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BOOK REVIEWS

Tributes and transformations

Boland, J. N. and Fitz Gerald, J. D. (editors) 1993 *Defects and Processes in the Solid State: Geoscience Applications* (The McLaren Volume) Elsevier, Amsterdam. Price: 140 Dutch Guilders.

The volume is a tribute to the work of Alex McLaren on his retirement. The volume starts with a jesuitical homily to Alex by James Boland. It is a personal tribute, quite at home in the setting of a family celebration. But a tribute by Alex's "family" of former Monash and ANU colleagues and students is certainly not what this volume is about. There is a range of contributions from non family members which help to give the volume some breath and depth. Nor is the volume totally dedicated to electron microscopy; there are also papers devoted to optical microscopy, to crystallography and to mineral deformation.

The book is sub-divided into three sections. The first on deformation is the largest, and with twelve contributions covers half the book. Phase transformations and exsolution, with five contributions, is the second topic to be covered. The third on defects, mechanisms and microstructures contains six papers. It differs from the first section in that its contents are more mineralogically orientated.

It is the first section that is of greatest interest to structural geologists. It begins with a review of transformation plasticity by Meike. Much of the article is devoted to a search for a definition of the phenomena encompassed by transformation plasticity, and for the micromechanisms that are responsible for it. Speculation is raised as to what micro-mechanisms actually occur during a phase transformtion that can lead to the enhanced plasticity. But no clear answers are given. Are these not the answers that electron microscopy should provide? Perhaps a better opening to this section would have been an overview of the contributions that electron microscopy has made to structural geology since Alex's initial contributions in the early 1970s. Several of the following contributions cover topics that were first researched in the 1970s, but this should not be taken to indicate that there has been little progress in this subject since then. Amongst the old favourites for TEM studies are papers on water-weakening in quartz (Gerretsen *et al.*), the Fish Hole ribbon quartz mylonites (Mawer and Fitz Gerald), deformation lamellae (Drury), and amorphous deformation zones in materials deformed both naturally (White) and experimentally (Dell'Angelo) at high stresses/strain rates. There is also a good sprinkling of contributions based mainly on traditional optical microscopy. They include CPO development in naturally deformed plagioclase (Kruhl) and the interplay between cataclastic and crystal-plastic processes in gabbroic mylonites (Stünitz; Lafrance and Vernon). Towards the end of this section, the contributions are more directed to experimental deformation. Ponozzo Heilbronner reports that in low strain experimental deformation of gypsum there is no evidence for strain localization, reconfirming the long held view that strain localization is a strain dependent phenomenon. Metal deformation is not overlooked, with a paper on the shear mode inelasticity of Fe under conditions of high pressure and temperature (Jackson).The final contribution presents a theory for the time dependent failure of fractal porous aggregates (Cook).

The second section of the book starts with the study of exsolution in two minerals; pyroxenes in the Whin Sill (Smith and Champness), and alkali feldspars (Brown and Parsons). The first is, again, a further look at a topic popular in the 1970s. The second is a consideration of the linked secondary exsolution effects due to strain and void formation brought about by primary exsolution in alkali feldspars. The third paper deals with phase transitions and domain growth in a feldspar analogue (Müller and Vojdan-Shemshadi). Together, these three papers provide excellent examples of the application of TEM to mineralogical research. They are followed by a paper on what could be regarded as an alkali feldspar analogue, namely the tweed microstructure of PbO (Withers *et al.*). The high standard of the contributions in this section is continued with the final contribution (Hyde) on the treatment of open and dense crystalline framework structures, to be found in a range of materials including many minerals, as hyperbolic films.

The third part of the book is more of a hotch-potch with the linking theme being mineral defect studies. The exception is the study of U and Pb diffusion in zircon (Lee) which, although not a defect study, is one where defects are intrinsically important. Instead of water in quartz, there is water in hydrothermally grown sapphire (Mainprice *et al.*) which, in this aspect, appears to be just like quartz. Quartz is, itself, treated in this section with a paper on the annealing of the Heavitree quartzite under controlled atmospheric conditions (Wang *et al.*). Some deformation was then done on the treated samples which may have made this contribution a candidate for the first section. Other papers deal with the planar defects in chalcedony (Cady *et al.*), and on the structure in hematite–magnetite interfaces (Bursill and Lin). The remaining paper deals with the structure and alteration of the major minerals in Synroc (Smith and Lumpkin), the Australian contribution to high level radioactive waste disposal. This is very much a topic of the 1990s and one in which TEM is expected to contribute much as the next millenium begins.

The volume will have appeal to those structural geologists who are actively engaged in electron microscopy applications. It gives a good, but limited, insight into the capabilities of TEM, but does not provide an overview of the subject or an indication of future advances. There is no article dedicated to SEM and the powerful techniques that this stablemate to TEM offers to structural geology, especially when the considerable capabilities of both are applied, hand in hand, to microstructural research. The book is, above all, a deserved tribute to the considerable contributions of Alex McLaren to the quantification of the micro-microstructural studies of minerals.

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Transformations in deformation

Oertel, G. 1996. *Stress and Deformation*. Oxford University Press. Price £49.50.

As stated in the Preface, "Stress and Deformation" arose from a series of lecture notes at University of California, Los Angeles. The need for the courses was simple – to introduce geologists to the principles of continuum mechanics. And, it is a cause that has been championed by Gerhard Oertel throughout his career. The book is a review of the continuum mechanics most relevant to structural geologists.

The eight chapters follow a traditional approach to continuum mechanics: 1. Vectors, 2. Fields, 3. Matter Tensors and Coordinate Transformations, 4. Stress, 5. Infinitesimal Strain, 6. Finite Strain, 7. Effects of Stress, 8. Strain History and Polar Decomposition. These chapters do not have equal emphasis in the book. The longest chapter, Matter Tensors and Coordinate Transformations is 33 pages long. Chapter on Fields (2) and Strain History and Polar Decomposition (8) are 3 pages each. The contents of the chapters do a good job of distilling the basic aspects of continuum mechanics that are useful for structural geology and geodynamics.

Because of its inception as a series of lecture notes, the format of "Stress and Deformation" is a bit unusual. Each of the eight 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.

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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