Crustal rotations from palaeomagic

Kissel, C. and Laj, C. (editors) 1988. *Palaeomagnetic Rotations and Continental Deformation*. Kluwer Academic Publishers, Utrecht, The Netherlands. 516 pp. Price Dfl 240, $129, £78.

Classical methods of structural and tectonic analysis are virtually incapable of detecting rotations about vertical axes, and are of very limited value in determining displacements. Palaeomagnetism has therefore been crucial not only in proving the reality of large-scale relative motions between continents, but also in the discovery of large differential rotations of crustal blocks in zones of intracontinental deformation. An increasingly pressing problem has been to explain how the rotations and displacements determined by palaeomagnetism have been accommodated by the visible structures, and a NATO workshop was therefore held in Greece in May 1988 to bring together field and theoretical structural geologists with palaeomagnetists for the purpose of mutual education and exchange of ideas. The meeting was evidently a success: this book, which comprises the proceedings, contains many useful and interesting papers, and is certainly a must for any departmental library.

That said, I would emphasize that the book suffers from many of the problems common to proceedings volumes. The quality of the papers is very variable, and some should not have been included. I have the strong impression that no attempt was made at peer-review: even the better papers contain errors that should not have passed the most rudimentary review or editorial procedures: inadequately labelled figures, undefined symbols, mistakes of syntax, and passages of text that simply do not make sense. The lack of editorial attention presumably allowed the rapid publication time of the volume, which appeared within seven months of the meeting. My own opinion is that a few more months publication time would have been well worth the improvement in scientific quality that peer-review would have contributed.

The 29 papers cover theory, physical modelling, methods of measuring strains and rotations using geodetic, seismotectonic and palaeomagnetic techniques, and the results of measurements in various parts of the world. Several papers include basic mathematical descriptions of deformation and flow, and these lead into discussions of the way displacements on systematic sets of faults can be combined with rotations to achieve a given bulk deformation. Many of the problems of flow partitioning touched on here will be familiar to structural geologists concerned with crystallographic fabric development or the rotation of porphyroblasts, for example. The most elaborate of these kinematic models, that of Jackson & McKenzie, is intriguing, but is only valid for a unique orientation of the faults and an infinitesimal deformation. The reason is summed up by von Mises criterion: a general finite strain can only be achieved by slip on a minimum of five independent systems. This also invalidates in principle the analyses by Nur *et al.* and Garfunkel, who try to predict the rotations resulting from slip on one or two discrete sets of faults, and neglect the additional components of deformation required within the fault blocks to maintain continuity. Whether the predictions of these models have any significance can only be determined empirically: rotations (in Israel and in the Mojave desert) in the opposite sense to the bulk sense of shear, suggest that in fact they may.

A number of papers attempt to integrate various combinations of palaeomagnetic, seismotectonic, geodetic and structural data from specific areas: some of these, particularly from New Zealand and California, are very successful. Also interesting are those that deal with metamorphic or igneous terrains, such as the Pyrenean basement (McClelland & McCaig) and the Troodos ophiolite (Allerton), where there is no bedding to give an immediate indication of the palaeohorizontal. In these cases the analysis has to be in terms of the total rotational history of the rocks. A common problem with palaeomagnetic work is that the component of rotation about a horizontal axis is treated as an incidental feature that has to be 'corrected' before the component about the vertical axis can be determined, and the amount of tilt is commonly not even included in the published results. This can be very misleading: regional tilts are interesting and important; and the rotations determined by the traditional approach may not reflect what actually occurred. To take an extreme example, a rock body could be tilted about a horizontal axis quite different from its present strike, and then rotated about an oblique axis, normal to the inclined palaeohorizontal (e.g. bedding). The tectonic significance of this sequence of events would be quite different from that of the rotation about a vertical axis that a traditional palaeomagnetist might determine.

One potentially important result from a crystalline terrain was that of Dagley & Piper, from a metamorphic core complex in the Basin and Range province. They tentatively interpret their data in terms of a 30° tilt of the complex during exhumation. If correct, this implies that the presently gently-inclined detachment fault above the complex was originally much steeper. The authors appear not to have realized that this could be crucial evidence against the 'Wernicke model' for these faults, which they enthusiastically espouse in the paper.

A surprising and disappointing aspect of several papers is the analysis of fault-slip data in terms of palaeostresses. As Choukroune's paper in this volume points out, faults reflect finite displacements and should be analysed in terms of strain and rotation. One of the main reasons for the lack of a direct relationship between displacements and stress is that the material may rotate during deformation: in a conference devoted to the determination of rotations, it seems ironic that several participants were unaware of this elementary point.

The book contains many stimulating, provocative and informative papers. It is only a pity that they were not reviewed and selected more carefully.

J. P. Platt

Oxford, U.K.

A third helping of crust

Condie, K. C. 1989. *Plate Tectonics and Crustal Evolution* (third edition). Pergamon Press, Oxford. 476 pp. Price £55.50, $100.00 (hardback); £30.00, $49.50 (softback).

Earth is probably the only terrestrial planet, in this solar system, that possesses a continental crust. Though the others have *some* kind of crust, Earth again appears unique in having active plate tectonic processes. This book presents the major models for the origin and evolution of Earth's unique crust. Since that crust owes much of its character to plate tectonics, the two subjects are, quite rightly, brought together—a far more useful and instructive approach than separate treatment.

The author has written this book with advanced undergraduate and postgraduate students in mind, and assumes that the reader has a basic grounding in geology, chemistry and physics. He hopes that it may also find use as a reference work. The subject matter is drawn from the fields of geochemistry, structural geology and tectonics, geophysics, oceanography and petrology; it covers the evolution of the crust over the past 3.8 Ga. This third edition represents a rewriting of more than 75% of the text of the second. Numerous figures have been added and the appended tectonic map of the world has been updated. There are new sections on meteorites, seismic tomography, mantle convection, acretionary terranes, mantle magma sources and their evolution, continental growth, secular changes in Earth environments, and Venus, as well as a completely new chapter on exogenic Earth systems. To all intents and purposes it is a new book that attempts to present the most up-to-date views on the various subjects covered.

A vast range of subject matter is dealt with. The text is clearly written in a style that betrays the origin of the material (a course of lectures given by the author). The punctuation, spelling and sentence construction are distinctly American. The numerous figures are properly referred to as illustrative of the textual material. However, many have been borrowed from other publications, and a significant proportion of these would have benefited from redrafting. Despite this, the printing is generally sharp and clean. The paper used is smooth, white and relatively thin, though not distractingly transparent. I examined only the softback edition, presumably aimed at the student market, and cannot say whether any of these properties are functions of cover stiffness. One major annoyance is the liberal sprinkling of misprints, the most embarrassing being the misspelling of "magma" in the publisher's blurb on the back cover. The map also contains at least one typographical error, in relation to the type of crust to be found on Greenland. Each chapter is concluded with a number of very useful summary statements and sound suggestions for further reading. The latter are drawn from books rather than research papers— a particularly good way of directing the interested reader to a broad range of opinion. Significant research papers are copiously referred to, and it is pleasing to see many of 1987–1988, and even a few of 1989, vintage. A brief summary of chapter contents follows.