The Hawke's Bay Earthquake of February 3, 1931

THOUGH not in the front rank among the seismic regions of the world, New Zealand has been visited by several earthquakes with great crustal changes, such as those of 1823, 1848, 1855 and 1929. All these occurred in sparsely inhabited regions, and the death-roll of New Zealand earthquakes has hitherto been small, the greatest loss of life before 1931 being that of 17 persons during the Murchison or Buller earthquake of 1929. For the first time in its history, New Zealand, on February 3, 1931, experienced an earthquake in the neighbourhood of important towns, the population of Napier being 16,025, and that of Hastings 10,850.

The official report on the earthquake has recently been issued*. It is the joint work of several writers. The general account of the earthquake is given by Mr. F. R. Callaghan, its geological aspects are described by Mr. J. Henderson, the director of the New Zealand Geological Survey, and the seismological phenomena by Dr. C. E. Adams, Mr. M. A. F. Barnett and Mr. R. C. Hayes. Mr. P. Marshall studies the effects of the earthquake on the coast-line near Napier, and Mr. S. W. S. Strong the uplift in Sponge Bay. In the concluding section, Messrs. A. Brodie and A. G. Harris report on the damage to buildings. The whole volume is a notable contribution to our knowledge of an interesting earthquake.

The east coast of the North Island, from Cape Palliser to East Cape, a distance of about 300 miles, is practically straight, except for the deep indentation of Hawke's Bay, 50 miles across. Napier lies on the south-west coast of the bay, Hastings about 12 miles to the south.

The first known earthquake in the district since its settlement seventy-five years ago occurred on February 23, 1863. Several houses in Napier were then destroyed. On May 7, 1890, and again on August 9, 1904, the district was severely shaken by earthquakes with centres 180–200 miles south-east of Napier. On July 21, 1921, there was a strong local earthquake with its centre about twenty miles inland. During the next ten years, a number of slight or moderate shocks occurred either along an inland band or some distance out to sea, but the epicentral region of 1931 remained inactive.

Suddenly, without any warning shocks, the great earthquake began at 10.17 a.m. on February 3 (February 2, 10.47 p.m., G.M.T.). The shock was in two parts. The first part became rapidly stronger and was an uplifting movement combined with violent and confused swaying. Then, after a pause of about 30 seconds, followed the second part with a motion resembling a sharp bump downwards. The total duration was timed as $2\frac{1}{2}$ minutes. The number of known deaths was 256—161 in Napier, 93 in Hastings and 2 in Wairoa.

The isoseismal lines, depending on the Rossi-Forel scale of intensity, are reproduced in Fig. 1. They show that the intensity decreased rather regularly with increasing distance from the epicentre, except towards the south-west. In this direction, the disturbed area reached so far as Timaru, 460 miles from the epicentre, while the shock was not felt at Auckland, only 200 miles to the north-west. The area of

destruction, bounded by the isoseismal 9, is elongated, being about 100 miles long and 30 miles wide. Within it is a smaller area of similar form, in which the intensity reached the highest degree, 10, of the scale.

From the seismographic records at three stations (Arapuni, Wellington and Takapa), it was ascertained that the epicentre lay in lat. $39^{\circ} 20' S.$, long. $177^{\circ} 0' E.$ This point, represented by the black spot in Fig. 2, lies close to the west coast-line of Hawke's Bay, about 12 miles north of Napier. The same records give a focal depth of about 13 miles, which is approximately

FIG. 1. Isoseismal lines of the Hawke's Bay earthquake of February 3, 1931.

the same as that of several of the stronger after-shocks.

The changes in the surface features form one of the most interesting sections of the report. About 22 miles south-west of Napier begins a series of ridges, rents and cracks extending in a general north-easterly direction for about 6 miles from Lake Poukawa. The ridges were due to the shortening of the surface, as is shown by the absence of gaping cracks farther up the slope. Their usual height is 3–4 ft., but in places they rise 6–8 ft. above the general surface. They indicate that, as a rule, the country on the west side of the ridges moved relatively eastwards, and by an amount that, judging from the effect on the wire fences, must be measured in feet rather than in inches. At one point, indeed, a road is displaced horizontally between 6 ft. and 7 ft. Still farther to

* N.Z. Department of Scientific and Industrial Research, Bulletin No. 43: Report on the Hawke's Bay Earthquake (3rd February, 1931). Pp. 116. (Wellington, N.Z.: Government Printer, 1933.) 2s.

the north are two other similar series of ridges. The persistence of these ridges, along courses several miles in length, clearly points to movements along deep-seated fractures.

After the earthquake, the uplift of the land was at once noticed at Napier and along the coast to the north. Inland, however, it could only be traced by the rise of the bench-marks. Three lines of levelling were carried across the low-lying plain to the south of Napier. They revealed the existence of a line or narrow zone of no change, running south-west from a point on the coast about a mile south of Napier, and parallel to the ridges near Poukawa, etc., described above. The country north-west of this neutral line was elevated as a whole, and that to the south-east of it depressed, the greatest

FIG. 2. Hawke's Bay region. Circles indicate epicentres of after-shocks of the earthquake of February 3, 1931.

amounts shown on the sections being about 5 ft. upwards and nearly 3 ft. downwards. The first series of levels was made between June and October 1931. In March and April 1932, the levellings were repeated, and these showed that, in the interval, the upraised mass had sunk as a whole and fairly regularly, the subsidence being most marked (a little more than a foot) at points where the previous uplift was greatest. The re-triangulation of the district revealed displacements of three points by 13 in., 13 in. and 49 in.

The disturbances of the beach first become notable at a point 7 miles south of Napier. At the north-east corner of the Scinde Peninsula, on which Napier stands, the tide-gauge indicated a rise of 6 ft. Between this point and the entrance to Port Ahuriri, to the west of the city, the uplift was manifest from the bleached remains of calcareous Algæ. The Ahuriri Lagoon is shallow and its floor flat. The outer margin

was raised 6 ft. and the inner 3 ft. 9 in. As a result of this movement, wide areas of the lagoon-floor have been laid bare at all states of the tide. The total area of new land is estimated at about 5 sq. miles. Farther north, the uplift gradually increased from about 6 ft. 6 in. at a point 10 miles north of Napier to 9 ft. at one 10 miles beyond. Two miles to the north of the latter point, however, it seemed, though obscured, to decrease rapidly, until at and beyond a point 24 miles north of Napier, the uplift was too small to be discerned, with the exception of a small area to the west of the Wairoa River, in which there was a rise of about 2 ft.

The floor of Hawke's Bay is regular, the depth of water increasing slowly outwards to about 8 fathoms at a distance of one mile. After the earthquake, soundings were made in the bay. These showed a rise of about 6 ft., as on the adjoining coast. Later in February, and again a year afterwards, further lines of soundings were carried out, but, beyond the reduction in depth by about 6 ft., it was clear that there had been no marked distortion of the seabed.

Assuming that the fracture traced on land crosses the floor of Hawke's Bay to the uplifted coast beyond, it follows that the total length of the dislocation is not less than 40 miles, a length comparable with that of the fissures formed with the earthquakes of 1848 and 1855. Mr. Henderson thus concludes that, at the time of the earthquake, an earth-block, about 60 miles long in a north-east direction and at least 10 miles wide at one place, was uplifted, and that its central portion—and probably the whole block—was tilted gently and uniformly to the north-west.

One more phenomenon—and it is a most unusual one—may be noticed. On February 17, or a fortnight after the earthquake, some men were working on the beach of Tuamotu Island near Gisborne, when they witnessed the rapid uplift of a bank, formerly covered by a foot or two at low water, to an average height of 7 ft. They state that the reef "just rose out of the sea without warning". The new reef is in Sponge Bay, $2\frac{1}{4}$ miles from Gisborne, and has an area of about 2 acres. Its surface is slightly dome-shaped and is covered with large boulders. At the same time, the adjoining land was depressed a few feet, and broken into segments by numerous fissures. No earthquake was felt with the movement, nor was any recorded in the adjoining district.

The after-shocks were registered at Wellington, Hastings and elsewhere. At the former station, 175 miles from the epicentre, the numbers of shocks recorded were 151 on February 3, and, on successive days, 55, 50, 29, 24, 21, 12, and so on, until February 13, when there was a renewal of activity with 81 shocks, including one severe earthquake of intensity 8, with its epicentre 34 miles east of Napier. From February 3 until March 3, the total number recorded was 612. During February, 590 shocks were registered at Hastings, the total number until the end of the year being 938. The epicentres of 40 after-shocks from February 3 until the end of June 1932 were determined from the records. These are indicated by the small circles in Fig. 2. It will be seen that most of the after-shocks originated beneath Hawke's Bay, especially in its southern portion. Many of them are grouped along two bands, one running north from Cape Kidnappers, and the other in the east-north-east direction from the same cape for 10–15 miles, and then striking north-east right across the mouth of the bay.

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