

## BOOK REVIEWS

### Strange sounds record the structure beneath the British Isles

Kempler, S. and Hobbs, R. 1991. *The BIRPS Atlas*. Cambridge University Press, Cambridge, U.K. 124 pp. plus seismic profiles and location map. Price U.K. £80, U.S.A. \$150.

*The BIRPS Atlas* contains deep seismic reflection data collected by the British Institutions Reflection Profiling Syndicate from around the British Isles. The profiles were acquired between 1981 and 1988 and comprise some 12,000 km of data, augmented by about 2000 km of commercial data. All the profiles are time sections recorded to 15 s or more and were acquired off-shore. They are reproduced at a scale of 1:200,000; the original data at a scale of 1:50,000 are available at the cost of reproduction. Most of the profiles are unmigrated, with only selected examples displayed in migrated form. The profiles provide important new data, especially for the lower crust and part of the upper mantle under Britain and Ireland.

*The Atlas* provides a useful summary and integrated record of the work of the BIRPS group, comparable to similar datasets for U.S.A. (COCORP), Canada (LITHOPROBE) and areas of Europe (ECORS, DEKORP, etc.). It consists of a box of some 87 paper profiles, a location map and 124 page book summarizing the data and its interpretation. All profiles include a legend which describes the recording parameters and processing sequence of the data. The intention is to update *The Atlas* by the publication of 'supplements', presumably in the same format.

An introductory chapter provides an outline of the data coverage, a brief history of the BIRPS project, a list of personnel and a useful summary of the various acronyms which bedevil crustal seismology.

Chapter 2 discusses the acquisition, processing and interpretation of the data in a simple and straightforward manner aimed at the non-specialist. The original data were resampled for the purpose of compiling the Atlas. This has necessarily led to some loss of data but provides a fairly standard display which is useful in overview; I suspect even for those who have worked on some of the original data. The book attempts to outline some of the main features necessary to understand the interpretation of such seismic data. The processing has generally removed artifacts such as sea-bed multiples. The time sections are true scale only at a constant velocity of  $6 \text{ km s}^{-1}$  and show the usual features of 'push-down' of reflectors below low velocity sedimentary basins, etc. The inclusion of some migrated sections allows useful comparison with the unmigrated profiles.

Chapter 3 comprises a series of 'survey data sheets', which outline the rationale for each experiment, key references and specific features of the recording and processing of the data. The bulk of the text (91 of the 124 pages) then discusses the main results of the work. This is organized into six appendices corresponding to the geographical location of the various surveys and the organization of the accompanying profiles: (a) northwest Scotland; (b) Caledonides of west Britain and Ireland; (c) Variscides southwest of Britain and Ireland and the Atlantic margin; (d) northern North Sea; (e) central North Sea and (f) southern North Sea.

To the field geologist it is useful to remember that seismic profiles are not geological cross-sections; the authors provide this warning clearly, even if it is not printed at the bottom of every profile! Although high-quality seismic profiles are now routinely used by most structural geologists, it is worth emphasizing a few 'home truths', most of which are stated in the Atlas, but which I will freely translate as follows:

(1) Resolution of sub-surface features in most of the profiles is possible to a depth equivalent to about 75 m and a horizontal spacing of 1.5 km; field exposures rarely attain such dimensions!

(2) Seismic reflection profiles are good at resolving large-scale, flat-lying structures, but poor when it comes to sub-vertical structures, especially at lower crustal depths where continuous reflectors are rare. Is this the reason for the dominance of thrusts and sparsity of strike-slip and high-angle normal faults at depth? Note also that low-angle

extensional detachments are almost always interpreted as 'reactivated thrust faults', even when little evidence for this exists!

(3) Few deep-crustal reflectors can be traced directly to the surface, although the use of 'shallow' seismic profiles available mainly from oil exploration can help. This, combined with the fact that all BIRPS data was acquired at sea, inevitably allows plenty of scope for the reader to link his/her favourite surface structure with features seen on the profiles.

There is no doubt that the BIRPS project represents a major advance in our knowledge of the crust and upper mantle under Britain and Ireland; the data have already contributed to over 200 publications, which are cited in the reference section of *The Atlas*. Every geologist concerned with the study of the crust will gain much from the drawing together of this large volume of data. I guess that anyone who has worked on the geology of Britain or Ireland would select their own example of the contribution made by BIRPS data. It is reassuring to know that "it is not uncommon for the Moho reflector to be the most continuous and brightest reflection seen", but this observation is not ubiquitous and much has been learnt about the variation of the Moho beneath major structural features, such as the Viking and Central grabens, Atlantic margin, etc. The variation in the reflective nature of the lower crust has raised many interesting questions, and almost as many 'answers'! To my mind the work off NW Scotland, starting with the first BIRPS survey (MOIST) and including the deep penetration experiment to 30 s (DRUM), has provided one of the most interesting results. The 'Flannan reflector' (now sensibly a 'reflector' rather than a 'thrust') is a flat-lying feature and represents the most continuous, highest amplitude reflection imaged in the upper mantle.

This is an essential book for the libraries of all universities and institutes, especially those in the British Isles and western Europe. For many, this atlas will provide convenient and comprehensive access to these very important seismic data, although to make full use of the data the original profiles will be necessary. The purchaser has permission to photocopy the seismic sections for teaching and private purposes, which considerably increases the usability of the product. Despite this facility I suspect that some of the paper copies of the profiles will soon become 'well used', even if the main text retains its pristine condition for longer.

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### A comprehensive snapshot of Antarctic geology

Thomson, J. A., Crame, J. A. and Thomson, J. W. (editors) 1991. *Geological Evolution of Antarctica*. Proceedings of the Fifth International Symposium on Antarctic Earth Sciences held at Robinson College, Cambridge, 23–28 August 1987. Cambridge University Press, Cambridge. 722 pp. (ISBN 0-521-37266-6.) Price £50.00, U.S. \$89.50 (hardback).

This substantial volume of 722 densely printed, double-columned pages is a collection of research papers on the geology of Antarctica presented at a symposium held at Cambridge, U.K., in 1987. The meeting marked a major leap forward in the development of research in Antarctica. Time was when articles on Antarctic geology reporting the discovery of particular rock units from this remote and inaccessible continent provided sufficient justification for publication. This volume signalled that Antarctic geology is no longer in an exploration phase. It is evident from the wide range of disciplines and the quality of the research presented in these articles that the status of geological studies in Antarctica can stand comparison with similar studies from the other continents. All the exposed rock on Antarctica has now been mapped, at least on the reconnaissance scale, although most of the continent, some 98%, remains unexplored except by geophysical methods, as it lies buried beneath the ice sheets and glaciers. The papers provide a comprehensive snapshot of the current state of knowledge of Antarctic

geology, although the editors comment on a deficiency of information on the Ellsworth Mountains and Marie Byrd Land and complain of the paucity of geophysical data from offshore areas.

Two themes were identified by the convenors of the Cambridge Symposium: 'Tectonic evolution of the Antarctic crust' and 'Palaeoenvironmental evolution of Antarctica since the late Mesozoic'. Of the 114 papers included in the volume 97 fall within the scope of the first theme, grouped under the headings of the Craton, the Transantarctic Mountains, the Weddell and Ross Sea areas, the Pacific margin and Gondwana break-up, while 17 papers were concerned with the evolution of Antarctica since the Mesozoic.

Several of the articles on the East Antarctic Craton deal with the occurrences of granulites and charnockites reported during the early stages of Antarctic exploration. These articles bring these occurrences into the mainstream of high-grade metamorphic research with detailed lithological and structural mapping, petrographic, geochemical and isotopic analysis with  $P$ ,  $T$ ,  $t$  determinations and interpretations in terms of continental collisions by which they may be compared with other occurrences throughout the world. Structural studies include accounts of the sequence of ductile deformations during the formation of the craton, and brittle deformations affecting the basement and its sedimentary cover as a result of later tectonic events. Brittle structures include thrusts along the western margin of the craton related to the Ross Orogeny, and wrench faults, normal faults and joint patterns related to the rifting of Gondwanaland around the margins of the Antarctic craton to form the southern continents.

Studies in the Transantarctic Mountains describe the stratigraphy and sedimentary environments of the Late Proterozoic and early Palaeozoic sequences deposited on the western margin of the craton. During this period the passive margin changed to a subduction margin marked by the Late Proterozoic Beardmore and the Cambro-Ordovician Ross Orogenies. The earlier sediments were affected by folding, cleavage development and low grade metamorphism. Overlying post-orogenic Devonian to Permo-Carboniferous rocks of the Beacon Group include the deposits of the Late Palaeozoic Gondwanan glaciation. These rocks were affected by the mid Palaeozoic Shackleton event, attributed to microcontinental collision which developed a foreland basin and a foreland fold and thrust belt along the western margin of the continent. Colliding microcontinental blocks are identified in the Ellsworth Mountains and Marie Byrd Land, and may originally have included the South Island of New Zealand, Tasmania and southeastern Australia.

The Weddell Sea and Ross Sea areas with their extensive ice-shelves have been studied using geophysical methods, piston coring and DSDP boreholes. These studies have defined Mesozoic basins initiated as rift grabens at the time of the Mesozoic break-up of Gondwanaland and representing the failed arms of developing spreading systems. These rift systems were reactivated in the Late Cenozoic with associated magmatism which continues in Mount Erebus to the

present day. The nature of the underlying basement and upper mantle has been investigated through xenoliths incorporated in the Cenozoic volcanics.

The Pacific margin of Antarctica has been the site of subduction and accretion since the Late Palaeozoic when it formed part of the active margin of Gondwanaland. In Marie Byrd Land and the Antarctic Peninsula a late Palaeozoic metamorphic basement is intruded by plutonic rocks and overlain by volcanics forming a Mesozoic to early Tertiary Andean magmatic arc. Earlier intrusive foliated orthogneisses, with ultramylonites developed along localized shear zones, are intruded by later undeformed Cretaceous granites. The magmatic arc is fronted by a forearc basin with Mesozoic sediments and an accretionary complex which extends from Alexander Island in the south to the South Shetlands and the southern margin of South America. The accretionary complex is composed of rocks of oceanic affinity, folded and imbricated with structural evidence of oblique subduction during accretion. The rocks are metamorphosed to prehnite-pumpellyite, greenchist and locally blueschist facies. Recent volcanism in the Bransfield Strait is related to rifting, crustal extension and backarc spreading over the past few million years.

The series of papers on the Mesozoic break-up of Gondwanaland describe the initial mid-plate volcanism and the sequence of the separation of continental blocks progressively in a clockwise direction around Antarctica as established by oceanic magnetic anomaly patterns. Africa departed in the mid-Jurassic, followed by Sri Lanka and India in the early Cretaceous and Australia and New Zealand in the late Cretaceous.

The final selection of papers on the theme of Mesozoic to Cenozoic palaeoenvironments includes an account of the first dinosaur discoveries in Antarctica and of the development of angiosperm flora as well as the sedimentary development of the Antarctic passive margins through the Cenozoic. These sedimentary sequences provide evidence through included glacio-marine deposits for the commencement of glaciation in the Late Oligocene. The subsequent history of alternating periods of glaciation is recorded in seismic sections and borehole data from the Antarctica continental shelves.

The editors and publishers are to be congratulated on an extremely well-produced volume. The articles are abundantly illustrated with maps, essential for this region unfamiliar to most geologists, diagrams, half-tone field photographs and photomicrographs. An unusual feature in a collection of research articles is the comprehensive index, an invaluable aid to the user in tracking down a particular interest. The articles included in the volume provide a review of all aspects of the geology of Antarctica including the structural and tectonic development of this previously little known continent. On these grounds it should find a place in the library of every geological institution; the modest price should make this a practical possibility.

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