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BOOK REVIEWS

Island Arc Geology in New Zealand

Suggate, R. P., Stevens, G. R. & Te Punga, M. T. (editors) 1979. *The Geology of New Zealand.* Government Printer, Wellington. 2 vols., 820 pp., 2 1:1 000 000 folded maps. Price: hardcover NZ $92.50 plus $3.00 postage and packing.

New Zealand is currently in the throes of an orogeny. Its landscape is dynamic and rapidly changing. Over much of the country active mountain building, involving compressional deformation, earthquake faulting and volcanism, competes strenuously against erosional forces which include mountain glaciation and swiftly flowing rivers, laden with coarse sediment. Rapid near-shore sedimentation is affected by fierce currents, with much redistribution by longshore drift. Gaining my basic understanding of geology in a country where geological processes are so active was a rewarding and valuable experience. In particular, to have graduated in such an environment in 1968, the year when so many of the founding papers of the 'New Global Tectonics' were published, was intensely stimulating.

The present Kaikoura Orogeny came into focus as the interplay between the Pacific and Indo-Australian plates. In the South Island a post-Jurassic dextral displacement of some 480 km along the Alpine Fault had first been recognised by H. W. Wellman in 1949. This great structural feature now appeared as the main strand in a system of dextral transform faults linking westwards-directed subduction beneath the eastern North Island along the Hikurangi Trench (the southern continuation of the Tonga–Kermadec Trench) with eastwards subduction beneath the Fiordland Margin in the extreme south-west of the South Island, the plate boundary then continuing southwards along the Macquarie Ridge. An earlier, 'fossil' island arc assemblage could be recognised in the rocks of the Carboniferous–Jurassic N.Z. Geosyncline, and it became apparent that New Zealand has been straddling a plate boundary of some kind for at least the latter half of the Phanerozoic.

Since 1865, officers of the New Zealand Geological Survey, comparatively few in number, have striven to unravel the stratigraphy and structure of the country. Their efforts have been hampered by the rugged terrain, the often extensive and thick forest cover, and the sparsely fossiliferous, lithologically monotonous but structurally complex rocks of the N.Z. Geosyncline which outcrop over so much of the land area. Over the period 1950–1968, the entire country was geologically mapped on a scale of 1:250 000 to provide a uniform base for future work. Corresponding gravity and aeromagnetic maps have also now been published on the same scale for most of the country. The *Geology of New Zealand*, written by Geological Survey staff with contributions from Geophysics Division, D.S.I.R., was initially conceived and planned in 1960, during this phase of essentially reconnaissance mapping, but the gestation has been unfortunately prolonged. The foreword to the two volumes dates from 1974, the official publication date is listed as 1978, but the book actually appeared in December, 1979! While the second volume contains a supplement which updates the entire book to some extent on a chapter by chapter basis, the youngest listed reference I have found dates from 1977.

In plan, the book basically follows the stratigraphic record in New Zealand. This can be conveniently subdivided into three main phases; the 'Early Geosynclinal Cycle' (Late Precambrian–Devonian) culminating in the Devonian Tuhua Orogeny, the 'Era of the N.Z. Geosyncline' culminating in the Lower Cretaceous Rangitata Orogeny, and the 'Late Mobile Phase' (Cretaceous–Recent) with the Kaikoura Orogeny beginning in the Miocene and continuing today.

Volume 1 covers the first two of these major tectono-stratigraphic divisions. An introductory chapter, 'The New Zealand Environment', has sections on the submarine morphology and geology of the region, physiography, seismicity, gravity and magnetic anomalies, historic tectonic deformation and recent volcanism. It concludes with a brief outline of New Zealand geology and a summary of its floral and faunal history. Chapter 2 deals with the stratigraphy of the Early Geosynclinal Cycle, region by region, and Chapter 3 with the effects of the Tuhua Orogeny. Stratigraphic aspects of the N.Z. Geosyncline are covered in Chapter 4 with some discussion of metamorphism and regional structure. To some extent this overlaps with Chapter 5, which is concerned with the effects of the Rangitata Orogeny.

Volume 2 deals mainly with the Late Mobile Phase. Chapters 6–8 cover the palaeontology and stratigraphy of the Cretaceous, the Tertiary and the Quaternary respectively. Associated igneous activity is described in Chapter 9, which concludes with a discussion of volcanism and volcanic trends throughout New Zealand's geological history. The Kaikoura Orogeny is described in Chapter 10 with a special section on Quaternary deformation, and some discussion of its relationship to plate boundaries and sea-floor spreading in the Southwest Pacific. Chapter 11 is devoted to New Zealand's fossil record and contains an atlas of palaeogeographic maps. It is followed by a Supplement with sections updating all the preceding chapters to 1977. Through the entire book each chapter is followed by a list of references. General, geographic, stratigraphic, palaeontological and author indexes conclude the two volumes. One notable and deliberate omission is any detailed discussion of economic aspects of New Zealand geology, which have already been extensively reviewed by Williams (1974).

Handsomely bound, the book is lavishly and informatively illustrated throughout, with line diagrams, sketches and numerous photographs, many of them in colour. The illustrations of fossils are particularly fine. Two 1:1 000 000 maps depicting the geology of the North and South Islands are included in a back pocket of Volume 1, and a number of in-text maps deal with specific areas in greater detail. The inside front cover of each volume contains a useful relief and locality map of the country, while inside each back cover a stratigraphic table correlates New Zealand series and stages with the standard international divisions. A minor, but very irritating point is the inconsistent use of units. Geophysical units are uniformly metric, but heights and stratigraphic thicknesses are often given in feet. In a publication from a country where tyre pressure gauges are now calibrated in kilopascals, I find it particular exasperating to read about uplift rates of "... 35 ft/1000 yr ..."!

My view of the book as a whole is rather equivocal. Considered purely as a guide to New Zealand stratigraphy it succeeds admirably, despite being somewhat out of date, and though it is probably too expensive for all but a few individual buyers, most libraries should be prepared to purchase it on that basis. However, in its interpretative role, the book fell far short of my expectations. Though lip service is paid to the importance of New Zealand as a testing ground for understanding plate interactions, the book has failed to keep pace with the flood of new ideas which have appeared throughout its lengthy preparatory period, since the advent of plate tectonics over a decade ago. The supplementary material at the end of Volume 2 does little but whet one's appetite for a discussion of the various interpretative models which have been proposed for the N.Z. Geosyncline, and for pre-drift reconstructions of New Zealand in relation to Australia and Antarctica. Geophysical knowledge, particularly of New Zealand's seismicity, has also burgeoned over this period and considerably refined our understanding of the present-day plate boundary. For example, micro-earthquake studies have now accurately delineated the upper surface of the Pacific Plate at depths of 20–40 km, as it dips north-westwards beneath the Wellington region (Robinson 1978).

Of particular importance is the controversy over the timing of movements on the Alpine Fault. The book generally adheres to the view that most of the strike–slip displacement occurred in the Rangitata Orogeny; the alternative proposition that all displacements, including the oroclinal bending of the N.Z. Geosyncline, are entirely of Cainozoic age (starting in latest Eocene times at the earliest) is given only brief mention. This assumption strongly affects interpretation of both the Rangitata and Kaikoura Orogenies, and palaeogeographic reconstructions. However, though the controversy is by no means settled, evidence gathered over the last few years from sea-floor spreading data (e.g. Walcott 1978) and patterns of Tertiary sedimentation (Carter & Norris 1976, Norris *et al.* 1978; Cutten 1979) does favour a movement history largely confined to the Late Cainozoic. Fortunately, these and related matters are extensively discussed in a recent publication, 'The Origin of the Southern Alps' (*Roy. Soc. N.Z. Bull.* **18**, edited by Walcott,

R. I. & Cresswell, M. M., 1979), which forms a useful supplement to these volumes.

On a lesser scale the structural geologist will find much of interest, from Quaternary fault tectonics to the nappes of the Tuhua Orogeny and the relationships between deformation and metamorphism in the rocks of the N.Z. Geosyncline, first made famous by F. J. Turner in his classic studies of the Otago Schists (now, the Haast Schist Group). Other structural aspects worth attention are the interrelationships between faulting and sedimentation and the great prevalence of syn-sedimentary slump folding, often on a massive scale, through much of the stratigraphic record.

To update fully a massive compilation such as these volumes must be a daunting task. One can only regret the extent to which the long delay in publication has detracted from what is basically a well constructed and beautifully presented book.

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Predicting Earthquakes

Wyss, M. (editor) 1979. *Earthquake Prediction and Seismicity Patterns.* Contributions to Current Research in Geophysics, No. 8, Birkhauser, Basel. 238 pp. Price: hard-cover sFr68, DM72, US $45.

Bolt, B. (author of introductory passages) 1980. *Earthquakes and Volcanoes.* (Readings from Scientific American), Freeman, San Francisco. 154 pp, 89 colour illustrations, 36 black & white figures. Price: hard-cover £8.90; soft-cover £4.30.

For scientific and socio-economic reasons earthquakes continue to generate interest and concern and a specialist literature of their own. Although the two books under review differ somewhat in their scope and are intended for different readerships they both reflect this interest and concern.

Earthquake Prediction and Seismicity Patterns is one of an increasing number of books about prediction and seismic hazard reduction which have been published in the last five years. Many of these books are principally of value to seismologists and engineers but this one also contains much information of significance to structural geologists.

The book, eighth in the series *Contributions to Current Research in Geophysics*, is a reprint without repagination of Volume 117, Number 6 for 1979 of *Pure and Applied Geophysics*. It arose from an international conference on 'Seismic Gaps and Soon-to-Break Gaps' convened in 1978 by the U.S. Geological Survey. As the editor, Max Wyss, explains in his introductory notes, some of the eleven articles are almost unchanged from those delivered at the conference while others are revised or new. Wyss also emphasises the uncertainties involved in earthquake prediction and he notes that an originally cautious prediction may be sensationalised by the news media, with economically and socially harmful consequences. Because earthquake prediction is a sensitive issue in some parts of the World it was not possible for Wyss to gain the cooperation of a truly international panel of experts, and thus by way of explanation he was obliged to state (p. 1081): "... scientists from a major country have declined to contribute articles to this volume, unless all earthquake predictions for territories other than each author's native country are excluded. Editors cannot possibly suppress scientific information, but they must make sure that such articles are submitted to a rigorous peer review, in which, if possible, scientists from the country involved in the prediction should be included. Also, criticism of articles containing predictions, and editorials pointing out the rudimentary state of our knowledge, should be published along with the article in question".

The first article, by W. R. McCann, S. P. Nishenko, L. R. Sykes and J. Krause on 'Seismic gaps and plate tectonics: seismic potential for major boundaries', presents an overview of the potential for large shallow shocks in the Pacific (excluding New Zealand), South Sandwich, Caribbean and Indonesian regions. The paper, which is 66 pages long and superbly illustrated, deserves to become a classic reference in its field. A large coloured map (Fig. 1) shows the distribution of six categories of seismic potential, sites of successful forecasts, active volcanoes related to subduction, areas of tsunami risk, and a few representative focal mechanisms. Detailed information about specific regions follows in the main body of the paper. In their introductory sections the authors provide the reader who is unacquainted with the literature on seismic gaps with a concise account of the relationships between the characteristics of plate boundaries and the locations and magnitudes of earthquakes. Their Table 1 lists successful forecasts, and a note added in proof lists five $M \geqslant 7$ events which have occurred in predicted gaps since the manuscript was completed in May 1978. So that a global view of seismic gaps is available there is a need for a companion article on the Alpine–Himalayan zone.

In the succeeding paper J. W. Dewey and W. Spence discuss seismic gaps along the Peruvian coast. They recognize two parallel seismic zones; one the interface thrust, the other the coastal plate interior, and they conclude that earthquakes in one zone do not relieve strain in the adjoining one.

K. Mogi discusses 'Two kinds of seismic gaps' in the third article, which refers to Japanese examples.

Although it is the shortest paper in the book, that by T. Garza and C. Lomnitz on 'The Oaxaca gap: a case history' is the most fascinating to read because it is a vivid account of the economic and social impact of the publication of a paper in which Ohtake and his associates predicted that a $M = 7\frac{1}{2} \pm \frac{1}{4}$ earthquake would occur within a seismic gap they had recognized in Mexico. It was their misfortune that their work was misreported in a letter to the President of Mexico written by two non-seismologists, and that following receipt of this letter there were several misleading press releases. The earthquake did not occur on the day prophesied by the letter writers, but the panic created caused property value losses comparable to those anticipated for an actual earthquake. Garza and Lomnitz carry out a statistical reassessment of the original seismic data used to detect the gap and conclude that the evidence is inconclusive. A note added in revision reports that on 29 November 1978 a $M7.5$ earthquake occurred on the Oaxaca coast close to the originally predicted epicentre location. Ironically, it caused little damage and no significant economic disruption.

M. Wyss and R. E. Habermann in a paper on 'Seismic quiescence precursory to a past and a future Kurile Island earthquake' predict that a $M > 8$ earthquake "... will occur along the north Kurile island arc between latitude 45.5°N and 49.2°N at a time between now and 1994". In addition to their excellent account of the seismicity of the Kurile region the authors also provide the reader with some much needed definitions for use in this expanding branch of earth science.

Seismicity variations along the Makran coastal region of Pakistan and Iran are analysed by R. C. Quittmeyer who concludes that a future large earthquake will occur within the western part of the region.

W. H. K. Lee and D. R. Brillinger in a thoughtful review of Chinese earthquake history use 'Point Process Analysis' to detect recurrence intervals. They point out that only China and the Middle East possess recorded histories of 3000 years which may be used for assessments of historical seismicity.

The well-known sequence of post-1938 earthquake epicentres and fault breaks along the North Anatolian fault zone is re-analysed by M. N. Toksöz, A. F. Shakal and A. J. Michael in the eighth article. They detect a two-directional migration of epicentres away from a central region near longitude 39°E, the westward migration at 50 km/yr being five times faster than the eastward. They conclude that there are major seismic gaps at the western and eastern ends of the fault zone. The reproduction of their fig. 1, from an earlier paper by Toksöz and coworkers, is so poor that critical detail is not visible.

The paper by J. Delsemme and A. T. Smith on 'Spectral analysis of earthquake migration in South America' will be of interest to seismologists but its tectonic content is limited.

The penultimate article by Li-Sheng Huang, J. McRaney, Ta-liang Teng and M. Prebish establishes some correlation between twelve $M \geqslant 6$ events on the San Andreas fault system in southern California and rainfall patterns in that semiarid region.

The final paper, by Y. Fujii and K. Makane is on 'Anomalous crustal strain prior to the 1923 Kanto, Japan, earthquake as deduced from analysis of old triangulation data'; it seems somewhat out-of-place in this book.