COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record No. 1968 / 119

Visit to the 40th ANZAAS Congress, Christchurch,

New Zealand 1968

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SUMMARY

This record describes a visit to New Zealand made by the author to attend the 40th ANZAAS Congress at Christchurch. A brief description of the pertinent papers presented at the Congress is given.

After the Congress, visits were made to Department of Scientific and Industrial Research establishments at Lower Hutt and Wellington.

Recommendations are presented based on the observations made during the visit.

1. INTRODUCTION

The purpose of the visit to New Zealand from 29th January to 7th February 1968 was to present a paper at the 40th ANZAAS Congress held at Christchurch. After the Congress, visits were made to the Department of Scientific and Industrial Research's laboratories and offices at Wellington and Lower Hutt.

2. 40TH ANZAAS CONGRESS, CHRISTCHURCH, 1968.

The 40th ANZAAS Congress was held at the University of Canterbury, Christchurch, New Zealand, from 24th to 31st January 1968. Unfortunately because there was no section entirely devoted to geophysics and seismology, the papers of interest were presented in Section C (Geology) and Section H (Engineering). In future ANZAAS Congresses it would be preferable to group all the geophysical and seismological papers together in one section.

The most pertinent papers presented in Section C were by H.A. Doyle on "S travel-times and upper mantle structure"; I. McDougall on "The geomagnetic polarity scale of time and its implications" and W.J.H. van der Linden on "Structural evolution of the South-west Pacific Ocean". Abstracts of these papers are given in Appendix 1.

The symposium "Earthquake activity and engineering" was the main reason for my visit to Christchurch and the revised programme is given in Appendix 2.

The idea behind the symposium was that engineers and seismologists should get together to discuss matters of common interest in the field of earthquake engineering, and on the whole it was a very good idea. However, the time allowed for presenting papers was really too short for any worthwhile contribution to be made. In any further symposia of a similar nature, more time should be set aside for sessions of this sort, so that topics may be looked at more fully than was possible at Christchurch.

One of the most interesting papers was that presented by H.A. Doyle on behalf of Professor J.C. Jaeger. This was mainly concerned with the seismicity of south-east Australia. A brief review was given for the whole of the continent and this showed that sizeable earthquakes could be expected near Adelaide, in Western Australia, and in New South Wales. It also dispensed with the myth that Continental Australia is an old stable continent where no earthquakes occur. The results presented here should give impetus to seismology in Australia.

Abstracts of the papers presented at the symposium are given in Appendix 3. No abstracts were available for Professor J.C. Jaeger's or R.I. Skinner's papers.

3. VISIT TO WELLINGTON

Immediately after the ANZAAS Congress, I visited the Department of Scientific and Industrial Research establishments at Lower Hutt and Wellington.

Physics and Engineering Section, Lower Hutt

The Physics and Engineering Laboratory of the Department of Scientific and Industrial Research (D.S.I.R.) has a small laboratory at Lower Hutt concerned with strong motion studies from earthquakes.

They have about completed the task of setting up about 120 strong-motion units throughout New Zealand. Seventy of these are seismoscopes and the other fifty will be MO2 accelerographs. The MO2 instrument was developed by D.S.I.R. under the direction of R.I. Skinner, who leads the present team, and it is now being manufactured by Victoria Engineering Ltd. Calibration of the instruments is still being carried out by D.S.I.R., who keep a close check on the quality of the units being produced.

Seismological Section, Wellington

The remainder of my stay in New Zealand consisted of discussions at the headquarters of the Seismological Section at Wellington and of a visit to a field station to the north of the capital.

Staffing. Dr. R.D. Adams is the Superintendent of the Seismological Observatory; he is responsible to Dr. T. Hatherton, who is in charge of all geophysical activities at D.S.I.R. At the time of my visit there were four professional officers working full time in seismology, three technical officers, and six computers engaged in picking records. This is apart from the people manning the field stations, librarians, clerks, typists, and the like. The whole section concentrates entirely on seismology. Ionospheric physics and geomagnetism are carried out by other sections.

The observatory group has access to the D.S.I.R. workshops for any design and development work that has to be done and can also call on other sections of D.S.I.R. for additional Services if required. The workshops are situated at Lower Hutt and cover a wide range of disciplines.

Instrumentation. A total of 22 seismic stations are operated by the seismological office. Eight stations are situated in South Island and fourteen in North Island. In addition, the records from Scott Base, Raoul Island, and Campbell Island are also analysed in the office. Apart from the World-Wide Standard Stations most of the instrumentation consists of three-component short-period units. Usually they have a vertical Willmore with either horizontal Willmores or Wood Andersons.

Timing is provided by the New Zealand Time Service of the D.S.I.R., which broadcasts signals 15 times daily. These are automatically impressed on the records at all stations except Auckland, Bunnythorpe, and Wellington. Sprengnether TS100 clocks are used to provide minute marks at most of the field stations; because the clock corrections are provided by the impressed signals the clock settings are never altered.

Research currently underway. All professional staff are free from routine work, and this enables them to concentrate on specific research projects. At the time of my visit G.A. Eiby was working on a catalogue of New Zealand earthquakes; Dr. R.D. Adams on P'P' precursors; Dr. R.M. Hamilton on island arc structures; and A.A. Thomson on surface waves.

A computer programme written by Dr. R.M. Hamilton for the determination of earthquake epicentres is now being used for all New Zealand shocks. The USCGS preliminary epicentral determinations are not very reliable for New Zealand events and better results are obtained by using local station data only.

4. DISCUSSION AND RECOMMENDATIONS

By any standard, the calibre of the New Zealand seismological service is very good, and the earthquake engineering section is also most impressive. Both these sections serve as useful models for development of seismology and earthquake engineering in the Territory of Papua & New Guinea. For although the Territory of Papua & New Guinea is as yet nowhere near as developed as New Zealand it experiences about ten times as many comparable shocks per year as New Zealand. Eventually this implies that a seismological service at least as large as the New Zealand effort must be envisaged for the Territory.

As far as the Territory of Papua & New Guinea is concerned, the following recommendations are proposed:

1. The present programme of establishing three-component short-period stations throughout the Territory should continue until all shocks having a magnitude greater than 4 can be located.

2. At an early stage someone should be set aside to develop a computer programme for determining the epicentres of local events so that we can be independent of USCGS.

3. A network of accelerographs should be established as soon as possible to provide ground response curves for strong earthquakes.

As far as the Observatory Section is concerned I recommend:

The establishment of a three-component short-period station at Alice Springs to provide a better evaluation of Australian seismicity.

APPENDIX 1

ABSTRACTS OF PAPERS WITH A GEOPHYSICAL INTEREST

PRESENTED IN SECTION C OF THE 40TH ANZAAS CONGRESS 1968

The geomagnetic polarity scale of time and its implications by Ian MCDOUGALL (Australian National University).

The two principal hypotheses advanced to explain the strong bimodal distribution of the magnetic polarities of rocks are that the geomagnetic field has changed its polarity at certain times in the past and that some rocks possess the property of self-reversal, whereby they acquire a direction of magnetisation opposite to that of the prevailing geomagnetic field.

Corollaries of the first hypothesis are that rocks of the same age everywhere in the world would have the same polarity and that rocks with reversed and normal polarity would form a time sequence. This hypothesis can be tested by the application of palaeomagnetic and potassium-argon dating methods to rocks from different localities and of different ages. During the last five years a large number of determinations of polarity and age have been obtained; the data are remarkably consistent and provide very strong support for the field reversal hypothesis. Relatively long epochs of the same polarity are found but short term periods of opposite polarity, known as events, occur within the epochs. These results show that the geomagnetic field has changed its polarity at irregular intervals throughout at least the last 4 million years.

Confirmation of much of this polarity scale has recently been provided independently from studies of the magnetic polarity in sedimentary cores from the deep ocean basins. This has also allowed estimates to be made of rates of sedimentation.

The remarkably symmetrical linear magnetic anomalies across ridges and rises can be interpreted in terms of geomagnetic field reversals and provides strong evidence that ocean floor spreading on a large scale has occurred and is still taking place. Using the polarity time scale, rates of ocean floor spreading have been determined.

Structural evolution of the South-west Pacific Ocean by W.J.M. van der LINDEN (N.Z. Oceanographic Institute, Wellington)

The South-west Pacific Ocean comprises a series of orogenic belts that evolved in succession since the Palaeozoic and have been disrupted by subsequent processes of crustal spreading. The following units can be distinguished:

a) A Palaeozic geosynclinal belt including the Lord Howe Rise, parts of the South Island of New Zealand, the Campbell Plateau, and the Ellsworth and Whitmore mountains of West Antarctica. The geosynclinal development requires an original positioning of the system marginal to Australia and East Antarctica, the sources of sediment supply. After tectogenesis and upheaval this orogene was subaerial during the Permian and Jurassic to provide the sediments that accumulated in:

b) The Melanesian geosynclinal belt including New Caledonia, the Norfolk Ridge, the New Zealand Geanticline, the Chatham Rise, and the USARP Ridge in West Antarctica. During the Tertiary, blockfaulting and intrusion of oceanic basalts moulded the core of the system into its present shape.

c) The Outer Melanesian Zone, an island arc and trench complex of Upper Cretaceous and Tertiary age of which the Tonga-Kermadec system and possibly also the Macquarie Ridge are of importance in the area.

The three belts have been disrupted and separated by processes (centred on mid-ocean ridges) which are active in the mantle and which have resulted in the creation of new ocean basins such as the Tasman and Coral Sea Basins, the South and North Fiji Basins, and the south-western Pacific and Bellingshausen Basins.

The whole area is dissected by two fracture systems; one with a predominant NE-SW trend associated with processes of crustal spreading, the other with a dominantly NW-SE trend possibly indicating the path of stress release associated with the movement of the Earth's axis of rotation with respect to the crust.

<u>S travel times and upper mantle structure</u> by H.A. Doyle (Australian National University)

Comparatively few data have been published on S travel-times, largely because of the greater difficulty in picking S arrivals. S was measured on long-period records of 20 earthquakes in differing azimuths from North American stations in the range $28^{\circ} < \Delta < 82^{\circ}$. Station and source components were extracted from the travel-times.

S station anomalies showed a pattern similar to those for P, i.e. late in western USA, and early in central and eastern USA. They correlated with P anomalies at the same stations, and gave a ratio of S/P anomaly of 3.71 ± 0.43.

These large variations in station anomaly, of about 3 seconds for P and 8 seconds for S, are believed to originate in the upper mantle, where their velocities are related by the equation.

$$\alpha = 4.38 + 0.81\beta$$

This suggests that, in this region of the upper mantle, the incompressibility tends to remain constant, while the rigidity changes in association perhaps with large regional temperature differences.

APPENDIX 2

40TH ANZAAS CONGRESS 1968

SECTION H (E): ENGINEERING

Symposium: Earthquake Activity and Engineering

(with Section C)

REVISED PROGRAMME

Wednesday 31st January

First Session: 9.20 - 10.45 Room: E.13

Chairman: Mr. D.R. Gregg

1. Earthquake activity in the South-west Pacific - Prof. F.F. Evison, Victoria University of Wellington.

2. Earthquake location in New Zealand - Dr. R.D. Adams, D.S.I.R., Wellington.

3. Seismicity of South-east Australia - Prof. J.C. Jaeger, Australian National University. (Paper to be read by Mr. H.A. Doyle)

Second Session: 11.15 - 12.30 Room: E.13

Chairman: Mr. D.R. Gregg

4. Seismicity of Papua-New Guinea - Dr. D. Denham, Geophysical Observatory, Port Moresby.

5. Properties of earthquake sequences - Dr. R.M. Hamilton, D.S.I.R., Wellington.

Third Session: 2.00 - 3.15 Room: E.13

Chairman: Mr. I.L. Holmes

6. Philospohy of aseismic design - Mr. O.A. Glogau, Ministry of Works, Wellington.

7. Some problems of microzoning - Mr. R.I. Skinner, D.S.I.R., Gracefield.

8. Surface layer modification of seismic waves - Mr. R. Shepherd and Mr. J.H. Travers, University of Canterbury.

Fourth Session: 3.45 - 5.00 Room: E. 13

Chairman: Mr. I.L. Holmes

9. Multiple reflection method - Dr. T. Katayama, University of New South Wales. (Paper to be read by Prof. R. Traill-Nash).

10. Reconstruction following earthquake damage - Dr. B.R. Falconer, University of Auckland.

APPENDIX 3

ABSTRACTS OF PAPERS PRESENTED AT THE SYMPOSIUM OF EARTHQUAKE ACTIVITY AND ENGINEERING AT 40TH ANZAAS CONGRESS 1968

Earthquake activity in the South-west Pacific by F.F. EVISON (Victoria University of Wellington)

A fifth of the world's large shallow earthquakes occur in the South-west Pacific area, as well as a quarter of the large earthquakes of intermediate depth and nearly half of the large deep earthquakes. The shallow earthquakes are distributed along two great active chains: between the southern New Hebrides region and North-west New Guinea the activity is about three times greater than between Macquarie Island and the northern Tonga region.

Minor shallow activity occurs along the Pacific-Antarctic Ridge and the Indian-Antarctic Ridge, and very minor activity in eastern and central Australia. Other parts of the area, including Antarctica, are aseismic.

The active chains together include eight distinct regions of the asymmetric type, of which four are orientated towards the Pacific Ocean and four away from it. The concept of a circum-Pacific belt of activity has little meaning in the South-west Pacific area, which is a severe testing-ground for hypotheses concerned with large-scale processes and structures in the Earth's interior.

Earthquake location in New Zealand by R.D. ADAMS (Seismological Observatory, D.S.I.R., Wellington)

Large earthquakes occurring in New Zealand can be located within a few hours to an accuracy of 20 miles, but the final determination of the origin may take some months. Shallow earthquakes occur most frequently in two main regions: one covers a broad band extending along the east coast and through the centre of the North Island to the north of the South Island; and the other is Fiordland in the extreme south-west. Low frequency of earthquakes in other regions, however, does not imply that only low magnitude events will occur there. Earthquake swarms in regions of recent volcanism are a further form of shallow earthquake activity that occurs outside the main seismic regions. Intermediate and deep-focus earthquakes, of less engineering significance, occur mainly in a volume dipping westward beneath the North Island from its eastern margin.

Seismicity of Papua-New Guinea, 1958-1966 by D. DENHAM (Geophysical Observatory, Port Moresby)

A brief description is given of the main structural units in the Papua-New Guinea-Solomon Islands Region. It is shown how the location of earthquakes is related to these features. A new trend named the Bismarck Sea Lineament consisting of a line of shallow earthquakes across the Bismarck Sea is revealed. This is thought to be either an embryonic mid-ocean ridge or a fault zone.

Cross-sections both parallel and perpendicular to the strike of the New Britain Arc and the Solomon Chain are presented. These show that the North New Guinea coastal region of uplift is in fact on a trend different from the island arc structures of New Britain, and that most of the seismicity of the region is possibly associated with the spreading of the Solomon Sea.

Depth, magnitude, and strain release statistics for the period 1958-1966 are presented. These show that the strain release has been reasonably constant for the period, that most of the events occur in the depth range 20 to 80 Km, and that currently all events with magnitude 5 and greater can be located.

Finally isoseismal maps of typical New Guinea earthquakes are shown.

Properties of earthquake sequences by R.M. Hamilton (Seismological Observatory, D.S.I.R., Wellington)

Most large shallow earthquakes are followed by aftershocks, and many are preceded by foreshocks. Certain generalisations about the properties of these sequences can be made. The rate of aftershock occurrence usually decreases in inverse proportion to the time elapsed since the main shock. The number N of earthquakes having magnitude M or greater is given by $\log N = A-bM$, where a and b are constants. The magnitude of the second largest shock in a sequence is often one unit less than that of the main shock. The mean magnitude of groups of successive shocks is approximately constant. These relationships are exemplified by the aftershocks of the magnitude 7 earthquake off the coast of Fiordland in 1960, and those of magnitude 6 earthquake at Gisborne in 1966.

Surface layer modification of seismic waves by R. Shepherd and J.H. Travers (University of Canterbury)

The response of a structure to an earthquake is dependent on the ground motion at foundation level. Both the period and the amplitude of this motion can be affected by the characteristics of the near-surface layer.

A theory using the multiple reflection properties of elastic waves in a layered medium is used to relate the movements at ground level with those at depth.

An indication is given of the possible application of this technique to the determination of seismic design response spectra.

Multiple reflection method by T. Katayama (Chuo University, Tokyo)

The multiple reflection method is developed for the calculation of the dynamic response history of a multi-storeyed building subjected to ground excitations. The method, in which a uniform building is approximated by a uniform shear beam, is based on the wave equation describing the shear vibrations of uniform beam. Though the shear vibrations of a non-uniform beam do not obey a wave equation, an approximate procedure is introduced to treat a non-uniform building by the multiple reflection method. The method is an approximate one and is not intended to yield precise responses. However, the method possesses several advantages over the conventional numerical integration method. For example, it enables one to estimate the damping effect due to the energy transfer from a building to the ground. Estimates of sensible damping values due to the energy dispersion into the ground are made. Comparisons are made between the multiple reflection and the numerical integration methods to calculate dynamic response histories of multi-storeyed buildings subjected to earthquakes. Numerical examples illustrate the differences between the dynamic responses obtained by the two methods. The results suggest that the method may be effectively used for preliminary calculations.

Reconstruction following earthquake damage by Bruce H. Falconer (University of Auckland)

Various factors which influence development of a programme of reconstruction following earthquake damage are listed. It is suggested that variations of the factors with peoples, economies, and geography will inevitably cause wide variation in progress. As an aid to reconstruction, planning in advance of chance damage is advocated for New Zealand. Actions required upon occurrence of damage are listed, and comments are made upon a comprehensive plan for reconstruction. Provisions of the Civil Defence Act and of the Earthquake and War Damage Act are discussed, together with questions of adequacy of insurance funds. It is concluded that reconstruction after a major earthquake loss could be commenced only upon the basis of a planned economy for reconstruction. A list of recommendations for earthquake study is given.