two decades work in the north-east quadrant of the Pacific Rim has demonstrated great complexity of evolution of these accretionary belts which have developed through the interaction of continental and oceanic plates. Palaeontological and paleomagnetic evidence have been used to argue for very large displacements (of the order of hundreds or thousands of kilometres) of individual terranes relative to adjacent terranes and to the continental craton. Thus terrane tectonics has brought concepts, previously largely restricted to the study of continent–continent collision belts, to the study of the anatomy of Circum-Pacific accretionary belts.