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BOOK REVIEWS

Structures in tectonic context

Suppe, J. 1985. *Principles of Structural Geology*. Prentice Hall, New Jersey. 537 pp. Price: hardcover £48.00.

About two or three English-language text books of structural geology are published every year. Of those that are comprehensive in scope, aimed at undergraduates and have appeared in the last decade, perhaps two, *An Outline of Structural Geology* (1976) by Hobbs, Means and Williams, and *Foundations of Structural Geology* (1983) by Park, have gained very wide acceptance. I believe that Suppe's *Principles of Structural Geology* possesses the potential to join that list because not only does it cover most (but not all) classes of structure but it also contains original ideas and insights. In addition, sufficient tectonics is included and integrated with structural geology for the reader to be able to appreciate deformation products and processes in their broader context. But for its high price (£48.00) it would probably be on most students' essential reading lists. The publishers should consider producing a cheap soft-back version; perhaps concurrently with a second edition, which Suppe hints will be forthcoming.

The thirteen chapters of *Principles of Structural Geology* are collected into four parts: I. Introduction. II. Principles of Deformation, III. Classes of Structure and IV. Regional Structural Geology. The heart of the book is part III, "Classes of Structure," which comprises 247 of the total 537 pages, including the 30 taken up by the appendix, references and an unusually comprehensive index. A pleasing aspect of the chapters in part III is the way in which after describing each class of structure, Suppe employs the deformation principles given in part II to interpret them. From some, largely older texts, one gains the impression that once the author had 'got through' such fundamentals he heaved a sigh of relief.

Some elementary knowledge of plate tectonic theory is assumed in chapter 1, "Introduction to the Deformation of the Lithosphere". This assumption permits the author to knit together a selection of topics concerned with the morphology, properties and behaviour of large crustal units, both active and inactive. Chapter 2, "The Geometry of Map-Scale Structures" commences with relatively short but workmanlike accounts of recording structural observations and plotting 'stereographic' projections, but most of it is devoted to the technique of balanced section construction; the first time I have seen the axioms and practicalities set out in a text book.

"Strain and Stress", the theme of chapter 3, that opens part III will be familiar to many geologists trained after 1955 and hence it contains few surprises. The principal processes that enable rocks to flow are treated in chapter 4 "Deformation Mechanisms", which is succeeded by a masterful account of "Fracture and Brittle Behaviour" in Chapter 5. Suppe makes especially effective use of Mohr stress diagrams to explain relationships. Interestingly, in fig. 5.5, the entire range of failure between tensile and Coulomb fracture behaviour is referred to as transitional tensile behaviour, although there is a normal component of extension only across some of the fractures in the group. This definition of transitional tensile behaviour would not appeal to all workers but it possesses the merit of highlighting the conclusion that the effective least principal stress is tensile during the initiation of all fractures in the range. It is noteworthy, however, that in chapters 6 and 7, the author reverts to more customary usage, and includes only those fractures across which the effective normal stress is negative in the transitional tensile category. The statement (p. 170) "most joints are probably tensile or transitional tensile fractures" is an inference with which I agree completely.

The theme of 'Joints' is continued in chapter 6, the first of Part III. In my view, it is easily the best account in a text book of these enigmatic but universal structures since the publication in 1966 of Price's *Fault and Joint Development in Brittle and Semi-Brittle rock*. Especially rewarding is the section on the origin of joints from the perspective of crustal stress conditions. Suppe predicts that consideration of *in situ* stress measurements will in the future become more important in this context.

Before dealing with "Faults" in chapter 8, the structural aspects of magmatic, mud and salt intrusions and extrusions are considered in chapter 7. Emphasis in chapter 8 is given to faulting mechanisms and recent modifications to Anderson's classic theory of faulting. Chapter 9 "Folds", is largely a straightforward exposition of necessary material that is now common to most structural texts. Nevertheless, the section on fault-related folds, particularly fault-bend folds, presents a view that is generally underemphasized or considered only in the context of thin-skinned thrust belts. Boudins are briefly described in this chapter rather than with foliations or lineations as is customary. Boudins formed under high-grade conditions are called *inverse folds*, a term new to me. Chapter 10, "Fabrics", which discusses both penetrative and non-penetrative foliations, also contains some unusual nomenclature; *fanning* and *antifanning* are employed to describe convergent and divergent axial plane foliations, respectively. Part III concludes with a short account in chapter 11 of "Impact Structures". Suppe makes the thought provoking point, that if the average rate at which continents are lowered by denudation is 0.1 mm/year, then a crater 1 km in diameter and depth will be removed in only ten million years. Hence many impact structures older than about the medial Miocene are likely to be difficult to detect.

Section IV, which is devoted to 'Regional Structural Geology' comprises two chapters, 12 "Appalachians" and 13, "North American Cordillera". The choice of these two regions presumably reflects the author's judgement about the nationalities of the majority of his readers, but despite the concentration on United States and Canadian tectonic provinces those resident elsewhere will gain much of general interest from these two chapters. In many structural texts and courses, regional structural geology is a topic less favoured than, say, deformation processes. Suppe provides an excellent and succinct justification for its inclusion. His words are worth quoting in full (p. 416):

"Regional structural geology is a subject quite different in flavour from the rest of structural geology because it is first of all concerned with unique historical events and only secondarily with general classes of deformational processes. The goal of workers in regional structural geology is primarily to decipher the history and the associated present structural geometry and prior paleogeographies of some area of our planet. Regional structural geology also leads to important insights into the underlying physical processes and recurring historical themes that are repeated in space and time among the various mountain belts of the world."

In common with all good text books the enthusiasms of the author are clear from his choice of topics and it is difficult to quarrel with those of Suppe. There are, however, some surprising omissions of classes of structure. For example, mullions, chocolate tablet structure, shear bands and quartz rods are not discussed. Furthermore, some topics, such as the significance of stretching lineations, syntaxial and antitaxial growth fibres, the crack–seal mechanism of vein development and shear zones characterized by en échelon veins and/or a local secondary foliation are treated cursorily, or in much less depth than I would have expected.

A useful study hint of the author is the recommendation that those who are revising for an examination should read the index as a way of providing a check-list of topics that should be understood. I confess that after twenty years of teaching, this worthwhile idea came to me as a fresh one. A more conventional aspect of Suppe's book is the inclusion of exercises at the end of each chapter. Most worthy: do readers ever attempt to solve them? Two facets of the book which all students should attempt to emulate are the directness of Suppe's prose style and the clarity of his line drawings.

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Kinematic interpretations of structures

Nicolas, A. 1984. *Principes de Tectonique*. Masson, Paris. 200 pp. Price: softcover 101 FF.

To date, French students have no abundant literature on structural geology in their own language. Nicolas' book dedicated to the kinematics of structures within deformed rocks is now at their disposal.

After very basic considerations about stress and strain, the theory of discontinuous deformation and the mechanism of continuous deformation are briefly presented in the first three chapters. The following chapters present and interpret various types of structures within deformed rocks: the discontinuities of the brittle field (faults, joints,

gashes and stylolites); structures associated with homogeneous deformation (cleavage and lineations) and those which characterize heterogeneous deformation (folds and boudins). Incremental strain markers (pressure shadows and synkinematic crystals) are also considered. Lastly, as an appendix, some elements of tensor analysis and methods of finite strain measurements are given.

This book is original in that it favours a kinematic interpretation of structures rather than geometrical description alone. Its appreciation may well depend on a similarity of geological philosophy in the reader.

Finally, one must note that one of the advantages of this book, which will be translated into English, is its low price due to the camera ready copy.

Le livre de A. Nicolas, "*Principes de tectonique*", n'a pas son équivalent en français: il rassemble tous les apports récents concernant l'analyse des structures dans les roches déformées et leur interprétation en terme cinématique.

On y trouve d'abord les notions élémentaires de contrainte et de déformation, de la théorie de la déformation discontinue et de mécanisme de déformation continue. Cette partie de l'ouvrage est présentée très classiquement dans les trois premiers chapitres. Les chapitres suivants son consacrés aux structures: les structures caractéristiques de la déformation discontinuet (failles, joints, fentes de tension et stylolites), les structures liées à la déformation continue homogène (schistosité et linéations) et les structures liées à la déformation continue hétérogène (plis et boudins) sont successivement examinées. Les objets susceptibles de renseigner sur l'histoire (zones abritées, minéraux syncinématiques) sont inclus dans cette partie de l'ouvrage. Enfin, en annexe, sont donnés des éléments d'analyse tensorielle et de mesures de la déformation finie des roches.

L'originalité de l'ouvrage est bien évidemment de privilégier l'analyse cinématique par rapport à l'analyse géométrique. La question posée par l'auteur est celle de l'interprétation et non de la description. Chacun verra, dans ce choix, des avantages et des inconvénients.

Le succès de ce livre auprès des étudiants français qui n'ont pas à leur disposition une grande littérature sur le sujet, dans leur langue, est certain; ceci est sans nul doute dû au fait qu'il s'agit d'un livre de base, simple et clair et sa présentation économique est un encouragement supplémentaire.

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The R_f/ϕ technique

Lisle, R. J. 1985. *Geological Strain Analysis: A Manual for the R_f/ϕ Technique.* Pergamon Press, Oxford. 99 pp. Price: hardcover £11.50; soft cover £6.95.

This book is exactly what it says it is, a manual for the R_f/ϕ technique. Before readers are carried away by ecstasy at the thought of a book title and publisher's blurb that tell the truth, I should hastily add a caveat. The terminology of strain analysis is very precise and the "R_f/ϕ technique" is very different from the "unstraining R_f/ϕ technique"; in other words the book devotes almost all its attention to the analysis of originally random fabrics of the type very rarely seen in untectonized rocks. Even accepting the book at face value causes some difficulty because several nettles are not grasped, though the fairly specific restriction of scope does allow some grace. The theory of strain analysis involves some of the fundamental questions in structural geology but these are not tackled head on when they encroach upon the topic in hand. A much debated question is the geometrical relationship between planar/linear tectonic elements and the strain ellipsoid but this only rates a couple of lines. The phrase grain-boundary-sliding is nowhere to be seen despite the implications of this mechanism for strain analysis.

This book reflects the dichotomy of approach between analysts of finite/total/cumulative strain and those of strain histories. Page one in fact seems to suggest that nothing can be determined of the latter yet it is clear that analysis of initially non-random fabrics can only be successful if the strain history can be defined. In this regard the interesting debate of Siddans (1980) by De Paor (1981b) and Siddans (1981a) does not figure nor does another debate between these two authors on the subject of the R_f/ϕ method (De Paor 1980, 1981a, Siddans 1981b).

Much of the literature of strain analysis is liberally sprinkled with strings of assumptions which many people may find uncomfortable, thus letting them slip from view. The assumption/restrictions are not clearly spelt out in this text and several disturbing problems are left dangling. A handbook should guide the uninitiated firmly through the quagmire but here some quicksands were not fenced off. Non-ellipticity of markers was broached but the reader was told that little was known of "errors incurred by the use of markers which deviate in shape from exact ellipses". We are told a knowledge of initial shape factors is the basis of much strain analysis but page sixteen says "little is known of their R_i/θ properties". Rare 3-D analyses of tectonites (e.g. Bell 1981) appear to confirm our state of ignorance.

The acid test wasn't performed, that is, to ask a beginner to have a go at strain analysis of ellipsoid objects using this handbook. However, I suspect all would not be plain sailing. Several aspects were more clearly explained in the original publications and a series of omissions could cause problems (e.g. axes and curves on some graphs not labelled, R_i curves not formally named when introduced, and different lines on a graph having the same ornament when the text refers to them differently). The number of type-setting/proof-reading errors is mercifully small considering the abundance of elaborate equations.

The main advantage of the book is the publication of the standard R_i and θ curves for a variety of strain states making the method less exclusive. Unfortunately the limited scope means an opportunity was lost to produce a more definitive exposition on the fundamentals of strain analysis.

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Earth Science

Press, F. and Siever, R. 1986. *Earth* (4th edition). Freeman and Co, New York. 626 pp. Price: hardback £32.95; paperback £16.95.

The book, which first appeared in 1974, is written by two distinguished American geoscientists of whom one is a well-known sedimentologist at Harvard and the other has been a science adviser to the President of the U.S.A. It is written for first year university students who often have no particular intention to specialize in geology. The philosophy of the book is explained in a preface, although some of the suggested aims cannot be easily combined in an elementary presentation. To quote a few of the claims: the text is "broad", "stresses concepts", "shows how science is actually done", indicates "bases of geologic theories", "emphasizes dependence of geology on physics and chemistry", "is about geologic processes" and "methods", and "integrates the newest discoveries". That the authors by virtue of their experience and position are capable to carry out their complex task can be accepted; the real question, however, is whether this actually can be done.

The twenty three constituent chapters are divided into three parts, with the introductory part I referred to as Prologue, part II concerned with surface processes and part III with internal processes. Part I introduces basic geological notions, such as Earth's place in the solar system, its material composition, geological time and elements of structural geology. In general, part I reasonably presents a variety of geological concepts, although it is not clear why chapter 4 on structure, which suffers from minor errors, has been included at this stage.