

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.

REFERENCES

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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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Field Guide to the Rocky Mountains

- Beus, S. S. (editor) 1988. *Centennial Field Guide: Rocky Mountain Section*. The Geological Society of America, Boulder, Colorado, U.S.A. 489 pp. Price \$43.50.

This book is Volume 2 of a six volume series of field guides published as a part of the Decade of North American Geology project. It contains short articles and maps of 100 geologic locations in Arizona, Colorado, Idaho, Montana, New Mexico, South Dakota, Utah and Wyoming and the province of Alberta. Index maps at the front show the locations of all the sites along with main highways and the boundaries of the major physiographic provinces. A useful table cross-references the sites in each state with the various geologic topics covered along with the physiographic provinces. These allow a traveler in the region to quickly select sites of interest and plan a route.

Obviously, as the editor notes, many other significant sites could not be included; another volume or two could easily be added. Each site description includes an index map of the locality, access information, significance of the site, description of features to be observed and a short reference list. Most sites are on or near roads, but some require long walks.

Tectonic structures are described at 40 sites. A wide variety of structures occurs in this region. Eight of the sites are in the foreland thrust belt from Alberta to Utah. Others include: metamorphic structures (four), recent faulting (four), monoclines (three), gravity slides (four), salt tectonics (two), Basin and Range–Colorado Plateau transition (two), calderas (two), polyphase deformation (two), Laramide fault blocks and forced folds, fractures and mineralization, rejuvenation of basement structures, granite tectonics, igneous intrusions and associated structures, keystone faults, detachment and breakway faults, structural history from interpretation of unconformities and a meteorite impact. Other than one site, the major omission in this otherwise broad coverage is the structures in the large basement uplifts and intervening basins of Wyoming.

The volume is carefully edited. Each site description is concise and accompanied by guide maps, cross-sections and photographs. In a number of articles alternate interpretations of the described features are discussed. For those who wish to learn more about a particular locality, the reference list provides entry into additional sources.

More than half the volume contains sites about many other topics such as stratigraphy, glaciology, geomorphology, mineral deposits, igneous and metamorphic geology and paleontology. The traveler will be sorely tempted to make many more stops besides the ones originally planned. To have all of this in one volume at a reasonable price is, indeed, a bonanza.

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Meanings and definitions

- Lapidus, D. F. 1987. *The Facts on File Dictionary of Geology and Geophysics*. Facts on File Publications, New York. 347 pp. Price \$24.95 (hardback). (D. R. Coates—Scientific Adviser.)

One of the cardinal sins a reviewer can commit is not reading all of the book under review. I confess to not having read all of this one, but then, it is a dictionary. My approach has been to concentrate on those words which are currently favoured by structural geologists and tectonicians. At the outset, it has to be reported that much of the nomenclature employed by numerous authors of recent papers in the *Journal of Structural Geology* does not feature in this book. For example; listric fault, stretching lineation, sheath fold, transpression and accretionary prism are a few of the words not defined. Given that this dictionary is only 347 pages long, and all branches of geology and geomorphology are treated, this criticism might seem unfair: the author had to be selective. However, in her Preface, Dorothy Lapidus refers to the impact that plate tectonics and other new concepts have had on thinking and the redefinition of terms. Thus, I anticipated a more up-to-date approach; not just a few explanations of elementary plate-tectonic notions set in a matrix of the old geology.

Some definitions are incorrect, others merely bizarre. A small selection of these entries illustrates the problem. An odd statement is: "... faults of the same age and *depositional* (my italics) development are said to be conjugate". Kink bands are defined as "... narrow bands in which the beds assume a dip that is gentler or steeper than the adjacent beds". Plate tectonics is explained in terms of crustal units without mention of the lithosphere. Crust and lithosphere are, however, distinguished in their own entries. The modern usage in tectonics of 'terrane' is not explained but in her discussion of this word the author writes: "A term that is variously dying and being revived . . .", many of us might agree with the sentiment. Finally, I was surprised to read the opinion that Neogene is a "Largely obsolete name for the Miocene and Pliocene Epochs . . .".

Some terms that have been defined are, in my opinion, not worthy of inclusion considering those omitted. My list of words that could have been left out includes: breached anticline (synonym: bald-headed anticline), geanticline, salt lick, shear fold, spelunker (a caver) and tectogene. Although a decision to include 'geosyncline' can be justified on historical grounds, the author does not explain why the word has lost favour. She does, however, uncritically list the numerous subclasses of geosyncline, including 'zeugogeosyncline', my favourite when a student.

Despite the above somewhat carping comments it must be reported that many terms are adequately defined without the use of pretentious language or too many qualifying clauses. The meaning of some nomenclature is illustrated by line drawings, mostly rather crude, but occasionally fresher than the more formal figures of most texts. In particular, I liked the fence being deformed in different ways by different types of seismic waves. Notwithstanding its attractive features, this book cannot be recommended; there are many alternative and more authoritative dictionaries and glossaries.

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