

### Developments in Neotectonics

Whitten, C. A., Green, R. & Meade, B. K. (editors) 1979. *Recent Crustal Movements, 1977*. Elsevier, Amsterdam. 633 pp. Price: hard-cover US \$78.00.

This book, the Proceedings of the Sixth International Symposium on Recent Crustal Movements held at Stanford University in July 1977, is the thirteenth in the series *Developments in Geotectonics* and is a reprint of volume 52 of *Tectonophysics*. It contains 663 pages and comprises 51 papers, 37 abstracts, 2 special reports of related meetings, and Clarence Allen's well chosen words of introduction. Excluding the opening remarks and special reports the book is organized into seven sections of unequal length.

1. Crustal deformation using extra-terrestrial geodesy (62 pp.).
2. Measurement of strain, tilt and gravity (62 pp.).
3. Observed vertical crustal deformation (178 pp.).
4. Geological studies of Holocene deformation (139 pp.).
5. Observed horizontal crustal deformation (64 pp.).
6. Seismology (85 pp.).
7. Experimental and theoretical models (59 pp.).

Undoubtedly the editors were faced with the familiar problem of assigning papers to an appropriate section when their contents overlapped several themes; such as dilemma is likely to arise when a conference proceedings, such as this one, is conceived by a panel of editors who do not exercise firm control at the planning stage and who do not request particular experts to review certain topics.

Although appreciating that reviewer prejudice must operate when selecting a few articles for special mention the exercise is justified when attempting to guide potential readers. I have chosen papers which I believe contain material or ideas of direct relevance to structural geologists; some praiseworthy articles whose appeal is principally geophysical or geodetic are therefore excluded from my list.

'Recent Quaternary tectonics in the Hellenic Arc: examples of geological observations on land' (pp. 267–275) by Jacques Angelier of the University of Paris VI is a clearly written and well illustrated short article which relates an analysis of faults displacing Neogene and Quaternary rocks to ideas about Aegean plate tectonics. It provides for English-speaking geologists an account of some aspects of Angelier's work which is published elsewhere mainly in French.

Using examples from Japan or Peru, the paper on 'Migration of crustal deformation' (pp. 329–341) by Keichi Kasahava of the Earthquake Institute, Tokyo, demonstrates that crustal deformation migrates landwards at velocities of 10–100 km/year, a rate comparable with that of some migrating earthquake foci.

A thorough analysis of 1200 fault-plane solutions of low magnitude earthquakes generated by displacements on the Calaveras and San Andreas fault zones is presented by N. Pavoni of the Geophysical Institute, Zurich in a paper entitled 'A study of earthquake focal mechanisms in the Hollister area, Southern Coast Ranges, California' (pp. 363–371). The author's attempt to show the distribution of *P*-axes of different orientations (his figs. 2 & 3) is ingenious but is less vivid than plotting trajectories.

Perhaps because of its piquant flavour the short paper by D. J. Stierman, E. Zubrow and L. Atkinson of Stanford University on 'Remains of prehistoric human in strata deformed by the San Andreas fault near Stone Canyon, San Benito County, California' (pp. 381–387) attracted my attention. The naturally buried bones which were discovered in river terrace sediments are dated as about 5000 BP and allow the authors to conclude that the active fault zone extends at least 20 m beyond that part of the trace of the San Andreas fault which is being monitored for creep.

W. D. Page, J. N. Alt, L. S. Cluff and G. Plafker in a carefully presented article 'Evidence for the recurrence of large-magnitude earthquakes along the Makran coast of Iran and Pakistan' (pp. 533–547) argue from field observations of raised beaches and terraces that "... uplift occurs as discrete increments along different parts of the coast at different times". They consider that the recurrence of an earthquake of magnitude 8+ is likely within 125–250 years.

'Recent crustal movements in the Sierra Nevada-Walker Lane region of California-Nevada' are described in three separate papers which are parts 1, 2 and 3 (pp. 561–597) of a contribution by combinations of the authors D. B. Slemmons, D. van Warner, E. J. Bell, M. L. Silberman and C. O. Sanders from institutions in Nevada or California. Their linked papers demonstrate the value of integrating seismological, geological and geomorphological observations when attempting to interpret the neotectonics of a region.

Despite these six contributions and about another ten worthwhile papers it is difficult to recommend the purchase considering its price of US \$78.00 and that it has appeared already as volume 52 of *Tec-*

*tonophysics*. Although the inclusion of so many abstracts of less than one page is understandable in the original volume which reported on the symposium it is to be regretted that when the editors/publishers compiled the book they did not take the opportunity either to delete such ephemeral contributions or to request their authors to provide more extended texts. Perhaps the most glaring abuse of retaining an abstract is one which, occupying a page of the book, is a nine-line contribution by four authors in which they conclude that the advantages of a particular instrument will be explained and its features described.

P. L. Hancock

### Progress report on the Arabian-Nubian Shield

Tahoun, S. A. (editor) 1979. *Evolution and Mineralization of the Arabian-Nubian Shield*, Vol. 1. (Institute of Applied Geology, King Abdulaziz University Bulletin No. 3). Pergamon, Oxford. 187 pp., 2 folded maps, 68 figs. Price: hard-cover US \$33.00.

The modern study of the geology of Saudi Arabia can be said to have begun in 1950 when King Abdulaziz asked the USGS to investigate the rocks of western Arabia. Shortly afterwards in 1954 the Directorate General of Mineral Resources was established and since then groups from the United States, France, Britain and Japan have been cooperating with the DGMR in the location and evaluation of mineral deposits other than oil.

The investigations have utilised various techniques; satellite imagery, airborne geophysical surveys, ground surveys and aerial photography—and in 30 years or so a number of deposits have been located, the general outlines of the geology established, and theories put forward for the origin of the Arabian Shield. It seemed therefore to Dr. A. M. S. Al-Shanti of the Institute of Applied Geology of the King Abdulaziz University in Jeddah that the time was ripe to take stock of the current situation, not only in the Arabian Shield but also in the adjacent Nubian Shield.

The result was a symposium convened by Dr. Al-Shanti in February 1978 at which 320 participants from 25 different countries attended conference sessions and took part in field excursions. The papers presented ranged from reviews of the regional geology to accounts of research projects completed, and reports on others still in progress. They are to be published in four volumes of which this book is the first, the others being promised shortly.

The area under consideration includes rocks ranging in age from 1150 to 450 Ma and it was suggested that the term Pan-African should be extended from its original more restricted usage to cover this time interval during which the non-cratonic part of 'Africa' was evolving.

Recent work has provided much information on the distribution of rock types, their ages, geochemistry and associated metallogeny, and there are at present two main schools of thought on the origin of the Arabian-Nubian Shield. One suggests that the shield evolved essentially as intra-cratonic ensialic belts within a basement of older materials, whereas the other proposes that the shield resulted from the welding together of a series of island arcs with slices of ocean floor caught between them. As far as can be judged from the papers published in this volume these two models formed the central theme around which discussion centred.

Volume I is divided into four sections with a variable coverage. Structure and evolution (6 papers), Metallogeny (5), Plutonic rocks (3), Ophiolites (1). The overall plan of the four volumes has not been revealed but it would seem that other papers on these topics will be printed later.

*Structure and Evolution* begins with a rather brief overview of the geology of Western Arabia by Brown and Jackson who began working in the Yemen in the early 1950s and who were coauthors of the 1:500 000 geological map. They propose and describe eight major groups or super-groups in a lithostratigraphic sequence with a geochronological control. The plutonic and associated volcanic sequence has an overall trend from older basaltic oceanic suites to alkaline and peralkaline igneous rocks. Ophiolite suites are recognized and also two metallogenic episodes at 658 and 550 Ma. Unfortunately there is no attempt to delimit the groups on a map nor to display the proposed lithostratigraphy in tabular form (though one does appear later in the book accompanying the paper by Rye *et al.*)

In the second paper Gass proposes an evolutionary model for the Pan-African basement in Saudi Arabia, Egypt and the Sudan. He suggests on the one hand that the granitic rocks might be derived from descending plates from above subduction zones, and yet from the pos-

sible alignment of four or five N-S zones of ultramafic rocks he proposes at least three intra-oceanic island arc systems with back-arc basins which have been welded together during progressive cratonization. Before 900 Ma the Pan-African segment was truly oceanic, between 900 and 450 Ma it experienced transition tectonics and after 450 Ma it was truly continental. Unfortunately there are no diagrams to illustrate Gass' models.

This theme of ensialic versus intra-oceanic origin is taken up in a well-illustrated account by Kröner who reviews the development of a number of Pan-African belts from Damara to Zambesi and Arabia, and concludes that Precambrian tectogenetic processes were related to plate motions and therefore to plate tectonics. Much of the Pan-African crust formed as a result of ensialic processes at a time when extensive plate consumption did not exist. Kröner envisages successive imprints of mobile belts on the Precambrian craton with the transition from Precambrian ensialic plate tectonics to Phanerozoic Wilson-cycle plate tectonics taking place over the approximately 500 Ma-long Pan-African event.

One of the major problems of the shield—that of the absence of true Archaean basement which has not so far been recognized—is taken up by Hepworth in a discussion of the possible extension into Arabia of the Mozambique belt. His maps of structural trends and the folded relationship of the probably unconformable Red Sea Greenschist Assemblage on Sudanese basement does suggest that the latter may plunge to the N or NE and reappear as infolded or thrust slices in Arabia. There is the further implication that the Red Sea Assemblage may have been deposited on continental crust.

Abdel-Khalek discusses the complex structural history of a part of the Eastern desert of Egypt and notes the presence of serpentinites which may be ophiolites which he interprets as obducted slabs of upper mantle or oceanic crust.

In the final paper in this section Ramsay, Jackson and Roobol describe a SW-NE traverse from the Red Sea south of Jeddah to the Phanerozoic cover southwest of Riyadh, covering an area of some 60 000 km<sup>2</sup>. They recognize ten distinct structural/lithological provinces with a NW trend which may extend outside the area considered. Each belt has a complex sedimentary/metamorphic/structural history with rocks ranging from possible ancient basement to volcano-sedimentary types, probably deposited in intra-continental rifts or in volcanic arcs. The oldest rocks are 1100 Ma yet many have complex pre-800 Ma histories and may represent reworked sialic basement. The distribution of mainly plutonic rocks is shown in a good series of diagrams and there is a folded geological map.

The *Metallogenesis* section begins with an account by Al-Shanti and Roobol of the distribution of metalliferous deposits, in part within the whole area, but mainly in Saudi Arabia. They find no clear relation between the occurrence of ultramafic belts and that of Cu, Ag, Au, Pb and Zn except in the eastern part of Saudi Arabia where to the east of an ultramafic belt there is a zonation from the west to east of Cu/Au/Ag/Pb/Zn which has an asymmetry and a width similar to some in the Andes. This together with the higher proportion of felsic rocks suggests continental margin processes rather than ensimatic island arcs. They also describe a series of mineral deposits ranging from Fe and Ti in layered gabbros to rare earth pegmatites.

Vail also describes mineral distributions in his account of the general geology of the Nubian shield where he recognizes gneisses overlain by Greenschist Assemblage intruded by serpentinites, batholithic gra-

nites and young ring complexes. He considers the area to be mainly re-activated Pan-African granitic crust, perhaps related to inter-plate sutures with mineralization in marginal zones. It is difficult to detect an overall pattern but there is the possibility of a Proterozoic geosyncline across Nubia/Saudi Arabia with metallogenesis analogous to that in Circum-Pacific areas at present.

The presence of sutures over a wide area — but this time intra-plate—is also discussed by Sillitoe. The metallogenetic episodes are 620–500 Ma events and are post-subduction, the magmatism being triggered by intra-continental hot spot activity related to sutures. Most of the minerals are lithophile and related to granite magmatism. Further mineralization related to intracontinental rifts results in stratiform Cu and Pb/Zn deposits under shallow marine conditions.

El Shatoury and Al-Eryani describe a whole range of deposits in the Yemen from basement Cu/Co/Ni and Cu/Pb/Zn/Ag to more recent evaporites but there is little discussion of the geological controls.

Rye *et al.* investigated the sulphur isotopes of mineral deposits mainly in volcanic and volcanoclastic rocks and report a range of  $\delta^{34}\text{S}$  covering that normally found in nature. The environments of deposition range from stagnant euxinic basins (iron sulphides) to seawater hydrothermal systems (Cu Zn deposits). They provide a good tabular summary of the geological history and the related metalliferous deposits.

The *Plutonic Rocks* section includes an account by Fyfe of the tectonic significance of granite magmatism which makes only passing reference to Saudi Arabia.

There is a straightforward description of the Al-Halgah pluton, At-Taif by Al-Mishwt, and of the younger granite complexes of the Sudan by Almond. The latter plutons range from Proterozoic to Tertiary in age and contain peralkaline granites and syenites with similarities to Nigeria, and hence the presence of tin is possible.

The one paper in the *Ophiolites* section by Coleman *et al.* describes the Miocene (22 Ma) Tihama Asir ophiolite with its range of basic dyke swarms, layered gabbros, granophyres and basalts emplaced during the very early stages of Red Sea rifting. The similarities to Cyprus, Oman and Newfoundland are pointed out and this tholeiitic oceanic crust complex is said to be the first record of the separation of Arabia and Africa.

This handsomely bound book printed on high-quality paper contains only 187 pages of text and it is a pity that more of the contributions delivered at the conference could not have been included, thus reducing the number of volumes and hence the cost. There is no index (though this may come later) and no indication of the overall plan of the volumes. One has the impression that the editors felt it necessary to produce one volume quickly rather than wait for all the papers to be assembled. Some of the line drawings and photographs are poor, however the quality of the editing is good. A simplified geological map would have been a useful addition.

Some discussion of each individual paper is printed but it is fairly brief and it can only be assumed that the actual discussions were more lengthy and vigorous than have been reported.

There is enough in this volume however to lead one to look forward to the publication of the other three and thus to hope that the belief of the Vice President of King Abdulaziz University, that these volumes will serve as a basic reference for many years, will be justified.

R. Bradshaw