

## BOOK AND VIDEO REVIEWS

### Scandinavian Caledonides

Gee, D. G. and Sturt, B. A. (Editors) 1985. *The Caledonian Orogen—Scandinavia and Related Areas*. John Wiley & Sons, New York. 1266 pp. Price: £150.

These two volumes on the Scandinavian Caledonides, edited by David Gee and Brian Sturt, stem from a meeting in Uppsala in 1981, and so have taken some 5 years to reach us. For the sum of £150 two handsome books are provided, together weighing about 5 kg, neatly housed in a box with an envelope containing maps and other figures.

The volumes are aimed at providing both a comprehensive description of the fold belt through some 30 solicited articles, and a view of current research from articles submitted by their authors. They are divided into three parts, an Introduction, followed by a long mid-section on the Scandinavian Caledonides and a final section on Related Caledonian Areas. Five persons with their names on three or more articles, B. A. Sturt, D. Roberts, D. C. Gee, H. Furnes and M. B. Stephens, are involved in 16 of the 84 articles; these, with about 25 co-authors, account for over 20% of pages. What might be called the Bergen school of geology supplies almost 20%. There is a subject index at the end of the second volume, but no author index. Reference lists are to be found at the end of individual papers.

How does this compilation compare with its single-volume predecessor, by Strand & Kulling? First Gee & Sturt has the advantage of not being divided into two national reviews. Secondly, it contains a very useful geological map of the whole peninsula, as well as Bouguer and aeromagnetic anomaly maps. Thirdly, there is a vast amount of chemical data on the basic igneous rocks of the orogen in contrast with an almost complete absence in the older work. The new work reveals a thriving academic industry based on the discovery and exploitation of ophiolitic suites has been established, of which, naturally no trace is apparent in Strand & Kulling. (Although dated 1972, the latter apparently was completed as a manuscript some 5 years earlier.) In Gee & Sturt, however, the reader is bound to notice a rarity of reference to the large scale lateral movement in orogeny, established since the time of the Uppsala meeting. An exception is to be found in the paper by Harland on Svalbard (as well as in one on the north Appalachians). There seems to be widespread agreement amongst authors on the context of changing continental configurations over the Palaeozoic interval of interest. Rarely is this made explicit, however, even in Review papers. The authors of the one Soviet account included must be regarded as exceptions to this shared viewpoint.

The volumes are too uneven in cover, and geographic gaps too large, to satisfy the need for a descriptive geology of the Scandinavian Caledonides. Many of the Review articles, in particular, seem to be about other articles, rather than directly about the rocks of the fold belt. Sometimes, primarily through the use of well-chosen photographs, the prevailing tone of generality is relieved a little (e.g. in the Review of the Caledonides of Finnmark and Troms). The wonderful folds of Sørøy that grace the covers of both volumes, and act as frontispiece remain without mention. Most illustrations in the volumes are well-drawn, but in many cases accounts which already lack sections have maps without dips (e.g. pp. 419, 520, 557, 559, 560, 561, 571 and 581), a double blow to understanding. I have noticed few typographical errors.

The *Introduction* contains three useful articles successively on the Late Precambrian framework of the Scandinavian Caledonides, Late Precambrian continent dispositions and Palaeomagnetism in the Caledonian–Appalachian Orogeny. Inevitably these articles are referred to by few of the authors of other articles. The reader can with advantage use them to test the conclusions met elsewhere in these volumes.

The section *Scandinavian Caledonides* comprises 75% of the volumes and 62 articles. It is divided into six subsections on reviews, stratigraphy, structure, igneous activity, metamorphism and tectonic evolution.

The current orthodoxy on the Scandinavian Caledonides is made clear in the Introduction to the 'Regional Reviews'. The structural sequence is made up of a 'nappe stratigraphy' divided into a number of 'allochthons', the higher derived successively from more western

sources than lower. Three major phases of deformation have occurred. The first or Finnmarkian is early Ordovician; it is succeeded by the main or Scandian phase (Silurian–Devonian), and a terminal one stretching into the late Devonian. The more distantly transported nappes have travelled 100s of kilometres. This review has a map but not sections.

This introduction is followed by six commissioned reviews of the structures and stratigraphy of the SE Caledonides, the Caledonides of SW Norway, the central parts of the Scandinavian Caledonides, the Caledonides of N Norway and a geophysical summary of the Scandinavian Caledonides as a whole. The first two articles share the description of the southern end of the Scandinavian Caledonides and reach north towards the third which includes the best-known cross-section of the fold belt between Trondheim and Ostersund. All three reveal the diversity of the fold belt, as well as differences in the allocation of structural units (nappes) to the principal subdivisions these reviews recognize (introduced by Kulling in 1972). In a later Review in the section on Tectonic Evolution of the Trondheim–Ostersund tract, the first three of these sub-divisions, the Lower, Middle and Upper Allochthons, are assigned to Baltic origins but the last, the Uppermost Allochthon, to the opposite side of the Iapetus Ocean. The very concept of a named ocean, however, seems to invite oversimplification (e.g. on p. 229). Perhaps the term should be used only for the seaways developed after closure in the early Ordovician. Earlier plate arrangements are less well known and the seaways seem less simple. The review of the northern half of central Scandinavian Caledonides emphasises associations of sediments and igneous rocks supposedly indicative of ancient plate environments. The concluding Caledonian review on N Norway has welcome references to the particular, rather than the general, but is marred by some clumsy terms. Is it necessary to write of allochthonous nappes?

The 'Stratigraphy' section (18 articles) includes reviews on the Precambrian (one of a general nature and two on the late Precambrian sedimentary sequences), as well as Cambrian, Ordovician and Silurian Periods and Old Red Sandstones basins. There are articles dealing in detail with late Precambrian sequences (Alta in Finnmark and the Valdres area in the south). A companion article, comparing late Precambrian sequences from Svalbard and Greenland with those in Scandinavia, might have been more usefully placed with others on Greenland.

The concluding five articles on Stratigraphy are different from the rest. One is an account of shale geochemistry, another describes a melange deposit of unknown age (location approximate, map without dips), and the other three describe erosion surfaces cut into ophiolites and sediments above them. These latter papers would have been better put with the review of Scandinavian ophiolites, as well as others in the section on Igneous Activity. They would certainly have had more impact on the reader that way. In any event these papers make up a distinctive part of the Work.

The section on 'Structure', perhaps of greatest potential interest to readers of this Journal, in some ways is disappointing. This is partly because many of the relevant summaries are grouped in the Regional section. However, the rareness of articles based on structural data may reflect the genuine absence of such studies. The section begins and ends with studies of areas at the N and S extremities of the fold belt (Valdres and Finnmark). Each of them analyses thrusting in terms to which we have become accustomed. A third and shorter article, immediately following the second, discusses the structure of part of the same area in Finnmark with a style of explanation that has nothing to do with ramps, flats and so on. There is no acknowledgement of the difference of view, despite one of the Editors (B. A. Sturt) as an author, and such cross-reference an evident Editorial prerogative (e.g. p. 405). Nor is the reader enlightened in the related review (p. 163), of which the same Editor also is an author.

In the usual survey of the evolution of the Jotun nappe it is interpreted as far-travelled. Another paper reviews the concept of vertically co-ordinated tectonics (stockverk rather than thrusting) for Oppdal, an area just north of the Jotunheim. A companion article describes in more detail the structure of the Surnadal synform, which limits the Oppdal area to the north. The subject matter of all of these papers overlaps with two dealing with the formation of the eclogitic rocks of the adjacent Western Gneiss Region, placed in the section on Metamorphism.

The remaining papers in the structural section form three geographically defined groups. From Trondheim (after a gap of some 500 km without description), there are accounts of contiguous regions in Nordland, Sørfolda and Sulitjelma. Each manages almost entirely to ignore the sequences and structures of the other, and they have only two references in common. The Sulitjelma paper is one that would have qualified for inclusion in a section on the ophiolites of the fold belt, had there been one. A further group of three papers, deals with an area stretching across the fold belt in the latitude of Narvik. Two concentrate on lower structural units towards its east end. The third links the Precambrian Lofoten-Veterålen Massif and Caledonian sequences on the mainland. The two papers on Troms, between Narvik and Finnmark, one a review and the other concerning relative detail, have broad interest. This arises because it is in Troms that the Finnmarkian sequences meet those recognized in the southern part of the fold belt. The suggestion is made that nappes of the two sequences are interleaved and that no single surface will do to separate them.

At least half a dozen articles in other sections could be added to the nine arranged under the heading 'Igneous Activity', all based on chemical data from basic igneous rocks. The review of igneous activity and the succeeding review of ophiolitic bodies in the Scandinavian Caledonides have much in common with the review in the section 'Tectonic Evolution', and another paper in this section investigating the plate context of magmatism through igneous rock composition, for Troms and Finnmark. Attention has already been drawn to a previous cluster of papers on ophiolites (formation, emplacement, deformation, erosion, etc.). Two accounts on the Bergen district fall into this category. The article on the Fongen-Hyllingen layered basic intrusion of the Trondheim area seems to be the only one primarily concerned with an igneous body itself. That on the Artfjall Gabbro which follows it, concentrates like the majority, on what may be learned of the metamorphism and structures of the country rock from a study of the major magmatic body it contains.

The section 'Metamorphism' is dominated by the study of eclogitic rocks. This is natural, given the scale of the Caledonian high pressure metamorphism they have revealed, but it must remain a matter of regret that apart from the opening review only one paper deals with a different type of metamorphism. This is on medium-grade regional metamorphism, locally raised to higher levels in the aureole of the Krutfjell gabbro (Upper Allochthon); the location is obscure as neither latitude, longitude, grid references nor locality map are provided. One field of study that must be due to grow is that of metamorphism in the fold belt.

'Tectonic Evolution' is a short section comprising three roughly comparable papers, already mentioned under Igneous Activity, on volcanism and its environmental significance, the geochemistry of igneous rocks in Troms and Finnmark, and the evolution of the so-called eugeoclinal elements of the orogen. The fourth article, quite different from any other in these volumes, is on the evolution of the morphology of Scandinavia during the Mesozoic and Cenozoic.

The third section *Related Caledonian Areas* begins with an account of Svalbard, followed by eight articles on Greenland (comprising about half the section and 5% of the whole compilation). One of these articles is by John Haller, whose tragically early death preceded its publication. They are succeeded by an account of the Caledonides of Britain and Ireland, two papers on Shetland, one on the Moine Thrust Zone, articles on the non-Caledonian character of the Ligurian Orogeny, the possibly Caledonian rocks of Sardinia, the regional geology of a large part of Soviet Asia and of the northern Appalachians. The section ends with articles on the extent of the early (Finnmarkian) orogenic phase in Scandinavia and lastly on the distinction of phases such as Caledonian and Variscan.

What words can be used to sum up my reaction to such a large body of work? Two points may be made. First the volumes provide a very convenient entry point to a now voluminous literature and contain a wealth of data and opinion. Major libraries cannot afford to be without them. Second the matter of price: are they worth £150? I am inclined to say the price begins to seem reasonable when described as about 2.5% of the lowest level in the pay scale of a lecturer at a British university.

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## Fractured media

R. Engman and Z. Jaeger, 1986. *Fragmentation, Form and Flow in Fractured Media*. Volume 8 of *Annals of Israel Physical Society*. 628 pp. Adam Hilger, Bristol, U.K. Price: £49.50.

This book contains the proceedings of the F<sup>3</sup> Conference held at Neve Ilam (Israel) in January 1986, to which participants were invited personally, and whose papers were not refereed. Peer review was by audience questioning. The aim of the conference was to bring together materials engineers and scientists experienced in fragmentation, with physicists interested in probabilistic processes. The major topics considered were geometry and topology of voids and cracks, the blasting process and post-explosion flow. Some of the sub-topics which caught my eye as being of geological or geophysical interest included: scaling between macro- and microcracks; conductive and mechanical properties, their dependence on crack density; fractal form of surfaces and of broken solids; effect of sample size; particle size distributions and texture in fragmented media; flow in near-percolative media; permeability-porosity relations by effective medium theories and beyond; hydraulic fracture enhancement of flow; what are the laws of interactions between cracks? Rock was the most widely considered material at the conference, and I was struck by the attempts being made to apply percolation theory and fractal theory to rock fragmentation and fracture—albeit that the work is still mainly theoretical and inconclusive. The published volume will be a useful reference source for those who wish to enter this field. However, it has an eclectic flavour, and could not be described as exhaustive or authoritative—perhaps because of the limited attendance at the conference.

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## A video of ice deformation

*Dynamic Processes in Shear of Ice as a Rock Analogue*, presented by Chris Wilson. University of Melbourne, Australia. 30 min colour video. Price: PAL Aus.\$120; NTSC and SECAM Aus.\$130.

Videos of this type which allow us to observe the dynamics of geological processes are a welcome addition to teaching material. The experience of watching crystals deform and develop characteristic internal structures is an exciting one akin to accompanying Professor Lindenberg on a microstructural journey to the centre of an orogenic zone. The deformation features which are usually static and frozen in thin sections are here transformed into active and mobile elements all contending for a place in the final structure.

The evolution of the suite of microstructures developed by intracrystalline deformation is illustrated by time lapse photography of a thin ice sheet deforming between two glass plates under an optical microscope. The generation of slip bands, undulatory extinction and kink bands, together with examples of the grain boundary migration processes involved in dynamic recrystallization, are all observable in the sequences shown. In addition, the development of the crystallographic preferred orientations which accompany the deformation are included and the differences between the preferred orientations developed by simple shear and pure shear described. A final sequence demonstrates the grain boundary adjustments to the fabric which take place during an annealing event.

Having produced a similar video using para-dichlorobenzene as the analogue material I appreciate and applaud the effort which Chris Wilson and team have made with this one. The visual impact of the video is excellent and the experimental sequences are backed up by some clear graphics. The addition of some pointers to highlight the location of critical features would have helped a number of the sequences where rather a lot takes place quickly. In general the commentary is informative, but slightly repetitive and perhaps too detailed in one or two places where the action is too fast to allow easy assessment of the important events. Although slightly expensive at some £55, the tape does provide an important insight into the processes of intracrystalline deformation and a super teaching aid.

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