chapters is interspersed with multiple problems—one cannot read far without finding one. The answers for the problems are found in the "back" of the book—really, though, the answers to the problems constitute the majority of the book. The problems are an integral part of the book. To understand the point the author is trying to make, it is necessary to read, if not solve, the problems. These problems have apparently withstood the test of several generations of students at UCLA. The answers and problems are particularly useful, because they provide some practical experience at solving problems. Further, the problems provide a way of understanding the vector notation used extensively throughout the book. Vector notation is very difficult to comprehend when first encountered, especially by geology students who may not have used it previously.

The book is a very clear review of continuum mechanics. In the context of geology, however, the book has two major omissions. First, the physics covered in the book is rarely applied to the deformation of geological material. For instance, although the concept of finite strain is well described, how it applies to a naturally deformed rock is never addressed. The problems toward the end of the Effects of Stress (Chapter 7) are a welcome exception to this rule.

Second, the author generally ignores much of the structural geology literature. Many structural geologists have been working on these basic issues in continuum mechanics and have made significant headway in using these concepts. For example, Elliott (1972) is uncited in the chapter on strain history and polar decompositions (Chapter 8), and Hobbs *et al.* (1976) is uncited on the effects of stress (Chapter 7). A better referencing job (or perhaps a Further Reading section) would have allowed students to search for geological application of these concepts, which is particularly important considering the lack of geological examples cited above.

I see this book as part of a gradient from more geological to more continuum mechanics based texts for earth scientists. On the one geological extreme lies Ramsay (1967), which addresses mechanical behavior but without specifically using continuum mechanics literature. Means (1976) or Hobbs *et al.* (1976) are a step toward continuum mechanics, but with a clear emphasis on geology. Oertel's book is a continuum mechanics text, but one that focusses on the continuum subjects (e.g. second-order tensors) that are relevant to the earth sciences. Malvern (1969) or Fung (1965) are straight continuum mechanics books.

The writing of the book is rather straightforward, dense, and unadorned. This is not a book that one can read casually: it simply takes some commitment to get through a chapter (a drawback of the answer/problem format). This aspect may limit the book's use as a teaching text. An additional problem with using this book as a textbook for an advanced structural geology course is the lack of application to geological material mentioned above. However, the book is well-suited to be the primary text for an earth-science based continuum mechanics course.

As a reference book, I can easily recommend this book. It will be useful to teachers and researchers, particularly the former because of the problem/answer format. This book does fill a niche that is presently vacant—a self-guided book through continuum mechanics for students or anyone else who is motivated to use it.

N.B. G. Oertel provides a list of errata for the book by request.

References

Elliott, D. (1972) Deformation paths in structural geology. *Bulletin of the Geological Society of America* **83**, 2621–2635.

Fung, Y. C. (1965) *Foundations of Solid Mechanics.* Prentice-Hall, Englewood Cliffs, New Jersey.

Hobbs, B. E., Means, W. D., and Williams, P. F. (1976) *An Outline of Structural Geology.* Wiley, New York.

Malvern, L. E. (1969) *Introduction to the Mechanics of a Continuous Medium.* Prentice-Hall, Englewood Cliffs, New Jersey.

Means, W. D. (1976) *Stress and Strain.* Springer-Verlag, New York.

Ramsay, J. G. (1967) *Folding and Fracturing of Rocks.* McGraw-Hill, New York.

Basil Tikoff

Minneapolis, U.S.A.

Circling statistics

Fisher, N. I. 1995. *Statistical Analysis of Circular Data.* Cambridge University Press. Price: £35; $59.95

Although Statistics is one of the most fundamental disciplines affecting the way we live, it has perhaps the worst reputation of any subject. The saying 'lies, damn lies, and statistics' is known to almost everyone. However, this epithet is usually unfairly attributed. Statistics is not inherently flawed, it is just that we tend to use it badly because most of us do not know how to use it. This probably originates from our first experience as students with a course in statistical data analysis. I have *tried* to teach such a course to undergraduates for several years and usually find their response demoralising. I have adopted several different approaches, ranging from the traditional mathematical basis to (this year) a more visual approach based on recognising data patterns and involving interactive data manipulation. The traditional approach clearly fails; the mathematics immediately alienates most of the class to statistical techniques and they steadfastly refuse to learn or use them. I hope that the visual approach will provide a solution.

Nevertheless, anyone studying Earth Sciences needs to know something about statistics to be able to analyse their data properly. Furthermore, at one time or another, an Earth Scientist may have to deal with three different kinds of statistics because data can be distributed on the line, the circle or the sphere. However, the significant differences between these types of data are often unappreciated; for example, the definitions of randomness are quite different for linear and circular–spherical data. Although Earth Scientists are perhaps most familiar with linear data and statistics, both circular and spherical data abound in the Earth Sciences. In some respects, the statistical analysis of circular data falls somewhere between the statistical analysis of linear and spherical data, whilst in many cases it is often assumed that circular data from a restricted arc of angles can be treated in a similar manner to linear data (I have certainly been guilty of this oversimplification myself !). Thus, an updated and corrected paperback version of a textbook describing the modern approach to the statistical analysis of *circular* data is certainly welcome, particularly when it forms a companion volume to a previously published text describing the statistical analysis of *spherical* data (Fisher *et al.* 1987).

According to the author, this textbook aims to provide a unified and up-to-date account of conventional and new techniques for analysing circular data. Although aimed at the working scientist, university student and the statistical research worker, it is the former who receives priority. The approach is based on applications and examples, but the level of mathematical understanding assumed is that of a first year undergraduate course in mathematics, which may be off-putting to some. *Chapter 1* introduces the subject of circular data in terms of an historical overview. In *Chapter 2* methods of displaying a single sample of circular data and its description in terms of sample quantities are presented. Circular probability density distributions and their potential as models for circular data are considered in *Chapter 3*, whilst *Chapter 4* presents an example analysis of a sample of circular data. In *Chapter 5*, the analysis of two or more samples, and ways of combining estimates of parameters of interest, are discussed. *Chapter 6* deals with the problems of correlation and regression, whilst *Chapter 7* introduces the additional problem of analysing circular data which also includes a temporal or spatial component. Finally, *Chapter 8* describes some modern statistical techniques (e.g. bootstrap and randomisation methods) for testing and estimation of circular data.

The whole approach of the book is to try to persuade the reader to use circular statistics properly to analyse their data. A laudable aim but one which is not entirely successful simply because the approach taken is clearly founded in the traditional mathematical description of statistics, requiring a minimum first year undergraduate mathematical knowledge. This requirement is certainly too ambitious for the (UK) Earth Sciences student component of the intended audience and would probably tax some (many?) of the research (i.e. postgraduate) audience as well. I accept that there needs to be a formal theoretical treatment, but what would be really useful is an attractive (interactive?) approach which shows why we must be rigorous in our treatment of data but without baffling or alienating the reader. For example, I have already noticed that when introduced to computer software for stereographic analysis which includes some simple statistical appraisal, students are prepared to consider the statistics even though they have yet to be introduced formally or mathematically to their meaning.

Finally, I must emphasise that I do not wish to be critical of this book. It is certainly very good value for money at £16.95 for the paperback edition. Personally, I did not find the approach taken off-putting and I will certainly make use of it in my attempts to teach (circular) statistics to my students. For this I am indebted to the author. However, my bitter experience warns me that I should not expect many of my students to use this book when I recommend it to them. Hopefully, if they go on to serious data collection and appraisal, they will remember this book and give it the attention both it and their data deserve and demand. In the meantime, let me repeat my plea for a more intuitive approach to teaching all branches of statistical data analysis in the Earth Sciences, one which excites and therefore instructs.

References

Fisher, N .I., Lewis, T. and Embleton, B. J. J. (1987) *Statistical Analysis of Spherical Data.* Cambridge University Press.

Geoffrey E. Lloyd

Leeds University,

Skating on ice

Bennett, M. R. and Glasser, N. S. 1996. *Glacial Geology: Ice Sheets and Landforms.* Wiley. Price £19.99 softback; £45 hardback.

Research on glaciers and their geomorphic effects is conducted by scientists with widely divergent backgrounds and approaches. Scientists who have never trudged up a moraine, but with enviable facility in continuum mechanics, share journal space with those who meticulously describe and interpret glacial sediments but feel faint when confronted with differential equations. I am sympathetic toward attempts to synthesize and condense work from such different perspectives into a glacial geology text.

There is strong need for such a text. The widely used *Glaciers and Landscape* by Sugden and John is 20 years old. Drewry's *Glacial Geologic Processes* provides a good synthesis of concepts from glaciology and glacial geology but includes little on landform evolution and glacial history. Paterson's classic, *The Physics of Glaciers*, does not discuss glacial geomorphology.

The goal of this text is "to provide an account of glacial geology which is accessible to the undergraduate and uncluttered from unnecessary detail". The text, indeed, is not cluttered with details and is refreshingly thin. Its traditional but logical organization works well. After introducing the subject, the authors begin with a discussion of glacial history and the causes of ice ages. This is followed by two chapters aimed at introducing some of the fundamentals of glaciology: glacier mass balance and flow and the movement of water in glaciers. The following seven chapters focus on the processes and landforms of glacial erosion and deposition, including a discussion of lacustrine and marine sedimentation. The final chapter examines large-scale patterns of glacial sediments and landforms.

In evaluating an introductory text, such as this, a critical question is whether the authors succeed in reaching meaningful and accurate conclusions, despite the need to minimize detail. In the case of a glacial geology text, this requires a thorough knowledge of both the charactistics of glacial landforms and the mechanics of glacial processes. The authors consistently demonstrate that they are familiar with the former but not the latter. Their frequently misleading discussions of the mechanics of glacier flow, erosion, sediment transport, and deposition are the weakest parts of this book. For example, beginning students of glacial geology will learn from this book that the idealized temperature profile through a polar glacier is linear (it isn't), that the contact force between abrading clasts in glaciers and a rock bed depends primarily on the difference between the ice overburden pressure and the basal water pressure (it doesn't), and that deformation of sediment beneath the Antarctic ice streams has been observed directly (it hasn't). These and other misconceptions in this book are, in part, a result of an unfortunate reliance on interpretations, sometimes decades old, that are grounded more on intuition than on reliable measurements and sound physical reasoning. It is disturbing to see old myths perpetuated and modern studies neglected.

For this reason I suspect that structural geologists will find the descriptive aspects of the book interesting but many of the mechanical interpretations naive. Many glacial processes are highly relevant to structural geology: nonlinear viscous creep of ice, shearing, faulting, and comminution of granular materials beneath glaciers, the role of low effective stresses in sustaining fast glacier sliding, and the slow growth of cracks in bedrock loaded by glacier ice are examples of problems with obvious analogues in structural geology. Unfortunately, it is precisely these kinds of subjects that are not treated authoritatively in this text. For example, structural geologists will be surprised to learn on page 38 that creep and large-scale folding are two distinct ways in which a crystalline solid (ice) can deform.

Another shortcoming of the book is that by adopting the scope of earlier texts it does not address some to the most exciting and topical developments in glacial geology this decade. For example, the authors do not mention the discovery of quasi-periodic layers of ice-rafted debris (Heinrich layers) in sediment cores from the North Atlantic and the consequent flurry of hypotheses regarding past interactions between ice sheets, oceans, and climate. Nor do they discuss the complementary and unprecedented insights gained from recent Greenland ice cores. Structural geologists interested in the coupling between glacial erosion and tectonic uplift, an issue of widespread current interest, will find no discussion of the subject. I am tempted to attribute these omissions to the long duration of the publishing process, but citations that post-date these studies are included in the text.

It is perhaps, too easy to dwell on flaws and omissions; I would recommend this book for those interested in a concise description of glacial landforms and sediments. Geologists, however, interested in an accurate, contemporary synthesis of what is known about glacial geologic processes and history should look elsewhere.

References

Drewry, D. (1986) *Glacial Geologic Processes.* Edward Arnold, London.

Paterson, W. S. B. (1994) *The Physics of Glaciers.* Pergamon, Oxford.

Sugden, D. E. and John, B. S. (1976) *Glaciers and Landscape.* Edward Arnold, London.

Neal Iverson

Minnesota, U.S.A.

Controversies in Central America

Mann, P. 1995. *Geologic and Tectonic Development of the Caribbean Plate Boundary in Southern Central America.* Geological Society of America, Special Paper 295; 349 pp, 8 plates in pocket. Paper, $100.

This weighty volume contains 17 articles on the geology and tectonics of Panama and Costa Rica, organized by Paul Mann of the University of Texas and dedicated to Richard Weyl (1912–1988), a leader in geologic studies of Central America and the Caribbean. Though the majority of authors are American, some researchers are from Costa Rica, Mexico, Europe and Japan. There is a short biography of Weyl and a list of 33 of his most pertinent publications. Mann has written an excellent 22-page preface/introduction. The book is well-illustrated with line drawings, maps, and a few black-and-white halftones. The folded plates, split into two pockets fore and aft, are useful and amplify the texts, especially the last two which show bathymetry and a perspective diagram of offshore Pacific Costa Rica.

Paul Mann prepared a preface for the book, which contains several valuable sections. There is a history of geological work in the region, and several lists and maps of published and unpublished works. The organization and purposes of the volume are described. Mann's plan is