Report 280

Australian seismological report 1983

Compiled by Peter J. Gregson & David Denham

Bureau of Mineral Resources, Geology and Geophysics

Department of Resources & Energy

BUREAU OF MINERAL RESOURCES, GEOLOGY & GEOPHYSICS

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AUSTRALIAN SEISMOLOGICAL REPORT, 1983

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Peter J. Gregson & David Denham

(Division of Geophysics)

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ABSTRACT

Seismicity in the Australian region in 1983 was similar to 1982, i.e. below average. Of the 112 earthquakes of magnitude 3 or greater that were located, only two had a magnitude of 5.0 or greater. These were the Tasman Sea earthquake of 25 November which had a magnitude of MS 5.9 and the Beltana earthquake of 29 December which was felt over a wide area of South Australia and had a magnitude of ML 5.0. An earthquake at Cadoux on 26 January had a magnitude of ML 4.8. Isoseismal maps have been produced for the Beltana, Bowning, Cadoux, Leigh Creek, Milparinka 2, Tasman Sea, and Timor Sea earthquakes. Intensities of MMVI on the Modified Mercalli Scale were reported from the Cadoux earthquake. Two earthquakes were recorded on strong-motion accelerographs in Western Australia: the maximum acceleration was 340 mm s^{-2} recorded near Meckering from a magnitude 2.8 earthquake which occurred approximately 2 km from the accelerograph. Worldwide, the largest earthquake was in the New Ireland region, with a surface-wave magnitude of 7.9. The most destructive earthquake (ML 6.9) took place in Turkey on 30 October when at least 1342 people were reported killed.

INTRODUCTION

This report contains information on all earthquakes of Richter magnitude 3 or greater that were reported in the Australian region during 1983. It is the fourth of an annual series to be compiled by the Bureau of Mineral Resources, Geology & Geophysics (BMR), using data provided by various seismological agencies in Australia. Its purpose is to aid the study of seismic risk and to answer inquiries from scientists and the general public.

The report comprises four main sections: 'Australian earthquakes', which contains a summary of the 1983 seismicity and brief descriptions of the more important earthquakes; 'Network operations', which gives details of the seismographs that operated in Australia during 1983; 'Accelerograph data', which contains the results of the accelerograph network; and 'Principal World Earthquakes, 1983', which lists the largest and most damaging earthquakes that took place during 1983.

Throughout the report we refer to *magnitudes of* earthquakes and *intensities caused by* earthquakes. These terms are defined below.

Magnitudes

The magnitude of an earthquake is a measure of its size and is related to the energy released at its focus. The magnitude scale is logarithmic: thus a magnitude 6 earthquake produces ground amplitudes 10 times as large, and an energy release about 30 times as large, as a magnitude 5 earthquake.

A rule-of-thumb relation between magnitude and energy is

$$\log E = 4.8 + 1.5M$$

where E is in joules.

A shock of magnitude 2 is the smallest normally felt by humans, and earthquakes of magnitude 5 or more can cause major damage if they are shallow and close to buildings.

The following magnitude scales are in common use.

Richter magnitude (ML)

$$ML = \log A - \log A_0$$

as defined by Richter (1958, p. 340), where A is the maximum trace amplitude (zero-to-peak) in millimetres on a standard Wood-Anderson seismogram and $\log A_0$ is a standard value given as a function of distance (0-600 km). Richter's reference earthquake of ML 3.0 produces a trace amplitude of 1 mm, 100 km from the epicentre.

If standard Wood-Anderson instruments (Anderson & Wood, 1925) are not available, an equivalent Richter magnitude can be determined by correcting for the differences in magnification (see Willmore, 1979, para. 3.1.1).

Surface-wave magnitude (MS)

The surface-wave magnitude is normally applicable only to shallow earthquakes in the distance range 20-160 degrees, and in the period range T = 20 ± 3 s. When these conditions hold, MS values are calculated from the IASPEI (1967) formula

$$MS = \log \frac{A}{T} + 1.66\,\Delta + 3.3$$

where A is the ground amptitude in micrometers, T is time in seconds, and Δ is the epicentral distance in degrees (see Båth, 1981).

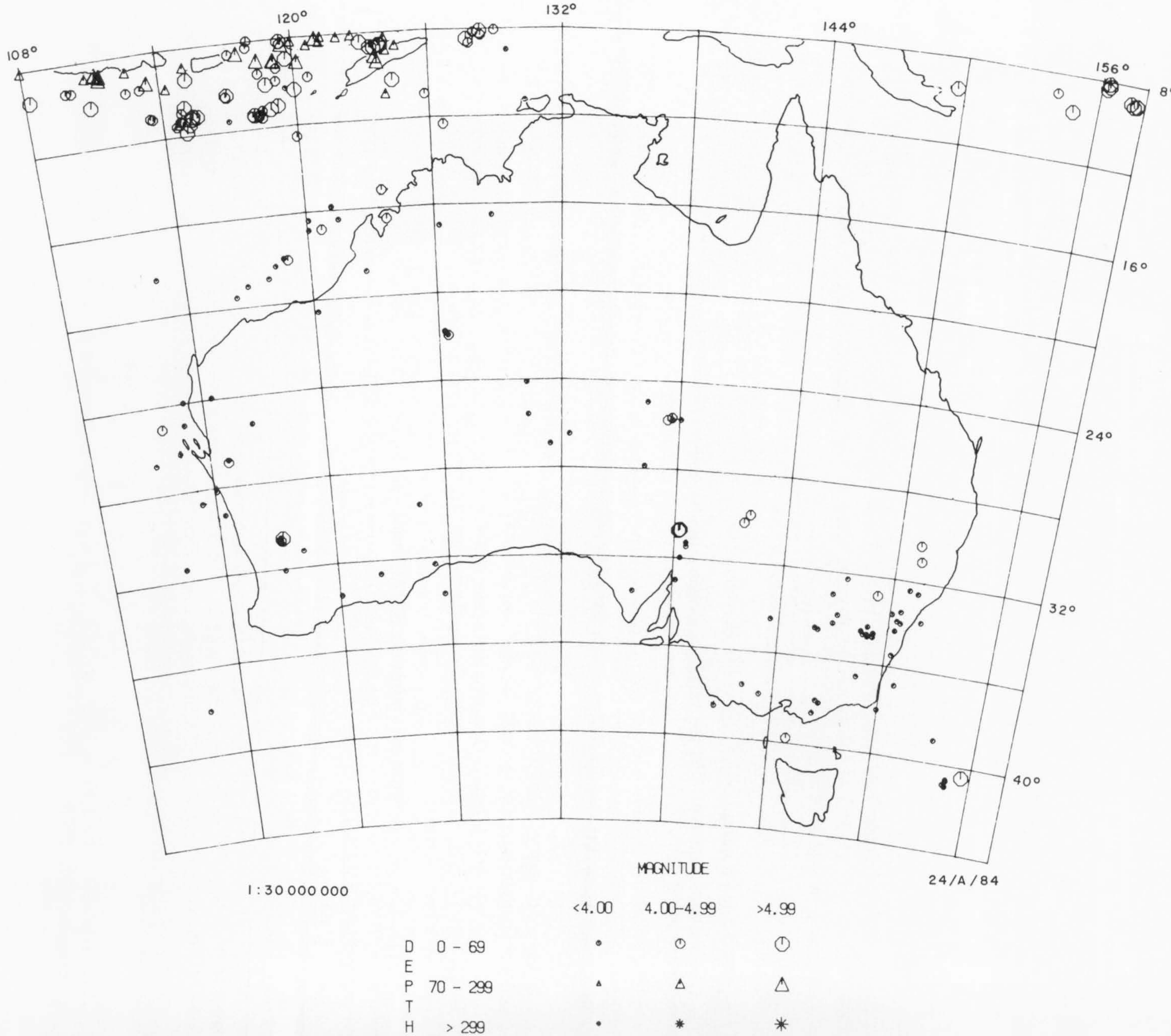


Fig. 1. Australian region earthquakes with magnitudes 3.0 or greater, 1983.

Body-wave magnitude (mb)

$$mb = \log \frac{A}{T} + Q\ (\ \Delta,\ h)$$

where A is the maximum mean-to-peak ground amplitude in microns of the P, PP, or S-wave trains, T the corresponding wave-period (seconds), and Q (Δ, h) a depth/distance factor. The Q factors were derived by Gutenberg (1945) and are given by Richter (1958, pp. 688-689).

Duration magnitude (MD)

$$MD = a \log t + b\ \Delta + c$$

where t is the length of the earthquake coda in seconds, Δ the distance from the epicentre, and a, b, and c are constants for a particular recording station.

Seismic moment magnitude (Mw)

$$Mw = \frac{\log M_o}{1.5} - 6.0$$

where M_o is the seismic moment (in Nm) and defined as

$$Mo = \mu\ AD$$

where μ is the rigidity, A the surface area displaced, and D the average displacement on that surface. This magnitude scale was proposed by Kanamori (1978).

Magnitude from isoseismals

In some cases where reliable magnitudes cannot be determined instrumentally (from seismograms), it is possible to calculate magnitudes from macroseismic data. In these cases McCue's (1980) formula was used

$$M(Rp) = 1.01\ ln(Rp) + 0.13$$

where Rp is the radius of perceptibility (in kilometres) of the MM(III) isoseismal. Magnitudes found by this method should be treated as approximate only, and may be revised as a result of further research.

Further information on magnitudes is available in McGregor & Ripper (1976), Båth (1981), and Denham (1982).

Intensity

The intensity of an earthquake is determined from its effects on people, buildings, and the Earth's surface. In this report we use the Modified Mercalli Scale (MM) as presented by Eiby (1966) for New Zealand conditions and listed in the Appendix. Essentially the MM scale is an assessment of how severely the earthquake was felt and the damage that was caused at a particular place. Some earthquakes are large enough to be felt over a wide area and an isoseismal map can be prepared. These maps indicate in detail the extent of the shaking. They are prepared mainly from information compiled from questionnaire canvasses, newspaper reports, and personal interviews and inspections.

During 1983 seven earthquakes were large enough to enable isoseismal maps to be prepared (Figs. 3 to 9).

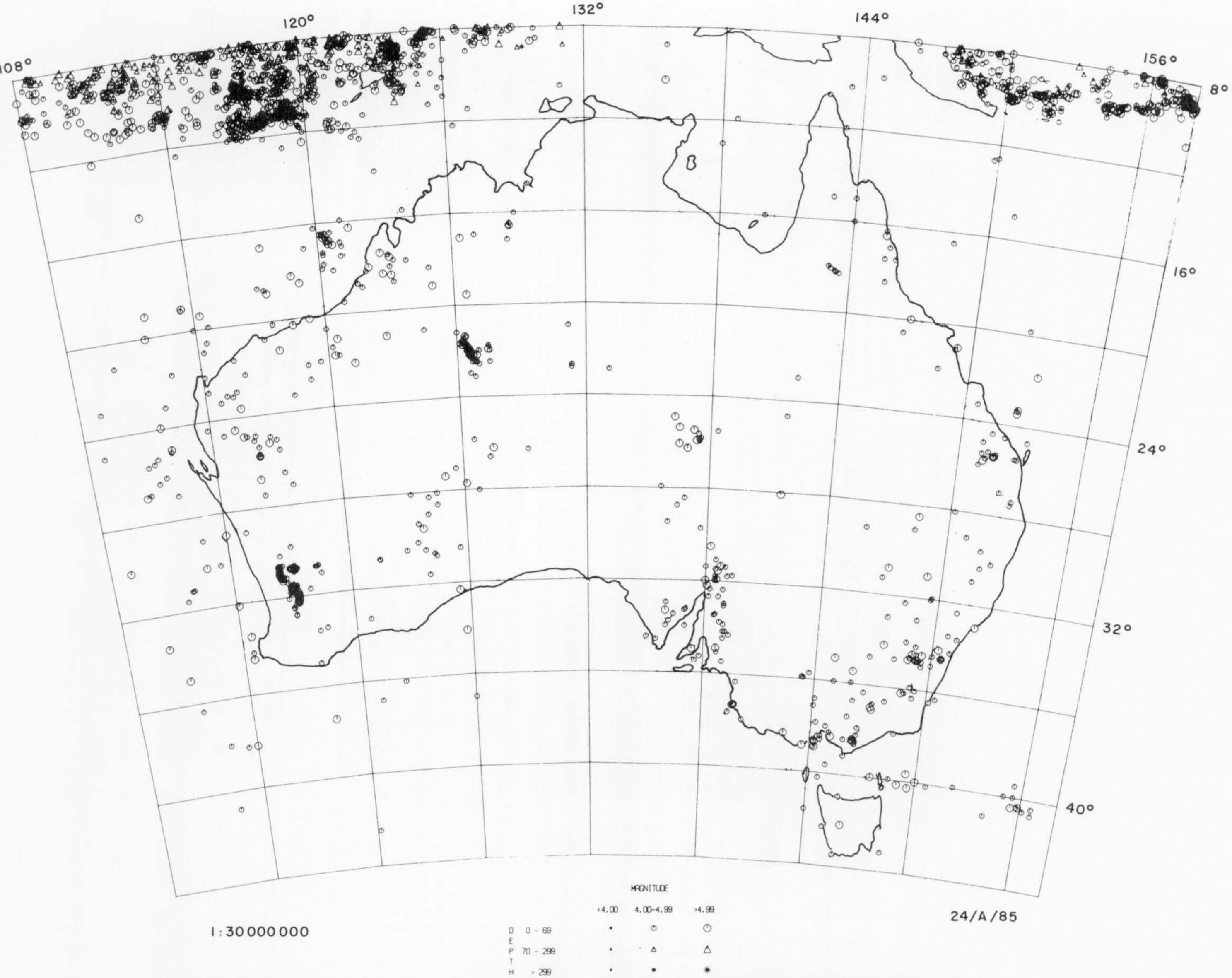


Fig. 2. Australian region earthquakes with magnitudes 4.0 or greater, 1873-1982.

AUSTRALIAN REGION EARTHQUAKES, 1983

Seismicity in the Australian region in 1983 was similar to 1982 (Gregson & Denham, 1986), i.e. below average. Figure 1 shows the locations of the 112 known 1983 earthquakes of magnitude 3 or greater, and Table 1 lists their hypocentral parameters. Figure 2 shows the distribution of magnitude 4 and greater earthquakes for 1873-1982.

The Southwest Seismic Zone in southwest Western Australia remained one of the most active areas, and 98 earthquakes were located there in 1983 compared with 164 in 1982. Fifty-seven were in the Cadoux area, the largest with magnitude ML 4.8 on 26 January. The rest were scattered throughout the zone from Ballidu in the north to Gnowangerup in the south. Most activity in Western Australia outside the Southwest Seismic Zone was offshore, scattered along almost the entire coastline except the southwest corner (Fig. 1).

In South Australia the largest earthquake (ML 5.0) was near Beltana south of Leigh Creek; otherwise there were only five earthquakes located of magnitude 3 or greater.

In eastern Australia the level of seismic activity was below average, with no earthquake larger than ML 5.0.

The largest earthquake in the Australian region (MS 5.9) was in the Tasman Sea on 25 November. It was the largest in that region for over 50 years (Denham, 1985).

Isoseismal maps were prepared for seven earthquakes.

Cadoux

At 06:16 UT (2.16 pm local time) on 26 January an ML 4.8 earthquake occurred 4 km north of Cadoux in southwest Western Australia (Fig. 3). Several isoseismal maps have been prepared for earthquakes in the area since the large earthquake of 2 June 1979.

The intensity experienced in the Cadoux area was MM V, with one report of MM VI near the epicentre. The earthquake was felt over an area of 50 000 km^2 and up to 200 km away to the southwest (Gregson & others, 1985).

Bowning

This ML 3.8 earthquake occurred at 9.26 am local time on Tuesday 8 March (23.26 UT, 7 March). The townships of Binalong, Bowning, and Yass were within an epicentral radius of 25 km and the maximum felt intensity of MM VI was reported from these centres (Fig. 4), corresponding to cracking of internal plaster and exterior masonry, substantial in isolated cases. The felt area extended to a radius of about 80 km, with some evidence of elongated isoseismals in a northerly direction.

This earthquake and the Bowning ML 4.5 and ML 5.0 events of 30 June 1977 and 4 July 1977 had virtually the same epicentre (Smith & McEwin, 1980). Compared to the larger of the 1977 events, this earthquake had a much smaller total felt area, but similar maximum felt intensities, indicating that the precise depth of one or more of these earthquakes is poorly known.

The isoseismal map was prepared by BMR staff using data from 80 returned questionnaires, of which 47 were 'felt' replies as shown in Figure 4.

Milparinka (April)

The first (ML 4.5) of the two Milparinka earthquakes (Figs. 5,6) occurred at 5.03 am Central Time on 9 April, about 20 km southeast of Milparinka. In Tibooburra, the only township in the region, most people were woken though few were frightened. There were isolated reports of minor damage, usually cracks in plaster work.

The isoseismals, though not well delineated, indicate a northwest-southeast trend in felt intensities; the felt region extended about 180 km to the south of the epicentre and 70 km to the east.

Questionnaires were distributed by BMR, and 83 forms were returned.

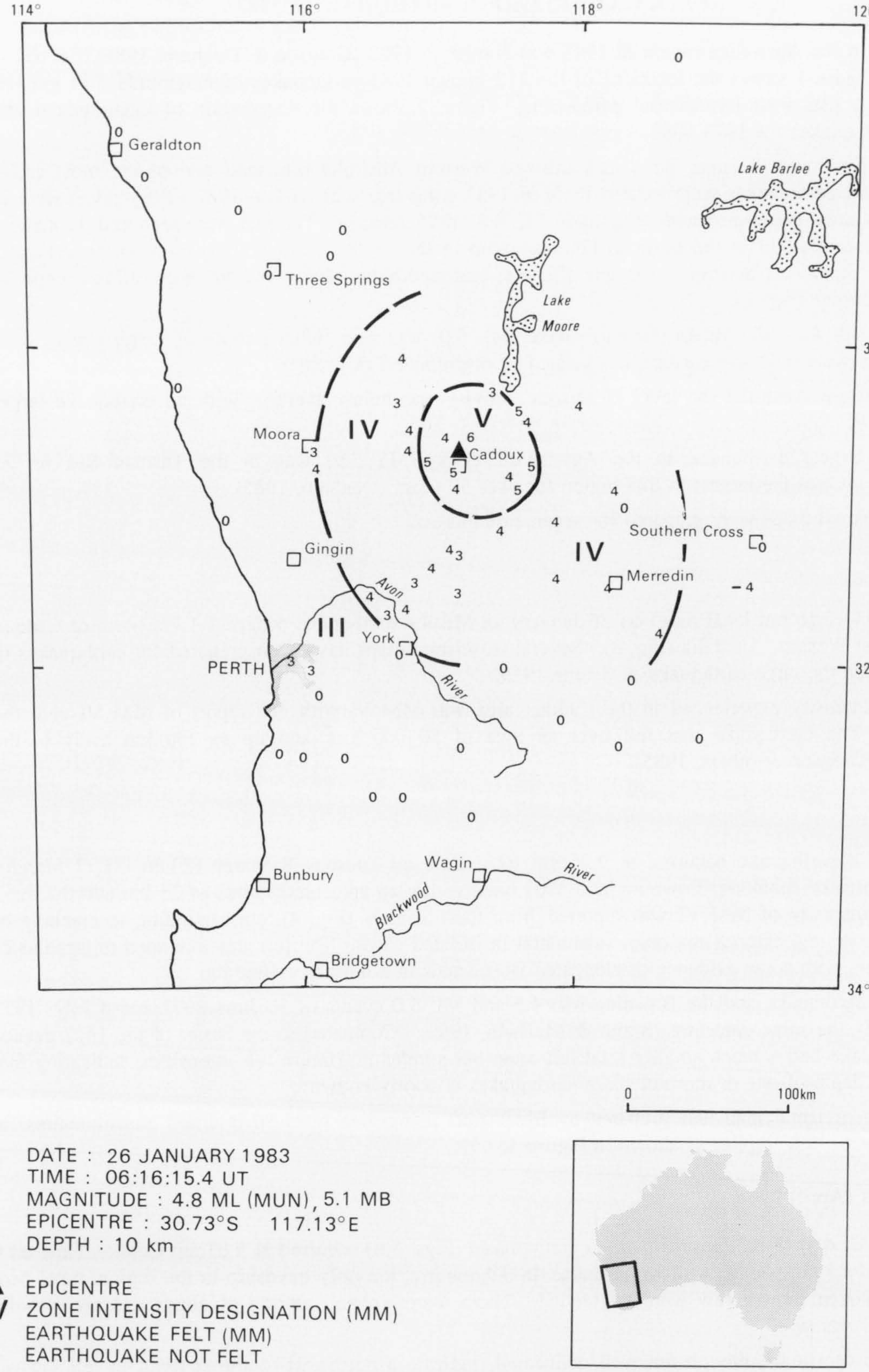


Fig. 3. Isoseismal map, Cadoux(WA) earthquake, 26 January 1983.

24/WA/29

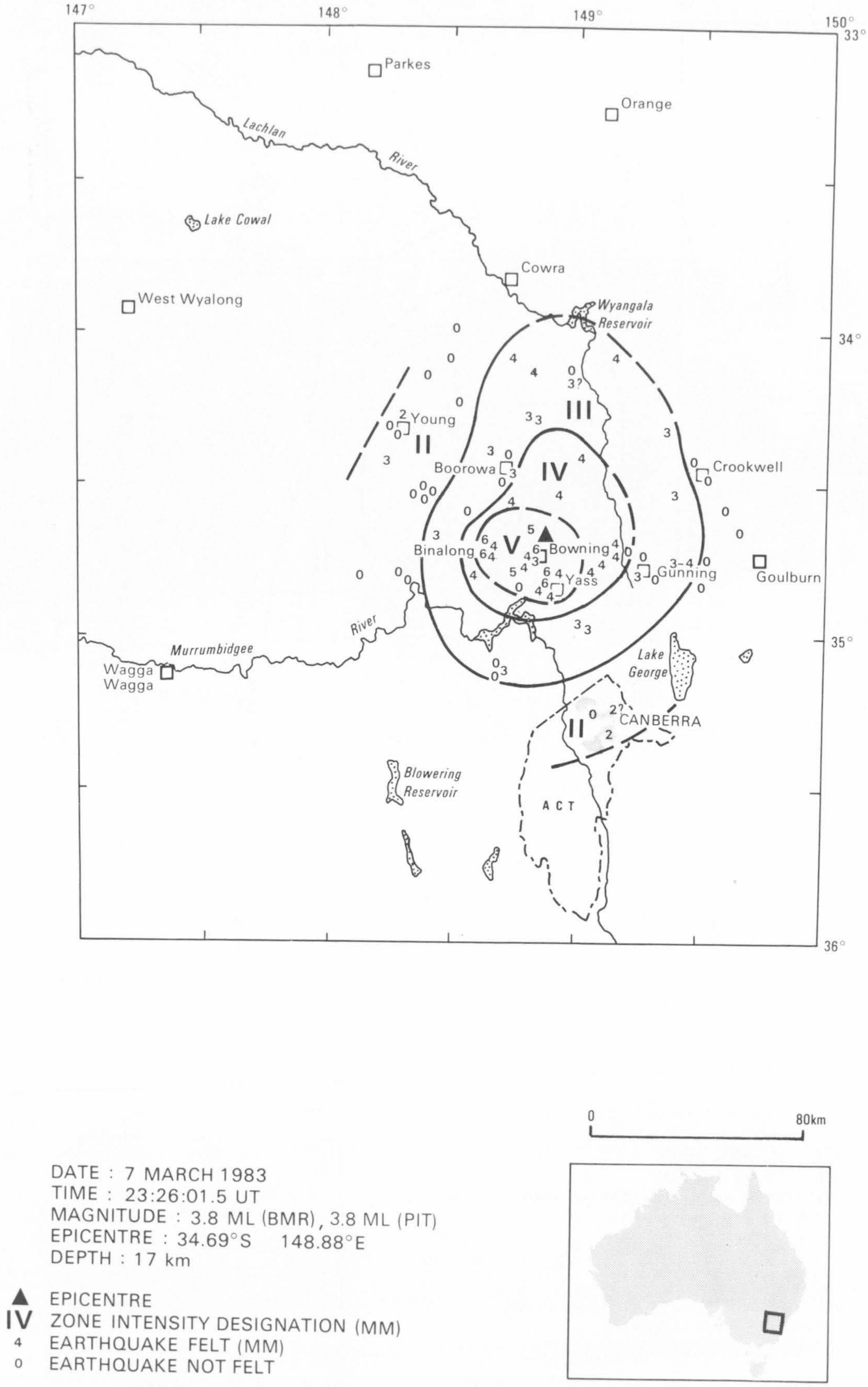


Fig. 4. Isoseismal map, Bowning(NSW) earthquake, 7 March 1983.

24/I55/12

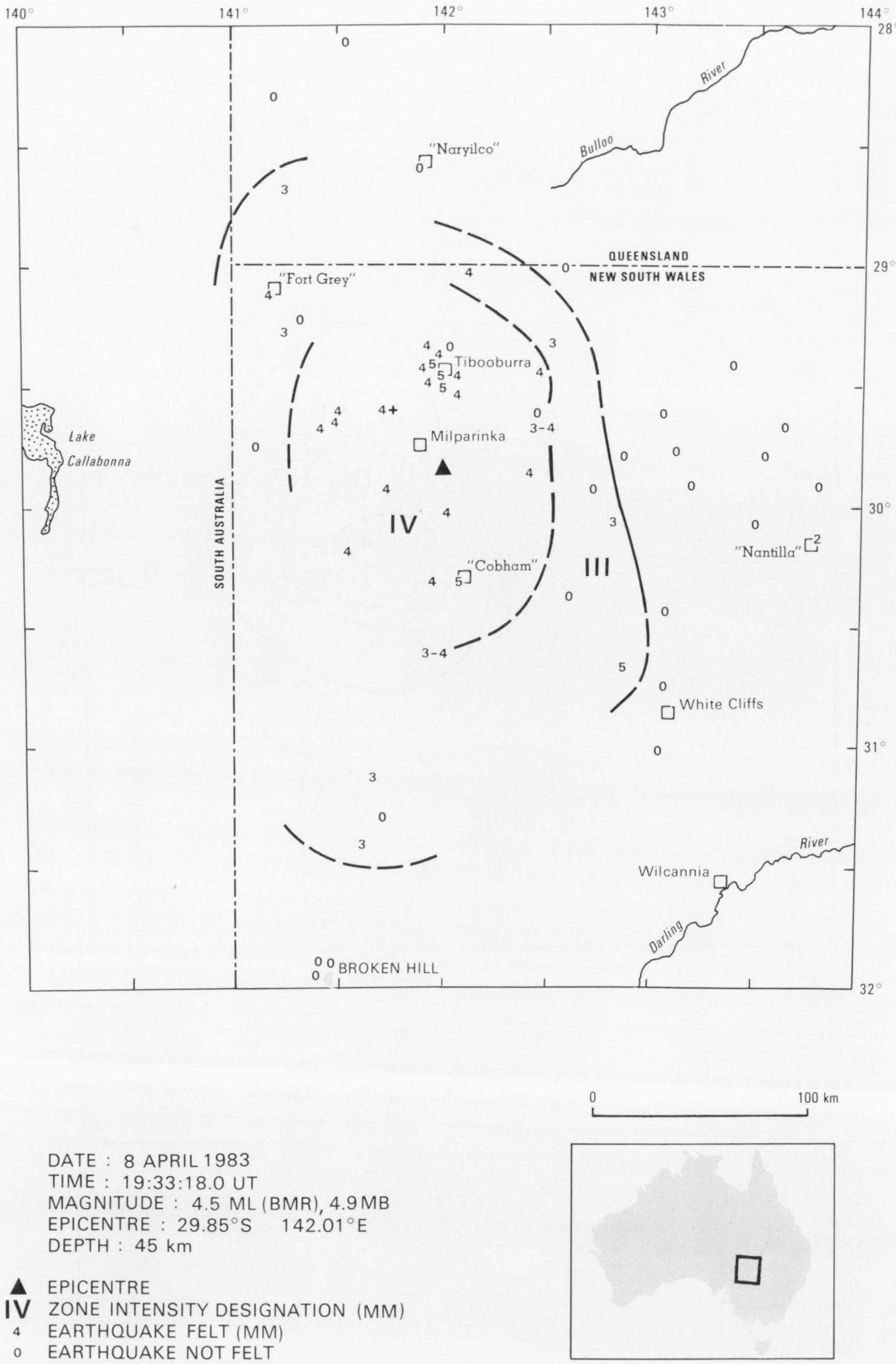


Fig. 5. Isoseismal map, Milparinka(NSW) earthquake, 8 April 1983.

24/H54/2

Milparinka (June)

The second earthquake (ML 4.7) (Fig. 6) occurred at 3.03 am Central Time on 21 June. The epicentre was 55 km south-southwest of the April event and thus the effects in Tibooburra were not as marked. Although the two earthquakes had similar magnitudes, the April event was felt more intensely over a larger area.

The isoseismals for both earthquakes are elongated northwest-southeast. A feature of the MM IV felt area for this earthquake is its relatively small extent (45 km) in the northeast direction.

BMR staff prepared Figure 6 using data from 84 returned questionnaires.

Timor Sea

Electric power and telephone services in parts of northern Australia were interrupted by the earthquake of 24 November 1983 (05:30 UT, ML 7.5), which occurred in the Banda Sea about 650 km northwest of Darwin (Fig. 7). The shock was strongly felt in the Indonesian islands of Sumba, Flores, Timor, and Alor, but there were no reports of casualties or damage (SEAN, 1983).

The maximum intensity reported in Australia was MM V in Darwin where there was minor damage. Strong shaking was experienced in Darwin, Wyndham, Kununurra, Derby, and Katherine. Intensities of MM IV were experienced over an area of 300 000 km in Australia, up to 900 km from the epicentre.

Figure 7 was prepared from responses to 200 'felt' report questionnaires distributed throughout northern Australia (Gregson & others, 1985).

The earthquake had effects similar to those of an earthquake on 29 October 1974 (Everingham & others, 1982), and was felt in Perth, as was the Indonesian earthquake of 19 August 1977.

Tasman Sea

The Tasman Sea earthquake (MS 5.9; Fig. 8) occured on 25 November UT in oceanic lithosphere beneath the abyssal plain about 500 km off the southeast coast of Australia. It was large enough to be felt in northeastern Tasmania and the coastal areas of southeast Australia. The maximum intensity was reported from Flinders Island where a value of MM IV was assigned.

Focal mechanisms of this earthquake (Table 3) have been determined by Denham (1985), Fredrich & others (in preparation), and USGS (1984). Essentially the mechanism is almost pure thrust faulting with the pressure axis (~ 140 degrees E of N) similar to those observed on the nearby Australian mainland for previous earthquakes (Denham, 1985).

Beltana

This earthquake occurred at 4.12 am local time on 30 December 1983 and awoke most people in the Leigh Creek area. It was the largest earthquake to have occurred in South Australia since 1972. The 'felt' area extended over about 10 000 km^2, with a maximum intensity of MM VI being assigned to the region near Parachilna, which contains the Beltana and Motpena homesteads. An isolated but multiply confirmed 'felt' report (MM IV) was received from as far away as Woomera.

There were three foreshocks and seventeen aftershocks, of which three were felt at Beltana.

The trend of the aftershock sequence (319 ± 4 degrees) is consistent with the focal mechanism, which indicates a northwest-trending left-lateral strike-slip fault caused by east-west compression. Table 4 indicates the focal parameters, taken from Greenhalgh & Denham (1986). The axis of maximum compression is similar to those obtained from six other South Australian earthquakes (McCue & Sutton, 1979; Singh, 1985).

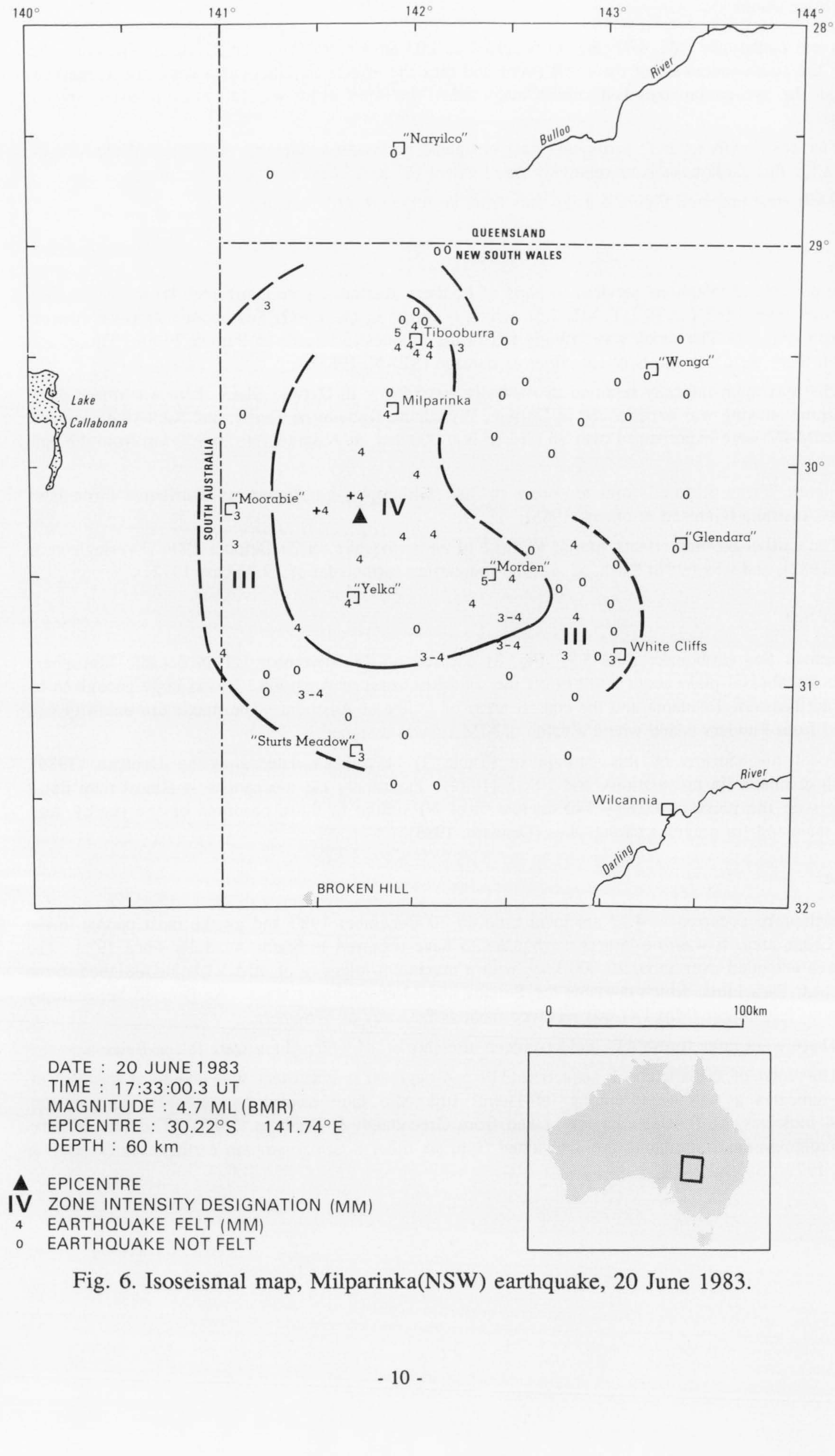
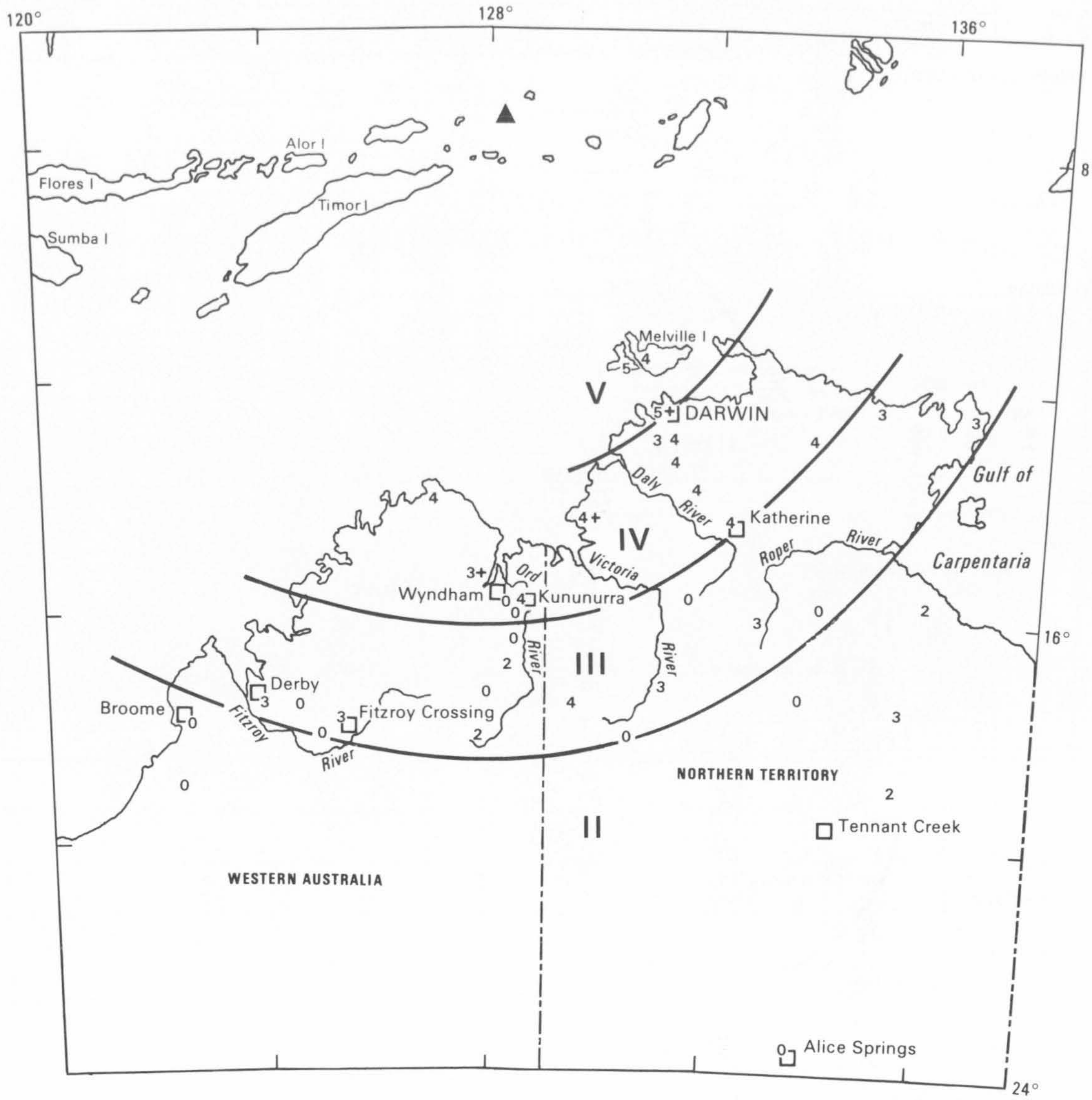
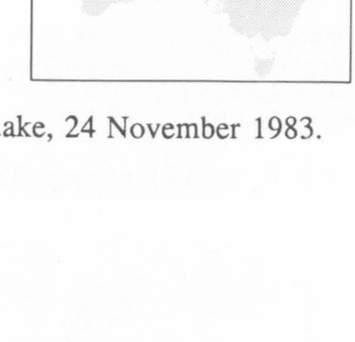


Fig. 6. Isoseismal map, Milparinka(NSW) earthquake, 20 June 1983.

24/H54/1





DATE : 24 NOVEMBER 1983
TIME : 05:30:34.2 UT
MAGNITUDE : 7.5 ML (MUN), 6.4 MB, 7.1 MS (GS)
EPICENTRE : 7.57°S 128.19°E
DEPTH : 180km

▲ EPICENTRE
IV ZONE INTENSITY DESIGNATION
4 EARTHQUAKE FELT (MM)
0 EARTHQUAKE NOT FELT

Fig. 7. Isoseismal map, Timor Sea earthquake, 24 November 1983.

24/09/193

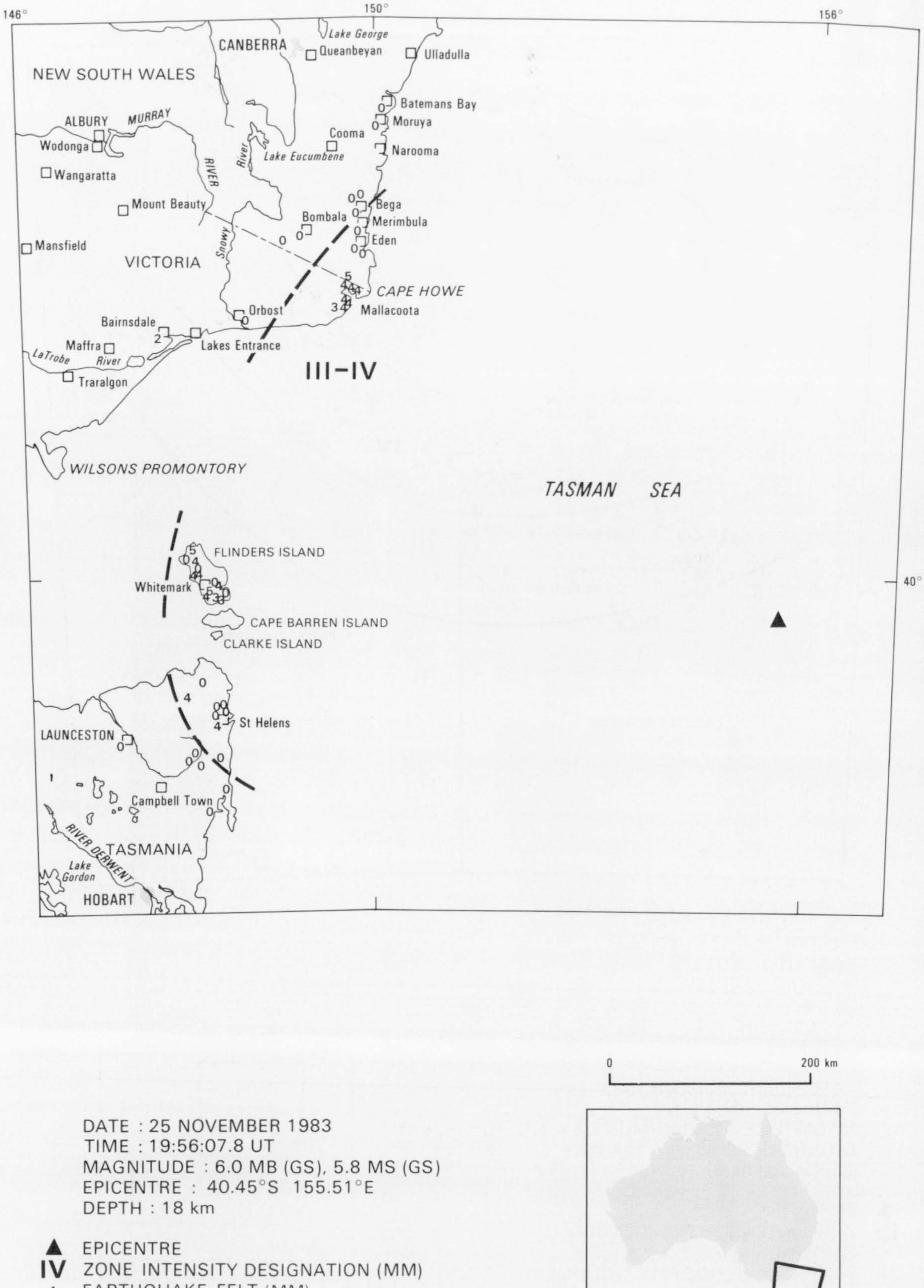
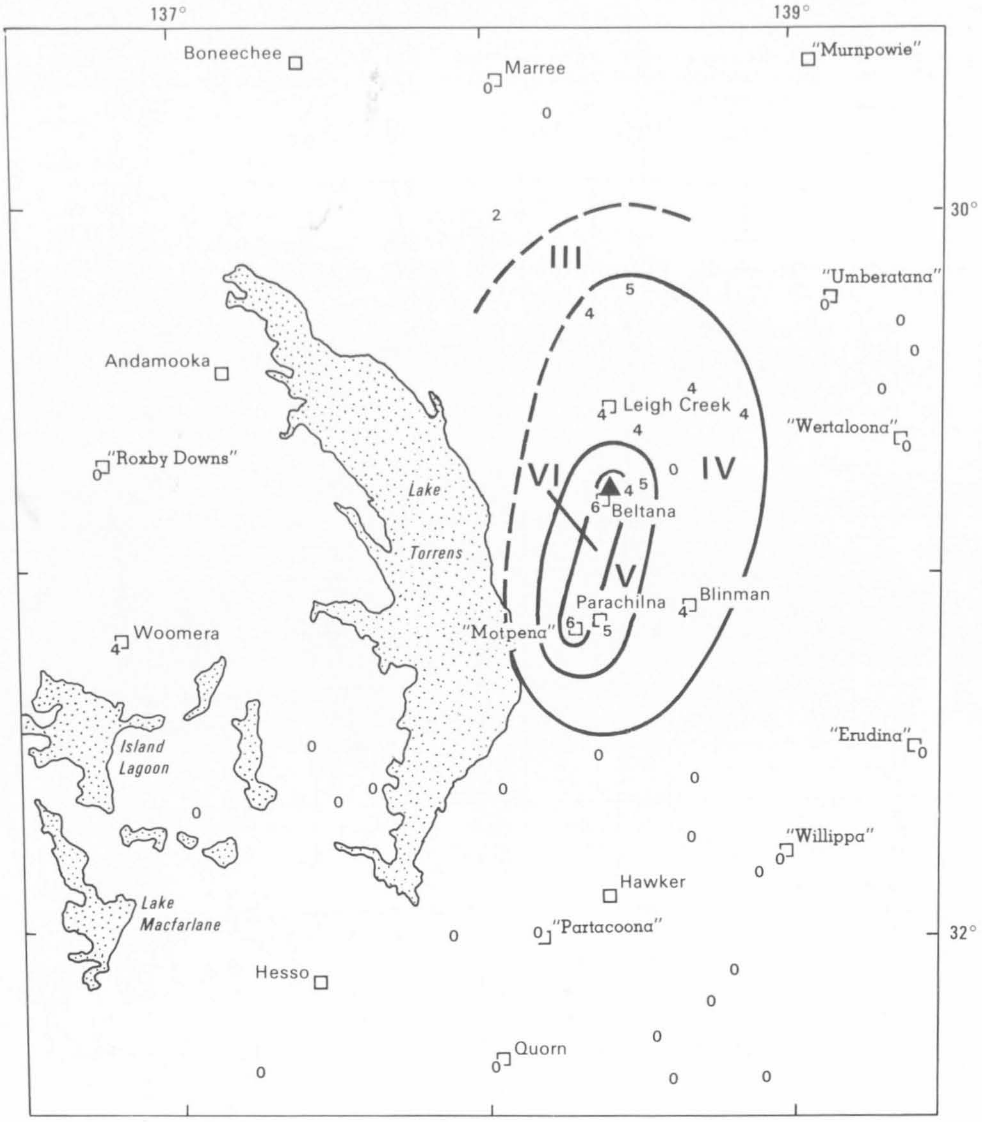
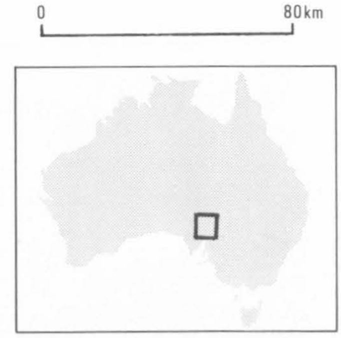


Fig. 8. Isoseismal map, Tasman Sea earthquake, 25 November 1983.

24/OA/3



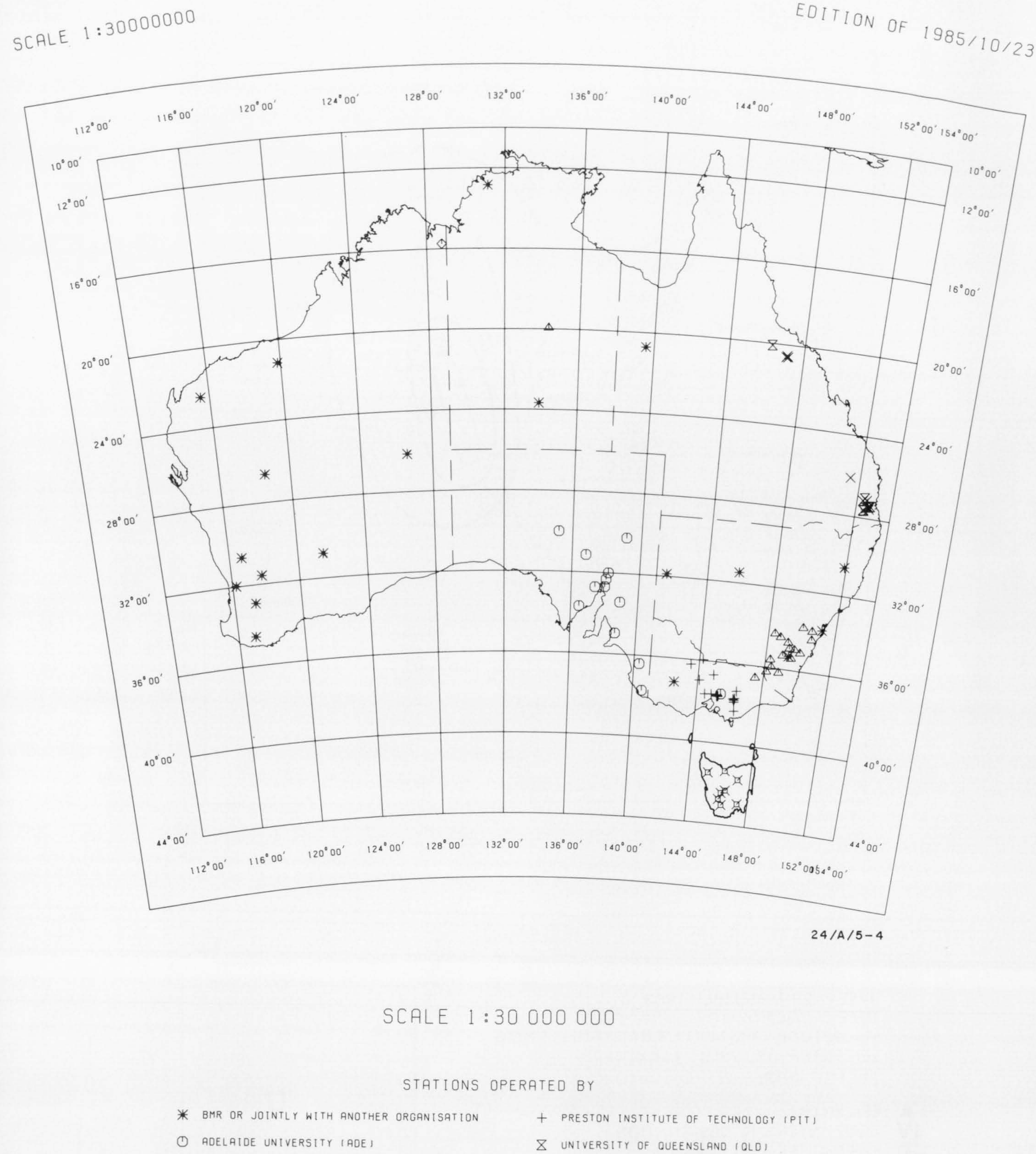


DATE : 29 DECEMBER 1983
TIME : 17:42:02 UT
MAGNITUDE : 4.5 ML(I), 4.8 ML (ADE), 5.3 MB
EPICENTRE : 30.79°S 138.40°E
DEPTH : 20km

▲ EPICENTRE
IV ZONE INTENSITY DESIGNATION
4 EARTHQUAKE FELT (MM)
o EARTHQUAKE NOT FELT

Fig. 9. Isoseismal map, Beltana earthquake(SA), 29 December 1983.

24/SA/7



SCALE 1:30 000 000

STATIONS OPERATED BY

- ✳ BMR OR JOINTLY WITH ANOTHER ORGANISATION
- ⏀ ADELAIDE UNIVERSITY (ADE)
- △ AUSTRALIAN NATIONAL UNIVERSITY (CAN)
- ⌘ UNIVERSITY OF TASMANIA (TAU)
- \+ PRESTON INSTITUTE OF TECHNOLOGY (PIT)
- ⧖ UNIVERSITY OF QUEENSLAND (QLD)
- ◇ WA PUBLIC WORKS DEPT (PWD)
- × GEOLOGICAL SURVEY OF QUEENSLAND (GSQ)

Fig. 10. Australian seismograph stations, 1983.

NETWORK OPERATIONS

Figure 10 shows the locations of the stations that operated continuously in Australia in 1983. Five new stations were commissioned during the year: Bucrabanyule, Merrimu, Mount Hope, and Rushworth in Victoria and Rocky Gully in Western Australia. Table 2 lists the co-ordinates of the stations and the types of seismograph in operation.

Regional epicentres were located by the main operating institutions listed on page iii, and BMR co-ordinated these to provide the list in Table 1. BMR also maintains the definitive Australian earthquake data file and provides basic earthquake data for the Australian region on request to scientists, insurance companies, engineers, and the general public.

ACCELEROGRAPH DATA

For earthquake hazard to be properly assessed it is necessary to estimate how the surface of the Earth will respond close to an earthquake. Conventional seismographs overload when strong ground motion is experienced, and accelerographs are normally used in these circumstances. Accelerographs are less sensitive and only operate when the ground motion reaches a threshold level.

Twenty accelerographs operated in Australia during 1983 (Table 5). Table 6 lists the principal facts from the 12 triggerings obtained during the year. The highest accelerations were recorded in the Southwest Seismic Zone of Western Australia; the largest acceleration, of 340 mms^{-2}, was recorded near Meckering from an ML 2.8 earthquake approximately 2 km from the accelerograph.

PRINCIPAL WORLD EARTHQUAKES, 1983

Table 7 lists earthquakes of magnitude 7.0 or greater, and/or damaging earthquakes, that occurred throughout the world in 1983. Figure 11 shows the locations of these earthquakes and the numbers of casualties.

The most destructive earthquake was that of 30 October in northeastern Turkey which killed at least 1342 people. The total world-wide death-toll for 1983 was about 2300 (about 1000 less than for 1982). The largest earthquake occurred on 18 March in the New Ireland region. It had a surface wave magnitude of 7.9 and caused damage (MM VII) along the southeast coast of New Ireland. Landslides and ground cracks occurred, trees were uprooted, and steam was ejected from fumaroles. A 25 cm tsunami was recorded at Rabaul.

These data are based on SEAN Bulletin of the Smithsonian Intitution (SEAN, 1983).

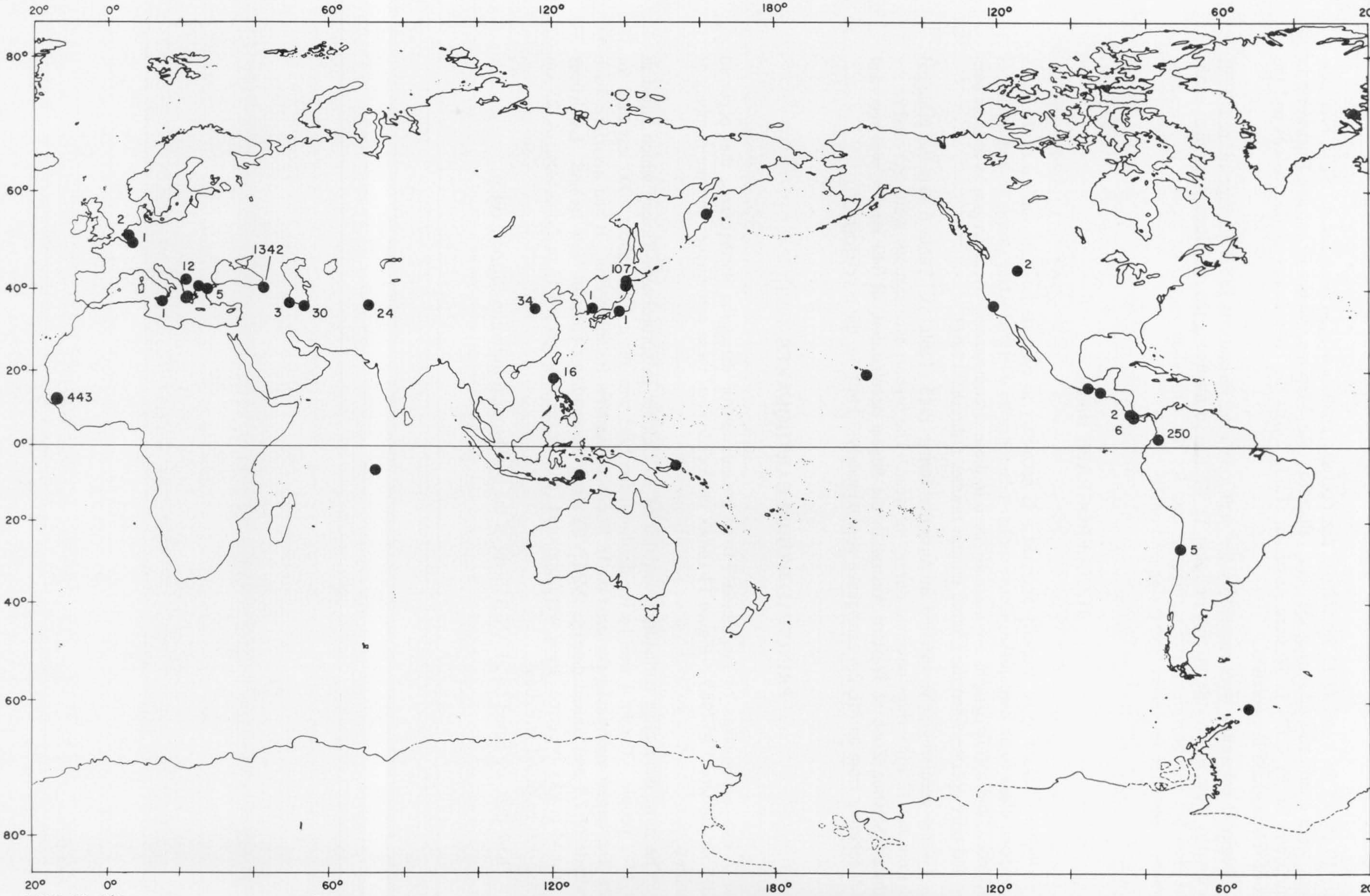


Fig. 11. Principal world earthquakes, 1983, showing numbers of reported deaths.

TABLE 1. AUSTRALIAN REGION EARTHQUAKES 1983: HYPOCENTRAL PARAMETERS

DATA SOURCE*	DATE yr mo dy	TIME (UT) hr mn sec	LAT° S	LONG° E	DEPTH (km)	MAGNITUDE	N**
MUN	83 01 01	20 52 02.9	32.100	117.180	10	3.2 ML	6
MUN	83 01 07	16 45 22.6	30.830	117.100	10	3.2 ML	4
MUN	83 01 08	04 53 00.0	16.450	121.500	10	3.6 ML	5
MUN	83 01 09	19 42 43	33.680	125.690	10	3.0 ML	3
MUN	83 01 12	14 57 33.0	16.400	120.100	37	3.4 ML	1
GS	83 01 13	02 47 24.0	16.844	120.689	33	4.1 MB	6
CAN	83 01 15	16 45 40.8	36.630	148.580	17	3.6 ML	2
MUN	83 01 17	21 57 29.0	32.320	125.230	10	3.9 ML	7
TAU	83 01 23	20 14 21.7	37.900	143.230		3.6 ML	5
MUN	83 01 26	06 16 15.4	30.730	117.130	10	4.8 ML	9
CAN	83 01 28	22 32 27.7	34.720	146.190	34	3.1 ML	8
MUN	83 01 30	04 50 00.0	30.720	117.110	10	3.7 ML	5
MUN	83 02 01	15 00 41.5	21.760	126.270	10	3.5 ML	6
CAN	83 02 06	23 13 51.5	31.080	151.330	25	4.6 ML	12
CAN	83 02 09	04 29 30	33.830	151.760	0	3.0 ML	7
CAN	83 02 25	05 48 40	38.040	146.660	0	3.1 ML	4
CAN	83 03 07	23 26 01.5	34.690	148.880	18	3.9 ML	12
MUN	83 03 13	16 58 17.5	18.000	118.760	37	3.5 ML	3
MUN	83 03 14	03 30 04.2	16.530	128.680	10	3.0 ML	4
QLD	83 03 17	19 07 37.7	18.072	149.441	25	3.2 ML	10
CAN	83 03 19	05 00 07	32.880	149.240	0	4.1 ML	10
MUN	83 03 19	05 06 41.0	38.000	112.040	10	3.7 ML	5
MUN	83 03 21	00 33 16.5	28.670	113.280	10	3.0 ML	2
CAN	83 03 22	13 39 35.3	34.350	150.400	19	3.5 ML	12
PIT	83 03 23	21 14 36.3	37.535	142.239	12	3.1 ML	15
CAN	83 03 24	06 53 35.3	34.770	149.220	13	3.6 ML	13
CAN	83 03 30	06 57 12	37.940	146.460	0	3.2 ML	7
MUN	83 04 05	04 50 40.0	25.300	116.350	10	3.4 ML	5
CAN	83 04 08	10 01 47.5	34.360	146.960	19	3.0 ML	10
BMR	83 04 08	19 33 18.0	29.850	142.010	45	4.5 ML	39
MUN	83 04 09	05 19 35.7	29.290	114.380	37	3.2 ML	3
MUN	83 04 11	05 08 35.0	21.940	126.420	37	3.0 ML	3
CAN	83 04 12	06 56 44.2	34.330	148.890	10	3.0 ML	12
CAN	83 04 14	15 16 36.2	33.460	150.600	29	3.0 ML	10
CAN	83 04 15	06 04 46.5	33.970	147.170	12	3.2 ML	10
MUN	83 04 21	21 18 17.4	18.090	118.970	37	4.3 ML	10
MUN	83 04 24	08 20 58	19.110	116.930	25	3.4 ML	3
MUN	83 04 24	09 18 16.5	26.680	111.220	37	3.1 ML	3
CAN	83 04 26	09 05 45	33.060	146.800	0	3.2 ML	8
CAN	83 04 29	16 51 04.8	32.560	151.390	10	3.6 ML	10
MUN	83 05 04	01 15 33.5	29.590	124.560	10	3.2 ML	5
PIT	83 05 08	12 17 16.6	34.451	143.519	17	3.7 ML	30
CAN	83 05 10	09 23 14	34.650	146.000	0	3.1 MN	6
MUN	83 05 10	22 16 55	18.860	117.970	10	3.0 ML	3
ADE	83 05 17	10 11 51.4	27.886	136.313	31	3.0 MN	11
BMR	83 05 18	00 36 15.1	25.757	137.655	37	4.1 ML	8
CAN	83 05 18	08 42 52.1	33.980	150.650	22	3.5 ML	9
GS	83 05 29	19 38 18.4	12.345	126.594	33	4.7 MB	9
ADE	83 05 31	06 34 52.9	33.579	135.860	11	3.2 MN	9
MUN	83 06 07	06 16 12.5	15.220	123.610	10	4.2 ML	3

TABLE 1 (contd)

DATA SOURCE*	DATE yr mo dy	TIME (UT) hr mn sec	LAT° S	LONG° E	DEPTH (km)	MAGNITUDE	N**
MUN	83 06 07	06 16 12.5	15.220	123.610	10	3.0 ML	3
PIT	83 06 15	00 50 07.6	38.583	140.728	10	3.3 ML	20
CAN	83 06 17	02 59 40.3	32.440	150.920	20	3.5 ML	13
CAN	83 06 17	15 45 28.9	34.600	149.230	15	3.1 ML	13
BMR	83 06 20	17 33 00.3	30.220	141.710	60	4.7 ML	37
MUN	83 06 29	15 24 42.0	18.870	122.650	10	3.5 ML	7
MUN	83 07 06	19 41 12.6	32.650	122.290	10	3.0 ML	4
CAN	83 07 14	17 02 49.7	35.470	150.380	38	3.0 ML	9
MUN	83 07 15	17 04 08.0	25.070	111.810	10	4.0 ML	9
BMR	83 07 29	17 14 21.1	33.010	138.200	22	3.2 ML	8
MUN	83 08 04	02 55 25.3	31.280	118.260	10	3.0 ML	5
MUN	83 08 05	14 11 44	31.520	111.930	10	3.0 ML	6
MUN	83 08 06	02 27 17	26.270	112.520	10	3.6 ML	4
CAN	83 08 06	08 31 38.1	34.550	148.540	16	3.0 ML	10
MUN	83 08 08	22 56 13	18.310	112.630	37	3.4 ML	2
CAN	83 08 12	07 42 22	32.300	147.500	0	3.3 ML	4
MUN	83 08 13	17 20 20.5	26.480	132.420	10	3.0 ML	2
CAN	83 08 14	10 43 34.7	34.770	148.930	0	3.1 ML	13
CAN	83 08 15	07 11 28	38.000	150.000	0	3.4 ML	6
MUN	83 08 15	17 36 46.6	30.760	117.100	10	3.4 ML	4
MUN	83 08 29	07 33 29.5	15.850	121.210	37	3.6 ML	6
MUN	83 08 31	07 21 42.5	20.560	120.180	10	3.8 ML	6
PIT	83 08 31	10 25 44.3	38.522	146.336	17	3.0 ML	33
MUN	83 09 02	18 22 28	23.990	113.030	10	3.7 ML	5
MUN	83 09 04	12 12 59.0	30.870	117.150	10	3.1 ML	6
MUN	83 09 08	18 46 11.3	16.940	126.220	10	3.0 ML	4
MUN	83 09 14	20 51 32.0	11.290	130.320	10	3.0 ML	3
BMR	83 09 18	20 26 24.5	31.990	138.370	3	3.3 ML	9
CAN	83 09 24	07 25 51.9	33.600	150.130	16	3.6 ML	13
MUN	83 09 25	05 16 01.0	21.800	126.270	37	3.3 ML	5
MUN	83 09 26	12 19 33.0	26.920	131.440	10	3.5 ML	4
MUN	83 10 03	07 51 25.0	25.010	112.940	10	3.6 ML	7
MUN	83 10 04	00 12 40.0	24.140	130.250	10	3.5 ML	4
BMR	83 10 05	23 49 30.4	30.360	151.190	0	4.0 ML	11
MUN	83 10 12	19 25 25.0	25.610	130.330	10	3.8 ML	1
PIT	83 10 15	20 50 44.1	39.775	145.027	10	4.4 ML	44
MUN	83 10 17	03 22 34.0	10.920	125.810	37	4.8 ML	3
MUN	83 10 24	00 53 56.0	26.940	114.920	10	4.0 ML	9
MUN	83 10 24	03 54 54.0	26.840	114.920	10	3.2 MB	3
CAN	83 10 28	14 09 56.5	36.810	150.790	17	3.0 ML	7
BMR	83 10 29	15 48 39.2	31.299	138.659	20	3.2 ML	8
MUN	83 10 30	01 09 03.0	16.530	123.774	37	4.2 ML	9
CAN	83 11 01	00 50 09	33.900	150.450	0	3.1 ML	9
MUN	83 11 01	10 46 27.8	18.320	118.340	37	3.3 ML	3
ADE	83 11 11	02 32 07.9	31.480	138.670	16	3.7 ML	18
MUN	83 11 11	18 21 55.0	19.560	116.340	37	3.5 ML	5
QLD	83 11 13	06 42 10.8	21.160	146.853	22	3.0 ML	6
BMR	83 11 21	03 04 37.5	25.749	138.099	0	3.6 ML	5
ISC	83 11 25	19 57 18.0	40.450	155.51	24	5.9 MS	358
BMR	83 11 25	20 44 17	40.161	155.032	5	3.0 ML	9
TAU	83 11 25	22 48 43.7	40.950	154.570		3.5 ML	6

TABLE 1 (contd)

DATA SOURCE*	DATE yr mo dy	TIME (UT) hr mn sec	LAT° S	LONG° E	DEPTH (km)	MAGNITUDE	N**
TAU	83 11 26	02 13 00.1	40.880	154.430		3.6 ML	4
TAU	83 11 26	11 32 22.4	40.700	154.600		3.2 ML	4
TAU	83 11 27	00 35 24.5	40.970	154.580		3.6 ML	8
BMR	83 11 28	13 46 37.6	24.989	136.375	20	3.9 ML	5
CAN	83 11 29	09 49 22.4	34.600	149.240	14	3.1 ML	12
MUN	83 12 01	15 45 05.0	21.960	126.450	10	4.1 ML	10
MUN	83 12 13	23 10 41.0	28.190	114.110	10	3.0 MN	3
MUN	83 12 18	15 10 31.0	16.850	120.070	37	3.8 ML	6
BMR	83 12 19	06 18 10.6	34.696	148.669	9	3.8 ML	17
MUN	83 12 25	03 06 02.0	33.480	120.090	10	3.0 ML	5
ADE	83 12 29	17 42 01.2	30.794	138.405	20	5.0 ML	39

* Codes denote contributors listed in the text, on page iii.
** Number of stations used to determine hypocentre.

TABLE 2. AUSTRALIAN SEISMOGRAPH STATIONS, 1983

CODE	NAME	LAT° S	LONG° E	ELEV. (m)	OP.*	TYPE**
QUEENSLAND						
AWMQ	MT GOLEGUMMA	24.0462	151.3157	125	GSQ	1
BDMQ	BOONDOOMA DAM	26.1120	151.4443	320	GSQ	1
BFCQ	GLENDON CROSSING	20.6140	147.1609	160	GSQ	1
BFRQ	GLENROY	20.5492	147.1052	160	GSQ	1
BMGQ	MT GRAHAM	20.6142	147.0608	160	GSQ	1
BRS	BRISBANE	27.3917	152.7750	525	QLD	5
CTAO	CHARTERS TOWERS	20.0883	146.2550	357	QLD	3
ISQ	MOUNT ISA	20.7150	139.5533	500	BMR	1
QNN	WIVENHOE DAM	27.3507	152.5404	120	QLD	3
WMBQ	MT BRISBANE	27.1155	152.5502	160	GSQ	1
WPLQ	PLAINLAND	27.6058	152.4168	160	GSQ	1
WPMQ	PINE MOUNTAIN	27.5357	152.7355	35	GSQ	1
WTGQ	TOOGOOLAWAH	27.1458	152.3333	130	GSQ	1
NORTHERN TERRITORY						
ASPA	ALICE SPRINGS	23.6669	133.9014	600	BMR	3
MTN	MANTON	12.8467	131.1300	80	BMR	1
WB2	WARRAMUNGA ARRAY	19.9444	134.3525	366	CAN	3
WESTERN AUSTRALIA						
BAL	BALLIDU	30.6065	116.7072	300	MUN	1
KLB	KELLERBERRIN	31.5778	117.7600	300	MUN	1
KLG	KALGOORLIE	30.7833	121.4583	360	MUN	1
KNA	KUNUNURRA	15.7500	128.7667	150	PWD/MUN	1
MBL	MARBLE BAR	21.1600	119.8333	200	MUN	1
MEK	MEEKATHARRA	26.6133	118.5450	520	MUN	1
MUN	MUNDARING	31.9783	116.2083	253	MUN	2
NAU	NANUTARRA	22.5442	115.5000	80	MUN	1
NWAO	NARROGIN	32.9267	117.2333	265	MUN	4
WBN	WARBURTON	26.1400	126.5780	457	MUN	1
RKG	ROCKY GULLY	34.5698	117.0103	300	MUN	1
NEW SOUTH WALES AND AUSTRALIAN CAPITAL TERRITORY						
AVO	AVON	34.3764	150.6150	532	CAN	1
BWA	BOOROWA	34.4250	148.7513	656	CAN	1
CAH	CASTLE HILL	34.6467	149.2417	700	CAN	1
CAN	CANBERRA (ANU)	35.3208	148.9986	650	CAN	1
CBR	CABRAMURRA	35.9433	148.3928	1537	CAN	1
CMS	COBAR	31.4867	145.8283	225	BMR	1
CNB	CANBERRA (BMR)	35.3137	149.3620	855	BMR	1
COO	COONEY	30.5783	151.8917	650	BMR	1
IVN#	INVERALOCHY	34.9650	149.6667	650	CAN	1
IVY#	INVERALOCHY	34.9722	149.7183	770	CAN	1
JNL	JENOLAN	33.8258	150.0172	829	CAN	1
KHA	KHANCOBAN	36.2136	148.1288	435	CAN	1
LER	LERIDA	34.9344	149.3642	940	CAN	1
MEG	MEANGORA	35.1007	150.0367	712	CAN	1
RIV	RIVERVIEW	33.8293	151.1585	21	RIV	2
SBR	SOUTH BLACK RANGE	35.4250	149.5333	1265	CAN	1
STK	STEPHENS CREEK	31.8817	141.5917	213	BMR	1
TAO	TALBINGO	35.5958	148.2900	570	CAN	1

TABLE 2 (contd)

WAM	WAMBROOK	36.1928	148.8833	1290	CAN	1
WER	WEROMBI	33.9503	150.5803	226	CAN	1
YOU	YOUNG	34.2783	148.3817	503	CAN	1
SOUTH AUSTRALIA						
ADE	ADELAIDE	34.9670	138.7136	655	ADE	2
CLV	CLEVE	33.6911	136.4955	238	ADE	1
EDO	ENDILLOE	32.3216	138.0483	300	ADE	1
HTT	HALLETT	33.4305	138.9217	708	ADE	1
HWK	HAWKSNEST	29.9578	135.2035	180	ADE	1
MGR	MT GAMBIER	37.7283	140.5710	190	ADE	1
NBK	NECTAR BROOK	32.7010	137.9830	180	ADE	1
PNA	PARTACOONA	32.0057	138.1647	180	ADE	1
RPA	ROOPENA	32.7250	137.4033	95	ADE	1
UMB	UMBERATANA	30.2400	139.1280	610	ADE	1
WKA	WILLALOOKA	36.4170	140.3210	40	ADE	1
WRG	WOOMERA	31.1046	136.7634	168	ADE	1
VICTORIA						
ABE	ABERFELDY	37.7194	146.3890	549	PIT	1
BFD	BELLFIELD	37.1767	142.5450	235	BMR	1
DRT	DARTMOUTH	36.5900	147.4928	950	CAN	1
BUC	BUCRABANYULE	36.2384	143.4982	210	PIT	1
GVL	GREENVALE	37.6186	144.9006	188	PIT	1
HOP	MOUNT HOPE	35.97	144.21	180	PIT	1
JEN	JEERALANG JUNCTION	38.3507	146.4198	330	PIT	1
KGD	KANGAROO GROUND	37.6988	145.2694	80	PIT	1
LIL	LILYDALE	37.6936	145.3424	80	PIT	1
MAL	MARSHALL SPUR	37.7491	146.2919	1076	PIT	1
MEM	MERRIMU	37.637	144.497	160	PIT	1
MIC	MOUNT ERICA	37.9443	146.3590	805	PIT	1
PAT	PLANE TRACK	37.8573	146.4556	771	PIT	1
PEG	PEGLEG	36.9848	144.0912	340	PIT	1
PNH	PANTON HILL	37.6346	145.2709	180	PIT	1
RUS	RUSHWORTH	36.6624	144.9468	145	PIT	1
TOM	THOMSON	37.8100	146.3480	941	PIT	1
TOO	TOOLANGI	37.5717	145.4900	604	BMR	1
TASMANIA						
MOO	MOORLANDS	42.4417	146.1903	325	TAU	1
SAV	SAVANNAH	41.7208	147.1889	180	TAU	1
SFF	SHEFFIELD	41.3375	146.3075	213	TAU	1
SPK	SCOTTS PEAK	43.0383	146.2750	425	TAU	1
STG	STRATHGORDON	42.7508	146.0533	350	TAU	1
SVR	SAVAGE RIVER	41.4888	145.2108	360	TAU	1
TAU	TASMANIA UNIV.	42.9097	147.3206	132	TAU	2
TRR	TARRALEAH	42.3042	146.4500	579	TAU	1

IVN until June 1983, IVY from June 1983

* Operator; see page iii.

** Type of seismograph

1. Short period (vertical and/or horizontal)
2. World-wide Standard Seismograph
3. Array
4. Seismological Research Observatory
5. Long and short period seismographs

TABLE 3. FOCAL MECHANISMS OF 1983 TASMAN SEA EARTHQUAKE

Solution	Denham(1985)		USGS*		Harvard*		Fredrich et al(1987)	
	azimuth	dip	azimuth	dip	azimith	dip	azimuth	dip
P-axis	319	3	118	6	334	15	155	2
T-axis	208	82	215	50	185	73	254	79
B-axis	49	7	23	39	66	8	166	46
Double couples	A	B	A	B	A	B	A	B
Strike	236	41	243	357	52	251	54	256
Dip	48	41	52	62	31	60	48	44
Slip	100	79	144	44	74	100	75	106
Seismic moment (Nm x 10^{18})	1.1		2.3		1.1		1.3	

* Data taken from EDR No. 11-83 (USGS, 1984).

TABLE 4. FOCAL MECHANISM OF THE 1983 BELTANA EARTHQUAKE

	Azimuth	dip
P-axis	97	1
T-axis	190	10
B-axis	11	85
Double couples	A	B
Strike	324	233
Dip	84	82
Slip	8	174

TABLE 5. ACCELEROGRAPH LOCATIONS, 1983

	LAT° S	LONG° E	ELEV.(m)	FOUNDATION	INS.*	OPE.**
New South Wales						
Oolong	34.773	149.163	600	Firm soil/ granite	SMA1	BMR
Yass	34.830	149.043	300		SMA1	BMR
Hume Weir	36.110	147.043	600	Dam wall	SMA1	WRC
Hume Weir	36.110	147.043	600	Dam wall	SMA1	WRC
Hume Weir	36.110	147.043	600	Dam wall	SMA1	WRC
South Australia						
Kangaroo Ck Dam	34.87	138.78	244	Slates/schists	MO2	EWSSA
Little Para Dam	34.75	138.72	102	Dolomite		EWSSA
Modbury Hospital	34.83	138.70		Marl & clay	MO2	PWDSA
Admin. Centre	34.925	138.608		Alluvium	MO2	PWDSA
Tasmania						
Gordon Dam	42.71	145.97		Quartzite	MO2	HEC
Western Australia						
Meckering						
Kelly's (ME-K)	31.694	116.982	200	Alluvium/	MO2 granite	BMR
Morrell's (ME-M)	31.659	117.089	220	Alluvium/	MO2 granite	BMR
Cadoux (CA-K)	30.696	117.161	300	Granite	MO2	BMR
Mundaring Weir (MU-W)	31.967	116.169	250	Concrete wall	SMA1	PWDWA
Ord River Dam wall (KU-W)	16.113	128.738	120	Rockfill	MO2	PWDWA
Perth						
Telecom) (PT-B)	31.953	115.850	10	Basement	SMA1	TEL
Exchange) (PT-M)	31.953	115.850	40	Middle floor	SMA1	TEL
Building) (PT-T)	31.953	115.850	70	Top floor	SMA1	TEL
Victoria						
Jeeralong (JNA)	38.351	146.419	330		PIT	PIT
Plane Track (PTA)	37.357	146.357	771		PIT	PIT

INS.* = Instrument

OPE.** = Accelerograph operators

BMR = Bureau of Mineral Resources, Canberra or Mundaring

EWSSA = Enginering & Water Supply Department, South Australia

HEC = Hydroelectric Commission, Tasmania

PIT = Phillip Institute of Technology

PWDSA = Public Works Department, South Australia

PWDWA = Public Works Department, Western Australia

TEL = Telecom (Perth)

WRC = Water Resources Commission, NSW

TABLE 6. ACCELEROGRAM DATA, 1983

YR MN DY	UT	LAT° S	LONG° E	ML	LOC	H/E	COM	T(S)	ACC	R	DUR
83 04 26	0713	31.69	117.03	2.2	ME-M	7/6	SZ	0.015	28		
							N	0.015	118	13.5	9.0
							E	0.015	60		
83 07 01	1718	31.59	116.95	2.0	ME-M	17/16	SZ	0.018	49		
							N	0.021	255	344	8.0
							E	0.021	225		
83 08 23	0200	37.83	146.38	1.5	PTA	7.2/7.2	PZ	0.07	2.3		
							N	0.07	1.3	3.4	
							E	0.07	2.2		
							SZ	0.08	2.0		
							N	0.07	2.8	4.1	
							E	0.10	2.2		
83 08 31	1025	38.52	146.34	3.0	PTA	76/74	PZ	0.08	1.2		
							N	0.10	1.3	2.1	
							E	0.10	1.1		
							SZ	0.08	2.8		
							N	0.11	3.7	6.1	
							E	0.11	3.9		
83 09 19	0120	37.84	146.37	1.5	PTA	7.9/7.9	PZ	0.04	4.0		
							N	0.04	2.9	6.4	
							E	0.04	4.0		
83 10 15	2050	39.78	145.03	4.4	JNA	198/197	SZ	0.25	1.8		
							N	0.25	2.1	3.5	
							E	0.29	2.1		
83 10 15	2050	39.78	145.03	4.4	PTA	245/245	E	0.25	2.6		
83 10 16	2150	37.69	146.36	2.1	PTA	25/20	PZ	0.08	2.3		
							N	0.08	1.8	3.9	
							E	0.06	2.4		
							SZ	0.07	2.0		
							N	0.07	2.5	4.1	
							E	0.07	2.5		
83 11 14	1324	37.79	146.36	1.5	PTA	16/11	PZ	0.04	0.7		
							N	0.03	0.8	1.2	
							E	0.03	0.6		
							SZ	0.05	1.5		
							N	0.05	2.1	3.7	
							E	0.05	2.7		
83 11 14	1334	37.78	146.37	1.5	PTA	16/11	PZ	0.03	0.8		
							N	0.03	0.8	1.4	
							E	0.03	0.8		
							SZ	0.03	1.8		
							N	0.04	2.2	3.7	
							E	0.05	2.4		

TABLE 6 (contd)

YR MN DY	UT	LAT° S	LONG° E	ML	LOC	H/E	COM	T(S)	ACC	R	DUR
83 11 14	1355	37.79	146.37	1.4	PTA	17/11	PZ	0.03	0.1		
							N	0.03	0.5	0.9	
							E	0.03	0.4		
							SZ	0.04	1.7		
							N	0.04	1.5	2.7	
							E	0.04	1.4		
83 11 25	1956	40.29	155.57	5.8	PTA	833/833	PZ	0.08	1.6		
							N	0.13	1.5	2.9	
							E	0.17	1.9		
							SZ	0.17	2.8		
							N	0.14	3.2	6.7	
							E	0.17	5.2		

KEY

YR = year
MN = month
DY = day
UT = universal time
LAT = latitude (degrees south)
LONG = longitude (degrees east)
ML = Richter magnitude
LOC = accelerograph location
H/E = hypocentral distance/epicentral distance in kilometres
COM = component
T(S) = ground period in seconds
ACC = peak ground acceleration in millimetres per second squared
R = resultant acceleration in millimetres per second squared
DUR = duration in seconds while ground acceleration remained above 0.5 centimetres per second squared

TABLE 7. PRINCIPAL WORLD EARTHQUAKES, 1983

(Earthquakes of magnitude 7.0 or greater, or causing damage or fatalities.
PAS--Pasadena, BRK--Berkeley, PMR--Palmer, Alaska, PAL--Palisades, New York,
JMA--Japan Meteorological Agency)*

Date	Origin time(UT)	Region	Lat.	Long.	Magnitude
Jan 17	12 41 29.7	Greece	38.03 N	20.23 E	6.1 mb 7.0 MS 7.2 MS(BRK) 7.1 MS(PAS)
Depth 9 km. Minor damage on Kefallinia, Levkas, and Zakinthos, and at Preveza and Killini. Felt in Albania, Italy, and southern Yugoslavia.					
Jan 24	08 17 39.6	Oaxaca, Mexico	16.15 N	95.23 W	6.3 mb 7.0 MS(BRK) 6.5 MS(PAS)
Depth 31 km. Damage in the Juchitan area and slight damage in the Mexico City area. Felt strongly in southeastern Mexico.					
Feb 25	18 22 12.9	Yugoslavia	41.96 N	21.54 E	4.7 mb
Depth 24 km. Twelve people died from heart attacks in the Skopje area. Slight damage near Dolno Kolicani. Felt (VI) at Skopje.					
Mar 15	17 27 26.3	Near south coast of Honshu, Japan	34.77 N	137.57 E	5.3 mb 4.8 MS
Depth 57 km. One person killed, two injured, and slight damage (IV JMA) in the Nagoya area. Felt (III JMA) in the Kyoto-Shizuoka area. Also felt (I JMA) in the Tokyo-Toyooka-Owase area.					
Mar 18	09 05 50.0	New Ireland region	4.88 S	153.58 E	5.6 mb 7.6 MS 7.9 MS(BRK)
Depth 88 km. Damage (VII) along the southeast coast of New Ireland. Landslides and ground cracks occurred, trees were uprooted, and steam was ejected from fumaroles in the Feni Islands. Slight damage (VI) and minor landslides in the Rabaul area, New Britain. Felt on Bougainville and (III) at Port Moresby, Papua New Guinea. Felt strongly by two ships at sea in the epicentral area. Twenty-five cm tsunami recorded at Rabaul. Minor tsunami observed in the Feni Islands and along the southeast coast of New Ireland.					
Mar 23	23 51 06.5	Greece	38.29 N	20.26 E	5.8 mb 6.2 MS
Depth 19 km. Seven people injured and 160 homes damaged in the Vonitsa area. Felt strongly along the west coast of Greece. Felt on Kefallinia, Levkas, and Zakinthos.					
Mar 25	11 57 49.3	Iran	35.95 N	52.26 E	5.2 mb 4.9 MS
Depth 33 km. Thirty people killed, 61 injured, many homes damaged, and landslides in the Damavand-Amol area. Felt at Teheran.					
Mar 31	13 12 53.6	Colombia	2.43 N	76.63 W	5.5 mb
Depth 10 km. At least 250 people killed, many injured, and extensive damage in the Popayan area.					
Apr 03	02 50 01.1	Costa Rica	8.72 N	83.12 W	6.5 mb 7.3 MS 7.2 MS(BRK)
Depth 37 km. Five people died from heart attacks, one person killed by a collapsing house, and several people injured in southeastern Costa Rica. Also felt strongly in southwestern Panama.					

* Based on 'Earthquake Data Reports' published by the US Geological Survey, and on the SEAN Bulletin of the Smithsonian Institution.

Date	Origin time(UT)	Region	Lat.	Long.	Magnitude
May 02	23 42 37.7	Central California	36.22 N	120.32 W	6.2 mb 6.5 MS 6.7 ML(BRK) 6.3 ML(PAS)
Depth 10 km. Forty-five people injured, 13 of them seriously in the Coalinga area. Damage estimated at US$31 million the worst damage occurring in the downtown area of Coalinga, maximum intensity VIII. More than 500 homes were severely damaged in the Coalinga area, also some damage at Avenal and other surrounding communities. Felt from Los Angeles to Sacramento and from San Francisco to Reno.					
May 26	02 59 59.6	Near west coast of Honshu, Japan	40.46 N	139.10 E	6.8 mb 7.7 MS 7.7 MS(BRK) 7.8 MS(PAL) 7.7 MS(PAS)
Depth 24 km. At least 104 people killed, some injured, and extensive damage to dwellings, roads, and vessels caused by earthquake and a tsunami along the Japan Sea coast from southern Hokkaido to the Niigata area, Honshu. Many of the casualties and much of the damage occurred on the Oga Peninsula. Tsunami damage occurred as far away as Yamaguchi Prefecture in southwestern Honshu, along the Japan Sea coast of USSR, and along the eastern and southern coasts of South Korea, where 3 additional people were killed. Felt (V JMA) at Akita. Felt on Hokkaido and throughout northern and central Honshu. Estimated tsunami heights were 14 m at Minehama, Honshu, 2-6 m along southern Hokkaido and northern Honshu, up to 8 m along the coast of USSR, and 4 m along the coast of South Korea.					
Jun 21	06 25 27.3	Hokkaido, Japan region	41.35 N	139.10 E	6.7 mb 6.9 MS 6.5 MS(BRK) 6.9 MS(PAS)
Depth 33 km. Some damage on northern Honshu. Felt (IV JMA) at Esachi, (III JMA) at Hakodate, and (I JMA) at Sapporo, Hokkaido. Felt (IV JMA) at Aomori and (III JMA) at Akita, northern Honshu. Felt widely on southern Hokkaido and northern Honshu, 1 m tsunami at Akita, Noshiro, and Wakami; 40 cm tsunami at Aomori and Fukura, northern Honshu. Fifty cm tsunami reported in many areas along the west coast of northern Honshu.					
Jul 03	17 14 23.1	Costa Rica	9.65 N	83.69 W	5.9 mb 6.2 MS 6.7 MS(BRK) 6.1 MS(PAS)
Depth 33 km. Two people killed, approximately 60 injured. Considerable damage to buildings. Landslides blocked and some roads damaged.					
Jul 05	12 01 27.3	Turkey	41.32 N	27.22 E	5.7 mb 6.1 MS 5.9 ML(ATH)
Depth 10 km. Five people killed, 25 injured, and damage in the Biga area. One person injured at Erdek, and slight damage in the Istanbul area. Felt also in eastern Greece.					

TABLE 7 (contd)

Date	Origin time(UT)	Region	Lat.	Long.	Magnitude
Jul 11	12 56 28.3	South Shetland Islands	60.89 S	53.02 W	6.1 mb 6.9 MS 7.0 MS(BRK) 6.7 MS(PAS)
Depth 10 km.					
Jul 20	22 03 29.2	Sicily	37.50 N	15.15 E	4.4 mb
Depth 33 km. One person died from heart attack and 20 people slightly injured in the Catania area.					
Jul 22	02 41 00.8	Western Iran	36.95 N	49.18 E	5.6 mb 5.0 MS
Depth 41 km. Three people killed, 41 injured, and 75 homes destroyed in the Zanjan area.					
Aug 02	09 01 05.5	France	49.15 N	6.70 E	3.5 ML(GRF)
Depth 0 km. One person killed and one person injured in a mine collapse.					
Aug 06	15 43 51.2	Aegean Sea	40.14 N	24.77 E	6.2 mb 7.0 MS 7.3 MS(BRK) 7.2 MS(PAS)
Depth 2 km. Slight damage on Limnos and to four monasteries in the Mount Athos area. Felt strongly in northern Greece, southern Bulgaria and northwestern Turkey.					
Aug 08	03 47 57.1	Near south coast of Honshu, Japan	35.50 N	130.07 E	5.9 mb 5.3 MS
Depth 25 km. One person killed, 28 injured, several houses damaged, and landslides in Kanagawa, Tokyo, Saitama, Shizouka, and Yamanashi Prefectures. A highway was cracked near Ogawa; felt (IV JMA) at Kofu, Mishima, Tokyo, and Yokohama. Felt (I JMA) from Osaka to Morioka and on Hachijo-jima.					
Aug 17	10 55 54.1	Near east coast of Kamchatka	55.88 N	161.29 E	6.6 mb 6.5 MS(BRK) 7.0 mb(PAS)
Depth 63 km.					
Aug 17	12 17 56.0	Luzon, Philippine Islands	18.23 N	120.86 E	6.2 mb 6.5 MS
Depth 29 km. Sixteen people killed, 47 injured and extensive damage in the Pasuquin-Laoag-Batac and Serrat areas. Sandblows, liquefaction, cracks on some highways, and many landslides occurred in the area. Felt (MM III) at Manila. Unconfirmed reports of a small tsunami along the coast of Ilocos Norte Province.					
Oct 04	18 52 14.9	Near coast of northern Chile	26.58 S	70.75 W	6.8 mb 7.3 MS 7.4 MS(PAL)
Depth 31 km. At least five people killed, some injured, and extensive damage in the Copiapo area. Felt strongly in much of northern Chile from Santiago to Arica in the north. Felt in parts of Argentina, Bolivia, and Brazil. Local tsunami reported at Valparaiso.					
Oct 28	14 06 06.3	Eastern Idaho	44.05 N	113.89 W	6.2 mb 7.3 MS 7.0 MS(PAL)
Depth 10 km. Two people killed, two injured, and considerable damage at Challis. One person injured and extensive damage at Mackay. Total damage estimated at US$2.5 million. Fault scarp extending for more than 35 km with vertical displacement up to 2.5m observed between Mackay and Challis. Felt in Idaho, Washington, Montana, Oregon, Nevada, Wyoming, Utah, and parts of Canada.					

TABLE 7 (contd)

Date	Origin Time(UT)	Region	Lat.	Long.	Magnitude
Oct 30	04 12 28.8	Turkey	40.18 N	42.29 E	6.1 mb 6.9 MS 6.9 MS(BRK)
Depth 33 km. At least 1342 people killed, many injured, 534 seriously injured, more than 25 000 people homeless, 50 villages completely destroyed in the provinces of Erzurum and Kars.					
Nov 06	21 09 43.9	Eastern China	35.23 N	115.21 E	5.7 mb 5.3 MS
Depth 33 km. Thirty-four people killed, about 2200 injured, about 3300 houses destroyed in the Heze-Dongming area of Shandong Province. Also felt in parts of Hebei and Henan Provinces.					
Nov 08	00 49 32.0	Belgium	50.72 N	5.35 E	4.7 mb
Depth 10 km. One person killed, one additional person died of a heart attack, 26 people injured, and hundreds of buildings damaged in the Liege area. Felt (V) in the southern Netherlands. Also felt in Luxembourg and West Germany.					
Nov 16	16 13 00.0	Hawaii	19.43 N	155.45 W	6.3 mb 6.6 MS
Depth 11 km. Six people injured and considerable damage (VII) at Volcano and Hilo. Slight damage (VI) at Honomu, Keaau, Naalehu, and Paauilo. Landslides blocked roads and knocked out phone communications. Total damage from the earthquake in excess of six million dollars. Also felt on islands of Maui and Oahu.					
Nov 24	05 30 34.9	Banda Sea	7.55 S	128.25 E	6.2 mb 7.1 mb(BRK)
Depth 187 km. Felt on Alor, Flores, Sumba, and Timor. Also felt in Australia from Darwin to Perth. See the isoseismal map in this Report.					
Nov 30	17 46 00.4	Chagos Archipelago region	6.88 S	72.12 E	6.6 mb 7.5 MS 7.7 MS(BRK)
Depth 10 km. Some damage (VI) to buildings and piers on Diego Garcia. Five foot rise in wave height in the lagoon and significant wave damage near the southeastern tip of the island. 40 cm tsunami at Victoria, Seychelles. Large zone of discolored sea water observed 35 to 40 nautical miles north-northwest of Diego Garcia.					
Dec 02	03 09 05.6	Guatemala	14.05 N	91.94 W	5.9 mb 7.1 MS(BRK) 6.7 MS(PAL)
Depth 65 km. Felt (VI) in southwestern Guatemala and (V) at Guatemala City. Also felt in El Salvador and Chiapas, Mexico.					
Dec 22	04 11 29.3	Northwest Africa	11.95 N	13.61 W	6.4 mb 6.2 MS
Depth 10 km. At least 443 people killed, 200 missing, 150 seriously injured, and extensive damage in the Gaoual-Koumbia area, Guinea. Felt in Guinea Bissau, Senegal, the Gambia, and Sierra Leone.					
Dec 30	23 52 40.5	Hindu Kush region	36.32 N	70.74 E	6.7 mb 7.2 mb(BRK)
Depth 222 km. Twelve people killed, 483 injured, and extensive damage in the Kabul-Samangan, Afghanistan areas. Twelve people killed, hundreds injured, and moderate damage in the Peshawar, Pakistan area. Some damage (VII) in Tajikistan, USSR. Felt in much of northwestern Afghanistan, northern Pakistan, northern India, and in Tajikistan, Uzbekistan, and Kirghizia, USSR.					

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APPENDIX

MODIFIED MERCALLI (MM) SCALE OF EARTHQUAKE INTENSITY

(after Eiby, 1966)

MM I — Not felt by humans, except in especially favourable circumstances, but birds and animals may be disturbed. Reported mainly from the upper floors of buildings more than ten storeys high. Dizziness or nausea may be experienced. Branches of trees, chandeliers, doors, and other suspended systems of long natural period may be seen to move slowly. Water in ponds, lakes, reservoirs, etc., may be set into seiche oscillation.

MM II — Felt by a few persons at rest indoors, especially by those on upper floors or otherwise favourable placed. The long-period effects listed under MM I may be more noticeable.

MM III — Felt indoors, but not identified as an earthquake by everyone. Vibrations may be likened to the passing of light traffic. It may be possible to estimate the duration, but not the direction. Hanging objects may swing slightly. Standing motorcars may rock slightly.

MM IV — Generally noticed indoors, but not outside. Very light sleepers may be awakened. Vibration may be likened to the passing of heavy traffic, or to the jolt of a heavy object falling or striking the building. Walls and frame of building are heard to creak. Doors and windows rattle. Glassware and crockery rattle. Liquids in open vessels may be slightly disturbed. Standing motorcars may rock, and the shock can be felt by their occupants.

MM V — Generally felt outside, and by almost everyone indoors. Most sleepers awakened. A few people frightened. Direction of motion can be estimated. Small unstable objects are displaced or upset. Some glassware and crockery may be broken. Some windows crack. A few earthenware toilet fixtures crack. Hanging pictures move. Doors and shutters swing. Pendulum clocks stop, start, or change rate.

MM VI — Felt by all. People and animals alarmed. Many run outside. Difficulty experienced in walking steadily. Slight damage to masonry D. Some plaster cracks or falls. Isolated cases of chimney damage. Windows and crockery broken. Objects fall from shelves, and pictures from walls. Heavy furniture moves. Unstable furniture overturns. Small and school bells ring. Trees and bushes shake, or are heard to rustle. Material may be dislodged from existing slips, talus slopes, or slides.

MM VII — General alarm. Difficulty experienced in standing. Noticed by drivers of motor-cars. Trees and bushes strongly shaken. Large bells ring. Masonry D cracked and damaged. A few instances of damage to Masonry C. Loose brickwork and tiles dislodged. Unbraced parapets and architectural ornaments may fall. Stone walls crack. Weak chimneys break, usually at the roof-line. Domestic water tanks burst. Concrete irrigation ditches damaged. Waves seen on ponds and lakes. Water made turbid by stirred-up mud. Small slips, and caving-in of sand and gravel banks.

MM VIII — Alarm may approach panic. Steering of motor-cars affected. Masonry C damaged, with partial collapse. Masonry B damaged in some cases. Masonry A undamaged. Chimneys, factory stacks, monuments, towers, and elevated tanks twisted or brought down. Panel walls thrown out of frame structures. Some brick veneers damaged. Decayed wooden piles break. Frame houses not secured to the foundation may move. Cracks appear on steep slopes and in wet ground. Landslips in roadside cuttings and unsupported excavations. Some tree branches may be broken off.

MM IX — General panic. Masonry D destroyed. Masonry C heavily damaged, sometimes collapsing completely. Masonry B seriously damaged. Frame structures racked and distorted. Damage to foundations general. Frame houses not secured to the foundations shift off. Brick veneers fall and expose frames. Cracking of the ground conspicuous. Minor damage to paths and roadways. Sand and mud ejected in alluviated areas, with the formation of earthquake fountains and sand craters. Underground pipes broken. Serious damage to reservoirs.

MM X Most masonry structures destroyed, together with their foundations. Some well-built wooden buildings and bridges seriously damaged. Dams, dykes, and embankments seriously damaged. Railway lines slightly bent. Cement and asphalt roads and pavements badly cracked or thrown into waves. Large landslides on river banks and steep coasts. Sand and mud on beaches and flat land moved horizontally. Large and spectacular sand and mud fountains. Water from rivers, lakes, and canals thrown up on the banks.

MM XI Wooden frame structures destroyed. Great damage to railway lines. Great damage to underground pipes.

MM XII Damage virtually total. Practically all works of construction destroyed or greatly damaged. Large rock masses displaced. Lines of sight and level distorted. Visible wave-motion of the ground surface reported. Objects thrown upwards into the air.

Categories of non-wooden construction

Masonry A Structures designed to resist lateral forces of about 0.1 g, such as those satisfying the New Zealand Model Building By-law, 1955. Typical buildings of this kind are well reinforced by means of steel or ferro-concrete bands, or are wholly of ferro-concrete construction. All mortar is of good quality and the design and workmanship are good. Few buildings erected prior to 1935 can be regarded as Masonry A.

Masonry B Reinforced buildings of good workmanship and with sound mortar, but not designed in detail to resist lateral forces.

Masonry C Buildings of ordinary workmanship, with mortar of average quality. No extreme weakness, such as inadequate bonding of the corners, but neither designed nor reinforced to resist lateral forces.

Masonry D Building with low standards of workmanship, poor mortar, or constructed of weak materials like mud brick and rammed earth. Weak horizontally.

Windows Window breakage depends greatly upon the nature of the frame and its orientation with respect to the earthquake source. Windows cracked at MM V are usually either large display windows, or windows tightly fitted to metal frames.

Chimneys The 'weak chimneys' listed under MM VII are unreinforced domestic chimneys of brick, concrete block, or poured concrete.

Water tanks The 'domestic water tanks' listed under MM VII are of the cylindrical corrugated-iron type common in New Zealand rural areas. If these are only partly full, movement of the water may burst soldered and riveted seams. Hot-water cylinders constrained only by supply and delivery pipes may move sufficiently to break pipes at about the same intensity.

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