includes two unconformities! Other exercises in this chapter include constructing an outcrop pattern, a folded surface, and drawing curvilinear structure contours. The beauty of these exercises lies in their size and simplicity. Having drawn one surface, students are not expected to add a further 10 parallel boundaries to their cross-section, and each map is only 7–8 cm square. I have tried some of these out on Leeds first-year students, and they completed them rapidly, spending their time on the substance of the problem rather than endless repetition of the same tasks. Like all the exercises in the book, the worked answers are painstaking, with several diagrams showing the stages by which the problem is solved. Alternative ways of drawing structure contours are explored and rejected, and any student with the patience to study the worked answers in detail will learn a great deal.

Chapter 4 deals with outcrop shapes, true and apparent thickness, and fold structures, including overturned limbs. Again, the pace at which new concepts are introduced is rapid, and the exercises will take the average student several hours. The next two chapters deal with linear structures, including lines of intersection, and with three-point problems. These exercises are necessarily rather artificial, relying on straight strike lines. If time is limited, some may wish to skip these chapters, and the next one on isopachytes, moving straight on to faults.

The calculation of movement across faults from displaced linear markers is dealt with in Chapter 8, before fault classification in Chapter 9. Although I can appreciate the philosophy behind this approach, I think the quantitative analysis of fault slip in rather artificial circumstances is overemphasized, particularly since the much more common situation of displaced fold axes is not dealt with until Chapter 13. There is a danger that students come to see map work in terms of precise geometrical constructions, and then become frustrated when these constructions don't work on real maps, and the answers have to be fudged or estimated. This is where Powell's approach begins to differ from that of Maltman (1990), who tries to get students doing simple calculations of fold plunge, fault separation etc on undoctored field examples. I have found some of Maltman's examples frustratingly unconstrained, but that is the real world! Having said that, Powell includes in these chapters some particularly clear illustrations of linked fault systems, and problem maps on simple thrust faults and more complex linked fault systems which are simply not available elsewhere.

Chapters 10–12 deal with folds, including structure contour patterns associated with plunging and non-cylindrical folds, fold profiles and associated structures such as cleavage. Many of these topics are conventionally dealt with in structural geology courses rather than map courses, and numerous examples exist in more conventional structural texts. Nevertheless, teachers of structural geology will find some novel new problem maps, and the worked answers make these an extremely valuable resource. A clear explanation of how fault types can be estimated by their effects on pre-existing folds is contained in Chapter 13, with some tricks in the examples to catch the unwary!

The final chapter consists of eight problem maps. These are all difficult, and have been designed by the author to combine many of the elements of mapwork. Examples include a linked thrust system which can be restored, a set of listric syn-sedimentary faults linked by transfer faults, folded thrusts, recumbent folds, and complex stratigraphic relationships. A variety of sources of data are used, and in some cases considerable inference must be made about topography. Any student capable of completing all these exercises without reference to the answers would have an exceptional feel for structural mapwork. The answers are exceptionally detailed, running to several pages and up to 11 diagrams each. The one major type of structure which is omitted is a complex strike-slip fault with flower structures, and indeed strike-slip faulting is not given the same attention as thrust and normal faulting anywhere in the book. Strike-slip fault exercises are difficult to devise, and I'm sure many would welcome their inclusion in a future edition.

All in all, I can thoroughly recommend this book, both as a do-it-yourself workbook for students at all levels, and as a source of ideas for hard-pressed lecturers. Both I and my colleagues have tested some of the exercises on Leeds students, and have found them user-friendly. At £13.99, the book is not beyond the reach of most pockets, particularly since it covers more than 1 year's work in most departments. It must be remembered however that the book is very structural in its approach, and graduates onto really quite difficult examples, which may be beyond some students. It is not a substitute for work on real, coloured geological maps at various scales, which students often find difficult even when structural geometries are relatively simple. As a text on appreciating three-dimensional geometries from maps, however, it is unequalled, and Derek Powell is greatly to be congratulated in finding a real niche in a crowded market.

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## Cutting through Europe

Blundell, D., Freeman, R. and Müller, S. (editors) 1992. *A Continent Revealed: The European Geotraverse.* Cambridge University Press, Cambridge, U.K. Price £15.95 (paperback); £35.00 (boxed set).

This publication summarizes the results from a series of geophysical experiments and data compilations carried out over about a 10 year period along a corridor 200–300 km wide running 4600 km from northern Scandinavia to Tunisia. These efforts were co-ordinated and planned under an umbrella project known as the European Geotraverse (EGT), which involved scientists and research council funding from all over western Europe. The aim of this book was to condense the essentials of the numerous publications in the professional literature resulting from this project into a series of short summary chapters with accompanying maps.

There are many good things to say about this publication. It is beautifully produced. The figures and maps are clearly drawn in the same style throughout. The maps (of tectonic units, gravity, heat flow, magnetics, Moho depth and earthquake focal mechanisms) are in colour, are easy to look at and uncluttered. The production quality of the whole package is very high indeed; it is data presentation at its best. The accompanying CD-ROM, containing much of the data used to compile the summary maps, is an excellent innovation, on which the authors and publishers are to be congratulated. For once, it is difficult to squeal at the price, which is most reasonable, given the quantity and quality of the maps.

The book itself is organized into seven chapters. The meat is in the central three chapters, one each on the seismic structure of the lithosphere, physical properties of the lithosphere, and recent activity (earthquakes, volcanism and vertical motions). Two short preceding chapters outline the history of the EGT project and the geological setting of western Europe. The final two chapters summarize the tectonic evolution of Europe and speculate on what wider significance this may have for the processes that operate in geodynamics. The whole book is astonishingly coherent. It really does read as if it were written by one author (in fact 15 contributed), and as if all the projects were carried out by a group of people who met regularly in a pub (perhaps wine bar, or bistro) to decide what to do next. It is quite an achievement to produce a multi-author book with such an internal coherence, and the book is much easier and more enjoyable to read as a result. Well done the editors.

Most people will be interested in the three data chapters that make up the core of the book. The chapter on seismic reflection and refraction experiments in particular summarizes a vast amount of data and analysis. Such a summary is certainly useful, and would be difficult to extract from the journal publications, particularly as this chapter helpfully puts each line segment in the context of the segment adjacent to it to the north or the south. However, there is little attempt to be critical of the data quality or interpretation in these chapters, nor, realistically, was there space for this in such a summary volume. Those interested in looking deeper will have to nerve themselves to plunge back into the journal literature. The necessary references are all given in this text. Certainly some interpretations, particularly of structure, are controversial and may not stand the test of time, and contoured or summary maps give an apparent uniformity to data that may be sparse or variable in quality. But it was never the function of this book to defend points of view. What it does do, and effectively, is allow one to compare different data sets in different places quickly.

It is obvious that the European Geotraverse project has been effective in promoting collaboration and goodwill between Europeans. But what of its scientific achievements? Are the huge resources that such collaborative programs tie up at the expense of smaller individual projects wisely spent? It is the assertion of the editors, announced in the Preface, that "the whole is greater than the sum of its individual parts". On this assertion hangs the justification for 'big science'. There is no doubt that some of the individual parts of the EGT are impressive, and will contribute to our general armoury of insights into the way continents evolve and deform. It is a significant observation, for example, that parts of Finland, which are virtually at sea level, have a crustal thickness of 60 km. The probability is that the lithosphere is 200 km thick under that region, and wondering why some Archean shields are like this will occupy many a geodynamicist whose interests are not confined to Europe. Do other EGT individual parts produce similarly general insights? I think most do not. The best contribute significantly to knowledge of the structure, composition or physical properties in particular places: in short, the work that any national Geological Survey should concern itself with. I see no convincing evidence that more general problems in geodynamics are best answered by information along an artificially straight line, designed to go through many different countries (the cynic would say, in order to raise both money and the political temperature). I would be surprised to find anyone who thought that a seismic line aimed at revealing insights into the recent and active evolution of the Mediterranean would be best sited from Genoa to Tunis: the real reason for its location is that it is a prolongation of a line 3000 km farther north in Scandinavia. The last chapter in the book, entitled *Geodynamics of Europe*, contains sections headed 'How does geology work?' and 'What drives tectonic processes?' I have to say that, in my opinion, the EGT does not contribute significantly to these general questions, nor was it ever likely to: they are much more likely to be addressed by focused, smaller projects in carefully chosen geographical locations (not necessarily in Europe) that have nothing to do with political borders and almost certainly don't lie along straight lines.

This publication will therefore appeal strongly to those who want to know about the lithosphere in particular parts of Europe. Those who seek more fundamental insights into continental tectonics and evolution will not find them here. My own view is that the EGT whole is no more than the sum of its parts: some of which are provocative and original, and others of which are not.

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## Global Positioning System

Hofmann-Wellenhof, B., Lichtenegger, H. and Collins, J. 1992. *GPS Theory and Practice*. Springer, Vienna. 326 pp. Price 550 Austrian Schillings, DM 79.00 (softback).

In so far as structural geology is concerned with measuring the deformation of rocks, GPS is one of the most powerful tools of structural geology. Admittedly the use of GPS is restricted to motions of the Earth's surface, and to geologically tiny time intervals, yet no one with an interest in tectonics can afford, any longer, to be ignorant of the results of GPS work. At the heart of the study of tectonics is the need to understand the dynamics of the manifold tectonic processes whose kinematics are often adequately described already. Frequently, the ability to discriminate between competing tectonic hypotheses lies in a knowledge of the velocity field in a deforming region. The techniques of structural geology and earthquake seismology are reasonably good at providing measures of strain and strain rate, but they are incapable of yielding information on rotation, and thus on the full velocity field unless assumptions are made in addition to the measurements. Palaeomagnetic data can provide supplementary information on rotations, but very rarely on when, or how rapidly, such rotations occurred. There is a need, therefore, for a tool that allows one to measure the full displacement field in a deforming region, and geodesy provides such a tool.

Several studies of crustal deformation were carried out using the techniques of conventional geodesy (triangulation plus trilateration or triangulation alone) but such studies relied usually upon the reoccupation of geodetic networks established on surveying rather than tectonic criteria. The rapid rise of precise positioning using satellite geodesy, and in particular the availability of portable receivers of the Global Positioning Systems (GPS) has provided the opportunity for Earth Scientists to design their own networks for tectonic purposes, and to carry out the fieldwork at an accessible cost. Measurements of baseline lengths are repeatable to one part in $10^7$, or better, so that in a region that is straining at $3 \times 10^{-15}\,s^{-1}$, or faster, the signal exceeds the noise in a few years. Better still, several high quality old terrestrial surveys exist, so the timescale can be extended back by decades or even a century.

For these reasons, it is likely that many readers of this journal may wish, some time soon, to come to grips with the results of GPS studies. To do this they will probably wish to dip into some authoritative text on geodesy and GPS. There are already several very good such texts, of which the book under review is one. Each text aims at as broad an audience as is possible within the constraints of a reasonable length and adequate depth of coverage of fundamentals.

Unfortunately, the potential range of readers is vast and Earth Scientists occupy a fairly small fraction of this range. Engineers, navigators, surveyors and even, perhaps, lawyers use GPS in greater numbers. Thus Earth Scientists are in a minority, even though they have been involved in GPS since its inception, and still provide part of the driving force towards the achievement of the highest precision GPS measurements. It's likely, then, that most readers of these pages will, if they are considering purchasing a GPS text for themselves, or a library, be swayed in that choice more by the degree to which the texts differ in their presentation of material relevant to the Earth Scientist than by variation in the (high) quality of presentation.

The book under review begins with chapters on the origins of GPS, and an overview of the way the system works, then chapters on reference systems, satellite orbits, the satellite signal and the quantities that can be measured using GPS. A chapter on The Survey itself follows, which is full of good advice, of a general sort. The observables you obtain from a survey are not, of course, the quantity of interest—baseline vectors—but are apparent distances to the satellites or (in geodetic practice) the phase of the signal. Considerable post-processing of data is required before the observables can be converted into the quantities of interest. Roughly one-third of the book is devoted to this processing. The book ends with a list of the application of GPS, and speculations about its future.

The book is well laid out, the mathematics is reasonable clearly presented and the references are up-to-date. Good though it is, I suspect this is not the book for an Earth Scientist. The book by Leick (1990) covers, in significantly more depth than the present one, several aspects of GPS that are valuable for the interested geologist. First, there are many more illustrations, which aid greatly in the presentation of concepts that are second nature to a surveyor but may be unfamiliar to others. In addition there is a separate chapter on the combination of GPS and terrestrial data, which is central to the use of GPS in tectonic studies, though not of great interest to other users. The two chapters on the geoid and reference systems are very clear and help drive home the important point that even when you have two time-separated, arbitrarily precise sets of GPS co-ordinators, you still have a way to go before you can determine deformation.

Leick also provides appendices on linear algebra and some of the essential statistics. To follow either of these books completely requires some trigonometry, some matrix algebra, and the tolerance of a notation involving Greek symbols. A former associate editor of *Journal of Structural Geology* assures me that such notation can constitute a barrier to understanding in otherwise well-disposed structural geologists. To him I would say two things: first if you can't use Greek symbols in a geodesy book, I don't know where you can: any Greek geodesist will tell you that geodesy is the second oldest profession, and began in Greece. Secondly, if Greek symbols turn you off, Smith (1988) has achieved the seemingly impossible task of writing a book on geodesy without equations; it even covers GPS.

### REFERENCES

Leick, A. 1990. *GPS Satellite Surveying*. Wiley-Interscience, New York.

Smith, J. R. 1988. *Basic Geodesy, An Introduction to the History and Concepts of Modern Geodesy Without Mathematics*. Landmark Enterprises, Rancho Cordora, California.

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## Deep-water rocks

Pickering, K. T., Hiscott, R. N. and Hein, F. J. 1989. *Deep Marine Environments—Clastic Sedimentation and Tectonics*. Unwin Hyman, London, U.K. Price £75 (hardback); £29.95 (paperback).

This well written book is a useful reference text, and will be a valuable addition to the shelves of many geologists. It is well referenced, richly illustrated with modern examples, and could be useful as a source text for specialist undergraduate courses in global tectonics or sedimentology. The balance of the book is clearly sedimentological, but it