

My immediate impression on examining the book was that the list of chapter headings seemed strangely organized. For example, it would seem more logical for the chapter on the description of mesoscopic structures (11) immediately to precede the chapter dealing with the structural analysis of these structures (8), rather than be placed three chapters later. It is also clear from the chapter headings that most of the chapters deal with the basic methods of geometric analysis. Consequently Chapter 10, which is essentially an essay on experimental rock deformation, comes as something of a surprise. Although it is clearly written and is one of the chapters I enjoyed reading most, it does not fit comfortably or logically with the other chapters. Perhaps this is to be expected in multiply authored texts.

As well as the standard chapters that can be found in all structural manuals there is an excellent chapter (12) on fracture analysis which provides a lucid and helpful guide to data collection and processing. I was however rather disappointed with the casual (and misleading) definitions given for the conditions necessary for the formation of shear and hybrid (shear/extension) fractures, definitions of crucial importance to this chapter. The authors state that shear fracture occurs when all the principal stresses are compressive and that hybrid fractures form when one of the principal stresses is tensile and when the Mohr circle touches the failure envelope at two points. They omit to mention that the essential condition that determines whether shear or hybrid fracture occurs is the state of normal stress across the potential fracture plane. If this is compressive (and this condition can be achieved under conditions where all the principal stresses are compressive or when one of them is tensile) then shear failure results. If it is tensile, hybrid fracture occurs. This criticism does not, however, significantly detract from the contribution this chapter makes to an area which few books have had the courage to tackle.

Topics such as stereographic projection, structural analysis in both single- and poly-deformed terrains and the description of mesoscopic structures are adequately covered and compare favourably with other comparable texts. The chapter on the analysis of two-dimensional strain (15) provides a brief introduction to strain and illustrates the main techniques of strain determination. It was however disturbing to read in the introduction to this chapter that we would be primarily concerned "... with permanent strains that develop as a consequence of plastic deformation". Using the term plastic, with its specific rheological implications, as a synonym for the more general term ductile (which is used elsewhere in the chapter) seems rather casual, especially in this context. In defining the parameters of strain it could have been made clearer that the parameters relate to strain "in a particular direction". I would also have liked to see a distinction made between lines of no longitudinal strain and lines of no finite longitudinal strain. It was refreshing to see the chapter rounded off with a brief discussion of the use geologists make of strain data once it has been acquired.

The explosion of interest in cross-section balancing and section restoration in the last 10 years requires that the subject be covered in any teaching manual. Chapter 14 provides a good introduction to this subject. I was particularly impressed by the second half of the chapter which successfully introduces the various problems associated with cross-section balancing by considering a series of progressively more complex examples. The chapter deals only with thrust systems and ignores extensional structures and the balancing of sections from extensional terranes. Consequently techniques such as the chevron construction are not covered.

It is difficult to produce a book of this size devoid of minor errors and this book has its share of typographical errors and errors of omission (e.g. labelling missing from diagrams). Sometimes the errors are particularly unfortunate, as for example in Chapter 1 where, after carefully distinguishing between the rake (pitch) and plunge of a lineation, the text refers to the plunge of some slickensides in figure 1 but quotes the pitch. Nevertheless, on the whole the book compares favourably with other manuals and I would recommend that it be given serious consideration by anyone involved in giving an introductory course in structural geology. However its price is high for a paperback (particularly in £ sterling), which could limit its sales as a student course book.

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- John Cosgrove
London, U.K.
- ### Map interpretation
- Lisle, R. J. 1988. *Geological Structures and Maps*. Pergamon Press, Oxford. 150 pp. Price £9.95 (flexicover), £19.50 (hardcover).
- There has long been a need for a book which tackled the interpretation of geological structures from maps with the logical approach that this book adopts. It breaks away, largely, from the dependency on unrealistic 'problem' maps used by past texts and yet is not as esoteric in its approach as two other recently published books in the same broad field (Moseley 1979, Butler & Bell 1988). In spite of the reservations I express below this excellent little book should be a suitable text for many first-year courses in British Universities as well as for some A-level syllabuses. I doubt, however, the publisher's 'blurb' that it will match G.C.S.E. syllabuses.
- The book, subtitled *A Practical Guide*, is concerned with the interpretation of simple structures from geological maps. It deals in turn with uniformly dipping beds, folding, faulting, unconformity, igneous rocks and folding with cleavage, the first three chapters being the more substantial. The geometry of the relevant structures is well described, definitions and classification are meticulous and the principles of map interpretation carefully explained. This is aided by excellent diagrams and sketch maps often using two colours and good use is made of some 40 black and white photographs. Most chapters contain some worked examples and each concludes with problems using small maps, often based on real situations, as well as photographs. No answers to the problems are given and there is no indication of what the publisher's response would be to a request to photocopy maps for class use. Few text errors were discovered, although on problem 3.6 there is one small area wrongly ornamented and one dip value seems incorrect.
- My most serious criticism is of the approach to the recognition of folds. The author, quite properly, encourages the student to distinguish outcrop (boundary) patterns that are a consequence of folding from those due to topographic interference. However, throughout this chapter there is little emphasis placed on the simple analysis of dip information in the recognition of fold geometry. All the example and problems maps which are meant to distinguish fold and topographic effects on boundary patterns depend on the identification of hinge points and axial surface traces from the drawing or envisaging of structure contours. In each case, because of the absence of any dip information, there are at least two possible ways of drawing quite regular structure contour patterns, giving contradictory interpretations. This reveals the limitations of the 'problem' map, which generally the author eschews; real maps of single-phase folding of this simple geometry would (or should) contain sufficient dip information to distinguish between these interpretations.
- I would also have liked to have seen more emphasis on the use of the known stratigraphic order in the interpretation of structure and vice versa. Although proper emphasis is given to the use of structure contours, their use in the construction of both profiles and normal cross-sections is not explained. Some consideration should also have been given to the construction of hinge shape where there is neither plunge nor structure contour information. A modified Busk construction would have been useful and I would have expected at least a mention of the problems of balancing and restoration.
- In the chapter on faulting, the emphasis is on classification and the distinction of slip and separation. I would have liked to have seen more attention given to faults, especially to their mutual attitudes, their relation to shortening and extension of the crust and in general to their geometry on real maps. Unconformities are quite fully treated (though not the analysis of non-planar surfaces) and igneous rocks receive a short but not unreasonable treatment in the context of the book. However, I would like to have seen more than two problem maps bringing the various aspects of interpretation together.

The final chapter dealing with folding and cleavage is decidedly out of place, embarking half-heartedly on an entirely new subject area. Cleavage/bedding relationships are described and illustrated, but the chapter ends lamely with two exercises based on two-dimensional sections and, like all the material in this chapter, not put into the context of geological maps.

Once again, I must emphasize that these criticisms should not detract from my overall welcome to the book. At this reasonable price it can be confidently recommended as a 'best buy' to back any course in elementary map reading.

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 Moseley, F. 1979. *Advanced Geological Map Interpretation*. Edward Arnold, London.

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Geological structures in the field

McClay, K. R. 1987. *The Mapping of Geological Structures*. Geological Society of London Handbook. Open University Press, Milton Keynes. 161 pp. Price £7.95.

This is a book that all field geologists should have, particularly those non-specialist in structural geology. Given the price, the size and content I believe it should be part of the field equipment for all undergraduate mapping camps, particularly those where mapping is undertaken in deformed rock sequences. It is essentially a field almanac for structural geology, and provides a well illustrated guide to field mapping and the interpretation of geological structures. Descriptions of the various structures and the techniques used to measure them are brief, but informative. References are kept to a minimum and readers will need to source other books if they require more information on the topics presented. Some key references are however provided at the end of the book. The book is well illustrated with simple but clear line diagrams and field sketches, backed up by excellent field photographs. Tables are used to simplify various structural aspects, such as the nature of the various types of foliations and lineations, what to measure, and what the structure and measurements mean in terms of mapping and unravelling the geological history of an area.

Topics covered include a discussion and description of primary (sedimentary) structures (Chapter 1); mapping techniques (Chapter 2); structures incorporating folds (Chapter 3); foliations (Chapter 4); linear structures (Chapter 5); faults and shear zones (Chapter 6); joints, veins and stylolites (Chapter 7); polyphase deformation (Chapter 8); and the interpretation and analysis of geological structures (Chapter 9). The Appendix includes a dip nomogram for the calculation of apparent dips, a graph for the calculation of thickness exaggeration with apparent dip, and a brief treatment of strain analysis, with the types of markers and the methods suitable for their analysis given in tabulated form.

The mapping techniques section is well documented covering aspects such as equipment, measuring techniques, recording field data, field safety and behaviour. Three compasses, the Silver Ranger 15T D-CL, the Freiburg and the Chaix compass, are shown in the book with most emphasis given to the Silver student compass, particularly in illustrating field measurement techniques. This section is excellent and will help immensely in directing students in the methods of measuring planar and linear features in rocks. The text description is easy to follow and is backed up by excellent field photographs which show the compass being used in various measurement positions. Direct measurements of suitably exposed planar surfaces is covered, as well as how to use either a stiff-covered field notebook or map board when there are no suitable surfaces on which to place the compass for measurement, or by sighting along the strike direction of the rock layer. Both direct measurement of a lineation as well as measurement of the pitch in a plane are treated.

The mapping techniques chapter introduces the stereographic projection and shows how the sample measurements plot on the net, but it does not cover the plotting and manipulation of structural data. The

readers are referred to both Phillips (1971) and Ragan (1985) for this material. Examples of maps produced using various base maps, and selected map symbols are given: these base maps include topographic map sheets, aerial photographs, and the use of a baseline to locate measurements in areas when no suitable base is available. There are five pages of good examples showing how to record field observations in a geological fieldbook, with emphasis placed on neat, legible, concise description and simple, annotated sketches. The taking of oriented samples is demonstrated, as well as advice given on how to take photographs of rock structures in the field.

Description of the various types of geological structures is concise, but adequate. Individual structures are defined and described to enable the reader to recognize these features in the field. Each chapter on structures has a very useful table listing 'what to measure', 'what observations to record', and points out the significance of the measurements as 'results of the analysis'. The chapter on *faults and shear zones* for example, initially introduces faults both from a dynamic (Anderson's classification) and descriptive (referring to extension, contraction and strike-slip faults) perspective. It then goes on to introduce the various geometries of contraction and extension faulting which have become popularized in the last few years. Shear zones are treated from both a brittle and ductile viewpoint with a description of Riedel shear fractures and gash veins leading into ductile zones with foliations, shear bands and/or C- and S-fabrics. Shear-sense criteria (kinematic indicators) are also briefly discussed.

The *polyphase deformation* chapter introduces the terminology in polyphase terranes and then discusses field recognition of poly-deformation. Fold interference patterns, folding of planar and linear structures, superposition of fabrics, and widely distributed bedding attitudes are given as the main indicators. Two pages are devoted to fold interference patterns illustrating their geometry and map patterns. Stereonet representations of refolded folds and folded lineations are also provided in the chapter. Perhaps more could have been done here, recalling information (such as fold vergence) from some of the earlier chapters, and giving a little more detail on mapping in polyphase terranes.

The chapter on *interpretation and analysis* stresses the importance of on-going interpretation of the map and structural data, as well as the construction of preliminary cross-sections during the field work. This enables not only identification of key problem areas, but also the testing of field hypotheses by attempting to predict the structures and the structural relationships at outcrops visited subsequently. Examples of various maps (outcrop map, interpretation map, cleavage and lineation map and a structural summary map) of a given area are shown, to provide guidance as to what can be done with the collected field data in an attempt to sort out the geological and structural history of a mapped area. Construction of cross-sections is given good treatment as these are important in the overall interpretation of the map. Section balancing is also introduced.

The main shortcoming of the book is the lack of an index. This omission makes it difficult if someone is trying to locate a particular structure or structural element. Other criticisms relate to the unfortunate use of genetic terms such as *fracture cleavage* and *pressure-solution cleavage* rather than spaced cleavage, the problems of determining an axial surface attitude when cleavage is fanning, and the fact that there is no mention of slickenside or slip surface analysis (see Arthaud 1969, Angelier 1975, Alexandrowski 1985) in the chapter on faults and shear veins. More could also have been given on report writing, and students using this book will therefore need to be given more information on this aspect of their mapping camp.

These omissions and usage do not however detract from the overall value of this pocket companion. It is more up-to-date, better illustrated, and better value for money than similar books by Wilson (1982) and Compton (1962, 1985). Although these cover some aspects of mapping in more detail, McClay's book provides the best treatment of rock structures, how to measure them and what they mean. The stated objective of the book is to provide a basic guide to field mapping and the interpretation of geological structures. I believe it does this extremely well, and at the same time stresses the importance of careful, accurate and systematic fieldwork. It is certainly a book to be recommended.

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