TE AROHA EARTHQUAKE, 9 JANUARY 1972

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ABSTRACT

The Te Aroha earthquake of 9 January 1972 (N.Z.S.T.) was of only moderate magnitude (5.1). It occurred at a shallow depth within a few kilometres of Te Aroha, where an intensity of MM VII was reached. Damage was mainly confined to domestic chimneys and contents of buildings in the Te Aroha region, but the felt area extended as far as Auckland, Mangakino and Whakatane. Numerous aftershocks occurred in the following month.

INTRODUCTION

An earthquake was felt extensively in the Waikato and surrounding regions at 9.33 a.m. (N.Z.S.T.) on Sunday, 9th January 1972. Its centre was within a few kilometres of Te Aroha, a town of some 3,500 inhabitants, where a substantial amount of minor damage occurred.

The main earthquake had a magnitude of 5.1, and was followed three minutes later by another shock of magnitude 4.6. About 160 aftershocks of magnitude 2.5 or greater were recorded in the first month following the earthquake. Shocks of the size of the main event are relatively common in New Zealand, where about 10 shallow events a year have a magnitude of 5 or greater.

Te Aroha lies about 100 km south-east of Auckland near the north-western limit of the Main Seismic Region of New Zealand (Eiby, 1971) and is periodically subjected to shaking from earthquakes originating in this region. The only other earthquake in recent years that has been located close to Te Aroha is that of 30 July 1964, of magnitude 4.0, at a position that agrees with that of the 1972 shock within the limits of error. This earthquake is reputed to have damaged chimneys in Te Aroha, and was felt at intensity MM IV as far afield as Waihi, Katikati and Tauranga.

Te Aroha is situated on the fault-controlled scarp where the Recent alluvium of the Hauraki Plains meets the northern part of the Kaimai Ranges, which here strike in a NNW-SSE direction. The ranges are composed of Tertiary volcanic rock, and the andesite cone of Mt. Te Aroha rises to 950 m within 3 km of the town. The Waihou River runs along the base of the ranges.

MAIN SHOCK

The formal origin of the main shock

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determined from readings at 15 stations of the New Zealand seismograph network is :-

1972 Jan 9^d 09^h 33^m 00^s.1±0^s.5 N.Z.S.T.

(Jan 8^d 21^h 33^m 00^s.1 U.T.)

37° 58±0° 03S, 175° 69±0° 05E

Focal depth: 12 km (assumed)

Standard error of origin: 2^s.6

(from 31 phases at 15 stations)

Richter Local Magnitude (M_L): 5.1

Details of station readings will be published in the New Zealand Seismological Report for 1972.

The epicentre is 4 km to the south of Te Aroha, and 1 km to the east of Waihou. Its formal standard error is about 4 km, and the epicentre must not be considered to be located more accurately than this. The epicentre falls mid-way between the concealed faulting presumed to lie along the base of the hills, and the late Quaternary trace that is mapped roughly parallel to the main ranges, about 8 km to their south-west, near the town of Waitoa (Healy, Schofield and Thompson, 1964). No movement was observed on either of these faults.

The focal depth of 12 km has been arbitrarily assigned, as the closest seismograph station, Karapiro, at a distance of 41 km, was too distant to enable the determination of a reliable depth shallower than this. Strong arrivals of the phase P_g at many seismograph stations show that the focus could not have been significantly deeper than 12 km. On the other hand, the comparatively high intensity reported at Te Aroha, from an earthquake of only moderate magnitude, suggests that the focus could well be appreciably shallower.

The directions of first motion of the P-wave arrival could be read at only six of the stations recording the earthquake. These observations were not numerous enough to define a source mechanism closely, but were consistent with normal faulting with nodal planes striking approximately N-S, one dipping steeply to the west and the other shallowly to the east. The most likely mechanism appears to be a downward movement of the plains relative to the ranges, along a steeply dipping normal fault.

FELT EFFECTS

Fig. 1 shows an isoseismal map and a selection of the observations of intensity on

FIGURE 1

Felt observations and isoseismals for Te Aroha earthquake. Intensities are on Modified Mercalli Scale. Innermost isoseismal is MM VII.

FIGURE 2

Broken chimney on a house near the hill in Te Aroha. Camera pointing towards east.

FIGURE 3

Damaged monuments in Te Aroha Cemetery. Camera pointing approximately towards south.

which it is based. These observations are those reported by the Seismological Observatory's regular network of felt reporters, supplemented by the distribution of additional questionnaires. One of us (R.D. A.) visited the area from 11 to 13 January.

It is evident from Fig. 1 that the highest intensities were confined to the epicentral area. MM VII was reported from Te Aroha, Waihou (4 km to the south-west), Te Aroha West (5 km to the south-east) and Elstow (7 km to the north-west). One report from Waihou was assigned an intensity of MM VIII.

In Te Aroha itself there was a pronounced difference in the degree of damage between the eastern part of the town on the lower slopes of the hill, and the western part of the alluvial plain across the Waihou River, apparently due to the difference in the type of underlying rock in the two areas. In the shopping area of Whitaker Street along the bottom of the hill, goods on shelves and in displays were not badly affected, and no gross damage was evident, although there was some chimney damage. (Fig. 2 shows a broken chimney on a house situated at the base of the hill.) In this area the intensity would be about MM VI. Across the river on the alluvium, small shops suffered substantial stock losses, and along Stanley Street a large proportion of chimneys was damaged, including those of modern well-built houses. Here there were also many reports of heavy furniture being moved and television sets being overturned. Such objects were thrown in a westerly direction, away from the hill. In this area the intensity was generally assessed at MM VII. There were no reports of damage to underground services in Te Aroha, and only a few instances of broken lavatory pans. No changes were reported in the flow of the hot soda springs in the Te Aroha Domain.

A few kilometres to the south of Te Aroha, the grandstand of the Te Aroha Jockey Club suffered the collapse of internal partitions and nearby there was much damage to monuments in the Te Aroha Cemetery (Fig. 3). As with the furniture in Te Aroha, in almost all instances the direction of fall was to the west, away from the hill.

The MM VI isoseismal includes Waitoa (8 km to the south-west of Te Aroha) and Waihi. The intensity had in general fallen to MM V at Morrinsville, but some minor chimney damage would indicate MM VI. The MM V isoseismal extends to Hamilton and includes Matamata, Tauranga, and the southern half of the Coromandel Peninsula. The limits of the felt areas extend to Auckland, Mangakino, Rotorua and Whakatane.

One instance of damage at some distance from Te Aroha was the effect on a 40 m high brick chimney at a dairy factory at Hautapu, near Cambridge, 40 km to the south-west of Te Aroha in an area of general intensity MM V. Some small vertical cracks were present in the chimney before the earthquake, but these opened to become much more evident after the shock. On the eastern side, cracks were visible most of the way down the chimney, in places up to $\frac{1}{2}$ cm wide.

A landslide reported in the press as occurring on the shore of Lake Karapiro, 12 km

upstream from the dam, and 40 km from Te Aroha, was found to be only a few feet across and to have occurred about an hour after the earthquake.

The Earthquake and War Damage Commission has received about 1300 claims arising from the earthquake, mainly from Te Aroha and its immediate surroundings. The total amount paid out in claims is estimated at about \$160,000. Apart from a few claims for damage to larger structures such as the grandstand and factory chimney mentioned above, the claims arose mainly from damage to domestic chimneys and contents of buildings.

AFTERSHOCKS

The largest aftershock occurred only three minutes after the main shock, and was the first aftershock that could be identified. Its magnitude was 4.6, and its relation to the main shock is such that the two events could be considered as a double earthquake. The next largest shock of the sequence occurred on January 18 at 07^h 25^m (N.Z.S.T.), and had a magnitude of 4.1. This magnitude is closer to that usually found for the largest aftershock following an earthquake of magnitude 5.1.

A preliminary analysis of aftershocks during the first 33 days, up to 1972 February 10, has been carried out, and 213 have been assigned provisional magnitudes, whose distribution is given in Table 1. It is likely that all events down to magnitude 2.5 have been recognised, but the fall-off in numbers below this magnitude is probably due to incomplete detection.

Table 2 is a chronological list of the shocks of magnitude 3.5 and greater. This is based on a provisional determination of magnitudes only, and further studies could cause this list to be amended. The initial activity on January 9 was followed by a single shock on January 11, and then four shocks on January 12 and 13. There was another period of activity from January 16 to 19, after which the number of shocks of all magnitudes diminished greatly. Two isolated shocks of magnitudes 3.7 and 3.4 on February 6 and 7 were not accompanied by any increase in the number of smaller shocks.

The positions of the aftershocks do not appear to differ greatly from that of the main shock. An indication of scatter may be obtained from differences in the interval between the P and S phases recorded at Karapiro, the nearest seismograph station, which is at a distance of 41 km from the epicentre adopted for the main shock. For this distance the time interval between P and S wave arrivals from a focus at a depth of 12 km is 5.0s. An S-P interval of 5.0s was, in fact, measured for 93 of the 204 events of the sequence for which this could be measured. 94% of all events had S-P intervals in the range of 4.5 to 5.5s, and all measured intervals were within the limits of 4.0 and 6.0s. These ranges imply that the extreme variation in distance of aftershocks from Karapiro is 8 km in either direction, and that 94% of recorded events were at a distance within 4 km of that of the main shock. Because of overloading of the instruments, the S-P interval at Karapiro could not be read for the largest aftershocks, which will be located independently. It would

seem, however, that the smaller aftershocks were concentrated in an area within a few kilometres of the main shock.

Although the aftershocks appear to originate from a small volume, their mechanisms are not all identical. At Karapiro the ratio of recorded amplitude of S waves relative to P waves varied by more than an order of magnitude, and although the direction of initial motion of the P wave was usually compressional, in some cases definite dilatational first motions were recorded. Thus the aftershocks cannot all be regarded as simply repeating the mechanism involved in the main earthquake.

CONCLUSIONS

This earthquake is a further reminder that earthquakes of moderate magnitude can cause significant damage when they occur at shallow depths beneath populated areas. The intensity of MM VII reported in the epicentral region is about as great as could be expected from an earthquake of this magnitude under normal conditions. The damage reported from Te Aroha shows again that domestic chimneys remain by

far the most vulnerable feature of buildings in New Zealand.

Further detailed work is being undertaken on the seismological aspects of the aftershock sequence, which has been well recorded.

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TABLE 1

Te Aroha Earthquake Sequence, 1972.

<u>PRELIMINARY MAGNITUDE-FREQUENCY RELATIONSHIP</u>	
<u>Magnitude Range</u>	<u>Number of Events</u>
5.0 to 5.4	1 (main event)
4.5 to 4.9	1
4.0 to 4.4	1
3.5 to 3.9	15
3.0 to 3.4	50
2.5 to 2.9	101
2.0 to 2.4	45

TABLE 2

Te Aroha Earthquake Sequence, 1972.

<u>PRELIMINARY LIST OF SHOCKS OF MAGNITUDE 3.5 AND GREATER</u>									
Dates and times are given in New Zealand Standard Time. Subtract 12 ^h to obtain Universal Time.									
d	h	m	s	M _L	d	h	m	s	M _L
Jan 09	09	33	00.1	5.1	Jan 13	04	00	08.6	3.8
	09	36	20.4	4.6		05	12	10.2	3.8
	09	58	06.9	3.5	16	12	46	11.7	3.5
	10	37	52.6	3.8		20	59	59.3	3.7
	12	36	18.6	3.6	17	19	02	34.5	3.5
	16	54	20.4	3.8	18	00	06	45.1	3.6
11	03	38	03.2	3.6		07	25	49.9	4.1
12	05	33	31.9	3.6	19	22	30	43.1	3.6
	16	44	33.4	3.7	Feb 06	00	00	23.2	3.7