The text is surprisingly readable given the large amount of mathematical formalism. Concepts are well illustrated by figures. However, it is the poor quality of many figures that I find the major drawback of this second edition. In this age of rapidly expanding use and utility of computers, particularly in the processing and interpretation of seismic data, the appearance of blotted, hand-drawn illustrations is a poor advertisement for the wealth of information available here.

Seismic reflection profiling remains the most widely used exploration technique. It also remains a tool that primarily, perhaps exclusively, provides us with geometries. These geometries may represent sedimentary layers, faults, shear zones, igneous intrusives or facies changes, but only lithological changes produce impedance contrasts that reflect seismic energy. Only where acquisition allows sources and receivers to be sited on most sides of a rock volume target, typically shallow targets involving well holes, can comprehensive collections of physical properties such as velocity and density be obtained and used. Sheriff & Geldart clearly reveal their background in economic exploration seismology by the large percentage of text they have again devoted to the often poorly constrained physical properties. Happily for structural geologists whose preoccupation is with structure geometries, these geometries retain the attention of industry as well.

The text is divided logically into 15 chapters that are well cross-referenced. These chapters will likely fall into three types for most structural geologists: useful, interesting and "thank you, but not today, I have a headache". In the first group are: 6. Characteristics of seismic events, and 10. Geologic interpretation of reflection data. These chapters document the usefulness of seismology in providing structural information at depth. In the second group are: 1. Introduction, 2. Theory of seismic waves, 5. Seismic velocity, 9. Data processing. These chapters reveal the possible pitfalls in assuming that a seismic section is a cross-section of the subsurface. The remaining chapters will be read largely by exploration geophysicists: 3. Partitioning at an interface, 4. Geometry of seismic waves, 7. Equipment, 8. Reflection field methods, 11. Reflection methods, 12. 3-D methods, 13. Special techniques, 14. Special applications, and 15. Background mathematics. Discussions of the contents of specific sections from a few of these chapters illustrate the strengths and weaknesses of this book as a whole.

The chapter describing characteristics of seismic events contains concepts important to anyone using seismic data to study structures. It states that the basic task is threefold: selecting those seismic events that represent primary reflections, converting travel times into depths and dips correctly, and mapping resultant coherent or continuous features. Recognition of a seismic event is based on its coherence, distinctive amplitude, phase (wave shape) characteristics, dip move out behaviour and normal move out behaviour. These criteria are explained by interspersing the discussion with important concepts such as spatial aliasing, convolved source wavelets, composite wavelets that represent a summation of reflectivity from numerous boundaries too closely spaced for full resolution, and focusing by lens-shaped structures. Characteristics of diffractions, multiples, out-of-plane reflections, refractions and surface waves are discussed so as to emphasize both the disadvantages posed by their presence in records as well as the additional information available in each if used properly. Resolution and wavelet shape receive much attention in the text, but continue to demand more coverage in my opinion. Recent work has shown that sedimentary processes, faulting, shearing and intrusive processes all occur in a self-affine (fractal) manner in nature, and therefore produce exponential distributions in the size of a particular feature. This implies that no matter what resolution is available to a particular seismic study, it can never resolve the finest-scale structure. Instead these structures will appear in seismic data as composite wavelets, phase incoherence along a particular reflector, scattered energy or anisotropy. This is currently an active field of research that can produce few certain conclusions at present, but it undoubtedly represents much potential information to structural geologists who study scale-invariant deformation in particular.

Within the chapter on data processing is a section about processes that reposition data, more commonly call data migration. It is central to making seismic reflection geometries useful to structural geologists. Developing good migration techniques has engaged geophysicists for decades and continues to do so. This text concisely summarizes the four main methods used for migrations today and discusses their relative merits and limitations. Migration is a computationally intensive process and improved computer hardware has led to ever-improving migration techniques. Better resolution and definition of the velocity field has led to improved migrated sections. The text understates recent advances in velocity field definition due to improved modelling of long-offset ("refraction") observations involving diving waves and wide-angle reflections. These models provide the continuous, average bulk velocities required for successful migrations and avoid interpolation and sampling problems associated with extrapolating detailed logs between randomly located wells. Several recent studies have shown that velocity fields determined from modelling of refraction observations are consistent with those determined from iterative depth migrations; it is only the truncation of diffraction hyperbolae by acquisition and progressing limitations that result in the traditional discrepancy between reflection stacking velocities and average bulk velocities. With enough effort, accurate velocity fields can be obtained and correct structural geometries reliably estimated.

The chapter on the geologic interpretation of reflection data will undoubtedly be the favourite of structural geologists. Its 70+ pages start off very slowly with summaries of plate tectonic concepts, but eventually become a very useful series of interpreted seismic sections that illustrate a broad range of common sedimentary structures including salt domes, reefs, unconformities, faults, folds. The last few examples include synthetic seismic sections that illustrate behaviour of rays within velocity models and show inexperienced interpreters just how much noise and spurious energy exists on typical seismic sections. As with the entire book, this chapter attempts to cover everything. It again fails, but unlike any other book I have encountered, it does achieve a balance between the generalized description of geological structures, the specific illustration of the structures with seismic sections, and the common discrepancies found between the two. Large format atlases of seismic data (e.g. the Bally atlases, the BIRPS Atlas) provide more complete examples. Many recent structural geology texts provide better descriptions of balancing cross-sections, folding and faulting but invariably shy away from the necessary illustration of these structures *in situ* because seismic sections require a thorough introduction.

It is this last point that leads me to highly recommend this book to both neophyte and well-seasoned structural geologists alike. The name of the game is understanding and describing geological features in three dimensions. No better tool exists than reflection seismic sections supported by good velocity models. This text tells those using such sections everything they will probably need to know to avoid pitfalls and feel confident in their interpretations. In the interpretation chapter it gives a few examples with which to practice; more challenging examples are available in published journal articles and atlases. Keep this text near-to-hand when interpreting the deterministic geometries of large-scale structures observed in the crust. Remain vigilant for a topic that is not included here: the stochastic properties of rocks at sub-resolution scale for most seismic studies, in other words, the effect of penetrative structures at scales below seismic resolution. Properties related to foliation and other aspects of structural geology that are studied at single outcrops and with thin sections may some day also be included in a text on exploration seismology, perhaps the third edition of Sheriff & Geldart.

## REFERENCES

Hatton, L., Worthington, M. H. & Makin, J. 1986. *Seismic Data Processing, Theory & Practice*. Blackwell Scientific Publications, Oxford.

Yilmaz, O. 1987. Seismic Data Processing. Society of Exploration Geophysicists, Investigations in Geophysics.

*Cambridge, U.K.* *David B. Snyder*

## Mapping Again

Barnes, John W. 1995. *Basic Geological Mapping, 3rd Edition*. John Wiley & Sons, Chichester, U.K. Price (paperback) £10.99.

This is a welcome new edition of this excellent little book in the Geological Field Guide Series. It is essentially aimed at a British undergraduate audience with a new valuable chapter on writing geological reports for our final year mapping projects. However, its information is universal and, indeed, it has advice for mapping in climates warmer than our own.

There does not appear to be a lot of new material, but for those not familiar with the previous editions, it is a thorough and well-thought-out treatment of all aspects of *basic* mapping, complemented by the other books in the series for more advance techniques. The principal chapters deal with: Instruments and equipment; Geological maps and base maps, including aerial photographs and a new very brief section on satellite images; Methods of geological mapping with a brief new section on underground mapping; Field measurements and techniques; Rocks, fossils and ores; Field maps and notebooks; Fair copy maps and other illustrations; Cross-sections and 3-D illustration; the new chapter on geological reports; appendices on safety, closed compass traverses and plane tabling and a new equipment checklist; there is a good reference list and (now, thankfully) an index.

In a few respects the text does differ significantly from the instructions given to students at Manchester and, I believe, at a number of other institutions in the U.K. For example, I would like to have seen the emphasis given to *total* outcrop mapping with traverse-mapping restricted to very special circumstances. I think students should be *strongly* encouraged to be "fastidious" about outcrop shape (cf. p.36) and to ink-in their notebook (cf. p.91); at the very least, the latter exercise makes them re-read their notes and gives an opportunity for an important end-of-the-day summary and a statement of what they need to do the next day. I also differ from the book author in that I think it important that students record *all* readings in their notebooks (cf. p.56); this gives a back-up in the event of lost maps, as well as a list for the stereographic presentation of the data. Form-lines are not mentioned; their construction in mapping well-bedded rocks, when boundaries are not present, can be an extremely useful technique.

Several common criticisms of students' maps are not covered here. Firstly, the lack of thought they give to the effect of topography on hidden boundaries, both in the field and in subsequent extrapolation; if there is one justification for all the time many British departments give to the drawing of strike-lines, it is in their use for this purpose. Another common error is the assumption that hidden faults have to be vertical (i.e. straight on the map) and that the *apparent* displacement of a planar boundary by a fault is its *real* displacement vector. While a 'postage stamp' key to a field-map is permissible, a true-scale columnar section, with schematic representation of lithological and thickness variation, is essential to a good final map. Finally, it is very difficult to persuade students to take into account information from the *whole map* when constructing cross-sections; this is where strike-line construction can come in again, and down-plunge profile construction, where appropriate.

Two points which might be considered for future editions. 1:10,000 base maps are now prohibitively expensive; when GIS becomes available we should be able to down-load maps of any scale of any area, but until that day comes students might consider enlarging the cheaper 1:25,000 maps, which have exactly the same detail. Secondly, although the author dismisses satellite imagery as beyond the pocket of the student and the scope of the book, it is getting more accessible and of better quality; a SPOT image, for instance, will enlarge to 1:10,000 with at least as good resolution as an aerial photograph.

This begins to sound like a list of complaints about the book, whereas I am just using this review to air my personal prejudices about student mapping. In any case, I must not be too critical, as John Barnes is obviously a big bloke; according to Table 3.1, his average pace is 1.7 metres! But seriously, these comments should in no way detract from the general excellences of this book. It can be warmly recommended to you and your students.

*Manchester, U.K.* *Jack Treagus*