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Visit to International Symposium on Recent Coastal Movements and Associated Seismicity Wellington, New Zealand

February 1970

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SUMMARY

An international symposium on recent crustal movements and associated seismicity was held at Wellington, New Zealand, in February 1970. The symposium was attended by scientists working in many disciplines, brought together by the common interest of studying earth movements.

Evidence of recent crustal movements is now accumulating over the whole world. Some of this was presented at the symposium, together with descriptions of techniques in measuring the strain changes.

The proceedings were followed by a tour of the northern part of the South Island of New Zealand, where dramatic evidence of recent crustal movements can be inspected along various faults in the northern Alpine fault system.

1. INTRODUCTION

An international symposium on recent crustal movements and associated seismicity was held at the Victoria University of Wellington, New Zealand, from 10-18th February 1970. The conference was organized by the Royal Society of New Zealand and was attended by more than 100 delegates from over 20 countries.

The purpose of the symposium was to co-ordinate research in the three disciplines of Geodesy, Geology, and Seismology, in the field of recent crustal movements - particularly in the active continental margins and the island arcs in the circum-Pacific and Southeast Asia regions. Papers on a wide range of topics related to this theme were presented.

Crustal movements usually occur either as sudden discrete steps resulting from earthquakes or as slow creeps associated with gradual stress release. In some places, such as California, both types of movements have been recognized and it has been possible to study the phenomena in considerable detail.

In tectonically active areas like Japan, California, and New Zealand the study of recent crustal movements is very important. Not only is it pertinent to our understanding of the tectonic forces at work in the earth's crust but it is of great economic value in terms of possible loss of life during an earthquake and building damage following a seismic event or earth creep.

The timing of the conference was most appropriate, for in the last few years considerable advances have been made in seismology and in the techniques being used to measure geodetic parameters. The venue was pertinent in that New Zealand has a well developed fault system demonstrating recent crustal movements as well as experiencing a high degree of seismicity.

After the conference a tour of the South Island was undertaken to inspect recent movements along several faults in the Alpine fault system.

2. REVIEW OF PAPERS PRESENTED

The first papers presented at the conference were review papers in Geodesy, Seismology, and Geology. These were presented by Kasahara from Japan, Allen from U.S.A., and Pavoni from Switzerland. The advances in all fields have been considerable in recent years and, as Kasahara stressed, the interdisciplinary work has been particularly impressive. In Japan the geodetic and seismological approaches have been complementary and in general the seismic pressure axes agree well with the main geodetic movements (at least over the last 50 years). Kasahara stressed the need for carrying out accurate geodetic surveys at regular intervals in earthquake zones with the ultimate goal of earthquake prediction.

Kasahara was followed by Allen, who reviewed recent seismological advances. Among the more significant he listed: the reliability of long period seismographs in studying the focal mechanisms of earthquakes, the establishment of the double-couple as the source mechanism at the focus of the earthquake; and the use of seismic 'moments' as defined by Brune (1968) to estimate the rate of displacement in a zone and to predict the total crustal movement.

He then discussed the problem of triggering earthquakes by: man-made dams (Kariba, Hoover, Cremesta, Koyna, etc); fluid injection (Denver, Colorado); and nuclear explosions. These triggering phenomena led him to suggest that the whole crust is in a state of stress and that earthquakes occur only in zones of weakness. This concept is particularly important in a case like Meckering, where the earthquake occurred in a very old and 'stable' part of the Australian continent.

The geological review paper by Pavoni was not very impressive. He presented a global study of active faults throughout the world, paying special attention to the horizontal component of crustal movements. He stated that the directions agree well with the mean directions of principal horizontal pressure as determined from the study of earthquake focal mechanisms. However, his interpretations did not agree well with recent observations in the earth's trench-ridge system and must be regarded cautiously.

The general reviews were followed by sessions on the instruments used in measuring strain, and some important theoretical aspects of crustal deformation. After these papers were presented different parts of the world were examined in detail. I shall not attempt to review all these papers but will describe briefly what I considered to be the more important points.

Perhaps the most impressive technological advances have been made in the distance measuring field. The development of laser geodimeters capable of measuring distance to the order of 1 part in 10^6 have enabled surveyors to establish very accurate grids which can be used to measure deformations. Coupled with the laser geodimeters, which have now been developed and are available on a commercial basis, are the laser interferometers which are currently being built and tested at various research institutions in the U.S.A. and Europe. In principle the laser strain meter should be able to measure strain amplitudes with an accuracy of a few parts in 10^{15} and some instruments have already operated with an accuracy of one part in 10^{12} for brief periods. However the site limitations and the stability of the laser seem to be serious restrictions to the instrument approaching the theoretical limits. Even so, the laser instrument is a big advance on the Benioff strain gauge which can detect strains down to about one part in 10^9. Some of the results of the one kilometre laser strain meter operating near Seattle in Washington were presented.

The conference next considered different areas of the world and the observations of recent crustal movements in these parts. The New Zealand and United States contributions were the largest and most impressive. Three of the most significant papers came from the U.S.A. These were presented by Nason from the Earthquake Mechanism Laboratory, Stewart from Menlo Park, and Meade from the Coast and Geodetic Survey.

Nason's work has shown conclusively that active fault-creep slippage is taking place on segments of the Hayward, Calaveras, and San Andreas faults in central California. Evidence from the study of roadways, pavements, fences, and buildings indicates that fault creep has continued, at least, over the past 40 years with slippage rates varying from 6-25 mm/yr in the Hayward and Hollister areas. Most of the slippage occurs in distinct creep events lasting up to one week. These are frequently observed to propagate along the fault at a velocity of up to 10 km/day. All the movements measured have been horizontal. Nason suggested that fault-creep slippage and seismic fault slippage (as in earthquakes) appear to be alternative forms of active fault movement.

Stewart's paper described the seismic effort of the National Center for Earthquake Research in California. The organization now has a network of more than 30 seismograph stations in central California spaced at 5-30 km intervals and covering an area 75 x 150 km. They locate about 2000 earthquakes annually, covering a magnitude range from -1 upwards. This has involved a tremendous amount of work in picking seismograms and to alleviate this problem a computer system of picking records is being developed. Onset times as determined automatically and by hand differ by less than 0.1 second for impulsive events.

Meade presented the measurements of horizontal movement observed along the San Andreas fault system made by repeat surveys. His work confirmed the earlier work by Hoffman of the California Department of Water Resources. However, one of the most significant results was that in one location, east of the Hayward fault, small changes in angles has been observed within a small net of stations without any accompanying distance changes. This was interpreted as being a direct geodetic measurement of the distortion in a crustal block, prior to sudden failure or creep, due to stress accumulation.

The full proceedings of the conference will be published and it is recommended that a copy is purchased for the BMR library.

The symposium closed with a business meeting which adopted the following resolutions:

(1) This International Symposium on Recent Crustal Movements and Associated Seismicity, noting the interdisciplinary and international co-ordination achieved during the present meeting, is strongly in favour of similar meetings being held at regular intervals, in areas of high tectonic activity.

(2) This International Symposium on Recent Crustal Movements and Associated Seismicity, noting the large amount of scientific work in progress in the Circum-Pacific region on recent crustal movements and associated seismicity, and considering the advantages of co-ordinating this work, recommends that the Commission on Recent Crustal Movements of the I.A.G. consider the establishment of a sub-commission for the study of the Circum- Pacific region.

An ad hoc committee of seven was set up to plan future activities.

3. POST-CONFERENCE TOUR

The main symposium was followed by a post-conference tour of the South Island to study recent crustal movements along the Alpine fault system in the northern part of the South Island.

Most of the recent crustal movements are in evidence as fault scarps resulting from recent earthquakes, and those from the 1848 and 1888 events are still visible along the Awatere and Hope faults. On some of the rivers crossing the main faults a large number of faulted terraces has been preserved. The most impressive of those visited were at the Branch River on the Wairau fault. These have been described by Lensen (1968) in some detail, and consist of at least 10 separate terraces on each side of the fault. The relative displacements

between the oldest and youngest terrace amounts to some 65 metres of lateral and 10 metres of vertical displacement. The age of the oldest surface is about 20,000 years BP. Each displacement is apparently the result of an earthquake working the same fault line and there is no evidence of creep since the last distinct movement.

The Alpine fault is something of an enigma. A 450 km right lateral offset was recognized by Wellman (Benson, 1950) in 1949 on the main segment of the fault and this has been supported by petrological work on the matching sections. (Suggate, personal communication). Geometrical considerations based on the locations of the mid-ocean ridges and spreading rates lead to a current right lateral off-setting rate of the order of 4.5 cm/year. However, no earthquakes have been associated with the main section of the Alpine fault in historic time and there is no evidence of postglacial creep. All the movements associated with earthquakes have occurred in the main bifurcations such as the Hope, Clarence, and Awatere faults. No slow creep has been detected.

The seismological evidence is also paradoxical because the seismicity of the main central region is very low indeed, and no events associated directly with the main southern fault are known in historical time.

One of two conclusions can be drawn from these observations. The first is that the stress field which caused the main Alpine fault has changed and there will be no further movements in that region until the stress field changes. The second is that the stress is gradually building up to produce a really big earthquake.

4. CONCLUSIONS

As a result of interdisciplinary study the evidence for crustal movements and large-scale earth shifts is gradually accumulating from all over the world. It would seem that the proposal to establish two geodimeter networks in New Guinea is in line with similar work being carried out in California and Japan and it should definitely be carried out.

The suggestion that most areas of the earth's crust are stressed is appropriate to Australia and is probably pertinent in the Meckering earthquake, and to loading of the crust due to the filling of dams. Finally I would like to express my appreciation to the organizers of the conference, who did excellent work in arranging a most successful conference and series of tours.

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