THE NEW ZEALAND SEISMOGRAPH NETWORK

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Practical seismological research depends largely on the location of earthquakes, and the location of earthquakes depends on the quality and number of seismograph stations near the region of their occurrence. Realising this, the New Zealand Government in 1962 authorised a plan to upgrade the New Zealand seismograph network over a period of several years to a total of more than 20 stations in the main islands, - a proposal that was actively supported by the Institution of Engineers.

There are various requirements in the location of earthquakes in a seismic region. Following a major earthquake, like the recent shock near Inangahua, a rapid estimate of its position and magnitude must be made, without great accuracy being called for, so that civil authorities can be warned what effects are likely to have been experienced in various regions. Later, a more detailed analysis is required, to establish the position of the earthquake as reliably as possible, so that its relation to geological and other surface features can be established, and also its relationship to any aftershocks that may occur.

Earthquakes are located by comparing the arrival times recorded at various stations, with those expected on some model of earth structure. To obtain a unique solution of the earthquake's epicentre, focal depth and origin time, four readings are required, but in practice many more stations are used, and a trial origin is repeatedly adjusted until the best fit is obtained, a process carried out swiftly and accurately on a computer. Modern seismographs can time the arrival of an earthquake wave to 0.1 sec, if it is sharp enough, and as these waves have a velocity through the Earth of between 5 and 8 km/sec, the distance from each station to an earthquake can theoretically be established to within a kilometre. Because of variations in local geological structure, agreement between theoretical and observed travel times of seismic waves is seldom better than a second or so, which in practice limits the accuracy of earthquake location to about five miles, unless the structure of the region is particularly well known, or there are several stations very close to the earthquake and strategically located round it.

The stations operating in New Zealand in 1968 are shown in Fig. 1, from which it may be seen that there are now 23 in the main islands. Only a few more stations are needed to give adequate coverage, and new stations are under construction near Oamaru and Napier. After the completion of these, the only further stations planned are at Kaikoura and in the Bay of Plenty area. Within this spacing of stations earthquakes can be located to an accuracy of five to ten miles, and in particular areas, or when additional stations are em-

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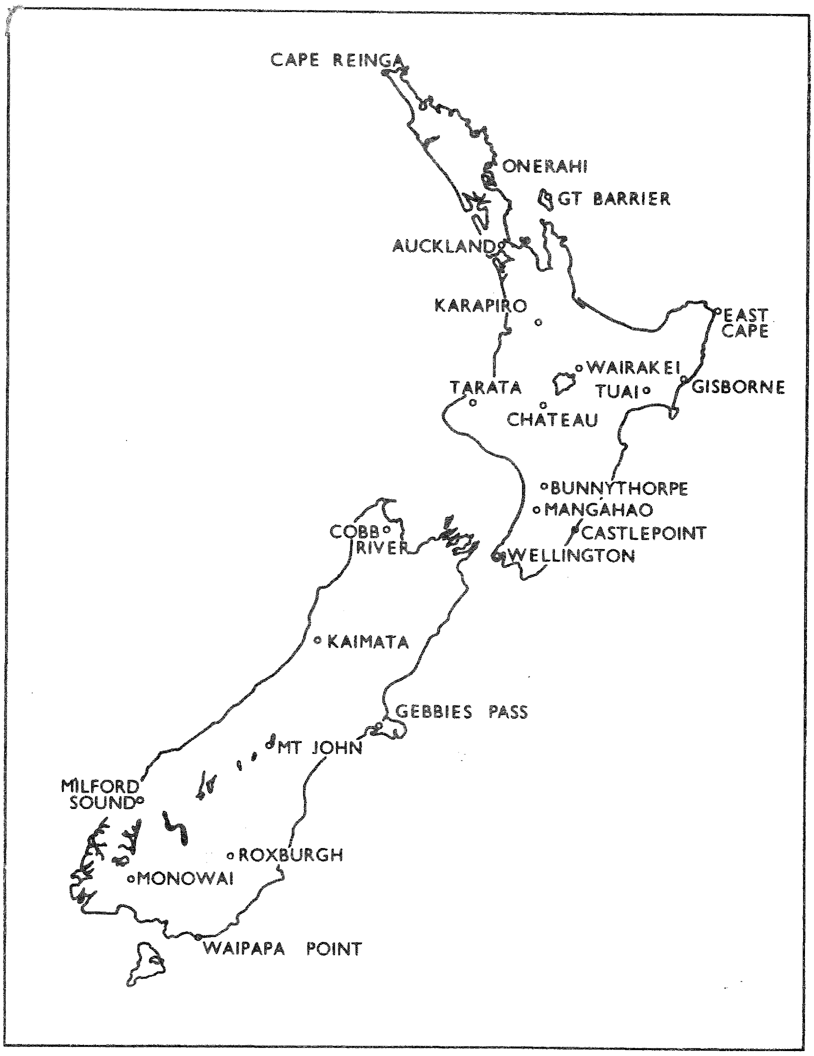

Fig. 1. Seismograph stations within New Zealand

ployed, to an even greater accuracy. Examples of extremely well-located earthquakes are those of the swarm near Taupo in December, 1964, and the aftershocks of the 1968 Inangahua earthquake, for which additional stations were installed in the active areas. The focal depth of a shallow earthquake is particularly difficult to determine unless there is a station within a distance from the epicentre comparable with the depth, and it is only in special cases that accurate depths can be given for earthquakes in the crust.

Most New Zealand stations are equipped with relatively simple seismographs, of the Willmore type, which record on a photographic chart the vertical component of earth movement. Where there is no suitable building available, the Observatory has built a standard recording building to house the recorder, photographic equipment, and timing gear, while the sensitive pick-up or seismometer is placed in a small concrete chamber which can be located at any suitable site up to a quarter of a mile away. The cost of such an installation is up to $5000, about equally divided between buildings and instruments.

Because of the restriction imposed by the shape of the land mass of New Zealand, earthquakes in different parts of the country cannot be located with equal reliability. Shocks outside the bounds of the network, particularly those extending north-eastwards from the Bay of Plenty, have greater uncertainty, and in other areas, too, the disposition of stations about the earthquakes makes unambiguous location difficult. Such a case was the Seddon earthquake of April, 1966 which was well defined as lying along a line extending through Cook Strait in a NW-SE direction, but extremely difficult to locate on this line.

Readings from overseas stations can give valuable assistance in locating the larger New Zealand earthquakes. Because rays to such stations all leave the earthquake at a steep angle downwards, they are less liable to interference from local variations in structure, and it has even been claimed that earthquake origins can be determined more precisely by distant stations than by near ones. A further factor is that all determinations of earthquake position assume some model of earth velocity, which is necessarily only an approximation to actual earth structure. Recent evidence has led to the seismic velocities used in the location of local earthquakes from New Zealand stations being increased by several percent. This has brought origins determined solely by New Zealand stations into much closer agreement with their positions as determined by over-

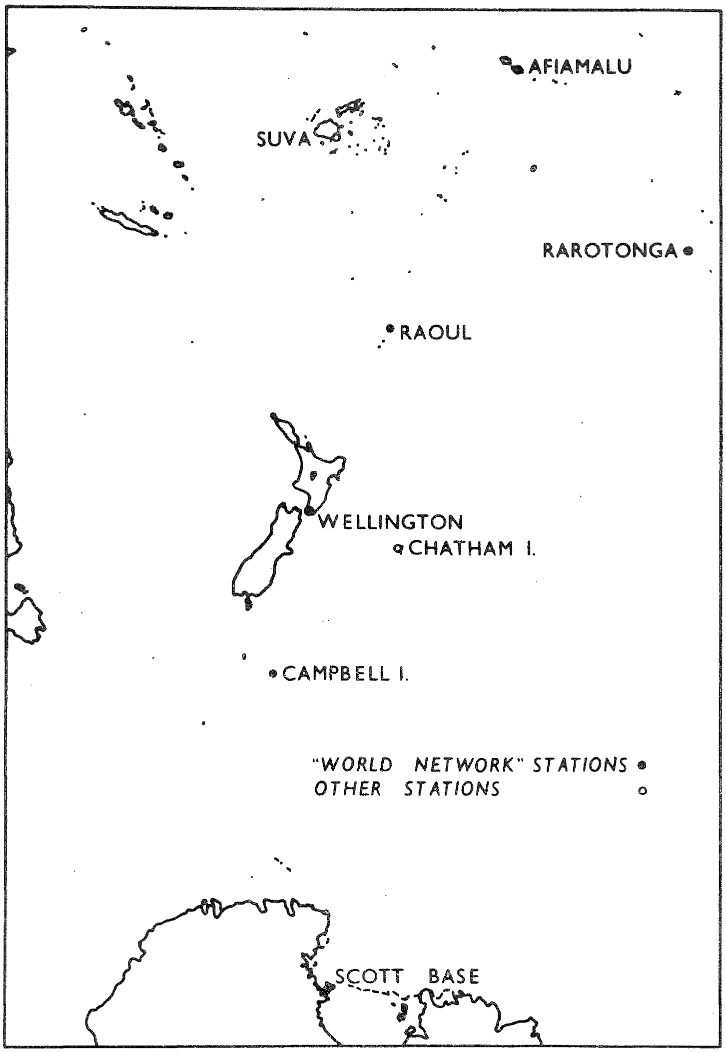

Fig. 2. New Zealand controlled seismograph stations beyond New Zealand

seas agencies. Thus the position of the Inangahua earthquake determined by the United States Coast and Geodetic Survey was only five miles from that found using readings from New Zealand stations alone interpreted in terms of the revised velocities. Using conventional velocities would have increased the disagreement to about twelve miles. By combining the readings from the New Zealand stations with those obtained overseas, a particularly well-determined origin was found about midway between the separate solutions. In this process we have, in fact, used overseas readings to calibrate our own network, so that earthquakes too small to be recorded overseas may be located with greater accuracy by our own network.

It is the local network in the main islands of New Zealand that we rely on for the location of our own earthquakes. As part of our wider responsibility to world seismology, the Seismological Observatory also operates recording stations in Western Samoa, Rarotonga, Fiji, Raoul Island, Chatham Islands, Campbell Island, and at Scott Base, as shown in Fig. 2. The spread of these stations covers a substantial proportion of the world's surface area, and aids greatly in providing world coverage of recordings of major earthquakes. The stations at Western Samoa, Rarotonga, and Scott Base, together with that at Wellington, form part of the World Wide Standard Seismograph Network set up by the United States several years ago. Unlike the simple Willmore stations in New Zealand, each comprises six separate instruments to record both short and long period earth movement in the vertical and two horizontal directions. Records from more than one hundred such identical stations all over the world are copied at a central data centre in the United States, and are available at a nominal cost to all seismologists for research purposes. These instruments are not the first world network seismographs to be run in New Zealand, for the original Milne seismograph installed in Wellington in 1900 was part of an earlier network set up by the British Association for the Advancement of Science.

The strength of the New Zealand seismograph network, however, lies in its ability to pinpoint local earthquakes, and our density of well-equipped stations under unified control is unsurpassed in any other area of comparable earthquake activity.