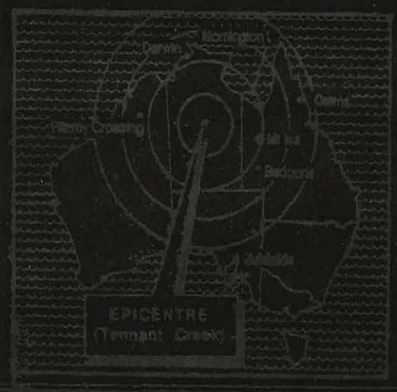
Atlas of isoseismal maps of Australian earthquakes

Part 3

compiled by Kevin McCue

AGSO
AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

North Qld quake sends seismic



From Page One

NORTH Queensland towns reported a calm night as centres across the state from Mount Isa to Cairns felt aftershocks from Friday's quakes at Tennant Creek.

Cairns was shaken around 10.10 p.m. Friday but no serious damage was reported and electricity supplies were not disrupted.

Guests at the month-old Cairns Hilton International Hotel felt the shock, with curtains and hanging plants swaying considerably.

Mount Isa suffered only slight damage in the tremor, also felt in Julia Creek, 200 km to the east.

Dr Chapman, head of the department that records earthquakes for the world seismic network, said yesterday's quake sent the Brisbane station's recording needle "right off the scale".

He said earthquakes were recorded by the Richter scale and the Modified Mercalli Scale (MMS).

NORTHE... DAILY LEADER, MONDAY, DECEMBER 21, 1925.

EARTHQUAKE SCARE

SYDNEY SHAKEN

GROUND STIRS AND HOUSES ROCK

PANIC AT NEWCASTLE

...E SUN

...SYDNEY FRIDAY, MARCH 11, 1949. (Tele. Editorial [illegible]) Price 2d.
...D. Sydney, for transmission by post as a newspaper. [illegible] Advertising [illegible] Circulation

...EMOR ROCKS ...ANY TOWNS

...e recorded at the Riverview Observatory.

...n flee from ...in panic

...big area of NSW were rocked ...by the most violent earth

NEW ZEALANDER KNEW. Mrs. H. A. Palmer, of Macquarie Street, city, who has experienced many tremors in New Zealand, felt today's tremor while in bed. "It was a definite tremor; I should know," she said.

...ousands wake in

...argest earth tremors in NSW history ... 40,000 square miles of the State at ...rday, jolting hundreds of thousands of ...in fright.

...or measured 5.5 on the Richter Scale ...e readings of some overseas earth... ...have killed thousands of people.

...Seismologists said yesterday that ...ong the brevity of the tremor and the ...sturdiness of buildings saved Sydney ...from a major disaster.

...At the height of the tremor, walls crack... ...ed in ordinary dwelling houses, and ...hicken smashed to the floor in Petrol and ...Chemist, and thousands of people ran [illegible]

QUA... ROC... STA...

ALL BUT THE KITCHEN SINK . . .

Mrs Margaret Robinson, who lives with her husband on a farm 15 miles from York on the York-Merkering road, had a terrifying experience.

When the quake struck, she was alone in the house preparing lunch.

To keep her feet as the house rocked, she gripped the edge of the kitchen sink and clutched it throughout the shock waves as the house collapsed around her.

When the quake was over, she found she was still supporting herself by the sink with only the roof overhead.

All the outside brick walls of the 25-square house had fallen and all the dividing walls were shattered. The floor was askew because the brick foundations had been dislodged.

Because the outside walls had fallen outwards, Mrs Robinson was unhurt and no furniture was damaged. The power was off, but the telephone still operated.

Her husband, Mr W. H. Robinson, said yesterday that his wife had been greatly shocked but did not need hospital treatment.

During the weekend, their three grandchildren, aged three, six and eight had stayed with them. He had left the house with them shortly before the quake to go to another property. He was driving his utility at the time of the quake and did not notice it.

He and his wife had lived in the house for 45 years. It was a solid building and had been renovated. It was insured, but he did not know whether his insurance covered earthquake damage.

The Robinsons started moving furniture from their wrecked house into the shearers' quarters on the farm yesterday afternoon.

They plan to stay with a married daughter for the time being.

WA was jolted by Australia's worst earthquake - now experts fear that another big one is on the way with fatal results

SYDNEY, Sunday.

...The ...st severe earthqua...e tremor experienced in New... ...for many years occurred just before 9 o'clock on Friday night ... whole of the Sydney area was shaken. The sh... ...tle, where it was severely felt, and on to Muswellbrook, ...remor was only slight. It was also experienced west to Dub... ...e tremor appeared to cease. The Blue Mountains received ...king.

...y and suburbs the shock was preceded by an eerie still... ...just on 10 minutes to 9 o'clock a sharp shock was felt. Houses ...indows rattled, and the ground was distinctly felt to tremble ...parts of the city. Many people rushed out of their houses in ...ricken condition. At Newcastle two severe shocks were felt, ...there was a panic in a picture theatre. The seismologists declare ...ock was thee severest on record.

...tremor Dr Cotton of the University

TREMOR SHAKES COAST

...An earth tremor off the North-West Coast near Wynyard at 6.06½ yesterday morning shook houses and startled people from Gowrie Park to Smithton and south to Queenstown.

No damage was reported to property or communications but dozens of people, in various centres, said that they had been alarmed — to say the least!

The centres which felt the tremor most strongly seemed to have been from Ulverstone to Smithton. It was also distinctly felt at Gowrie Park, Sheffield and Queenstown.

Department of Primary Industries and Energy

AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

AGSO Record 1995/44

Atlas of isoseismal maps of Australian earthquakes

Part 3

Compiled by

Kevin McCue

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The figure on the next page is from a newspaper article in *The Daily Telegraph* of 27 September 1902 reporting a talk by Professor Edgeworth David and is reproduced with permission. The article included the following quote

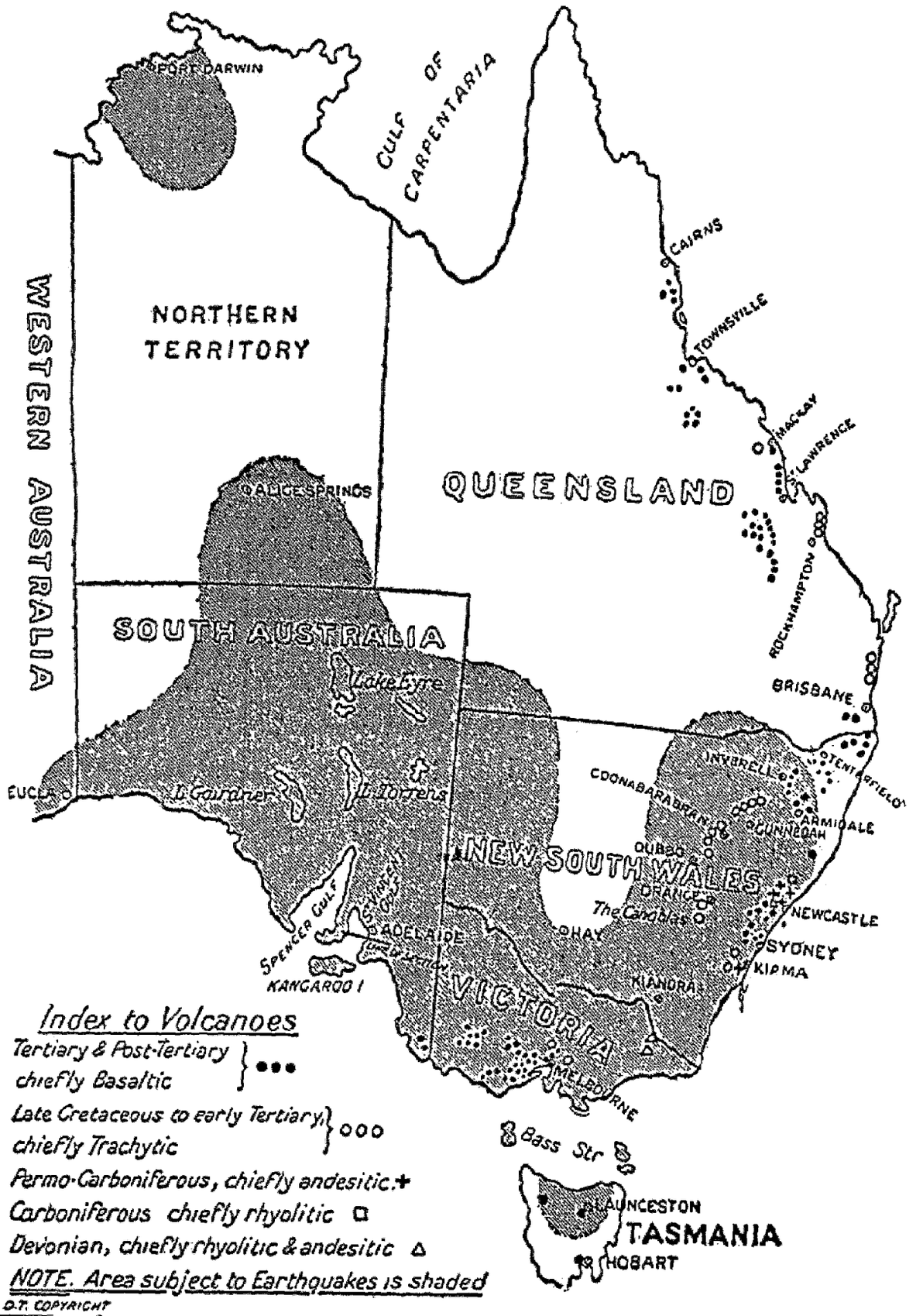
> The chief earthquake areas of Australia, as at present known, are situated on the south-east portion, from Eucla at the head of the Bight, about as far round at least as Newcastle, and northwards inland as far as New England.

This was written a week after Adelaide was shaken by a magnitude 6 earthquake centred in St Vincents Gulf, the so-called 'Warooka' earthquake for which a revised map is printed in this volume.

Contents

EARTHQUAKES AND VOLCANIC ACTION

IN AUSTRALIA AND TASMANIA



Abstract

This is the third volume of the isoseismal atlas compiled by AGSO and contains an additional 119 Australian isoseismal maps of earthquakes that occurred between 1841 and 1990.

The atlas contains at least one map in every decade since the 1840s. A loose leaf binder format was adopted so that additional maps could be inserted at a later time. Isoseismal maps in volume 3 and not in the first two volumes include those for:

- the largest recorded earthquake in continental Australia - offshore WA on 19 November 1906 magnitude Ms 7.2
- the largest known earthquake in Eastern Australia - north east of Tasmania on 12 May 1885 magnitude MI 6.8
- the largest earthquake on Eyre Peninsula South Australia - 16 April 1887 magnitude ML(I) 5.7.
- several small to moderate but important earthquakes in or near the major urban areas of Melbourne, Adelaide and Newcastle and
- three Indonesian earthquakes felt in Northern Australia.

Major earthquakes in the Indonesian Banda Arc shake tall buildings in Adelaide and Perth, some of which have generated tsunamis that sweep Australia's northwest coast which is why they are included in the atlas.

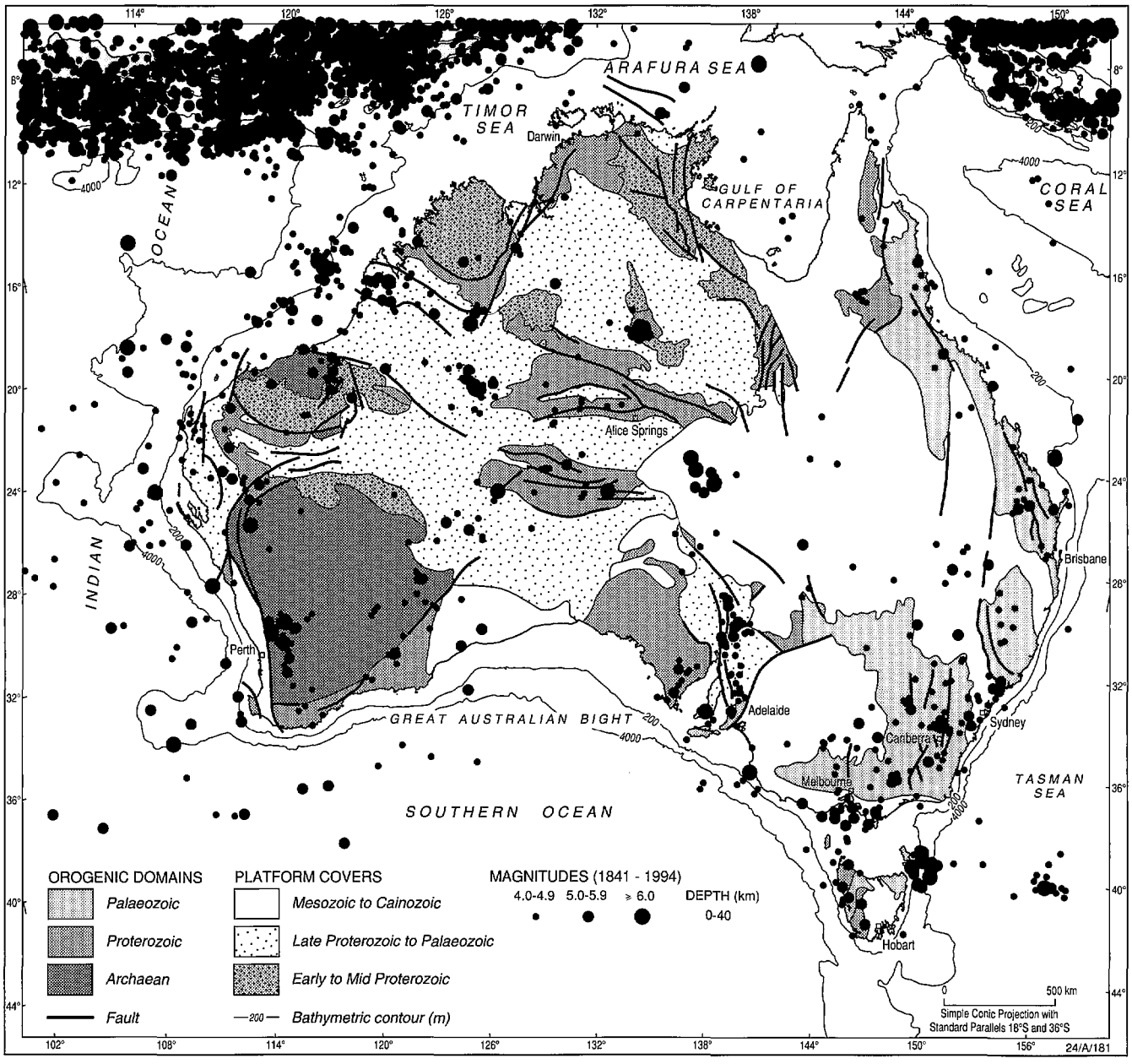


Figure 2 Epicentres of earthquakes in the Australian region 1841 - 1994

Table 1 Hypocentral parameters - Isoseismal Atlas Part 1

No.	Locality	Origin Time (GMT/UTC)			Epicentre		Magnitude			
		y	m d	h m s	Lat°S	Long°E	M(I)	ML	Ms	mB
1	Mount Barker SA	1883	7 07	13 58	35.1	138.7	4.7			
2A	Beachport SA	1897	5 10	05 26	37.33	139.75	6.5			
2B	Beachport SA	1987	5 10	05 26	37.33	139.75	6.5			
3A	Warooka SA	1902	9 19	10 35	35.0	137.4	6.0			
3B	Warooka SA	1902	9 19	10 35	35.0	137.4	6.0			
4	Warrnambool Vic	1903	7 14	10 29	38.43	142.53	5.3			
5A	Bundaberg Qld	1918	6 06	18 14 24	23.5	152.5		6.0	5.8	
5B	Bundaberg Qld	1918	6 06	18 14 24	23.5	152.5		6.0	5.8	
6	Kurrajong NSW	1919	8 15	10 21 21	33.5	150.7		4.6		
7	Murrumbateman NSW	1924	3 06	23 45 00	34.9	149.0	4.0			
8	Mornington Vic	1932	9 02	18 22 32	38.2	145.0		4.5	4.2	
9	Gayndah Qld	1935	4 12	01 32 22	25.5	151.7	5.2		5.4	
10A	Meeberrie WA	1941	4 29	01 35 41	26.8	116.1		7.2	6.8	7.3
10B	Meeberrie WA	1941	4 29	01 35 41	26.8	116.1		7.2	6.8	7.3
11	Marysville Vic	1944	11 02	14 05 43	37.4	145.9	4.0			
12	Maryborough Qld	1947	6 11	10 03 13	25.5	152.7	4.0			
13	Robe SA	1948	8 06	03 29 23	37.36	139.68	5.6		5.4	
14A	Dalton-Gunning NSW	1949	3 10	22 30 33	34.74	149.20		5.5	4.6	
14B	Dalton-Gunning NSW	1949	3 10	22 30 33	34.74	149.20		5.5	4.6	
15	Mackay Qld	1950	4 05	19 50 52	21.1	149.2	4.4			
16	Atherton Qld	1950	6 19	09 00 00	17.5	145.5	4.0			
17	Bolgart WA	1952	3 11	06 09	31.3	116.5	5.1			
18	Gunning NSW	1952	11 19	01 59 16	34.8	149.25		4.9	3.6	
19A	Adelaide SA	1954	2 28	18 09 52	34.93	138.69	5.4		4.9	
19B	Adelaide SA	1954	2 28	18 09 52	34.93	138.69	5.4		4.9	
20	Mourilyan Qld	1954	5 04	07 05 00	17.7	146.0	4.4			
21	Gabalong WA	1955	8 30	13 52	30.7	116.4	5.8			
22	Queenstown Tas	1958	1 01	00 07 00	42.2	146.1		5.3		
23	Rock Flat NSW	1958	9 01	11 19 32	36.40	149.24		4.0		
24	Cairns Qld	1958	12 01	10 38 33	16.5	145.5	4.4			
25	Berridale NSW	1959	5 18	06 13 00	36.22	148.64		5.3	3.8	
26A	Mount Glorious Qld	1960	11 17	05 00 17	27.33	152.85		4.4		
26B	Mount Glorious Qld	1960	11 17	05 00 17	27.33	152.85		4.4		
27A	Robertson-Bowral NSW	1961	5 21	21 40 02	34.55	150.50		5.6		
27B	Robertson-Bowral NSW	1961	5 21	21 40 02	34.55	150.50		5.6		
28	Nourning Spring WA	1963	1 18	05 49 16	32.25	117.17		4.9	4.1	5.4
29	Port Davey Tas	1963	11 03	12 00 40	43.49	145.80		4.4	3.9	
30	Bass Strait Tas	1964	11 14	10 53 04	40.22	144.60		4.5		
31	Great Lake Tas	1964	12 09	16 38 41	41.80	146.63		3.4		
32	Quorn SA	1965	8 28	00 26 39	32.23	138.30		5.0		4.9
33	Mount Hotham Vic	1966	5 03	19 07 54	37.04	147.13		5.0		4.3
34A	Meckering WA	1968	10 14	02 5 8 50	31.60	117.00		6.9	6.8	6.0
34B	Meckering WA	1968	10 14	02 58 50	31.60	117.00		6.9	6.8	6.0
35	Landor WA	1969	6 17	19 54 32	25.26	116.73		5.6	5.1	5.7
36	South Gippsland Vic	1969	6 20	11 15 28	38.47	146.30		5.3	4.8	
37A	Calingiri WA	1970	3 10	17 15 11	31.11	116.47		5.1	5.1	5.7
37B	Callingiri WA	1970	3 10	17 15 11	31.11	116.47		5.1	5.1	5.7
38	Spalding SA	1971	1 06	23 54 30	33.46	138.56		4.6		
39	Western Port Vic	1971	7 06	21 55 01	38.42	145.11		5.0	4.9	
40	Dalton NSW	1971	11 03	20 05 37	34.78	149.17		4.2		
41A	Picton NSW	1973	3 09	19 09.14	34.14	150.29		5.5	5.3	5.5
41B	Picton NSW	1973	3 09	19 09 14	34.14	150.29		5.5	5.3	5.5
42	Meckering WA	1974	7 09	10 46 47	31.65	117.0		4.3		5.3
43	Manmanning WA	1974	9 04	23 17 42	30.79	116.97		4.5		5.8
44	Banda Sea	1974	10 29	03 14 15	6.88	129.46			6.6	6.5
45	Meckering	1974	11 19	09 30 23	31.63	117.03		4.0		
46	Kimberley WA	1975	3 06	23 51 26	17.08	126.38				5.2

Table 1 (cont.) Isoseismal Atlas Part 1

47	Marble Bar	1975 7 24	22 23 42	21.09	120.47			5.1
48	Gladstone SA	1976 2 27	11 44 51	33.30	138.45	3.6		
49	Preston Vic	1976 7 09	08 27 40	37.73	145.03	1.3		
50	Lockhart NSW	1976 8 23	19 14 51	35.30	146.47	4.2		
51	Meckering WA	1976 10 29	06 04 48	31.64	117.00	4.7		
52	Albany WA	1977 5 15	19 16 08	35.00	117.95	4.5		
53	Bowning NSW	1977 6 30	12 48 22	34.67	148.87	4.5		3.9
54	Bowning NSW	1977 7 04	20 05 20	34.65	148.89	5.0		
55	Bowning NSW	1977 7 04	20 05 20	34.65.	148.89	5.0		4.2
55	Indonesia	1977 8 19	06 08 51	11.16	118.41		7.9	7.0
56	Adelaide SA	1977 08 20	21 55 20	34.91	138.89	3.4		
57	Balliang Vic	1977 12 02	13 32 33	37.86	144.26	4.5		
58	Esk Qld	1978 4 26	11 53 14	27.23	152.31	3.5		
59	Maroonah H'stead WA	1978 5 01	03 42 53	23.64	115.59	5.7		
60	Margaret River WA	1978 6 09	12 31 18	33.93	115.20	3.0		
61	Heron Island Qld	1978 11 28	17 33 36	23.36	152.43	5.0		4.8
62	Scoresby Vic	1979 4 16	23 24 47	37.89	145.25	2.6		
63A	Cadoux WA	1979 6 02	09 48 01	30.79	117.16	6.2	6.2	6.0
63B	Cadoux WA	1979 6 02	09 48 01	30.79	117.16	6.2	6.2	6.0
64	Kempsey NSW	1979 9 06	13 07 59	30.87	152.98	3.1		
65	Cadoux WA	1979 10 11	04 04 12	30.79	117.15	4.8		5.0
66	Offshore Fremantle WA	1980 12 08	00 12 08	32.12	114.11	5.2		4.6
67.	Cadoux WA	1980 12 10	04 35 06	30.73	117.15	5.0		4.0
68A	Bass Strait Vic	1981 6 16	21 35 56	38.90	144.20	4.9	4.2	
68B	Bass Strait Vic	1981 6 16	21 35 56	38.90	144.20	4.9	4.2	
69	Appin NSW	1981 11 15	16 58 10	34.25	150.90	4.6	3.9	4.3
70	Suggan Buggan NSW	1981 11 30	02 09 08	36.69	148.33	3.7		

Table 2 Hypocentral parameters - Isoseismal Atlas Part 2

No.	Locality	Origin Time (GMT/UTC)			Epicentre			Magnitude		
		y m d	h m s		Lat°S	Long°E	M(I)	ML	Ms	mB
1	Mackay Qld	1875 11 11	10 50		22.0	148.5	4.3			
2	Warwick Qld	1875 11 24	11 00		28.1	152.0	3.8			
3	Ipswick Qld	1877 2 26	21 45		27.5	152.8	4.5			
4	Warwick Qld	1880 8 10	19 00		28.9	151.9	3.6			
5	Gayndah Qld	1883 8 28	16 55		25.5	151.7	5.9			
6	Gayndah Qld	1883 8 28	18 20		25.5	151.7	5.2			
7	Berridale NSW	1885 1 21	01 10		36.3	149.1	4.6			
8	Yass NSW	1886 11 29	17 00		34.75	148.8	5.5			
9	Eidsvold Qld	1891 1 05	03 34		25.4	151.1	4.0			
10	Cairns Qld	1896 2 27	10 58		17.0	145.7	4.3			
11	Mundubbera Qld	1910 11 24	23 00		25.7	151.2	5.2			
12	Kilcoy Qld	1912 5 01	16 20		27.0	152.5	4.8			
13	Ravenswood Qld	1913 12 18	13 54		20.0	147.0	5.7		4.7	5.8
14	Bundaberg Qld	1918 6 06	18 23		23.5	152.5	5.5			
15	Bundaberg Qld	1918 6 06	19 20		23.5	152.5	5.7			
16	Boolaroo NSW	1925 12 18	10 47	10	33.0	151.6		5.0		
17	Gayndah Qld	1935 6 01	12 12		25.5	151.7	4.3			
18	Gayndah Qld	1935 7 18	19 30		25.5	151.7	4.1			
19	Armidale/Guyra NSW	1938 6 27	22 38	47	30.1	151.6		4.7		
20	Daintree Qld	1942 4 10	03 00		16.2	145.7	3.8			
21	Delubra Qld	1951 12 30	20 34	03	25.8	151.0	4.0			
22	Maryborough Qld	1952 6 24	01 44	04	25.5	152.8		4.8	4.4	
23	Dawes Qld	1953 2 06	17 49	31	24.7	150.7	3.7			
24	Many Peaks Qld	1953 12 03	15 42	49	24.5	151.4	4.4			
25	Many Peaks Qld	1953 12 03	15 58		24.6	151.3	3.8			
26	St George Qld	1954 9 19	10 37	06	28.5	148.6		5.3	4.1	
27	Biggenden Qld	1954 9 21	20 29	22	25.3	152.0	3.8			
28	Murgon Qld	1955 2 01	11 09	30	26.15	151.80	3.6			
29	Mt Stanley Qld	1955 4 10	22 36	15	26.7	152.2	3.2			
30	Gayndah Qld	1955 9 10	06 12	54	25.5	151.6	3.4			
31	Mt Perry Qld	1955 12 01	05 33	51	25.1	151.7	3.2			
32	Adelaide SA	1959 3 02	12 22		34.98	138.73	2.6			
33	Melrose SA	1959 9 09	04 17	30	32.7	138.2		4.2		
34	Uralla/Tamworth NSW	1959 10 12	21 23	40	30.95	151.75		4.7		
35	Mamblin SA	1959 11 02	01 17	57	33.36	135.98		5.2		
36	Cummins SA	1960 8 30	21 23	50	34.20	135.75		4.2		
37	Mackay Qld	1960 10 19	11 37	07	21.0	149.3		4.3		
38	Kingcote SA	1962 5 16	21 41	36	35.51	137.66		4.4		
39	Innisfail Qld	1963 3 28	04 29	52	17.6	146.2	3.2			
40	Banda Sea	1963 11 04	01 17	13	6.94	129.53				7.8
41	Mundubbera Qld	1964 3 25	06 14	38	25.3	151.4		4.1		
42	Hawker SA	1976 1 25	20 22	54	31.93	138.50		4.6		
43	Goondiwindi Qld	1965 6 03	21 59	57	28.08	150.22		5.3		4.4
44	Mundubbera Qld	1967 7 18	07 48	04	25.65	151.15	4.0			
45	Wilpena SA	1972 4 18	22 20	40	31.58	138.62		5.3		
46	Adelaide SA	1972 10 17	12 40	07	35.00	138.51		3.4		
47	Dorrigo NSW	1973 7 29	13 58	04	30.09	154.37		4.5		
48	Willunga SA	1975 7 14	18 02	23	35.25	138.58		3.4		
49	Coalstoun Lakes Qld	1975 11 12	10 29	47	25.6	151.9	3.2			
50	Gold Coast Qld	1976 9 22	04 33	09	28.0	154.0		3.4		
51	Dawes Qld	1976 10 01	00 46	40	24.8	150.7	3.2			
52	Inglewood Qld	1977 3 05	06 04	11	28.14	150.35		4.5		
53	Scartwater Qld	1978 5 24	17 38	00	20.7	146.6		3.2		
54	Truro SA	1979 7 04	09 18	45	34.39	139.19		3.5		
55	Kimba SA	1979 10 22	11 13	40	33.31	136.95		3.5		
56	KImba SA	1980 4 15	00 38	05	33.26	137.03		4.3		
57	Ashford NSW	1980 9 04	21 05	45	29.13	150.94		4.0		

Table 2 (cont.) Isoseismal Atlas Part 2

58	Clare Valley SA	1980 11 13	08 56 16	33.74	138.83	3.7		
59	Tenthill Qld	1981 3 24	18 34 16	27.67	152.24	2.7		
60	Cadoux	1981 4 07	20 15 58	30.74	117.16	4.5		
61	Monogorilby Qld	1981 5 10	14 39 38	26.33	150.73	4.1		
62	Mt Pleasant SA	1981 8 31	19 35 17	34.71	139.04	2.8		
63	Glen Innes NSW	1981 10 11	09 26 35	29.64	151.75	3.2		
64	Cadoux WA	1982 1 24	04 06 19	30.90	117.12	4.3		3.5
65	Cadoux WA	1982 2 06	15 24 38	30.88	117.15	4.9		4.7
66	Inverseel NSW	1982 3 04	10 02 43	29.82	151.20	3.6		
67	Corryong NSW	1982 3 09	00 09 26	36.24	147.92	3.4		
68	West Wyalong NSW	1982 5 20	07 36 18	33.96	147.24	3.6		
69	Glen Innes NSW	1982 6 08	03 13 24	29.66	151.63	2.9		
70	Glen Innes NSW	1982 6 09	04 32 47	29.66	151.63	3.5		
71	Glen Innes NSW	1982 7 05	09 02 29	29.67	151.63	2.2		
72	Wonnangatta Vic	1982 11 21	11 34 19	37.20	146.96	5.4	3.8	4.8
73	West Wyalong NSW	1982 11 26	00 11 17	33.94	147.25	4.6		5.4
74	Cadoux WA	1983 1 26	06 16 15	30.73	117.13	4.8		5.1
75	Bowning NSW	1983 3 07	23 26 01	34.69	148.88	3.8		
76	Milparinka NSW	1983 4 08	19 33 18	29.85	142.01	4.5		4.9
77	Milparinka NSW	1983 6 20	17 33 00	30.22	141.74	4.7		
78	Timor	1983 11 24	05 30 34	7.57	128.19	7.5	7.1	6.4
79	Beltana SA	1983 12 29	17 42 02	30.79	138.40	4.8		5.3

Table 3 Hypocentral parameters - Isoseismal Atlas Part 3

No.	Locality	Origin Time (GMT/UTC)			Epicentre		Magnitude			
		y m d	h m s		Lat°S	Long°E	M(I)	ML	Ms	mB
1	Newcastle NSW	1841 01 27	21 55		32.8	151.6	4.9			
2	Newcastle NSW	1842 10 27	19 30		32.6	151.6	5.3			
3	Circular Head Tas	1859 11 21	18 50		40.7	145.2	5.4			
4	Maitland NSW	1868 06 18	14 00		33.0	151.5	5.3			
5	Mt Hotham Vic	1868 08 29	18 50		37	147	5.0			
6	Jenolan Caves NSW	1872 10 18	18 50		33.7	150.0	5.3			
7	Southwest Tas	1880 02 03	06 30		43.0	146.4	5.5			
8	C Barren Is Tas	1884 07 13	03 55		40.5	148.5	6.4*			
9	Tasman Sea	1885 05 12	23 37		39.9	148.9	6.8*			
10	Kapunda SA	1886 09 28	16 00		34.1	139.5	5.1			
11	Mt Bryan SA	1887 04 16	13 10		33.46	138.96	4.5			
12	Eyre Peninsula SA	1887 04 16	22 10		34.3	135.8	5.7			
13	Dalton NSW	1888 07 05	10 15		34.8	149.1	5.3			
14	Robertstown SA	1889 02 12	06 45		34.0	139.0	4.9			
15	Port Phillip Bay Vic	1891 06 07	04 24		38.1	144.8	4.5			
16	Tasman Sea	1892 01 26	16 48		40.4	149.5	6.9*			
17	Kapunda SA	1893 08 13	02 10		34.38	138.97	3.6			
18	Burra SA	1896 08 22	02 46		33.69	138.91	4.3			
19	Burra SA	1896 08 22	07 00		33.69	138.91	4.0			
20	Burra SA	1896 08 23	11 30		33.71	138.94	4.2			
21	Robe SA	1898 04 10	21 10		37.32	139.71	4.9			
22	Robe SA	1899 05 02	03 30		37.2	139.6	5.3			
23	Bulli NSW	1902 02 28	12 20		34.3	150.8	4.1			
24	Mid North SA	1902 05 07	05 10		32.75	138.50	4.8			
25	Marrabel SA	1902 05 13	18 50		34.09	138.93	3.5			
26	Caltowie SA	1902 06 05	22 35		33.13	138.36	3.1			
27	Spalding SA	1902 09 18	21 00		33.52	138.50	4.4			
28	Warooka SA	1902 09 19	10 35		35.0	138.0	6.0			
29	Warooka SA	1902 09 20	09 25		35.0	138.0	4.4			
30	Warooka SA	1902 09 20	09 37		35.0	138.0	4.8			
31	Spalding SA	1902 09 21	04 10		33.52	138.50	4.1			
32	Warrnambool Vic	1903 04 06	23 52		38.5	142.5	4.4			
33	Clare SA	1903 08 14	11 40		33.91	138.60	4.1			
34	Melbourne Vic	1904 07 09	09 30		37.9	145.3	4.0			
35	Riverton SA	1905 08 21	18 35		34.2	138.8	4.9			
36	Indian Ocean WA	1906 11 19	07 18	43	21.45	104.80	7.6			
37	Peterborough SA	1908 04 09	16 25		32.95	138.64	4.7			
38	Queenstown Tas	1908 05 04	09 50		42.0	145.4	5.0			
39	Cleve SA	1911 10 24	12 00		33.92	136.73	4.8			
40	Cleve SA	1911 10 26	10 00		33.92	136.73	5.5			
41	Westcoast Tas	1911 11 04	01 27		42.1	145.1	4.8			
42	Bega NSW	1912 01 17	20 05		36.6	149.8	4.6			
43	Adelaide SA	1914 05 28	13 21		34.95	138.70	4.2			
44	Seal Rocks NSW	1916 06 10	17 51		32.25	152.50	4.6	4.5		
45	Jamestown SA	1921 04 23	19 00		33.36	138.81	5.1			
46	Westcoast Tas	1924 03 01	11 55		41.6	145.0	5.1			
47	Boorowa NSW	1930 10 27	02 40	20	34.4	148.8	5.3			
48	Dalton NSW	1934 11 18	21 58		34.8	149.2	5.6			
49	Nilpena SA	1939 03 26	04 00		31.1	138.3	5.7	5.8	5.7	
50	West Tasman Sea	1946 09 14	19 48	50	39.97	149.35	6.2	5.8	5.4	
51	Adelaide SA	1954 03 02	20 15		34.93	138.69	3.2			
52	Queenstown Tas	1958 01 01	00 07	22	42.2	146.1		5.3		
53	Port Davey Tas	1963 11 03	12 00	40	43.5	145.8		4.4		
54	Northwest Tas	1971 05 26	11 58	09	40.48	145.01		3.0		
55	Burnie Tas	1971 06 15	20 06	25	40.98	145.83		4.0		
56	Zeehan Tas	1972 03 04	16 25	38	41.93	145.41		3.0		
57	Strahan Tas	1973 06 03	11 08	08	42.32	145.08		4.0		

Table 3 (cont.) Isoseismal Atlas Part3

58	Freycinet Peninsula Tas	1974 05 22	09 23 47	42.23	148.53		2.3		
59	Arthurs Lake Tas	1976 07 02	14 41 38	42.05	147.07		2.8		
60	St Leonards Vic	1977 09 22	20 55	38.18	144.72		3.1		
61	Burnie Tas	1978 05 04	11 34 52	41.02	145.68		3.0		
62	Orford Tas	1978 10 20	00 52 48	42.68	147.88		2.7		
63	Rowley Shoals WA	1979 04 23	15 45 10	16.66	120.27	6.1		5.7	5.9
64	Walhalla Vic	1980 05 21	04 47	37.95	146.49		4.0		
65	Bass Strait Vic	1981 06 16	21 33 56	38.90	144.20		5.1	4.2	
66	Cooyar Qld	1984 03 04	07 12 58	26.94	151.79	2.7	2.2		
67	Oolong NSW	1984 08 09	06 30 14	34.81	149.17	4.3	4.3		
68	Murgon Qld	1984 10 30	06 29 48	26.31	151.96	4.7	4.2		
69	Fraser Is. Qld	1985 02 08	08 23 42	25.12	153.62	4.7	3.5		
70	Lithgow NSW	1985 02 13	08 01 23	33.49	150.18	4.3			
71	Norsman WA	1985 07 28	07 39 47	32.51	122.22	5.6	4.8		
72	Proserpine Qld	1985 08 02	12 16 58	19.44	149.20	4.7			
73	Cadoux WA	1985 10 10	13.34 30	30.75	117.11	4.3			
74	Timor Sea	1985 10 23	00 49 16	11.04	125.04				6.0
75	Cadoux WA	1985 11 27	23 18 21	30.77	117.08	4.5			
76	Canberra ACT	1985 11 28	20 51 12	35.28	149.11	2.4			
77	Coulstoun Lakes Qld	1985 12 02	06 19 01	25.39	151.73	3.2			
78	Oolong NSW	1986 01 07	10 06 50	34.76	149.18	3.1			
79	Somerset Dam Qld	1986 01 08	09 55 57	27.15	152.50	3.2			
80	Augusta WA	1986 01 15	22 11 28	34.51	114.99	3.8			
81	Upper Colo NSW	1986 02 20	21 43 55	33.30	150.60	3.9			
82	Temma Tas	1986 03 16	01 53 01	41.27	144.33	4.1			
83	Marryat Creek SA	1986 03 30	08 53 48	26.33	132.52	5.8	5.6		
84	Arthur River WA	1986 05 17	12 41 28	33.43	117.24	4.2			
85	Ravensthorpe WA	1986 05 17	14 57 44	33.75	119.93	3.4			
86	Meckering WA	1986 09 01	13 53 49	31.63	117.06	4.1			
87	Kangaroo Is SA	1986 12 12	04 24 49	36.12	136.58	4.6			
88	Tennant Ck NT	1987 01 07	20 01 51	19.8	133.9	5.4			
89	Cadoux WA	1987 03 07	05 38 07	30.77	117.09	4.5			
90	Bega NSW	1987 06 13	04 34	36.61	149.80	2.6			
91	Oolong NSW	1987 06 16	13 26 41	34.79	149.17	2.9			
92	Banda Sea	1987 06 17	01 32 56	05.58	130.88				6.7
93	Dampier WA	1987 06 19	13 32 03	20.56	116.69		3.7		
94	Oolong NSW	1987 06 20	08 23 26	34.76	149.19		3.0		
95	Lithgow NSW	1987 06 24	15.04 55	33.44	150.15		4.3		
96	Oolong NSW	1987 06 26	23 28 40	34.76	149.20		3.1		
97	Wooroloo WA	1987 07 05	05 28 41	31 78	116.34		3.0		
98	Nhill Vic	1987 12 22	15 06 30	36.11	141.54		4.9		
99	Wyalkatchem WA	1988 01 06	03 42 08	31.2	117.5		4.3		
100	#Tennant Creek NT	1988 01 22	00 36 01	19.81	133.98			6.3	
	Tennant Creek NT	1988 01 22	03 57 29	19.83	133.98			6.4	
101	Tennant Creek NT	1988 01 22	12 05 01	19.84	133.99			6.7	
102	Marble Bar WA	1988 01 28	01 56 18	21.05	119.60		5.0		
103	Doubtful Bay WA	1988 02 06	05 23 58	16.18	124.51		5.7		
104	Banda Sea	1988 05 30	21 11 11	7.50	128.32				6.5
105	Bunnaloo NSW	1988 07 03	08 23 12	35.73	144.49	4.1	4.0		
106	Barrier Range NSW	1988 09 07	07 07 42	31.43	141.64		3.9		
107	West Wyalong NSW	1989 01 05	20 48	33.82	147.12		3.9		
108	Tanunda SA	1989 02 27	06 45	34.60	139.21		4.9		
109	Jindabyne NSW	1989 04 18	03 51 34	36.40	148.57		3.7		
110	Mt Olga NT	1989 05 28	02 55 21	25.25	130.65	5.6	5.6	5.1	5.4
111	Margaret River WA	1989 07 20	09.29 25	33.97	114.89		3.2		
112	Darwin NT	1989 07 23	20 43	12.59	130.49		4.0		
113	Arno Bay SA	1989 08 13	19 17 43	33.85	136.45		3.1		
114	Hambidge SA	1989 09 07	08 08 30	33.55	135.92		2.9		
115	Broome WA	1989 10 13	09 59 15	17.64	122.44		5.4		
116	Craddock SA	1989 10 15	11 35 07	32.27	138.67		3.1		

Table 3 (cont.) Isoseismal Atlas Part 3

117	Beachport SA	1989 11 08	05 06 31	37.55	140.06		3.9		
118	Newcastle NSW	1989 12 27	23 26 58	32.95	151.61	5.6	5.5	4.6	5.7
119	Newcastle NSW	1989 12 29	09 08 11	32.96	151.63		2.1		

* These magnitudes were derived by Michael-Leiba (1990) using a unique set of equations relating intensity and magnitude.

\# The second large earthquake at Tennant Creek was so soon after the first that a single isoseismal map was drawn on reports for both.

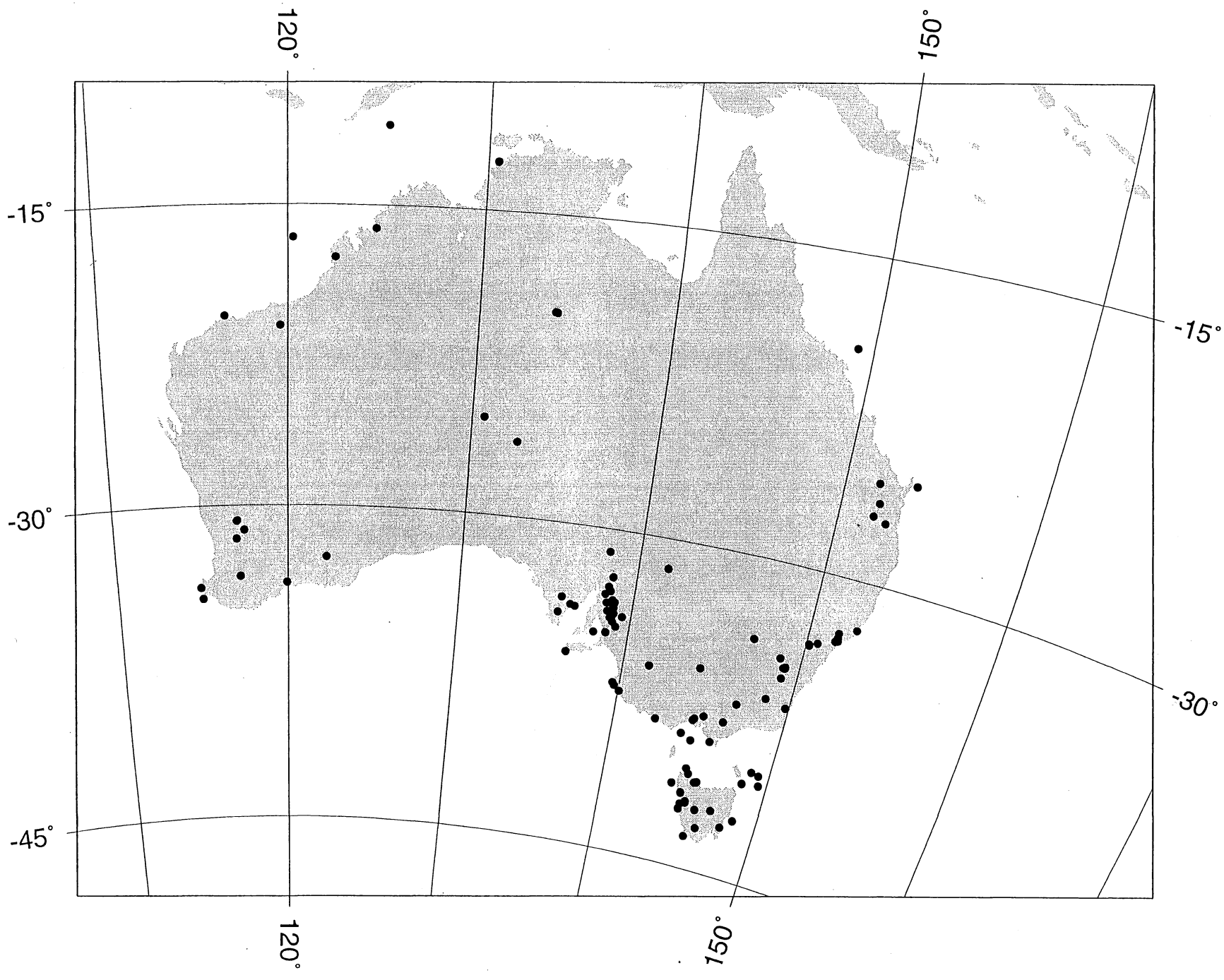


Figure 3 Epicentre f Atlas Vol 3 earthquakes

INTRODUCTION

This is the third isoseismal atlas compiled by AGSO (the earlier two when AGSO was known as the BMR). BMR Bulletins 214 (Everingham & others, 1982) and 222 (Rynn & others, 1987) together contain isoseismal maps of 162 earthquakes that occurred in Australia between 1875 and 1983. The first atlas was initiated by Everingham to collect together all known maps published at the time. It contained information on most of the larger, widely felt or damaging earthquakes. The second atlas compiled by Denham included a large subset of Queensland earthquakes, many of them small, as a result of an intensive and timely study by Rynn (1987). Edgeworth David admitted in 1902 to a total lack of knowledge of Queensland earthquakes when he compiled the map of Australian earthquakes reproduced in the frontispiece and this remained the status quo until Rynn's study.

This the third volume contains isoseismal maps of 119 earthquakes that occurred between 1983 and 1990, and of previously undocumented historical earthquakes. It was conceived after many 'lost' Tasmanian questionnaires from the 1970's and 1980's were rediscovered at the University of Tasmania. The maps drawn from this information complemented maps compiled by Michael-Leiba (1990) of earlier Tasmanian earthquakes covering the period 1859 to 1946. The atlas was fleshed out with a series of maps of the early earthquakes near Newcastle NSW and selected earthquakes in South Australia, and then swamped by an amazing number of additional South Australian earthquakes uncovered by Katherine Malpas and Alison McArdle. Some of these had not been converted to AGSO format when this report went to press.

The atlas contains at least one map in every decade since the 1840s. A loose leaf binder format was adopted so that additional maps could be inserted at a later time. Isoseismal maps in volume 3 and not in the first two volumes include those for:

- the largest earthquake in continental Australia - offshore WA on 19 November 1906 magnitude Ms 7.2
- the largest earthquake in Eastern Australia - 12 May 1885 magnitude MI 6.8 and
- the largest earthquake on Eyre Peninsula South Australia - 16 April 1887 magnitude ML(I) 5.7.
- several small but important earthquakes in or near the major urban areas of Melbourne, Adelaide and Newcastle.
- three Indonesian earthquakes felt in Northern Australia.

The frequency of isoseismal maps by State but excluding the Indonesian earthquakes is:

Atlas	*State/Territory*								*Total*
	WA	SA	NT	Tas	Vic	NSW	ACT	Q'ld	
1	20	9	-	4	10	15	-	10	68
2	4	15	-	-	1	18	-	39	77
3	17	34	5	20	8	25	1	6	116
Total	41	58	5	24	19	58	1	55	261

Why continue to draw up isoseismal maps when AGSO operates a sophisticated national broad-band telemetered seismographic network? Isoseismal maps enable seismologists to estimate the epicentre and magnitude of pre-seismograph earthquakes. For engineers and insurers they show the distribution of the effects of shaking and provide valuable information on attenuation rates and microzonation effects for computing earthquake risk, and for estimating probable maximum losses (PML). They are of particular significance in Australia, where instrumental strong-motion data are scarce and the period of instrumental recording is short. Such maps provide a direct comparison of both the area of damage and the felt area for similar sized earthquakes; in different geological provinces within Australia, and between those in Australia and in

other countries. They also provide useful constraints on the influence of different foundation materials on the ground motion at sites at the same epicentral distance.

Because of the sparseness of instruments to record strong ground motion in Australia we will have to rely for many years on the careful analysis of felt intensities to assess earthquake risk. Therefore it is essential that a comprehensive and reliable source of these data is maintained. New and additional historical isoseismal maps will continue to be included in annual AGSO seismological reports (eg. Denham & Gregson, 1984; McCue & Gregson, 1992).

The atlases are a convenient compilation of known intensity maps for Australian earthquakes for use as a basic macroseismic data source.

Terminology used in the text, maps, tables, and map descriptions is the same as used in the first 2 atlases and is republished in Appendix 2. The modified Mercalli (MM) scale, still the basis of modern Australian intensity estimates, is described in Appendix 3.

EARTHQUAKE DATA

Tables 1, 2 and 3 list details of earthquakes for which isoseismal maps have been published in the three volumes of the Atlas. The details were extracted from AGSO's earthquake datafile, which contains earthquake parameters obtained from AGSO or State Government earthquake monitoring agencies and universities. The selection of hypocentres and magnitudes for earthquakes in this volume is based on a careful examination of available data and an appraisal of published information on the earthquakes.

Hypocentres Before 1958, instrumentally determined hypocentres are either not available or have large uncertainties because instrumental recordings were rare, timing was inaccurate by modern standards, and appropriate crustal models were non-existent. Until the mid-1950s only five seismographs were in continuous operation on the Australian continent, at Brisbane, Adelaide, Perth, Melbourne, and Sydney. Most of the early epicentre maps show epicentres that were determined from macroseismic observations, the epicentre plotted in the centre of the zone of highest intensity though this may not always coincide with the true epicentre. A striking recent example where the centre of damage and epicentre did not coincide was the earthquake near Newcastle NSW on 28 December 1989 where the centre of damage was at Hamilton, about 15 km from the computed epicentre taken as the centre of the uncertainty ellipse.

Epicentres and focal depths have been computed with increasing accuracy since the late 1960s for a number of reasons; the number of seismographs has increased from 5 in 1956 to more than 100 in 1990, computers were introduced in the 1960s to determine epicentres, and better crustal models became available from inversion of recorded travel times. Even now the accuracy of an epicentre can vary from 1 or 2 km to perhaps 30 km depending on the distribution and epicentral distance of the phase arrival times used to locate it. A concerted effort has been made by AGSO over the last decade to reduce this uncertainty for earthquakes down to magnitude 3.0 by filling gaps in the coverage of Queensland, Western Australia, and northern New South Wales (Fig. 2).

The uncertainty of focal depths in routine analysis is about $\pm$10 km although some focal depths have been accurately determined to within 1 or 2 km by using local networks where the epicentral distance and focal depth are comparable, by recognising depth phases recorded at teleseismic distances, or by using seismic body-wave inversion techniques.

Magnitudes The magnitude of each earthquake (Appendix 3) is listed in Table 1. Local magnitude (denoted ML) was the most commonly determined magnitude, and is the most widely used by researchers, engineers and insurance agents.

In Western Australia, all the listed ML values were determined by Mundaring Geophysical Observatory (AGSO) and in Eastern Australia by the AGSO Seismological Centre and cooperating agencies in State Governments and universities (Appendix 3).

Magnitudes that could not be determined instrumentally (from seismograms), were calculated from macroseismic data using either McCue's (1980) formula:

$$ML(I) = 1.01\ ln(Rp) + 0.13$$

where *Rp* is the radius of perceptibility in kilometres of the MMIII isoseismal and *ln* is the natural logarithm to base e, or the equations of Greenhalgh & others (1989) using the radii of the III, IV and V isoseismals. The magnitudes of earthquakes in Tasmania were derived by Michael-Leiba (1989a, b) using other relationships. Magnitudes determined by these method are approximate and may be revised as a result of further research.

ISOSEISMAL MAPS

Maps that have been published elsewhere are reproduced here without major modifications to the overall shape of the isoseismals although minor modifications may have been made to standardise the presentation. For example isoseismals drawn over the sea have been eliminated but their trend is indicated by a dash. The isoseismals on each map are drawn to enclose all intensity observations equal to or greater than a given intensity, but isolated intensity reports which do not fit the general pattern have been ignored; thus the isoseismals are smoothed or filtered to some extent.

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Many people contributed to this atlas by providing maps, data, newspaper reports, references or other information and due acknowledgment has been made in the text. Many cannot be named such as those who compiled the Newspaper Cuttings Book at Riverview Observatory for many decades, or those early scientists who collected and contributed information on early earthquakes to the Australasian Association for the Advancement of Science.

At AGSO this included (in order of the number of maps): Kevin McCue, Dr Marion Michael-Leiba, Peter Gregson, Trevor Jones, Dr David Denham, Edward Paull, Dr David Palfreyman, Lesley Hodgson, Victor Dent, Robert Corkery and James Lewis. Several students working at AGSO under the CSIRO's Science Club also contributed to the data collection including Michelle Gahan and Andrew McCallum.

Katherine Malpas with Professor Stewart Greenhalgh from Flinders University and David Love and Alison McArdle at the Sutton Institute of the Department of Mines and Energy South Australia, compiled maps for many other South Australian events. Contributing staff at the Seismology Research Centre, RMIT in Victoria included Gary Gibson, Vaughan Wesson, Tony Corke and Wayne Peck. From Queensland, the macroseismic data were collected by Russell Cuthbertson (formerly from the Queensland Department of Resource Industries) and Col Lynam at the University of Queensland, Dr Jack Rynn from CERA and Professor Bruce Boreham, Byron McKavanagh, Craig Bugden and Bill Cooper from the University of Central Queensland. In Tasmania, June Pongratz and Vagn Jensen collected felt reports for the post-1970 earthquakes.

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APPENDIX 1: TERMINOLOGY

ACCELERGRAPH. An insensitive seismograph for measuring ground acceleration as a function of time, close to the epicentre.
ACTIVE FAULT. A fault along which slip has occurred in the last 500 000 years, or on which earthquake foci are located.
AFTERSHOCKS. Smaller earthquakes following the largest earthquake of a series and concentrated in a restricted crustal volume near the focus of the mainshock.
EARTHQUAKE. The vibrations of the Earth caused by the passage of seismic waves radiating from the fault rupture.
EPICENTRE. The point on the Earth's surface directly above the focus (or hypocentre) of an earthquake.
FAULT. A fracture or zone of fractures in rock along which the two sides have been displaced relative to each other. The total fault offset may range from one millimetre for a very small earthquake to tens of metres for the largest earthquake.
FOCAL DEPTH (OF EARTHQUAKES). The depth of the focus (hypocentre) below the surface of the Earth.
FOCUS (HYPOCENTRE). The point at which fault rupture commences.
FORESHOCKS. Smaller earthquakes preceding the largest earthquake of a series concentrated in a restricted crustal volume.
HYPOCENTRE (FOCUS). The point at which rupture commences.
INTENSITY (OF EARTHQUAKES). An assessment of ground shaking by an experienced observer from the damage done to structures, from changes in the Earth's surface, and from felt reports (see Appendix 2).
INTENSITY QUESTIONNAIRE. Special form or card designed about the Modified Mercalli scale of intensity listing questions to which simple answers indicate the intensity of an earthquake. The answers to these questionnaires gathered from an area around a felt earthquake can be integrated with field observations and other reports in drawing isoseismal maps (see Appendix 4).
ISOSEISMALS. Contour lines drawn to separate one level of seismic intensity from another.
MACROSEISMIC EFFECTS (OF EARTHQUAKES). Those effects that can be observed on a large scale in the field without instrumental aid.
MAGNITUDE. A quantity that is characteristic of the total energy released by an earthquake, in contrast to 'intensity', which subjectively describes earthquake effects at a particular place. Richter (1935) devised the logarithmic magnitude scale in current use to define local magnitude (ML) in terms of the ground motion that would be measured by a standard type of seismograph located 100 km from the epicentre of an earthquake. Several other magnitude scales are also in use; for example, the body-wave magnitude (mB) and surface-wave magnitude (Ms), which use body-waves and surface-waves respectively, and the duration magnitude (MD), which is based on the length of time that the seismogram is disturbed. Mw is a magnitude derived from the seismic moment (Mo; Kanamori, 1977). Magnitude scales are open-ended. For magnitude relations, see McGregor & Ripper (1976) or Båth (1981).
MEIZOSEISMAL REGION. The area of strong shaking and significant damage caused by an earthquake.
MODIFIED MERCALLI (MM) SCALE. A numerical index describing the effects of an earthquake. The scale in common use today is the Modified Mercalli scale of 1931, in which intensity values are indicated by capital Roman numerals from I to XII. The narrative descriptions of each intensity value are given in Appendix 2.
RISK (SEISMIC). The probability of damage. Hazard is the probability of earthquake occurrence within a given time interval and region.
ROSSI-FOREL (RF) SCALE. A numerical index describing the effects of an earthquake (in common use before the adoption of the MM scale in about 1931).
SCARP (FAULT). A step or steep slope formed by displacement of the ground surface.

SEICHE OSCILLATION. Resonant oscillation in closed or semiclosed bodies of water.
SEISMICITY. The distribution of earthquakes in space and time.
SEISMOGRAPH. An instrument for recording, as a function of time, the motions of the Earth's surface that are caused by seismic waves.
SEISMOLOGY. The study of earthquakes, seismic sources, and wave propagation through the Earth.
STRONG GROUND MOTION. The shaking of the ground near an earthquake source made up of large-amplitude seismic waves of various types.
TELESEISM. The trace of an earthquake recorded on a seismogram more than 1000 km from the source.

APPENDIX 2: MODIFIED MERCALLI (MM) SCALE OF EARTHQUAKE INTENSITY (New Zealand version, 1965, 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 been 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 favourably 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 liked 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 buildings 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 cracked. A few earthware toilet fixtures cracked. Hanging pictures more. 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, glassware, and crockery broken. Objects fall from shelves, and pictures from walls. Heavy furniture moves. Unstable furniture overturned. Small church and school bells ring. Trees and bushes shake, or are heard to rustle. Loose material may be dislodged from existing slips, talus slopes, or shingle slides.

MM VII General alarm. Difficulty experience in standing. Noticed by drivers of motorcars. 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 cracked. Weak chimneys broken, 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 motorcars 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 broken. 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 shifted 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 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 0.1g, such as those satisfying the New Zealand Model Building Bylaw, 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 or 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.

APPENDIX 3: MAGNITUDE SOURCES

Estimates of earthquake magnitude have been obtained from several sources. The table below identifies the codes, on the atlas maps and in Table 1, with the agencies that provided the estimates. 'I' indicates that the magnitude has been estimated from intensity results as per McCue (1980).

ABE	K. Abe and S Noguchi (1983)
ADE	Department of Mines & Energy, South Australia
AGSO	Australian Geological Survey Organisation, Canberra ACT
BMR	Bureau of Mineral Resources, Geology and Geophysics, Canberra ACT
CAN	Australian National University, Canberra ACT
E	I.B. Everingham, personal communication, from the Riverview, Perth, and Melbourne seismograms
GR	Gutenberg & Richter (1954)
GS	United States Geological Survey - National Earthquake Information Service (NEIS), USA
I	Magnitude determined from intensity data
ISC	International Seismological Centre UK
MUN	BMR Mundaring Geophysical Observatory, Perth WA
RIV	Riverview Observatory, Sydney NSW
WIV	Wivenhoe Dam Network, southeastern Qld.

Isoseismal map of the Newcastle earthquake New South Wales - 27 January 1841

The following letters were sent to the editor of the *Sydney Morning Herald* (2nd, 3rd or 5th) following the earthquake:

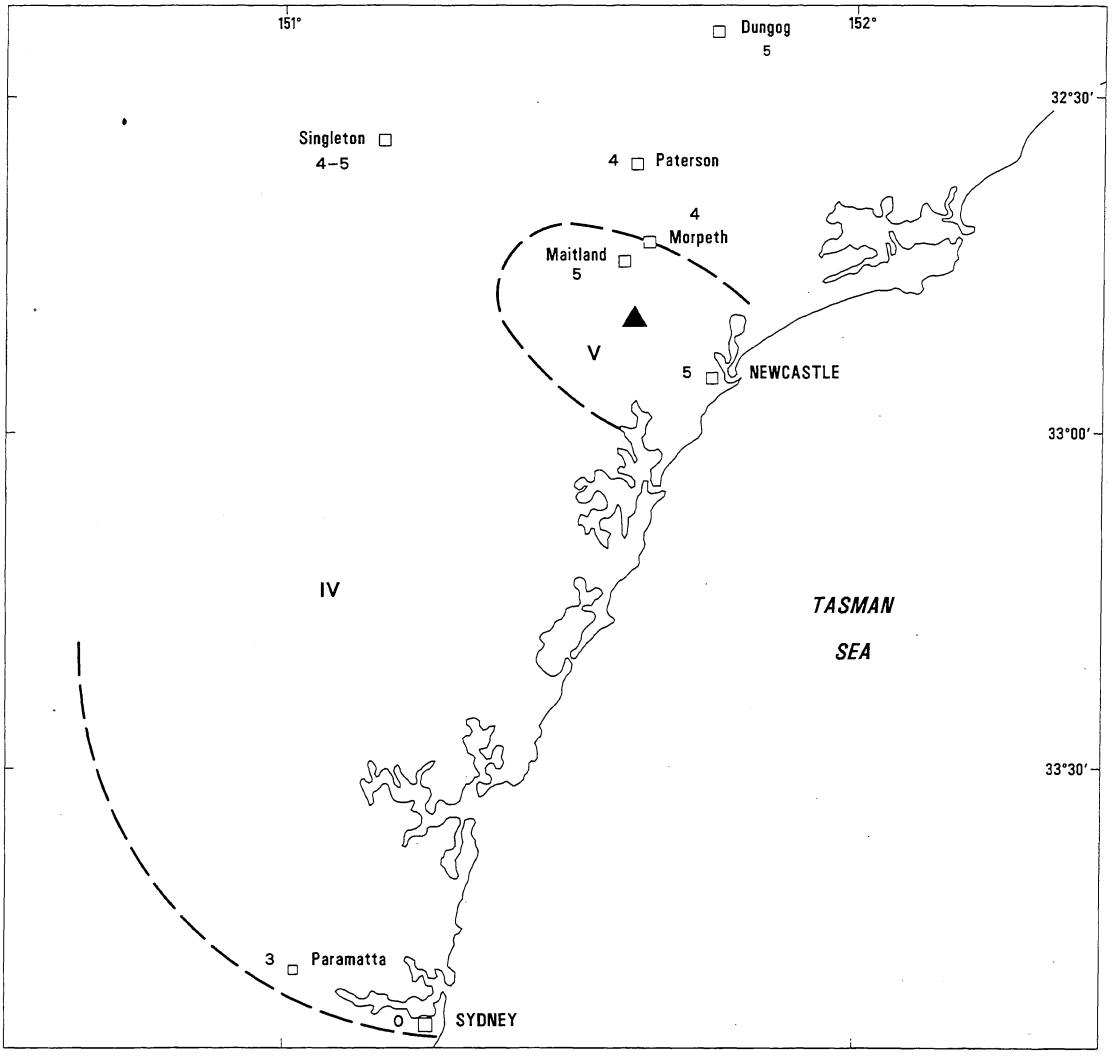
> Sir - On Thursday last, the 28th January, at about a quarter after seven o'clock, A.M., I was aroused from my slumbers by a violent tremulous motion of the bed on which I lay, accompanied by an uncommon noise, like that of a coach driving furiously over a recently macadamised road. The noise and undulations, if they may be so called, lasted for from ten to fifteen seconds, during which period I observed all the moveables in the house vibrating.
>
> I was satisfied in my own mind at the time that it must have been the shock of an earthquake, and on going to the door was doubly convinced that my opinion was correct as the elements were in a state of quiescence and the face of heaven placid and serene.....
>
> The shock has been experienced throughout the length and breadth of the district, and I have been conversing with gentlemen from the Paterson River who say that at the same hour they experienced a similar shock. The noise and undulatory motion of the earth travelled apparently from east to west....
>
> Sir, your most obedient servant,
> E MacKinlay
> Hermitage, William's River Jan 30.

Note: (from David Palfreyman and Cynthia Hunter) Hermitage was his property on the outskirts of Dungog. From the 1841 census, one learns that there were only 4 dwellings of stone or brick in the district of Dungog and a further 4 in the county of Durham out of a total of 217 dwellings for both census areas - rather a small number, although no damage is mentioned.

> EARTHQUAKE AT MAITLAND - Having observed with gratification the attention paid to meteorological science by the *Herald*, I beg to state in connection with this subject (sic) that the inhabitants of this neighbourhood, about 8 o'clock this morning (January 28) experienced a shock from an earthquake. So perceptible was this that a number of people left their houses for the purpose of ascertaining the cause of alarm. Its duration did not exceed 6 or 8 seconds. I have not however heard of any accident resulting from it although the shock was so severely felt by some persons (we are informed) as to throw them to the ground.....
>
> EARTHQUAKE - Singleton, January 29 - Yesterday morning, about 8 o'clock the shock of an earthquake was felt in this town and neighbourhood; which though but slight and momentary, caused a considerable sensation - the good people all running out of their houses together, to ascertain what was the cause of their furniture being shook and their cups and glasses set jiggling. In one direction (that of Dulwich) it was felt thirteen miles off; but how much further, or to what distance in other directions, is not known. This morning we have a rumour that it reached Maitland. A person coming towards Singleton on horseback was unconscious of the shock, but remembers his horse giving a violent leap on one side about the identical time.

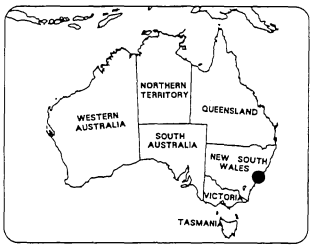
Contributors: Cynthia Hunter and David Palfreyman BMR provided newspaper accounts of this earthquake, the isoseismal map was compiled by Kevin McCue.

ISOSEISMAL MAP OF NEWCASTLE EARTHQUAKE, NEW SOUTH WALES
27 JANUARY 1841



DATE:	27 JANUARY 1841
TIME:	21:55 GMT
MAGNITUDE:	4.9 ML(l)
EPICENTRE:	32.8°S, 151.6°E

▲	*Epicentre*
IV	*Zone intensity designation*
3	*Earthquake felt (MM)*
0	*Earthquake not felt*



24/156–2/4

Isoseismal map of the Newcastle earthquake
New South Wales - 27 October 1842

The Sydney Morning Herald, 1 November 1842 carried the following stories:

WINDSOR - Earthquake Oct 28. We had a slight shock of an earthquake here this morning, at twenty minutes before six. I was lying down, but not asleep, and was thoroughly roused by feeling the bed tremble under me, at the same time that the sash of the window shook violently in the frame; I looked out and found it was dead calm. Our nurse, who was in the next room (up and attending on her mistress), was surprised at finding a wardrobe, against which she was standing, shaking; she went first to one window, which was rattling, and then to the other to see what was the matter. This gives some index to its duration, which may have been five or six seconds; but of this I am by no means certain. The shock was violent enough to wake a person, which in fact, it did.

We are given to understand it was slightly felt by two or three persons in Parramatta.

PORT STEPHENS - Earthquake. An earthquake was felt at Port Stephens, by one account at half past five, and another at six o'clock, last Friday morning (October 28). It was felt by all in my family and also at Stroud. The rumbling or shock lasted two or three seconds.

STROUD - Earthquake. We had a slight shock of an earthquake here about a quarter before six this morning, which lasted several seconds; indeed so long, that after I was convinced it was one, I had time to leave the house and walk outside; the walls and everything inside fairly shook. I have enquired of my neighbours who all felt it.

NEWCASTLE - Earthquake. On Friday morning last, the 28th instant, two shocks of earthquake were felt at Newcastle, by many of its inhabitants, who were awoke thereby out of their sleep, and who describe their beds as if tilted on one side, and regaining their original position being violently shaken under them, while the walls of their chamber seemed to be falling down. Those persons who had risen from their beds when the second shock occurred, about half past five, state the earth as quivering beneath them, and themselves shaken, as if lifted off the ground. The present instance makes the fourth shock of earthquake felt on the Hunter since the commencement of the month of August, 1837.

PATRICK'S PLAINS - Earthquake. On Friday morning, the 28th October, the shock of an earthquake was very sensibly felt in the town of Singleton and neighbourhood. It is differently described by different persons; the discrepancies in their statements being sufficiently accounted for by their being all in bed , and most of them asleep, at the time, it having occurred at half-past five o'clock in the morning. One fancied the shaking of the stretcher on which he lay was occasioned by some violence against his hut. Another thought his bed had been moved under him for fun. One 'gude wife' imagined it was her spouse endeavouring to rouse her , and under this impression of course declined to rise, though if she had known it was an earthquake she would doubtless have treated the matter with more respect.

One was only conscious of one shock, another of two, and a third states there were three; but all agree that there was a shaking or vibratory motion in various parts of the town at the same time - even in the most substantial brick building (sic - Ed.).

The previous shock of an earthquake in this place was on the morning of 26th of January 1841, about 8 o'clock - which was likewise slight, though perhaps not so slight as the present one.

PATERSON - Earthquake. October 28. This morning at 25 minutes past 5 o'clock, there were two distinct shocks of an earthquake in this township and the immediate neighbourhood. The first was a slight tremulous motion of the earth, with only a murmuring noise like that of dragging cumbrous furniture over an irregular floor - this shock lasted about fifteen seconds. While endeavouring to account for a noise and shaking of the house, by no means common, another shock much more violent and of longer continuance followed, only a few minutes after the former. This shock rocked the house so much as to cause a clatter with everything pendant - it lasted forty seconds, and was so violent as to create alarm for safety. I could not for a minute or two divert my mind from the apprehension that the whole fabric was loosened; and some persons complained of a slight sensation of sickness immediately after. This latter shock was accompanied with very little noise; a decayed tree on the bank of the river fell at the moment of the shock; but persons near it were not sensible of any other motion than that occasioned by the fall of the tree.

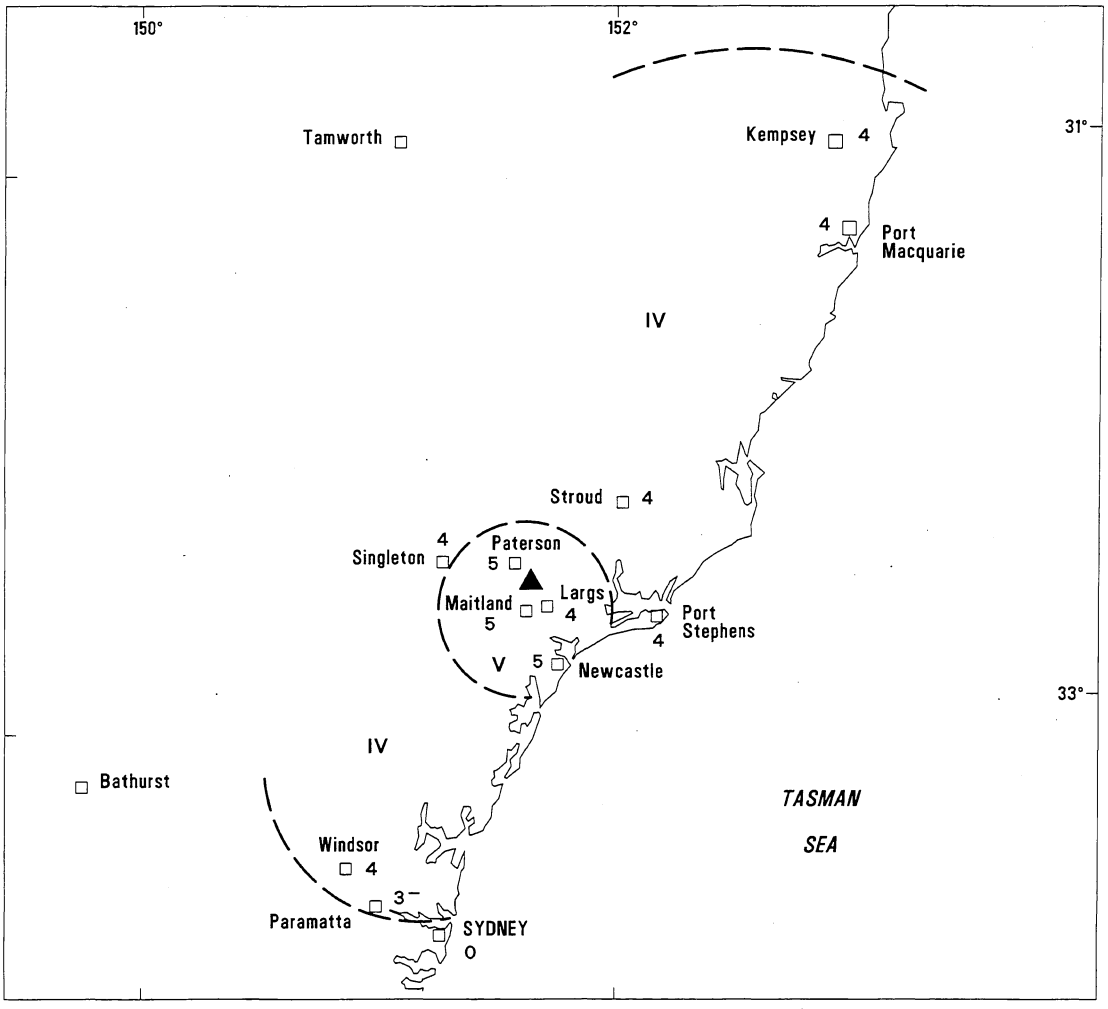
The following letter was written by Dr Ludwig Leichhardt to Dr William Nicholson, Newcastle upon Tyne on October 31, 1842

My dear friend,

On the 28 October at 1/4 to 6 in the morning I was awakened by a violent shaking of the house, as if some heavy body had dropped onto it. Messrs. Wilton and Crummer, however, had the same experience although they live several thousand paces away from us. There was therefore no doubt that an earthquake had occurred. Other people had felt a similar shock at 3 o'clock in the morning. [*from margin:* Mr Wilton the local clergyman, told us this was the 4th earthquake he had experienced during the time he had been at Newcastle 1837-1841. Mr Clarke informs us that a shock had been felt at Windsor at 20 minutes to 6 in the morning on Friday the 28th of October. The earthquake was also felt at Port Stephens, and at Stroud (near Pt Stephens). It was felt very strongly at Port Macquarie. *Later in different ink:* On the Macleay River. On the Paterson. In Van Diemens Land 1788, 1801, 1803, 1804].

Contributors: Both Cynthia Hunter and David Palfreyman provided newspaper accounts of this earthquake, the isoseismal map was compiled by Kevin McCue.

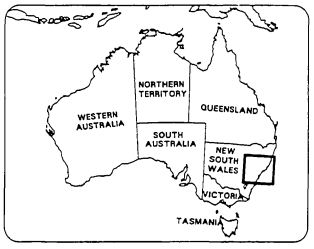
ISOSEISMAL MAP OF NEWCASTLE EARTHQUAKE, NEW SOUTH WALES
27 OCTOBER 1842



0 100 km

DATE: 27 OCTOBER 1842
TIME: 19:30 GMT
MAGNITUDE: 5.3 ML(l)
EPICENTRE: 32.6°S, 151.6°E

▲ *Epicentre*
IV *Zone intensity designation*
4 *Earthquake felt (MM)*
0 *Earthquake not felt*



24/156-2/3

Isoseismal map of the Circular Head earthquake Tasmania - 21 November 1859

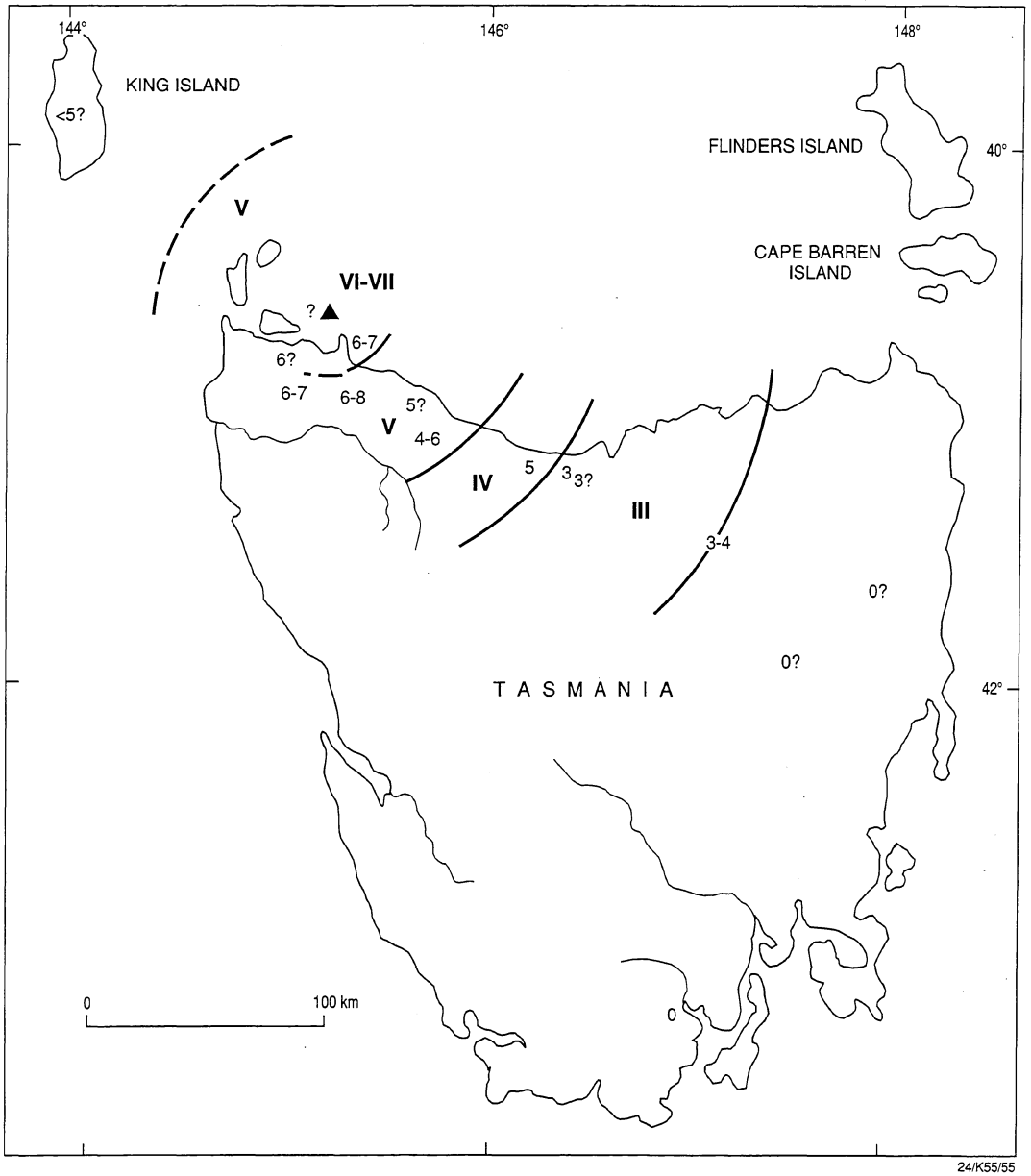
Reports of the earthquake were found in various newspapers (Michael-Leiba, 1989) including the Hobart Town Daily Mercury, the Cornwall Chronicle, the Examiner, the Argus, the Age and Geelong Advertiser. It was felt from King Island to Launceston and most strongly in the Circular Head - Black River area where a brick oven was destroyed, several brick chimneys were damaged and bottles and crockery were upset. The earthquake was not felt in Hobart or southern Victoria.

The magnitude was assessed from the radii of the MMIII, MMIV and MMV isoseismals to be equivalent to ML 5.4 with a scatter of ± 0.3 due to the location uncertainty (Michael-Leiba, 1989).

She mentions that four foreshocks were felt in the preceding 14 hours.

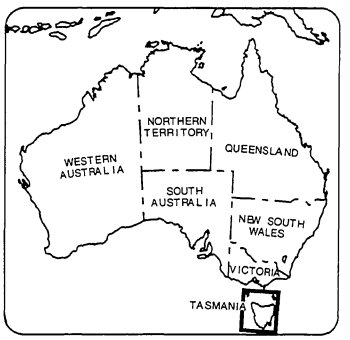
Contributors: The map was compiled by Dr Marion Michael-Leiba.

ISOSEISMAL MAP OF THE CIRCULAR HEAD EARTHQUAKE, TASMANIA
21 NOVEMBER 1859



DATE: 21 NOVEMBER 1859
TIME: 1850 GMT
MAGNITUDE: 5.4 MI, 5.4 ML(I)
EPICENTRE: 40.7°S, 145°E

▲	*Epicentre*
IV	*Zone intensity designation*
5	*Earthquake felt (MM)*
0	*Earthquake not felt*



Isoseismal map of the Maitland earthquake
New South Wales - 18 June 1868

The Newcastle Chronicle of June 20, 1868 reported on the earthquake:

HEAVY SHOCK OF AN
EARTHQUAKE
in the
HUNTER RIVER DISTRICT

'A large majority of the inhabitants of Newcastle and the surrounding district were greatly startled, and in many instances much alarmed, at midnight, on Thursday last, by feeling what was in most instances, immediately recognised as the shock of an earthquake....

The actual damage done is very small indeed, so far as Newcastle is concerned, and is confined to the jamming of doors, the displacement of small articles of crockery, and the cracking of walls. The eastern wall of the Ship Inn sustained a few cracks, and some bricks were knocked off the new buildings in King Street. The building that sustained the most damage was the house occupied by Mr Alcock, in Hunter Street, the front of which is cracked considerably. About a foot of the wall of a detached kitchen at the rear of the premises was knocked down.'

At East Maitland 'a considerable quantity of damage was done in the way of shaking down plaster and so forth, but the only building which sustained any very serious damage (as far as I can ascertain) is the Bank of Australasia, in this town. The whole edifice was very much shaken, and exhibits cracks of more or less magnitude all over. The porch is very much damaged, being almost entirely separated from the main building.'

Clarke (1869) discussed this earthquake at great length and deduced that: `it was a severe shock located under the ocean, not many miles to the eastward of the mouth of the Hunter (River).' The size he judged from the felt area of 40 000 square miles (on land). Clarke described three sizes or classes of earthquakes as defined by Mallet (1954): `great earthquakes destroy multitudes of people and devastate wide areas, mean earthquakes produce damage of an inferior kind and minor earthquakes do little harm and occur frequently.' The radii of these three kinds of shocks Mallet deemed to be 540, 180 and 60 geographic miles respectively. On this basis Clarke concluded that: 'this would place the earthquake of 18th June in the second class'.

There was a sufficient population density in New South Wales in 1868 to collect enough data to draw an isoseismal map which is similar to that of the 1925 Boolaroo earthquake compiled by McCue (in Rynn & others, 1987).

Clarke (1869) also discussed the similar sized earthquake near Newcastle in 1841(see above).

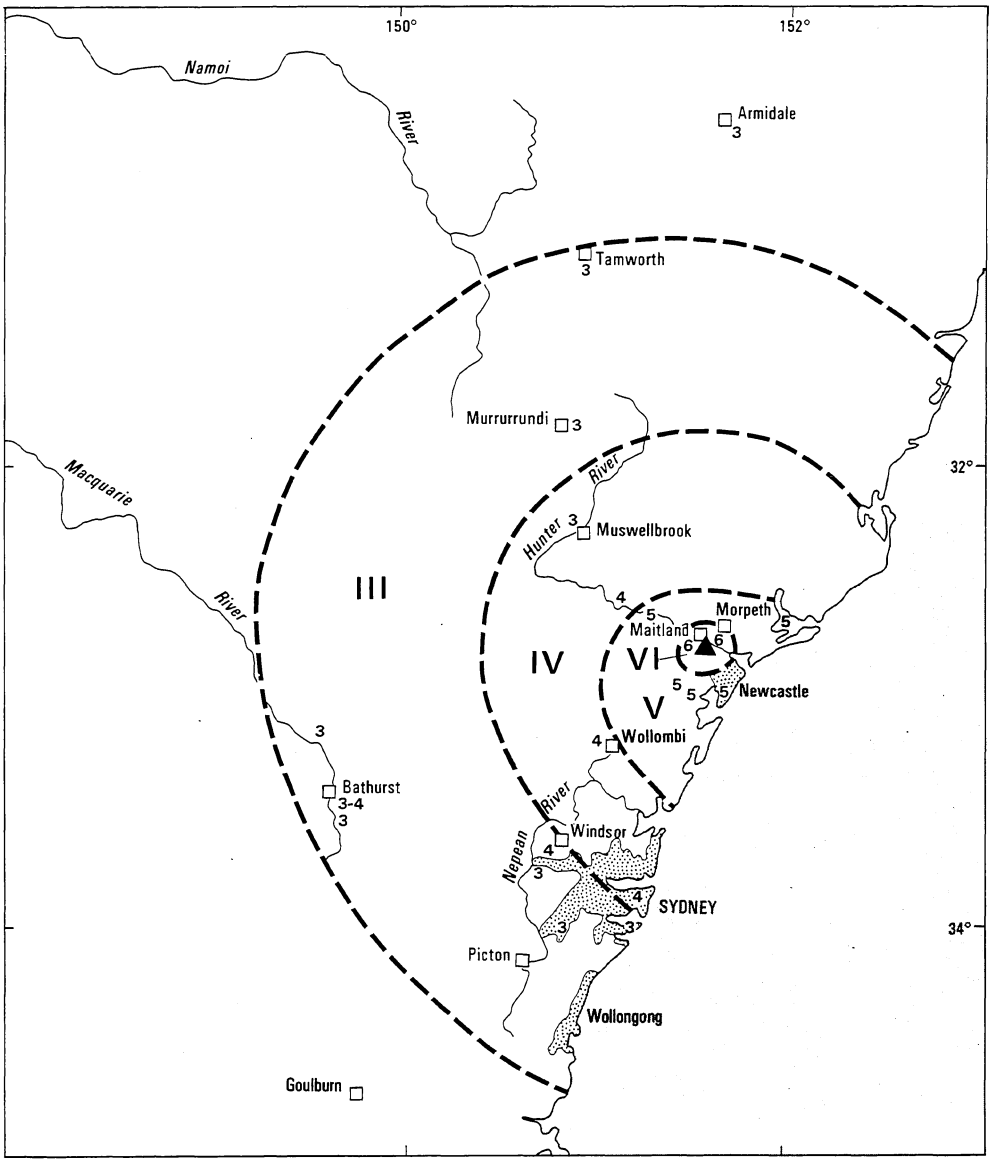
The Maitland Mercury carried a later report on 30 June 1868:

THE LATE EARTHQUAKE - The effects of the recent convulsion have been hitherto noticed only in connection with the damage done to buildings (Ed - not recorded elsewhere), but we are told that in Cabbage-Tree Gully (a depression among the range of mountains bounding the Paterson) the earth-wave has left marks of its progress of an entirely different character; there huge rocks have been split and rent, and stones which for years have been embedded in the soil are upheaved and overturned. so great a change has been worked in the aspect of the place that our informant (revealed as Mr C R Middleton in a subsequent article in the *Maitland Mercury* 13 July 1868) assures us a visit to the locality would amply repay the toils of the journey.

We cannot learn, from further inquiry, that the shock on the Wednesday night noticed by Mr Swan, of Lemon Grove, was felt by any other person in that neighbourhood, but in Mr John Lee's house, West Maitland, three persons observed it, and recognised it as a slight shock of earthquake.

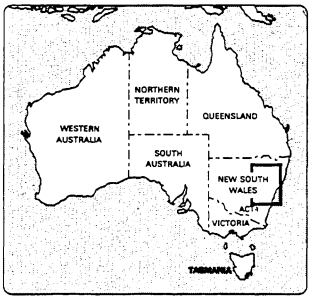
Contributors: Cynthia Hunter unearthed some of the obscure newspaper articles, the map was compiled by Kevin McCue.

ISOSEISMAL MAP OF THE MAITLAND EARTHQUAKE, NEW SOUTH WALES, 18 JUNE 1868



DATE : *18 June 1868*
TIME : *14:00 UT*
MAGNITUDE : *5.3 ML (I)*
EPICENTRE : *32.8°S, 151.6°E*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/156/10

Isoseismal map of the Mt Hotham earthquake
Victoria - 29 August 1868

The following quotes from the telegraph manager at Bairnsdale, Mr Saxe, and Mr Oliver at Deptford as quoted by Ellery (1874), indicate that the earthquake epicentre must have been close to Deptford where the shaking was strong and an aftershock felt. The earthquake was also felt at Bright, Buckland and Beechworth but not at Port Albert or Wingan Inlet. Although there was only a small population in Northeast Victoria at the time and so few felt reports, the earthquake must have had a magnitude of about 5 to have been noticed as far as Albury:

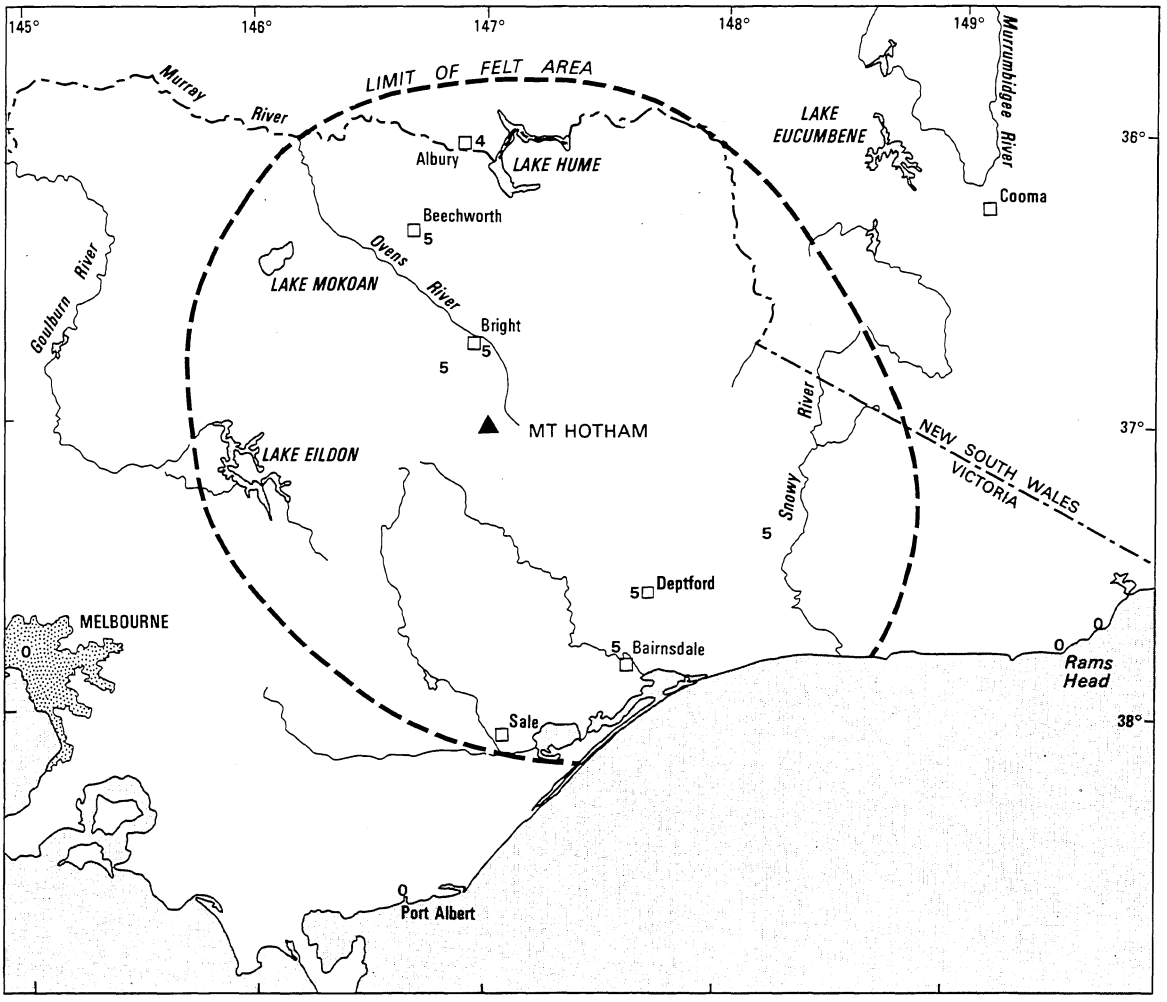
> 'About 4.50 this morning (30 August local time) two severe shocks of earthquake were felt here (Bairnsdale). The first shock lasted about a second; then an interval of a second, and then another shock of quite thirty seconds duration. A rumbling noise was heard for about three minutes after the shock. The wave seemed to travel from west to east. Many persons ran out of their houses, fearing that they would fall.' (Saxe)

> 'Quarter past eight o'clock Monday night: I had just written when we had another shock, which lasted about thirty seconds. The night is very dark and cloudy; people here are rather alarmed.' (Oliver)

Doyle & others (1968) were the original references for this earthquake.

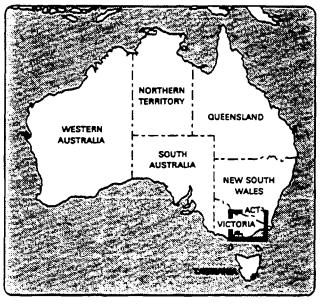
Contributors: The map was compiled by Kevin McCue.

ISOSEISMAL MAP OF THE MOUNT HOTHAM EARTHQUAKE, VICTORIA, 29 AUGUST 1868



DATE : *29 August 1868*
TIME : *18 : 50 UT*
MAGNITUDE : *5.0 ML (I)*
EPICENTRE : *37°S, 147°E*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/J55/26

Isoseismal Map of the Jenolan Caves Earthquake
New South Wales - 18 October 1872

Robert Wilson writing in the Canberra Times of 12 May 1990 about a miner who made his fortune from the *Star of Hope* goldmine included the following paragraph:

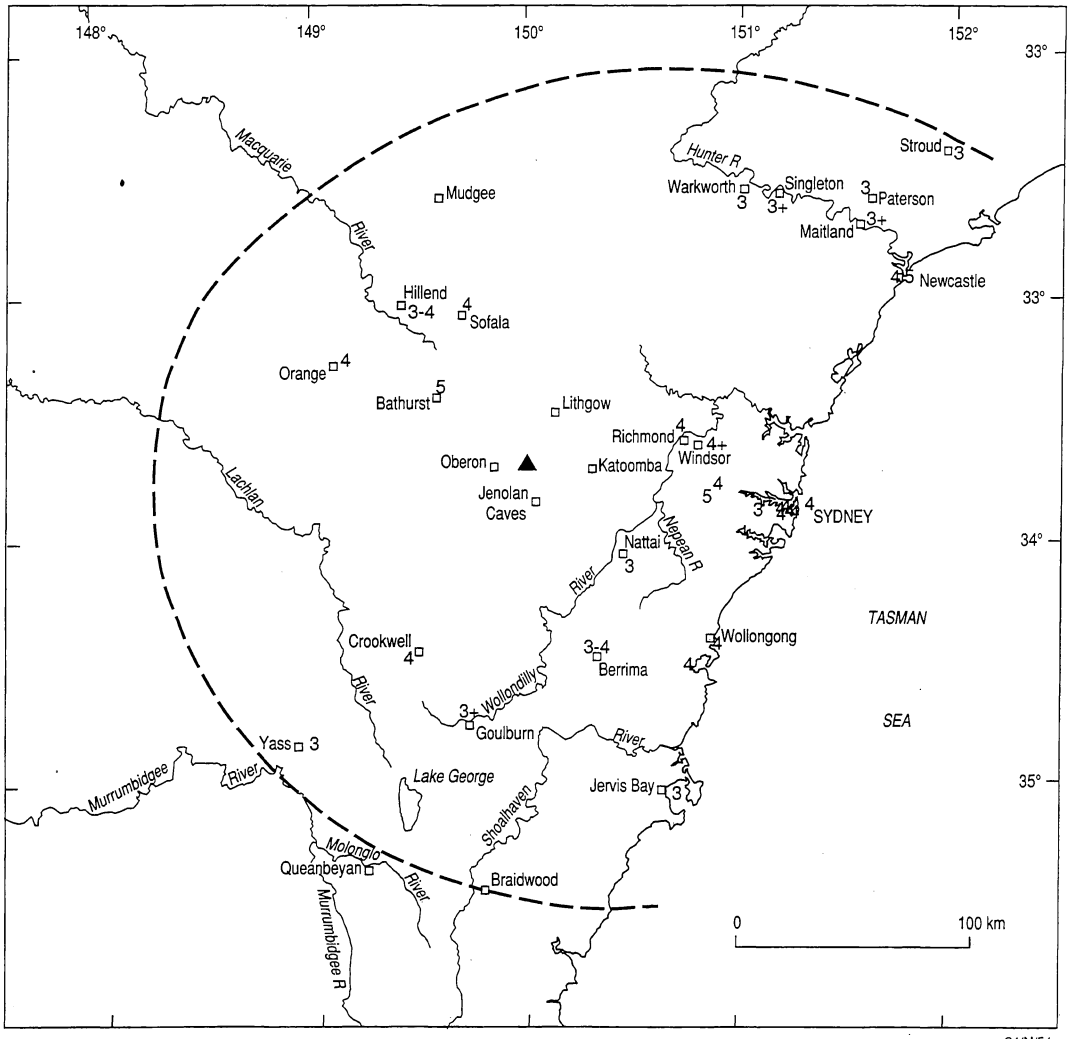
> By a strange coincidence, at about 7 pm on the same evening, October 19, 1872 (wrong day -Ed.) the whole of the Hill End gold field had been rocked by a severe earthquake, causing people to flee from their homes in panic.

Contemporary newspaper reports indicate that pedestrians in downtown Sydney had trouble walking such was the severity of shaking there, and in Bathurst the startled residents fled from their homes into the street. The intensity was no less severe in Newcastle where people were alarmed and panes of glass in a skylight of Rouse's Hotel reportedly fell and broke. One prisoner in the Goulburn Gaol claimed he had experienced several earthquakes in New Zealand but none as distinct as this one.

The shaking was felt over an approximately circular area of radius 180 km, but there was surprisingly no damage. The lack of high intensities and not-felt reports makes locating the epicentre difficult but the centre of the felt area is in the vicinity of Jenolan Caves and Oberon so we have tentatively assigned this is as the epicentre.

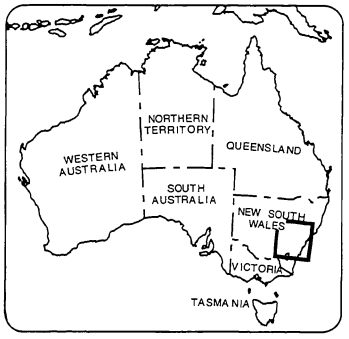
Contributors Cynthia Hunter (1991) devoted two pages of her book to this earthquake and made available her unpublished collection of Newspaper clippings. Dr David Palfreyman unearthed additional newspaper references. Kevin McCue drew up the isoseismal map.

ISOSEISMAL MAP OF THE JENOLAN CAVES EARTHQUAKE, NSW
18 OCTOBER 1872



DATE: 18 OCTOBER 1872
TIME: 18:50 GMT
MAGNITUDE: 5.3
EPICENTRE: 33.7S, 150.0E
DEPTH: 15 km

▲ *Epicentre*
IV *Zone intensity designation*
4 *Earthquake felt (MM)*
0 *Earthquake not felt*



Isoseismal map of the Southwest Tasmania earthquake 3 February 1880

This earthquake was felt throughout Tasmania in the afternoon of 3 February 1880 but not on King or Flinders Islands. Michael-Leiba, (1989) compiled this map from the accounts in Local newspapers; the Mercury, the Launceston Examiner, the Devon Herald, Tasmanian Mail and Cornwall Chronicle.

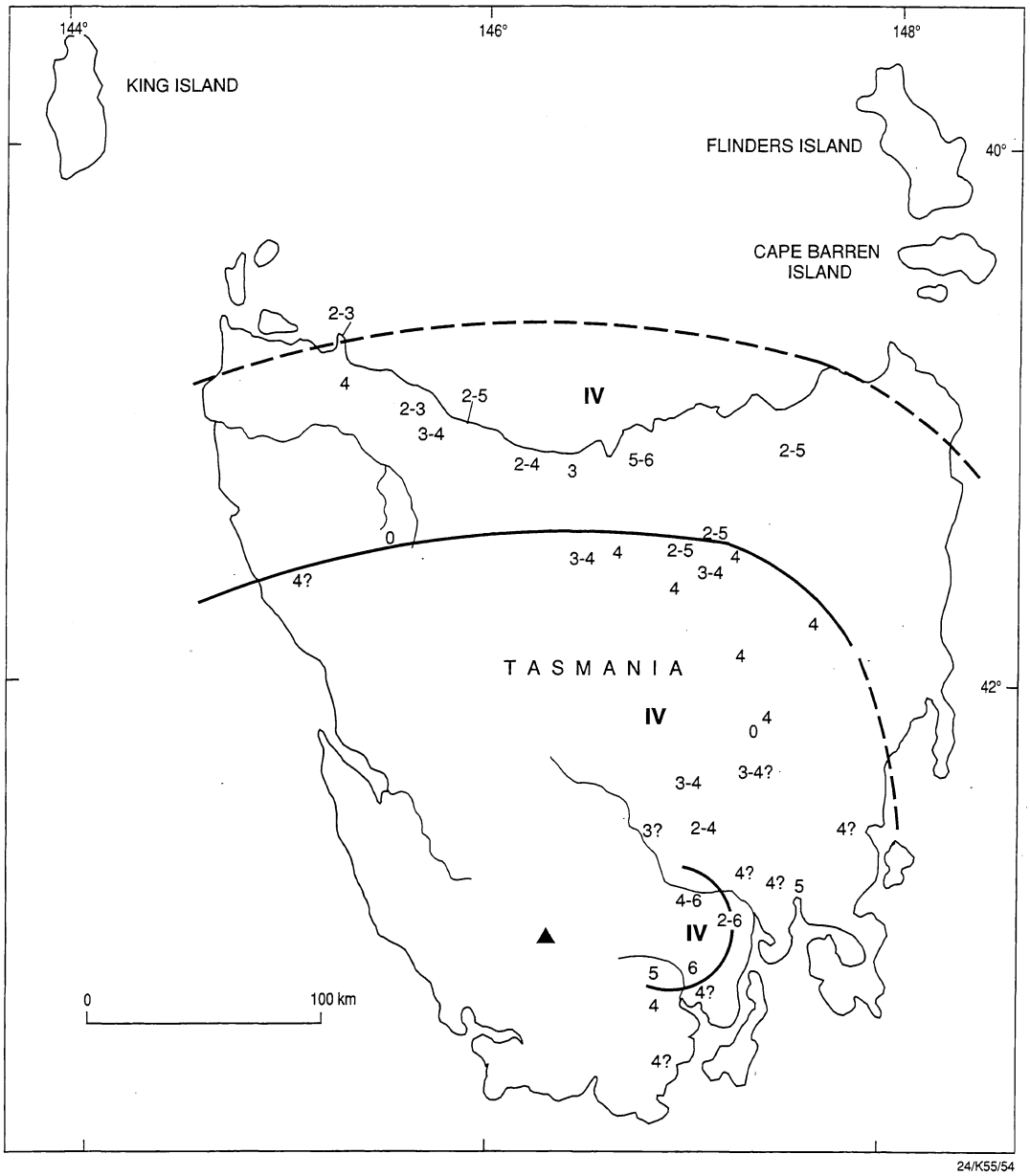
She records " The earthquake was felt most strongly in the Huon and Derwent valleys. In New Norfolk it shook goods off shop shelves and glass from windows. In Franklin, plaster was shaken from the ceiling of two or three buildings, and a chimney at the Kent Hotel was cracked. There was one instance of bells being set ringing and one or two cases of crockery being displaced and furniture 'stirred', causing the residents to run outside.

"The effects appeared very site dependent at Emu Bay, because people whose houses were close to the igneous rocks on the northwest shores of the bay were not troubled by the earthquake, whereas those on sedimentary rocks to the southwest were terrified."

The epicentral location is poorly defined ± 50 km according to the author, and the magnitude equivalent ML 5.5 also uncertain although the reader should compare this map with that for the January 1958 Queenstown earthquake, the later earthquake is the smaller of the two from its correspondingly smaller felt area.

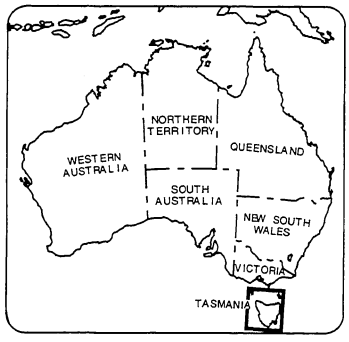
Contributors: The map was compiled by Dr Marion Michael-Leiba BMR.

ISOSEISMAL MAP OF THE SOUTHWEST TASMANIA EARTHQUAKE
3 FEBRUARY 1880



DATE: 3 FEBRUARY 1880
TIME: 0630 GMT
MAGNITUDE: 5.5 Ml
EPICENTRE: 43.0°S, 146.4°E

▲	*Epicentre*
IV	*Zone intensity designation*
5	*Earthquake felt (MM)*
0	*Earthquake not felt*



Isoseismal map of the Cape Barren Island earthquake Tasmania - 13 July 1884

This was the third largest event in an amazing sequence of earthquakes that lasted from 1883 to 1892 (Shortt 1885, Biggs 1886, Hogben 1892, Ripper, 1963 and Michael-Leiba, 1989). During 1884, more than 900 earthquakes were felt in northeastern Tasmania. This earthquake at 2.48 am local time caused minor damage in Launceston and was felt throughout Tasmania and in parts of southeastern Victoria and New South Wales.

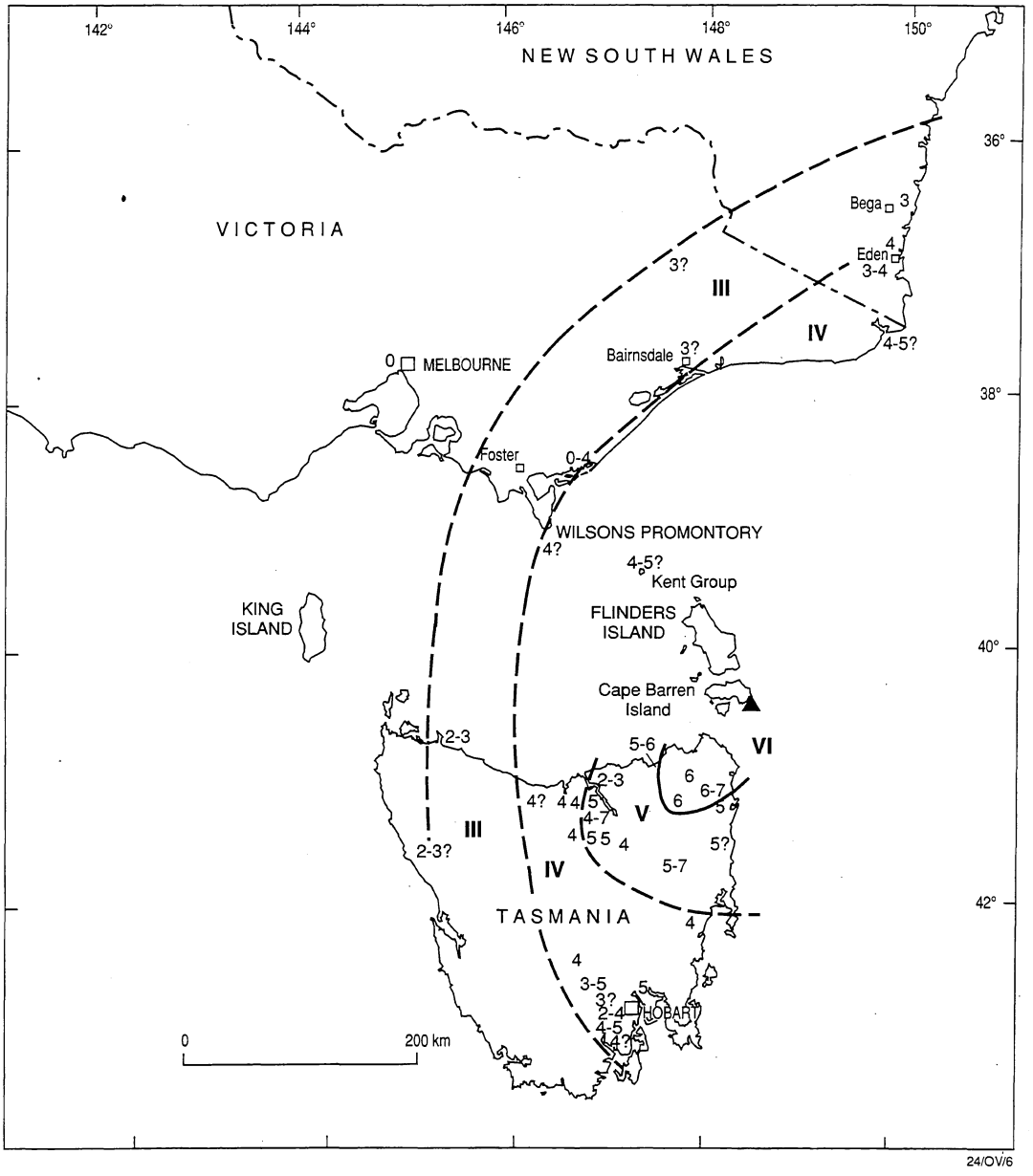
The isoseismal map was compiled by Michael-Leiba (1989) from the contemporary scientific papers by Shortt (1895) and Biggs (1896), the report of the Committee on Seismological Phenomena in Australasia (1892), lighthouse keepers' logs and reappraisal of original newspaper reports from the Mercury, the Launceston Examiner, the Devon Herald, the Argus and the Sydney Morning Herald.

The earthquake was felt as far north as Bega NSW and throughout most of Tasmania, and southeast Victoria. It was not felt in Melbourne and not reported felt on King Island.

The magnitude of ML 6.2 was computed by Michael-Leiba (1989) from the amplitude recorded by Biggs (1896) on his early model seismoscope.

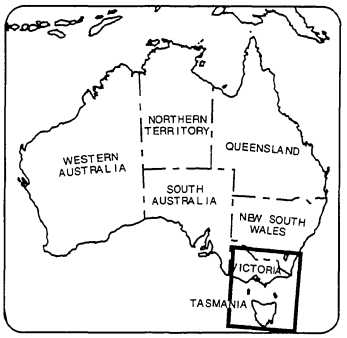
Contributors: The map was compiled by Dr Marion Michael-Leiba BMR.

ISOSEISMAL MAP OF THE CAPE BARREN ISLAND EARTHQUAKE, TASMANIA
13 JULY 1884



DATE: 13 JULY 1884
TIME: 0355 GMT
MAGNITUDE: 6.2 ML, 6.4 MI
EPICENTRE: 40.5°S, 148.5°E

▲ *Epicentre*
IV *Zone intensity designation*
5 *Earthquake felt (MM)*
0 *Earthquake not felt*



Isoseismal map of the Tasman Sea earthquake
Tasmania - 12 May 1885

From contemporary accounts assembled by Ripper (1963) and Michael-Leiba (1989) the activity of the 1883 - 1892 swarm had decreased by 1885 and only about 200 earthquakes were felt in that year, this the largest.

Michael-Leiba states 'In Launceston, damage occurred in and near the Central Business district, with people rushing out into the streets, chimneys being damaged, windows cracked, a wall cracked, a couple of cases of falling plaster and several instances of objects being thrown down and damaged. At St Andrew's Church the finial of one of the pinnacles fell to the ground.

In Hobart a large clock over a shop stopped, bells in some of the offices were set ringing, and the St David's Cathedral bell is said to have tolled twice.

At Goulds Country the earthquake shook limbs off trees and frightened everybody out of their houses.'

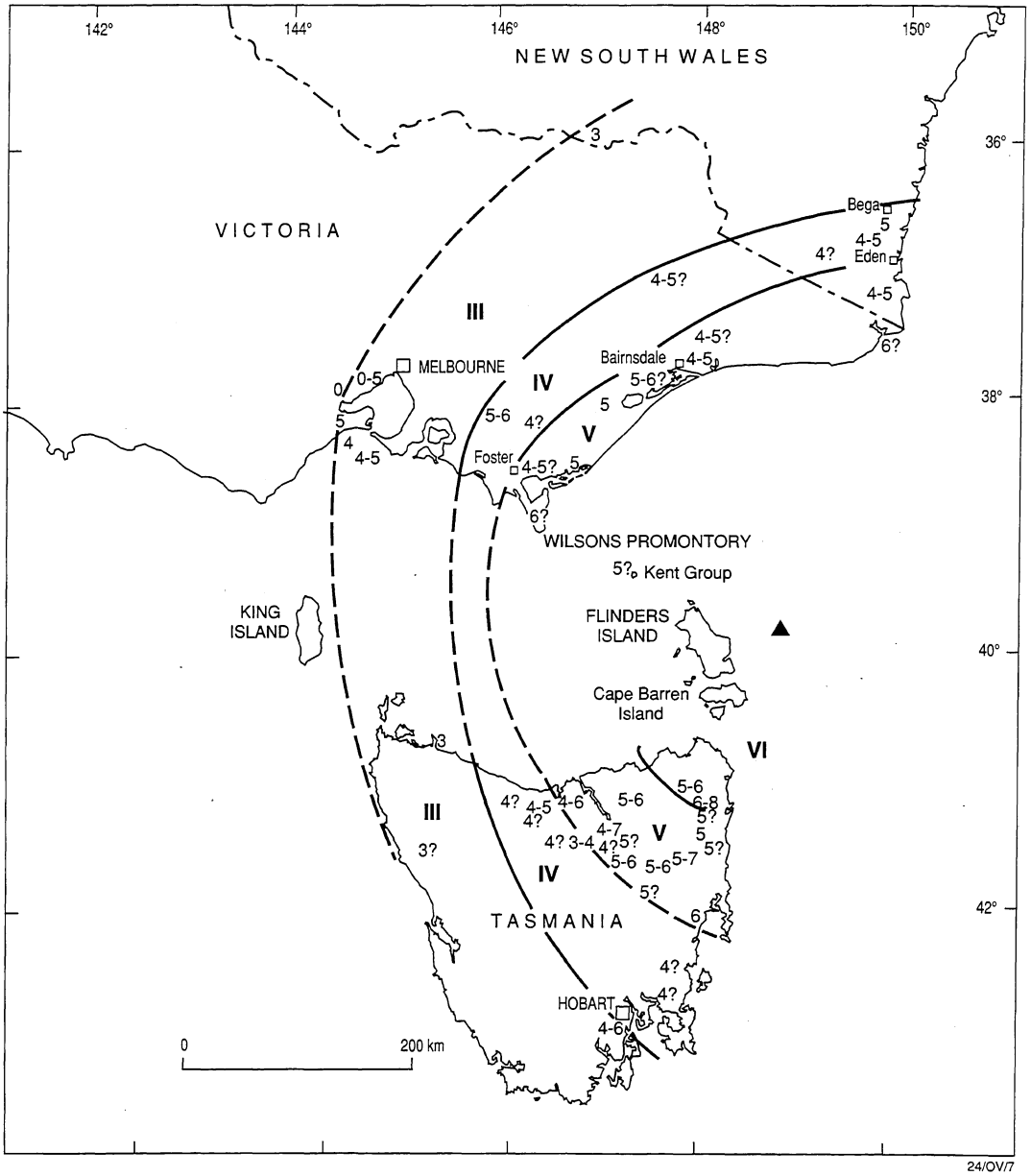
Captain Shortt (1886) reported that the earthquake was 'the heaviest experienced since September, 19 1884, and the great distance the shock was felt from the centre of disturbance shows it to be as strong as the very severe one of July 19th last year. He continued that it was 'felt very severely at the Kent Group lighthouse about a dozen panes of glass have been broken from the commencement.'

The earthquake was felt throughout Tasmania and in southeast Victoria and New South Wales, slightly more widely than the 13 July 1884 earthquake and rated accordingly by Michael-Leiba at magnitude MI 6.8. Shortt reported that the shock was felt at Melbourne and 'as far north as Candelo, which is 258 miles south of Sydney.'

The equivalent Richter magnitude Michael-Leiba computed from the amplitude recorded on Biggs' seismoscope was ML 6.5.

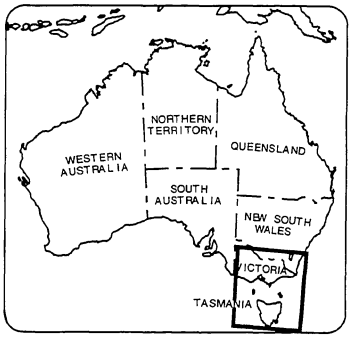
Contributors: The map was compiled by Dr Marion Michael-Leiba BMR.

ISOSEISMAL MAP OF THE TASMAN SEA EARTHQUAKE, TASMANIA
12 MAY 1885



DATE: 12 MAY 1885
TIME: 2337 GMT
MAGNITUDE: 6.5 ML, 6.8 MI
EPICENTRE: 39.9°S, 148.9°E

▲ *Epicentre*
IV *Zone intensity designation*
5 *Earthquake felt (MM)*
0 *Earthquake not felt*



Isoseismal map of the Kapunda earthquake
South Australia - 28 September 1886

The Advertiser, The Chronicle, The Kapunda Herald and *The Bunyip* all reported this earthquake. The experience of people at Burra is typical for small, close shallow earthquakes in Australia - the shaking was of short duration and quite strong but not sufficient to cause other than minor non-structural damage. From *The Kapunda Herald* (Friday October 1st) we read:

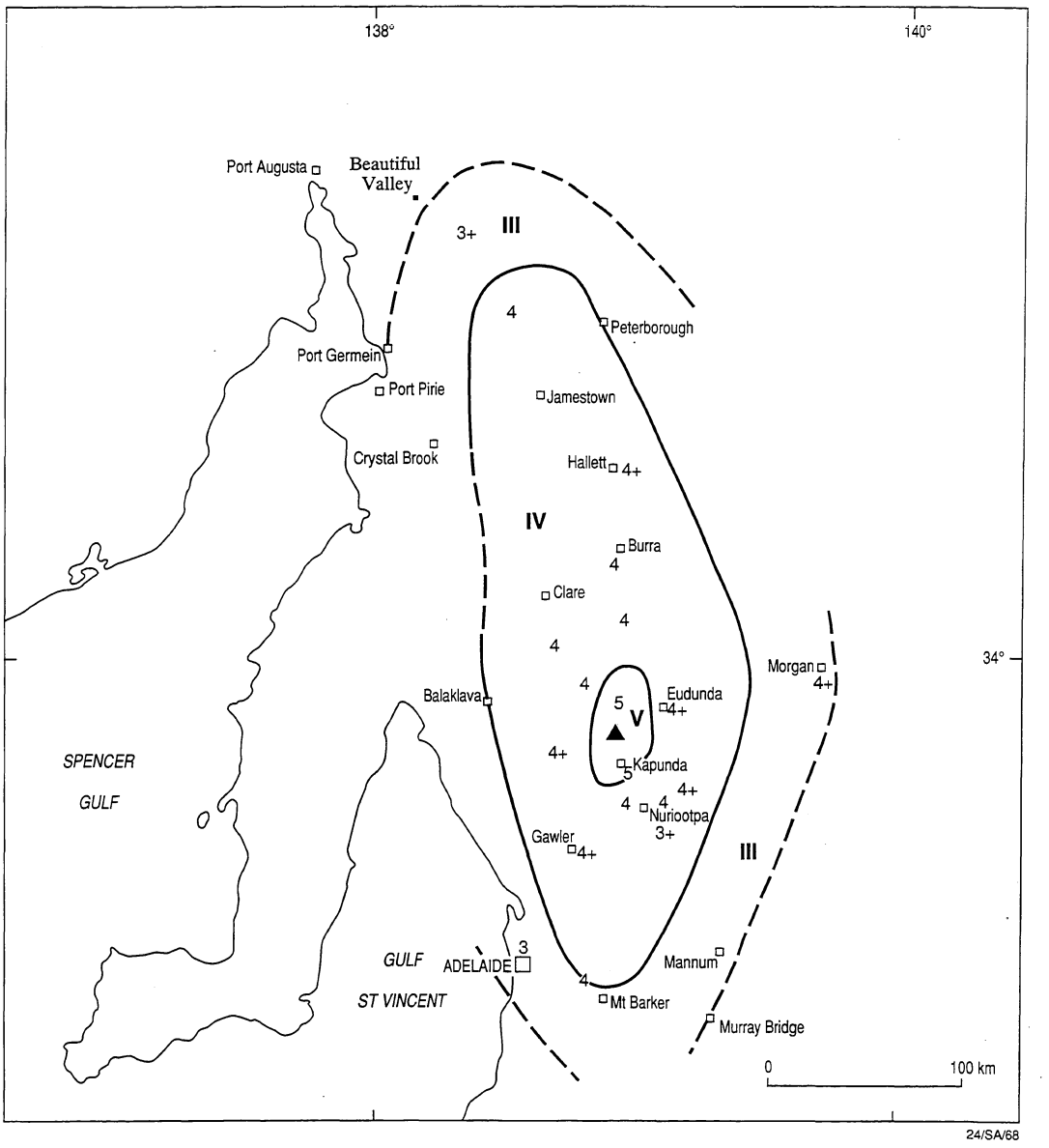
> 'Earthshock - On Wednesday last at about 4 a.m. a shock of earthquake was experienced in Burra, as well as the surrounding district. The taller (? - Ed.) buildings perceptibly shook and glasses were set rattling and windows shaking for several seconds.'

At Morgan, the earthquake was also felt on the river steamers and was reported to have been 'the most severe shock ever felt by any of the people here.' An aftershock was also felt at about 6 a.m., so Morgan must have been close to the epicentre.

Contributors: This map was compiled by Kevin McCue. The felt reports which enabled construction of this isoseismal map were collected by Ms Alison McArdle of the Sutton Institute, SADME, on special contract to BMR.

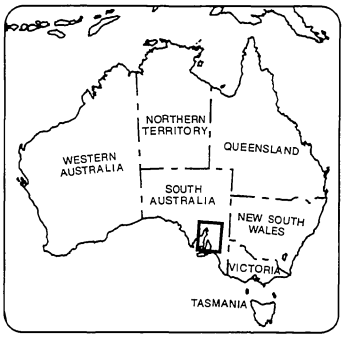
ISOSEISMAL MAP OF THE KAPUNDA EARTHQUAKE, SOUTH AUSTRALIA

28 SEPTEMBER 1886



DATE: 28 SEPT 1886
TIME: 18:45 GMT
MAGNITUDE: 4.5 ML
EPICENTRE: 34.25°S, 138.90°E

△	*Epicentre*
IV	*Zone intensity designation*
4	*Earthquake felt (MM)*
0	*Earthquake not felt*



Isoseismal map of the Mount Bryan earthquake
South Australia - 16 April 1887

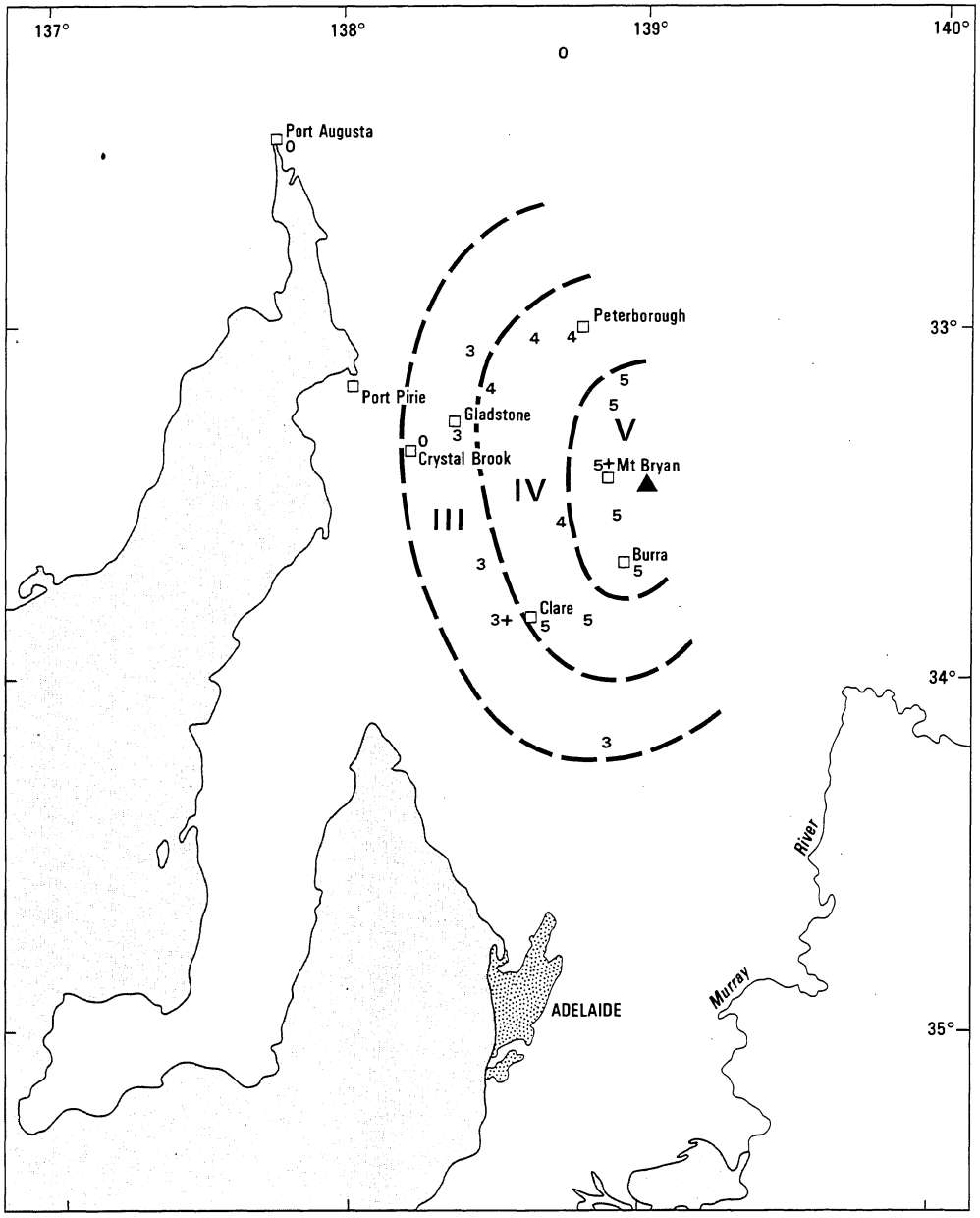
Among the reports of an earthquake shock telegraphed to *The Register* on 17 April 1887 was the following from Hallett:

> 'A very severe shock of earthquake was felt here last night about 10.30, lasting fully ten seconds. It appeared to travel from north-west to south-east. At Mount Bryan Hotel it shook some plaster off the ceiling. I am informed that another slight shock was felt this morning at Booborowie between 5 and 6.'

Isoseismal maps of later earthquakes in the Flinders Ranges in 1965 and 1971 (Everingham & others, 1982) also exhibit this strong north-south elongation of the isoseismals, parallel to the fold axis of the ranges.

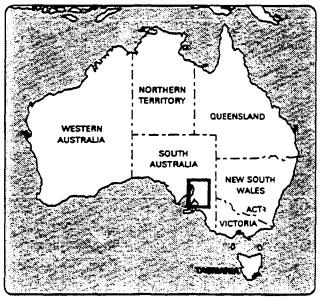
Contributors: This map was compiled by Kevin McCue. The felt reports which enabled construction of this isoseismal map were collected by Ms Alison McArdle of the Sutton Institute, SADME, on special contract to the BMR.

ISOSEISMAL MAP OF THE MT BRYAN EARTHQUAKE, SOUTH AUSTRALIA, 16 APRIL 1887



DATE : *16 April 1887*
TIME : *13:10 UT*
MAGNITUDE : *4.5 ML (I)*
EPICENTRE : *33.5°S, 139.0°E*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/SA/28

Isoseismal map of the Eyre Peninsula earthquake
South Australia - 16 April 1887

The 2 November 1959 earthquake was previously thought to have been the largest to have occurred on the Eyre Peninsula in the period of written history. Comparison of the felt areas of the 1887 and 1959 (Rynn and others, 1987) events shows that the earlier earthquake was by far the larger of the two and approximately the same size as the 1954 earthquake. Sir Charles Todd (1918), the South Australian Government Astronomer, wrote
the following summary regarding this earthquake:

> 'On the morning of the 17th, a shock was felt at Adelaide about 7.40 am. This shock was somewhat severe, and was felt over a large area of country, including the northern areas, Yorkes Peninsula, and over Eyre's Peninsula as far west as Streaky Bay.'

The Adelaide Observer of 23 April 1887 published the following telegraph from a Yaranyacka correspondent:

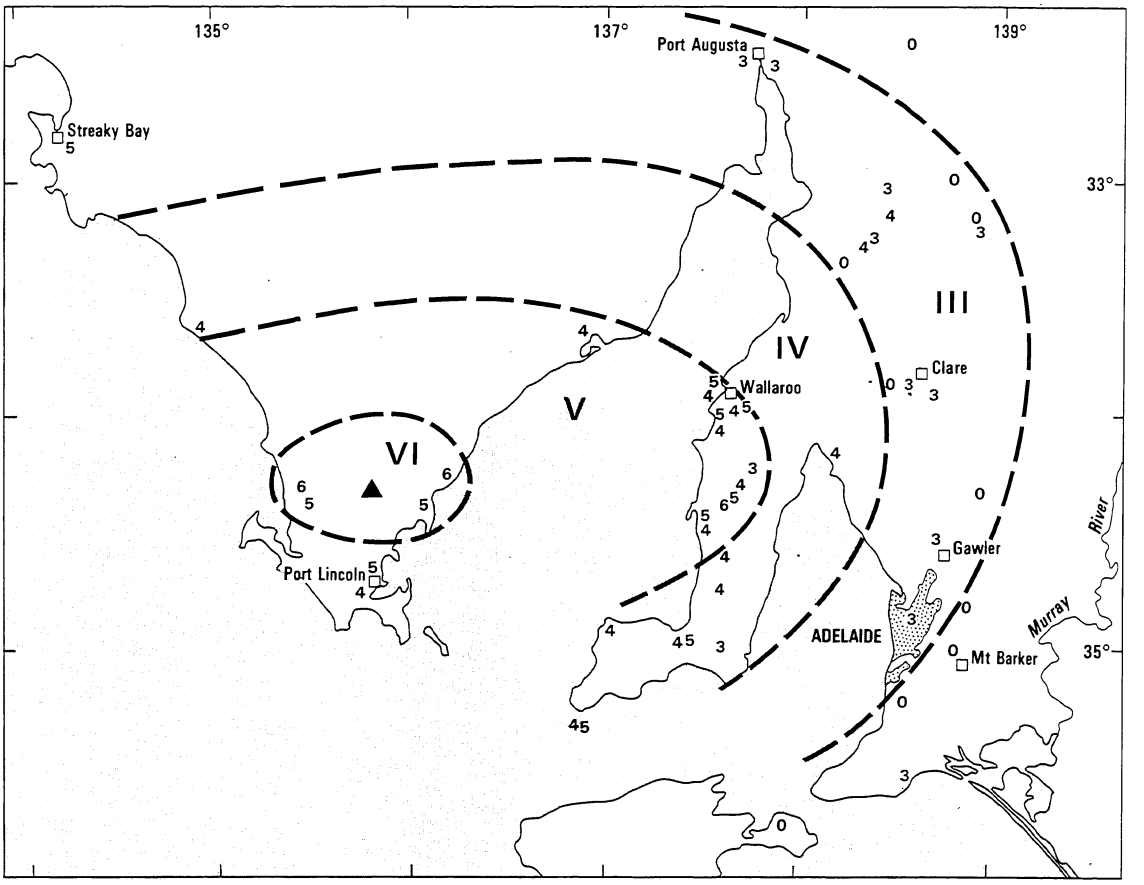
> 'A severe shock of earthquake was felt here yesterday about 7.40 am. It appeared to be travelling from north to south nearly. The ground seemed to heave up. Women and children were terrified, and people were nearly thrown off their legs. Buildings cracked, and the chimney of the Burrawing Hotel had a narrow escape of being thrown down. The rumbling sound lasted some time going east of south. After the main shock slight shocks were felt for some time.'

The Chronicle of 30 April 1887 printed the following telegraph from Tumby:

> 'The earthquake shock on Sunday appears to have been more severe further inland. It was felt some 30 miles south of this place, though no serious damage is reported, the greatest being the cracking of one or two chimneys. Two other shocks were felt during Tuesday night, but they were not nearly so severe as the first. The whole affair has put the neighbourhood more or less in a state of fear. Plaster from several houses is reported to have fallen on Sunday and the trees swayed beneath the shock'.

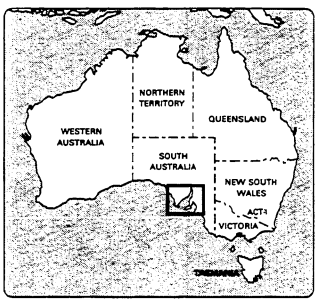
Contributors: The map was compiled by Kevin McCue. The felt reports which enabled construction of this isoseismal map were collected by Ms Alison McArdle of the Sutton Institute, SADME, on special contract to the BMR.

ISOSEISMAL MAP OF THE EYRE PENINSULA EARTHQUAKE, SOUTH AUSTRALIA, 16 APRIL 1887



DATE : *16 April 1887*
TIME : *22:10 UT*
MAGNITUDE : *5.7 ML (I)*
EPICENTRE : *34.3°S, 135.8°E*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



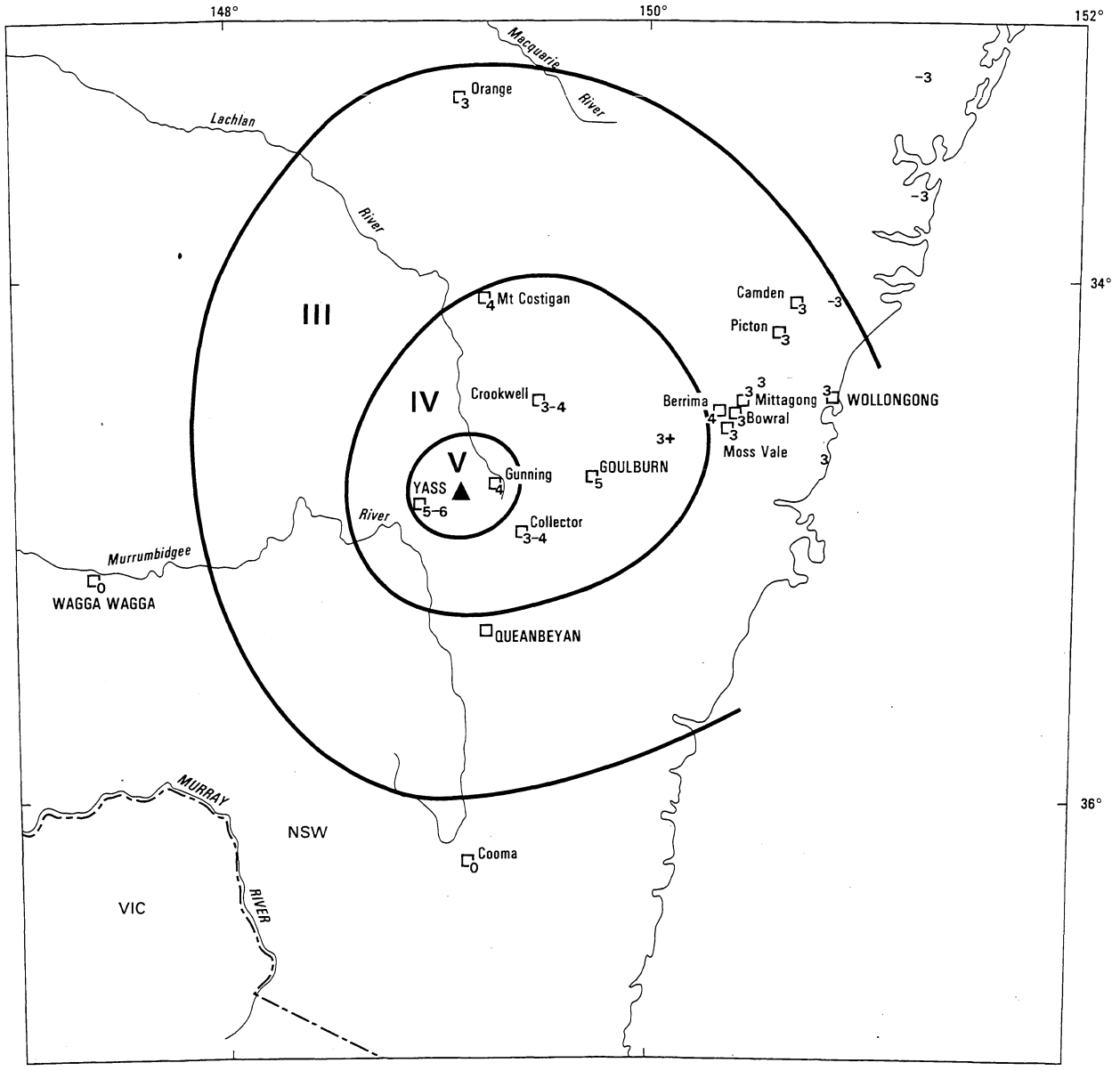
Isoseismal map of the Dalton earthquake
New South Wales - 5 July 1888

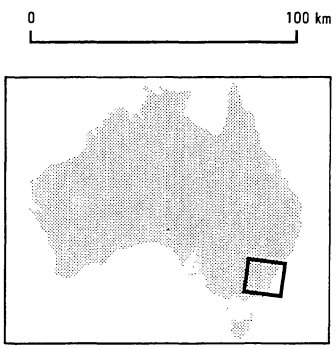
Less than two years after a magnitude ML 5.5 earthquake struck this rural area of New South Wales (Rynn & others, 1986), another moderate sized earthquake occurred. The following description is from McCue & others (1989):

> Cleary (1967) followed Burke-Gaffney (1952) in assigning this earthquake to the Robertson-Bowral region of NSW though the limited number of newspaper reports, 22 in all, indisputably point to Yass and Gunning, 100 km to the west, as being the towns closest to the epicentral region.
>
> The only damage report emanated from Yass, where the walls of a row of houses were reported to be split by shock (The Yass Courier, 10 July 1988), the type and quality of building materials were not specified.
>
> The earthquake was felt as far away as the northern suburbs of Sydney and at Orange, but not at Cooma or Wagga, so it was smaller than the 1886 earthquake described by Denham in Rynn & others (1986) and the later 1934 event discussed by McCue below. The isoseismal map presented here in Figure 1 is not well constrained but a magnitude of ML (I) 5.3 has been derived from the radius of perceptibility (McCue, 1980).

Contributors: This map was compiled by Kevin McCue.

ISOSEISMAL MAP OF THE DALTON- GUNNING EARTHQUAKE, NEW SOUTH WALES, 5 JULY 1888





DATE : 5 JULY 1888
TIME : 20:15:00 UT
MAGNITUDE : 5.3 ML (I)
EPICENTRE : 34.8°S 149.1°E
DEPTH : SHALLOW

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

24/N/19

Isoseismal map of the Robertstown earthquake
South Australia - 12 February 1889

A rather severe earthquake shook the South Australian colony on the afternoon of Tuesday 12 February 1889 at about 16:35 local time (07:25 GMT). The earthquake was felt over a wide area, extending from Whyte Yarcowie in the north to the Mount Lofty Hills in the south and from St. Vincent's Gulf in the west to the River Murray in the east.

Details pertaining to the earthquake were extracted from relevant newspapers in the South Australian Public Library and in the National Library of Australia. Consequently an isoseismal map was constructed using 50 felt reports. From this map, the local magnitude was determined to be 4.9 (using the empirical relationship between magnitude and the radius of perceptibility, Rp (McCue, 1980) and the epicentre was located near Robertstown (34.0°S, 139.0°E). This agrees well with the epicentre computed by Burke-Gaffney (1951) at (33.9°S, 139.0°E).

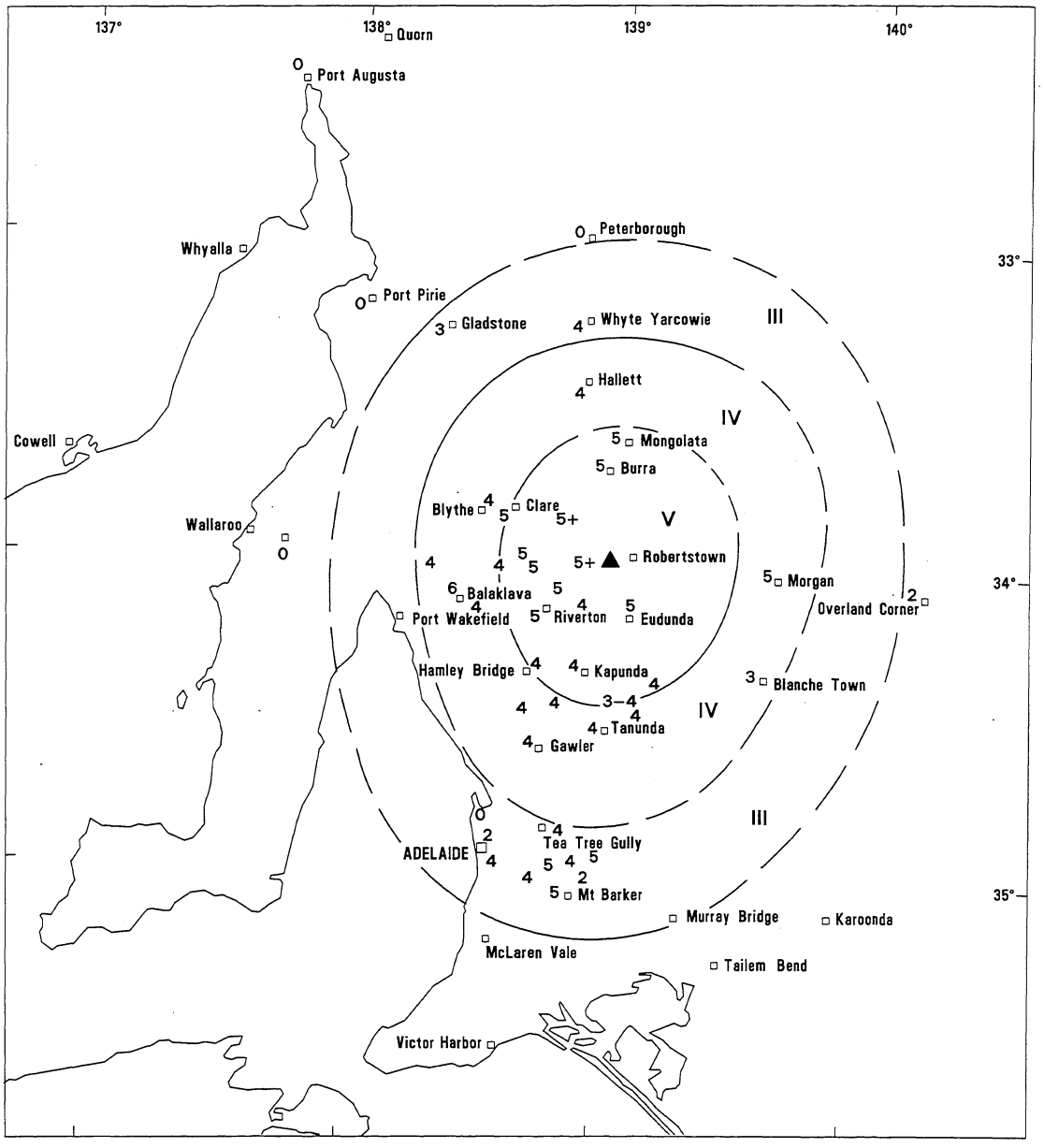
The earthquake was the most severe known for many years, and "caused considerable alarm to many nervous and guilty mortals" in Farrel's Flat (*The Kapunda Herald*, 19 February 1889). In many centres, the earthquake was sufficiently pronounced to shake plaster from ceilings, to cause floors and walls to vibrate audibly and to displace furniture and other loose articles. No damage of any moment to buildings was reported. At Mt Templeton, the earthquake was preceded by a severe foreshock which collapsed a chimney through a ceiling (Kapunda Herald, 19 February 1889). There were no reports of aftershocks.

The Robertstown earthquake was fractionally larger than the 1883 event at Mount Barker (ML 4.7), and significantly smaller than the Beachport event of 1897 (ML 6.5). Thus the Robertstown earthquake is the second largest known earthquake to have occurred in South Australia between 1836 and 1897.

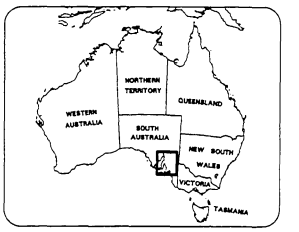
It is worth noting, that prior to the Standard Time Act of 1895, Adelaide was 9 hours 50 minutes ahead of Greenwich, England. Smaller settlements isolated from capital centres are suspected to have adopted a time based on their longitude. Thus `felt reports` containing times reported from such small towns should be adjusted according to their longitude.

Contributors: Robert Corkery and Kevin McCue investigated the felt reports and drew up this isoseismal map.

ISOSEISMAL MAP OF THE ROBERTSTOWN EARTHQUAKE, SOUTH AUSTRALIA, 12 FEBRUARY 1889



DATE: 12 February 1889
TIME: 06:45 UTC
MAGNITUDE: 4.9 ML (I)
EPICENTRE: 34.0°S 139.0°E



▲ *Epicentre*
IV *Zone intensity designation*
4 *Earthquake felt (MM)*
0 *Earthquake not felt*

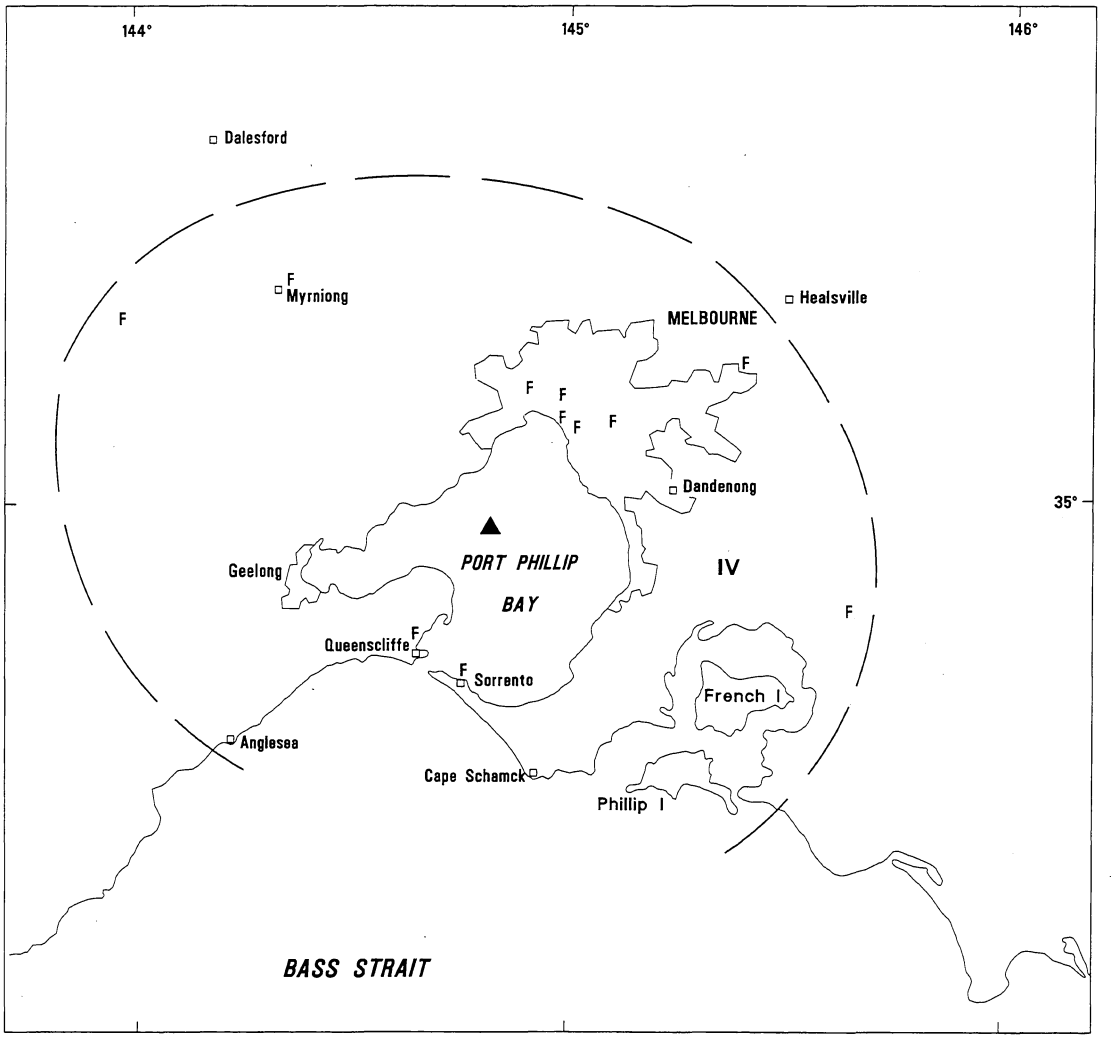
24/SA/34

Isoseismal map of the Port Phillip Bay earthquake Victoria - 7 June 1891

Contemporary reports listed places where the earthquake was felt without enough details to assign an intensity. The resultant epicentre and magnitude must be considered preliminary until more details are unearthed but because the earthquake is important for hazard estimates, being so close to a major city, it was decided to publish this preliminary map.

Contributors: Kevin McCue investigated the felt reports and drew up this isoseismal map from BMR archival material.

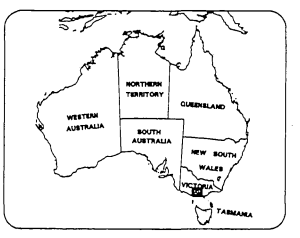
ISOSEISMAL MAP OF PORT PHILLIP BAY EARTHQUAKE, VICTORIA
7 JUNE 1891



0 50 km

DATE: 7 June 1891
TIME: 04:24 GMT
MAGNITUDE: 4.5 ML (I)
EPICENTRE: 38.1°S 144.8°E

▲ *Epicentre*
IV *Zone intensity designation*
F *Earthquake felt – intensity not reported*



24/J55/30

The Tasman Sea earthquake
26 January 1892

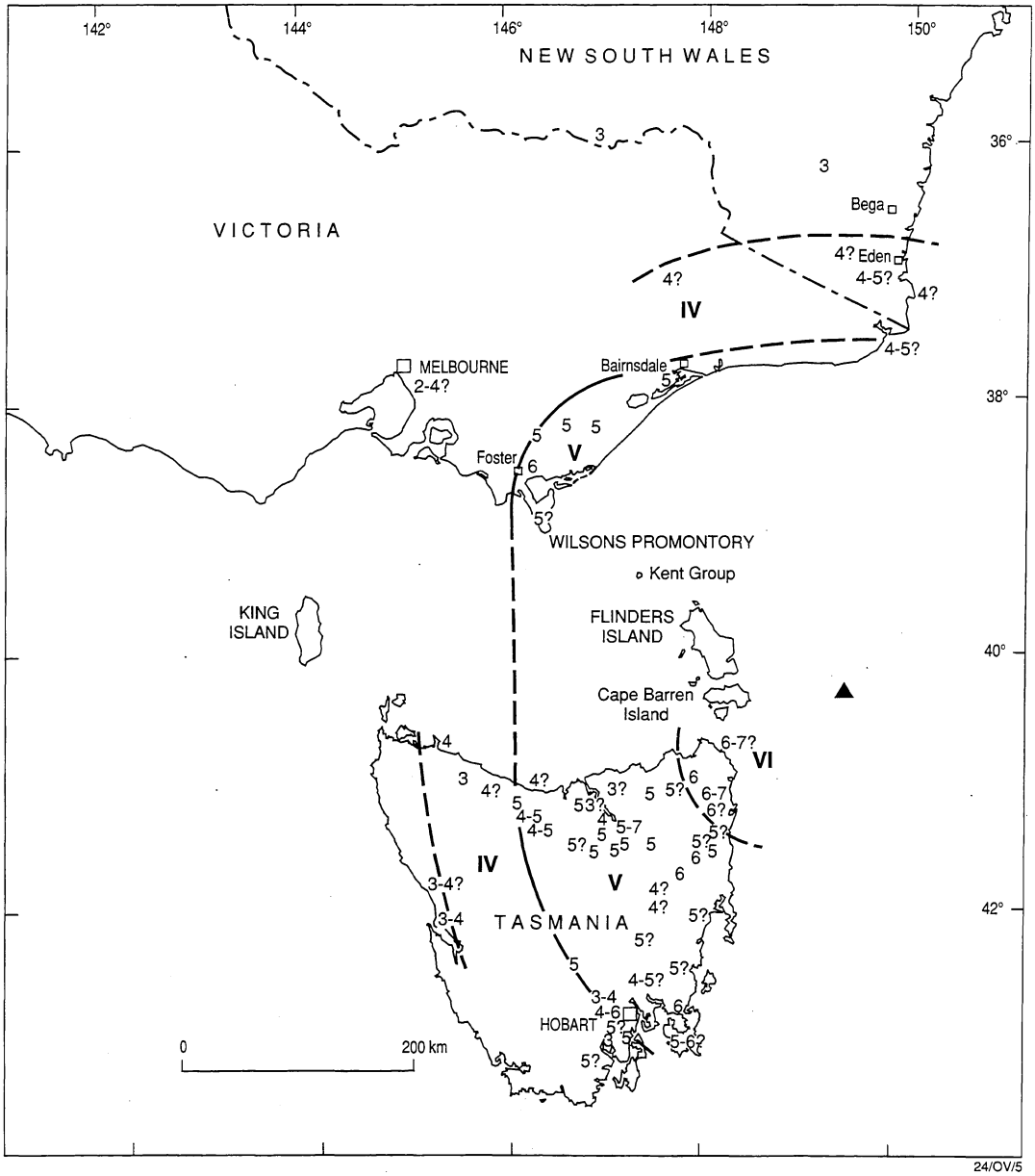
This is another of the events studied by Michael-Leiba (1989) 'This earthquake at 2.48 am local time on 27 January 1892 occurred at the end of the 1883 - 1892 swarm when the activity had dwindled to about four events per year. It was however the largest event of the series.'

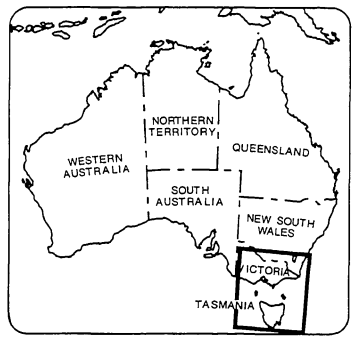
> In Launceston the tremor woke many people and a number jumped out of bed in alarm, some running out into the street. The shocks were felt more strongly by people living on the hills...There were several instances of falling chimneys, ornaments and plaster from walls. However the greatest damage was at the General Hospital where a chimney fell. The bricks landed in Dr Jermyn's room and crashed onto the verandah greatly alarming the patients 'some of whom fainted and others went into fits, according to the north-west Post of January 28, 1892.'
>
> In Hobart, Hogben (1892) reported that the earthquake stopped clocks, overturned flowerpots, threw down bowls, rang bells, rocked beds, rattled windows and dislodged rocks.
>
> The maximum intensity in Victoria was reported from Foster just north of Wilson's Promontory, where the Age stated that 'the chimney lamps at the Royal Hotel as well as the crockery and glassware at Ridgway's Store, were shaken down and the residents were in a state of fear. It appeared as if the town was going to be levelled.'

Michael-Leiba suggests that the earthquake may indeed have been a doublet with individual events separated by 5 to 10 minutes. It was the largest known earthquake in eastern Australia.

Contributors: This map was compiled by Dr Marion Michael-Leiba.

ISOSEISMAL MAP OF THE TASMAN SEA EARTHQUAKE, TASMANIA
26 JANUARY 1892





DATE: 26 JANUARY 1892
TIME: 1648 GMT
MAGNITUDE: 6.9 MI
EPICENTRE: 40.4°S, 149.5°E

▲	*Epicentre*
IV	*Zone intensity designation*
5	*Earthquake felt (MM)*
0	*Earthquake not felt*

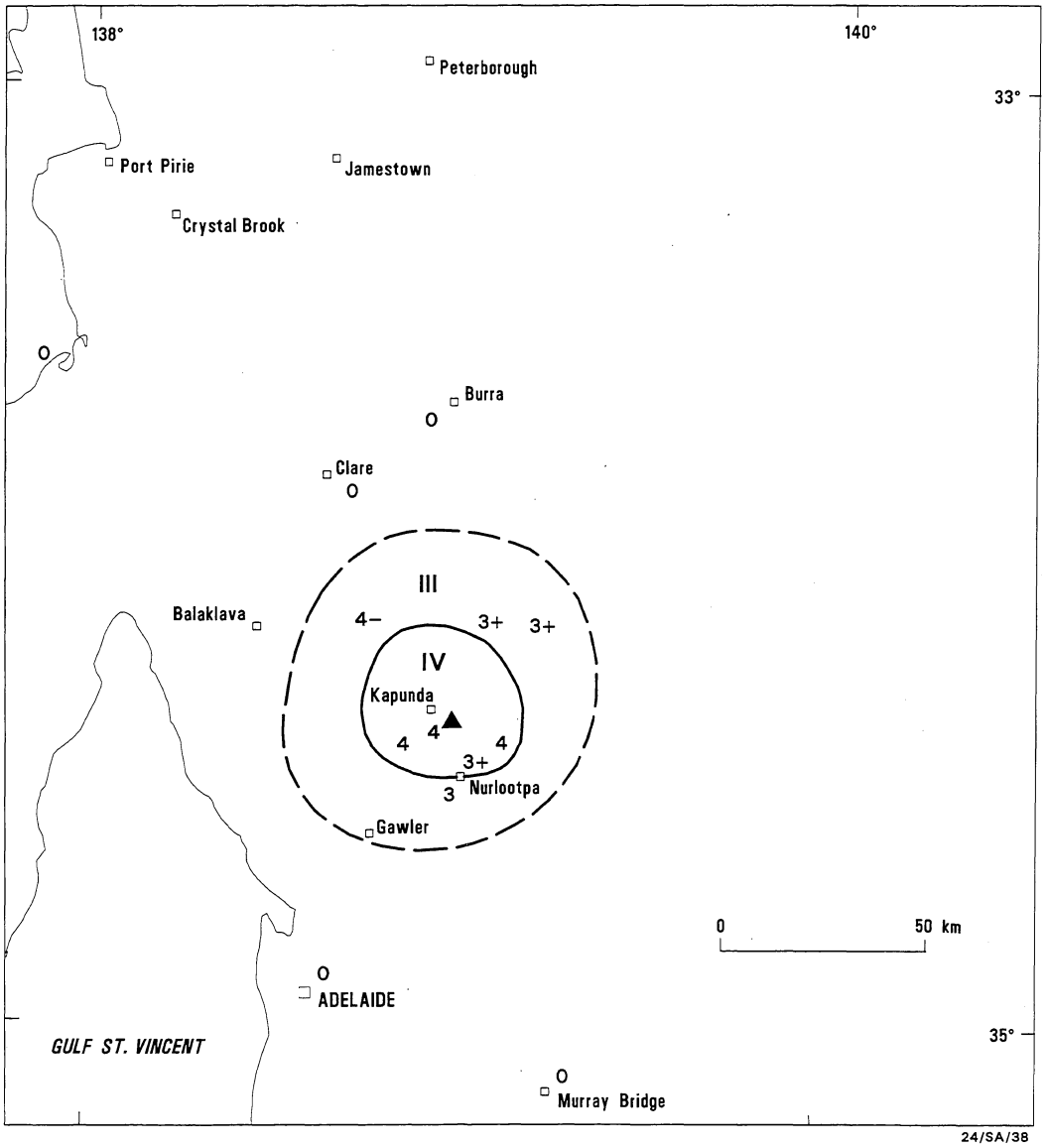
Isoseismal map of the Kapunda earthquake
South Australia - 13 August 1893

The Kapunda Herald of 13 August 1893 reported on the earthquake effects at various towns including:

> Truro A very distinct shock of earthquake was felt here just before noon to-day, accompanied by a loud rumbling noise, lasting about 10 - 15 seconds. The service was in progress at the Truro Church at the time and the majority of the people fancied there was a bolt outside as the noise sounded something like a heavy vehicle going at great speed.
>
> Riverton On Sunday morning a shock of earthquake was felt. It was accompanied by a distinct rumbling sound like that caused by a heavy wagon passing along a macadamised road.

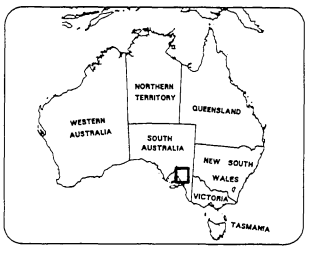
Contributors: This map was compiled by Katherine Malpas, Flinders University SA and the South Australian Department of Mines & Energy.

ISOSEISMAL MAP OF KAPUNDA EARTHQUAKE, SOUTH AUSTRALIA
13 AUGUST 1893



DATE: 13 AUGUST 1893
TIME: 02:10 GMT
MAGNITUDE: 3.6 ML (I)
EPICENTRE: 34.38°S 138.97°E

▲	*Epicentre*
IV	*Zone intensity designation*
3	*Earthquake felt (MM)*
0	*Earthquake not felt*



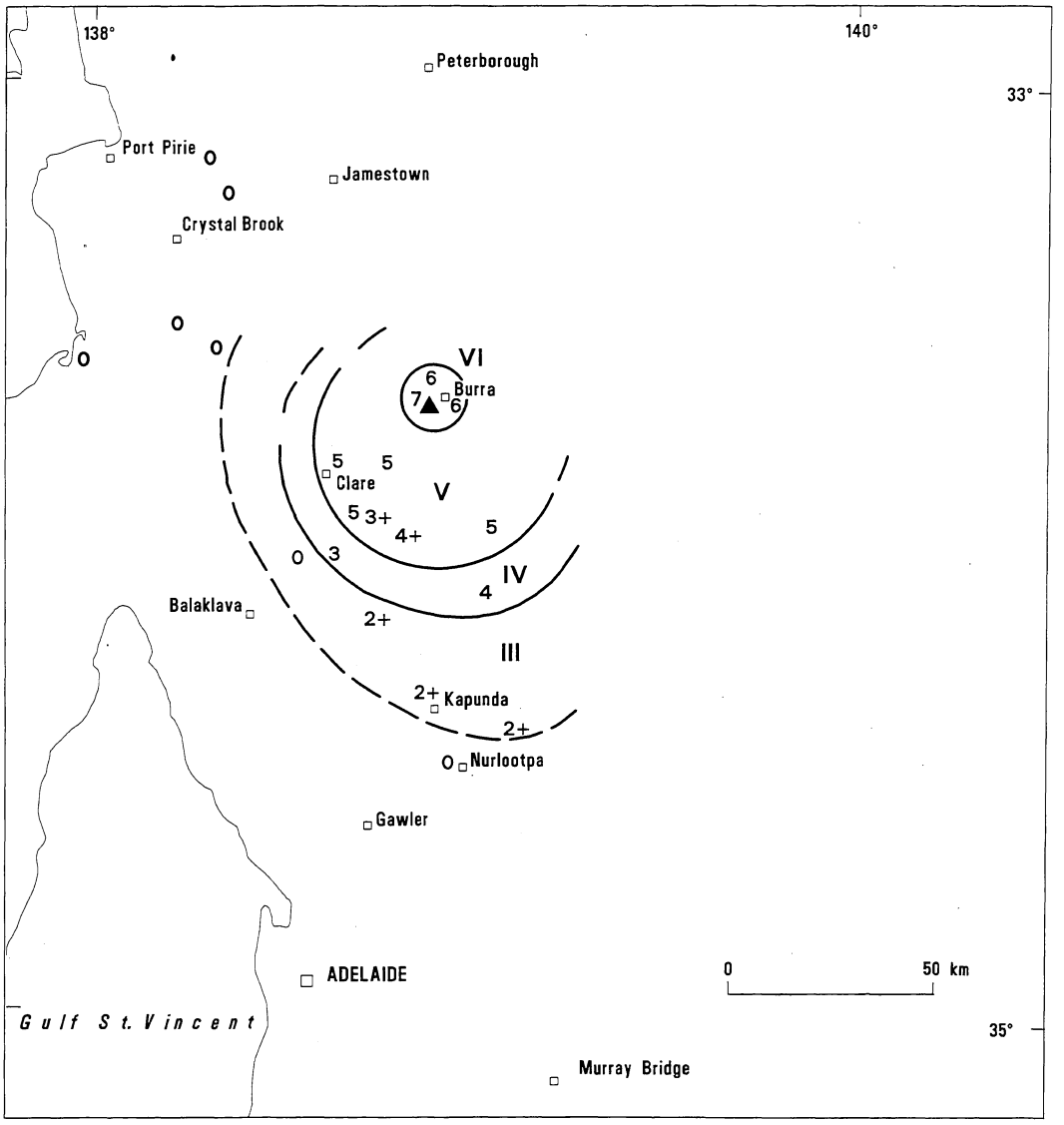
Isoseismal map of the Burra earthquake
South Australia - 22 August 1896

According to *The Burra Record* of Wednesday 26 August 1896 there was great excitement in the town:

> At about 12:17 on Saturday last a severe shock occurred in Burra which caused dwellings of all descriptions to shake and in several instances such damage was done. The shock appeared to travel from west to east and is said to be the worst ever felt in the neighbourhood. Great excitement prevailed among the residents many of whom rushed outside their dwellings in fear of the buildings tumbling down upon them. Later in the afternoon two more shocks were felt which caused much alarm. Crockery rattled and pictures on the walls were disarranged. The Post Office buildings suffered from shock, the walls being cracked in a couple of places. The dressing rooms at the rear of the Institute suffered and at the Royal Exchange Hotel the ceiling is cracked in every room on the second floor. At the time of the first shock men were engaged in the Aberdeen ballast quarries, where the shock was also felt but with the exception of a small quantity of debris falling from the sides of the cutting and a crack at the top nothing serious happened. Bricks from several chimneys were removed and falling upon the roofs of the houses lent additional terror to the occurrence. The walls in four private dwellings opened about two or three inches and the dust from the walls filled the rooms.

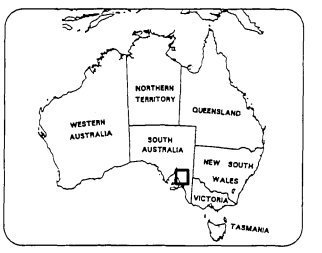
Contributors: This map was compiled by Katherine Malpas, Flinders University SA, and the South Australian Department of Mines & Energy.

ISOSEISMAL MAP OF THE BURRA EARTHQUAKE, SOUTH AUSTRALIA
22 AUGUST 1896



DATE: 22 AUGUST 1896
TIME: 02:46 GMT
MAGNITUDE: 4.3 ML (I)
EPICENTRE: 33.69°S 138.91°E

▲	*Epicentre*
IV	*Zone intensity designation*
3	*Earthquake felt (MM)*
0	*Earthquake not felt*



Isoseismal map of the Burra earthquake
South Australia - 22 August 1896

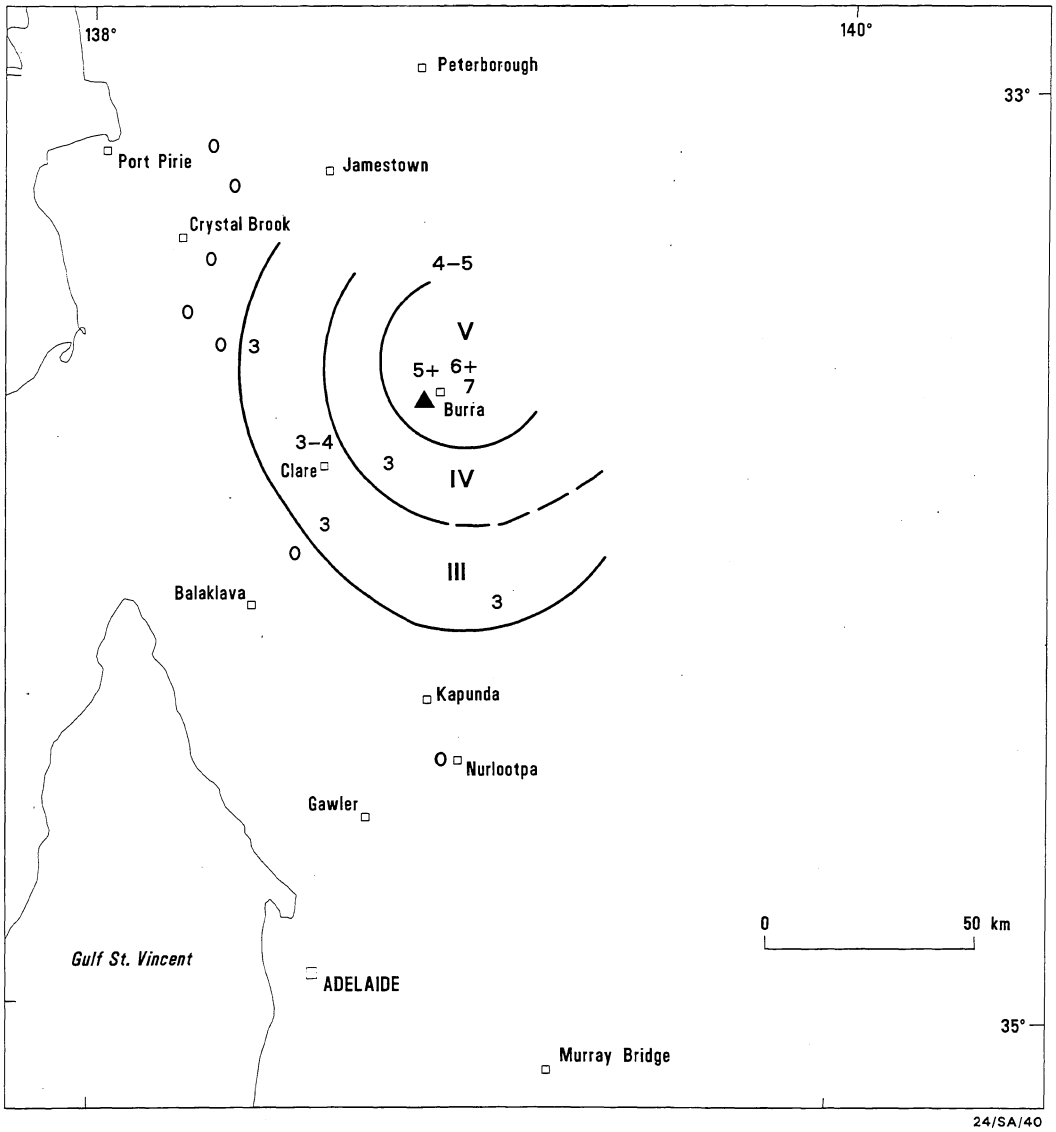
The above story in *The Burra Record* of Wednesday 26 August 1896 contained the following extract:

> .....Later in the afternoon two more shocks were felt which caused much alarm. Crockery rattled and pictures on the walls were disarranged.

The earthquake was felt in many other towns in the area but not as strongly as those at noon Saturday and 9 pm Sunday mentioned above and below.

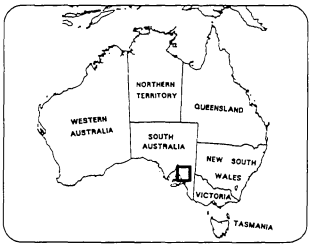
Contributors: This map was compiled by Katherine Malpas, Flinders University SA, and the South Australian Department of Mines & Energy.

ISOSEISMAL MAP OF THE BURRA EARTHQUAKE, SOUTH AUSTRALIA 22 AUGUST 1896



DATE: 22 AUGUST 1896
TIME: 07:00 GMT
MAGNITUDE: 4.0 ML (I)
EPICENTRE: 33.69°S 138.91°E

▲ *Epicentre*
IV *Zone intensity designation*
3 *Earthquake felt (MM)*
0 *Earthquake not felt*



Isoseismal map of the Burra earthquake
South Australia - 23 August 1896

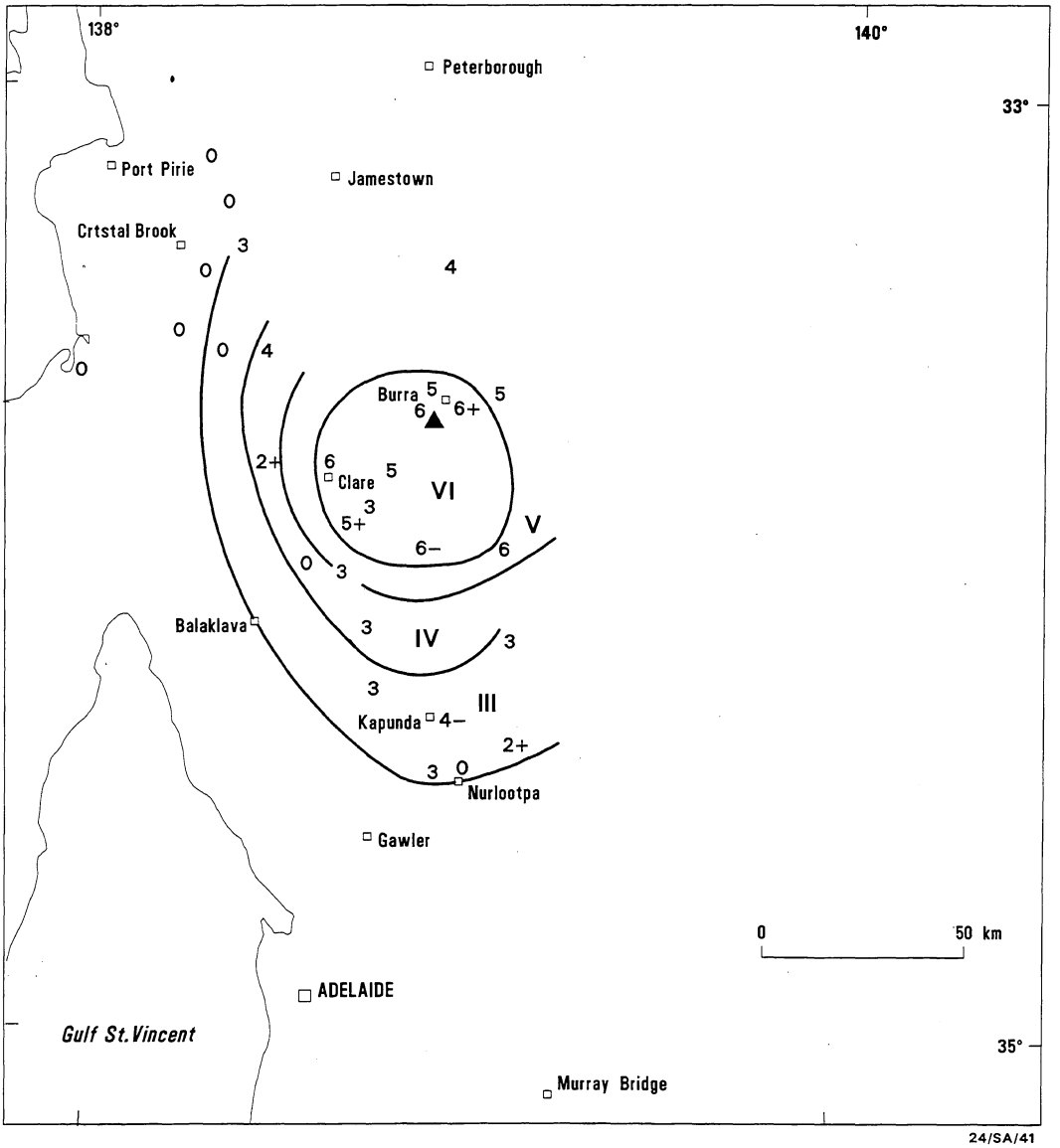
The Burra Record of Wednesday 26 August 1896 continued the description of the earlier earthquakes given above:

> On Sunday evening at about 9 o'clock another shock occurred just when many people were retiring to rest. Mothers with their children rushed outside of their homes and some could not be persuaded to return for the night but preferred camping out until morning.

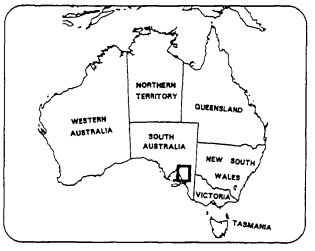
The Chronicle of August 1896 reported an earlier earthquake, on Sunday morning at about 3 o'clock: 'many residents were aroused from sleep by a severe tremor.' The article also noted that several Kooringa residents left by the train for the south and it continued further: '..Such an occurrence is quite unprecedented in these parts, and consequently considerable fear is manifested among the people, especially women and children.

Contributors: This map was compiled by Katherine Malpas, Flinders University SA, and the South Australian Department of Mines & Energy.

ISOSEISMAL MAP OF THE BURRA EARTHQUAKE, SOUTH AUSTRALIA
23 AUGUST 1896



DATE: 23 AUGUST 1896
TIME: 11:30 GMT
MAGNITUDE: 4.2 ML (I)
EPICENTRE: 33.71°S 138.94°E



▲ *Epicentre*
IV *Zone intensity designation*
4 *Earthquake felt (MM)*
0 *Earthquake not felt*

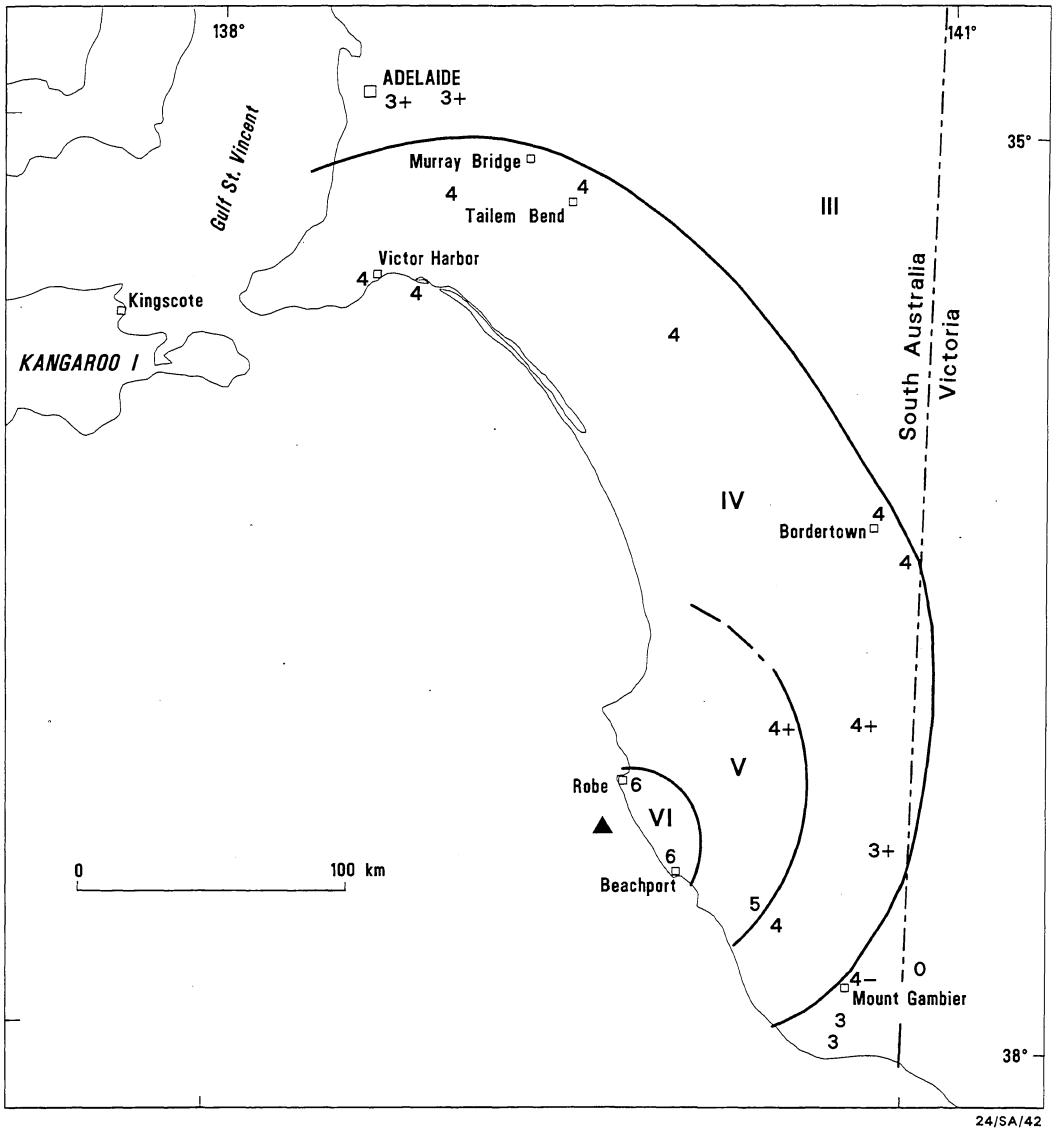
Isoseismal map of the Robe earthquake
South Australia - 10 April 1898

The following article was printed in *The Southeastern Standard* on the Tuesday after Easter, 12 April 1898:

> The revival of earthquake shocks - It is nearly 12 months since the severe earthquake shock which alarmed so many residents of Mt Gambier was felt, but unpleasant recollections were revived yesterday morning at about 20 minutes to 7 when a shock sufficient to awaken many people was experienced. Windows rattled slightly and a rumbling noise such as a vehicle makes when drawn over hollow ground was heard. A few people of nervous disposition were somewhat alarmed but the shock was comparatively slight.

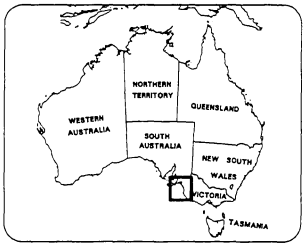
Contributors: This map was compiled by Katherine Malpas, Flinders University SA, and the South Australian Department of Mines & Energy.

ISOSEISMAL MAP OF THE ROBE EARTHQUAKE, SOUTH AUSTRALIA
10 APRIL 1898



DATE: 10 APRIL 1898
TIME: 21:10 GMT
MAGNITUDE: 4.9 ML (I)
EPICENTRE: 37.32°S 139.71°E

▲ *Epicentre*
IV *Zone intensity designation*
3 *Earthquake felt (MM)*
0 *Earthquake not felt*



Isoseismal map of the Robe earthquake South Australia - 2 May 1899

Almost two years to the day after the largest known South Australian earthquake occurred in the Southeast of the State (McCue, 1975), and when the extensive aftershock sequence had appeared over, another smaller but frightening earthquake occurred (Underwood, 1972).

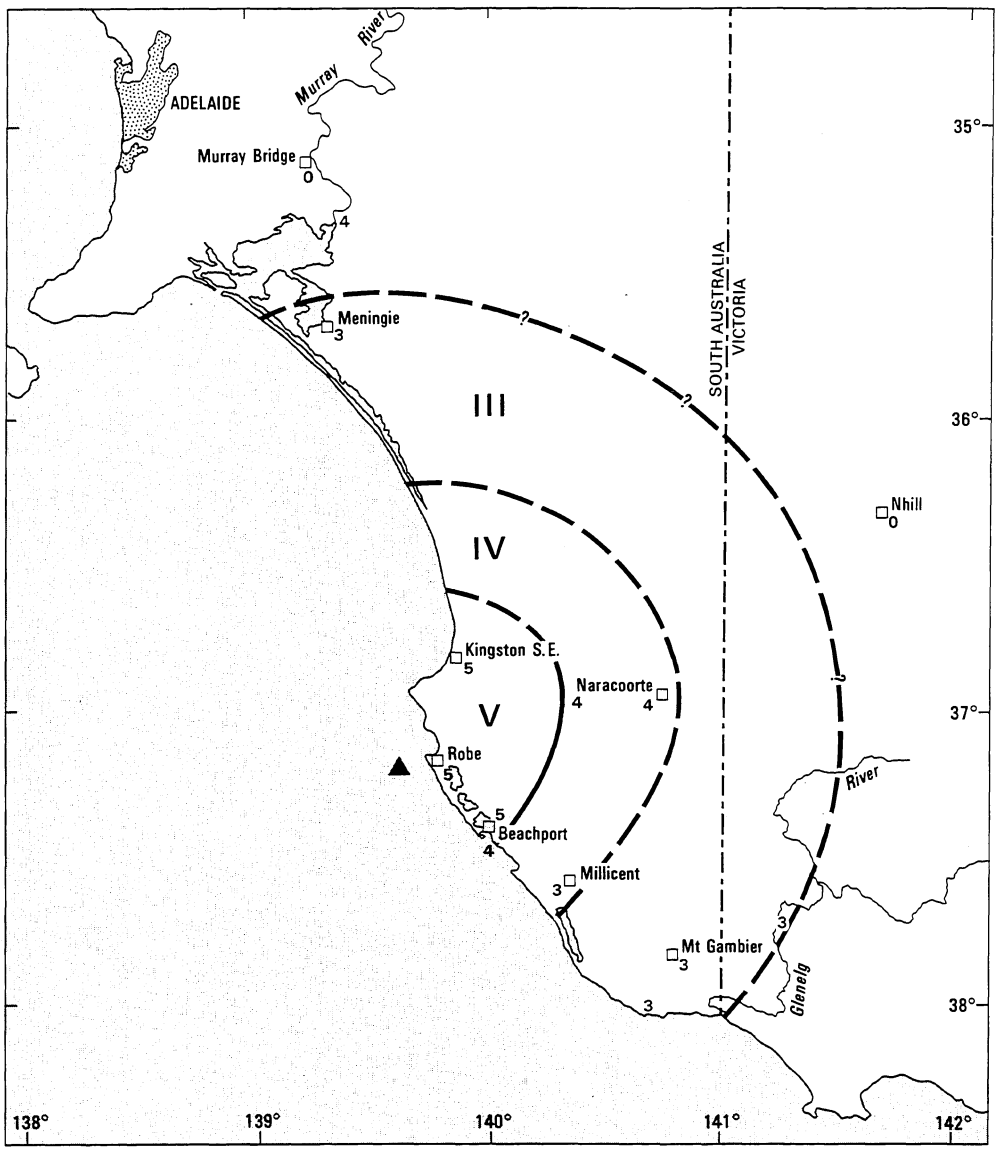
Under the heading 'Earthquakes in the South-East', *The Register* of 3 May 1899 printed the following telegraph from Robe:

> 'An extremely severe shock of earthquake occurred at 12.57 today. It commenced like the original shock with thunderings in the distance, and as it grew nearer it shook everything with great force. People ran into the streets expecting a repetition of the shock of two years ago, but it gradually passed off. No damage is reported apart from the usual falling of plaster'.

Surprisingly the earthquake was also felt at Wellington, about 210 km north of the likely epicentre off Robe, whereas the furthest report to the east was at Carew in Victoria only 150 km away.

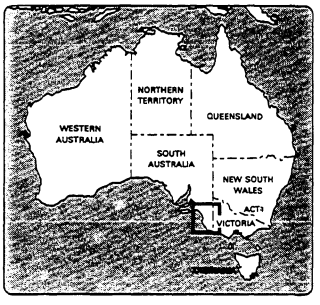
Contributors: This map was compiled by Kevin McCue from information gleaned from South Australian and Victorian newspapers by Alison McArdle under contract to BMR.

ISOSEISMAL MAP OF THE ROBE EARTHQUAKE, SOUTH AUSTRALIA, 2 MAY 1899



DATE : *2 May 1899*
TIME : *03:30 UT*
MAGNITUDE : *5.3 ML (I)*
EPICENTRE : *37.2°S, 139.6°E*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/SA/30

Isoseismal Map of the Bulli Earthquake New South Wales 28 February 1902

Reports of this earthquake near Sydney were found in the Sydney Morning Herald of Monday 3 March 1902 and the Illawarra Mercury of Wednesday 5 March 1902. The Sydney Morning Herald headline read:

EARTHQUAKE SHOCKS

SOME REMARKABLE EXPERIENCES

MILES OF COUNTRY AFFECTED

DWELLINGS SEVERELY SHAKEN

The SMH newspaper summary of the effects of the earthquake began:

> On Friday night last, somewhere between 10 and 11 o'clock, the inhabitants throughout a considerable area in the coastal district of the State were startled by the sudden rocking of their dwellings and by earth tremors, which varied in intensity from slight to heavy shocks, accompanied by rumbling noises not unlike distant thunder.

The Government Astronomer, Mr Russell, said they had not felt the shocks at the Observatory. However telegraphic reports were received from centres within about 50 km of Bulli, from as far southwest as Mossvale and north to Bellevue Hill on the southern foreshore of Sydney Harbour. No damage was reported despite the dramatic headline, and the strongest shaking seems to have been at Bulli where:

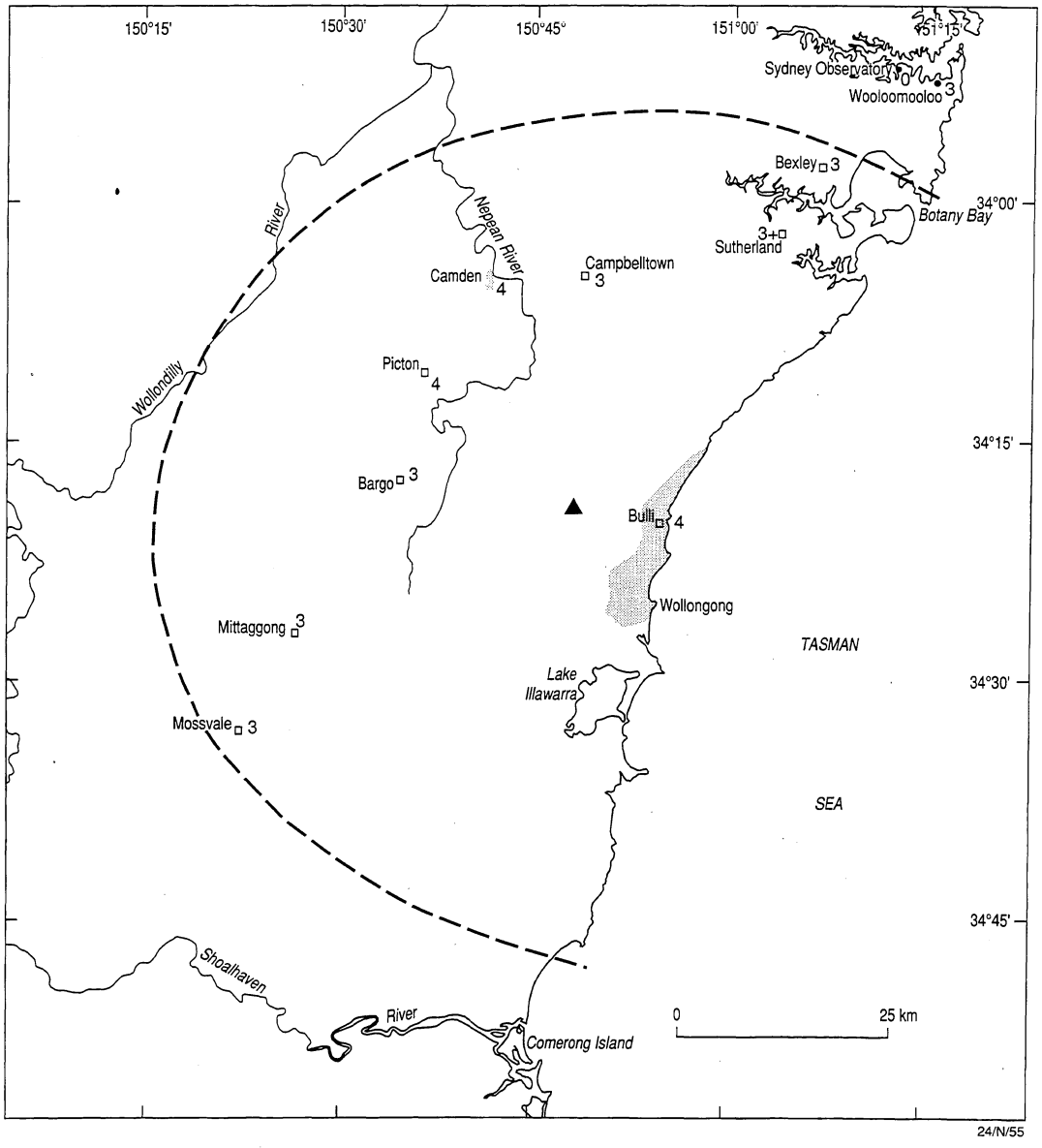
> the shock was preceded by a low rumbling noise similar to distant thunder, followed by a dull explosive sound. Persons in houses at the time describe it as resembling some ponderous weight being precipitated against a building....Old residents state that it must be 30 years since there was a similar experience in this district (they could have been referring to either the 1868 Maitland or 1872 Jenolan Caves earthquake - Ed.).'

The isoseismal map indicates an epicentre west of Bulli, near the epicentre of the 15 November 1981 Appin earthquake (Rynn & others, 1982). The felt area is commensurate with a magnitude 4 earthquake.

The SMH reporter appended a report of an earthquake felt in West Maitland the following morning (Saturday), '.....and the vibration was strong enough to shake houses and cause windows and doors to rattle'. No other reports of this earthquake have been found to date.

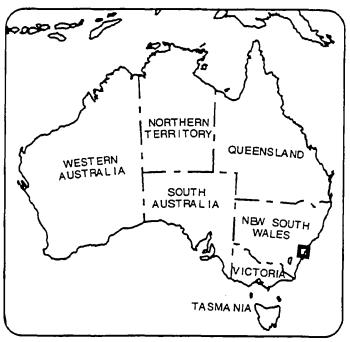
Contributors Dr David Palfreyman unearthed the first newspaper reference to this earthquake and Kevin McCue drew up the isoseismal map.

ISOSEISMAL MAP OF THE BULLI EARTHQUAKE, NSW
28 FEBRUARY 1902



DATE: 28 FEBRUARY 1902
TIME: 12:20 GMT
MAGNITUDE: ML 4.1 (±0.3)
EPICENTRE: 34.3°S, 150.8°E

▲	*Epicentre*
IV	*Zone intensity designation*
4	*Earthquake felt (MM)*
0	*Earthquake not felt*



Isoseismal map of the Mid North earthquake
South Australia - 7 May 1902

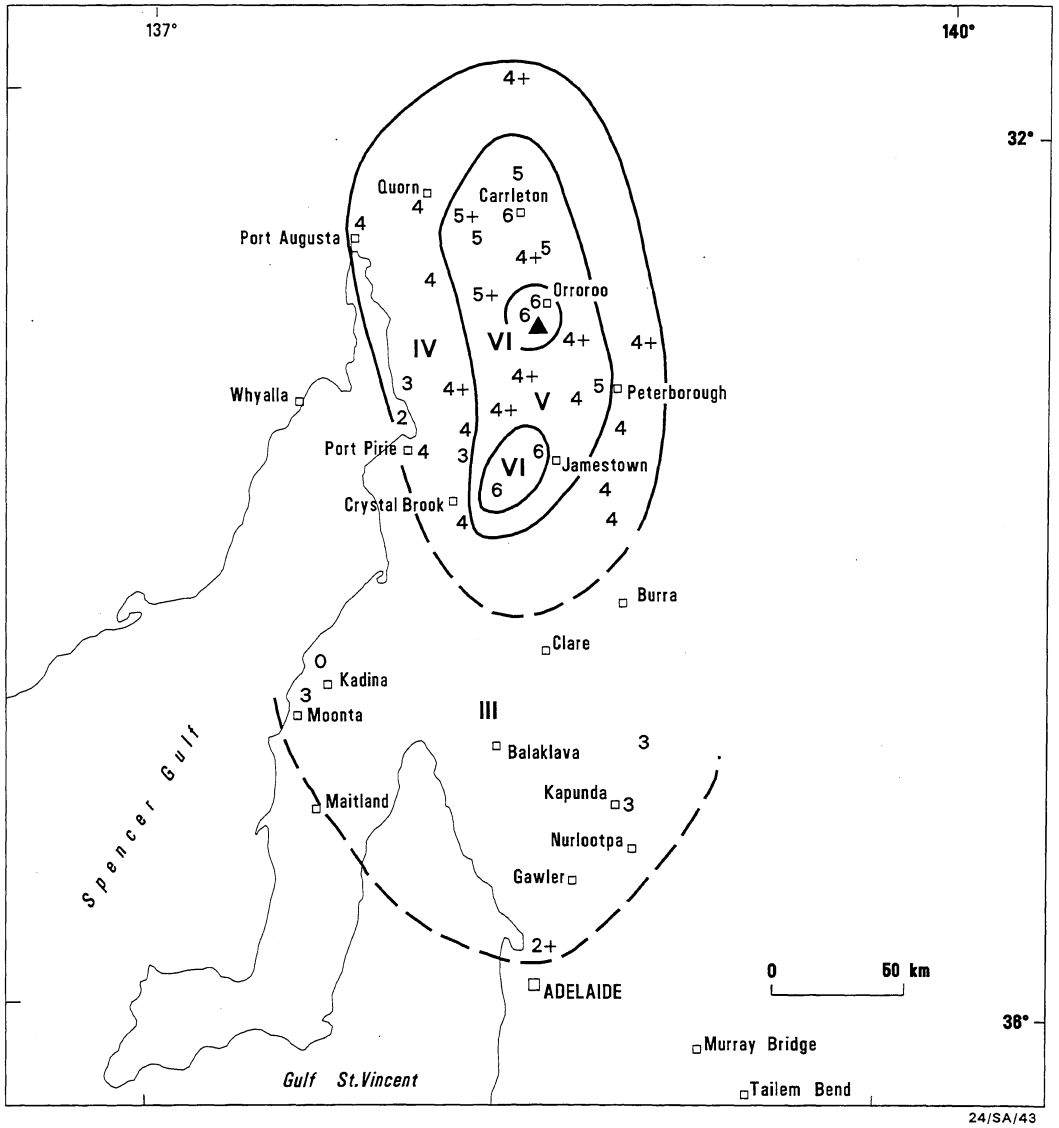
At 2:40 pm on Wednesday afternoon, 7 May 1902, the small towns of Carrieton, Orroroo and Jamestown experienced a sever tremor. Although little damage was done, objects were thrown from shelves and people were greatly concerned. Surrounding townships felt it less severely and received a nice shakeup. It was just perceptible as far south as Adelaide. The location of the epicentre is very uncertain (Malpas, 1991).

The Register of 9 May 1902 reported on the effects of the earthquake at various towns in the mid-north of South Australia:

> Jamestown 7 May - A severe shock of earthquake was felt here at about 1/4 to 3 this afternoon causing furniture and glassware and crockery on the shelves to shake very perceptibly. In some of houses it brought down some of the ceilings of the rooms.

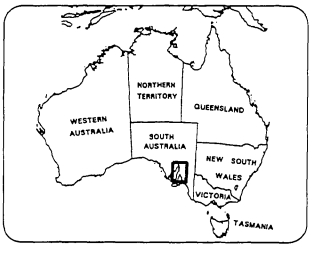
Contributors: This map was compiled by Katherine Malpas, Flinders University SA, and the South Australian Department of Mines & Energy.

ISOSEISMAL MAP OF THE MID NORTH EARTHQUAKE, SOUTH AUSTRALIA
7 MAY 1902



DATE: 7 MAY 1902
TIME: 05:10 GMT
MAGNITUDE: 4.8 ML (I)
EPICENTRE: 32.75°S 138.5°E

▲	*Epicentre*
IV	*Zone intensity designation*
3	*Earthquake felt (MM)*
0	*Earthquake not felt*



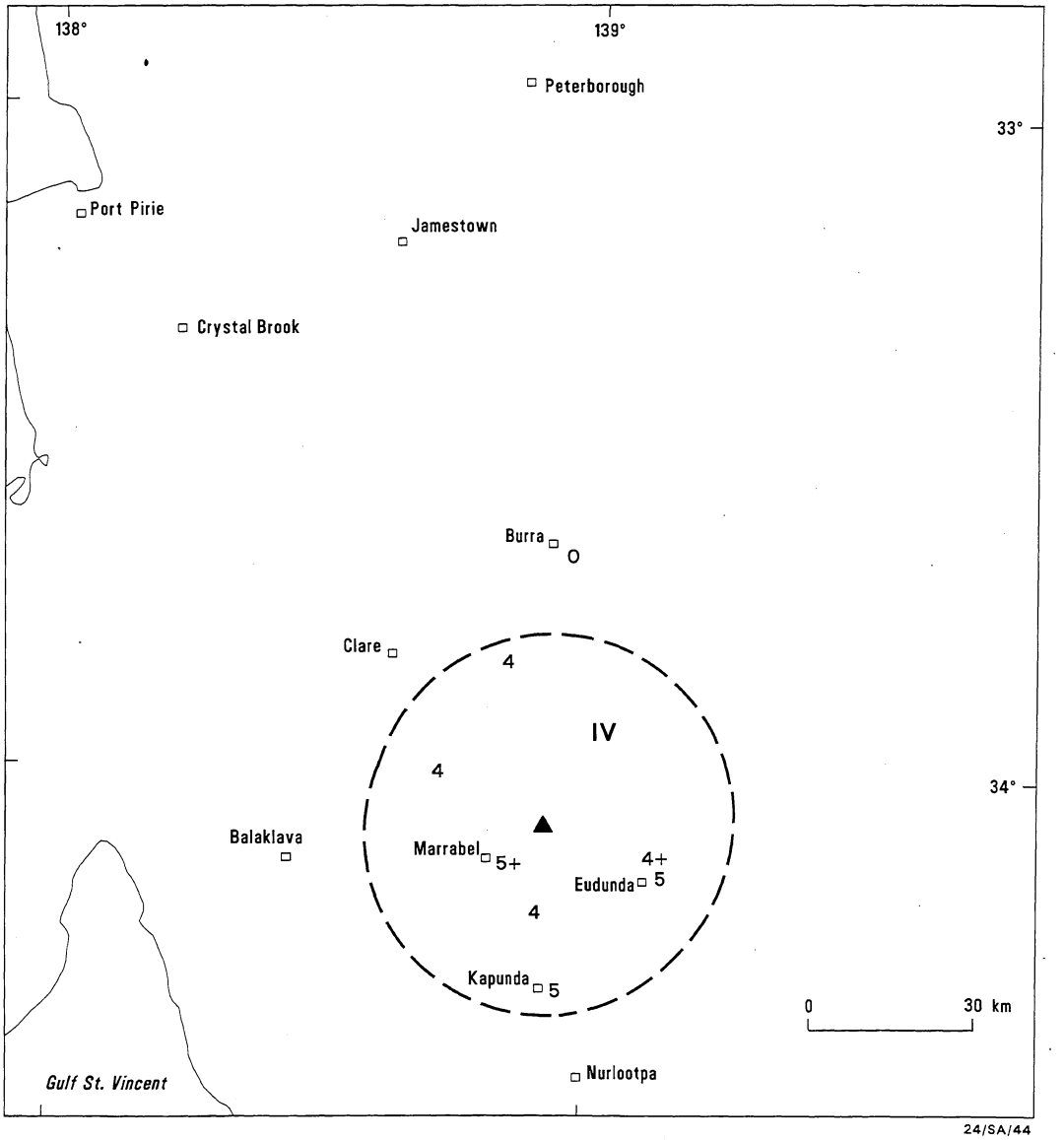
Isoseismal map of the Marrabel earthquake
South Australia - 13 May 1902

The Chronicle of 24 May 1902 carried reports of the earthquake from Eudunda, Auburn and Marrabel:

> Marabel A severe earthtremor occurred here at 4:12 this morning. Almost all the residents were awakened by the shock which lasted from 10 to 15 secs and was accompanied by a loud rumbling sound like distant thunder. Buildings doors windows and roofs rattled. (Malpas, 1991).

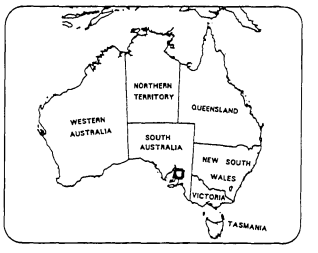
Contributors: This map was compiled by Katherine Malpas, Flinders University SA, and the South Australian Department of Mines & Energy.

ISOSEISMAL MAP OF THE MARRABEL EARTHQUAKE, SOUTH AUSTRALIA
13 MAY 1902



DATE: 13 MAY 1902
TIME: 18:50 GMT
MAGNITUDE: 3.5 ML (I)
EPICENTRE: 34.09°S 138.93°E

▲ *Epicentre*
IV *Zone intensity designation*
5 *Earthquake felt (MM)*
0 *Earthquake not felt*

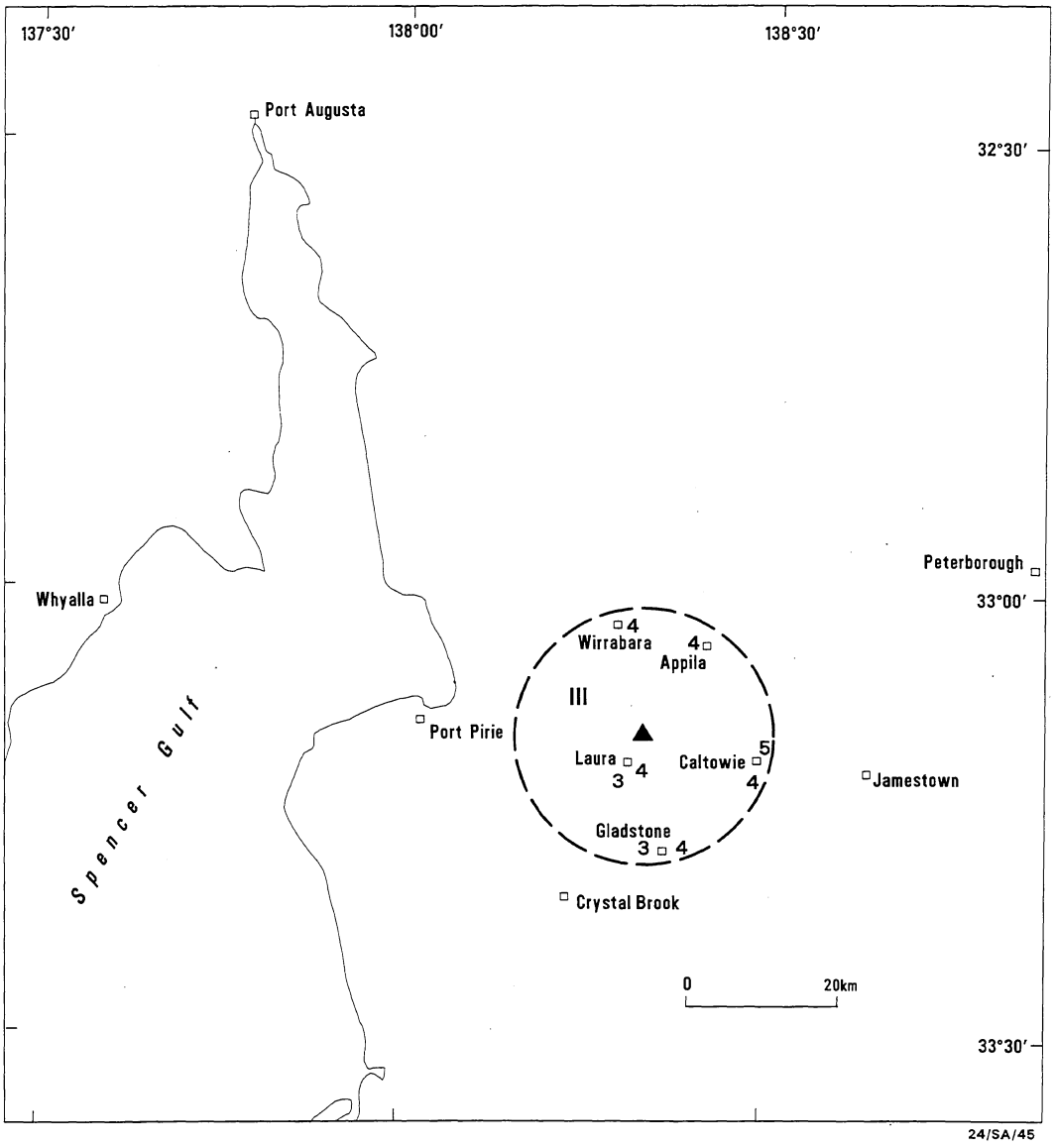


Isoseismal map of the Caltowie earthquake South Australia - 5 June 1902

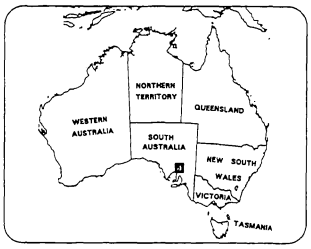
This small earthquake was felt at Caltowie, Appila, Laura, Wirrabara and Gladsone but Malpas (1991) has not included details of the felt reports.

Contributors: This map was compiled by Katherine Malpas, Flinders University SA, and the South Australian Department of Mines & Energy.

ISOSEISMAL MAP OF THE CALTOWIE EARTHQUAKE, SOUTH AUSTRALIA 5 JUNE 1902



DATE: 5 JUNE 1902
TIME: 22:35 GMT
MAGNITUDE: 3.1 ML (I)
EPICENTRE: 33.13°S 138.36°E



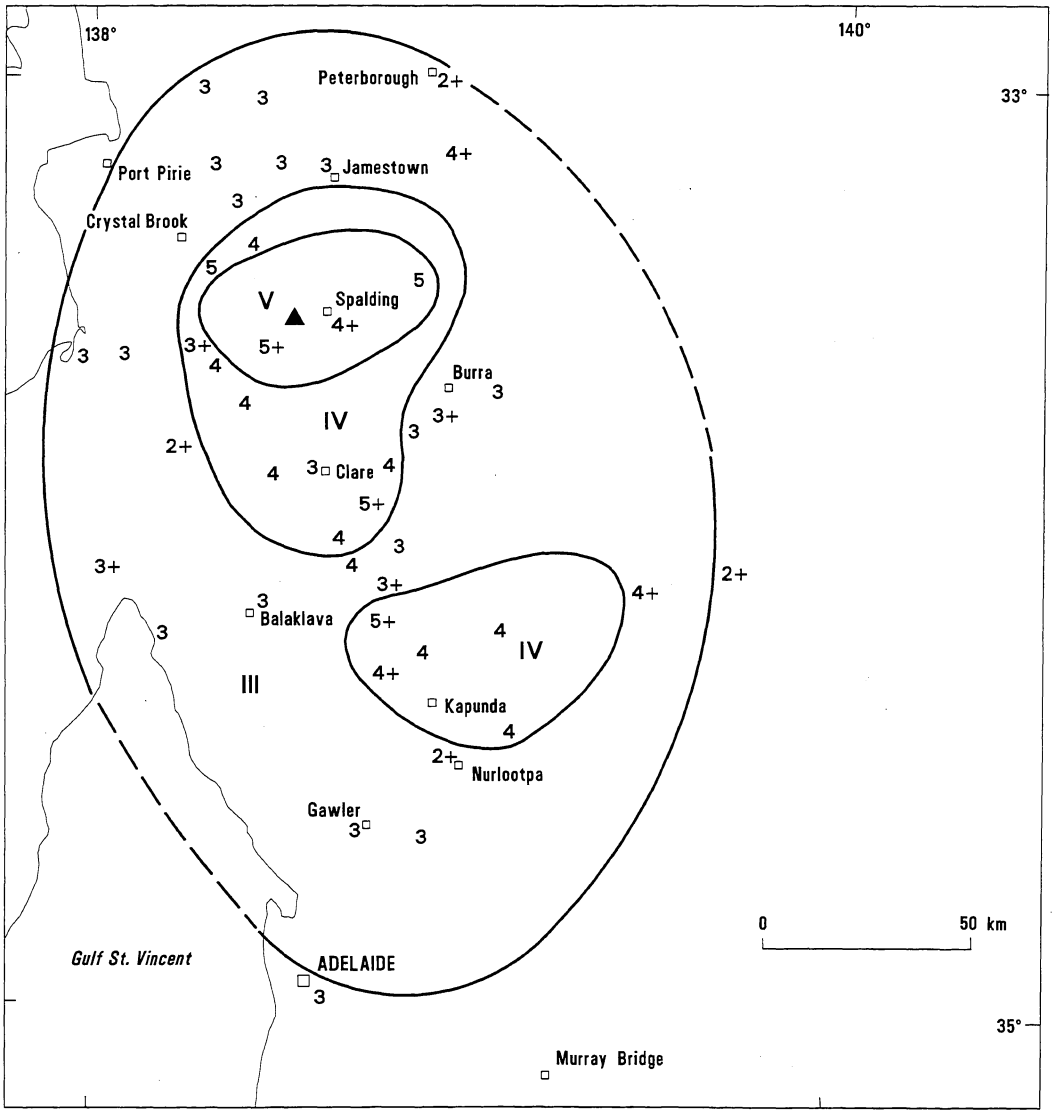
▲ *Epicentre*
IV *Zone intensity designation*
3 *Earthquake felt (MM)*
Earthquake not felt

Isoseismal map of the Spalding earthquake
South Australia - 18 September 1902

This earthquake at 6:30 am on Friday morning had been assumed to be a Warooka foreshock, but as a result of detective work by Malpas (1991) the epicentre has been moved nearer Spalding in the mid-north of the State. Telegrams from Blyth, Hallett, Koolunga, Riverton, Tarlee and Yacka reported a severe shock though it was not felt at Adelaide or Warooka.

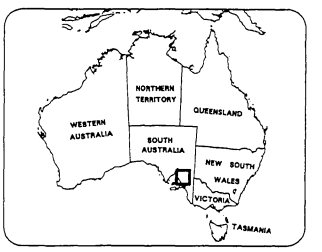
Contributors: This map was compiled by Katherine Malpas, Flinders University SA, and the South Australian Department of Mines & Energy.

ISOSEISMAL MAP OF THE SPALDING EARTHQUAKE, SOUTH AUSTRALIA
18 SEPTEMBER 1902



DATE: 18 SEPTEMBER 1902
TIME: 21:00 GMT
MAGNITUDE: 4.4 ML (I)
EPICENTRE: 33.52°S 138.50°E

▲ *Epicentre*
III *Zone intensity designation*
4 *Earthquake felt (MM)*
Earthquake not felt



Isoseismal map of the Warooka earthquake South Australia - 19 September 1902

Named after the small town at the bottom of York peninsula where several stone and masonry buildings including a school sustained significant damage, this earthquake at 8:05 pm on Friday night is the second largest known in South Australia. It was the first time damage was caused in Adelaide by an earthquake, but not the last.

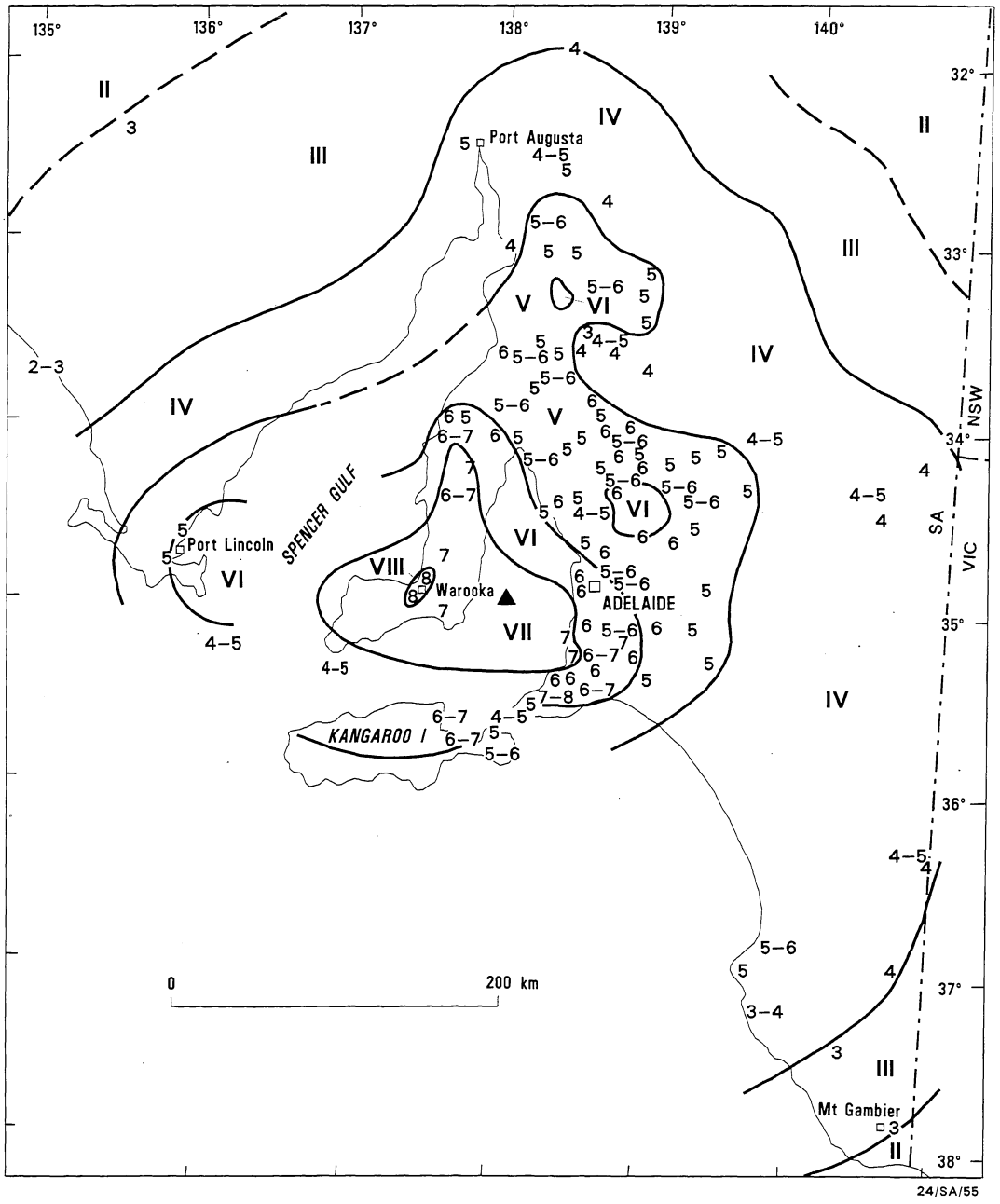
This is the third version of an isoseismal map for this earthquake, the earlier two by Todd (in Dodwell, 1910) and Griffith (in Howchin, 1917) converted from Rossi-Forel to Modified Mercalli intensity by Everingham & others (1982). Malpas (1991) re-interpreted the original information and derived a magnitude of 5.9 though we have stayed with magnitude 6.0 because the radius of perceptibility in her map is even larger than that mapped in the earlier two figures for which a value of 6.0 was derived. Both Griffith and Malpas agree that the highest intensity was MM VIII though Todd's converted intensity is VII.

The epicentral location is also disputed, Malpas plotting it at Warooka though agreeing that the intensity at Clarendon south of Adelaide was similar to that at Warooka. We have moved the epicentre into Gulf St Vincent where there is better evidence for locating the epicentre of the largest aftershock.

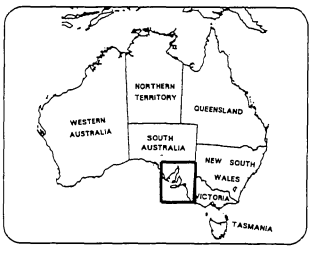
Two people died of heart attacks in Adelaide as a result of this earthquake which McCue & McArdle (1992) have claimed were the first earthquake fatalities in Australia.

Contributors: This map was compiled by Katherine Malpas, Flinders University SA, and the South Australian Department of Mines & Energy.

ISOSEISMAL MAP OF THE WAROOKA EARTHQUAKE, SOUTH AUSTRALIA
19 SEPTEMBER 1902



DATE: 19 SEPTEMBER 1902
TIME: 10:35 GMT
MAGNITUDE: 6.0 ML (I)
EPICENTRE: 35°S 138°E



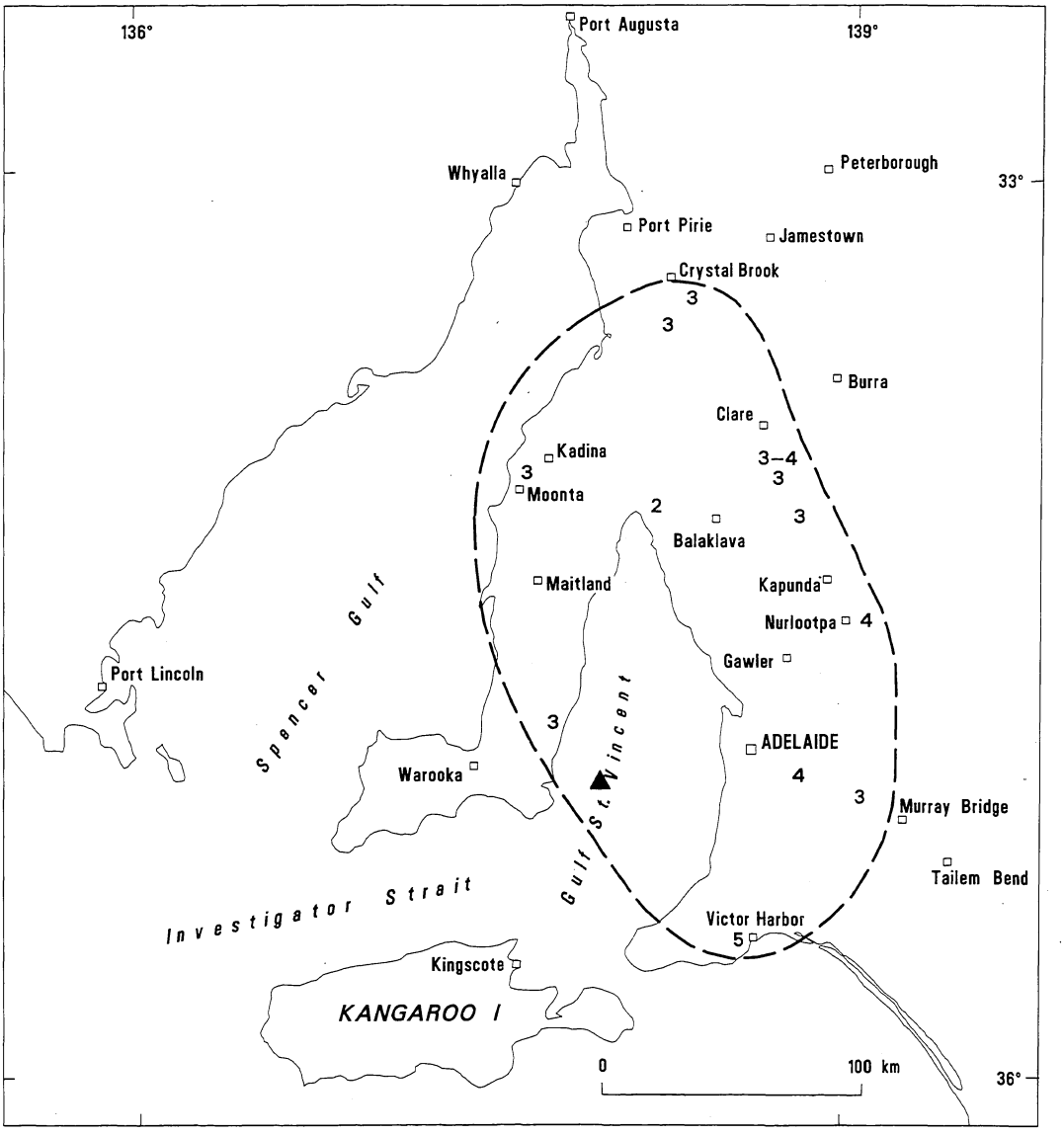
▲ *Epicentre*
IV *Zone intensity designation*
6 *Earthquake felt (MM)*
Earthquake not felt

Isoseismal map of the Warooka aftershock
South Australia - 20 September 1902

This was previously considered to have been a Warooka aftershock but the plotted intensities (Malpas , 1991) indicate that the earthquake was probably centred somewhere in the mid-north of the State, perhaps near Gawler, but not at Warooka where it was not apparently felt.

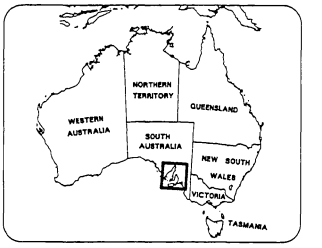
Contributors: This map was compiled by Katherine Malpas, Flinders University SA, and the South Australian Department of Mines & Energy.

ISOSEISMAL MAP OF THE WAROOKA AFTERSHOCK, SOUTH AUSTRALIA 20 SEPTEMBER 1902



DATE: 20 SEPTEMBER 1902
TIME: 09:25 GMT
MAGNITUDE: 4.4 ML (I)
EPICENTRE: 35°S 138°E

▲ *Epicentre*
Zone intensity designation
3 *Earthquake felt (MM)*
Earthquake not felt

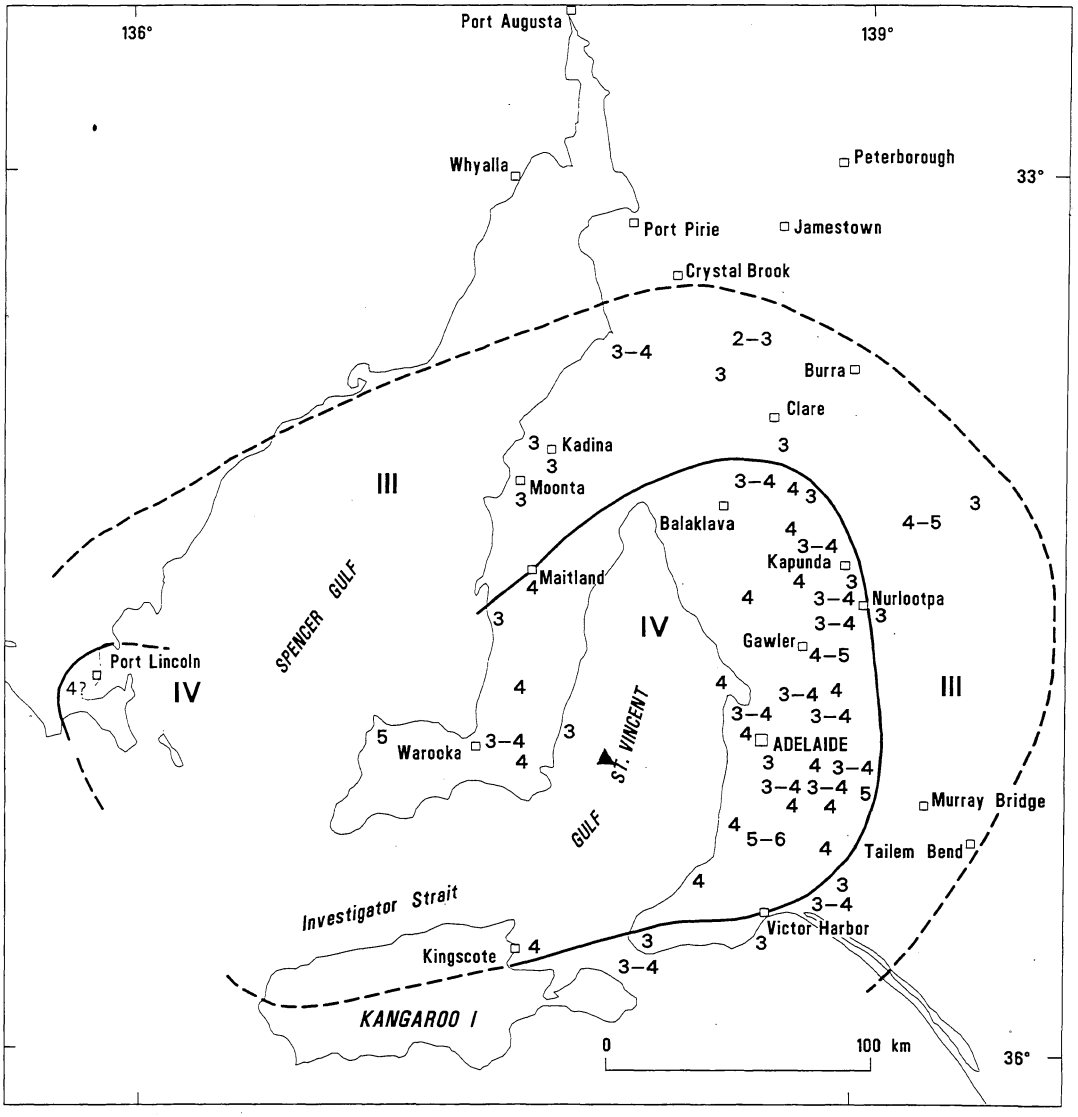


Isoseismal map of the Warooka aftershock
South Australia - 20 September 1902

This earthquake must be considered an aftershock of the previous days earthquake near Warooka and not another mid-north epicentre because of the distribution of felt intensities (Malpas, 1991), yet it was felt only slightly at Warooka supporting an epicentre of this event and the mainshock in St Vincent's Gulf.

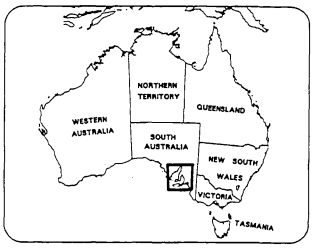
Contributors: This map was compiled by Katherine Malpas, Flinders University SA, and the South Australian Department of Mines & Energy.

ISOSEISMAL MAP OF THE WAROOKA AFTERSHOCK, SOUTH AUSTRALIA 20 SEPTEMBER 1902



DATE: 20 SEPTEMBER 1902
TIME: 09:37 GMT
MAGNITUDE: 4.8 ML (I)
EPICENTRE: 35°S 138°E

▲ *Epicentre*
IV *Zone intensity designation*
3 *Earthquake felt (MM)*
Earthquake not felt

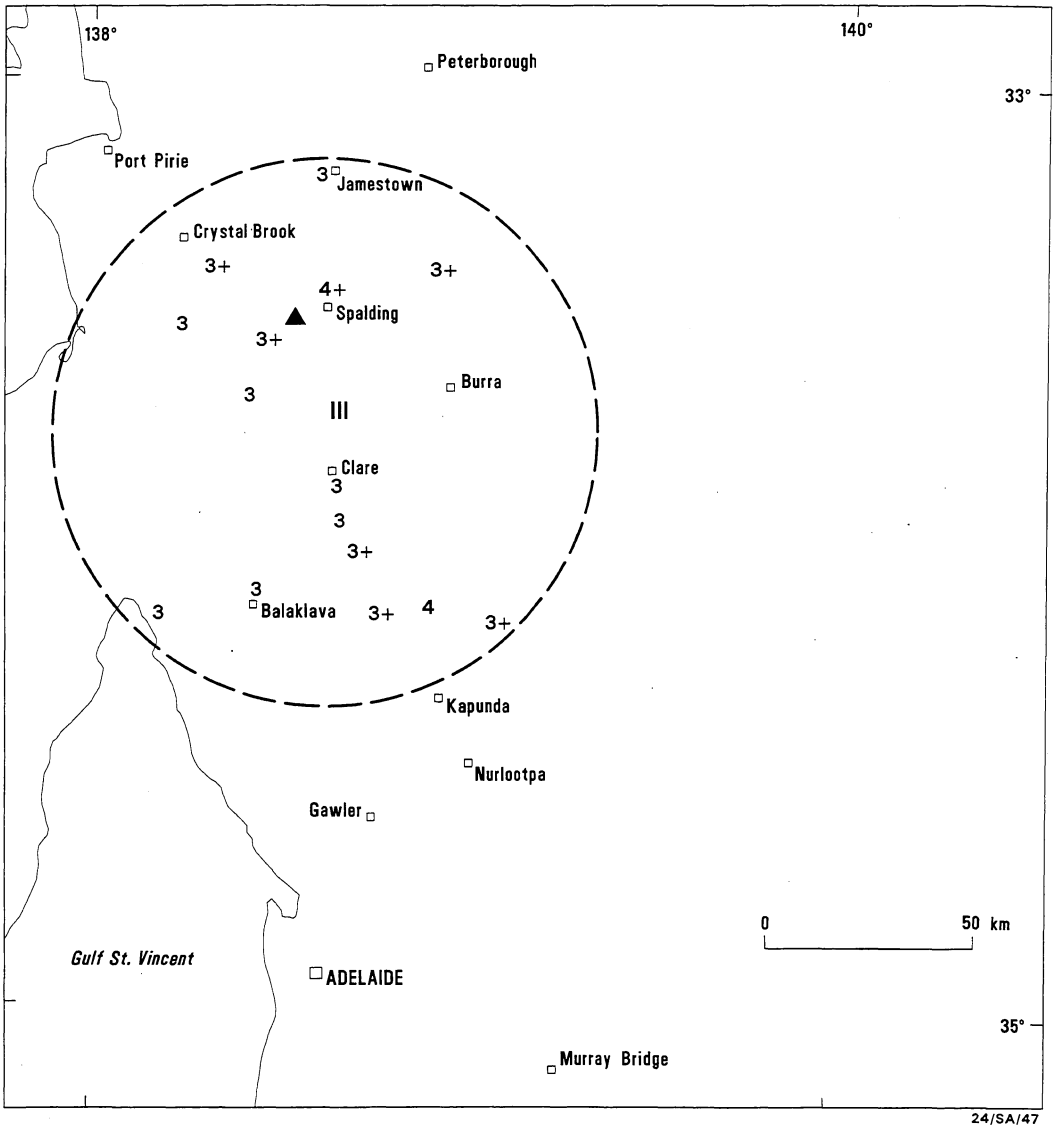


Isoseismal map of the Spalding earthquake
South Australia - 21 September 1902

This earthquake at 1:40 pm on Sunday 21 September, occurred during the Warooka aftershock sequence, but its epicentre was near Spalding (Malpas, 1991) like the earlier, larger earthquake of 18 September. It was felt over a radius of 65 km but nowhere was it described as more than a slight or moderate shock.

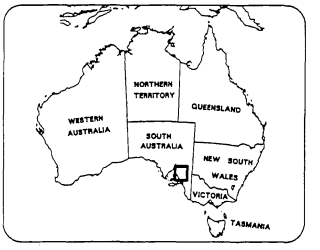
Contributors: This map was compiled by Katherine Malpas, Flinders University SA, and the South Australian Department of Mines & Energy.

ISOSEISMAL MAP OF THE SPALDING AFTERSHOCK, SOUTH AUSTRALIA 21 SEPTEMBER 1902



DATE: 21 SEPTEMBER 1902
TIME: 04:10 GMT
MAGNITUDE: 3.9 ML (I)
EPICENTRE: 33.52°S 138.5°E

▲ *Epicentre*
III *Zone intensity designation*
4 *Earthquake felt (MM)*
Earthquake not felt



Isoseismal map of the Warrnambool earthquake Victoria - 6 April 1903

This was the first of two earthquakes to damage Warrnambool in 1903 (McCue, 1978; Everingham & others, 1982) and was recorded on a Milne seismograph which had been installed in Melbourne in 1901. This was a low-gain undamped instruments and most unsuited to record local earthquakes so very little could be gleaned from the short trace. Professor Gregory from Melbourne University with Mr Baracchi, Government Astronomer, visited Warrnambool to view the damage and interview the people affected but their information and any report have been long lost. The contemporary newspapers carried stories and letters for weeks.

The Warrnambool Standard of Wednesday 8 April 1903 led with:

ALARMING EARTHQUAKE AT WARRNAMBOOL
RESIDENTS TERROR-STRICKEN
SERIOUS DAMAGE TO PROPERTY
SOME REMARKABLE INCIDENTS

The AGE newspaper of 8 April 1903 with:

AN ALARMING EARTHQUAKE
PANIC AT WARRNAMBOOL
VERY SEVERE SHOCKS
BUILDINGS MUCH DAMAGED

WARRNAMBOOL, Tuesday.

Warrnambool was this morning thrown into a state of consternation by a pronounced earthquake shock, which commenced at 9.52 and continued for 10 or 12 seconds. A loud rumbling noise, accompanied the disturbance, and the earth shook so that many people almost fell to the ground. Public buildings and private houses rocked and shook, and the inhabitants were struck with fear and trembling rushing out of their homes in alarm. All places of business were temporarily deserted by the employees, and at the State School the pupils, panic stricken, rushed for the doors and windows. Some of the lady teachers were so terrified that they could do little to reassure the children.

Eventually the scholars numbering between 700 and 800 were got back into the building. Then the blackboard, which had been shaken askew by the shock, fell to the floor with a bang, and another stampede of frightened children followed. Ultimately the head teacher, Mr Braithwaite, as it was impossible to compose the scholars, and as the nerves of some of the teachers were also too much shaken for effective duty, dismissed the school for the day. The parents who were anxious for the safety of their children, appreciated the act. In all the private schools also there were scenes among the pupils, and the younger children clung to the skirts of the teachers, and cried for their mothers. Some pupils were nearly shaken off the forms, and at Warrnambool Academy two or three desks were overturned.

Everything movable in residences was disturbed; ornaments crashed to the floor, pictures fell from the walls, and crockery was thrown down from dressers. Several chimneys were knocked down, and serious figures were produced in the walls of a number of stone houses.

The course of the earthquake was from north-west to north-east. The earthquake was severely felt at Port Fairy also, and it is surmised that it had a submarine origin, and travelled under the sea. The breakwater at Warrnambool was thus in direct line, and that massive stone structures, which cost a quarter of a million sterling, was much shaken though not apparently damaged. The steamer Flinders was lying at the breakwater, and those aboard experienced an extraordinary sensation. Captain McEachern had just stepped from the vessel on to the breakwater when the shocks came. He felt two distinct shocks in rapid succession, and says the breakwater seemed to 'jump about under him'. He had felt earthquake shocks before in Tasmania, but nothing so violent as today's visitation.

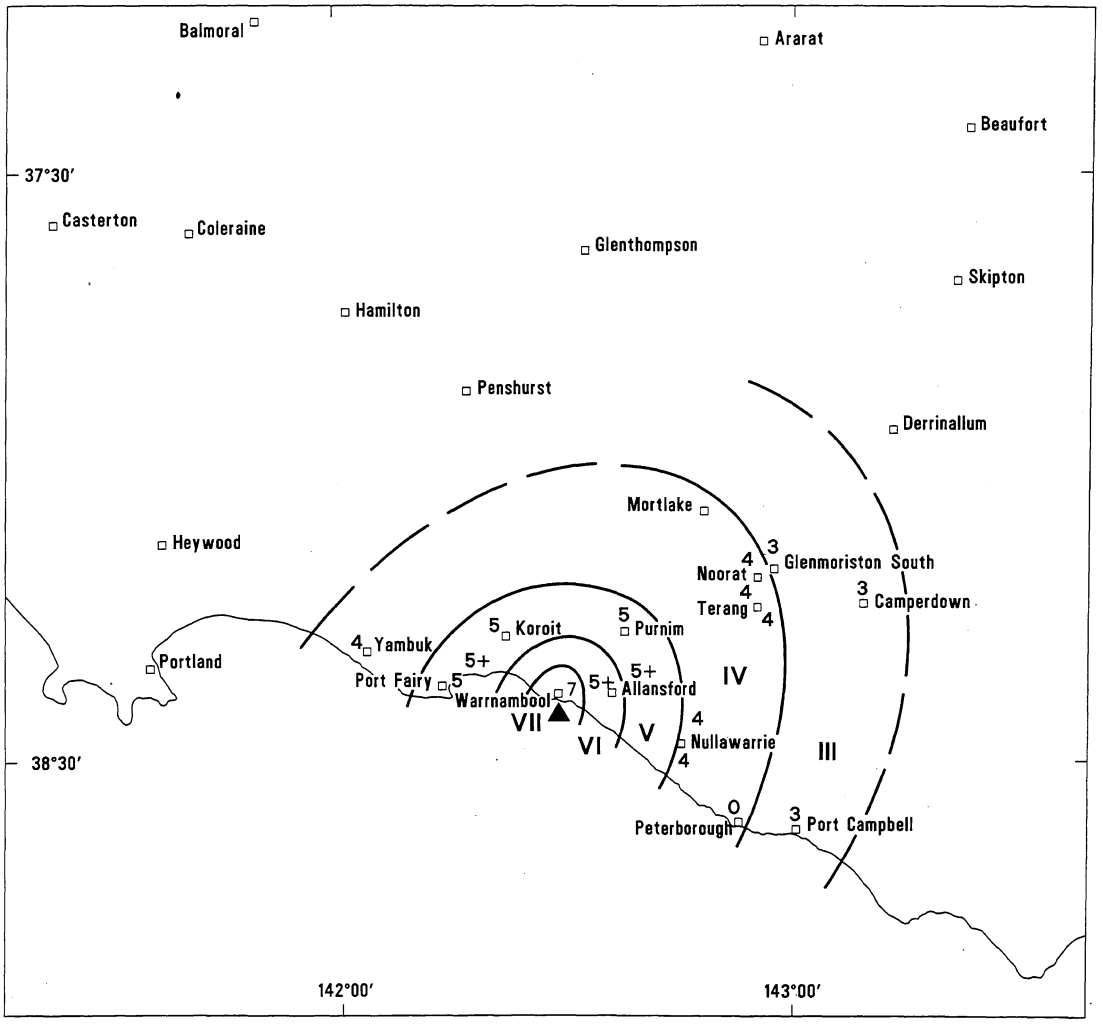
The Bayview Hotel, situated in this part of the town, had a very severe shaking, its walls being greatly damaged. In several bedrooms plaster was wrenched away in large pieces, and fell on the beds, in some cases on the pillows, but the time being morning of course the beds had no occupants. The outer walls of the hotel are also cracked, and the surmounting pediments have been dislodged.

The earthquake played havoc with two of the upper rooms in the town hall, tearing away the plaster from the walls and ceiling, leaving ugly cracks behind it, smashing the globe of a chandelier and severing a gas tube. The damage is considerable, as the upper portion of the outer wall is also cracked right through. At the shire hall large quantities of plaster fell and at the post office vents have been produced in the ceilings. The police station was rocked sharply, and the contents of ink bottles on the desks were spilt. At St John's Presbyterian Church a massive cement cross toppled off one of the turrets on a tower and fell through the roof. A stone house in Banyan Street was so seriously shaken that the occupants refuse to re-enter it. In some of the stores quantities of crockery were thrown down and broken and bottles and glasses were smashed in hotels.

DAMAGE TO HOUSES

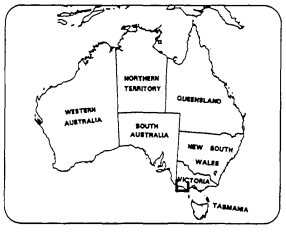
At the Commercial Hotel a tank burst on the top of the roof and flooded the dining room. The most violent effects of the shock were felt at the Hopkins, about a mile and a half north-east of the town. The country residence of Mr G Rolfe, of Melbourne, is situated on the banks of the river and when the earthquake occurred the building rocked about in a most alarming fashion. Mr Rolfe was sitting in an arm chair at the time, and was thrown forcibly to the floor. Mrs Rolfe was in the same room, and was knocked insensible by a heavy book which fell from the bookcase. Two young ladies were in an upstairs bedroom, and in their fright were

ISOSEISMAL MAP OF THE WARRNAMBOOL EARTHQUAKE, VICTORIA
7 APRIL 1903



DATE: 7 April 1903
TIME: 23:52 GMT
MAGNITUDE: 4.3 ML (I)
EPICENTRE: 38.4°S 142.5°E

▲ *Epicentre*
VI *Zone intensity designation*
4 *Earthquake felt (MM)*
0 *Earthquake not felt*



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rushing downstairs, when their progress was obstructed by a table which had been removed by the shock from the upper landing to a point about midway down stairs, where it completely blocked their escape. Eventually, however, they struggled over it, but by that time the vibration had ceased. All the occupants received a terrible fright. Nearly every room in the home was damaged, large pieces of plaster falling from ceilings and portions of cornices crashing to the ground. Heavy pieces of furniture were shifted out of position, glassware was broken and crockery smashed.

The outside walls exhibit big cracks, and chimneys are similarly damaged. The chimney of a cottage close at hand was so badly affected that it had to be pulled down. At the Anglers and the Hopkins River hotels, wooden buildings, all the bottles, glasses and decanters were hurled from the shelves in the bar, and the liquor in each case was destroyed, damage being close to the value of about 10 pounds. Mirrors were broken and crockery destroyed. The brick chimney at the Hopkins Hotel was twisted round. Several other places along the river were damaged. At the residence of Mrs Dawson damage was done to the extent of 100 pounds by the destruction of chimneys cracking of walls and internal injury; whilst the houses of Messrs J Weir, R Selby, J Trigg and others were damaged in a modified degree.

HAVOC IN THE CEMETERY

At the approach to the Anglers' Hotel there is a fissure in the road 40 feet long and one inch wide. The cemetery is situated in this vicinity, and it presents a most extraordinary spectacle, on account of the havoc wrought amongst the tombstones and monuments. Nearly every gravestone and other memorial has suffered. Most of the heavy columnar monuments were shifted from their bases, and others were toppled over to the ground and in other cases the urns, crosses and other surmounting ornaments were dislodged. Tombstones of various kinds are lying at all angles, and many of them have been irreparably damaged by contact in their fall with surrounding iron railings. The east wall of the cemetery is badly cracked for a distance of five chains, and at the north-east corner the toping stone is all away, and large vertical fissures have been produced. The total damage to the cemetery and its monuments is estimated at 500 pounds.

A STONE MASONS EXPERIENCE

A stonemason named John Davies had a thrilling experience in the cemetery. He was engaged engraving an inscription on an imposing monument when the disturbance occurred. He was standing on a box, and, feeling it go from beneath his feet, he clung to the column he was operating on. The column rocked perceptibly in his arms, and the massive urn on top fell over on the opposite side. He suffered a great fright. A peculiar incident occurred at the State School, illustrating the extent to which the building was affected. A long, hollow brass curtain rod was stretched across one of the rooms, and after the shock it was picked up on the floor in the form of an arc. The walls of the room had evidently swayed towards each other and bent the rod, and when they regained their natural position it fell in the ground in the shape in which it was found. Great presence of mind was displayed by the lady teacher Miss Evans. She averted what might have been a tragedy. She was engaged with a class of 70 juveniles in an upstairs room, and when the shock took place they all rushed to the door at the head of the stairs.

Contributors: David McCue retrieved and copied the early Victorian newspaper reports of this earthquake from the Victorian Public Library, Melbourne. The map was compiled by Kevin McCue.

Isoseismal map of the Clare earthquake
South Australia - 14 August 1903

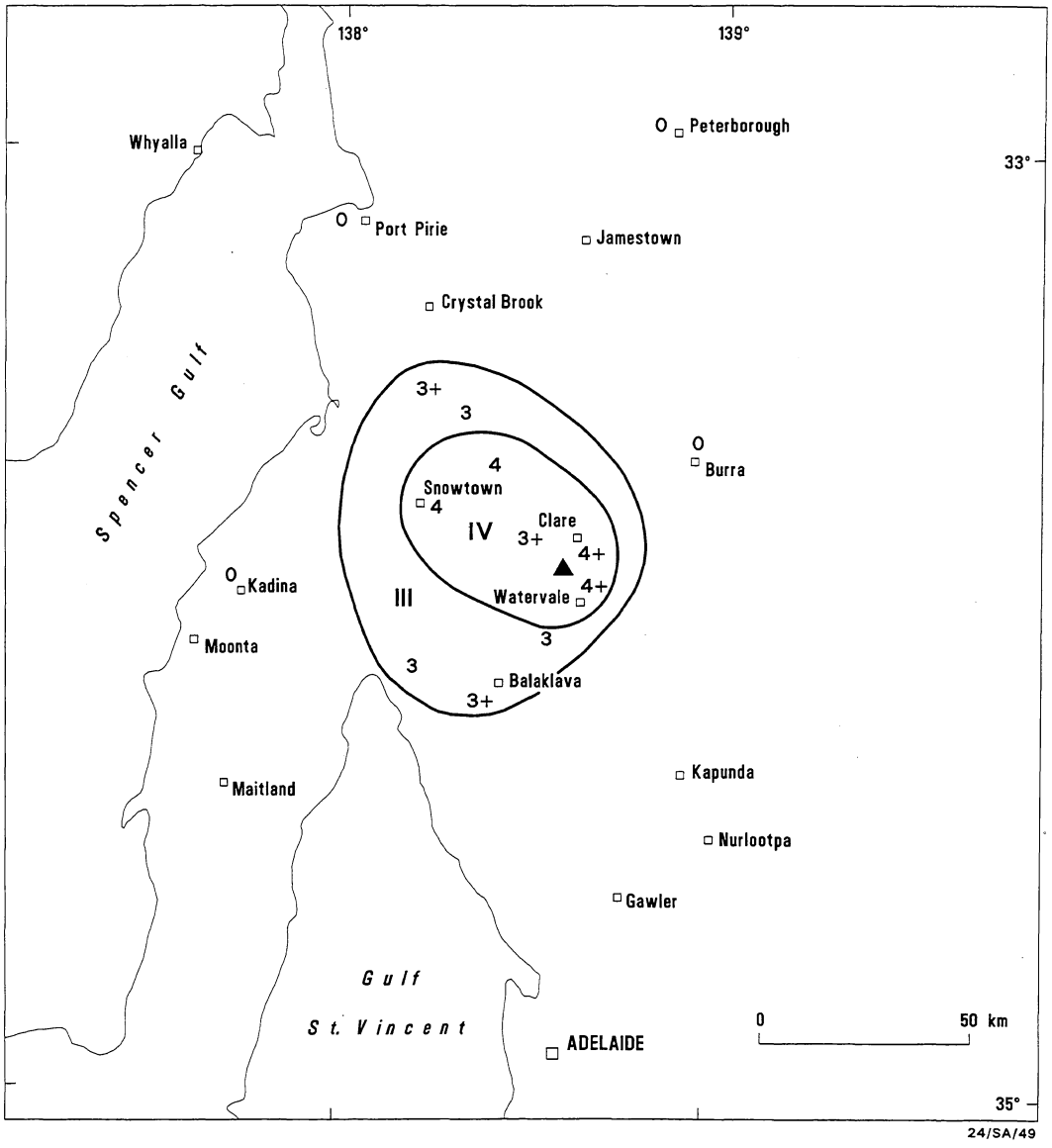
The Advertiser of 17 August 1903 and *The Observer* of 22 August 1903 reported the effects of this earthquake (Malpas, 1991). An extract from *The Observer* states:

> Clare Two earth tremors were felt here last evening. The first of which occurred at 7:30 was slight, the second however was rather severe. The houses experienced a slight rocking. It lasted about 7 seconds. The residents were much alarmed.

Malpas (1991) derived a magnitude of 4.1 for this earthquake, the largest of four small earthquakes north and south of Adelaide between 4 and 14 August.

Contributors: This map was compiled by Katherine Malpas, Flinders University SA, and the South Australian Department of Mines & Energy.

ISOSEISMAL MAP OF THE CLARE EARTHQUAKE, SOUTH AUSTRALIA
14 AUGUST 1903



DATE: 14 AUGUST 1903
TIME: 11:40 GMT
MAGNITUDE: 4.1 ML (I)
EPICENTRE: 33.91°S 138.60°E

▲	*Epicentre*
IV	*Zone intensity designation*
3	*Earthquake felt (MM)*
0	*Earthquake not felt*

Isoseismal map of the Melbourne earthquake
Victoria - 9 July 1904

Several people wrote to Mr Baracchi the Government Astronomer about the earthquake and fortunately these records have survived to the present day in the AGSO holdings of Commonwealth Archives. An extract from a typical letter dated 13 July from Mt Rothwell, Little River reports:

> Sir
> The earthquake which was reported east of Melbourne occurred here about half past seven (I think) that was the time).....It caused only a slight tremor, but the sound was very distinct and reminded me of heavy waggons passing in the street in a quiet part of a town. I should say it lasted fully 30 seconds or more.
> Yours truly
>
> P N Chirnside

Similar reports came from St Kilda, Balwyn, South Yarra, Malvern, Murrumbeena, North Brighton, Olinda Vale, Emerald and Windsor.

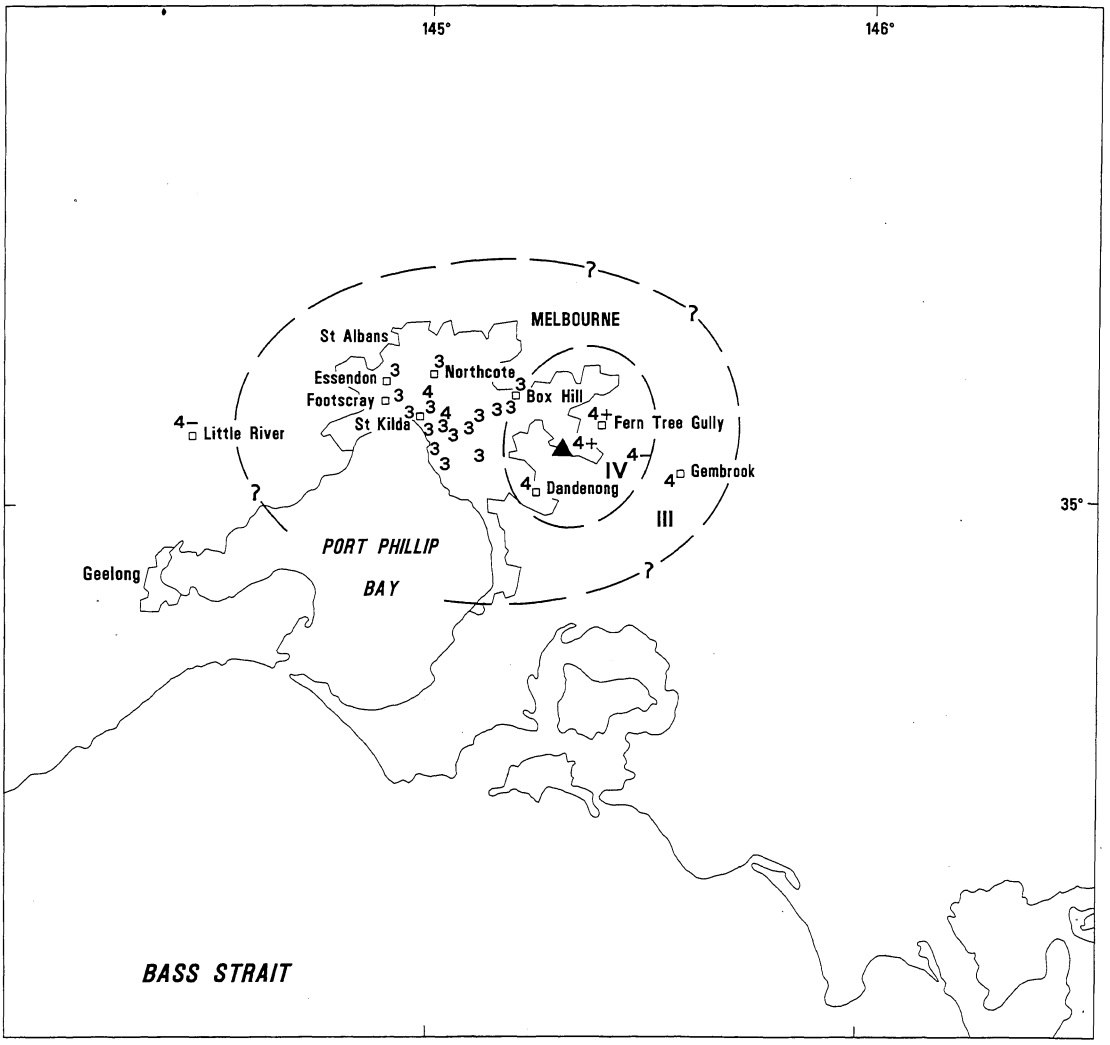
Mr B A Smith from Malvern noted 'observed time 7h 28m 10s to 7h 28m 20s by watch'. He telephoned the exchange at 7 47 pm to get a correction and noted that 'the shock was felt for 3 or 4 seconds before time was first observed and maximum intensity was about 2 s before 7h 28m 10s by watch.' The watch was 1m 15s fast.

The Windsor telephone exchange confirmed the time as 7 27 pm when the telephone shutters rattled.

There were few reports from places east of the supposed epicentre near Fern Tree Gully, so the epicentre could well have been further to the east and its magnitude larger.

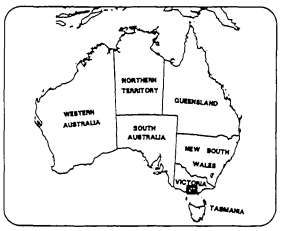
Contributors: Kevin McCue used the felt reports which had been entered into the Melbourne Observatory's 'Earthquake Book' by Miss Watt on 20 August 1904, to draw this isoseismal map.

ISOSEISMAL MAP OF THE MELBOURNE EARTHQUAKE, VICTORIA, 9 JULY 1904



DATE: 9 JULY 1904
TIME: 09:30 GMT
MAGNITUDE: 4.0 ML (I)
EPICENTRE: 37.9°S 145.3°E

▲ *Epicentre*
IV *Zone intensity designation*
4 *Earthquake felt (MM)*



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Isoseismal map of the Riverton earthquake
South Australia - 21 August 1905

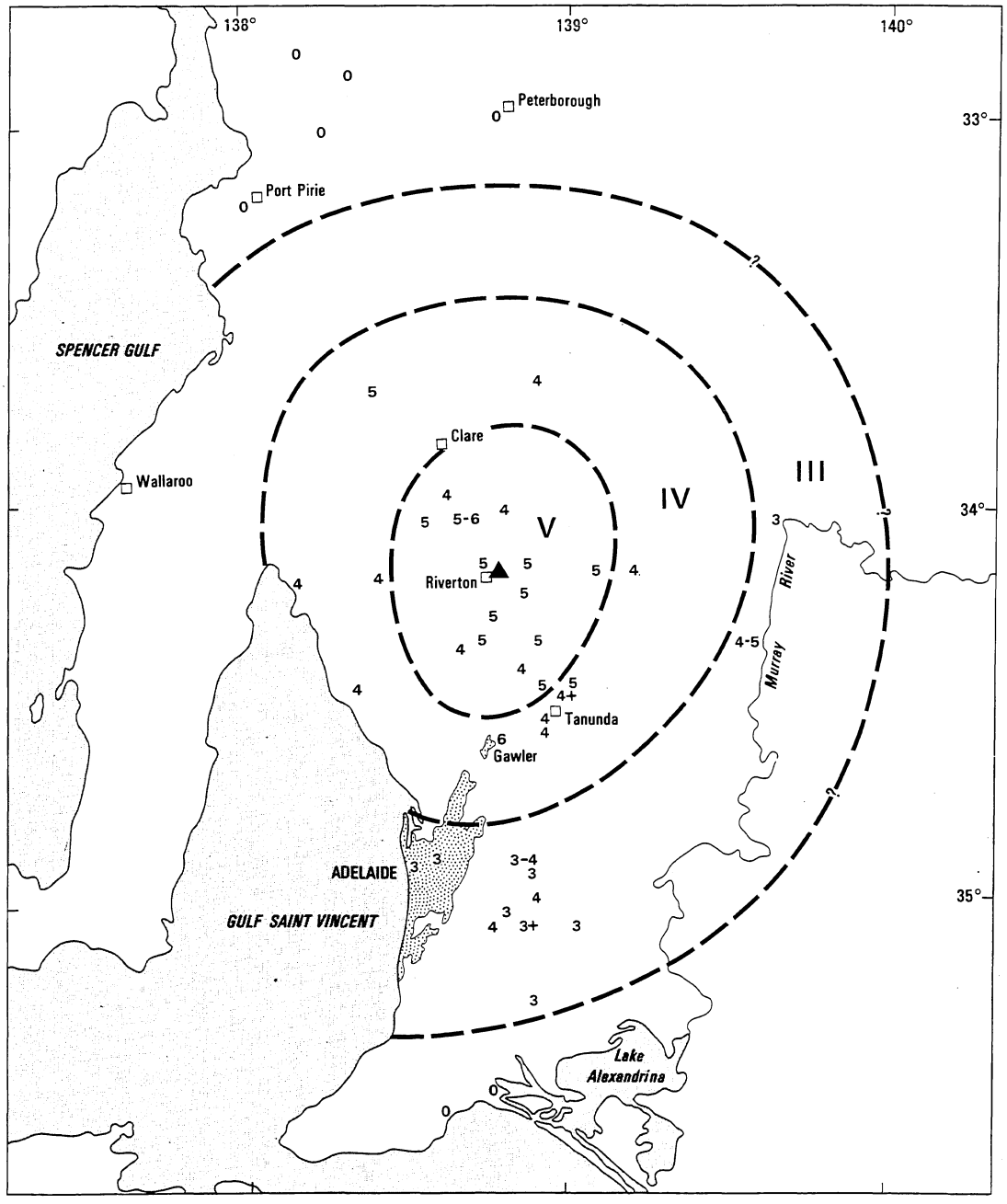
The following report is from *The Bunyip* newspaper of 25 August 1905:

> `Shortly after 4 am on Tuesday many residents of the town and district were awakened by an earth shock. The rattling of windows, shaking of buildings etc. were very perceptible and in a few instances slight damage occurred. The effects were noticeable for upwards of half a minute. The shock is reported from most other places in the State'

Minor damage was reported; for example at Nairne where some of the residents complained of plaster falling off their ceilings and in one instance to the NE of this village, ornaments were knocked off a mantle shelf. The isoseismal map yielded a location near Riverton and a magnitude of ML(I) 4.9.

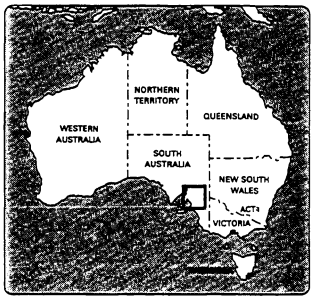
Contributors: Alison McArdle, Sutton Institute, South Australian Department of Mines and Energy collected together the felt reports and newspaper articles. The map was compiled by Kevin McCue.

ISOSEISMAL MAP OF THE RIVERTON EARTHQUAKE, SOUTH AUSTRALIA, 21 AUGUST 1905



DATE : *21 August 1905*
TIME : *18:35UT*
MAGNITUDE : *4.9ML(I)*
EPICENTRE : *34.2°S, 138.8°E*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



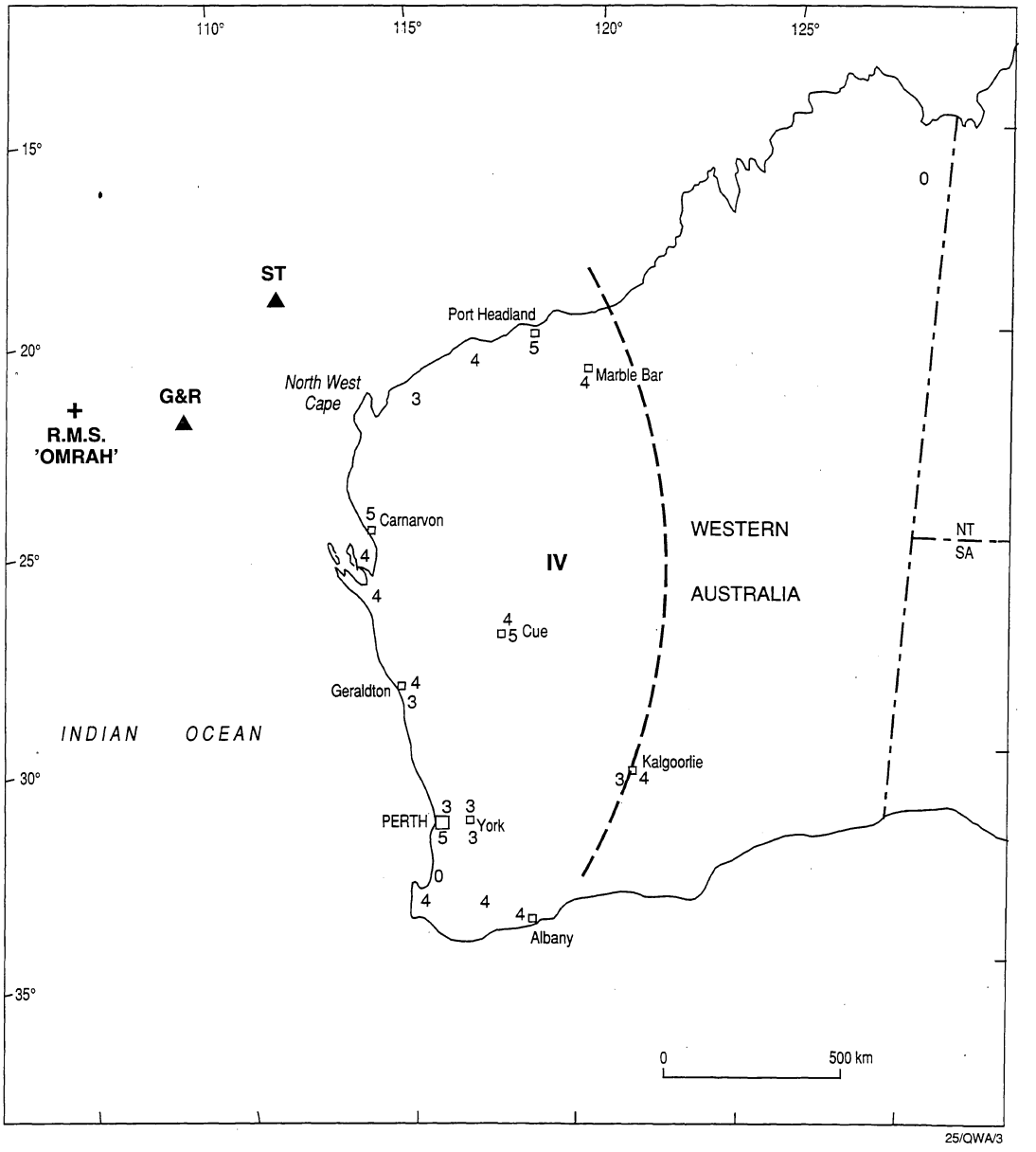
Isoseismal map of the Indian Ocean earthquake
Western Australia - 19 November 1906

This earthquake is the largest known intraplate earthquake in the Australian region. According to *The Daily News* 'it was felt practically throughout the State'. Gregson and Everingham (1991) reviewed the various estimates of its epicentre and concluded that it was in all probability near the position of the vessel Omrah which is marked on the map. No damage was done but it rocked bottles off shelves in Carnarvon, the town closest but still more than 500 km from the epicentre, and it was felt clearly at Albany 1700 km away.

Whilst Gregson and Everingham (1991) implied it had a magnitude of about ML 7.6 from its felt area, and Gutenberg and Richter gave it a magnitude of Ms $7^{3}/_{4}$, Abe and Noguchi (1983) reevaluated the magnitude as Ms 7.2.

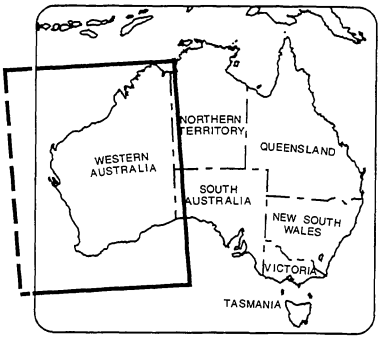
Contributors: Ian Everingham collected together the felt reports and newspaper articles and Peter Gregson compiled the map.

ISOSEISMAL MAP OF THE INDIAN OCEAN EARTHQUAKE, WESTERN AUSTRALIA
19 NOVEMBER 1906



	(G&R)	(ST)
DATE:	19 NOVEMBER 1906	
TIME:	07.18.03 GMT	07.18.41 GMT
MAGNITUDE:	7.75 (MS)	
EPICENTRE:	22°S, 109°E	19.1°S, 111.8°E
DEPTH:	60 km	

▲ *Epicentre*
IV *Zone intensity designation*
5 *Earthquake felt (MM)*
0 *Earthquake not felt*



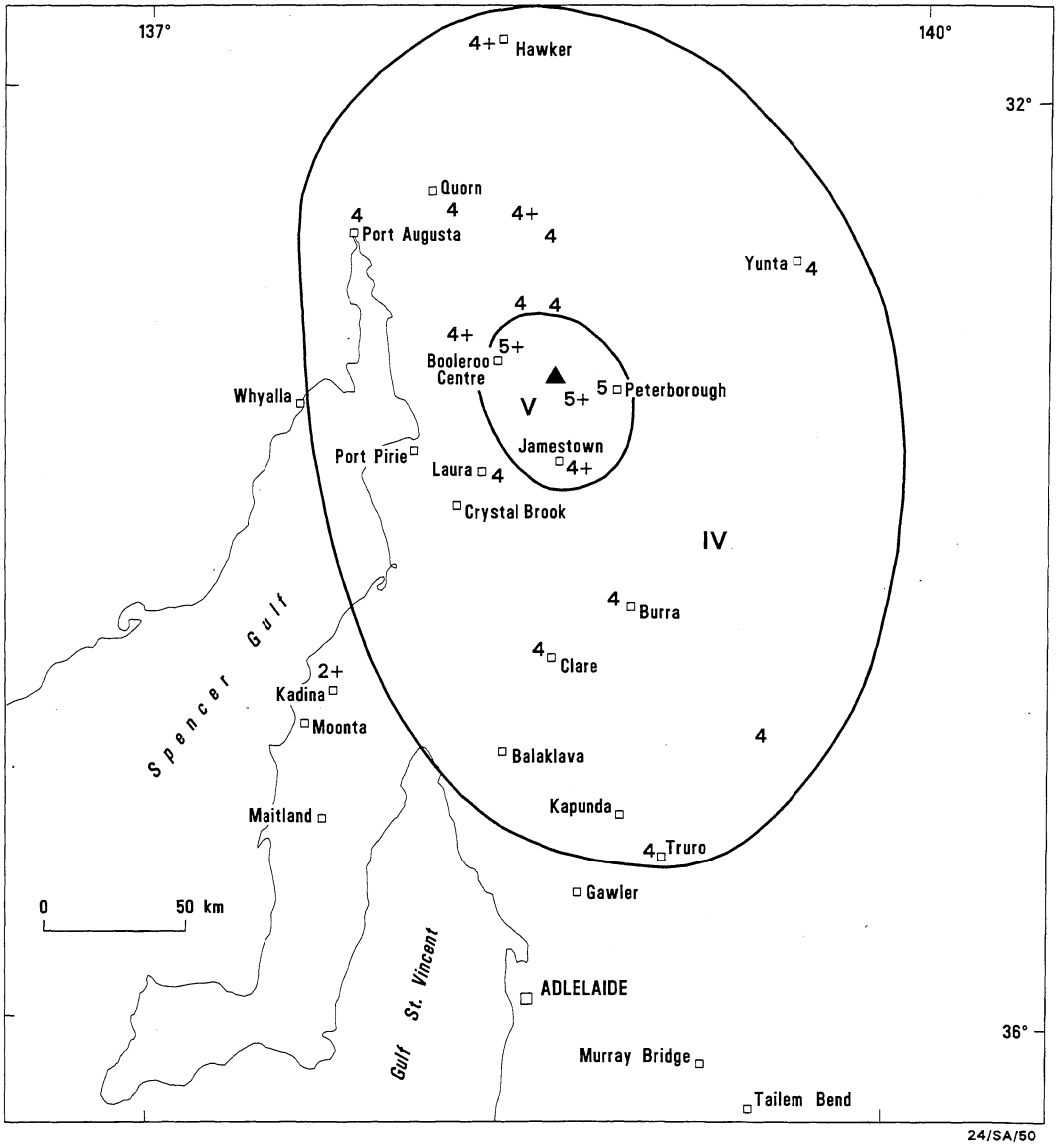
Isoseismal map of the Peterborough earthquake
South Australia - 9 April 1908

The Observer of 18 April 1908 labelled it a mild earthquake and published reports from many towns in the mid-north of the state, typical of which was the following:

> CARRIETON One of the severest earth tremors for some years was felt this morning at 2 o'clock. It lasted for fully a minute shaking crockery and other articles. The direction seemed to be from west to east. It was accompanied by a loud rumbling noise.

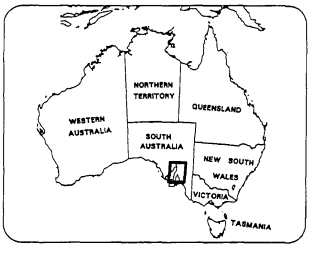
Contributors: This map was compiled by Katherine Malpas, Flinders University SA, and the South Australian Department of Mines & Energy.

ISOSEISMAL MAP OF THE PETERBOROUGH EARTHQUAKE, SOUTH AUSTRALIA
9 APRIL 1908



DATE: 9 APRIL 1908
TIME: 16:25 GMT
MAGNITUDE: 4.7 ML (I)
EPICENTRE: 32.95°S 138.64°E

▲ *Epicentre*
IV *Zone intensity designation*
4 *Earthquake felt (MM)*
Earthquake not felt



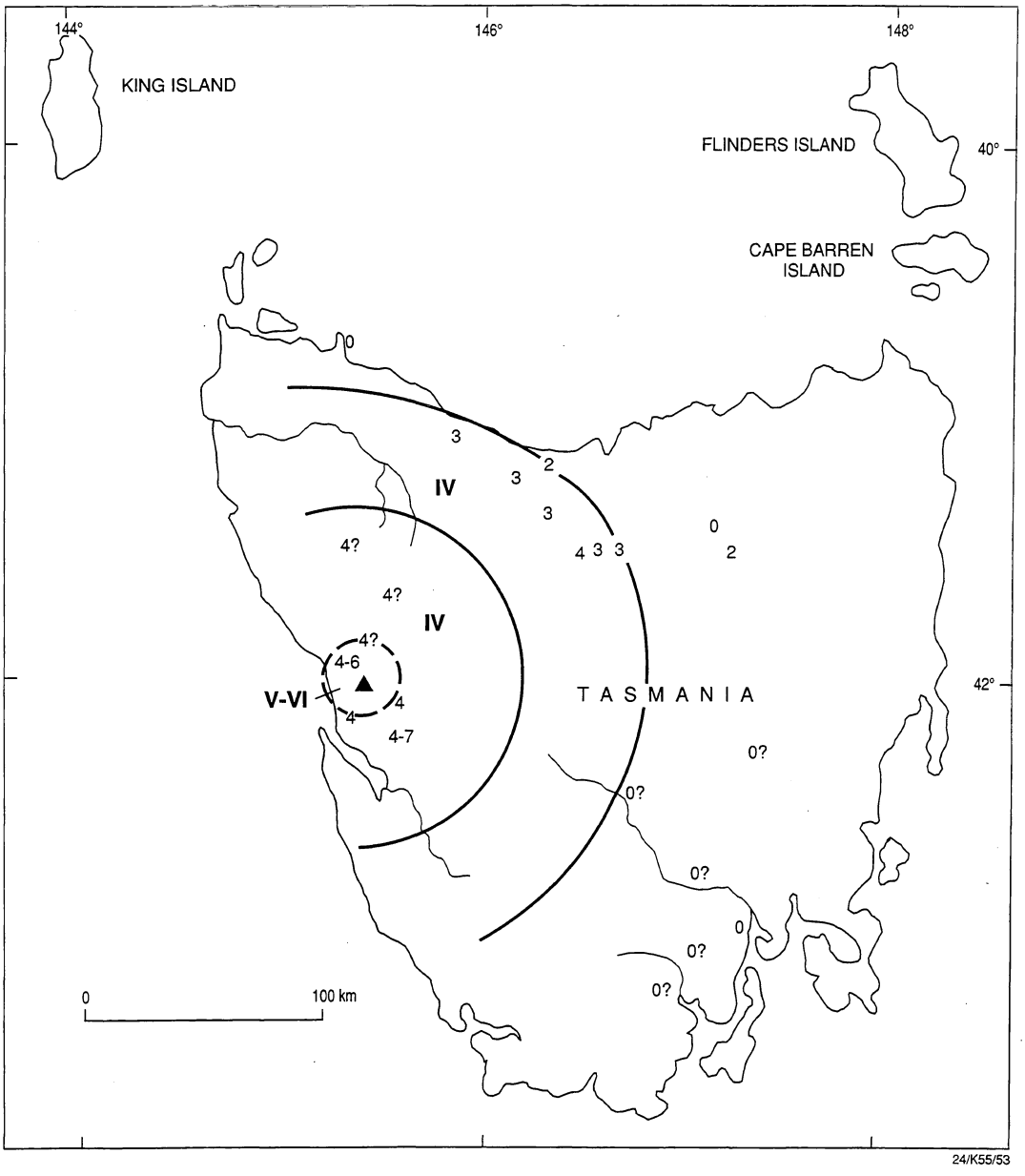
Isoseismal map of the Queenstown earthquake Tasmania - 4 May 1908

The earthquake at 7.50 pm local time was felt in northwestern Tasmania, but most strongly at Queenstown. Michael-Leiba (1989) investigated Tasmanian newspaper reports and compiled the isoseismal map. The area was so sparsely populated that only six places reported feeling the earthquake. She reports

> 'In Queenstown, people rushed out of their houses and, in some places, crockery was thrown from shelves and plaster fell from walls and ceilings. One or two buildings had slight cracks, two water tanks burst and the top of one chimney was shaken off.'

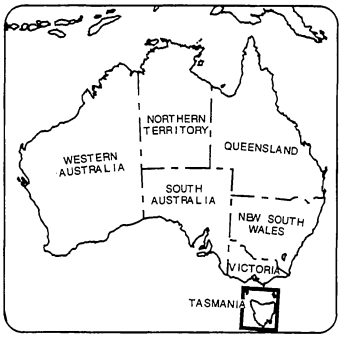
Contributors: Dr Marion Michael-Leiba compiled the information and isoseismal map.

ISOSEISMAL MAP OF THE QUEENSTOWN EARTHQUAKE, TASMANIA
4 MAY 1908



DATE: 4 MAY 1908
TIME: 0950 GMT
MAGNITUDE: 4.8 MI, 5.0 ML(I)
EPICENTRE: 42.0°S, 145.4°E

▲ *Epicentre*
IV *Zone intensity designation*
5 *Earthquake felt (MM)*
0 *Earthquake not felt*

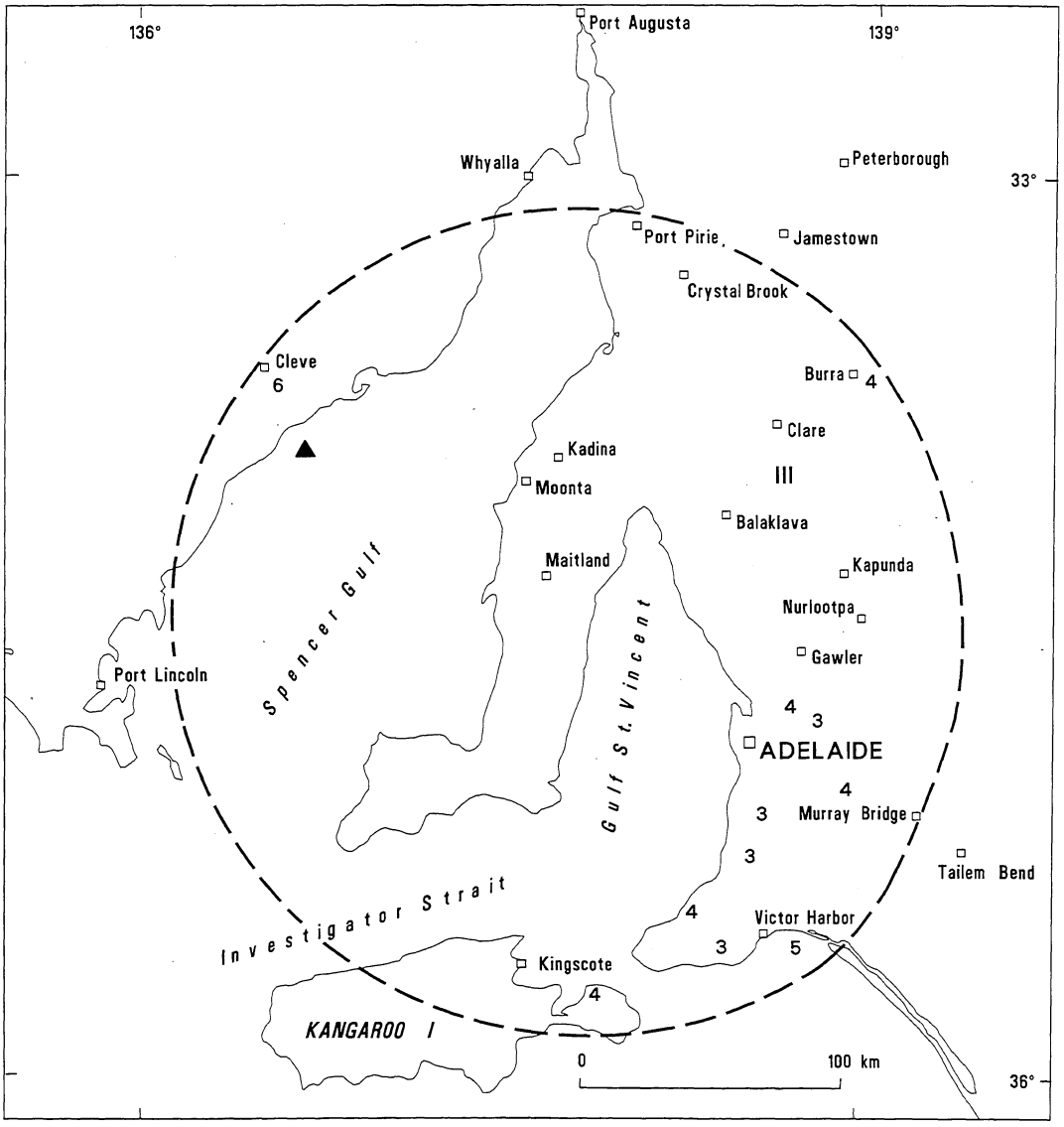


Isoseismal map of the Cleve earthquake
South Australia - 24 October 1911

According to newspaper reports at the time, this earthquake at 9:30 pm was felt in towns south of Adelaide and on Kangaroo Island. It was not felt in Adelaide but was reported felt in North Adelaide.

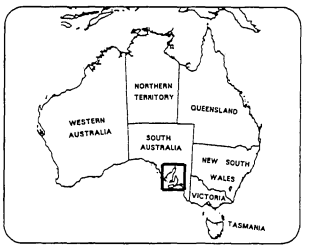
Contributors: This map was compiled by Katherine Malpas, Flinders University SA, and the South Australian Department of Mines & Energy.

ISOSEISMAL MAP OF THE CLEVE EARTHQUAKE, SOUTH AUSTRALIA, 24 OCTOBER 1911



DATE: 24 OCTOBER 1911
TIME: 12:00 GMT
MAGNITUDE: 4.8 ML (I)
EPICENTRE: 33.90°S 136.70°E

▲ *Epicentre*
III *Zone intensity designation*
3 *Earthquake felt (MM)*
Earthquake not felt



Isoseismal map of the Cleve earthquake
South Australia - 26 October 1911

This earthquake was reported felt across all three peninsulas bordering the Spencer and Saint Flinders Gulfs. Malpas (1991) quotes from *The Advertiser* newspaper that at Cleve:

> As a result of the heavy earthshocks, several underground tanks have been cracked so badly that they have become empty. Many buildings suffered severely and in one case an iron ceiling was bent out of shape.

The Chronicle reported that:

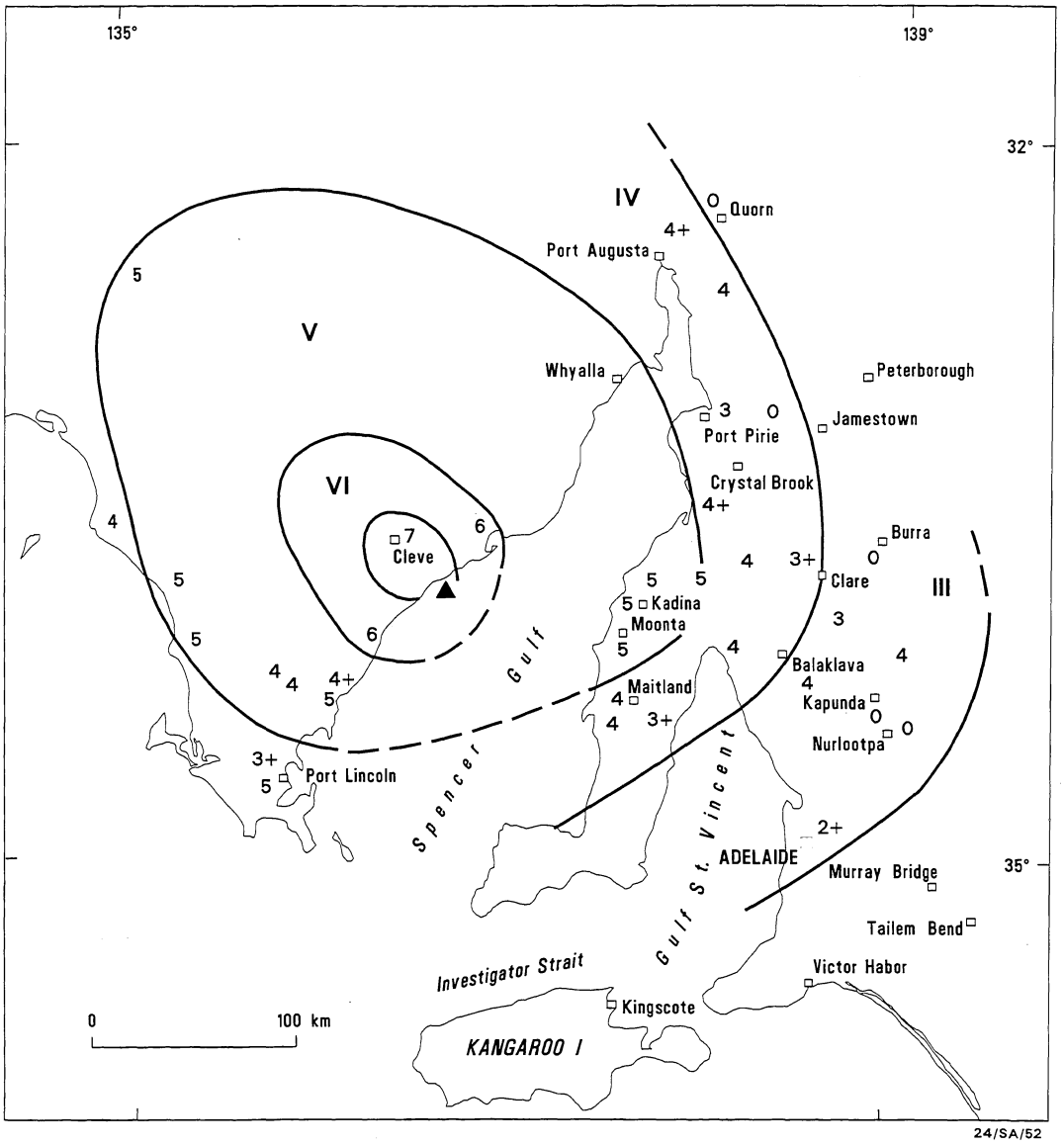
> Cleve still exists. A large earthquake was seen in the vicinity last night and smashed some crockery.

At Adelaide it was felt by one reporter as a moderately severe tremor which rattled doors and windows violently, by another as sufficiently large that people rushed out of doors, and by yet another that it was very slight. The duration was variously estimated as lasting from 2 seconds by some to 2 minutes by others.

Malpas (1991) estimated that the magnitude was about 5.5.

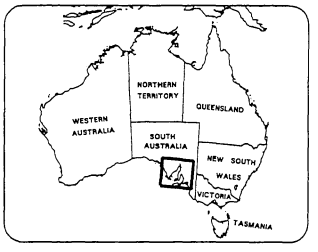
Contributors: This map was compiled by Katherine Malpas, Flinders University SA, and the South Australian Department of Mines & Energy.

ISOSEISMAL MAP OF THE CLEVE EARTHQUAKE, SOUTH AUSTRALIA
26 OCTOBER 1911



DATE: 26 OCTOBER 1911
TIME: 10:00 GMT
MAGNITUDE: 5.5 ML (I)
EPICENTRE: 33.92°S 136.73°E

▲ *Epicentre*
IV *Zone intensity designation*
5 *Earthquake felt (MM)*
0 *Earthquake not felt*



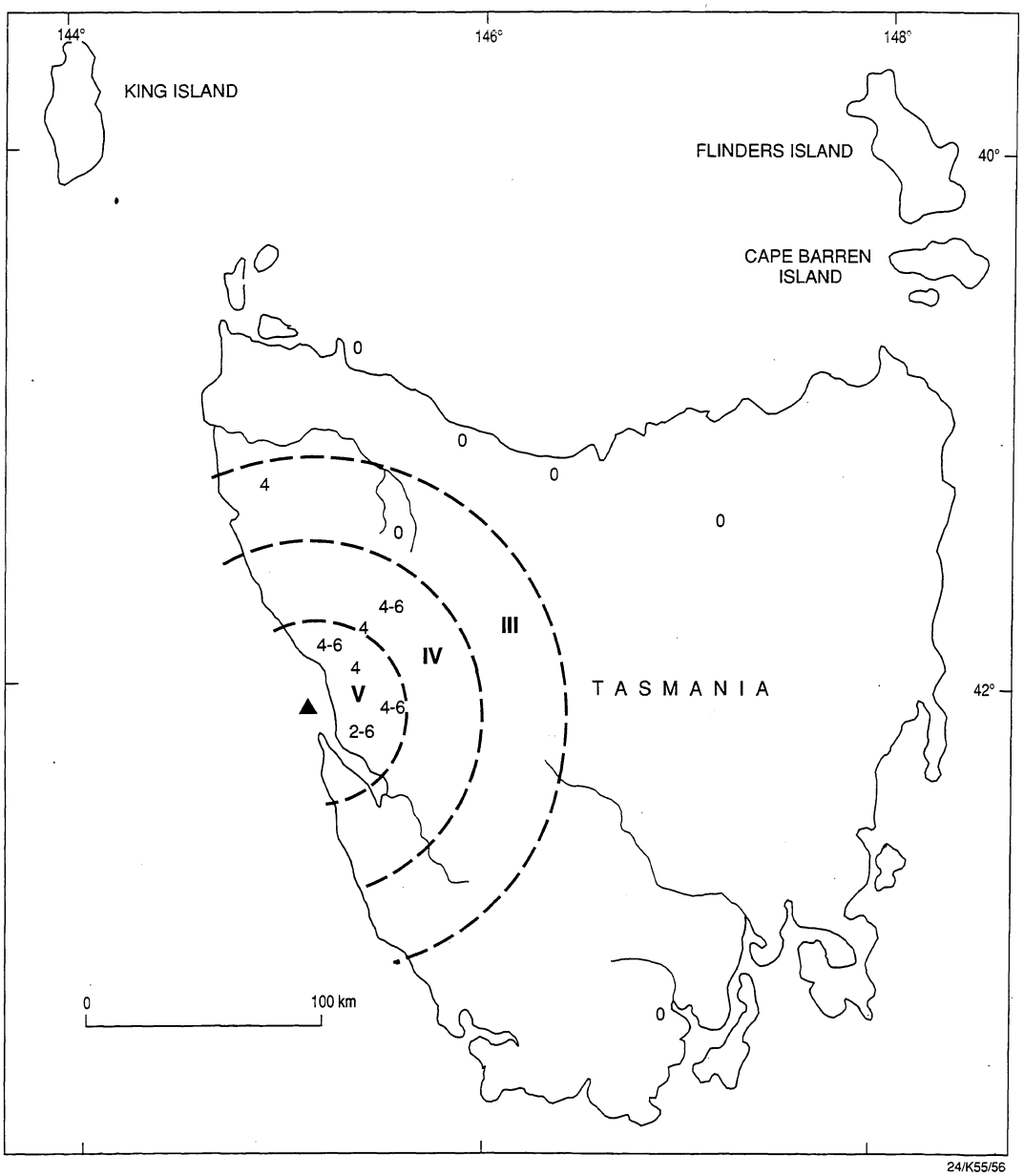
Isoseismal map of the West Coast earthquake
Tasmania - 4 November 1911

This earthquake was studied by Michael-Leiba (1989). It occurred at 11.27 am local time and was felt most strongly on the central west coast at Zeehan. It was not felt along the north coast of Tasmania. Reports of the earthquake were carried in *The Mercury, The Zeehan and Dundas Herald, The North West Post, the Advocate and Times* and *Circular Head Chronicle.* From *The Zeehan and Dundas Times* we read:

> 'most severe tremor felt...It was preceded by a peculiar rumbling, and as the movement passed by, houses were considerably shaken, giving much alarm to residents, especially those in brick buildings..'

Contributors: Dr Marion Michael-Leiba compiled the information and isoseismal map.

ISOSEISMAL MAP OF THE WESTCOAST EARTHQUAKE, TASMANIA
4 NOVEMBER 1911



DATE: 4 NOVEMBER 1911
TIME: 0127 GMT
MAGNITUDE: 4.8 MI, 4.8 ML(I)
EPICENTRE: 42.1°S, 145.1°E

▲ *Epicentre*
IV *Zone intensity designation*
5 *Earthquake felt (MM)*
0 *Earthquake not felt*

Isoseismal map of the Bega earthquake
New South Wales - 17 January 1912

The report in *The Sydney Morning Herald* began:

> `Residents of the southern and South Coast districts were alarmed early yesterday morning by a severe shock of earthquake, which appeared to have originated at sea and travelled from a south-easterly direction towards the north-west. The shock was preceded by a loud rumbling noise as of distant thunder, and at precisely 5 minutes past 6 o'clock violent earth tremors were experienced.'

The shock, fortunately, was of but short duration, and as far as can be ascertained no one was injured and no serious damage was done to property. Earthquakes have on many occasions been experienced in the southern districts of this State, otherwise the alarm of the residents would probably have been very much greater.

At Tilba Tilba *The Sydney Morning Herald* reports:

> `A distinct shock of earthquake was felt here at five minutes past 6 this morning, and lasted about 5 seconds. The first intimation was a sudden report, and then a heavy tremor in a south-easterly direction. Residents report that their homes shook, and their crockery was rattling. Apparently the tremor was between Tilba and the coast, and thence out to sea. Some residents report another, as having occurred about 4 o'clock, but it was not so severe.'

At Cooma *The Sydney Morning Herald* reports:

> `An earthquake shock, lasting a minute, felt at Cooma and in the district this morning, shortly after 6 o'clock, was sufficiently severe to rattle windows and wake sleepers. The shock travelled in a north-westerly direction.'

The Cooma Express also reported the earthquake:

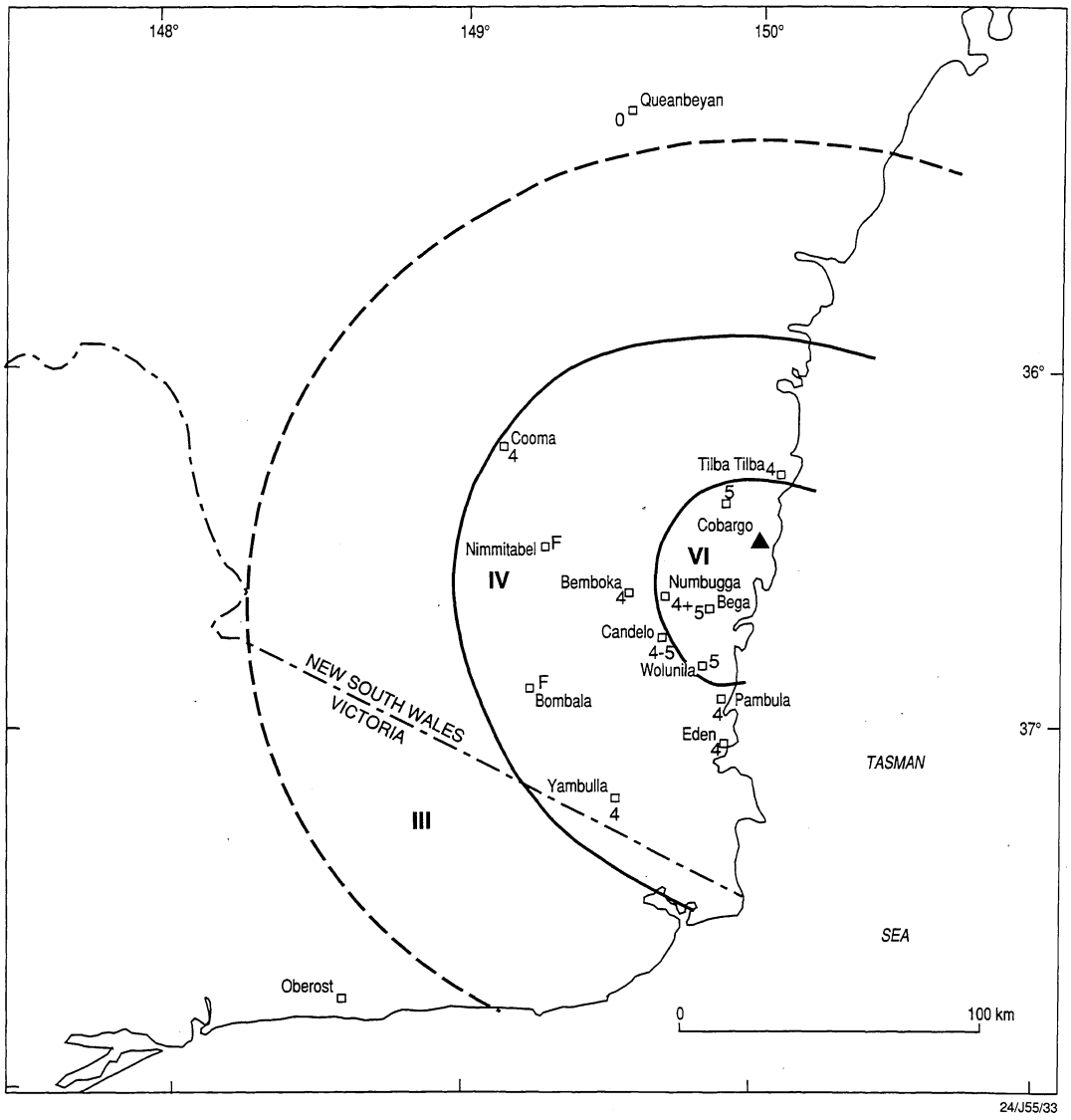
> `A very sharp shock of earthquake was experienced in Cooma yesterday morning at 9 minutes past 6. The tremor seemed to be travelling slightly to the north of west and was very pronounced all over the town and neighbourhood. It lasted nearly half a minute and was so severe as to bang doors and cause crockery and tinware to rattle very decidedly, creating a good deal of consternation. Similar conditions were experienced at Cobargo, Pambula and Bega.

The earthquake is listed by Burke Gaffney (1951) but with the wrong date - 27 January.

Contributors: This map was compiled by Kevin McCue.

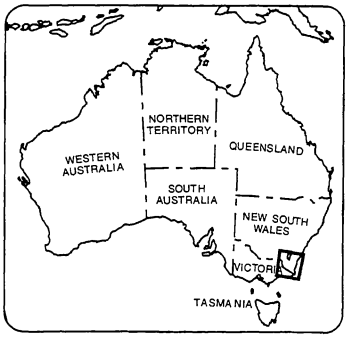
ISOSEISMAL MAP OF THE BEGA EARTHQUAKE, NSW

17 JANUARY 1912



DATE: 17 JANUARY 1912
TIME: 20:09 GMT
MAGNITUDE: 4.9 ± 0.3
EPICENTRE: 36.5°S, 150.0°E

▲ *Epicentre*
IV *Zone intensity designation*
4 *Earthquake felt (MM)*
0 *Earthquake not felt*



Isoseismal map of the Adelaide earthquake
South Australia - 28 May 1914

Many newspapers in South Australia carried the story of Adelaide's earthquake. Extracts from that in *The Register* of May 29, 1914 are as follows:

SHARP EARTHSHOCK
ADELAIDE PEOPLE ALARMED

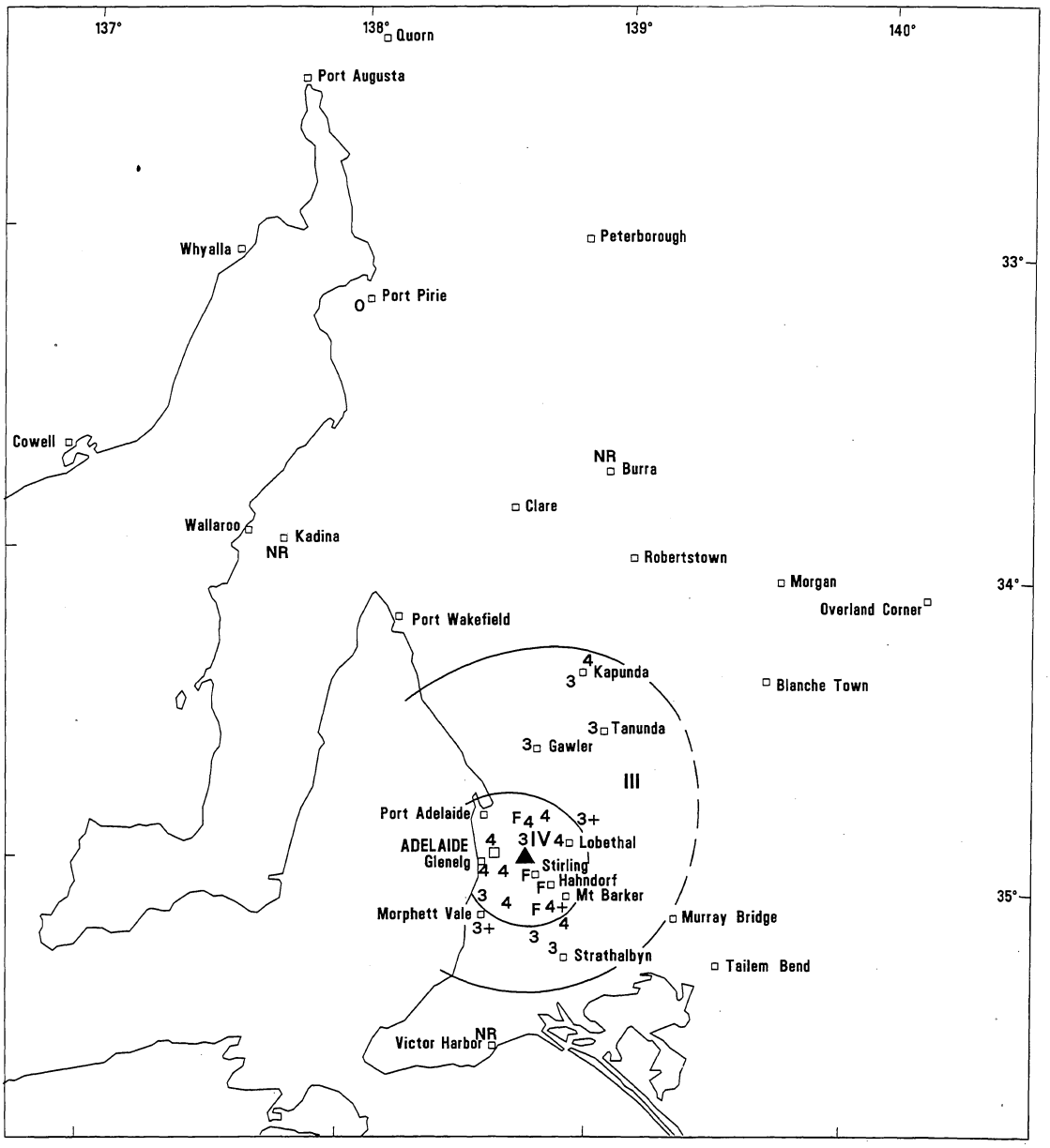
At nine minutes to 11 o'clock last night an earth tremor was recorded in a measure that was certainly beyond a joke. The actual tremor was preceded by an uncanny muffled like distant roar. People living at the foot of the hills got the idea that overtime was being put into blasting operations at the quarries. The report was followed by a determined tremor that lasted from five to ten seconds. It was a short and sharp affair, but the quake was the most lively one that people in the Adelaide metropolitan area have experienced since the memorable disturbance that did so much damage in September 1902, including the demolition and burning of the Troubridge Light.

Plenty of people who were in bed and dozing off were rudely awakened by the sharpness of the shock. A seismic shudder is always out of the common when it is felt in the Register's ferro-concrete building and the staff within distinctly noted the visitation....Nobody reported any damage worth noting.....

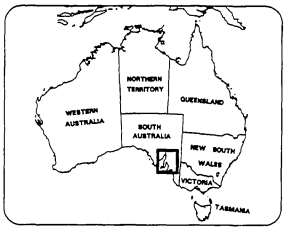
The Government Astronomer (Mr Dodwell) and the Meteorological Officer (Mr Bromley) both felt and heard the quake, and the latter timed it at 10:51 pm. The barograph at the observatory recorded the tremor.

Contributors: This map was compiled by Kevin McCue. The felt reports which enabled construction of this isoseismal map were collected by Alison McArdle of the Sutton Institute, SADME, on contract to BMR.

ISOSEISMAL MAP OF THE ADELAIDE EARTHQUAKE, SOUTH AUSTRALIA, 28 MAY 1914



DATE: 28 May 1914
TIME: 13:21 GMT
MAGNITUDE: 4.2 ML (I)
EPICENTRE: 34.95°S 138.7°E



▲ *Epicentre*
IV *Zone intensity designation*
4 *Earthquake felt (MM)*
0 *Earthquake not felt*
F *Felt*

24/SA/35

Isoseismal map of the Seal Rocks earthquake New South Wales - 10 June 1916

The following extract from the *Wingham Chronicle and Manning River Observer* of 14 June 1916 was provided by the Manning Valley Historical Society at the request of Ms Cynthia Hunter during the course of her research into earthquakes in the Hunter Valley (Hunter, 1991).

> A shock of an earthquake was experienced along the coast from Newcastle to Taree last Sunday morning between 3 and 4 o'clock.
> At Seal Rocks the lighthouse walls were cracked, a ceiling in one room came down bodily, and the light was extinguished.
> At Forster, houses were violently shaken and some of the people ran into the streets.
> at Tuncurry, a similar state of affairs existed. Mr Slowman of the Belle View Hotel describes the first intimation as being like a team of horses dragging a heavy lorry violently over a cobbled road.
> At Taree, Miss Lean who was sleeping on the balcony was awakened by the violent rattling of the bottles and photographic paraphernalia in her brother's studio.
> Mr Storm was also awakened by the stock in his jewellers shop rattling. Whilst a family that lived behind the hospital were so alarmed by the shaking of their house, that for a few minutes they all huddled together wondering what had happened.

The earthquake was felt in Sydney, about 200 km from south of the epicentre and reported by the *Sydney Morning Herald* of 14 June 1916 (copies of which were in the Riverview Observatory newspaper clippings book).

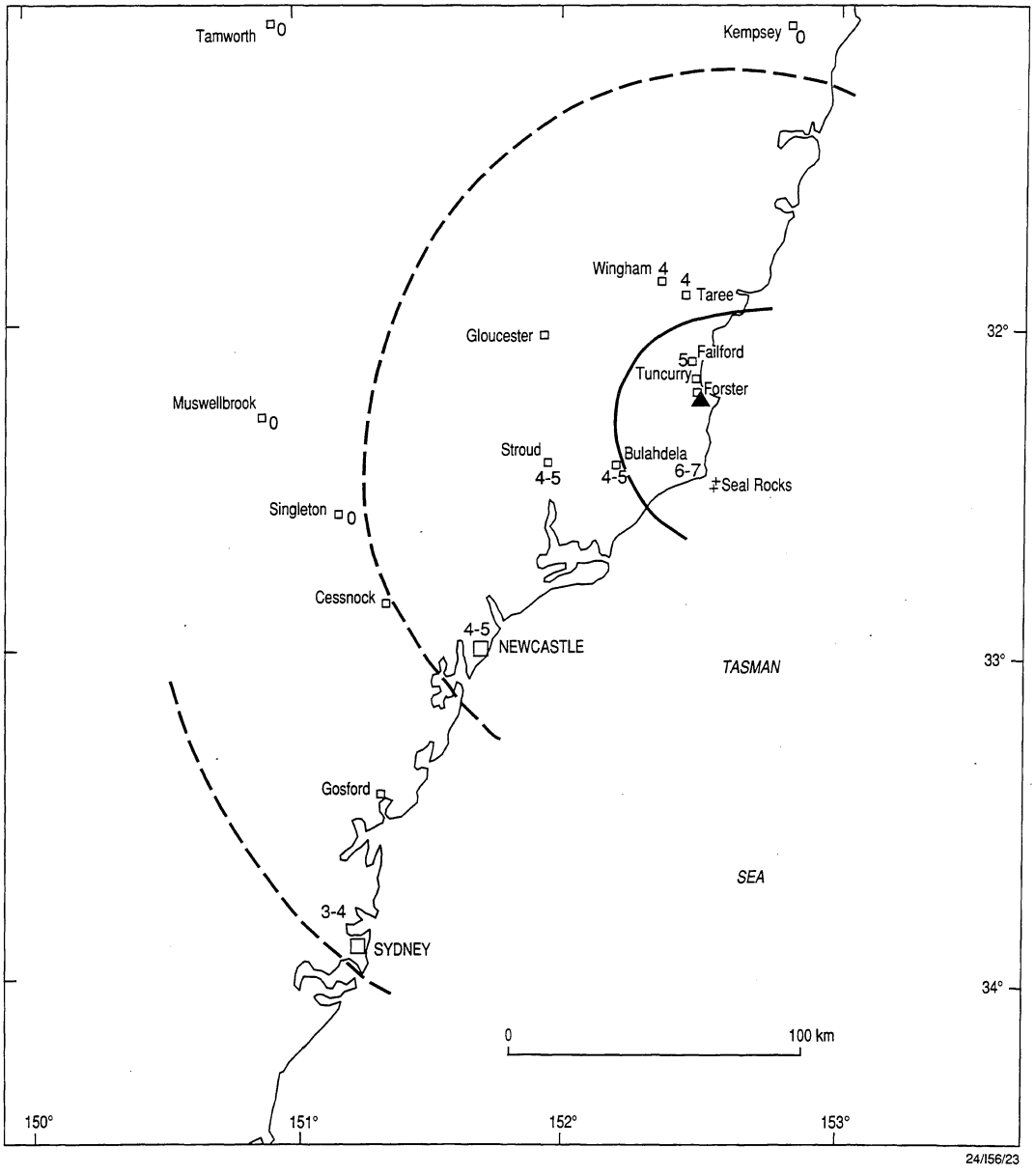
> In many parts of Sydney the earthquake was felt, people being awakened by the shaking of their beds and the rattling of crockery. Buildings were violently shaken in some places.
> ..... Father Pigot, who is in charge of the observatory (Riverview) stated yesterday that this small earthquake is interesting as being the nearest undoubted tectonic disturbance recorded in Sydney since the Riverview observations began, in March 1909, the next being the Cooma-Bega shock of January 17, 1912, at about twice the distance - 200 miles.

Contributors: The isoseismal map was drawn by Andrew McCallum, a work experience student under the guidance of Kevin McCue at the Australian Seismological Centre. McCallum wrote a short report on the effects of the earthquake gleaned from Hunter's (1990) book and other newspaper reports, and he determined its magnitude using both the intensity data and the Riverview seismogram and station bulletin (No 6, June 1916) which reported the measured ground amplitude.

McCallum also noted that neither of the previous studies of the historical seismicity of NSW (Burke-Gaffney, 1951; Drake, 1974) mentioned the earthquake although it was discussed in some detail in the Riverview Seismographic Bulletin.

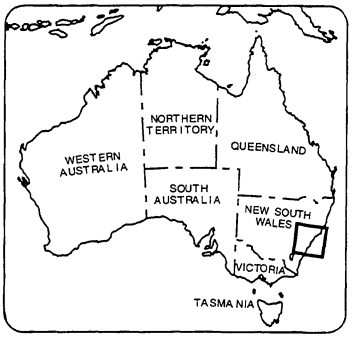
ISOSEISMAL MAP OF THE SEAL ROCKS EARTHQUAKE, NSW

10 JUNE 1916



DATE: 10 JUNE 1916
TIME: 17:51 (GMT)
MAGNITUDE: 4.6
EPICENTRE: 32.25°S 152.50°E

▲ *Epicentre*
IV *Zone intensity designation*
4 *Earthquake felt (MM)*
0 *Earthquake not felt*



Isoseismal map of the Jamestown earthquake
South Australia - 23 April 1921

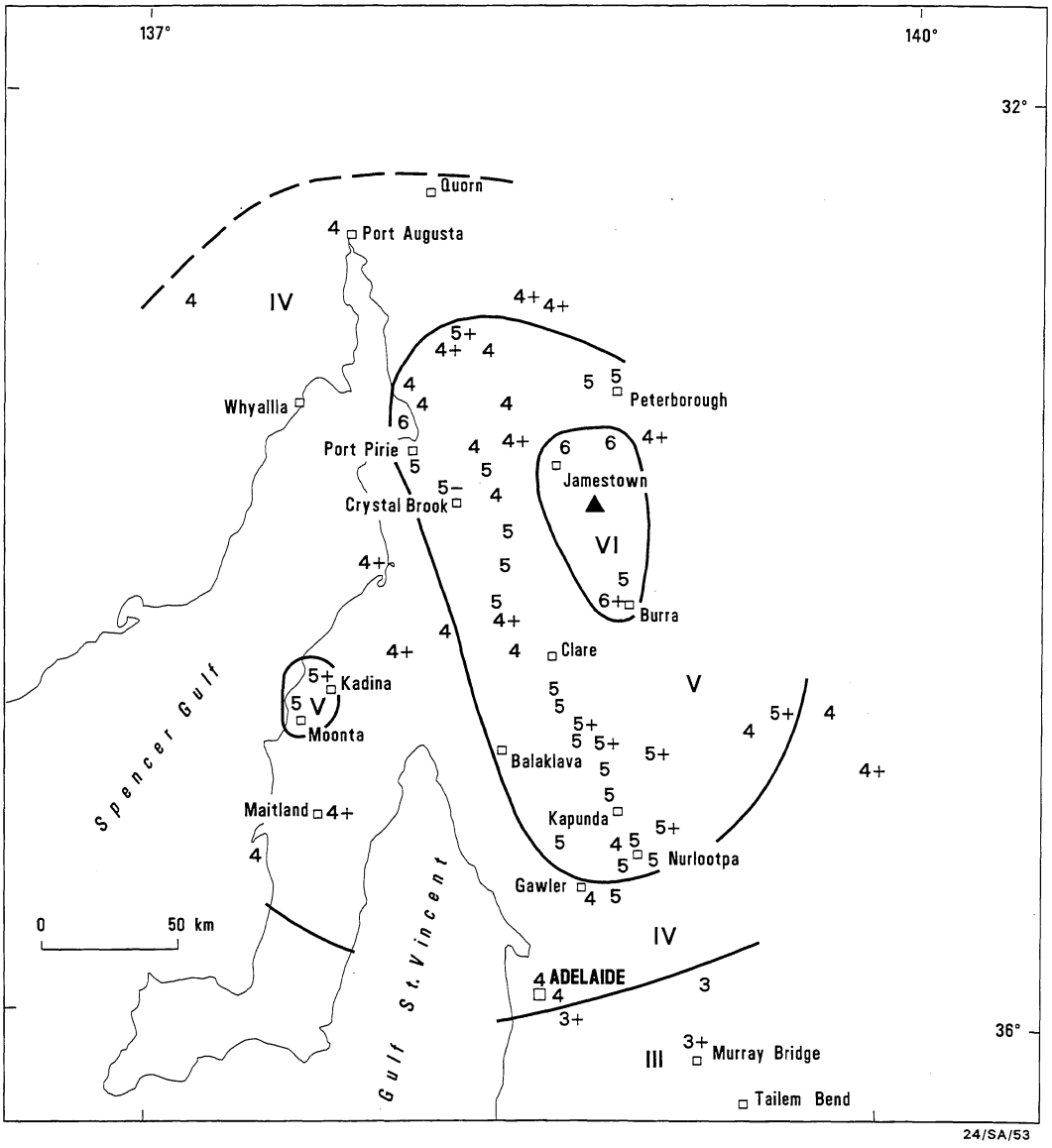
The contemporary *Burra Record* unearthed by Malpas (1991) reported that:

> On Sunday morning last, most of the residents of Burra were suddenly awakened at 4:40 am by a loud rumbling. By the time folk were fully awake, the noise had become much louder, the vibration had increased and for about ten seconds buildings were shaken, causing the windows, doors and roofs to rattle.... Several reports are to hand of cracked walls and fallen plaster but no serious damage was done.....Mr F Spencer, our local jeweller has written 'In reference to the severe earthshock experienced on Sunday, the seismograph I have under construction records that the direction of the movement was from north to south, the first shock being very severe. It continued with some force for 30 seconds then gradually ceased. It lasted in all 80 seconds. The portion of the seismograph which shows direction gives the first movement as coming from the north-east which is very decided.

The Advertiser of 27 April 1921 gave the time of the first phase as 04:30:38, the second as 04:30:57, and the long waves as 04:31:09. These are consistent with an epicentre about 160 km north of Adelaide.

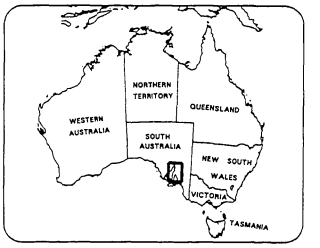
Contributors: This map was compiled by Katherine Malpas, Flinders University SA, and the South Australian Department of Mines & Energy.

ISOSEISMAL MAP OF THE JAMESTOWN EARTHQUAKE , SOUTH AUSTRALIA 23 APRIL 1921



DATE: 23 APRIL 1921
TIME: 19:00 GMT
MAGNITUDE: 5.1 ML (I)
EPICENTRE: 33.36°S 138.81°E

▲ *Epicentre*
IV *Zone intensity designation*
4 *Earthquake felt (MM)*
Earthquake not felt



Isoseismal map of the West Coast earthquake Tasmania - 1 March 1924

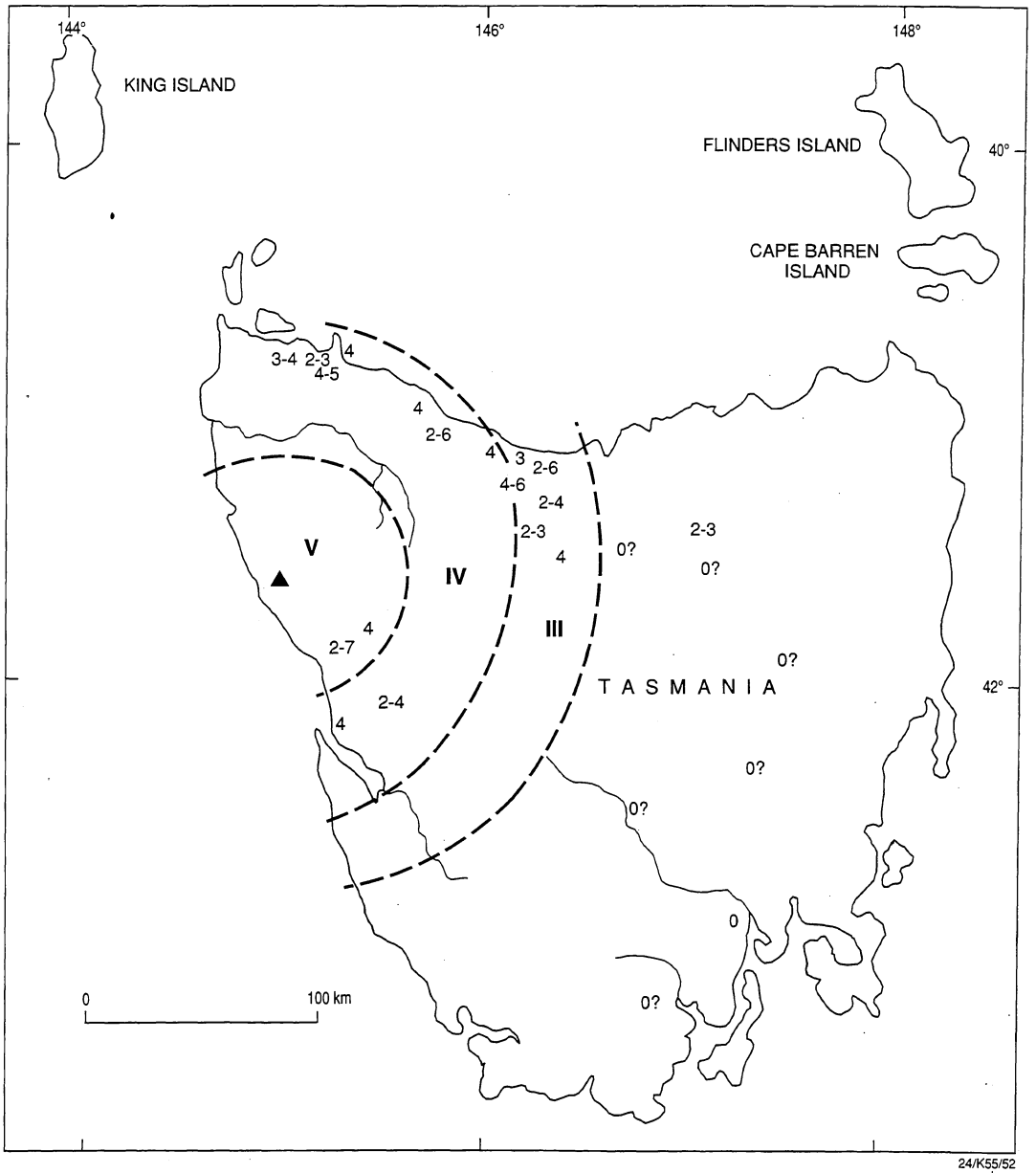
This earthquake was the last reported by Michael-Leiba (1989) in her exhaustive study of early Tasmanian earthquakes. It occurred at 9.55 pm local time and was felt most strongly on the central west coast at Zeehan. It was not felt on King Island or in Victoria. Reports of the earthquake were carried in the Mercury, the Examiner, the Advocate and Circular Head Chronicle. From the Mercury we read:

> 'Zeehan residents rushed out of their houses and places of entertainment on to the roads panic stricken. Picture frames and ornaments fell off walls of houses and were smashed.'

Minor damage to crockery and glassware was reported at Devonport, Burnie and Sprent on the north coast of Tasmania.

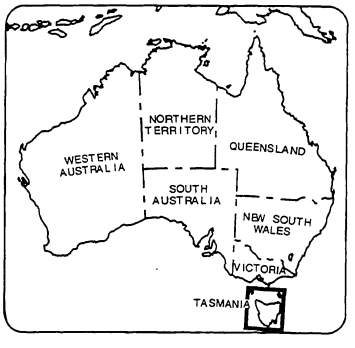
Contributors: Dr Marion Michael-Leiba compiled the information and isoseismal map.

ISOSEISMAL MAP OF THE WESTCOAST EARTHQUAKE, TASMANIA
1 MARCH 1924



DATE: 1 MARCH 1924
TIME: 1155 GMT
MAGNITUDE: 5.2 MI, 5.1 ML(I)
EPICENTRE: 41.6°S, 145.0°E

▲ *Epicentre*
IV *Zone intensity designation*
5 *Earthquake felt (MM)*
0 *Earthquake not felt*



Isoseismal map of the Boorowa earthquake
New South Wales - 27 October 1930

The Canberra Times, 28th October 1930, devoted little space to the effects of the earthquake in Canberra apart from commenting that

> 'tremors were felt in Canberra yesterday at five minutes past twelve and caused some alarm. Government offices and dwellings were shaken and farmers experienced the shocks in various parts of the Territory. In one case the shock was serious enough to cause the ringing of a telephone.'

It continued with reports from New south Wales centres

> '...at Murringo two shocks shook the houses and dislodged crockery from the shelves and pictures from the walls...Shocks were also felt in some suburbs of Sydney , but they were very slight.'

The Sydney Morning Herald and *The Lithgow Mercury* also briefly covered the story. It was not apparently felt as far north as Lithgow or Portland.

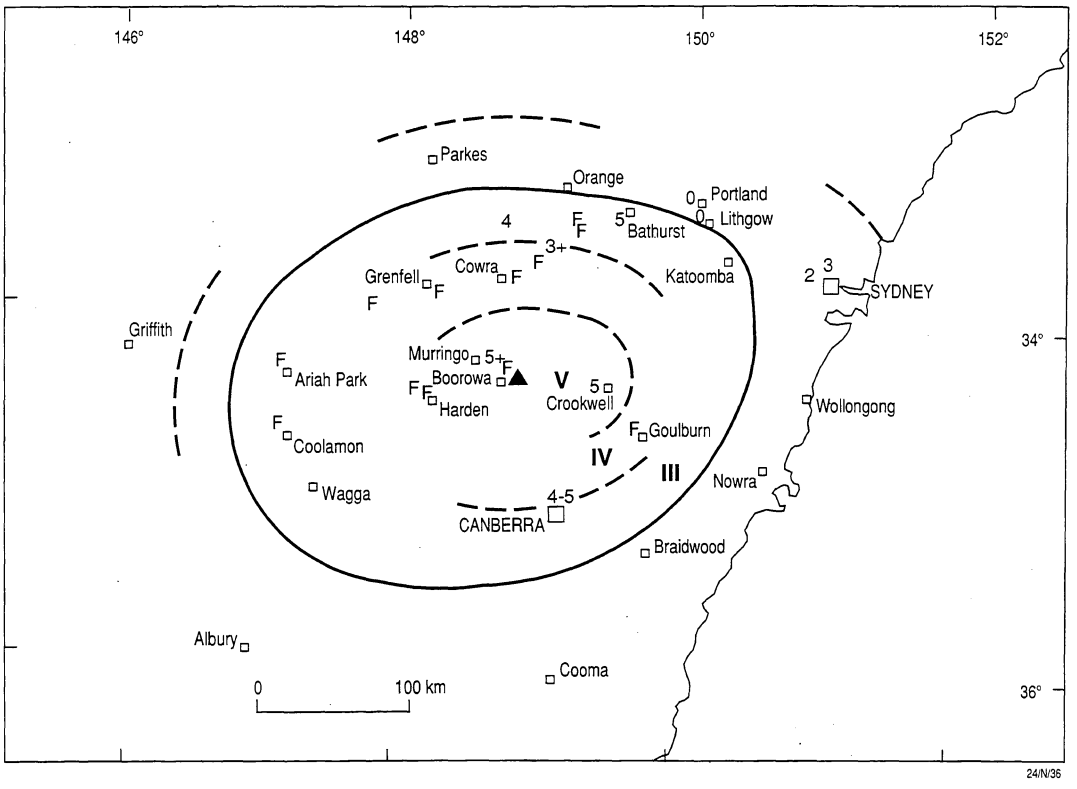
Effects in the epicentral region are summarised in a book on the history of Boorowa by Helen Lloyd (1990):

> During the 1930's the Boorowa District, including Gunning, suffered continuous earthquakes. Hundreds were felt throughout the south west districts in January, 1933, and at Gunning they were occurring nearly every day. One of the worst quakes that hit Boorowa was on 27th October, 1930, consisting of two tremors that shook the houses violently. The first was more pronounced and lasted ten seconds, the blackboard and a large picture fell from the walls of the public school and one wall was left with a large crack in it. A chimney fell from one house onto a stack of bottles, adding to the confusion. The walls at the Council Chambers cracked in several places and old cracks opened up further. Plaster in large houses fell from the walls at the Mechanic's Institute, crockery fell from the shelves of houses as walls cracked and plaster fell.

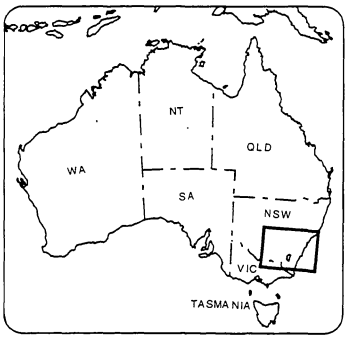
There is a reference in her book to an earthquake in March 1852 that shook Boorowa with 'incredible violence' lasting for three-quarters of a minute and two earthquakes in June and October 1911. There were no further details on these events but Lloyd records that 'on the first of December 1886, Boorawa was hit with a violent earthquake lasting twenty seconds, affecting every house and at the termination of the quake there was a terrific exploding noise'.

Contributors: This map was compiled by Kevin McCue. Lesley Hodgson browsed through newspapers at the National Library for references and Dr David Palfreyman unearthed the 'Boorowa over 160 years of white settlement' reference.

ISOSEISMAL MAP OF THE BOOROWA EARTHQUAKE,NEW SOUTH WALES
27 OCTOBER 1930



DATE: 27 OCTOBER 1930
TIME: 02:40:20 GMT
MAGNITUDE: ML(I) 5.3±0.2
EPICENTRE: 34.4°S, 148.8°E



▲ *Epicentre*
IV *Zone intensity designation*
4 *Earthquake felt (MM)*
F *Earthquake felt*
0 *Earthquake not felt*

Isoseismal map of the Dalton earthquake
New South Wales - 18 November 1934

This earthquake was described by McCue & others (1989) from which the following account was extracted:

> The lead story in *The Sydney Morning Herald* of 20 November 1934 stated: `Probably the severest earthquake recorded in New South Wales was experienced at 8 o'clock yesterday morning when a wide area of the State was shaken .' It continued: `The worst damage was reported from Gunning where practically every brick and stone building received damage in some form, huge rocks were split, trees were felled, and great fissures were opened in the ground.'

The earthquake was the culmination of a week long series of foreshocks and was reported to be the worst shock in the history of Gunning. It was followed by a long series of aftershocks, one of which, on Monday 25 November was felt at least as strongly in Cooma, 160 km distant, as was the mainshock.

Several buildings in Gunning lost chimneys and one baker's oven was so badly cracked that it was rendered useless. In many houses the walls cracked and plaster fell from the ceilings. Pictures on walls were dislodged and in some instances turned right round. Such reports are commensurate with an intensity of VIII on the Modified Mercalli scale. At Dalton the damage was reported to have been extensive though no details were given.

According to *The Canberra Times* the water in the Canberra swimming pool (at Manuka) was considerably agitated and in the pool office the telephone wobbled enough to tinkle the bell as if it were ringing. Early morning strollers reported that the road appeared to be undulating and trees vibrated violently.

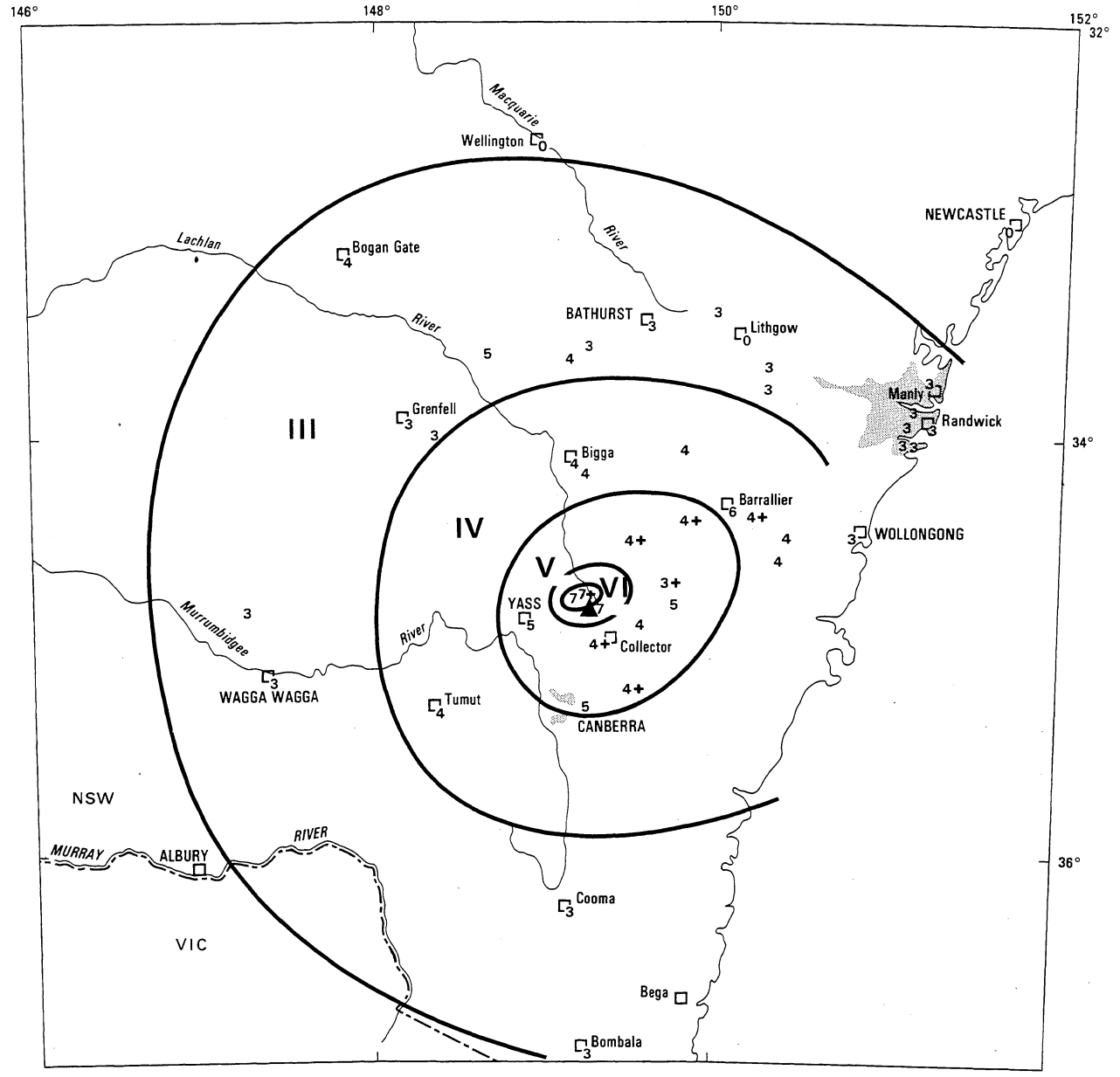
The Sydney Morning Herald reported that: `deep fissures appeared in the road between Dalton and Gunning in four places. The fissures apparently run for a considerable distance and although they are mere cracks in some places, they are several inches wide in others.' Cracks were also reported to have opened in a ridge 3 km west of Gunning but afterwards closed up. ...

According to *The Sydney Morning Herald* residents in practically all suburbs of Sydney felt the tremor.

From the isoseismal map, the radius of perceptibility was about 250 km which converts to a magnitude of ML(I) 5.6 (McCue, 1980) which is the same as that measured by Drake (1974) from the Riverview seismogram.

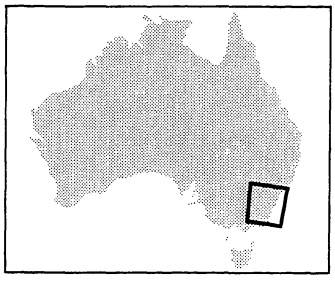
Contributors: This map was compiled by Kevin McCue with help from Lesley Hodgson who assisted with data collection.

ISOSEISMAL MAP OF THE DALTON-GUNNING EARTHQUAKE, NEW SOUTH WALES, 18 NOVEMBER 1934



DATE : 18 NOVEMBER 1934
TIME : 21:58:41 UT
MAGNITUDE : 5.6 ML (RIV), 5.6 (I)
EPICENTRE : 34.8°S 149.2 °E
DEPTH : SHALLOW

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



24/N/20

Isoseismal map of the Nilpena earthquake
South Australia, 26 March 1939

The lead story of *The News* on Tuesday 26 March 1939 concerned this earthquake and was headlined `Seven tremors felt in 3 days, Chimney crashes Walls Crack'. The story continued:

> Every wall in the seven-roomed homestead (Motpena Station near Parachilna) cracked, and a chimney in a nearby building crashed in the first shake experienced on Sunday afternoon. Two other tremors occurred that day, two yesterday and two more about 4 am today.

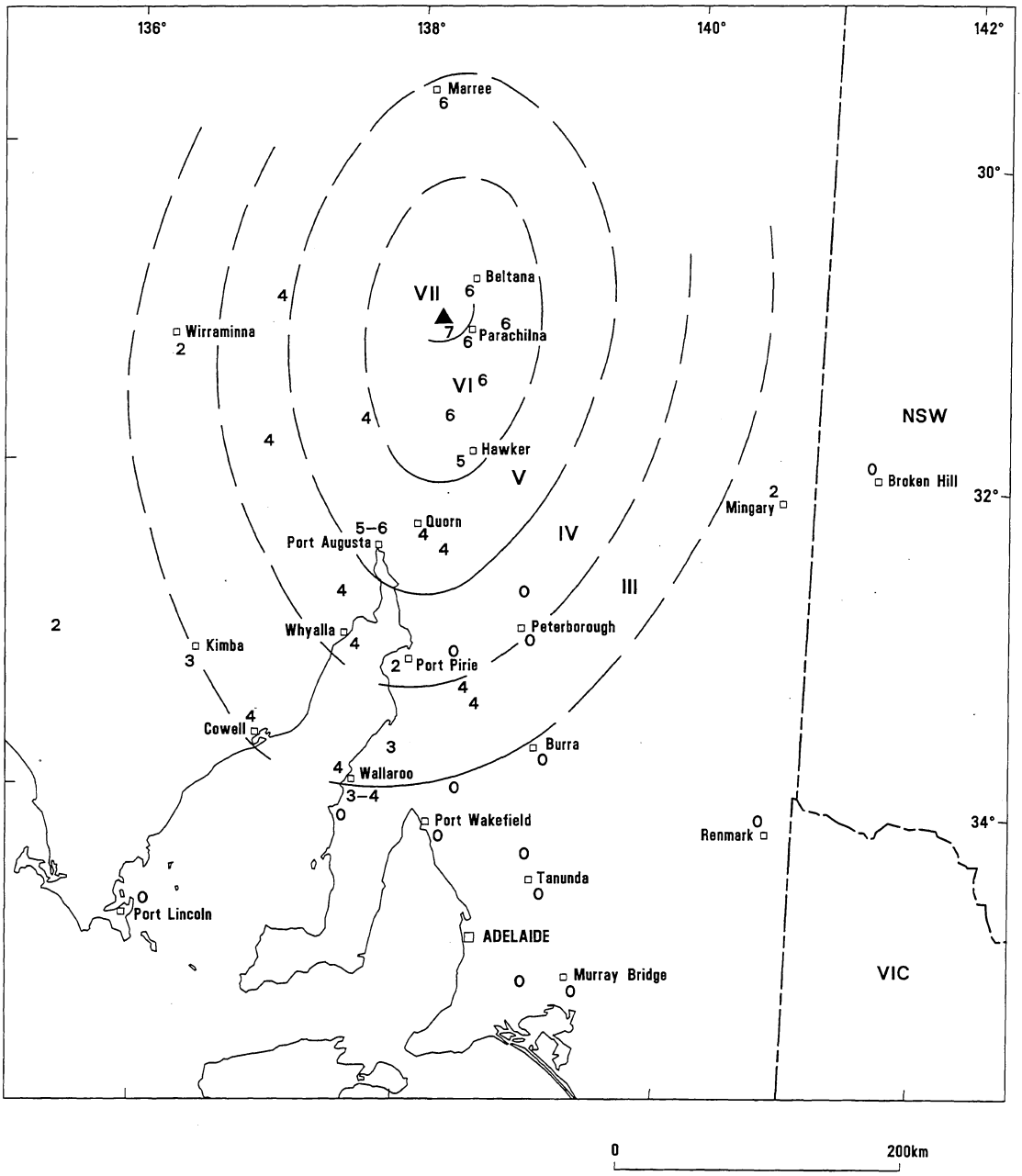
The *Adelaide Chronicle* commented further on 30 March that:

> So severe was one of the shocks that water lying five feet below ground in a tank near the house splashed over the top..... Stock were terrified , and cracks were appearing in the ground. A strange feature of the disturbance was that sandhills in the district were altering their appearance, as the sand was falling through fissures in the earth.

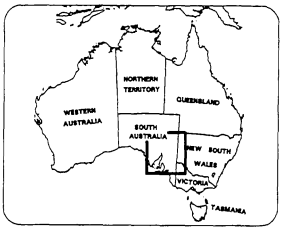
Relocation of the epicentre using previously unpublished arrival times and reinterpreted phase arrival times from the Perth seismograms, gave an epicentre only 20 km east of the macroseismic epicentre. Burke-Gafney's (1951) epicentre at (30.55°S, 138.00°E) is also close, and he only used phase times from Adelaide, Melbourne and Riverview.

Contributors: The isoseismal map was compiled by Robert Corkery whilst temporarily employed at AGSO under the direction of Kevin McCue. Corkery and McArdle unearthed 45 reports of the quake from contemporary newspapers and the report of Bullen and Bolt (1956) who in 1954, distributed questionnaires to the region. These potentially useful records have not been found.

ISOSEISMAL MAP OF THE NILPENA EARTHQUAKE, SOUTH AUSTRALIA, 26 MARCH 1939



DATE: 26 March 1939
TIME: 03:56 GMT
MAGNITUDE: 5.7 ML (I), 5.8 ML (ADE), 5.7 MS (EDG)
EPICENTRE: 31.1°S 138.3°E



▲ *Epicentre*
IV *Zone intensity designation*
4 *Earthquake felt (MM)*
0 *Earthquake not felt*
EDG *From Everingham, Denham and Greenhalg (1987)*

24/SA/33

Isoseismal map of the West Tasman Sea earthquake (Flinders Island) - 14 September 1946

The earthquake at 5.48 am local time was felt throughout Tasmania and in Gippsland Victoria. Michael-Leiba and Jensen (1993) reexamined contemporary newspapers and lighthouse keepers logs to draft the isoseismal map. Acording to them, the highest intensity was in Launceston where the earthquake broke windows and crockery and cracked plaster in some buildings.

> The tremor caused one of the relay bells at the Launceston fire station to ring. Fireman A Neville, one of the four men on duty at the time, said the station shook so violently he thought it was "falling to bits". He said the trestle beds in the dormitory at the station were shot back and forth by the force of the tremor.

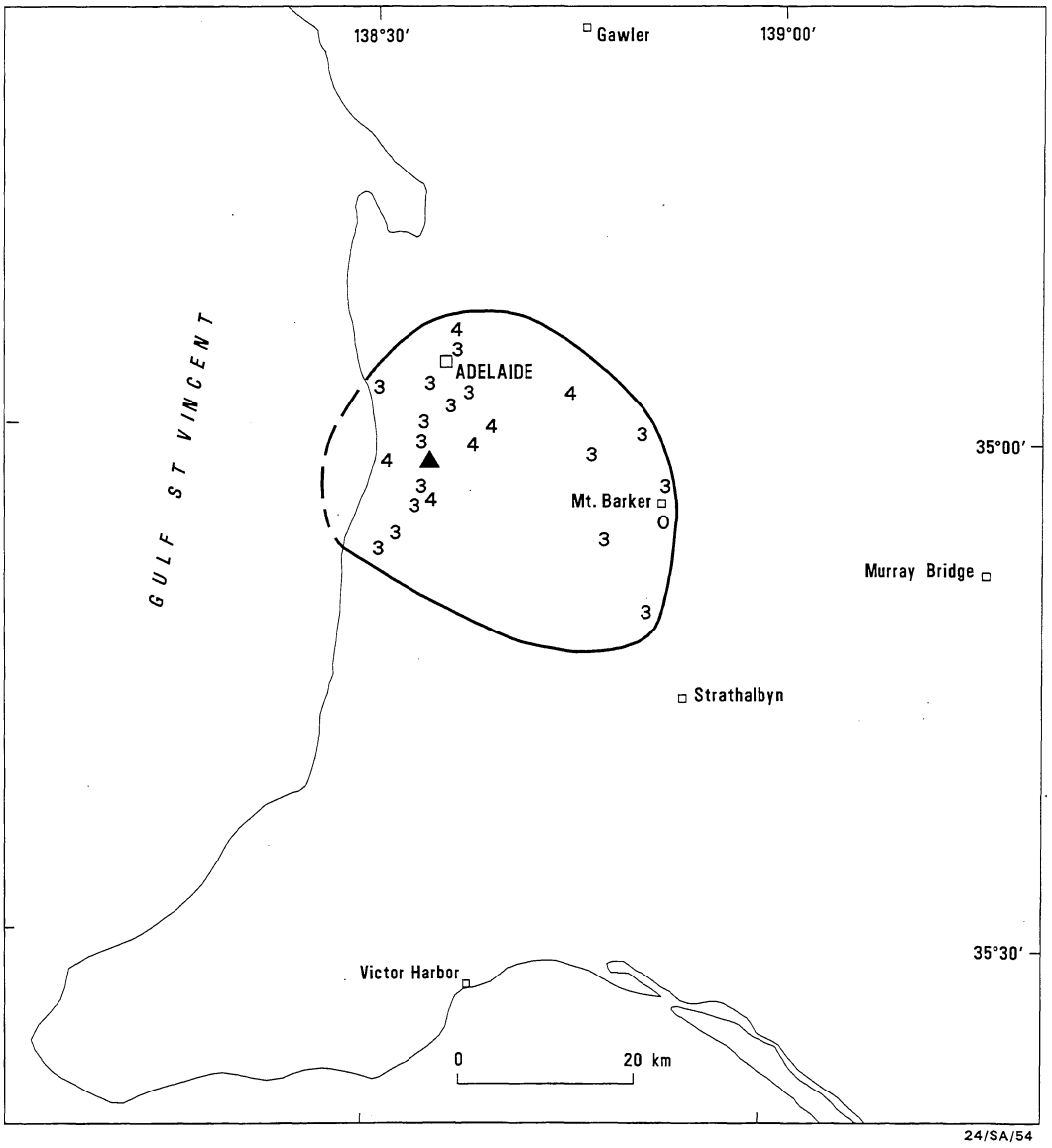
In both Foster and Orbost in Victoria, ornaments fell from shelves and were damaged.

Contributors: Dr Marion Michael-Leiba BMR and Vagn Jensen University of Tasmania compiled the information and isoseismal map.

Isoseismal map of the Adelaide aftershock
South Australia - 2 March 1954

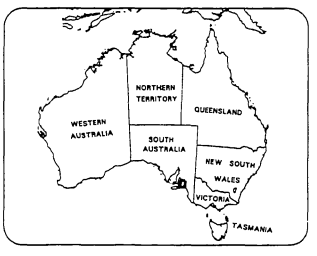
Contributors: This map was compiled by Katherine Malpas, Flinders University SA, and South Australian Department of Mines & Energy.

ISOSEISMAL MAP OF THE ADELAIDE AFTERSHOCK, SOUTH AUSTRALIA 2 MARCH 1954



DATE: 2 March 1954
TIME: 20:15 GMT
MAGNITUDE: 3.2 ML (I)
EPICENTRE: 34.93°S 138.69°E

▲ *Epicentre*
Zone intensity designation
3 *Earthquake felt (MM)*
0 *Earthquake not felt*



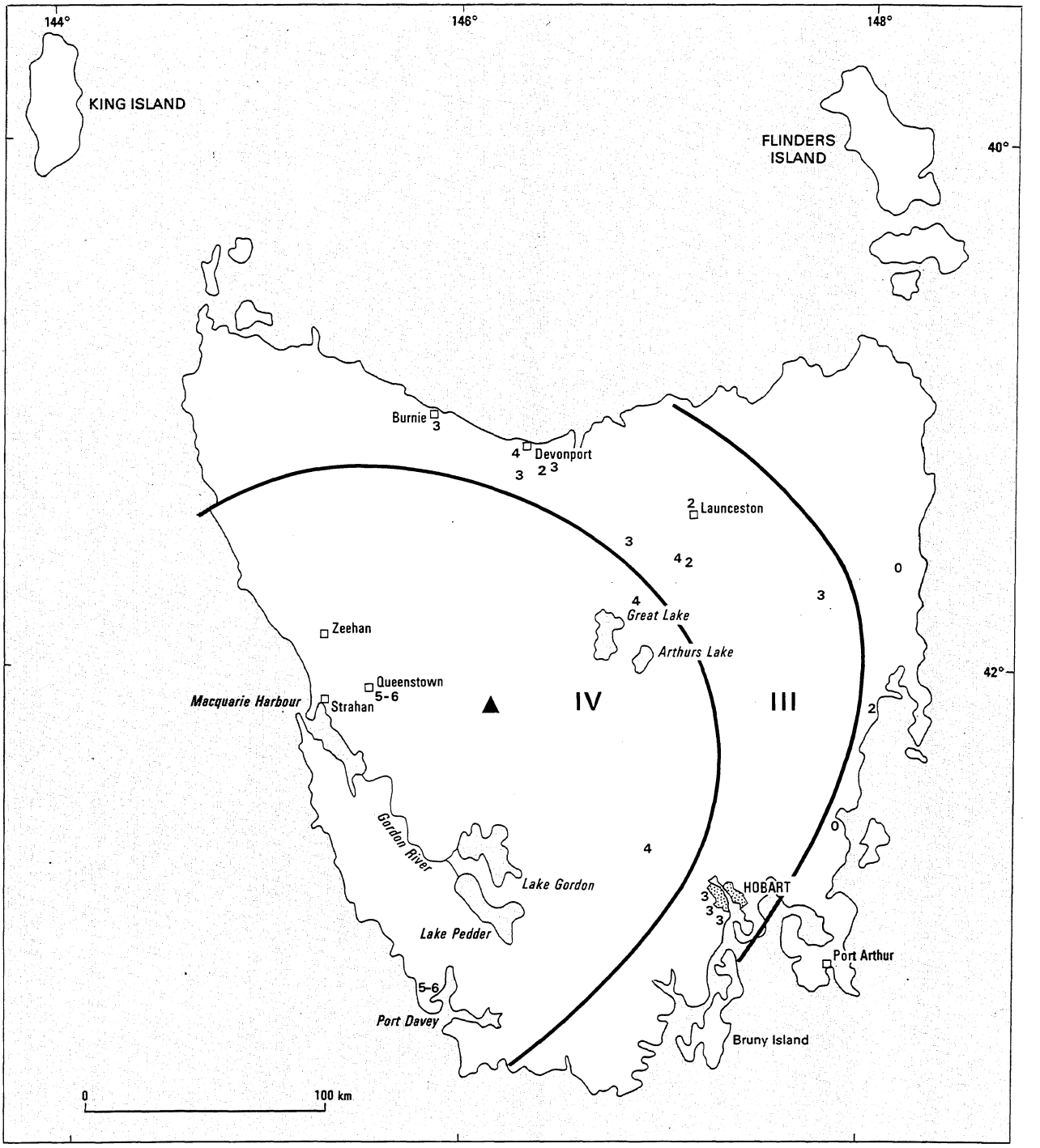
Isoseismal map of the Queenstown earthquake
Tasmania - 1 January 1958

Additional data unearthed in the records at Tasmania University was sufficient to redraw the earlier map from Ripper (1963) which was reproduced in Everingham & others (1982) but without intensities. This later version is included for completeness. The description from Everingham & others (1982) is as follows:

> This earthquake was the first local shock to be recorded by instruments in Tasmania. It occurred on New Year's Day, 1958 soon after the Fort Nelson seismograph station, sited near Hobart, began operation. The main earthquake was felt strongly at Queenstown (MM V) and as far away as Burnie (MM III), Launceston (MMII), and Hobart (MMII). It was followed by several aftershocks.

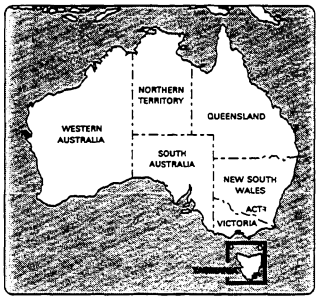
Contributors: This map was recompiled by Kevin McCue based on an original by Ian Ripper and using the same data collected by the University of Tasmania.

ISOSEISMAL MAP OF THE QUEENSTOWN EARTHQUAKE, TASMANIA, 1 JANUARY 1958



DATE : *1 January 1958*
TIME : *00:07:22 UT*
MAGNITUDE : *5.3 ML (RIV)*
EPICENTRE : *42.2°S, 146.1°E*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/K55/1

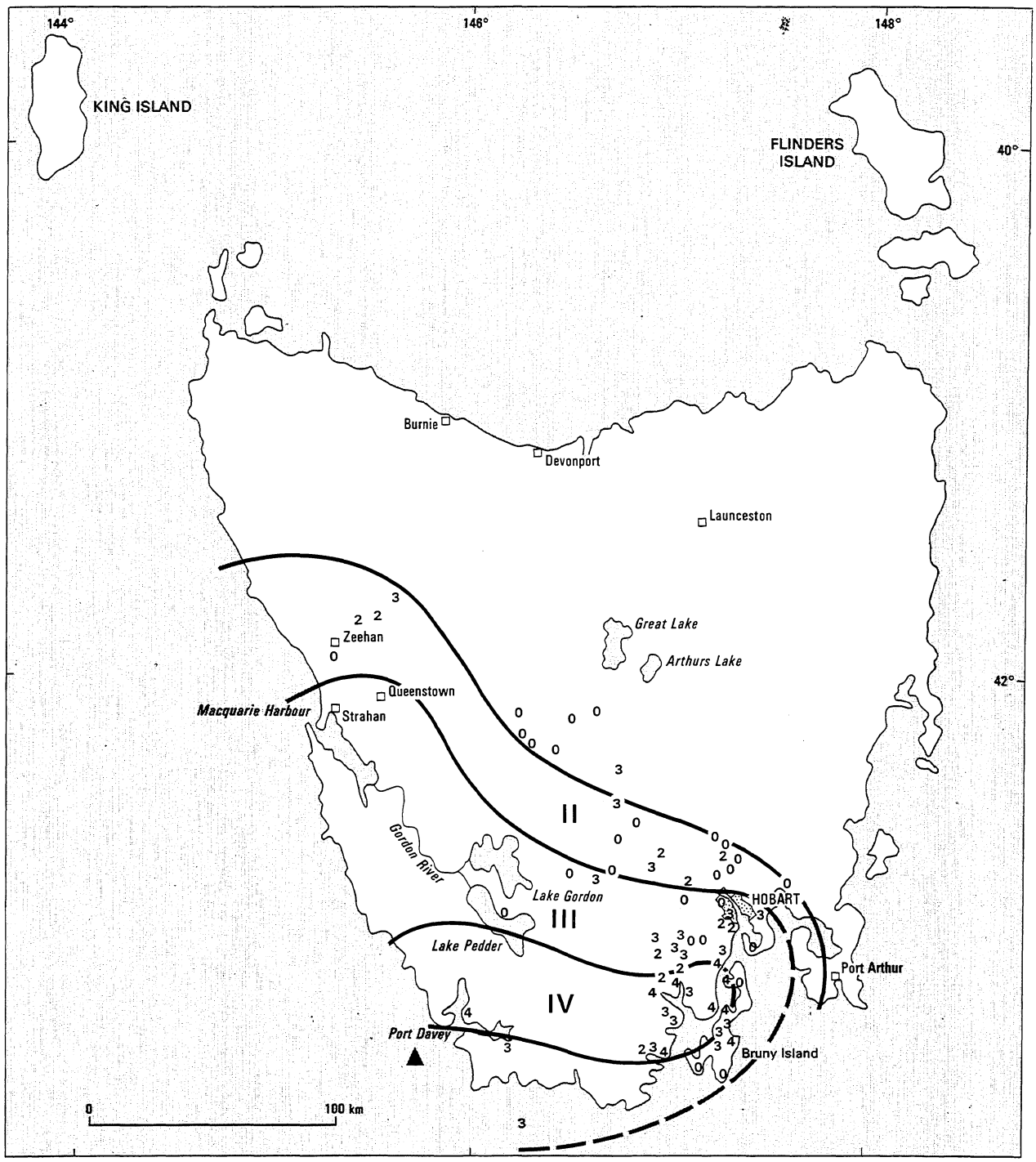
Isoseismal map of the Port Davey earthquake Tasmania - 3 November 1963

Data recently unearthed at the University of Tasmania enabled reconstruction of the isoseismal map originally drawn by Ripper (1963) and reproduced by Everingham & others (1982). The individual intensities were omitted from the original map and their inclusion was considered sufficiently important to warrant publication of another version of the map. The description from Everingham & others (1982) is as follows:

> On the evening of 3rd November 1963, an earth tremor shook southern Tasmania. Unfortunately the weather at the time was stormy, with blustery winds and rain, so that the shock passed unnoticed in many places.
>
> The weather, or wind force, at the moment of the shock may be a controlling factor of the isoseismal pattern, rather than conditions at the focus of geological structure (Ripper, 1963).

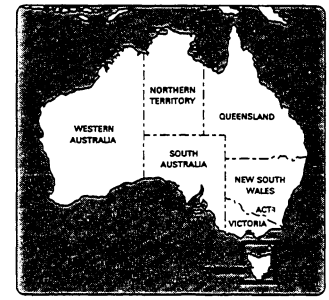
Contributors: This map was recompiled by Kevin McCue based on an original by Ian Ripper and using the same data collected by the University of Tasmania.

ISOSEISMAL MAP OF THE PORT DAVEY EARTHQUAKE, TASMANIA, 3 NOVEMBER 1963



DATE : *3 November 1963*
TIME : *12:00:40 UT*
MAGNITUDE : *4.4 ML (BMR)*
EPICENTRE : *43.5°S, 145.8°E*
DEPTH : *10 km*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



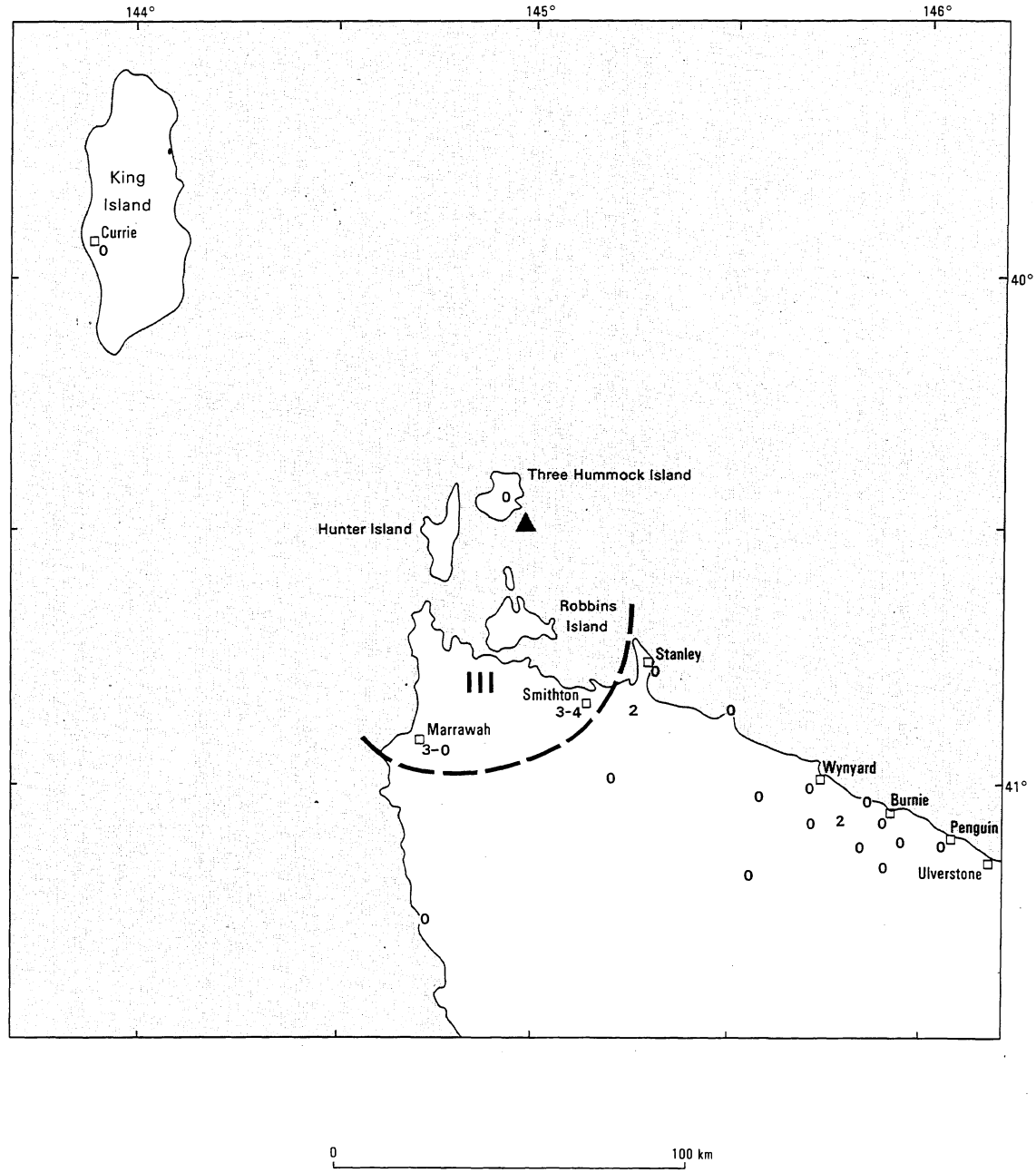
24/K55/2

Isoseismal map of the Northwest Tasmania earthquake 26 May 1971

This small earthquake was felt only in the northwest corner of Tasmania where the highest intensity was only 3 to 4. No trace of it was noticed at Burnie where the next earthquake was located only three weeks later. The isoseismal map was drawn using data recently rediscovered in files held at the University of Tasmania.

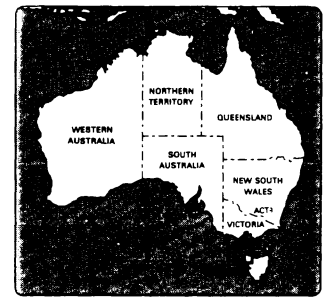
Contributors: An intensity survey was conducted by the University of Tasmania, Geology Department, and the data was held in files recently rediscovered at the University. This map was compiled by Kevin McCue.

ISOSEISMAL MAP OF THE NORTHWEST TASMANIA EARTHQUAKE, 26 MAY 1971



DATE : *26 May 1971*
TIME : *11:58:08.9 UT*
MAGNITUDE : *3.0 ML*
EPICENTRE : *40.48°S, 145.01°E*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/K55/20

Isoseismal map of the Burnie earthquake
Tasmania - 15 June 1971

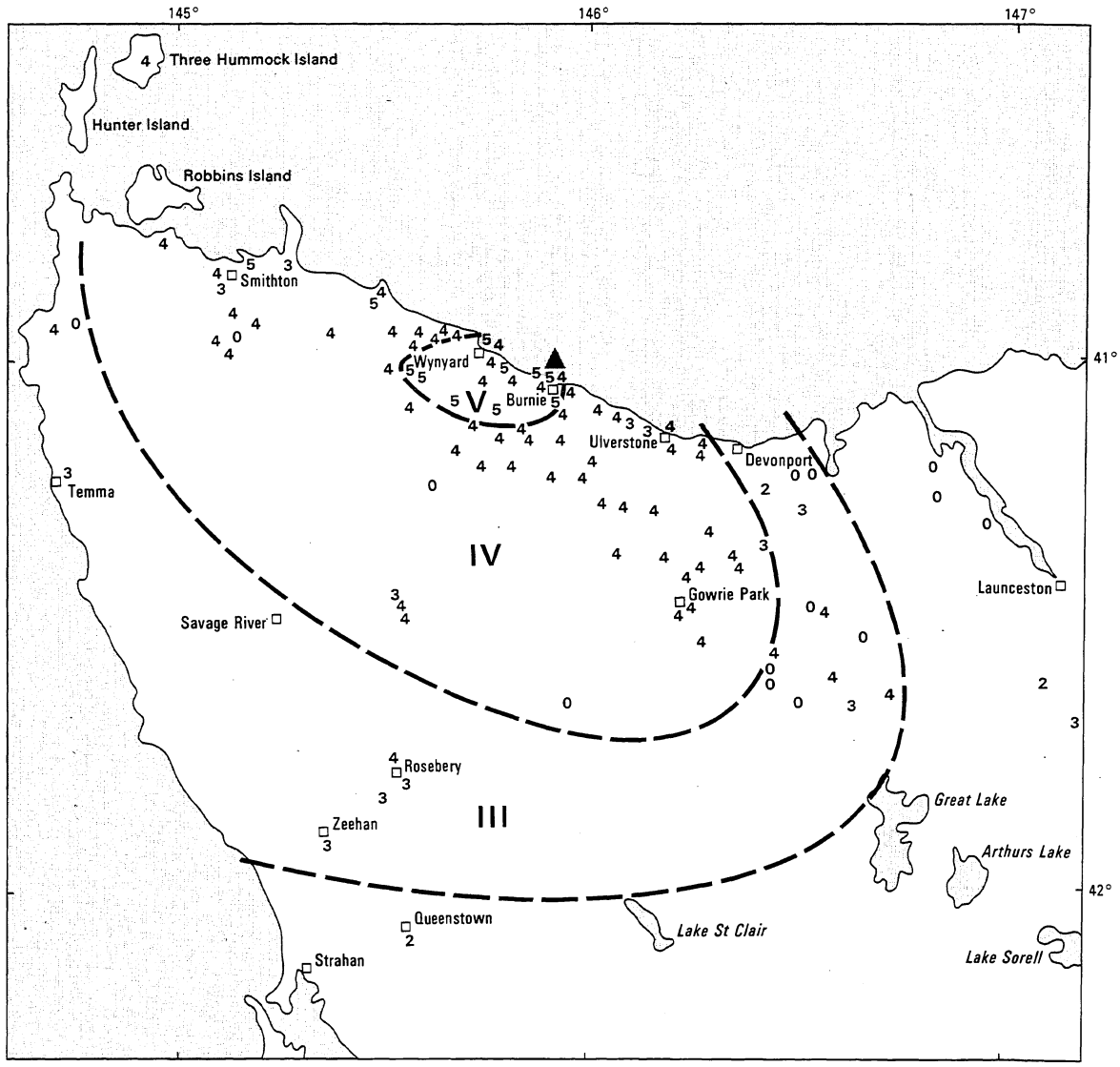
Numerous effects consistent with intensity V were reported in the Burnie/Wynyard area on Tasmania's north coast and the shock was felt as far as Queenstown, 160 km from the epicentre.

The Advocate of Thursday June 17, devoted prominent space to the story with the headline:

> TREMOR SHAKES COAST
>
> An earth tremor off the North-West coast near Wynyard at 6.06$^1/_2$ yesterday morning shook houses and startled people from Gowrie Park to Smithton and south to Queenstown.
>
> No damage was reported to property or communications but dozens of people, in various centres, said that they had been alarmed - to say the least!
>
> From Penguin, there were reports of moving furniture, shaking windows and rattling crockery.

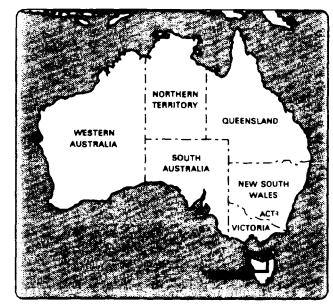
Contributors: An intensity survey was conducted by the University of Tasmania, Geology Department, and the data was held in files recently rediscovered at the University. This map was compiled by Kevin McCue.

ISOSEISMAL MAP OF THE BURNIE EARTHQUAKE, TASMANIA, 15 JUNE 1971



DATE : *15 June 1971*
TIME : *20:06:24.7 UT*
MAGNITUDE : *4.0 ML (TAU)*
EPICENTRE : *40.98°S; 145.83°E*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



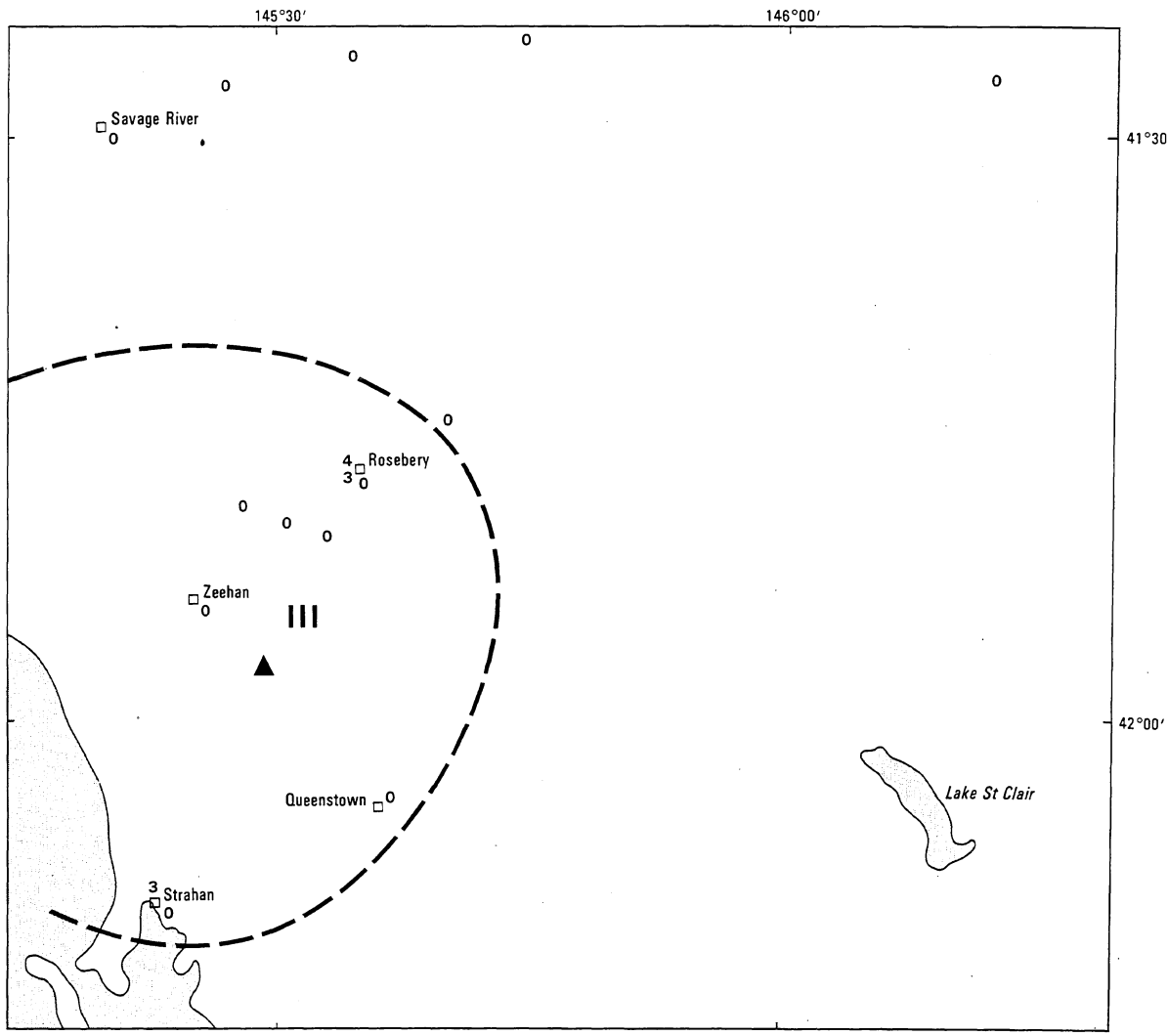
24/K55/26

Isoseismal map of the Zeehan earthquake
Tasmania - 4 March 1972

Staff at the Geology Department, University of Tasmania, distributed questionnaires following this earthquake near Zeehan on Tasmania's west coast but only three felt reports were received. Most Tasmanian's would have been soundly asleep at this early hour of the morning which, with the remoteness of the epicentral region, would undoubtedly help account for the sparseness of the data.

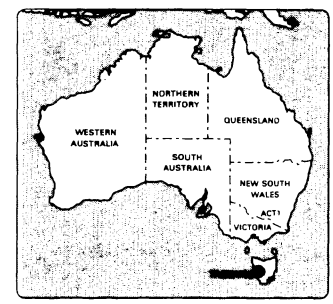
Contributors: An intensity survey was conducted by the University of Tasmania, Geology Department, and the data was held in files recently rediscovered at the University. This map was compiled by Kevin McCue.

ISOSEISMAL MAP OF THE ZEEHAN EARTHQUAKE, TASMANIA, 4 MARCH 1972



DATE : *4 March 1972*
TIME : *16:25:38.4 UT*
MAGNITUDE : *3.0 ML (TAU)*
EPICENTRE : *41.93°E, 145.41°S*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/K55/23

Isoseismal map of the Strahan earthquake
Tasmania - 3 June 1973

Staff at the Geology Department, University of Tasmania distributed questionnaires following this moderate sized earthquake off the central west coast of Tasmania and 'not felt' reports outweighed 'felt' returns by three to one. The felt area is not well differentiated and no effects rated more than intensity IV. This and the other magnitude ML 4 earthquake of 15 June 1971 were the largest Tasmanian earthquakes of the 1970's.

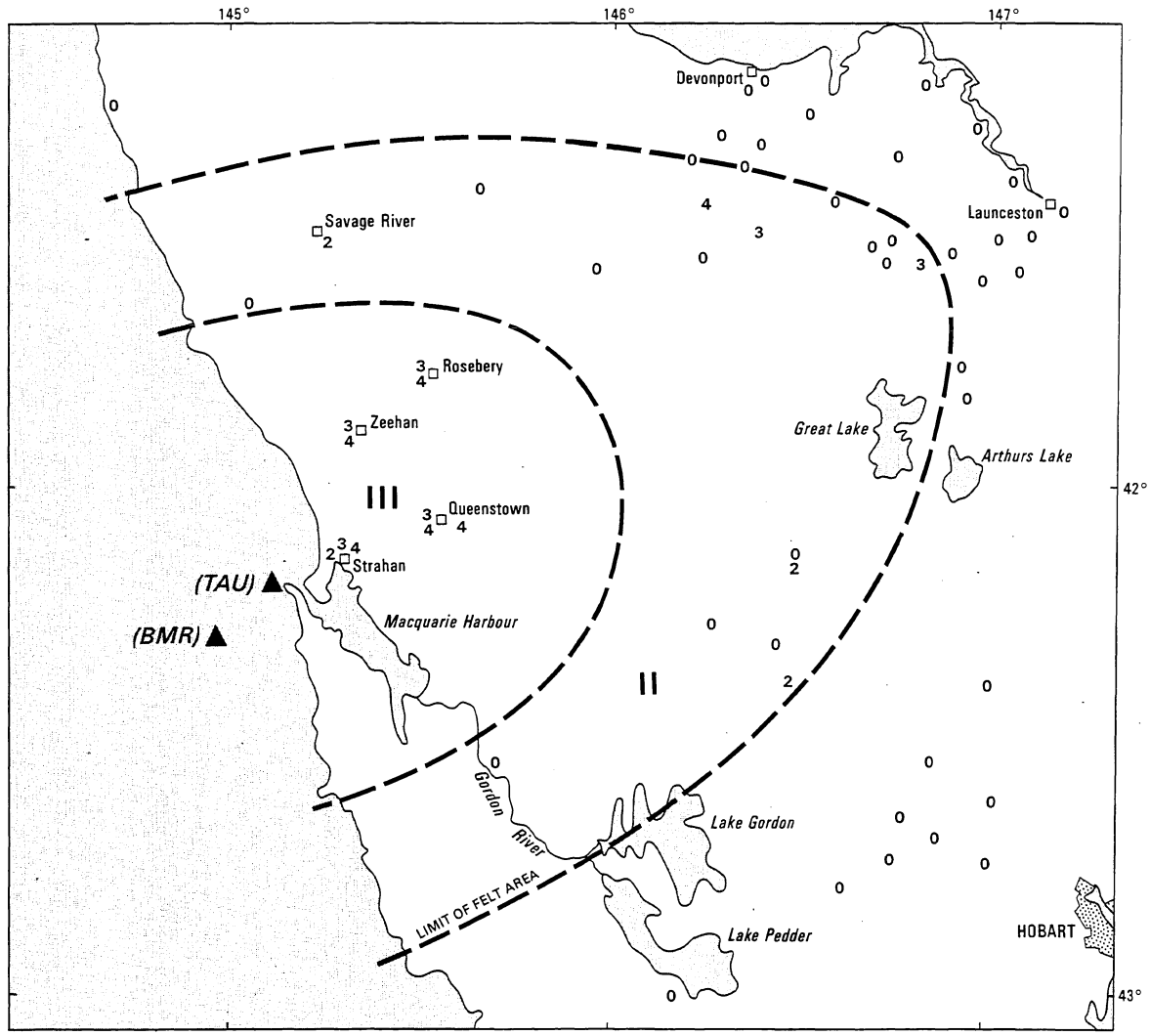
The Advocate of 4 June carried a short story:

> TREMOR ROCKS WEST COAST
>
> An earth tremor shook a wide area of the West Coast last night. The tremor which made a rumbling noise and lasted about 10 seconds, rattled windows and buildings and brought people into the streets at Rosebery, Zeehan, Strahan and Queenstown.
>
> There was a tremor at Strahan on May 24.

The Advocate weighed in with a follow up story on 5 June quoting Dr Underwood (HEC) as saying that West Coasters could expect an earthquake every two or three years.

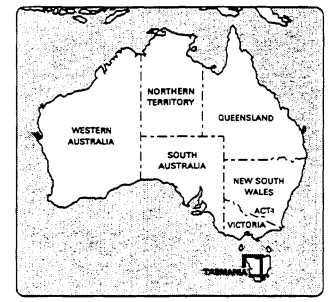
Contributors: An intensity survey was conducted by the University of Tasmania, Geology Department, and the data was held in files recently rediscovered at the University. This map was compiled by Kevin McCue.

ISOSEISMAL MAP OF THE STRAHAN EARTHQUAKE, TASMANIA, 3 JUNE 1973



DATE : *3 June 1973*
TIME : *11:08:08.0 UT*
MAGNITUDE : *4.0 ML (TAU, BMR)*
EPICENTRE : *42.32°S; 145.08°E (TAU)*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



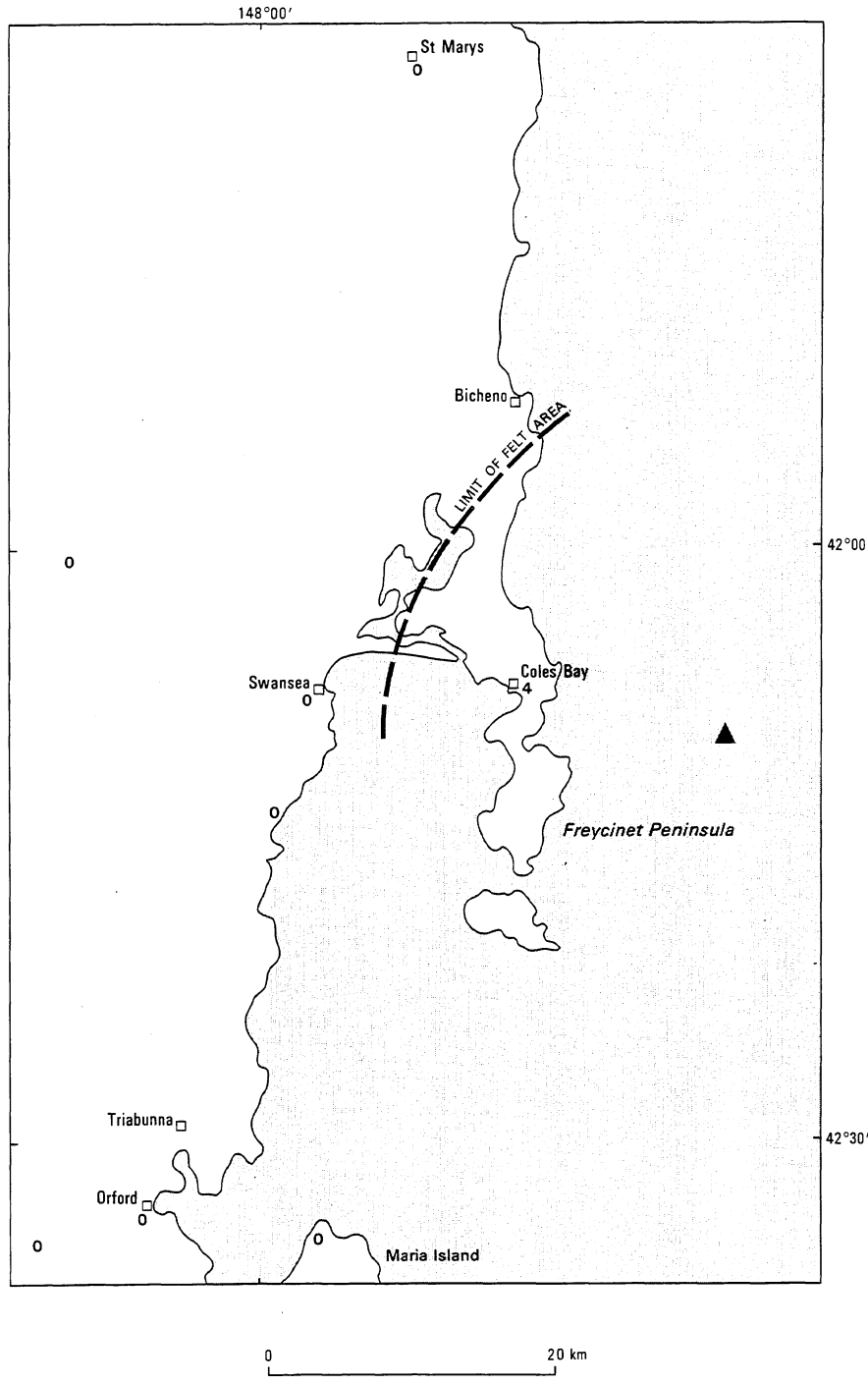
24/K55/21

Isoseismal map of the Freycinet Peninsula earthquake
Tasmania - 22 May 1974

Staff at the Geology Department, University of Tasmania, distributed questionnaires after this small earthquake off the east coast. It was felt at Coles Bay but the lack of other felt reports limited contouring to the MMIII isoseismal which just delineated the felt area to the Freycinet Peninsula.

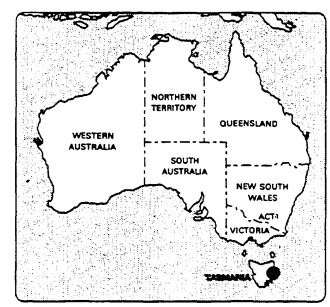
Contributors: An intensity survey was conducted by the University of Tasmania, Geology Department, and the data was held in files recently rediscovered at the University. This map was compiled by Kevin McCue.

ISOSEISMAL MAP OF THE FREYCINET PENINSULA EARTHQUAKE, TASMANIA, 22 MAY 1974



DATE : *22 May 1974*
TIME : *09:23:47 UT*
MAGNITUDE : *2.3 ML (TAU)*
EPICENTRE : *42.23°S, 148.53°E*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



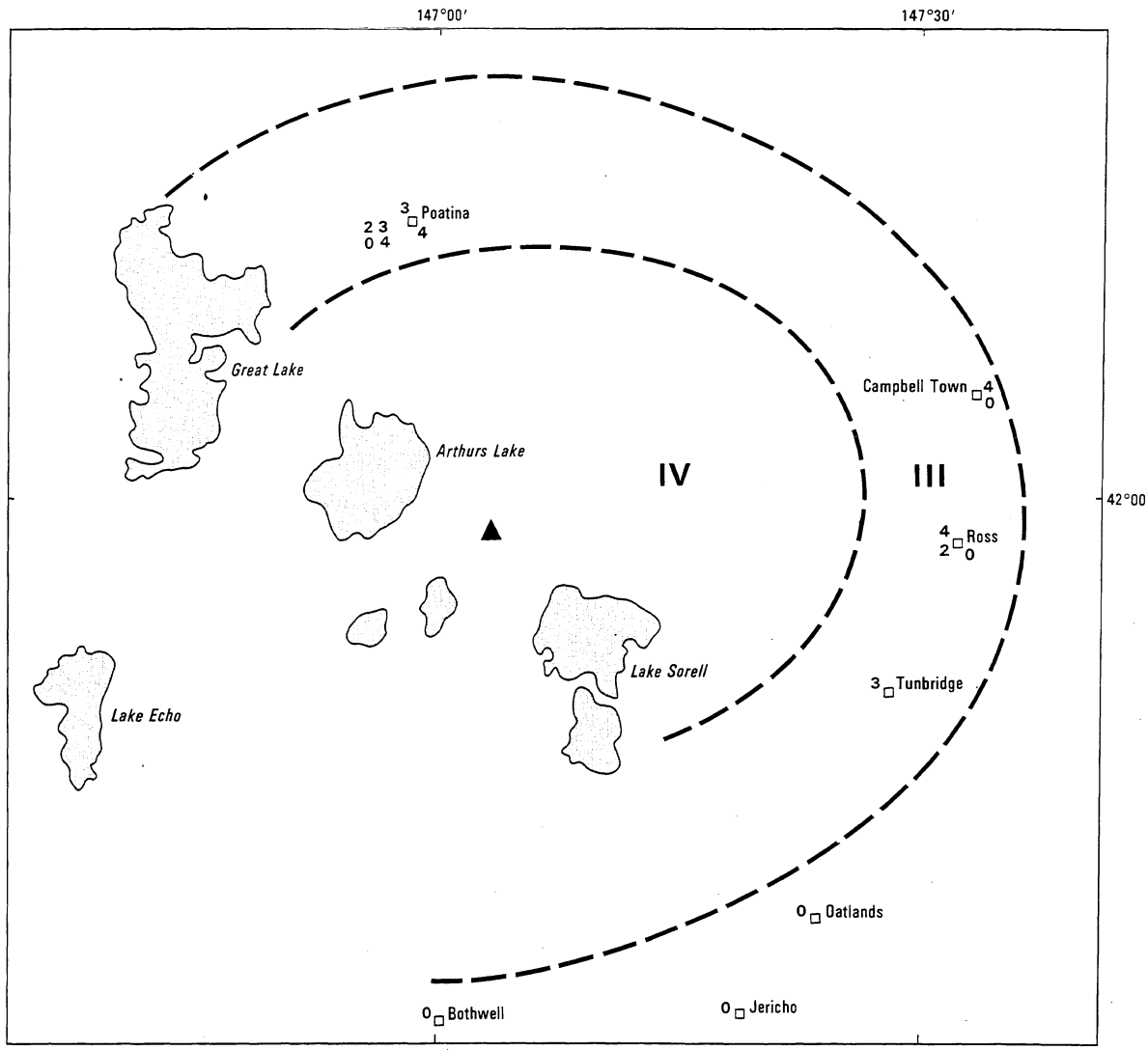
24/K55/28

Isoseismal Map of the Arthurs Lake earthquake
Tasmania - 2 July 1976

The sparseness of Tasmania's population in the central highlands accounted for the low density of intensities reported in the epicentral region, the nearest of which, at Poatina, was approximately 40 km from the computed epicentre where intensities ranged from II to IV.

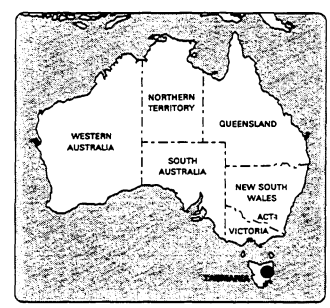
Contributors: This map was compiled by Kevin McCue BMR. Staff at the Geology Department, University of Tasmania, distributed the questionnaires.

ISOSEISMAL MAP OF THE ARTHURS LAKE EARTHQUAKE, TASMANIA, 2 JULY 1976



DATE : *2 July 1976*
TIME : *14:41:37.8 UT*
MAGNITUDE : *2.8 ML (TAU)*
EPICENTRE : *42.05°S, 147.07°E*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/K55/24

Isoseismal map of the St Leonards earthquake
Victoria - 22 September 1977

The earthquake affected the Melbourne area as reported in Friday afternoons final (extra) edition of *The Herald* newspaper of 23 September, page 5:

TREMOR HITS SUBURBS

An earth tremor cracked walls in Melbourne and Geelong today. It was felt along the Mornington Peninsula, parts of Geelong and suburbs around Caulfield, Carnegie and Toorak.

Measuring three on the Richter scale, the tremor lasted three seconds from 6.55 am.

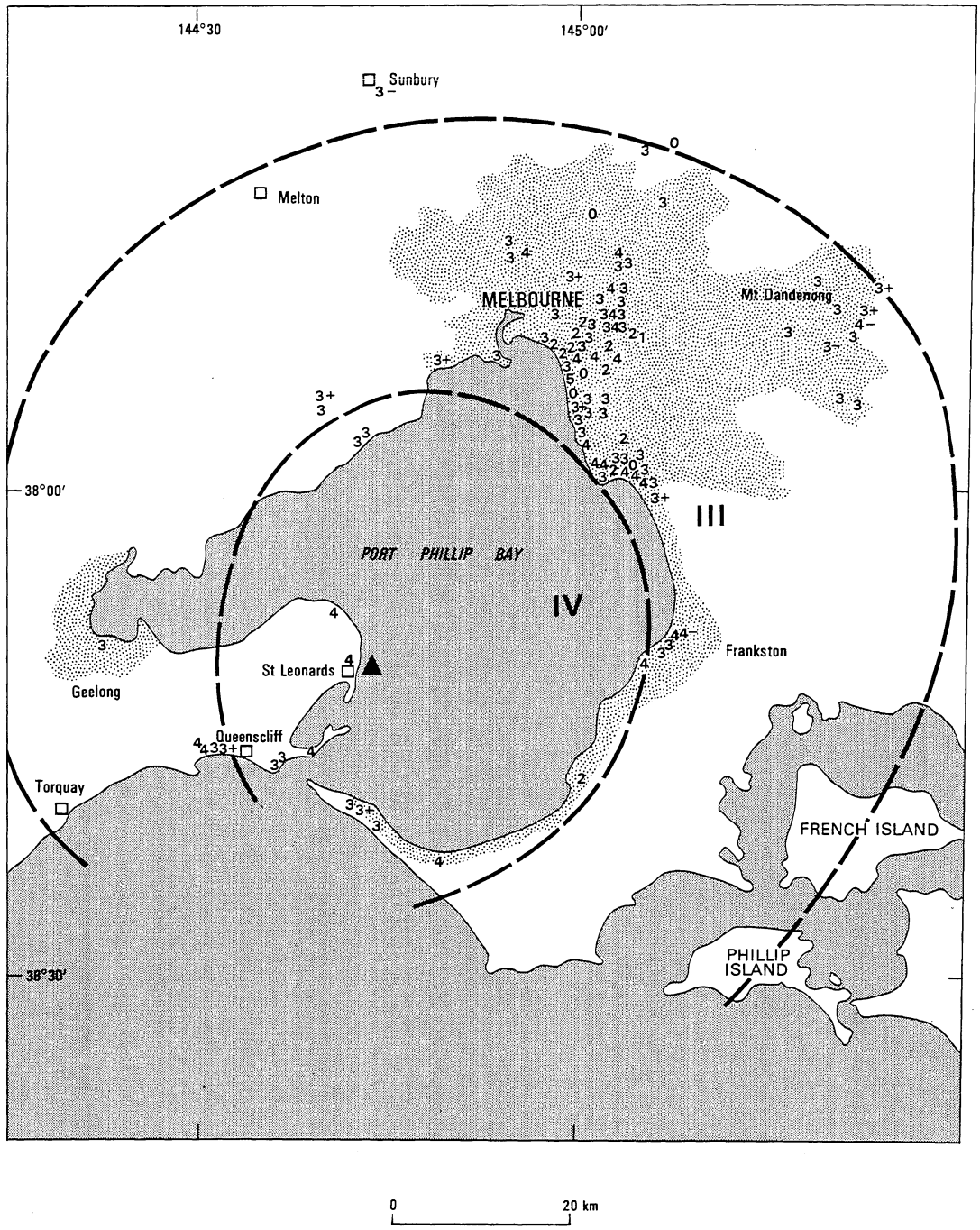
Mrs Helen Lacey of Tudor Court, Frankston, said a soft rumbling noise preceded the tremor. 'It sounded like a far-away truck or train and then it struck,' she said. 'It cracked the ceiling and paintwork in several rooms.'

Mrs Gwenda Syme, of Nepean Highway, Portsea, said her room shook for several seconds during the tremor. 'Nothing was broken or fell from the shelves but the whole house shook,' she said.

Dr Lindsay Thomas, a lecturer at the Geophysics Department at Melbourne University, said the tremor was probably caused by a movement under Port Phillip Bay.

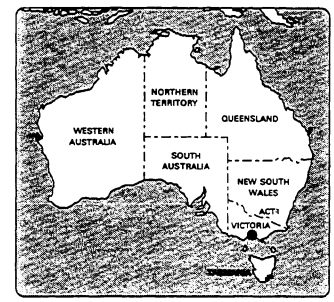
Contributors: This map was compiled by Gary Gibson & Tony Corke, Seismology Research Centre RMIT Bundoora, Victoria and Kevin McCue.

ISOSEISMAL MAP OF THE ST. LEONARDS EARTHQUAKE, VICTORIA, 22 SEPTEMBER 1977



DATE : *22 September 1977*
TIME : *20:55 UTC*
MAGNITUDE : *MD 3.1 (PIT)*
EPICENTRE : *38.18° ± 0.05°S, 144.72° ± 0.02°E*
DEPTH : *15 km (± 5)*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



Isoseismal map of the Burnie earthquake
Tasmania - 4 May 1978

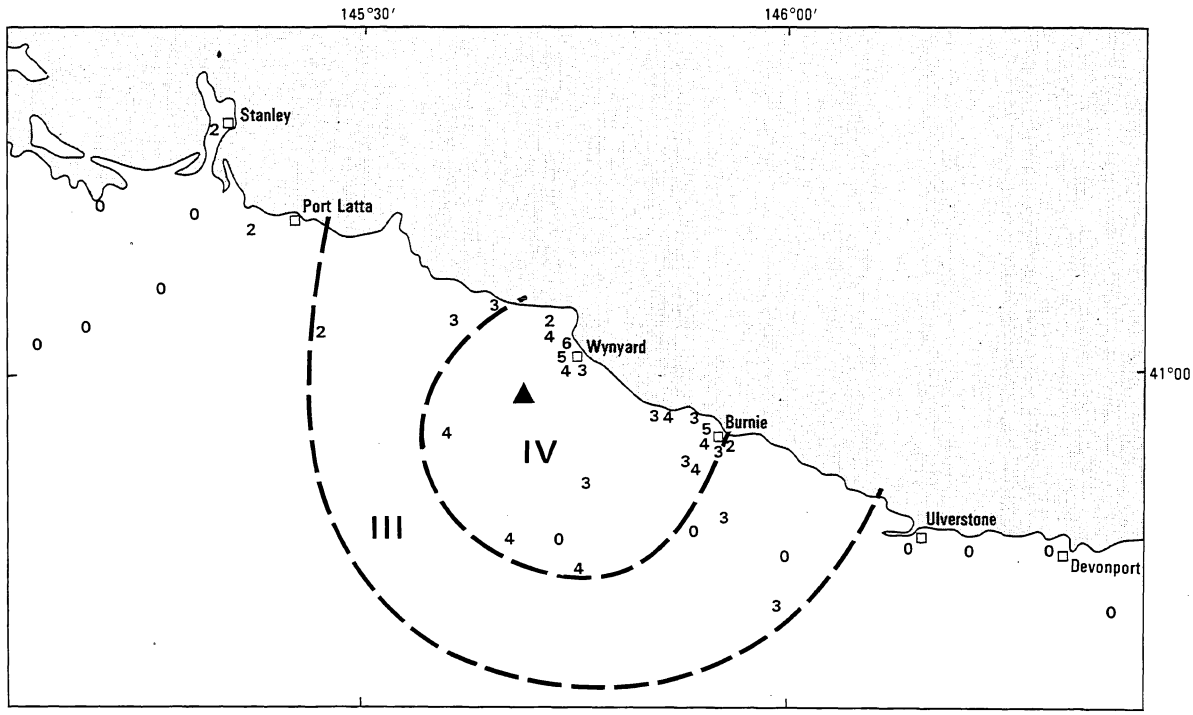
This event occurred at 9.35 pm on 4 May. Minor non-structural damage was reported at Wynyard and the intensity reached V at Burnie 22 km away as a result of this small earthquake west of Burnie. The epicentre is in the same general region as that of the ML 4 earthquake on 15 June 1971.

Extracts from the story published by *The Examiner* on its front page on May 5th are as follows:

> A 60 km stretch of the North West coast was shaken by an earth tremor at 9.35 pm yesterday. The tremor which began with a loud explosive noise lasted just a few seconds and was felt as far west as Wynyard and east to Penguin. No one was reported injured but many people were shaken.
>
> The only damage reported to police was a small crack in one of the walls at Wynyard High School, Kamarah student hostel.
>
> Somerset barman, Wayne Elliot, who was working in the bottle department said he thought a truck had hit the back wall. 'It was like a loud explosion,' he said.

Contributors: This map was compiled by Kevin McCue. Staff at the Geology Department, University of Tasmania, distributed the questionnaires.

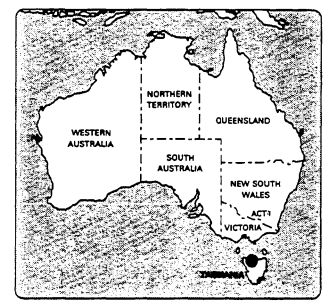
ISOSEISMAL MAP OF THE BURNIE EARTHQUAKE, TASMANIA, 4 MAY 1978



0 50 km

DATE : *4 May 1978*
TIME : *11:34:52.4 UT*
MAGNITUDE : *3.0 ML (BMR, TAU)*
EPICENTRE : *41.02°S, 145.68°E*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*

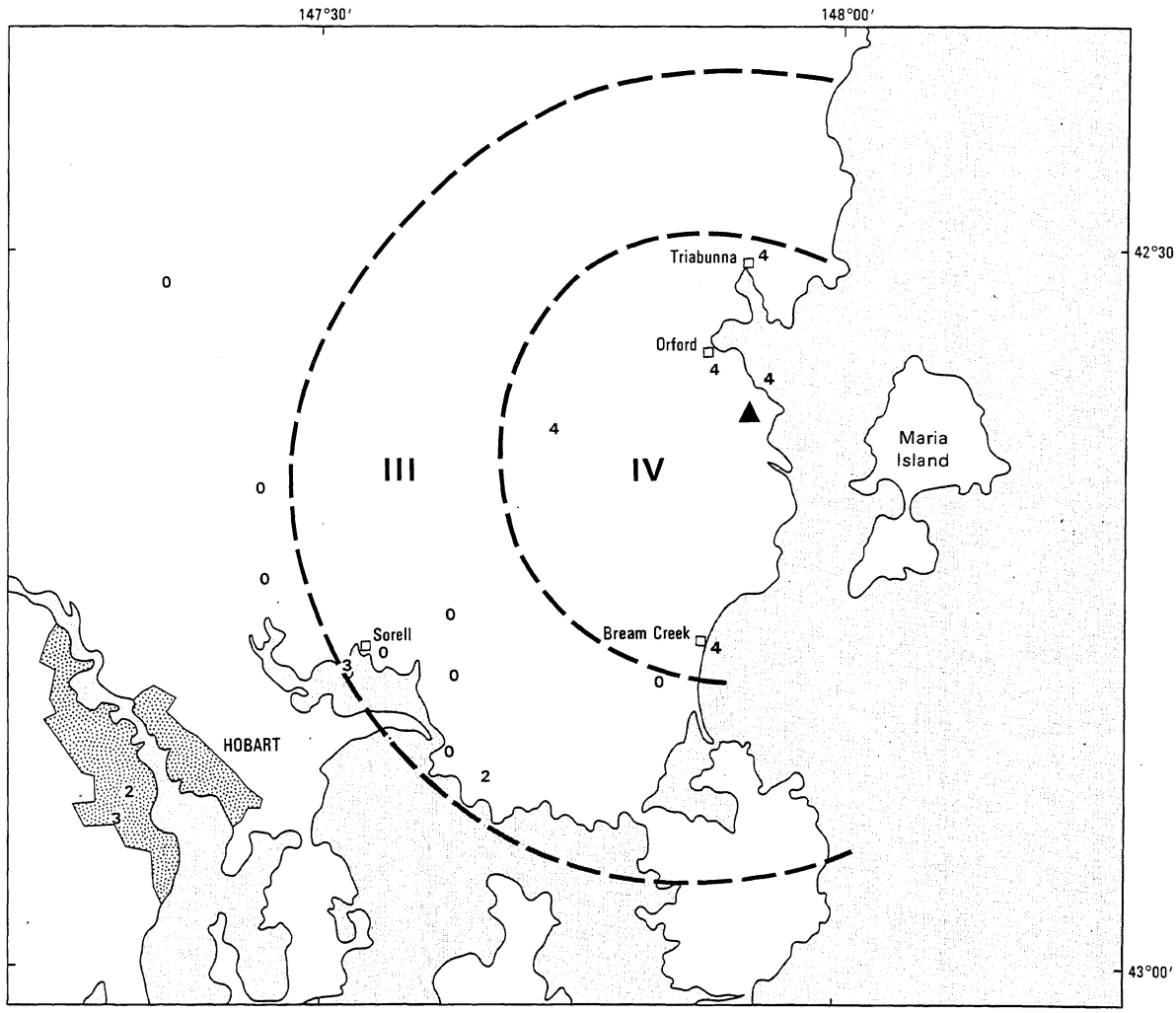


24/K55/25

Isoseismal map of the Orford earthquake
Tasmania - 20 October 1978

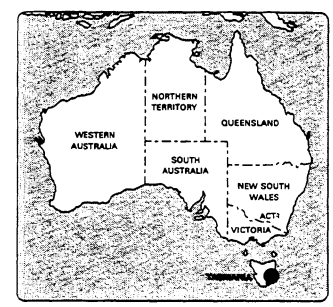
Contributors: This map was compiled by Kevin McCue. Staff at the Geology Department, University of Tasmania, distributed the questionnaires.

ISOSEISMAL MAP OF THE ORFORD EARTHQUAKE, TASMANIA, 20 OCTOBER 1978



DATE : *20 October 1978*
TIME : *00:52:48.0 UT*
MAGNITUDE : *2.7 ML (TAU)*
EPICENTRE : *42.68°S, 147.88°E*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/K55/22

Isoseismal map of the Rowley Shoals earthquake
Western Australia - 23 April 1979

Only weeks after this earthquake off the northwest coast of WA, a large earthquake damaged the small wheatbelt town of Cadoux, northeast of Perth and deflected interest from this remote earthquake. The intensity questionnaires remained in a filing cabinet at Mundaring for 16 years but were dusted off to draw up the map.

Residents at Derby and Port Hedland along the northwest coast of Western Australia experienced intensities of MM IV with the maximum intensity of MM V being felt at Broome.

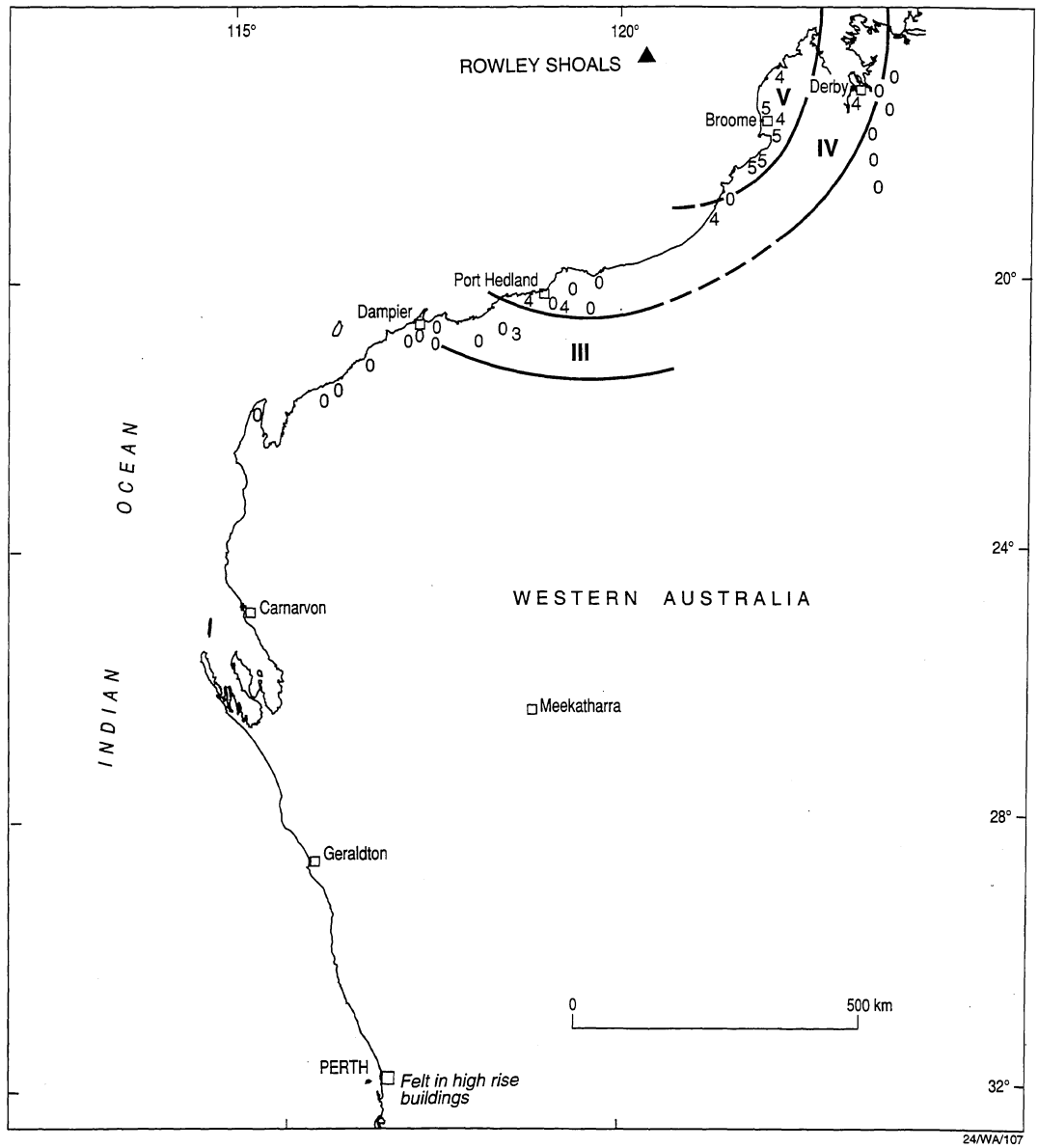
The earthquake was felt in some of the taller buildings in Perth, 1650 km away from the epicentre.

Tide gauge recordings along the coast of Western Australia showed no unusual sea level fluctuations.

Two foreshocks and 28 aftershocks were recorded between 22 April and 26 May, ranging in magnitude from ML 3.3 to ML 5.7.

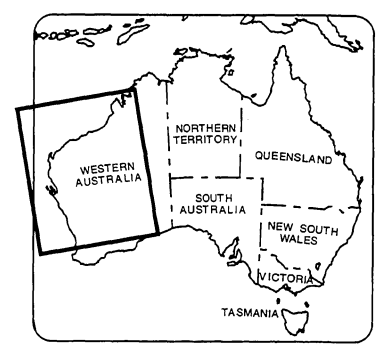
Contributors: This map was compiled by Peter Gregson.

ISOSEISMAL MAP OF THE ROWLEY SHOALS EARTHQUAKE, WA
23 FEBRUARY 1979



DATE: 23 APRIL 1979
TIME: 05:45:09.8 UTC
MAGNITUDE: 5.9 MB (USGS)MS 5.7, ML (1) 6.1
EPICENTRE: 16.66°S, 120.27°E
DEPTH: 34 (±1) km

▲ *Epicentre*
IV *Zone intensity designation*
4 *Earthquake felt (MM)*
0 *Earthquake not felt*



Isoseismal map of the Walhalla earthquake
Victoria - 21 May 1980

The Latrobe Valley Express carried a report of the earthquake in its May 22 edition on page 39 and headlined the story *Tremors in the hills:*

> Several earth tremors were reported in the Walhalla/Erica area yesterday. People at the Thomson Dam site noticed tremors at about 10 am, and these were also picked up at Erica and Rawson.
>
> Later in the day 72 year-old Bill Jones at Cooper's Creek felt two tremors...at 2.48 pm, and another at 2.59. 'They were bad ones - I was about to run outside.'
>
> He said the last bad tremor in the area occurred about 10 years ago.
>
> No damage was known to be caused by any of the disturbances.

There were nine earthquakes in the series between 21 and 28 May and the epicentres were about 4 km south-east of Walhalla, on the Yallourn Fault (Gibson and Wesson, 1978). All seismographs in Victoria were driven full scale by the two main shocks so magnitudes were computed from the coda duration (Cuthbertson, 1977) and ranged fom -0.5 to 4.0. Computed focal depths were in the range 10 to 15 km.

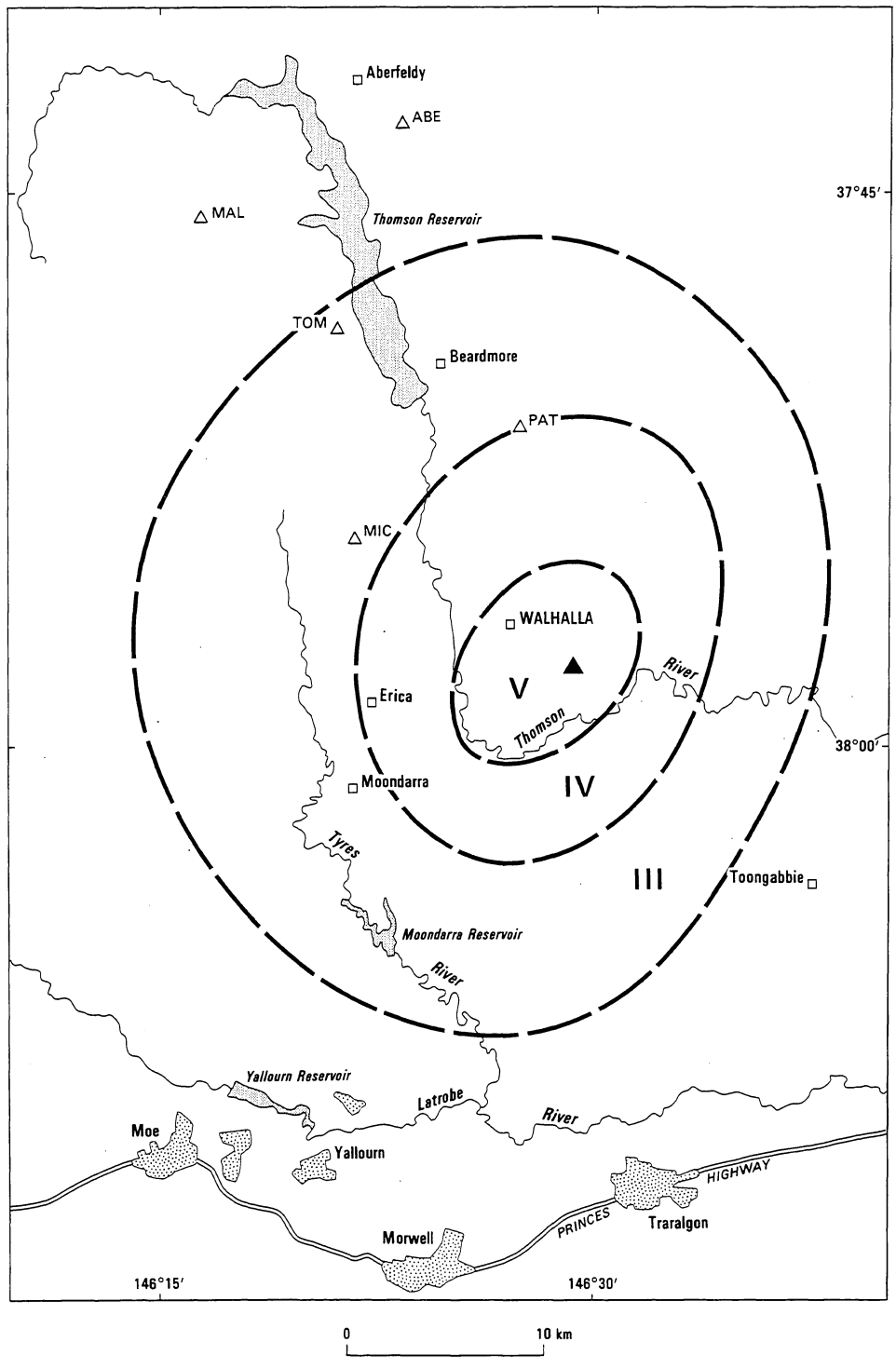
Many people felt the three largest events (3.7, 4.0, 3.1), most describing the second as being the strongest and the third as the weakest, consistent with the magnitudes. The maximum intensities were experienced in Walhalla and Coopers Creek where most people indoors ran outside. No damage was reported but kitchen utensils fell from shelves. The earthquake was not felt by people in cars.

The isoseismal map has been produced from two surveys in the area and a telephone survey of the surrounding area. The large area within the intensity IV and V isoseismals is another indication of a relatively deep focus. The small felt area for an earthquake of this size may be partly attributed to the mid-afternoon origin time but also to the high attenuation of seismic wave amplitudes that is suspected to occur in the area.

The main shock was felt and heard by an SRC seismologist Grant King who had removed the tape from the Yerilla recorder at Mount Erica and was about to insert a replacement!

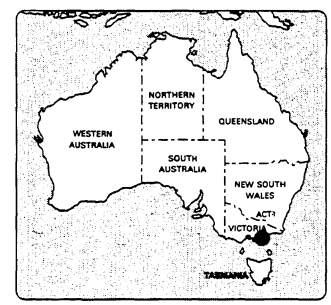
Contributors: This map was compiled by Gary Gibson, Seismology Research Centre (SRC), RMIT Bundoora, Victoria.

ISOSEISMAL MAP OF THE WALHALLA EARTHQUAKE, VICTORIA, 21 MAY 1980



DATE : *21 May 1980*
TIME : *4:48 UTC*
MAGNITUDE : *4.0 MD (PIT)*
EPICENTRE : *37.95°S, 146.49°E*
DEPTH : *15 km .*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/J55/27

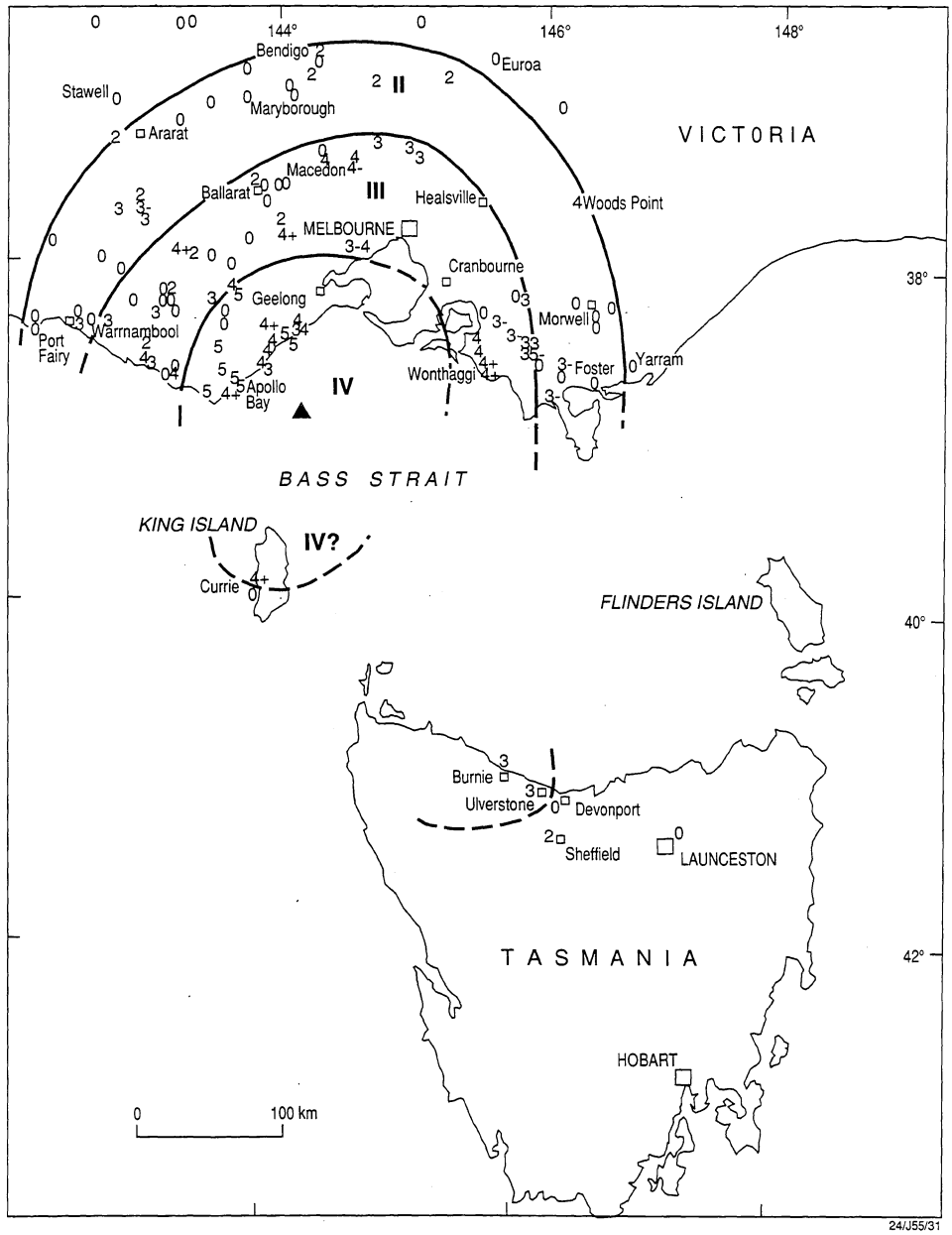
Isoseismal map of the Bass Strait earthquake
Victoria - 16 June 1981

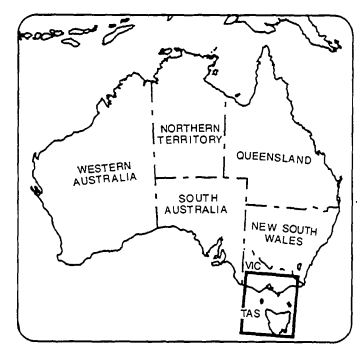
Contrary to the notation on the map published in the first (BMR) AGSO atlas, this earthquake was felt in northwestern Tasmania as reported by the *Advocate* of 18 June 1981:

> Miss Mandy Moore of Maud St., West Ulverstone said she woke at 7.30 am to find the bed was moving. She said: 'I didn't know if I was dreaming or had gone off my head, I didn't know what was happening.'
> Mrs Doris Wing of Grove St central Ulverstone, said she felt the earthquake distinctly: 'I was sitting in bed listening to the radio news. There was one fairly big movement then a little tremor, then it finished.'
> A Sheffield resident believes she felt the tremor while in bed also.

Contributors: This BMR map was amended by Kevin McCue.

ISOSEISMAL MAP OF THE BASS STRAIT EARTHQUAKE, VICTORIA
16 JUNE 1981





DATE: 16 JUNE 1981
TIME: 21:33:55.9 UT
MAGNITUDE: 5.1 ML (PIT), 4.2 MS (BMR)
EPICENTRE: 38.90°S 144.20°E

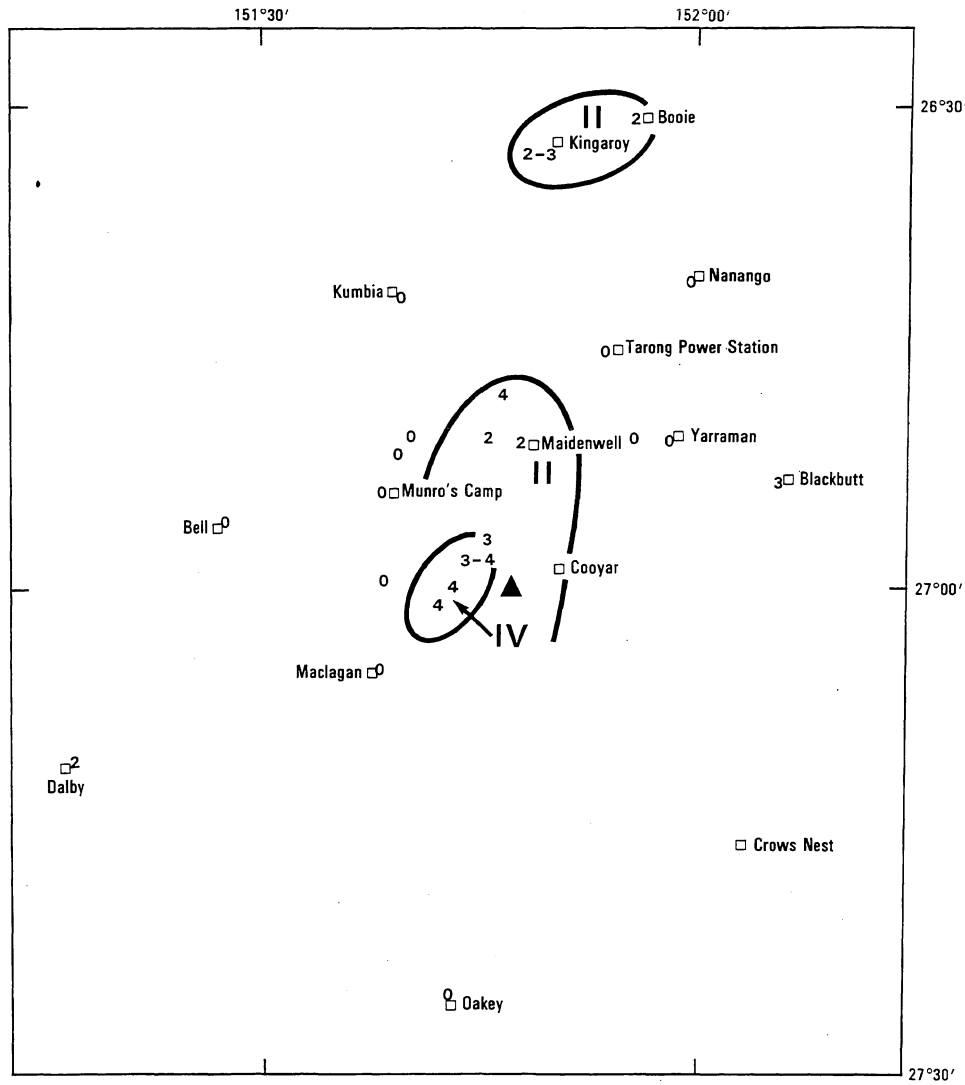
▲	*Epicentre*
IV	*Zone intensity designation*
4	*Earthquake felt (MM)*
0	*Earthquake not felt*

Isoseismal map of the Cooyar earthquake
Queensland - 4 March 1984

This earthquake occurred at 5:11 pm EST near Cooyar, a small town about 120 km north of Toowoomba Queensland. It was felt over an area of about 300 km^2 with the strongest rated intensity MM IV 10 km west of Cooyar (Rynn, 1986).

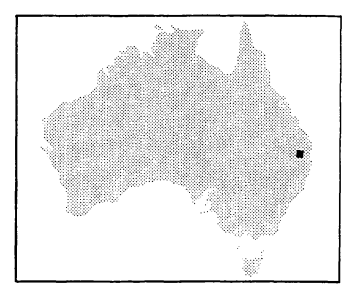
Contributors: This map was compiled by Dr Jack Rynn University of Queensland.

ISOSEISMAL MAP OF THE COOYAR EARTHQUAKE, QUEENSLAND, 4 MARCH 1984



DATE : *4 March 1984*
TIME : *07:12:58.2 UT*
MAGNITUDE : *2.2ML(UQ), 2.7ML(I)*
EPICENTRE : *26.94°S 151.79°E*
DEPTH : *4 km*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/G56/18

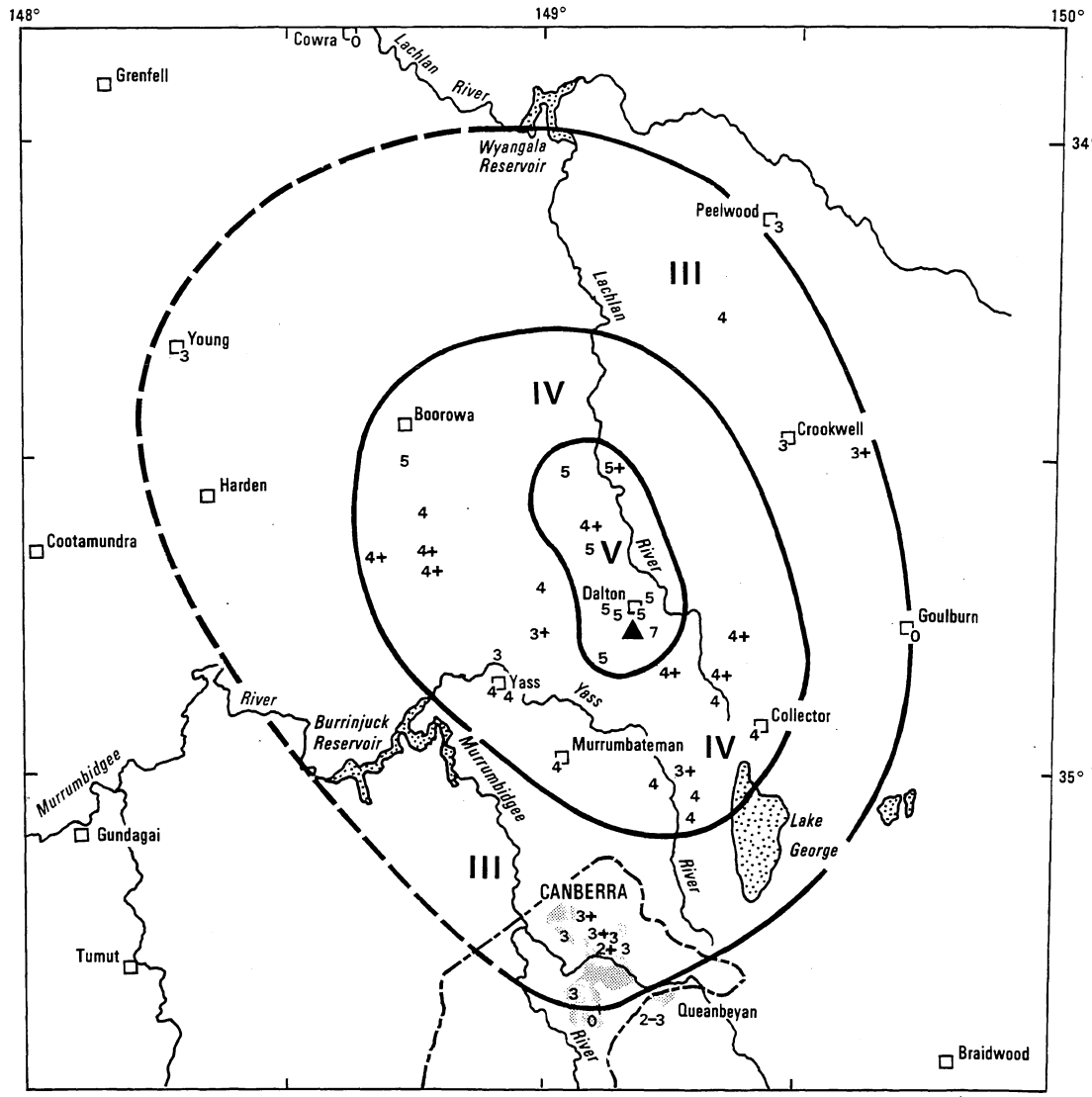
Isoseismal map of the Oolong earthquake
New South Wales - 9 August 1984

The following description is based on that from McCue & others (1989); The earthquake struck at 4.30 pm on 9 August causing extensive cracking in a brick homestead at Oolong and the Anglican Church in Dalton, both of which had suffered damage during the 1949 earthquake. Questionnaires were distributed by BMR staff and the responses compiled with newspaper reports and verbal accounts to produce the isoseismal map. Shaking was felt over an average radius of about 70 km which corresponds to a magnitude of ML(I) 4.4. A similar magnitude, ML 4.3, was determined at the BMR from Eastern Australian seismograms.

Revision of the attenuation relationship for south-eastern Australia by Michael-Leiba and Malafant (198) has resulted in the downgrading of the magnitude of this earthquake to ML 4.0

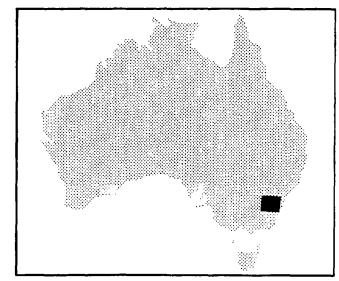
Contributors: This map was compiled by Brian Gaull and Angela Bullock of AGSO with minor additions from Kevin McCue.

ISOSEISMAL MAP OF THE OOLONG EARTHQUAKE, NEW SOUTH WALES, 9 AUGUST 1984



DATE : 9 AUGUST 1984
TIME : 06:30:14.0 UT
MAGNITUDE : 4.3 ML (BMR)
EPICENTRE : 34.81°S 149.17°E
DEPTH : 5km

▲	*Epicentre*
IV	*Zone Intensity Designation*
4	*Earthquake Felt (MM)*
0	*Earthquake Not Felt*



24/155/13

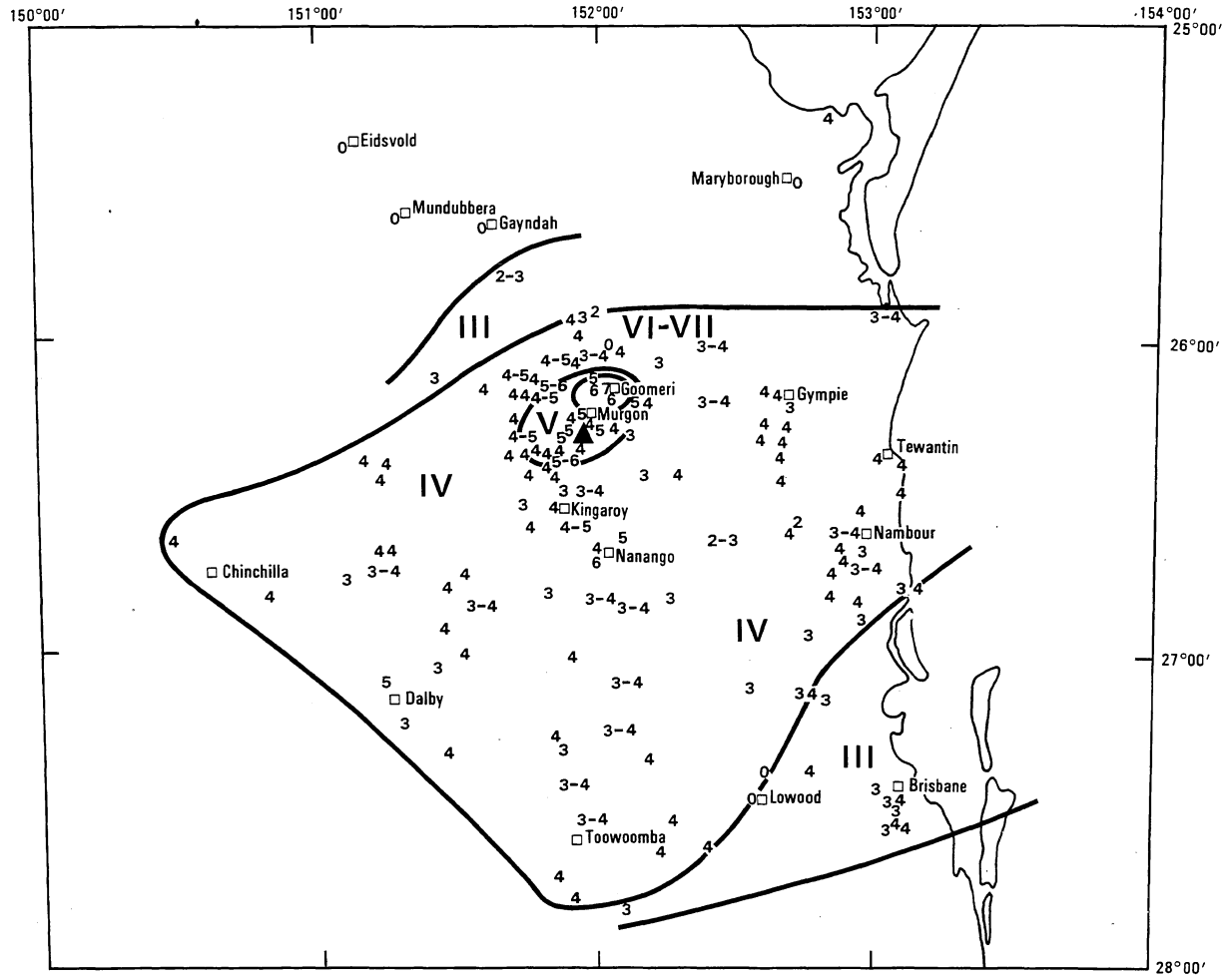
Isoseismal map of the Murgon earthquake
Queensland - 30 October 1984

The epicentre is near Murgon in the South Burnett district about 165 km northwest of Brisbane where the earthquake was slightly felt. Minor damage was reported from Goomeri and shaking is reported to have been sufficiently strong to shake objects off walls and shelves in the Wondai, Goomeri and Murgon districts (Rynn, 1986).

Four small aftershocks, all smaller than ML 2.0, were recorded on the Wivenhoe Dam seismographic network.

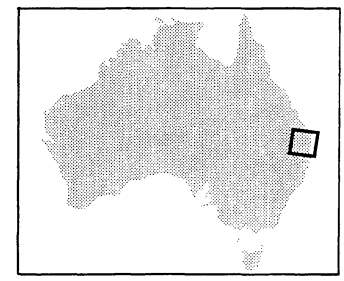
Contributors: This map was compiled by Dr Jack Rynn University of Queensland.

ISOSEISMAL MAP OF THE MURGON EARTHQUAKE, QUEENSLAND, 30 OCTOBER 1984



DATE : *30 October 1984*
TIME : *06:29:48.2 UT*
MAGNITUDE : *4.2ML(UQ), 4.7ML(I)*
EPICENTRE : *26.31°S,151.96°E*
DEPTH : *6 km*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



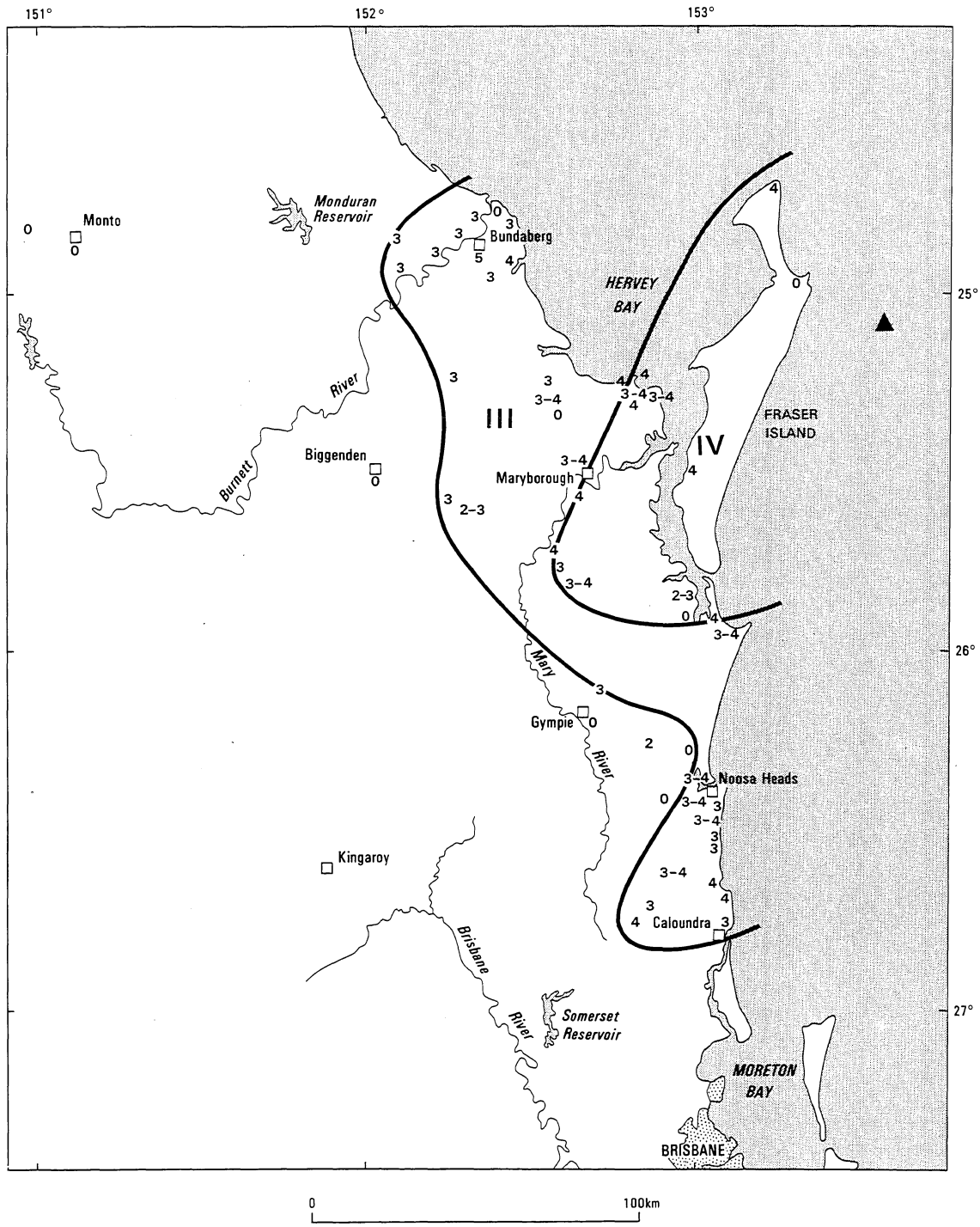
24/G56/19

Isoseismal map of the Fraser Island earthquake
Queensland - 8 February 1985

At 6:23 pm EST the Queensland Central Coast towns of Bundaberg, Maryborough and Noosa Heads were shaken by an earthquake located out to sea off Fraser Island. There was no damage reported and the maximum intensity was rated MM IV-V.

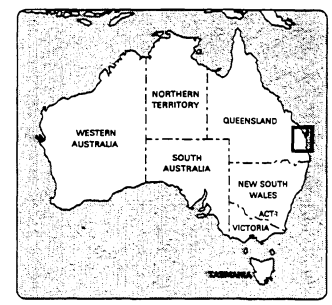
Contributors: This map was compiled by Dr Jack Rynn University of Queensland.

ISOSEISMAL MAP OF THE FRASER ISLAND EARTHQUAKE, QUEENSLAND, 8 FEBRUARY 1985



DATE : *8 February 1985*
TIME : *08:23:42UT*
MAGNITUDE : *4.7 ML (UQ)*
EPICENTRE : *25.12°S, 153.62°E*
DEPTH : *10km*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



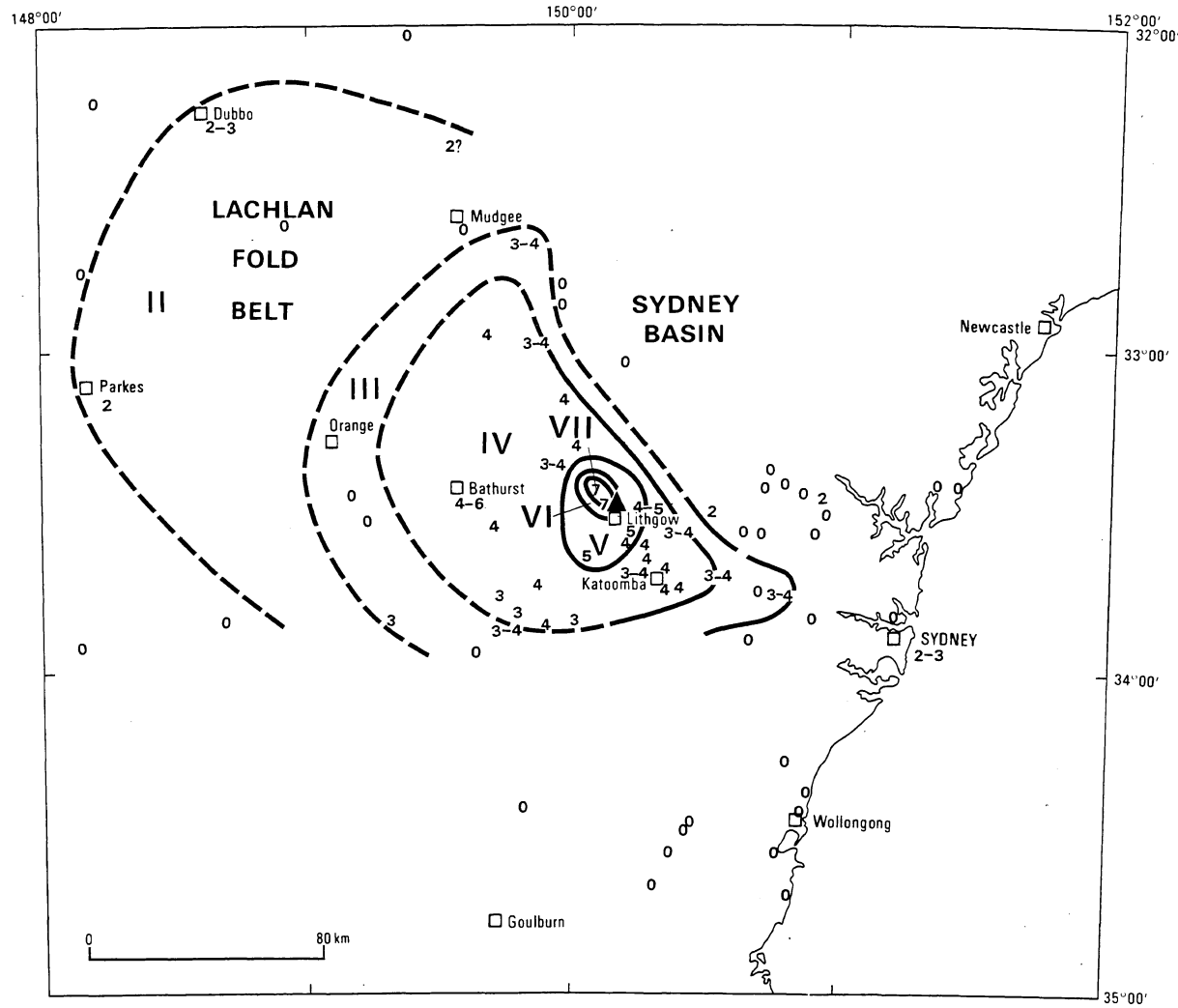
24/G56/20

Isoseismal map of the Lithgow earthquake New South Wales - 13 February 1985

The epicentre of this earthquake at 7:01 pm EST near Lithgow NSW is only 120 km west-northwest of Sydney where it was felt by several people. Some chimneys in Lithgow were partly demolished, windows were broken and some masonry walls were cracked. The shaking caused a power blackout due to the cutout of a mercury relay. The maximum intensity was assessed as MM VII. (Michael-Leiba & Denham, 1987).

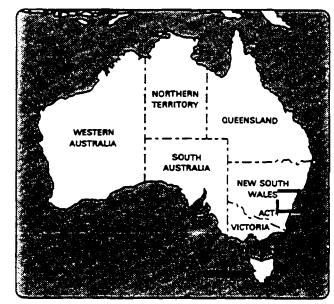
Contributors: This map was compiled by Dr Marion Michael-Leiba, BMR.

ISOSEISMAL MAP OF THE LITHGOW EARTHQUAKE, NEW SOUTH WALES, 13 FEBRUARY 1985



DATE : *13 February 1985*
TIME : *08:01:22.8 UT*
MAGNITUDE : *4.3 ML (BMR)*
EPICENTRE : *33.49°S, 150.18°E*
DEPTH : *7 km*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/N/14

Isoseismal map of the Norseman earthquake Western Australia - 28 July 1985

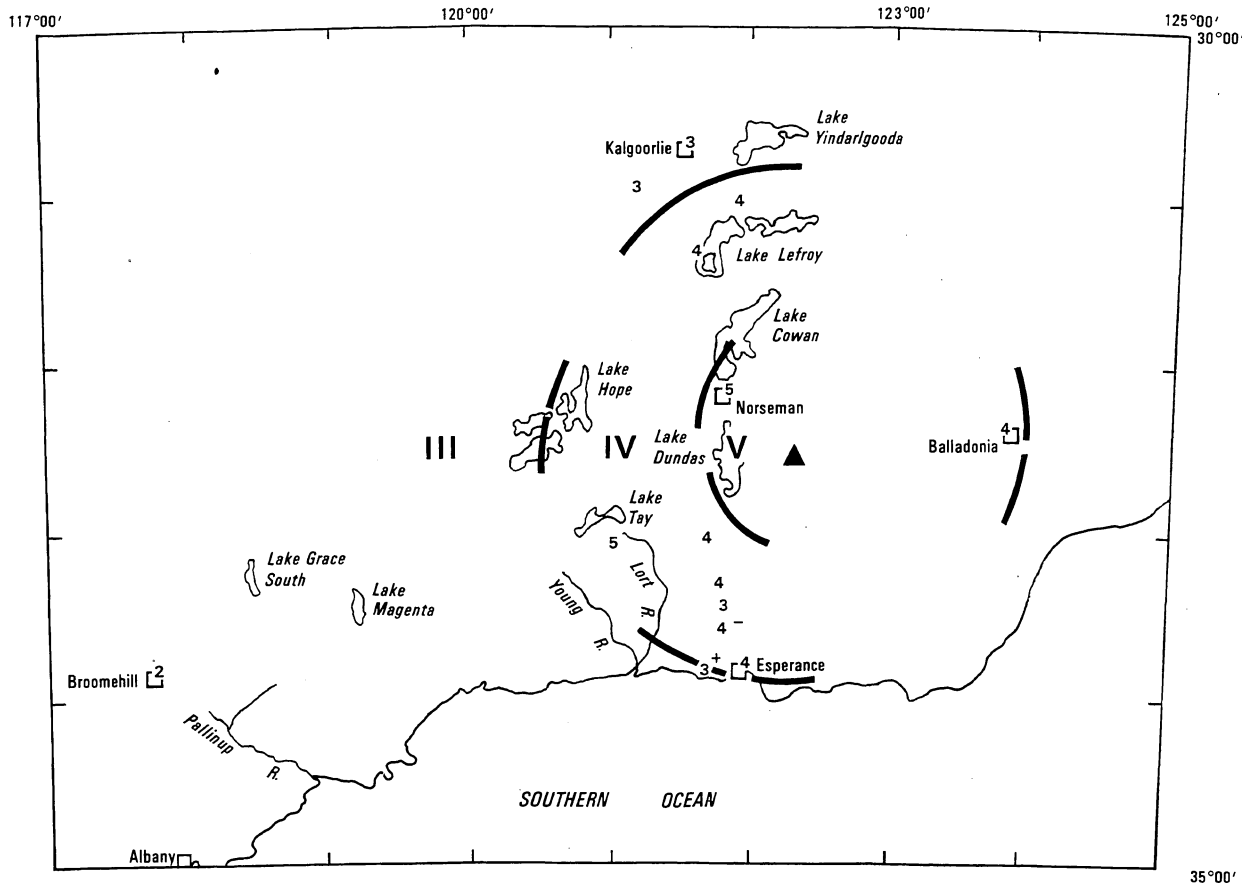
The low population density in the epicentral region resulted in few reports that this earthquake was felt and the maximum intensity was MM V at Norseman, the closest town to the epicentre. There was no damage but objects were moved on shelves. At Broomhill 450 km from the epicentre, water slopped to and fro in a fishtank in a wood-framed house.

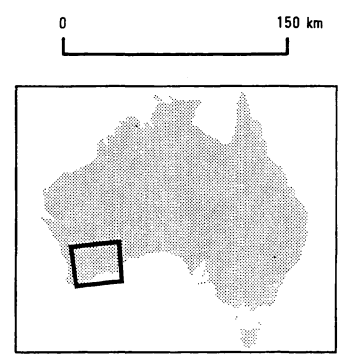
There were 16 aftershocks of magnitude 3 or more within a month of the mainshock.

The epicentre and those of several earlier earthquakes, are on the Fraser Fault which marks the southeastern edge of the Yilgarn Block.

Contributors: This map was compiled by Peter Gregson.

ISOSEISMAL MAP OF THE NORSEMAN EARTHQUAKE, WESTERN AUSTRALIA 28 JULY 1985





DATE : 28 JULY 1985
TIME : 07:39:47.3 UT
MAGNITUDE : 5.6 ML (MUN)
EPICENTRE : 32.51°S, 122.22°E
DEPTH : 10 km

▲ EPICENTRE
IV ZONE INTENSITY DESIGNATION (MM)

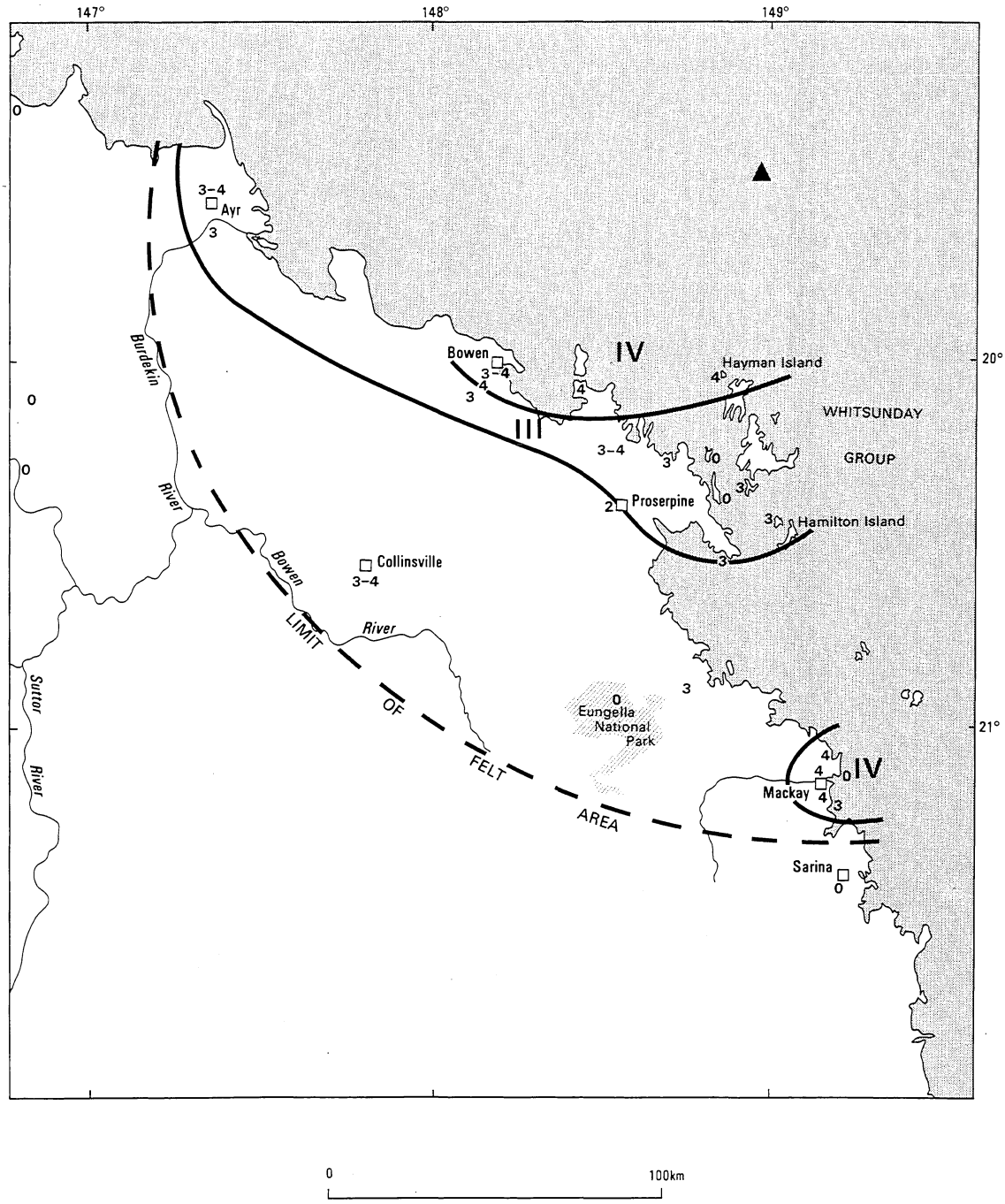
24/WA/71

Isoseismal map of the Proserpine earthquake Queensland - 2 August 1985

The epicentre was computed to be in the inner Great Barrier Reef about 50 km north of the Whitsunday Islands in East-Central Queensland. The maximum intensity was MM IV at Bowen, McKay and on Hayman Island.

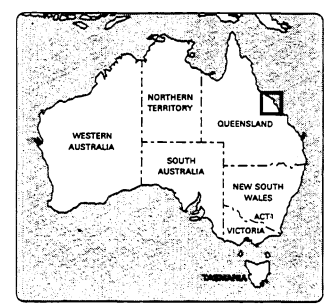
Contributors: This map was compiled by Dr Jack Rynn University of Queensland.

ISOSEISMAL MAP OF THE PROSERPINE EARTHQUAKE QUEENSLAND, 2 AUGUST 1985



DATE : *2 August 1985*
TIME : *12:16:58UT*
MAGNITUDE : *4.7 ML (UQ)*
EPICENTRE : *19.44°S, 149.20°E*
DEPTH : *10km*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/F55/5

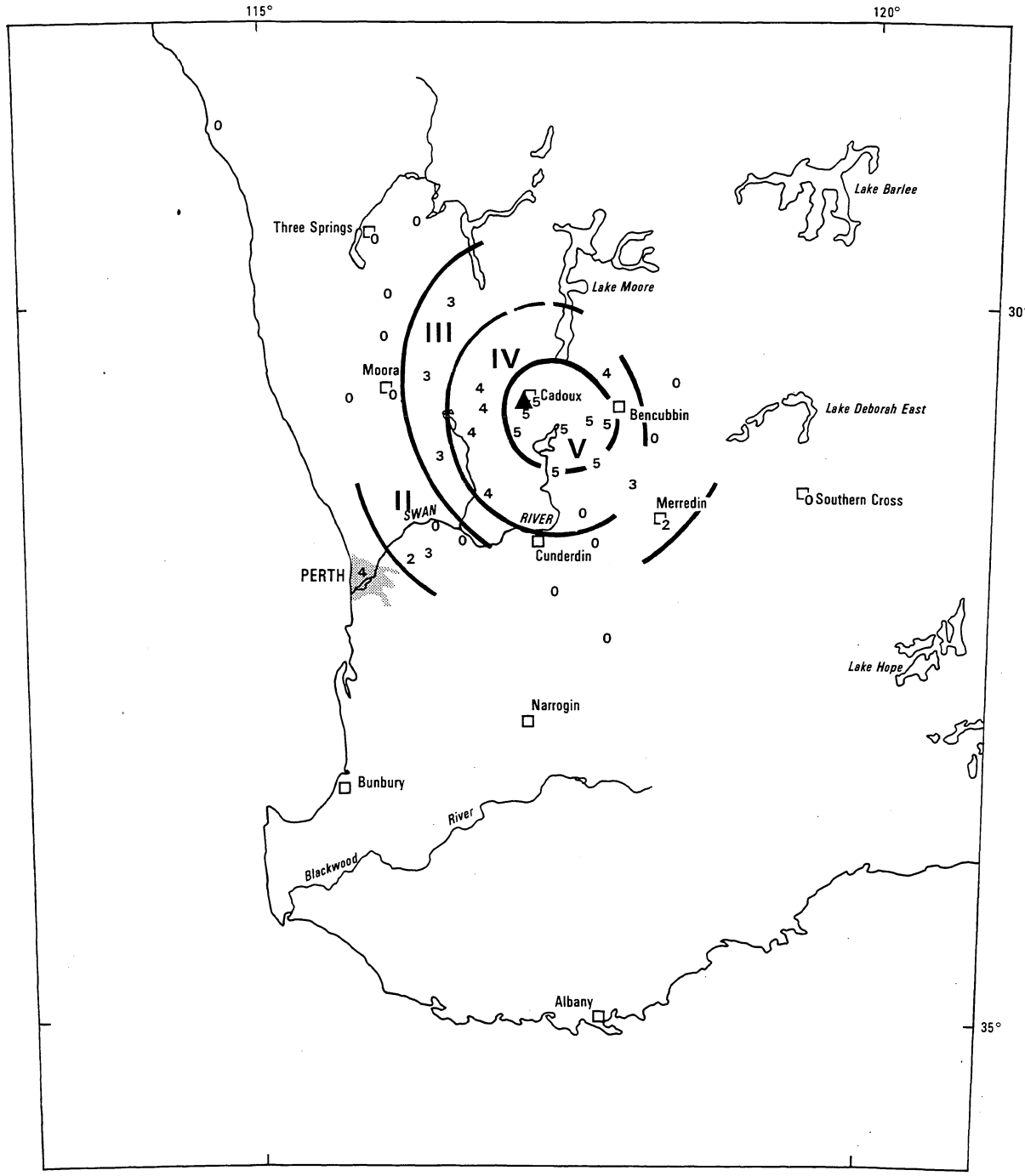
Isoseismal map of the Cadoux earthquake
Western Australia - 10 October 1985

Another earthquake near Cadoux, the frequency of earthquakes has not yet returned to normal levels since the magnitude Ms 6.2 earthquake on 2 June 1979 (Gregson & others, 1987). There was no damage in Cadoux where the assessed intensity was MM V.

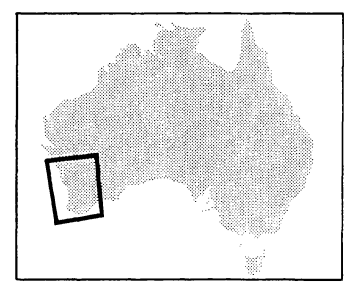
The area enclosed by the MMIV and MM V isoseismals is much larger than that for the same sized earthquake near Cadoux on 24 January 1982 which we attribute to the time of day. This earthquake occurred in the evening of October 10 but the 1982 event was in the middle of the day.

Contributors: This map was compiled by Peter Gregson.

ISOSEISMAL MAP OF THE CADOUX EARTHQUAKE, WESTERN AUSTRALIA
10 OCTOBER 1985



0 200 km



DATE : 10 OCTOBER 1985
TIME : 13:34:30.5 UT
MAGNITUDE : 4.3 ML (MUN)
EPICENTRE : 30.75°S 117.11°E
DEPTH :

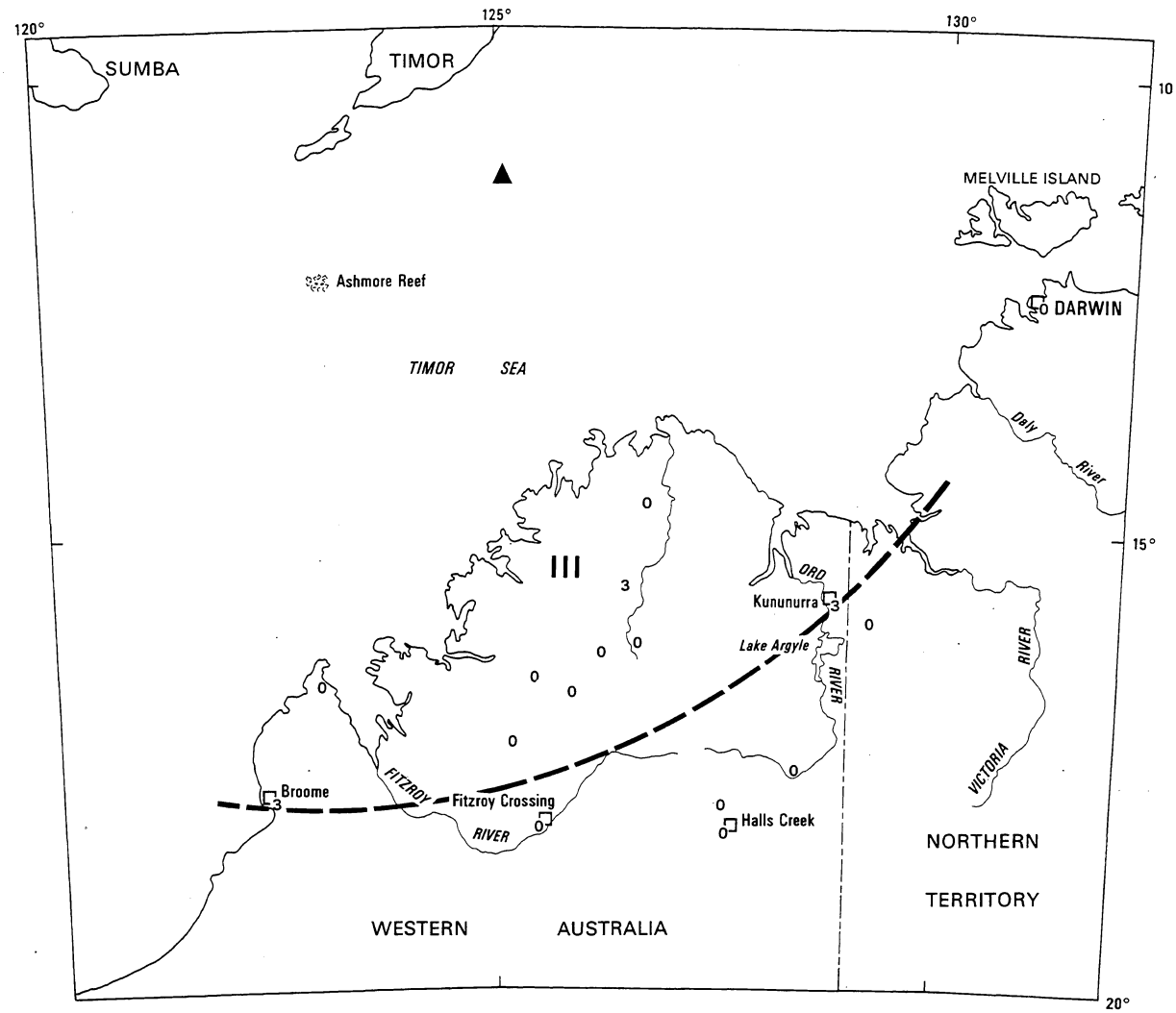
▲ EPICENTRE
IV ZONE INTENSITY DESIGNATION
4 EARTHQUAKE FELT (MM)
0 EARTHQUAKE NOT FELT

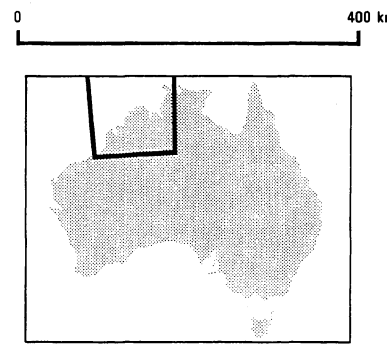
Isoseismal map of the Timor Sea earthquake Indonesia - 23 October 1985

This large shallow earthquake south of Timor was felt at Broome and Kununurra in Western Australia, 700 km from the epicentre, but there were no reports of it being felt in Darwin in the Northern Territory (Gregson & others, 1987). In Australia, the earthquake was most strongly felt by exploration drillers on an oil rig on Ashmore reef, 300 km offshore and approximately 350 km southwest of the epicentre (Gregson & others, 1987).

Contributors: This map was compiled by Peter Gregson.

ISOSEISMAL MAP OF THE TIMOR SEA EARTHQUAKE, 23 OCTOBER 1985





DATE : 23 OCTOBER 1985
TIME : 00:49:16.0 UT
MAGNITUDE : 6.0 MB (GS)
EPICENTRE : 11.04°S 125.04°E
DEPTH : 46 km

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

24/OA/4

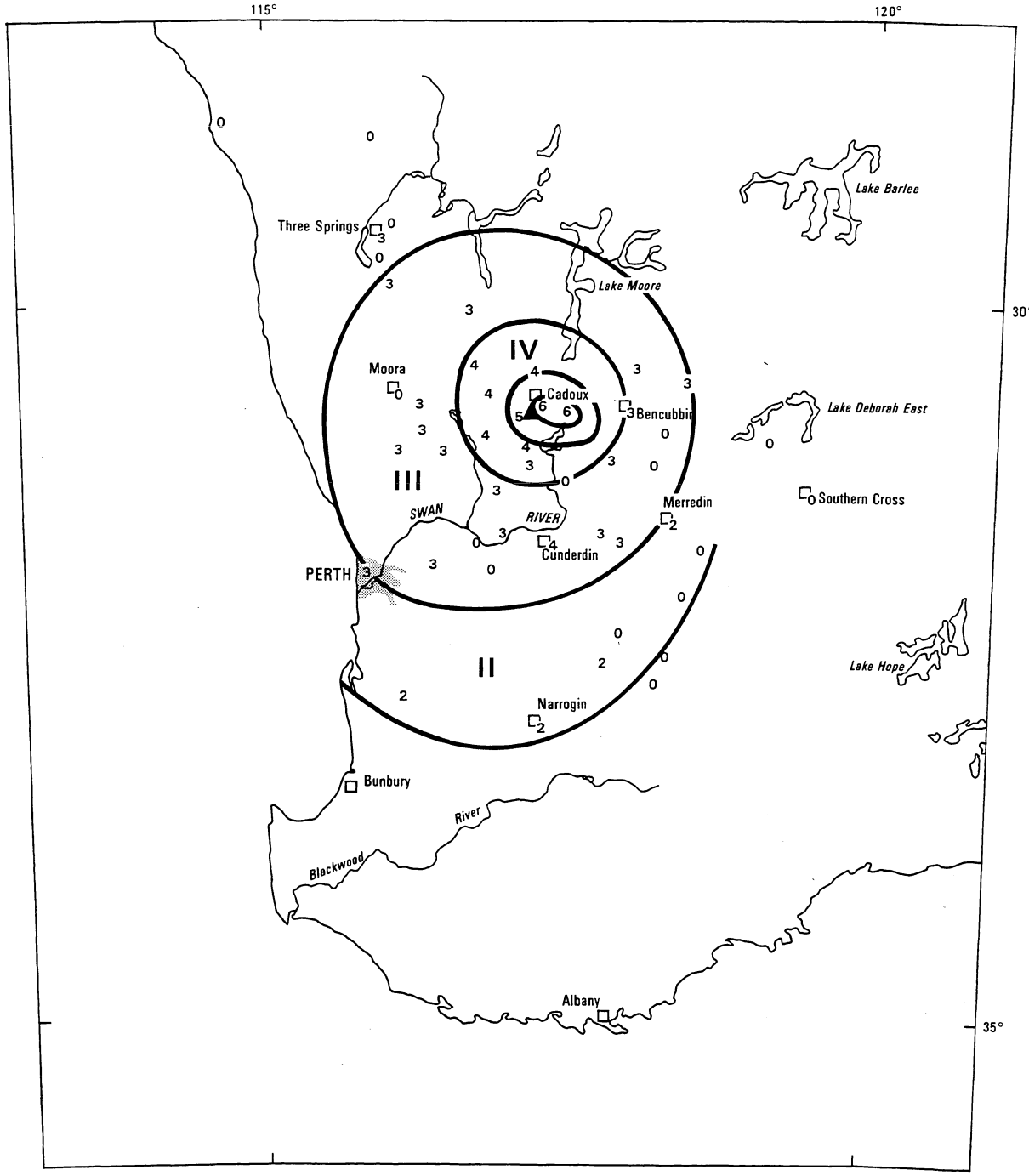
Isoseismal map of the Cadoux earthquake Western Australia - 27 November 1985

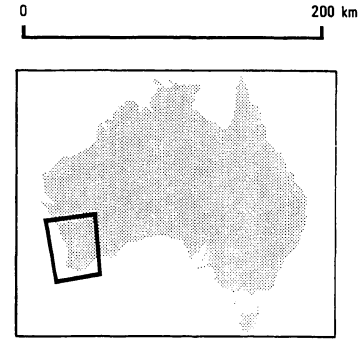
Seven weeks after the earthquake of 10 October 1985 described above, Cadoux was again shaken by a local earthquake, this one slightly larger at magnitude ML 4.5. The epicentre was 5 km southwest of Cadoux where the intensity was MM VI. It was felt over an area of 100 000 km^2 and at distances up to 260 km from the epicentre.

Several thousand earthquakes have been recorded in Cadoux since the Ms 6.2 mainshock on 2 June 1979, and isoseismal maps have been drawn up for the largest nine of them (Gregson & others, 1987).

Contributors: This map was compiled by Peter Gregson.

ISOSEISMAL MAP OF THE CADOUX EARTHQUAKE, WESTERN AUSTRALIA
27 NOVEMBER 1985





DATE : 27 NOVEMBER 1985
TIME : 23:18:20.7 UT
MAGNITUDE : 4.5 ML (MUN)
EPICENTRE : 30.77°S 117.08°E
DEPTH :10 KM

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

24/WA/73

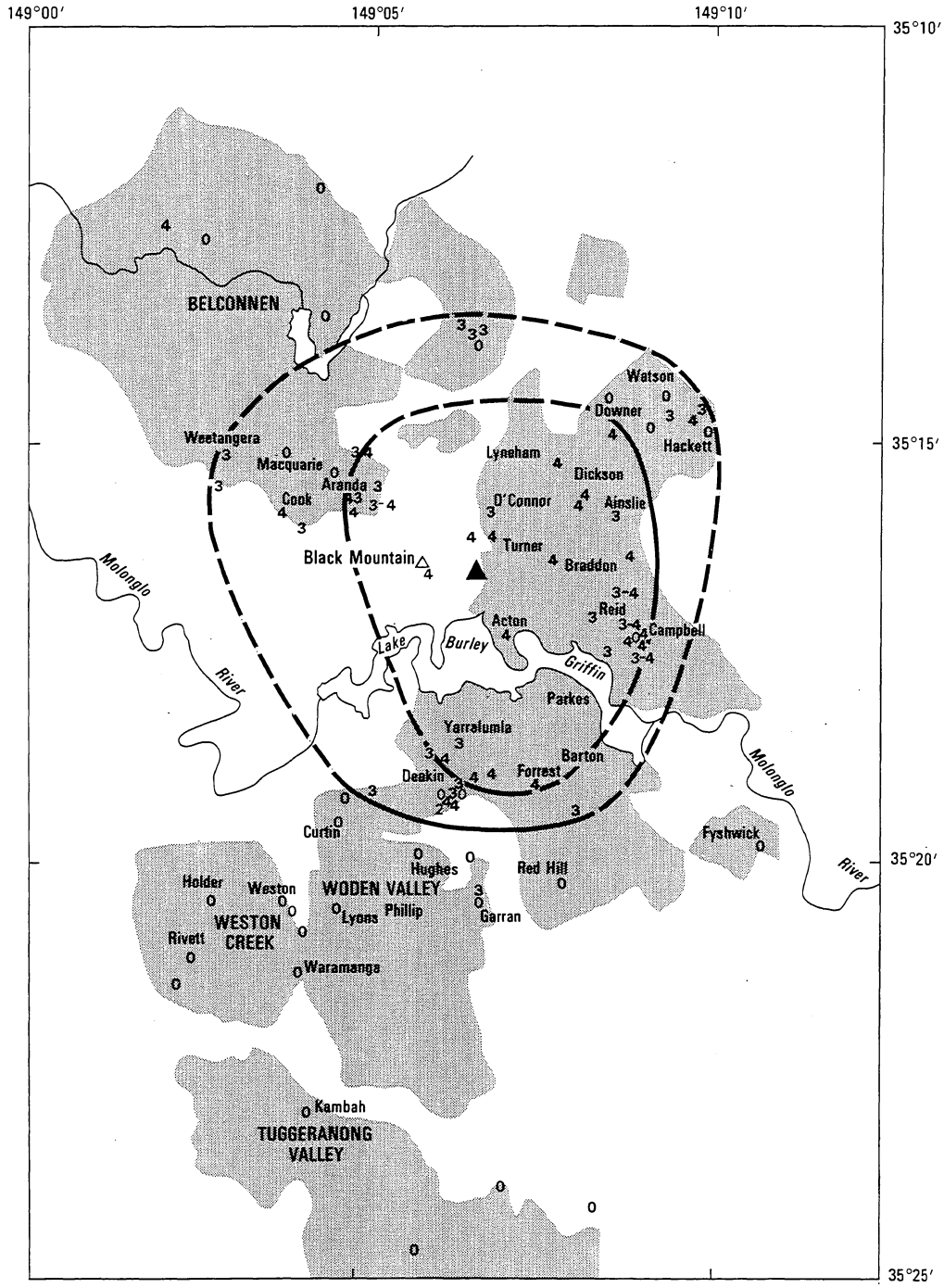
Isoseismal map of the Canberra earthquake Australian Capital Territory - 28 November 1985

Residents of the inner suburbs of Canberra were surprised rather than frightened by the shaking from a small earthquake at 7:51 am on a normal working day. At this time of day, many people in cars or buses were on route to work and none of them reported feeling the earthquake. The maximum intensity was MM IV.

Shaking was felt over a radius of about 4 km from the epicentre near the Telecom Tower on Black Mountain, only 1 km west of the City Centre. One of the more distant observers in a 2 storey house in Curtin reported that on hearing the noise, they had thought their 10 year old son had fallen down the last few stairs.

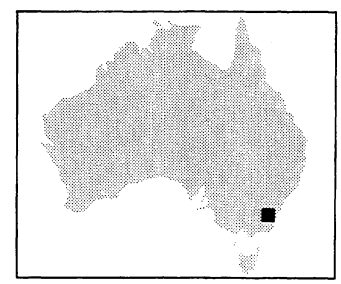
Contributors: This map was compiled by BMR's Dr Marion Michael-Leiba using information collated from a questionnaire distributed through BMR and newspaper reports.

ISOSEISMAL MAP OF THE CANBERRA EARTHQUAKE, AUSTRALIAN CAPITAL TERRITORY, 28 NOVEMBER 1985



DATE : 28 NOVEMBER 1985
TIME : 20:51:12.2 UT
MAGNITUDE : 2.4 ML (BMR)
EPICENTRE : 35.28° S 149.11° E
DEPTH : 2 km

▲	*Epicentre*
IV	*Zone Intensity Designation*
4	*Earthquake Felt (MM)*
0	*Earthquake Not Felt*



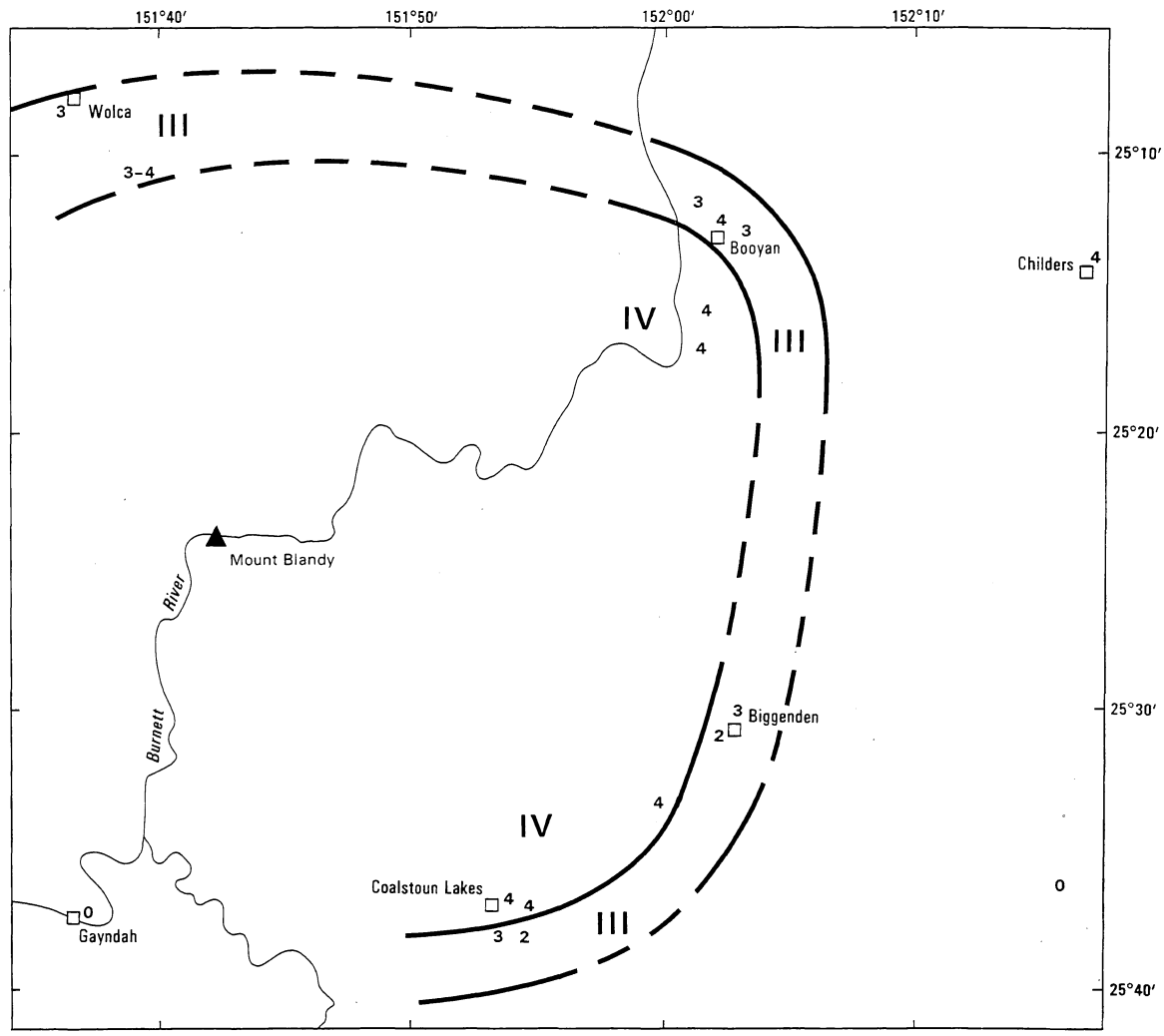
Isoseismal map of the Coalstoun Lakes earthquake Queensland - 2 December 1985

This small (ML 3.3) earthquake occurred at 4:19 pm about 20 km north of Gayndah in Southeast Queensland. In all, 37 people reported feeling the earthquake but the isoseismal map is poorly constrained.

The epicentre is in the middle of a Quaternary volcanic province which includes the two very well preserved cones at Coalstoun Lakes, the latest eruptive activity dated at some 600 000 years before the present.

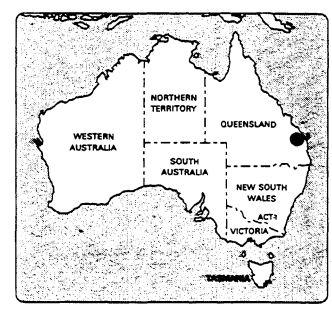
Contributors: This map was compiled by Dr Jack Rynn, University of Queensland.

ISOSEISMAL MAP OF THE COALSTOUN LAKES EARTHQUAKE, QUEENSLAND, 2 DECEMBER 1985



DATE : *2 December 1985*
TIME : *06:19:01UT*
MAGNITUDE : *3.2 ML (GSQ)*
EPICENTRE : *25.39°S, 151.73°E*
DEPTH : *10km*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/G56-6/2

Isoseismal map of the Oolong earthquake New South Wales - 7 January 1986

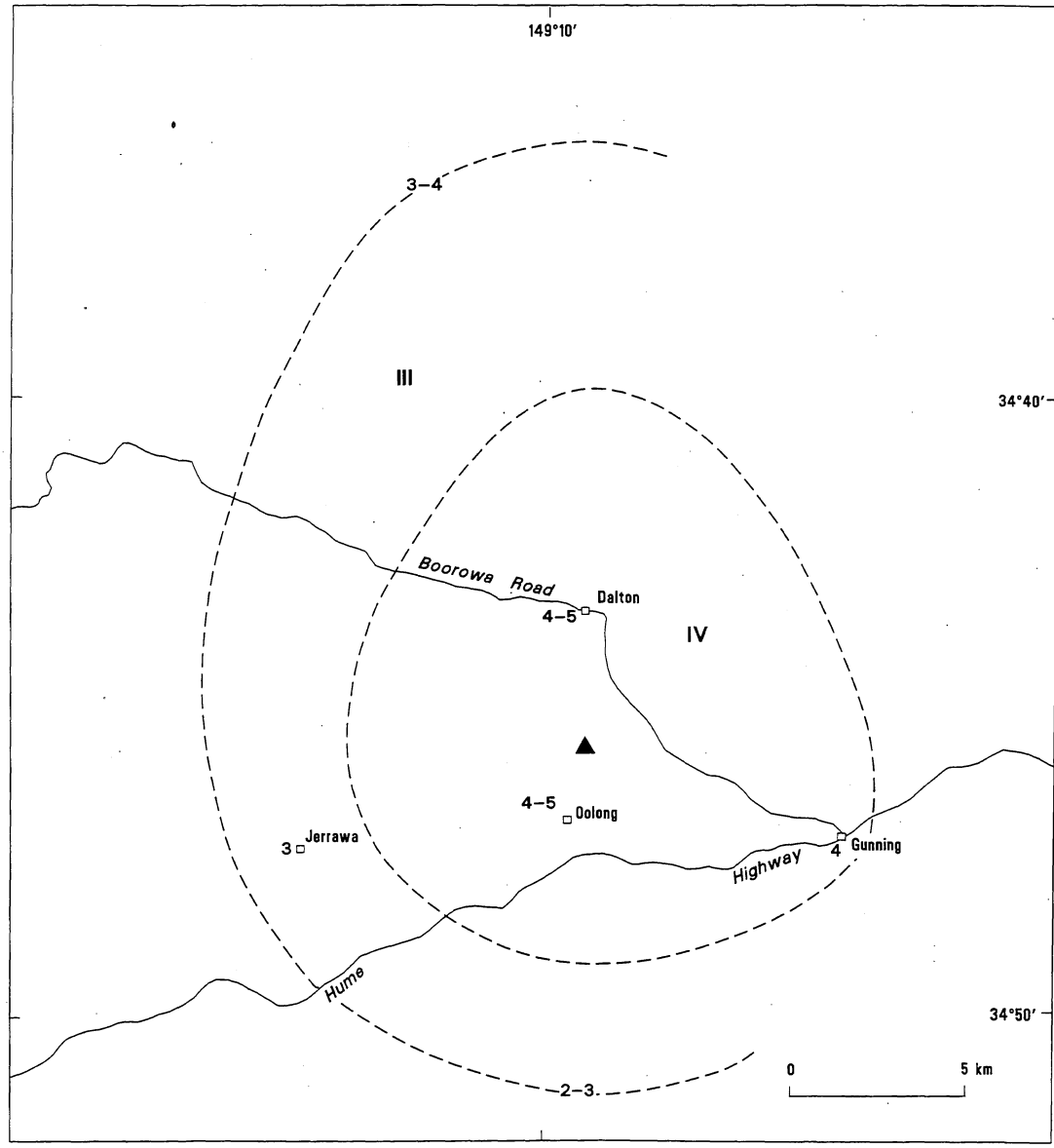
Felt reports were obtained by personal and phone interview. Where the report indicated that the event was heard but not felt, it was assigned an intensity of MMII.

The earthquake caused minor damage to St Matthews Church at Dalton. This building had been damaged during earlier earthquakes, most recently by the magnitude ML 4.0 event of August 1984. The 1986 earthquake dislodged plaster and stone from pre-existing cracks and produced a new crack behind the altar. A peak ground acceleration of 1.15 ms^{-2} was recorded on a digital accelerograph at a distance of 4 km from the epicentre (Michael-Leiba in Gregson and Moiler, 1990).

The isoseismals are asymmetric, the event was felt more widely to the north and northwest than to the south. This may be a geological effect. The southern observation points are on or close to granite, whereas the relatively high intensities to the north and west of Dalton were recorded on sediments. However, the observations plotted on the map were the only ones collected and there is a paucity of them to the south, so this may be the reason why the isoseismals are asymmetric. It is interesting to note that in the isoseismal map of the August 1984 Oolong earthquake (McCue and others, 1989), the MMV contour is asymmetric to the northwest. This suggests that the asymmetry of the contours may be a regional effect, though the data for the larger 1984 event also suffered from paucity of observations immediately south of the epicentre.

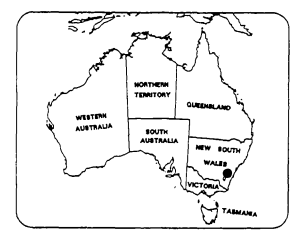
Contributors: This map was compiled by Dr Marion Michael-Leiba of BMR and the late Vicki Klein of Ups and Downs, Dalton.

ISOSEISMAL MAP OF THE OOLONG EARTHQUAKE, NSW, 7 JANUARY 1986



DATE:	7 JANUARY 1986
TIME:	10:06:49.6 UTC
MAGNITUDE:	3.1 MD (BMR)
EPICENTRE:	34.76°S 149.18°E
DEPTH:	2 km

▲	*Epicentre*
IV	*Zone intensity designation (MM)*
4	*Earthquake felt (MM)*
0	*Earthquake not felt*



24/155/30

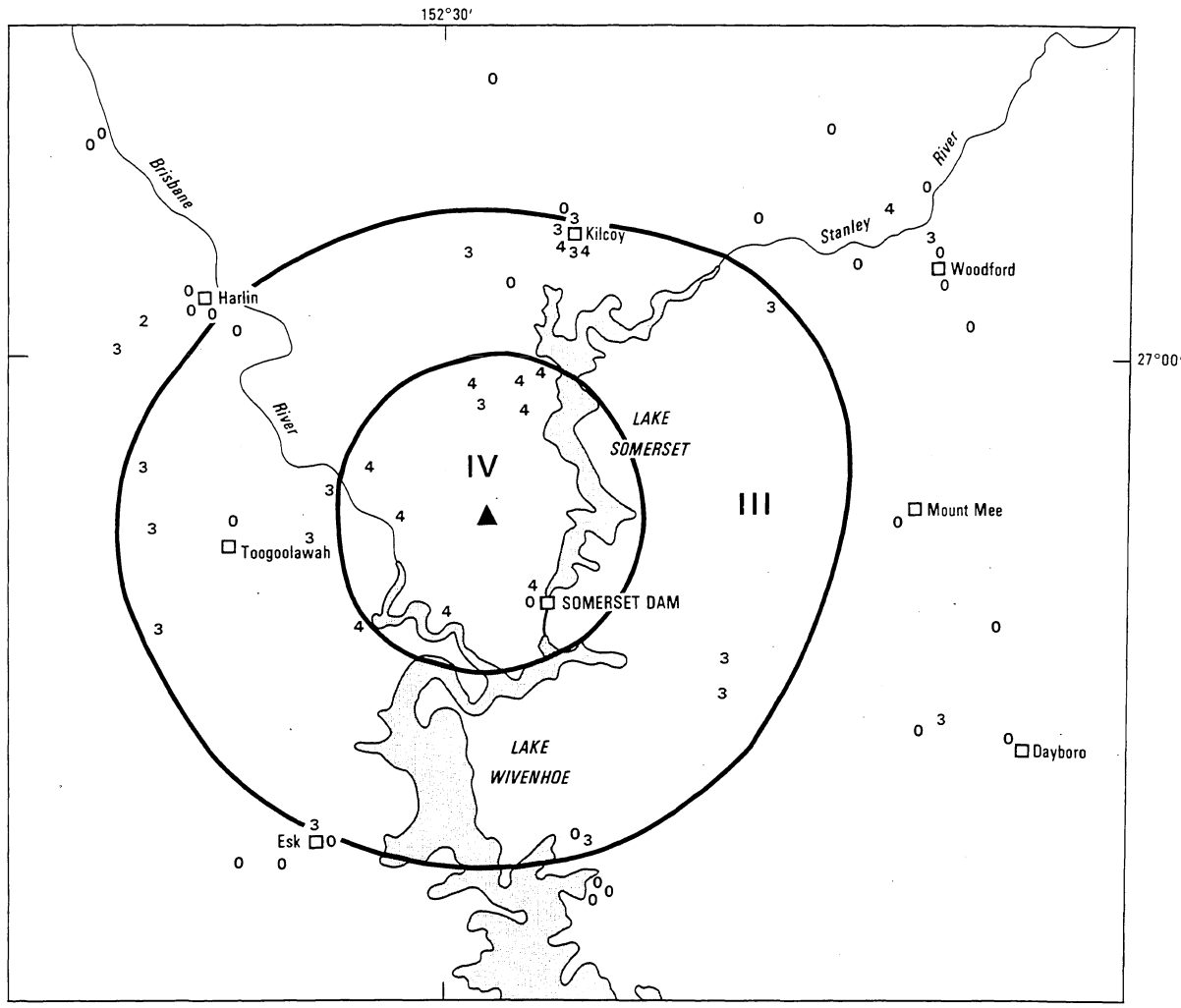
Isoseismal map of the Somerset Dam earthquake Queensland - 8 January 1986

Staff of the Queensland Department of Mines conducted an isoseismal survey of the area affected by this earthquake which occurred at 7:55 pm EST. The epicentre was near the Somerset Dam in Southeast Queensland and only 5 km from the nearest seismograph of the Wivenhoe Dam network.

There were unconfirmed reports of damage to some buildings within the 20 km radius of perceptibility. Two tiny aftershocks were recorded within 2 days of the main event, the larger of the two at magnitude ML 1.0 was felt by some residents of Somerset Dam.

Contributors: This map was compiled by Russell Cuthbertson at the Queensland Department of Mines.

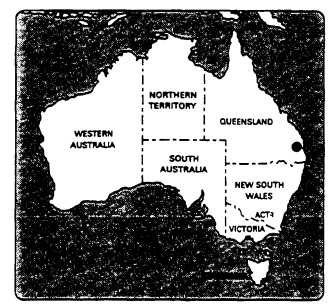
ISOSEISMAL MAP OF THE SOMERSET DAM EARTHQUAKE, QUEENSLAND, 8 JANUARY 1986



0 10 km

DATE : *8 January 1986*
TIME : *09 : 55 : 57.0 UT*
MAGNITUDE : *3.2 ML*
EPICENTRE : *27.15°S;152.50°E*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/G56-14/4

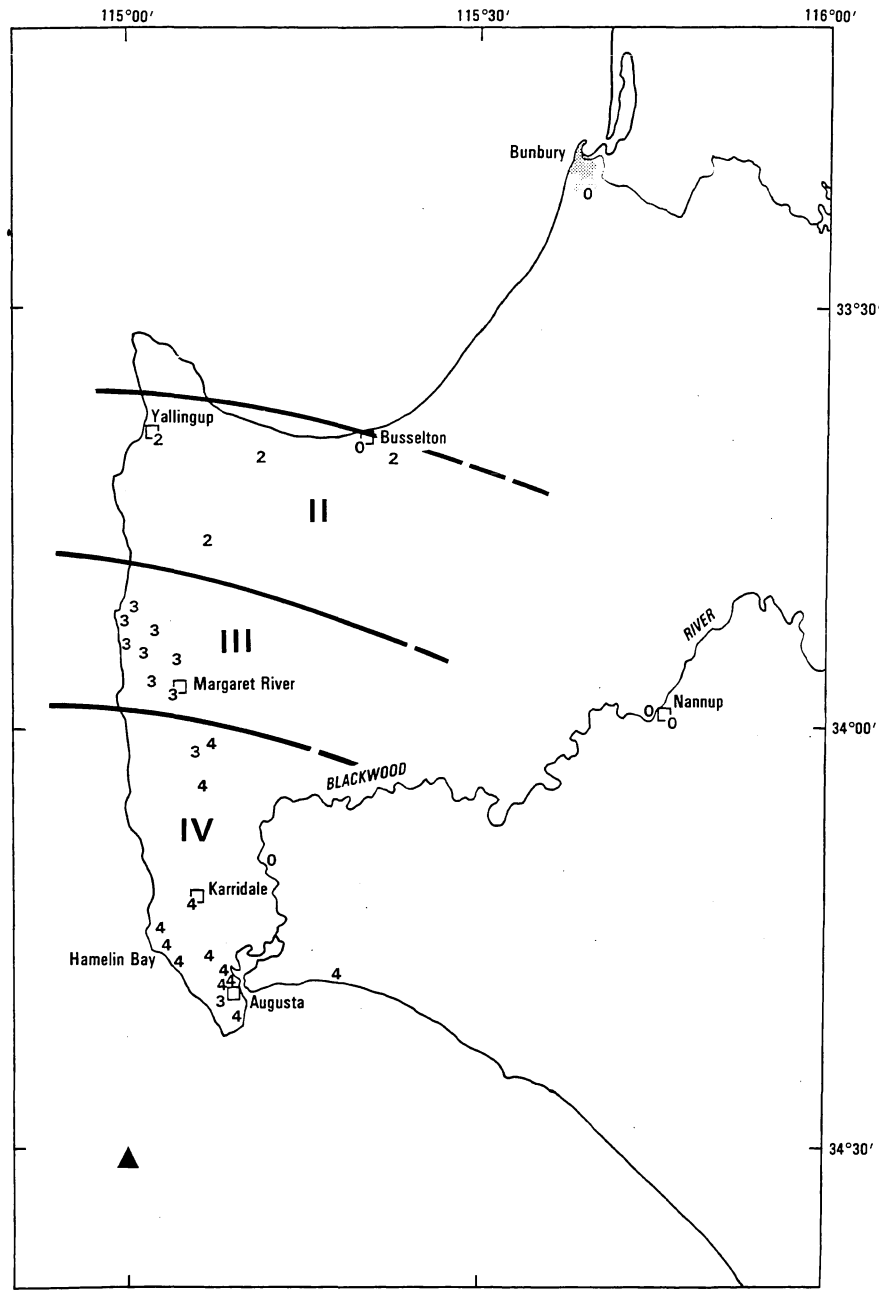
Isoseismal map of the Augusta earthquake Western Australia - 15 January 1986

Residents of the southwest corner of Western Australia experienced this earthquake at 6:11 am WST, and its epicentre was computed to be offshore some 24 km southwest of Augusta. There was no damage and the earthquake was perceptible out to 100 km from the epicentre.

The early hour and sparse population contributed to the lack of felt reports.

Contributors: This map was compiled by Peter Gregson, BMR Mundaring.

ISOSEISMAL MAP OF THE AUGUSTA EARTHQUAKE, WESTERN AUSTRALIA
15 JANUARY 1986



0 40 km

DATE : 15 JANUARY 1986
TIME : 22:11:28.0 UT
MAGNITUDE : 3.8 ML (MUN)
EPICENTRE : 34.51°S 114.99°E

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

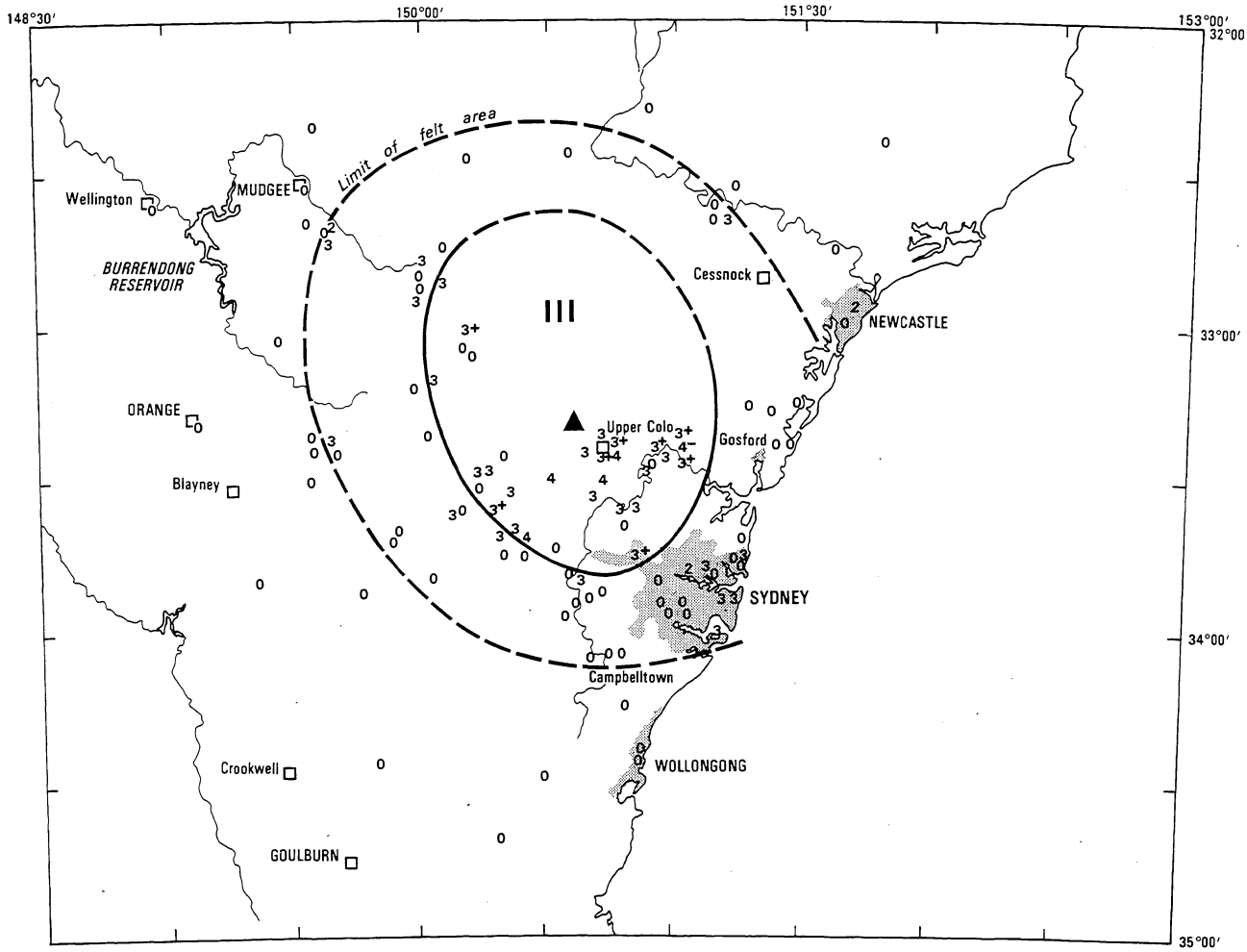
24/150/4

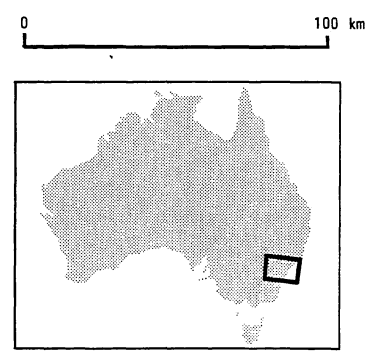
Isoseismal map of the Upper Colo earthquake
New South Wales - 20 February 1986

The epicentre of this magnitude 4.0 earthquake which struck at 8:44 am EST, is only 90 km from Sydney. It was felt from the central coast in the north to Wollongong in the south and not only caused no damage but was not strongly felt anywhere, not even in the epicentral area. It may have been deeper than normal though there is no indication of this apart from the unusual distribution of intensities.

Contributors: This map was compiled by Kevin McCue and Trevor Jones.

ISOSEISMAL MAP OF THE UPPER COLO EARTHQUAKE, NEW SOUTH WALES, 20 FEBRUARY 1986





DATE : 20 FEBRUARY 1986
TIME : 21:43:55.3
MAGNITUDE : 3.9 ML
EPICENTRE : 33.30°S 150.60°E
DEPTH : 2 km

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

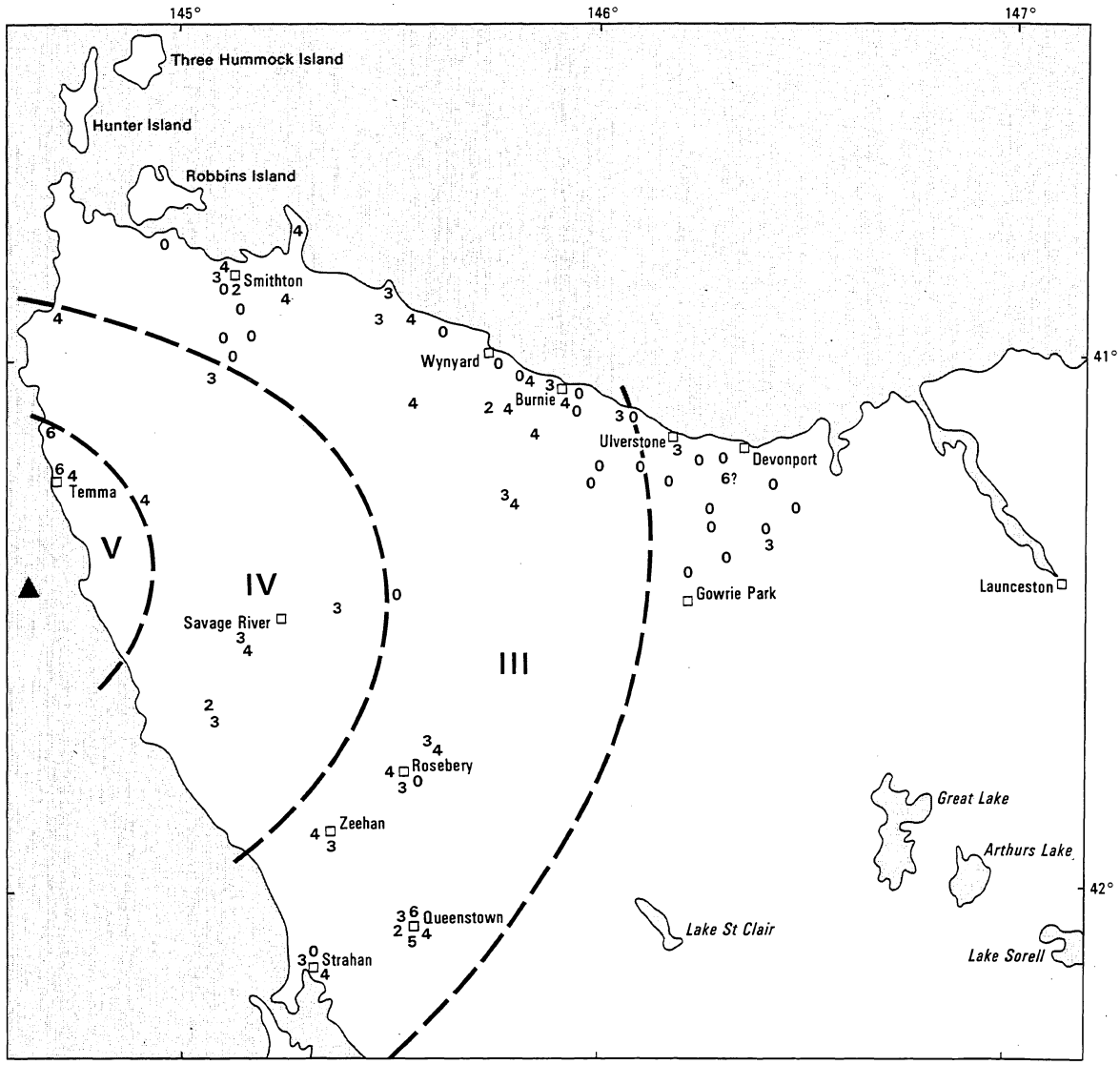
24/N/25

Isoseismal map of the Temma earthquake
Tasmania - 16 March 1986

This is the largest Tasmanian earthquake recorded during the 1980s. It caused minor non-structural damage at Temma on the northwest coast of Tasmania and was felt as far as Queenstown and Devonport up to 200 km away.

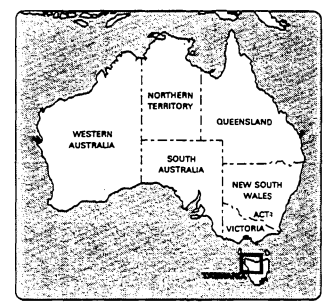
Contributors: This map was compiled by Kevin McCue. Staff at the Geology Department, University of Tasmania, distributed the questionnaires.

ISOSEISMAL MAP OF THE TEMMA EARTHQUAKE, TASMANIA, 16 MARCH 1986



DATE : *16 March 1986*
TIME : *01:53:01 UT*
MAGNITUDE : *4.1 ML (BMR)*
EPICENTRE : *41.27°S, 144.33°E (TAU)*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/K55/27

Isoseismal map of the Marryat Creek earthquake South Australia - 30 March 1986

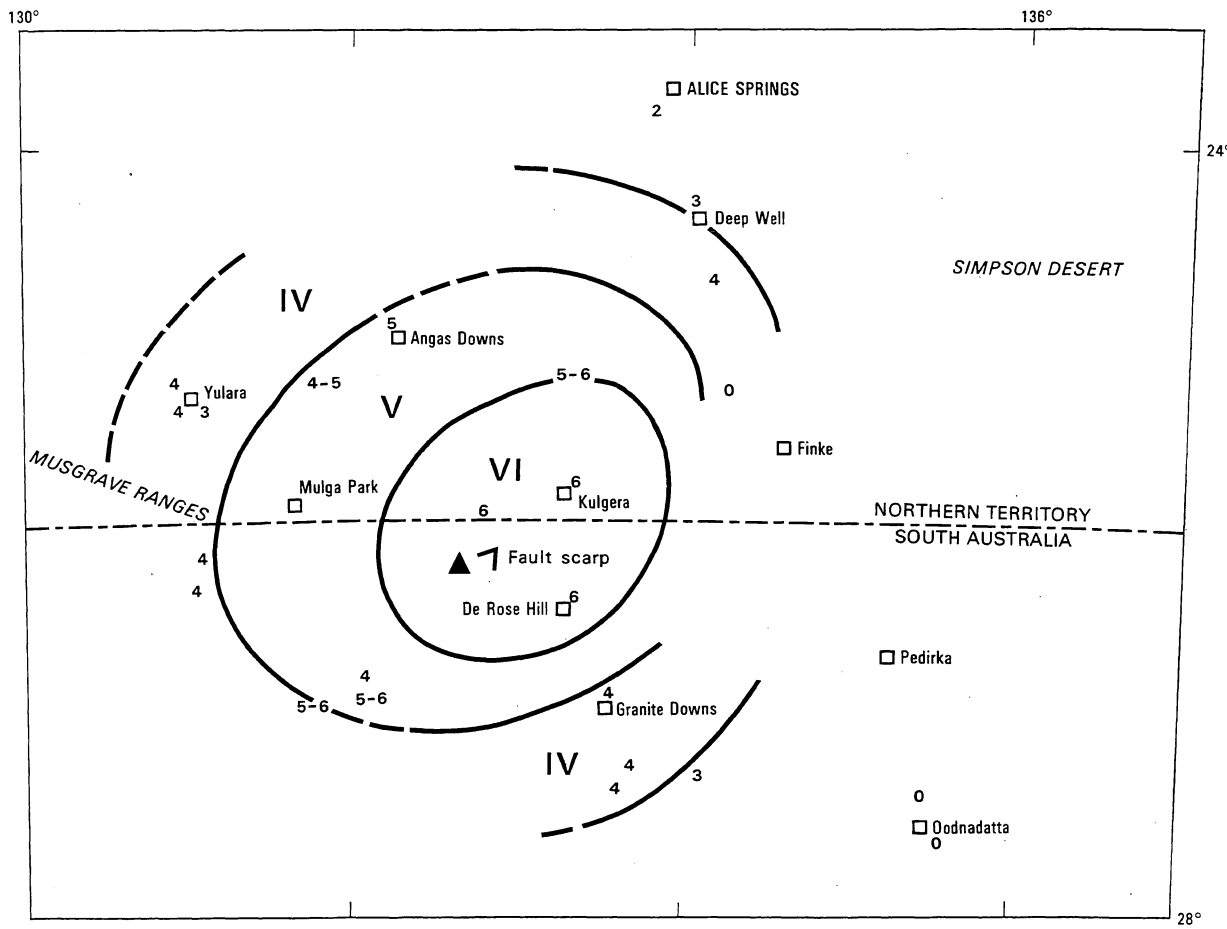
Following this magnitude Ms 5.8 earthquake in the sparsely populated Musgrave Ranges in the far north of South Australia, seismologists at Flinders University distributed questionnaires to homesteads and post offices covering a large area of the Centre and South Australia. Damage was minor; cracking of homestead walls at De Rose Hill and Victory Downs which attracted an assessed intensity of MM VI. Minor shaking was observed by a few people at Alice Springs 300 km to the north and at Cooper Pedy 350 km to the south.

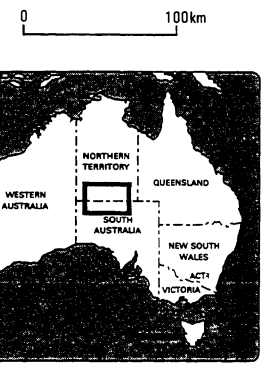
Seismology Research Centre Director, Gary Gibson happened to be in the area and detoured to the epicentral area where he was shown a 0.6 m high scarp offsetting the road and discovered by local rabitters the morning after, as they drove out to set up their traps. BMR hired a light plane and Trevor Jones and David Ebersole from the Alice Springs seismographic array were observers for a late afternoon overflight of the epicentral area. A 13 km long fault was clearly observed, the first in South Australia.

Brian Barlow from BMR and AUSLIG surveyors were attending a Geodesy conference in Adelaide. They drove up to Marryat Creek where they were joined by Trevor Jones from BMR. This group then mapped the fault scarp and installed markers that would be visible from the air for aerial photogrammetry (Barlow & others, 1986; McCue & others, 1987).

Contributors: This map was compiled by Stewart Greenhalgh and Roy McDougal from Flinders University with additional information from Gary Gibson RMIT and Trevor Jones BMR.

ISOSEISMAL MAP OF THE MARRYAT CREEK EARTHQUAKE, SOUTH AUSTRALIA, 30 MARCH 1986





DATE : *30 March 1986*
TIME : *08:53:48.8 UT*
MAGNITUDE : *6 ML*
EPICENTRE : *26.33°S, 132.52°E*
DEPTH : *5km*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*

24/G53/1

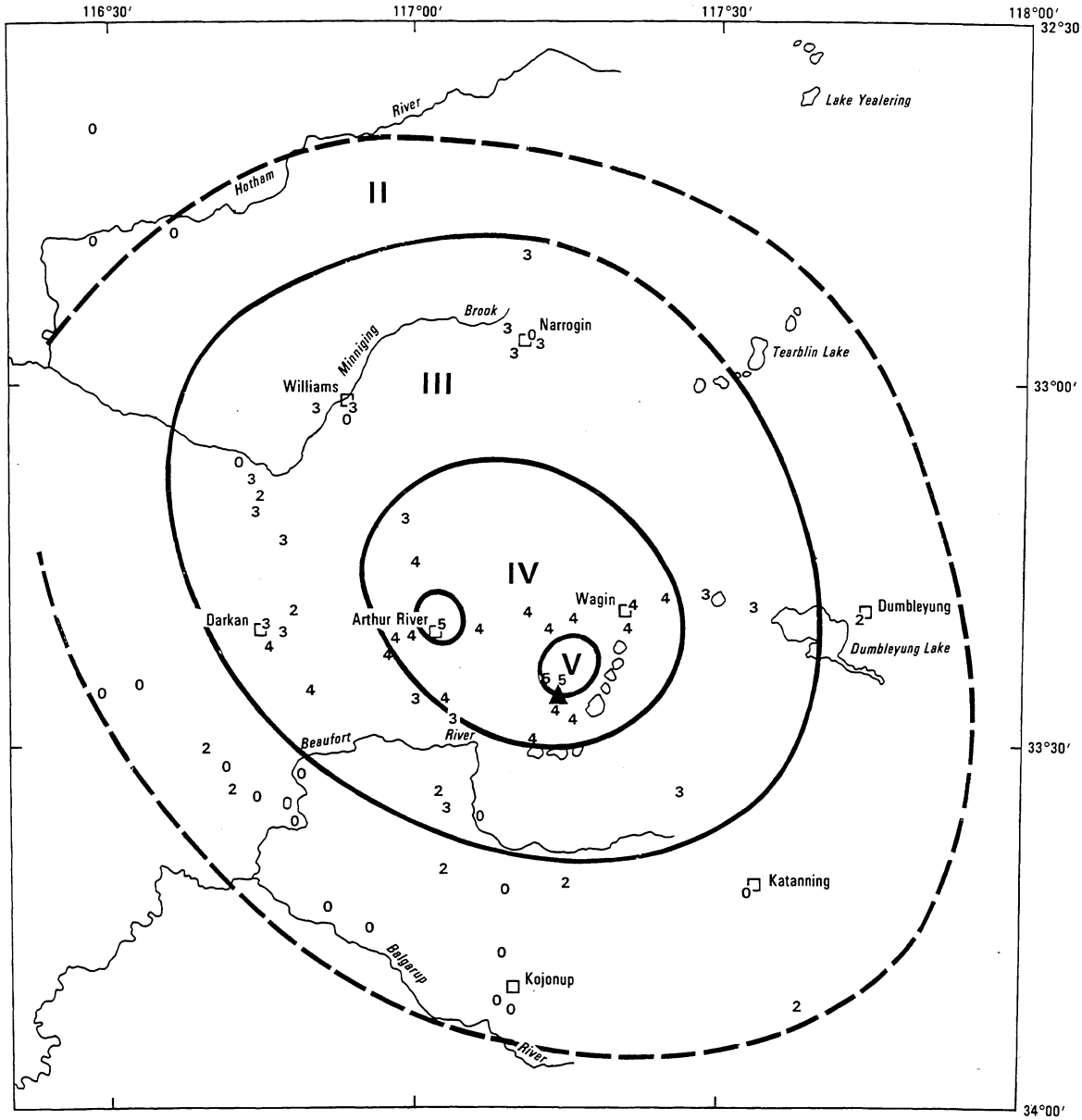
Isoseismal map of the Arthur River earthquake
Western Australia - 17 May 1986

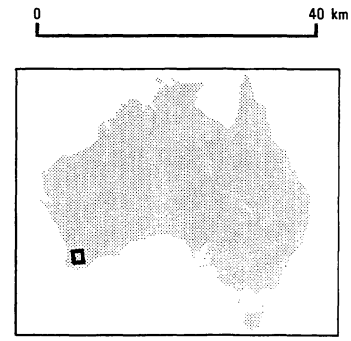
This magnitude ML 4.2 earthquake at 8:41 pm WST was centred near Wagin and Arthur River at the southern end of the South West Seismic Zone. Questionnaires were distributed from the BMR's Mundaring Observatory and a BMR seismologist then visited the area to make personal interviews resulting in a well constrained map.

Many people reported that a significant noise accompanied the tremor, many hearing but not feeling the shake. It was likened to an explosion or thunderclap close to the epicentre, and like a truck or roar from a chimney at distances to 70 km from the epicentre.

Contributors: This map was compiled by Peter Gregson.

ISOSEISMAL MAP OF THE ARTHUR RIVER EARTHQUAKE, WESTERN AUSTRALIA, 17 MAY 1986





DATE : 17 MAY 1986
TIME : 12:41:28.5 UT
MAGNITUDE : 4.2 ML (MUN)
EPICENTRE : 33.43°S 117.24°E

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

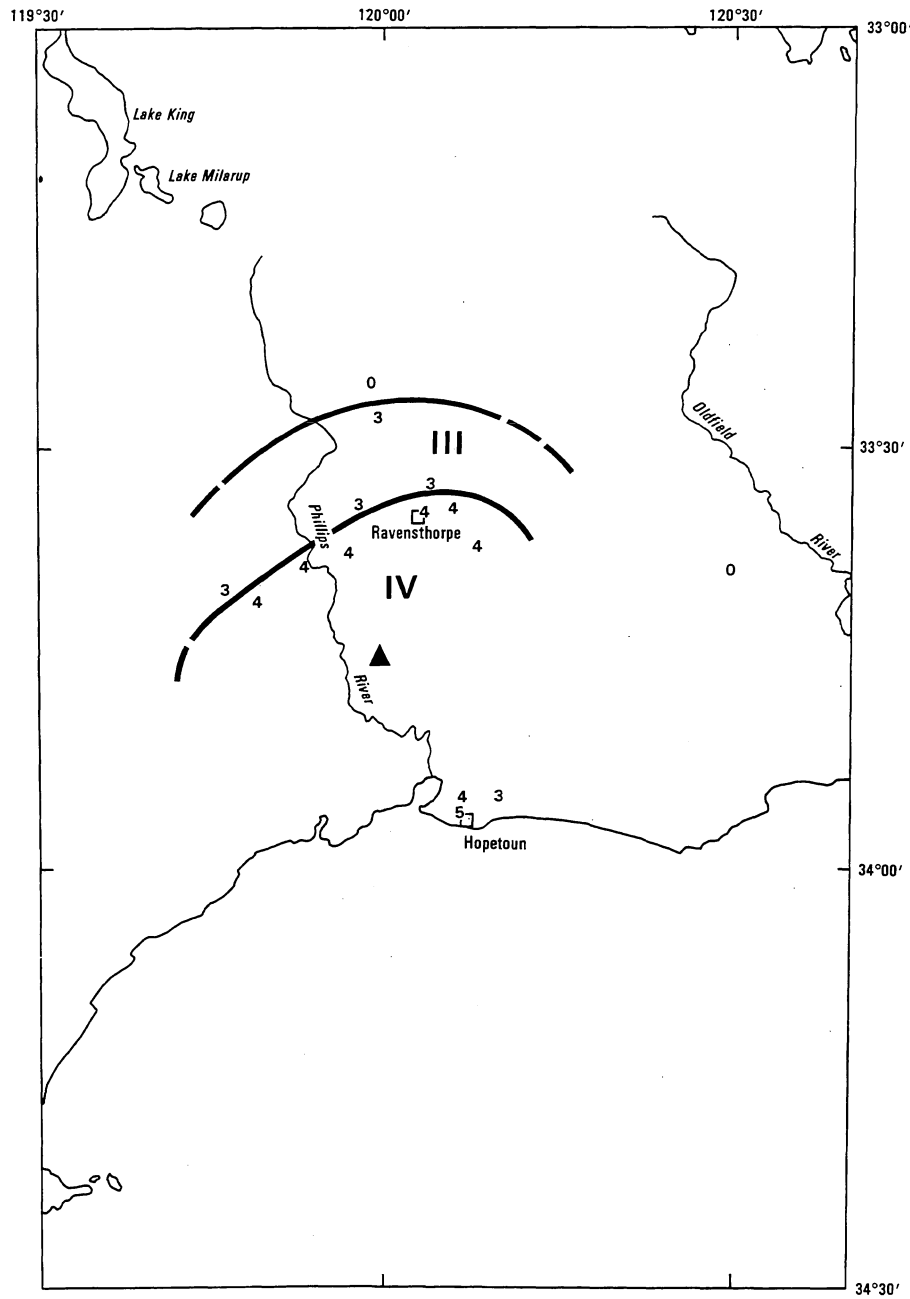
Isoseismal map of the Ravensthorpe earthquake
Western Australia - 17 May 1986

This was the second earthquake of the day. BMR's Mundaring WA office distributed questionnaires through the local high school because of the sparseness of the population. The maximum intensity uncovered was MM V but there are few residents in the epicentral region.

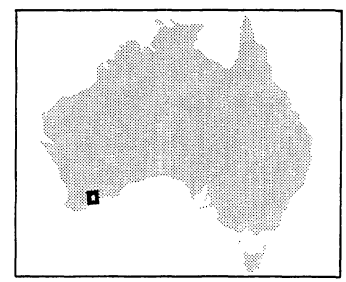
One of the interesting aspects of this earthquake is its proximity to a 35 km long Recent fault scarp discovered and mapped by geologists from the Geological Survey of Western Australia.

Contributors: This map was compiled by Peter Gregson.

ISOSEISMAL MAP OF THE RAVENSTHORPE EARTHQUAKE, WESTERN AUSTRALIA, 17 MAY 1986



0 40 km



DATE : 17 MAY 1986
TIME : 14:57:44.3 UT
MAGNITUDE : 3.4 ML (MUN)
EPICENTRE : 33.75°S 119.93°E

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

24/151/1

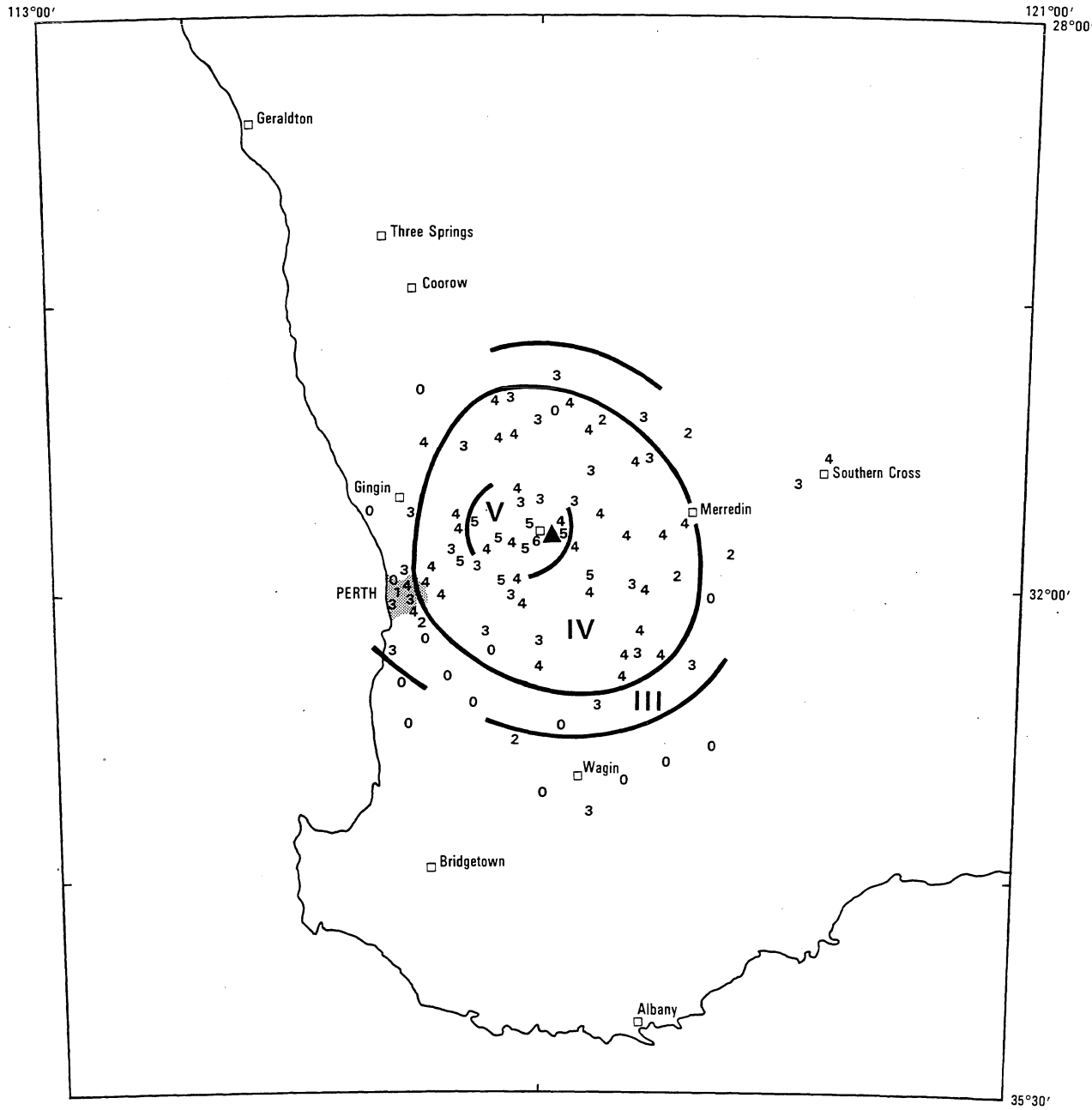
Isoseismal map of the Meckering earthquake
Western Australia - 1 September 1986

This epicentre of this earthquake at 9:54 pm was only 5 km east-southeast of Meckering and shook Meckering more strongly than any earthquake since that of 29 October 1968, an aftershock of the magnitude Ms 6.8 earthquake on 14 October 1968.

Many residents of Meckering were frightened by this earthquake, recalling the horror of October 1968. Reports in Perth varied from not felt to intensity MM IV, the same intensity observed on the western edge of the Yilgarn block closest to Perth.

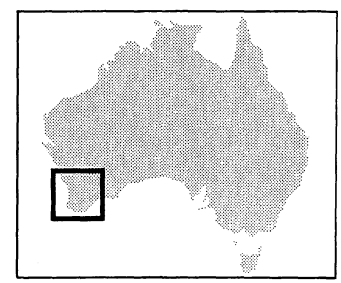
Contributors: This map was compiled by Peter Gregson.

ISOSEISMAL MAP OF A MECKERING EARTHQUAKE, WESTERN AUSTRALIA, 1 SEPTEMBER 1986



DATE : *1 September 1986*
TIME : *135349.7 UT*
MAGNITUDE : *4.1 ML (MUN)*
EPICENTRE : *31.63°S, 117.06°E*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



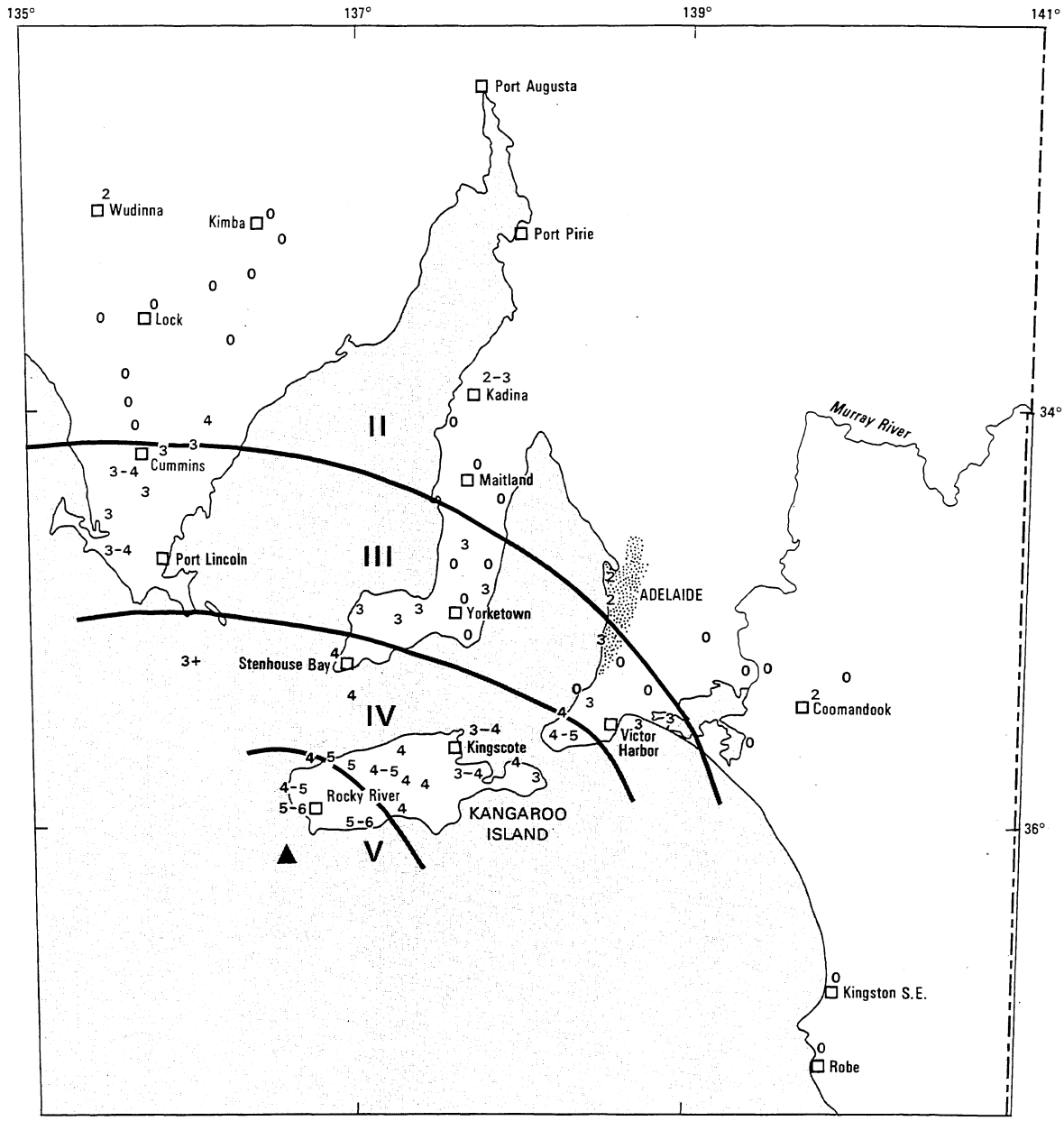
24/H50/22

Isoseismal map of the Kangaroo Island earthquake
South Australia - 16 December 1986

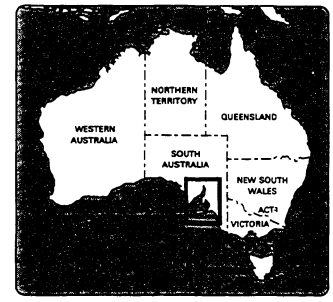
The computed epicentre of this earthquake at 3 pm local time was out to sea some 30 km southwest of Cape De Couedic, Kangaroo Island. A group of tourists in the Kelly Hill caves made a hasty exit after feeling the shaking for nearly 15 seconds. No damage was apparent in the caves or at the surface. The earthquake was felt on the Fleurieu, York and Eyre Peninsulas and a few people in Adelaide reported that they felt the earthquake.

Contributors: This map was compiled by David Love from the Sutton Institute, South Australian Department of Mines and Energy.

ISOSEISMAL MAP OF THE KANGAROO ISLAND EARTHQUAKE, SOUTH AUSTRALIA, 16 DECEMBER 1986



0 150 km



DATE : *16 December 1986*
TIME : *04:24:48.7UT*
MAGNITUDE : *3.6MD(ADE) 4.6ML(BMR)*
EPICENTRE : *36.12°S,136.58°E*
DEPTH : *8km*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*

Isoseismal map of the Tennant Creek earthquake
Northern Territory - 7 January 1987

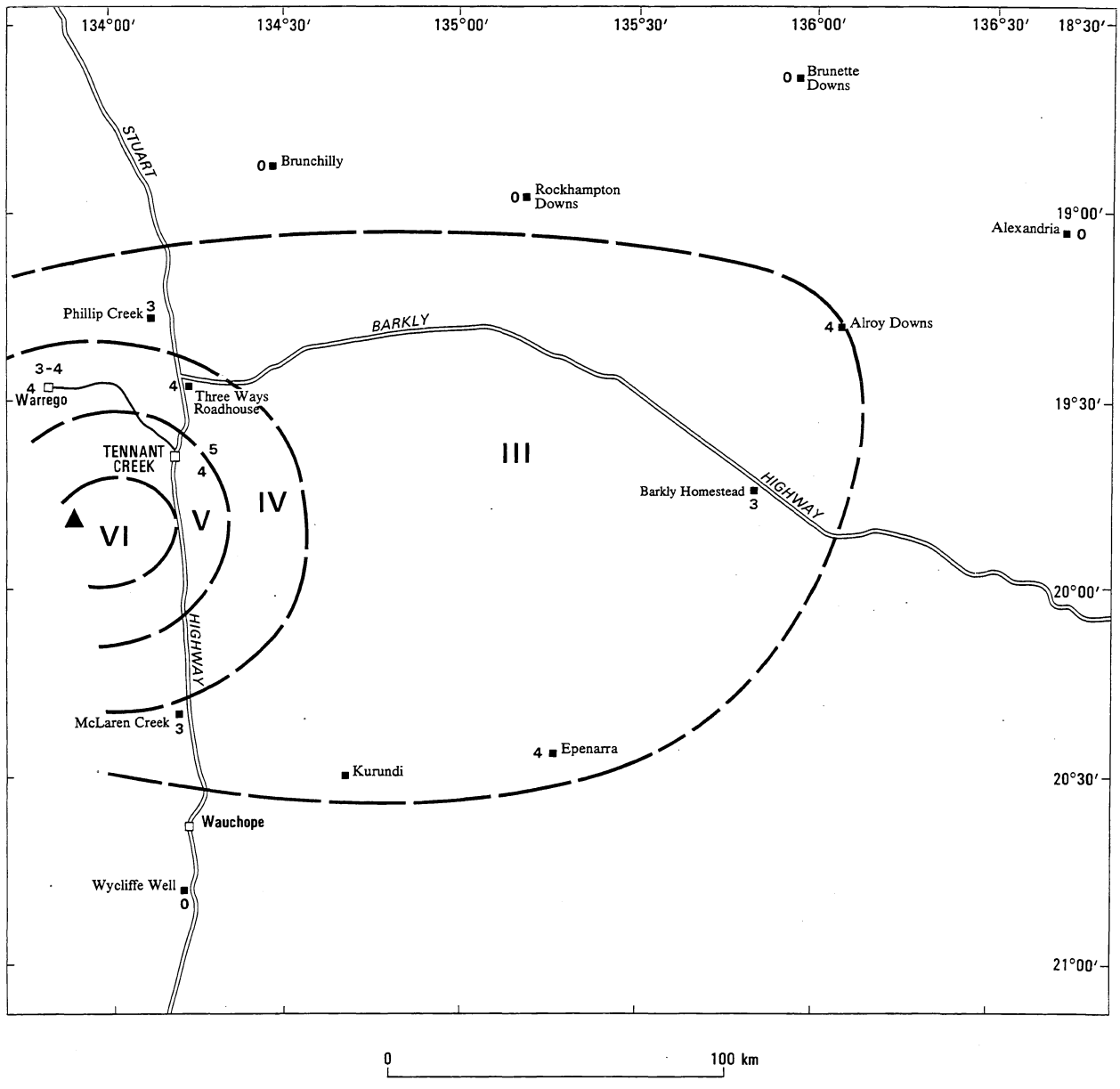
The earthquake on January 7, UTC (January 8, 5:32 am local time) was the largest of a series that commenced on January 5 and continued intermittently through the year. Many of these small earthquakes were felt in Tennant Creek, about 35 km from the epicentres. The fact that even 8 days after the main earthquake, *The Tennant and District Times* could devote most of its front page to a story headed: `EARTHQUAKE ROCKS TENNANT', says something of the social impact of the earthquakes on this central Australian town. The story continued:

> `Tennant Creek residents were stunned by earth tremors during last week, the first tremors were felt at 11.35 pm and 11.39 pm Monday January 5th. The second and strongest tremor of the two was described by many residents as sounding like a road train thundering by. Windows and crockery rattled as people felt the earth and floors move. This earthquake was also felt at Three Ways Roadhouse, 20 km north of Tennant Creek.....
>
> On Wednesday 7th at 9.48 am a small tremor was felt. A futher two tremors were registered on Thursday 8th, the largest being at 5.32 am which recorded at 5.6 on the Richter scale...This activity is the first of its kind in the district in recent times. Tennant Creek was previously regarded as a stable seismic area.
>
> Approximately 80 years ago, it is said that an earthquake in the Tanami desert caused a rift in the earth half a metre wide by two km. long.. Mr Trevor Jones from the Australian Seismological Centre in the Bureau of Mineral Resources is presently in Tennant Creek investigating the earthquakes. 'Even though the number of earthquakes per day is reducing, it is still possible that a large earthquake could occur', said Mr Jones.'

Prophetic words given what happened 12 months later (Jones & others, 1992).

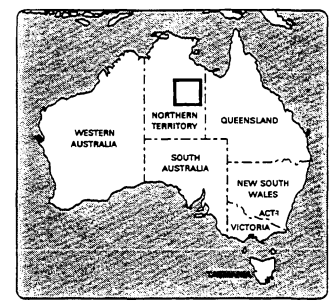
Contributors: An early version of this map was compiled by Trevor Jones and Jerry Vahalla, spot intensities were added in this final version by Kevin McCue.

ISOSEISMAL MAP OF THE TENNANT CREEK, NORTHERN TERRITORY, EARTHQUAKE, 7 JANUARY 1987



DATE : *7 January 1987*
TIME : *20:01:51 UTC*
MAGNITUDE : *5.4 ML (BMR)*
EPICENTRE : *19,8°S, 133,9°E*
DEPTH : *Shallow*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/E53-14/2

Isoseismal map of the Cadoux earthquake
Western Australia - 7 March 1987

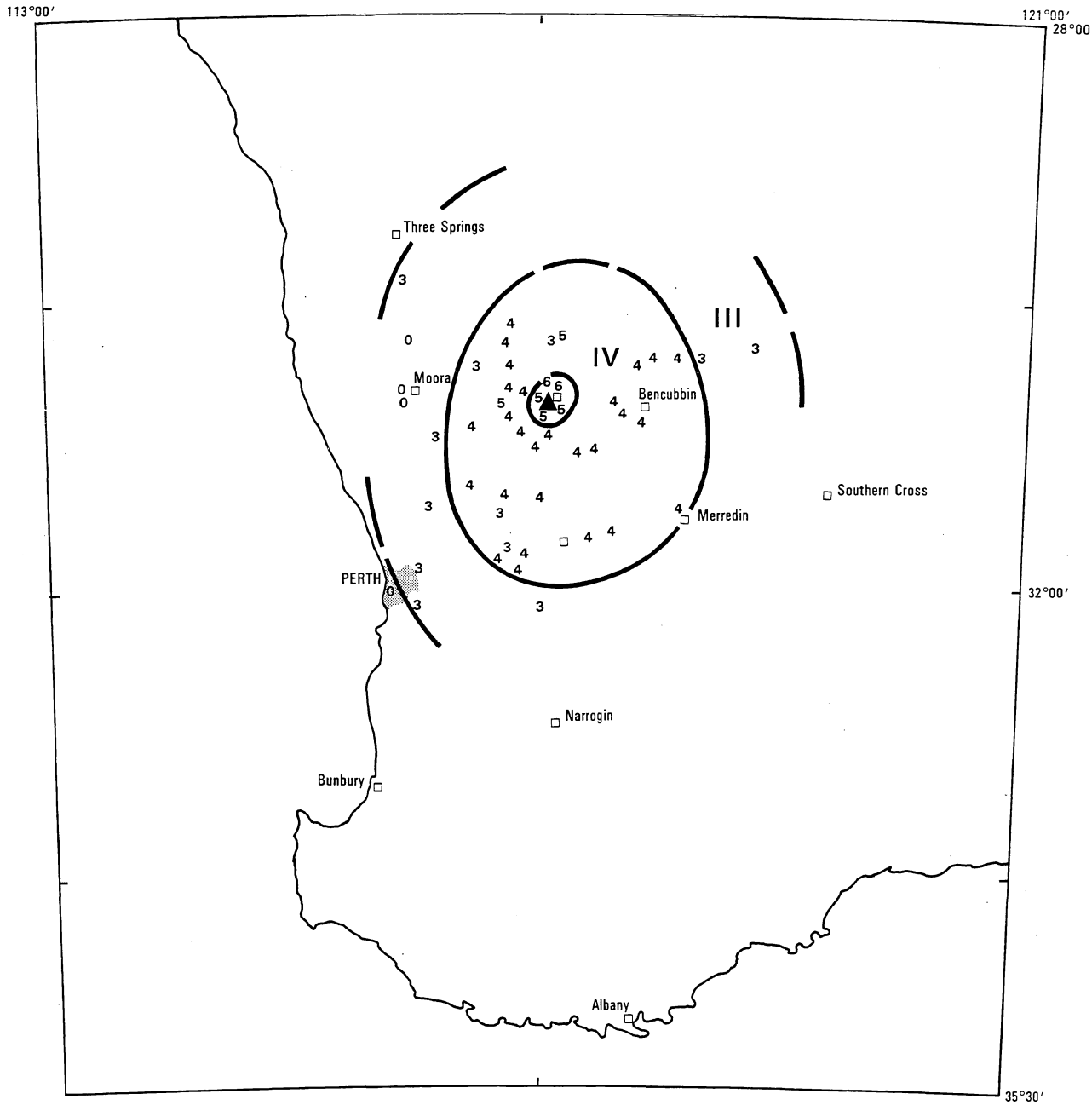
At 1:38 pm WST another magnitude 4.5 earthquake struck the Cadoux area. The computed epicentre was 4 km west-southwest of Cadoux which is 170 km northeast of Perth. The earthquake was felt in Perth's eastern suburbs but not in the CBD. In Cadoux the intensity was MM VI and nearby, ground cracks up to 2 mm wide could be seen on the Robb fault which was one segment of the surface faults formed during the 1979 magnitude Ms 6.0 earthquake.

This map is similar to that of the Cadoux earthquake of 10 October 1985 which had a magnitude of 4.3.

A digital accelerograph just 2 km from the fault trace recorded a peak ground acceleration of 3.0 ms^{-2}.

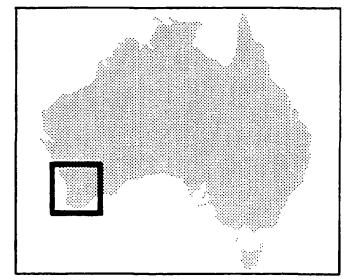
Contributors: This map was compiled by Peter Gregson.

ISOSEISMAL MAP OF A CADOUX EARTHQUAKE, WESTERN AUSTRALIA
7 MARCH 1987



DATE : *7 March 1987*
TIME : *053807.7 UT*
MAGNITUDE : *4.5 ML (MUN)*
EPICENTRE : *30.77°S, 117.09°E*
DEPTH : *5 km*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/H50/21

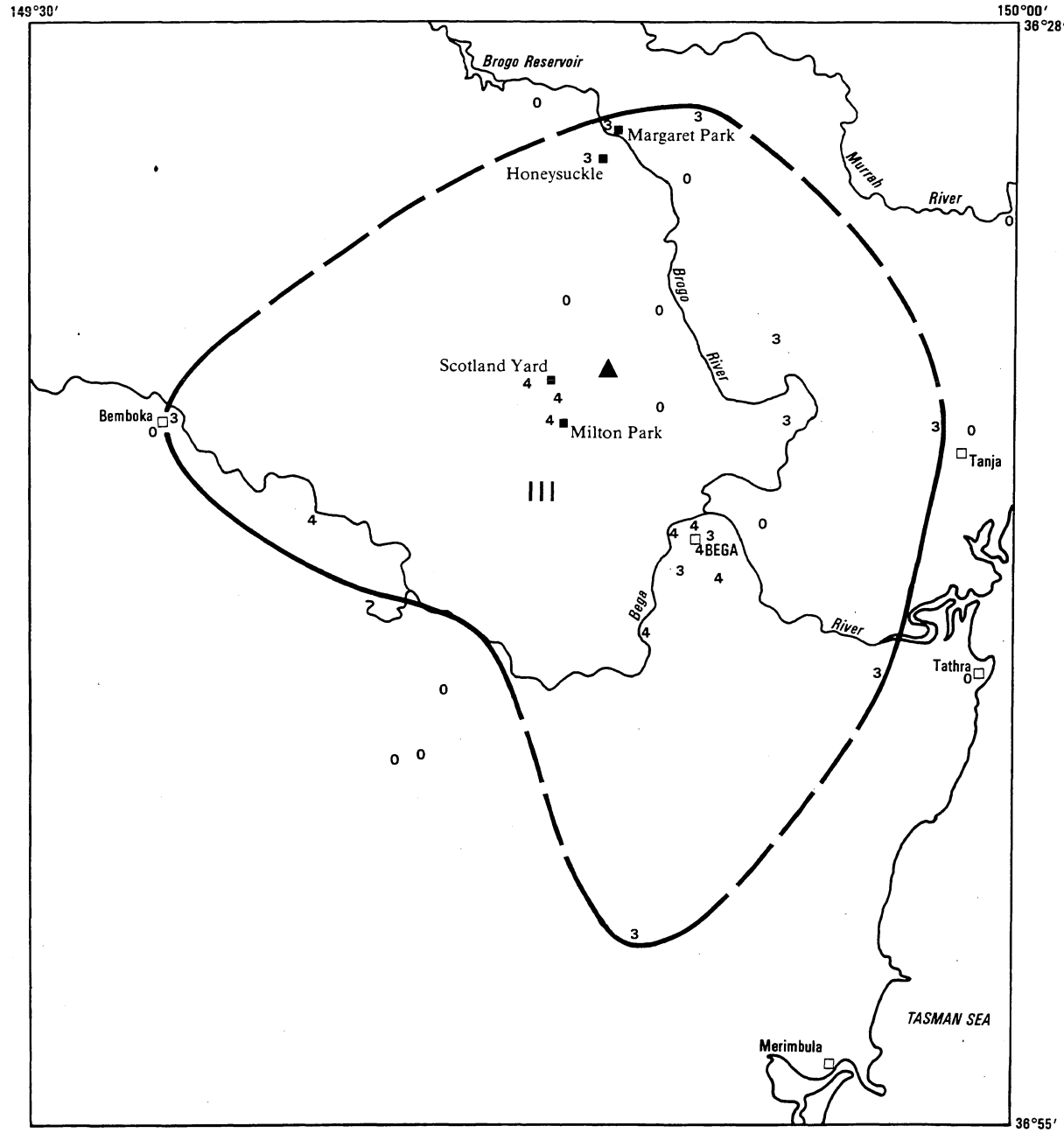
Isoseismal map of the Bega earthquake
New South Wales - 13 June 1987

This small earthquake near Bega at 2:34 pm was investigated via a telephone survey. Some health workers in the Bega hospital did not feel the earthquake yet other town residents reported the crockery rattling and their houses shaking. The maximum intensity was assessed as MM IV.

In the east at Tanja, a seated observer inside reported that she would probably not have felt the shaking had she been outside. To the north, people outside at the time heard an explosion and saw all the birds take off in alarm but they felt no shaking. To the northwest and near the computed epicentre, property owners at Scotland Yard and Milton Park reported feeling a jolt which vibrated their houses and they also reported hearing a sound like an explosion.

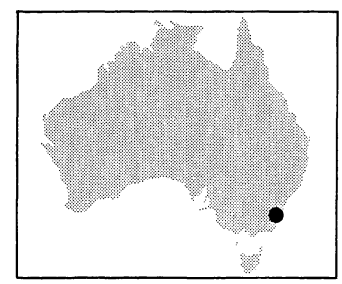
Contributors: This map was compiled by Dr David Denham.

ISOSEISMAL MAP OF THE BEGA EARTHQUAKE, NEW SOUTH WALES, 13 JUNE 1987



DATE : 13 JUNE 1987
TIME : 04:34 UT
MAGNITUDE : 2.6 ML
EPICENTRE : 36.61°S 149.80°E
DEPTH : Crustal

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/J55-4/1

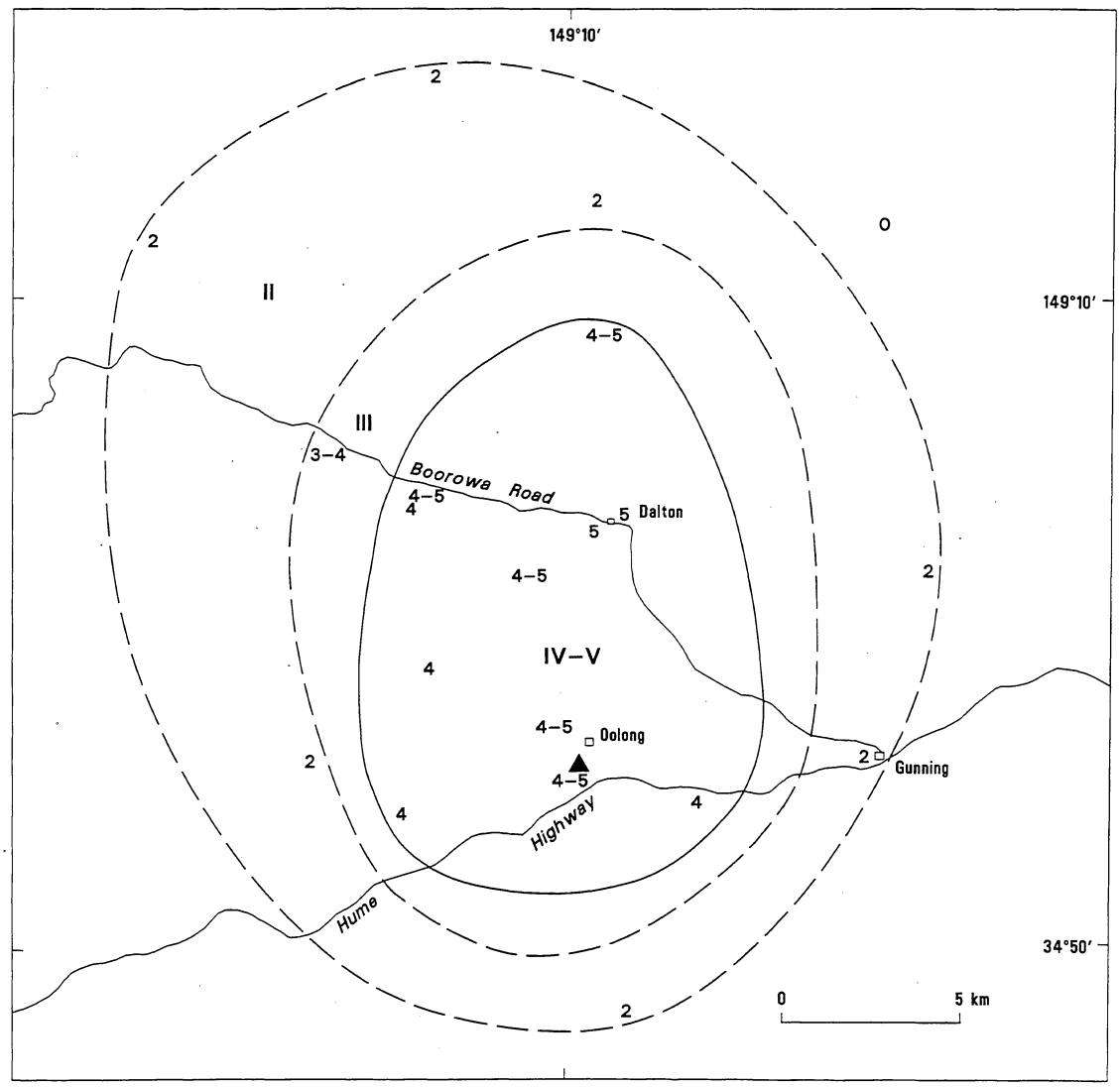
Isoseismal map of the Oolong earthquake
New South Wales - 16 June 1987

This small earthquake occurred at 11:26 pm EST and was sharp enough to wake people at Dalton but not surprisingly caused no damage. The isoseismal map was compiled from personal and telephone interviews. Where the earthquake was heard and not felt the intensity assigned was MM II.

There were 8 foreshocks in the preceding 7 hours and 13 aftershocks in the 11 hours following this earthquake.

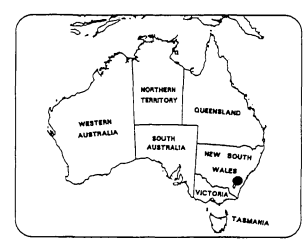
Contributors: This map was compiled by Dr Michael-Leiba, and the late Vicki Klein of Ups and Downs, Dalton.

ISOSEISMAL MAP OF THE OOLONG EARTHQUAKE, NSW, 16 JUNE 1987



DATE: 16 June 1987
TIME: 13:26:40.6 UTC
MAGNITUDE: 2.9 MD (BMR)
EPICENTRE: 34.79°S 149.17°E
DEPTH: 0 km

▲ *Epicentre*
IV *Zone intensity designation (MM)*
4 *Earthquake felt (MM)*
0 *Earthquake not felt*



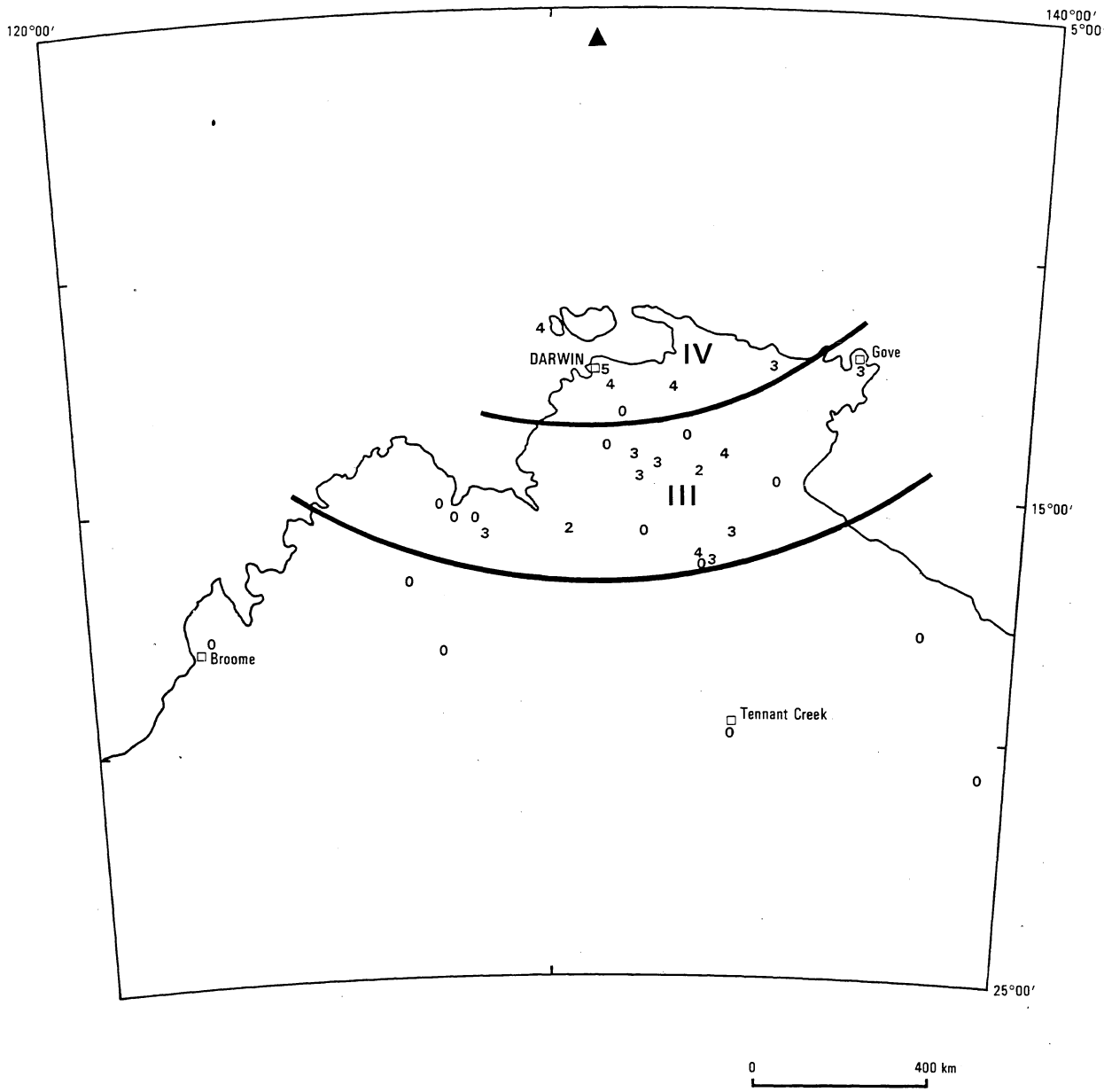
24/155/26

Isoseismal map of the Banda Sea earthquake Indonesia - 17 June 1987

No damage was reported in Darwin during this earthquake in the Banda Sea which was 740 km to the north of the city and at a depth of 84 km. Reports were returned from Gove and Katherine that the earthquake was felt, but the most surprising were those from Brisbane where a gentle swaying was observed by people on the second floor of buildings.

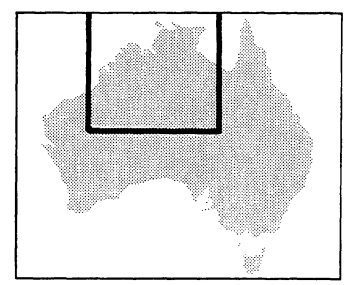
Contributors: This map was compiled by Peter Gregson.

ISOSEISMAL MAP OF THE BANDA SEA EARTHQUAKE, 17 JUNE 1987



DATE : *17 June 1987*
TIME : *013255.6 UT*
MAGNITUDE : *6.7 MB*
EPICENTRE : *5.583°S, 130.882°E*
DEPTH : *84 km*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



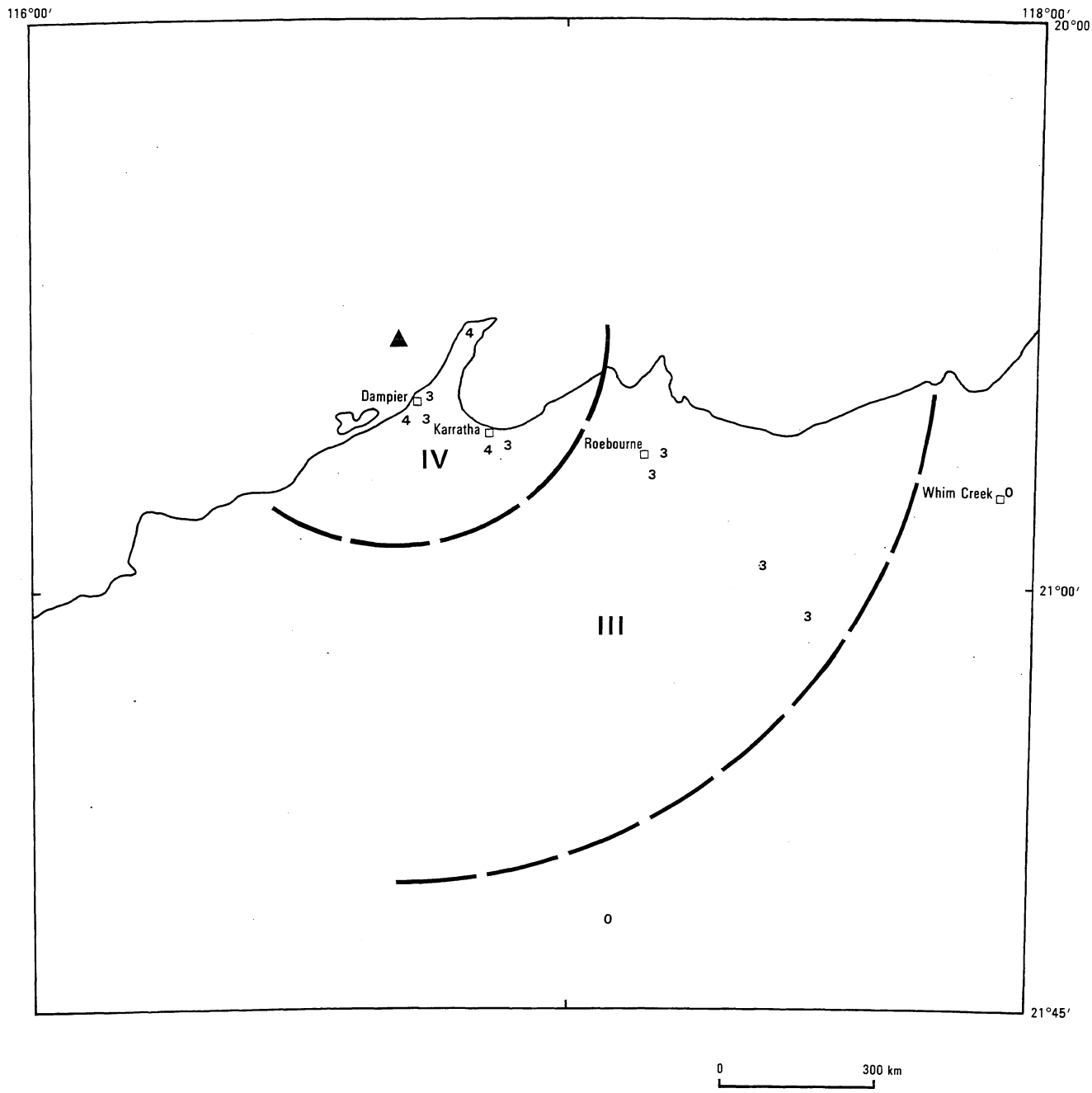
24/OA/5

Isoseismal Map of the Dampier earthquake Western Australia - 19 June 1987

This small earthquake occurred at 9:32 pm WST. The maximum intensity experienced was MM IV at Dampier and Karratha, 10 and 25 km from the epicentre. It was felt as far as 100 km from the epicentre. The region is sparsely populated and therefore isoseismals are sketchy.

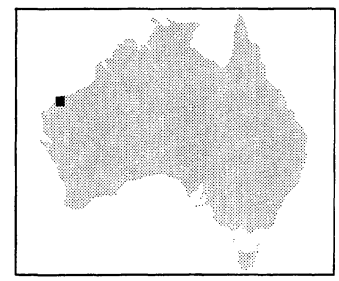
Contributors: This map was compiled by Peter Gregson.

ISOSEISMAL MAP OF THE DAMPIER EARTHQUAKE, WESTERN AUSTRALIA
19 JUNE 1987



DATE : *19 June 1987*
TIME : *133203.0 UT*
MAGNITUDE : *3.7 ML (MUN)*
EPICENTRE : *20.56°S, 116.69°E*
DEPTH : *5km*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/F50/3

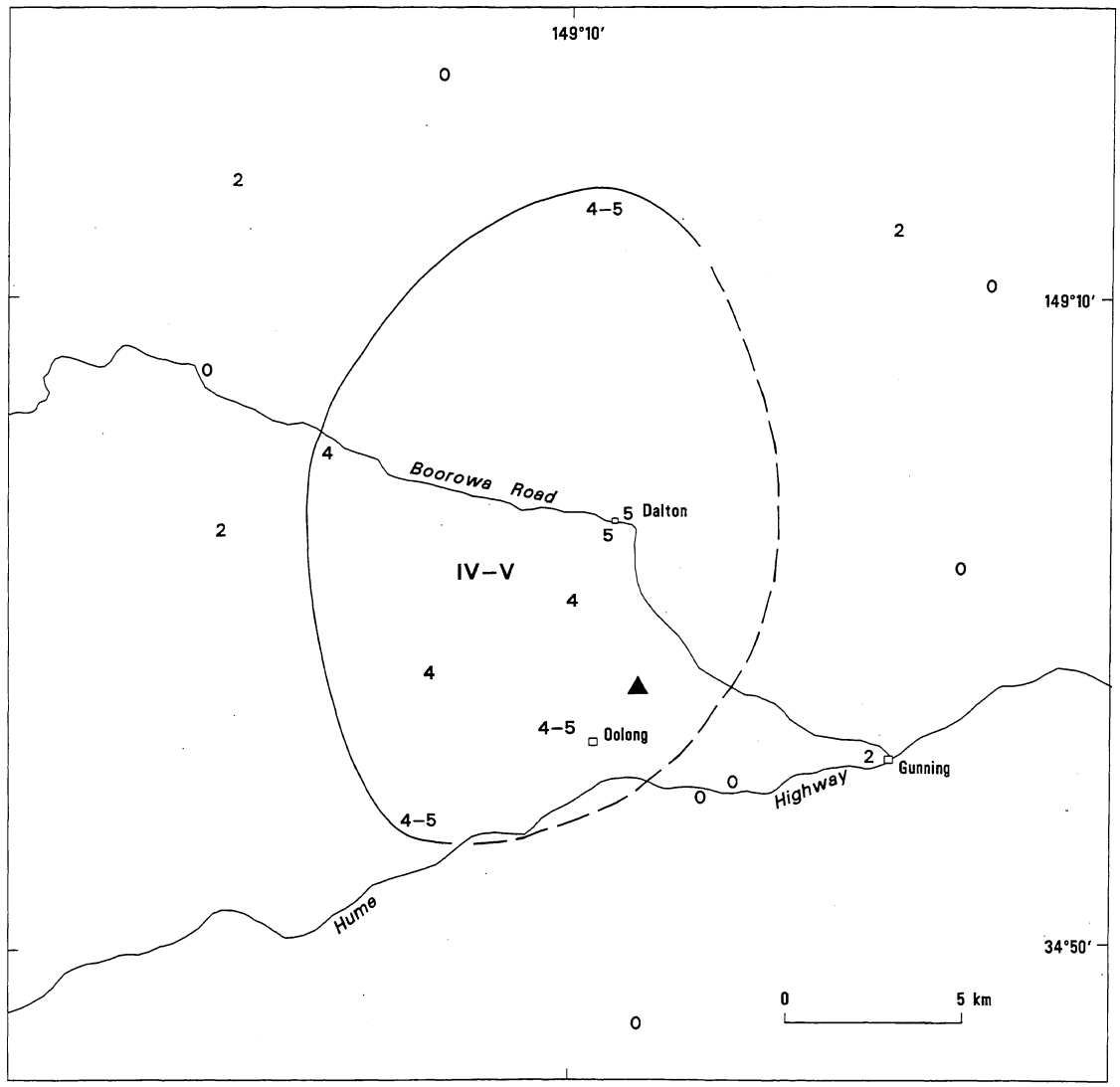
Isoseismal map of the Oolong earthquake New South Wales - 20 June 1987

This magnitude ML 3.0 earthquake occurred at 6:23 pm EST. Like the earlier event on the 16 June, the felt reports were collected by phone and personal interviews.

A digital accelerograph recorded a peak ground acceleration of 0.94 ms^{-2} at an epicentral distance of 3 km.

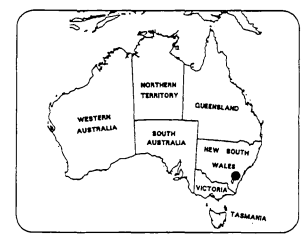
Contributors: This map was compiled by Dr Michael-Leiba and the late Vicki Klein of Ups and Downs, Dalton.

ISOSEISMAL MAP OF THE OOLONG EARTHQUAKE, NSW, 20 JUNE 1987



DATE:	20 June 1987
TIME:	08:23:25.6 UTC
MAGNITUDE:	3.0 MD (BMR)
EPICENTRE:	34.76°S 149.19°E
DEPTH:	2 km

▲	*Epicentre*
IV	*Zone intensity designation (MM)*
4	*Earthquake felt (MM)*
0	*Earthquake not felt*



24/155/27

Isoseismal map of the Lithgow earthquake
New South Wales - 24 June 1987

The 'Daily Mirror' front page story of June 25, 1987 was headlined `MIDNIGHT QUAKE - SYDNEY HOMES SHAKE' and there followed this account:

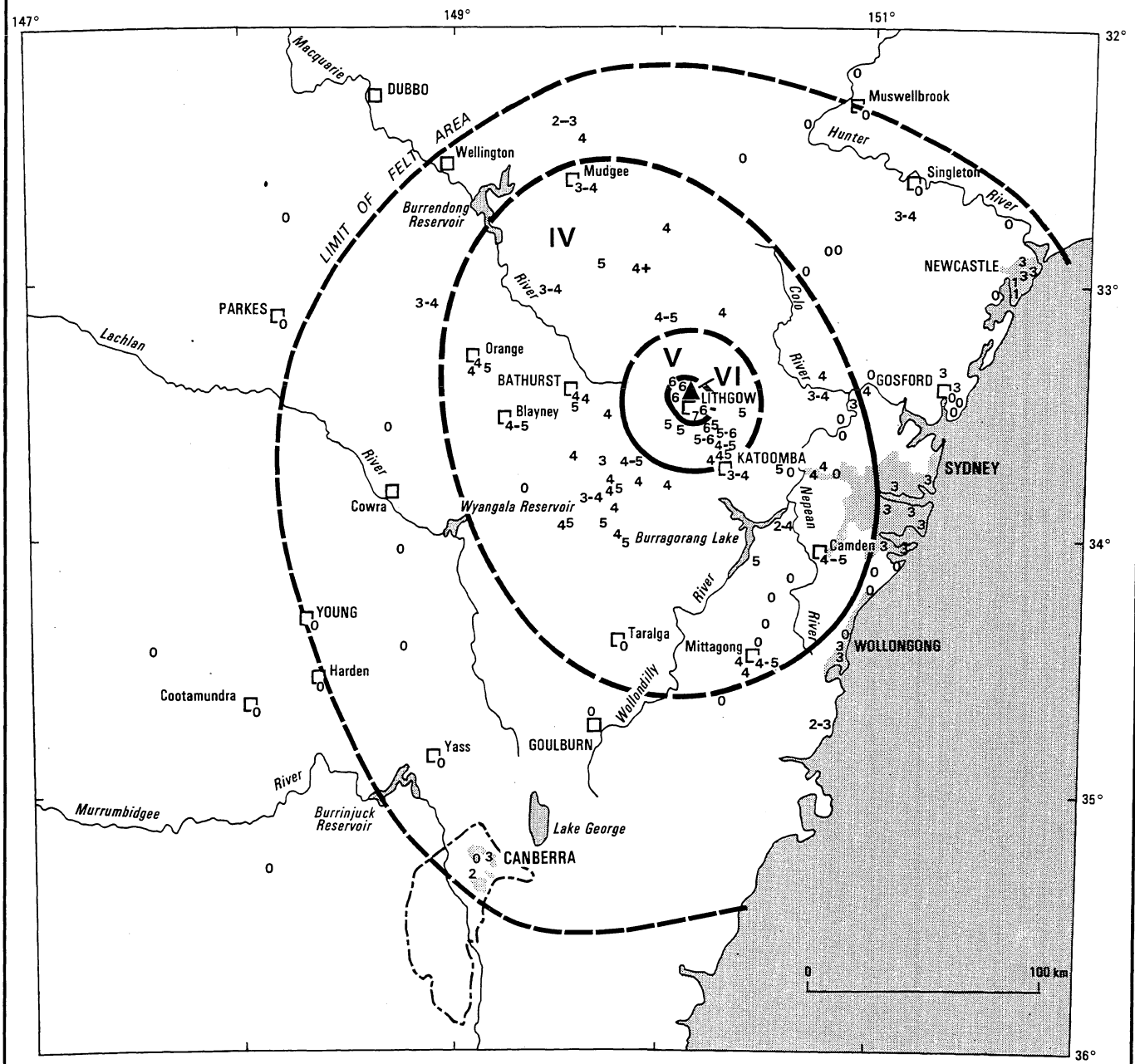
> An earthquake rocked Sydney and eastern NSW early today shaking awake thousands of terrified residents. More than 20 suburbs were struck by at least two hard hit tremors. Police switchboards were jammed for hours with people reporting loud explosions, rumblings and shaking windows, walls and floorboards. No major damage was reported around Sydney but there have been many reports of cracks in roadways and driveways.

Most of the damage was confined to buildings in the epicentral region near Lithgow but no engineered structures were damaged. The Lithgow 'Mercury' printed two photographs of housimg damage in the northeast of the City; one where a brick chimney had collapsed through the roof and ceiling into a house in Macaulay Street and another where the chimney of a house in Montague Street toppled, throwing bricks through the windows of the family's sedan car parked in the driveway of their house.

The isoseismal map opposite is very different to that of the earthquake near Lithgow on 13 February 1985 published by Michael-Leiba and Denham (1987), who invoked anisotropy to explain the assymetry in the isoseismals. No such effect is apparent in the felt reports of this earthquake which is of a similar magnitude to the 1985 earthquake.

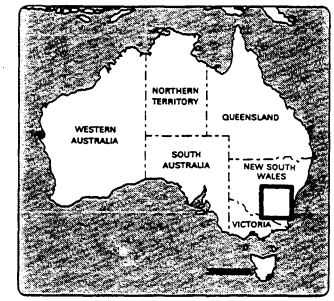
Contributors: This map was compiled by Trevor Jones, Kevin McCue and Jerry Vahala, AGSO.

ISOSEISMAL MAP OF THE LITHGOW EARTHQUAKE, NEW SOUTH WALES, 24 JUNE 1987



DATE : *24 June 1987*
TIME : *15:04:55.4 UT*
MAGNITUDE : *4.3 ML (BMR)*
EPICENTRE : *33.44°S, 150.15°E*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/N/26

Isoseismal map of the Oolong earthquake New South Wales - 26 June 1987

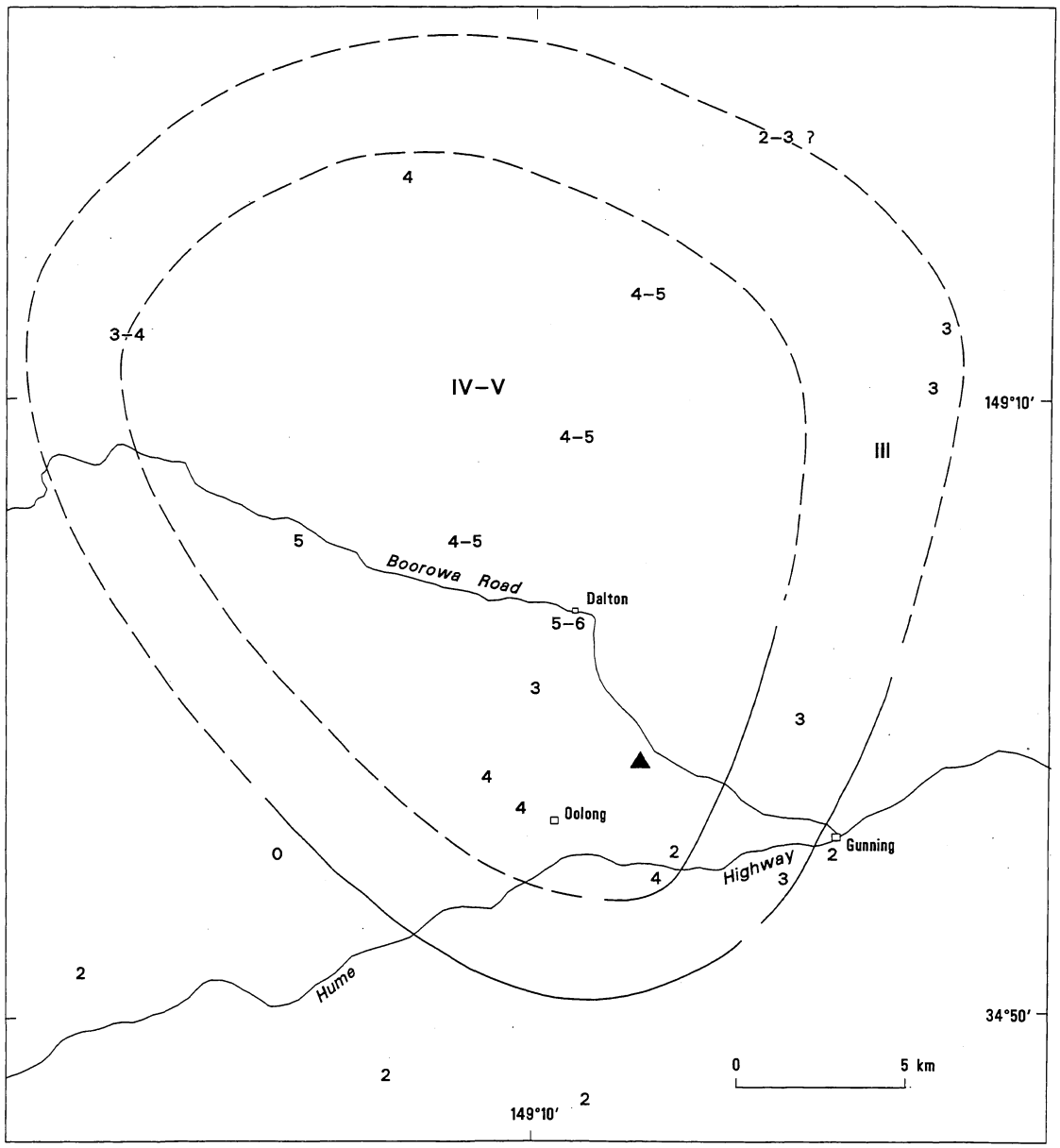
This magnitude ML 3.1 earthquake occurred at 9:28 am EST. At Dalton, everything rattled strongly enough that some objects fell off a shop shelf. It was the largest of the June swarm in the Dalton area and the largest there in 1987, and is close to the once-per-year earthquake. Like the earlier 2 events, the felt reports were collected by phone and personal interviews.

In the following 24 hours, there were 24 tiny aftershocks recorded on local seismographs.

Two digital accelerographs 4 km to the west and northwest recorded a peak ground acceleration of 1.0 ms^{-2} at an epicentral distance of 4 km.

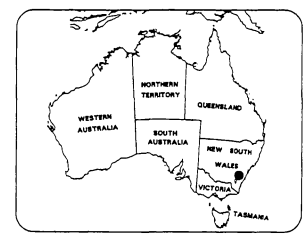
Contributors: This map was compiled by Peter Gregson.

ISOSEISMAL MAP OF THE OOLONG EARTHQUAKE, NSW, 26 JUNE 1987



DATE: 26 June 1987
TIME: 23:28:40.2 UTC
MAGNITUDE: 3.1 MD (BMR)
EPICENTRE: 34.76°S 149.20°E
DEPTH: 3 km

▲ *Epicentre*
IV *Zone intensity designation (MM)*
4 *Earthquake felt (MM)*
0 *Earthquake not felt*



24/155/28

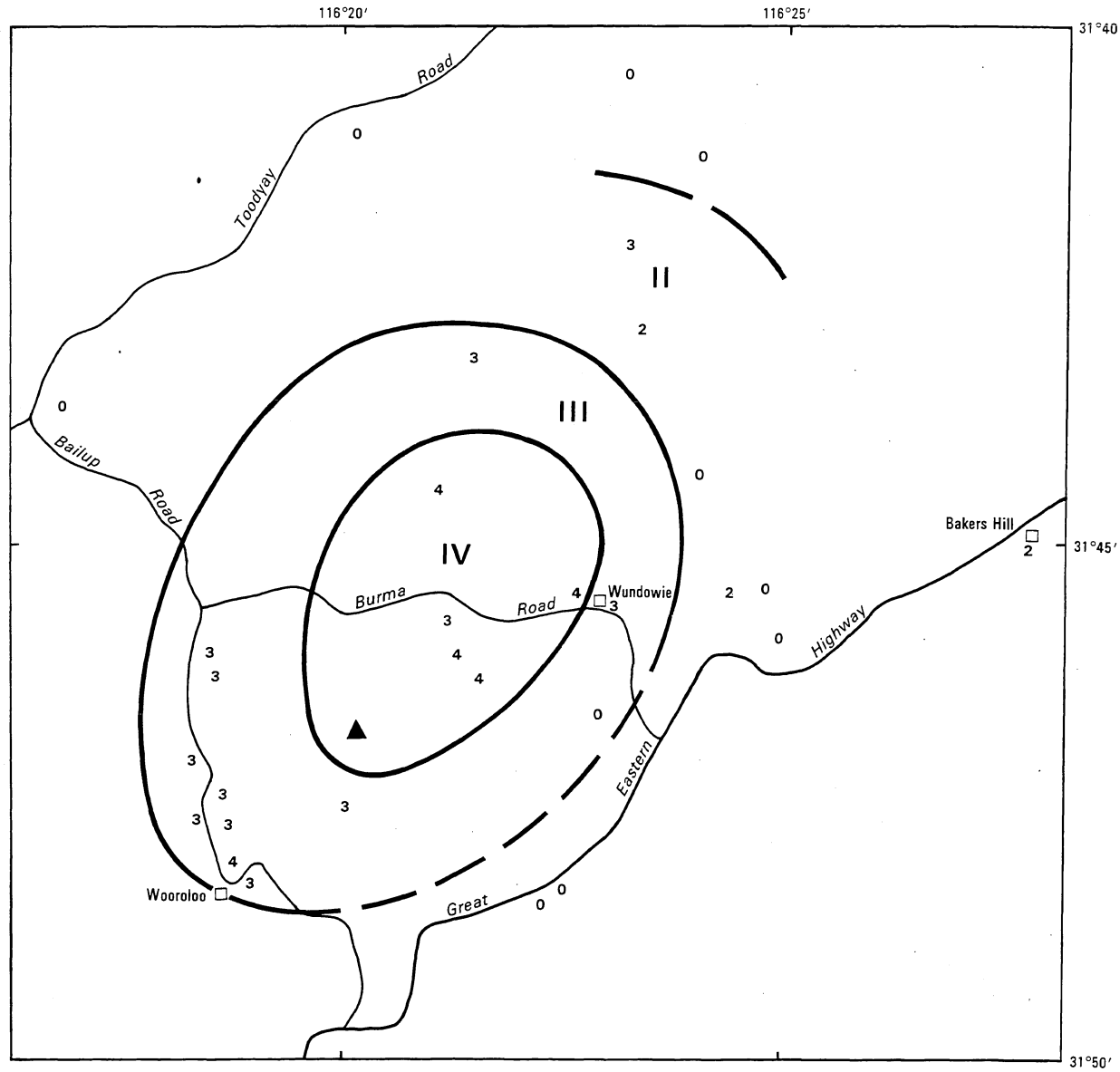
Isoseismal Map of the Wooroloo earthquake Western Australia - 5 July 1987

The earthquake at 1:28 pm WST was felt within 10 km of the epicentre with an isolated report from Bakers Hill, 13 km away.

Though small, the earthquake was interesting because its epicentre is the westernmost in this part of the Southwest Seismic Zone and the closest known to Perth, 40 km away and just 25 km from the Mundaring Observatory. Previously the closest earthquakes to Perth were near Talbot Brook and Clackline, 70 km to the east.

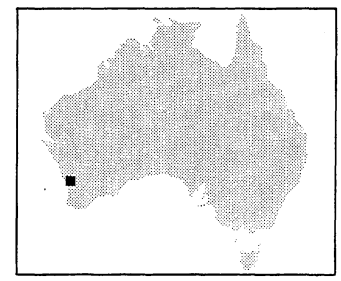
Contributors: This map was compiled by Peter Gregson.

ISOSEISMAL MAP OF THE WOOROLOO EARTHQUAKE, WESTERN AUSTRALIA 5 JULY 1987



DATE : *5 July 1987*
TIME : *052840.5 UT*
MAGNITUDE : *3.0 ML (MUN)*
EPICENTRE : *31.78°S, 116.34°E*
DEPTH : *5 km*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/H50-14/2

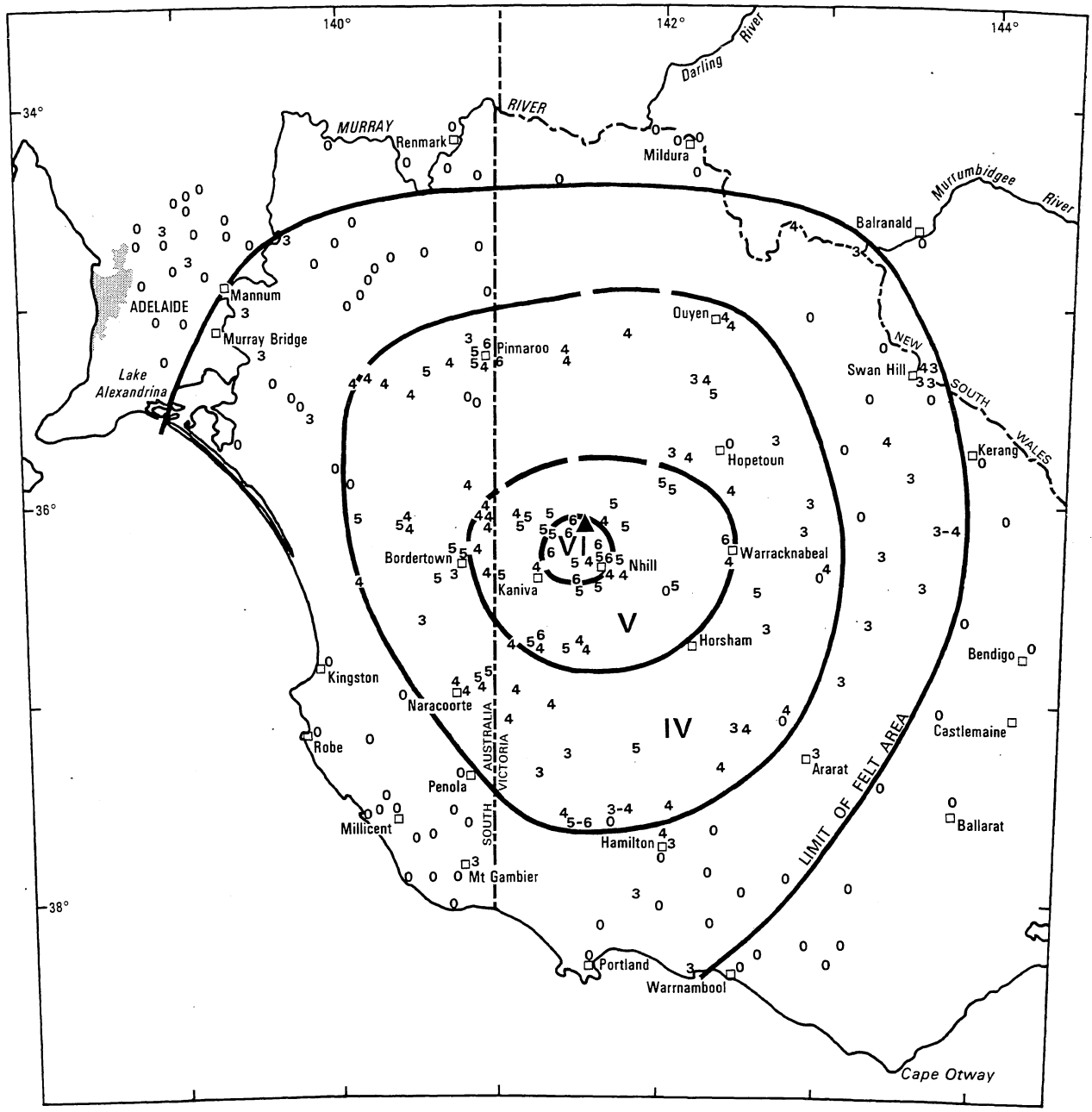
Isoseismal map of the Nhill earthquake
Victoria - 22 December 1987

There was no previous record of activity in 'The Little Desert' near Nhill in Western Victoria so this magnitude ML 4.9 earthquake at 1:06 am caused considerable alarm. Minor damage was reported in brick and mud-brick houses in the closest towns Yanac and Nhill and even as far afield as Bordertown in South Australia, 80 km from the epicentre. It was distinctly felt as far as Swan Hill to the north, Mt Gambier to the south and Murray Bridge to the northwest.

Several hundred questionnaires were distributed so the map is unusually well constrained.

Contributors: This map was compiled by Kevin McCue with questionnaires distributed by James Lewis, Trevor Jones and Mary Douch from AGSO, and interview reports from Gary Gibson, Seismology Research Centre. David Love from SADME also provided information on felt effects in South Australia.

ISOSEISMAL MAP OF THE NHILL EARTHQUAKE, VICTORIA, 22 DECEMBER 1987



DATE : *22 December 1987*
TIME : *15:06:30 UT*
MAGNITUDE : *4.9 ML*
EPICENTRE : *36.1°S, 141.5°E*
DEPTH : *6 (± 25) km*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*

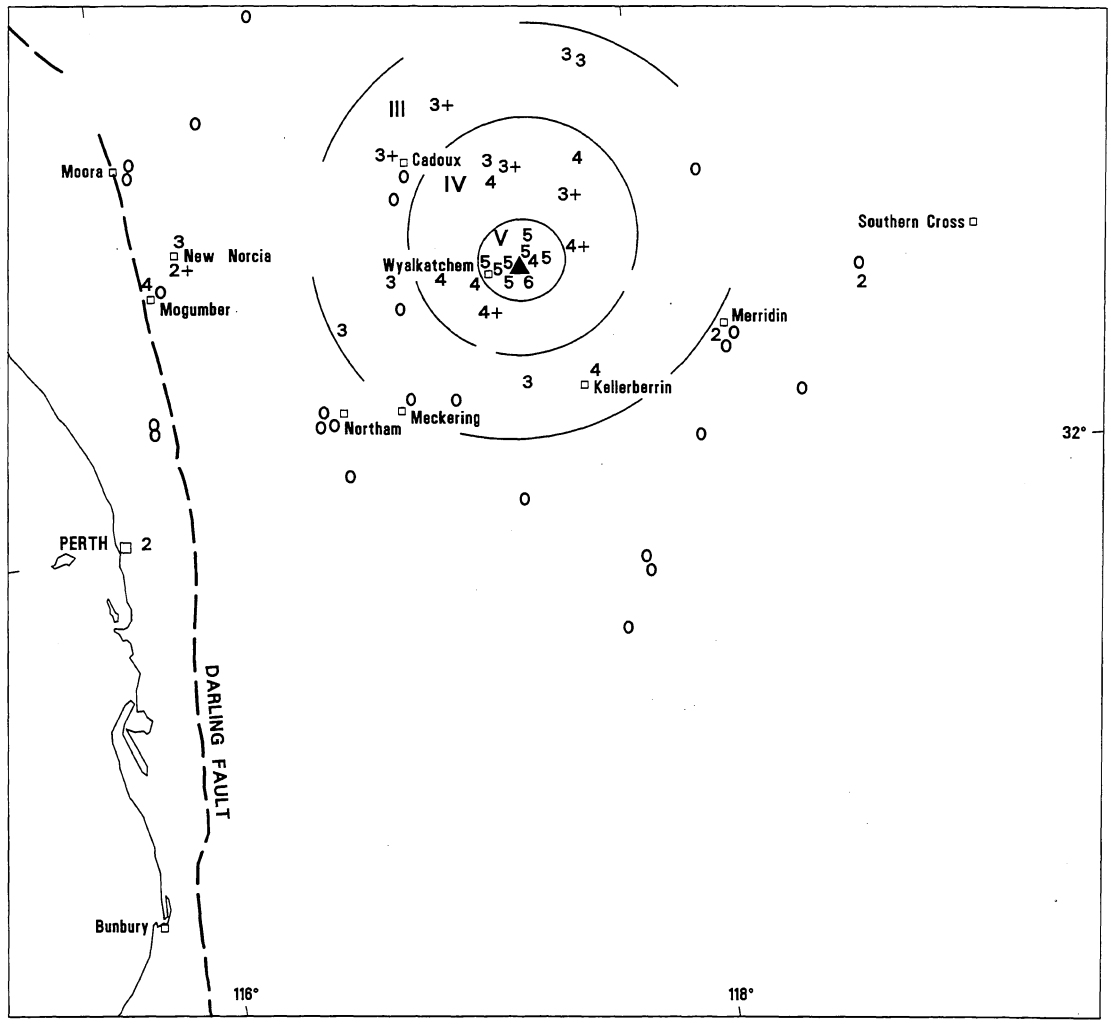
24/A/109

Isoseismal Map of the Wyalkatchem earthquake Western Australia - 6 January 1988

The wheatbelt town of Wyalkatchem (170 km northeast of Perth) was shaken by an earthquake of magnitude ML 4.3 at 11:42 local time (03:42 UTC) on 6 January. The isoseismal map was drawn from about 55 returned questionnaires, telephone calls, and a visit by Mundaring Observatory staff to the most affected area. A maximum intensity of MM VI was assigned on the basis of minor damage to a few brick farm houses. At one farm, a water trough set in concrete pads at ground level was broken in half, and the movement of a roof-mounted evaporative air conditioner caused breakage of some roof tiles. The earthquake was felt by a few people at Perth. A temporary seismograph was installed near Wyalkatchem for 6 weeks on 14 January and recorded 3 aftershocks above magnitude 2.0 (Dent, 1990).

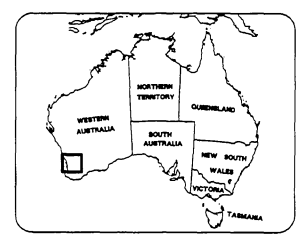
Contributors: This map was compiled by Peter Gregson.

ISOSEISMAL MAP OF A WYALKATCHEM EARTHQUAKE, WESTERN AUSTRALIA, 6 JANUARY 1988



DATE:	6 January 1988
TIME:	03:42:08 UTC
MAGNITUDE:	4.3 ML (MUN)
EPICENTRE:	31.2°S 117.5°E
DEPTH:	2 km

▲	*Epicentre*
IV	*Zone intensity designation*
4	*Earthquake felt (MM)*
0	*Earthquake not felt*



24/H50/25

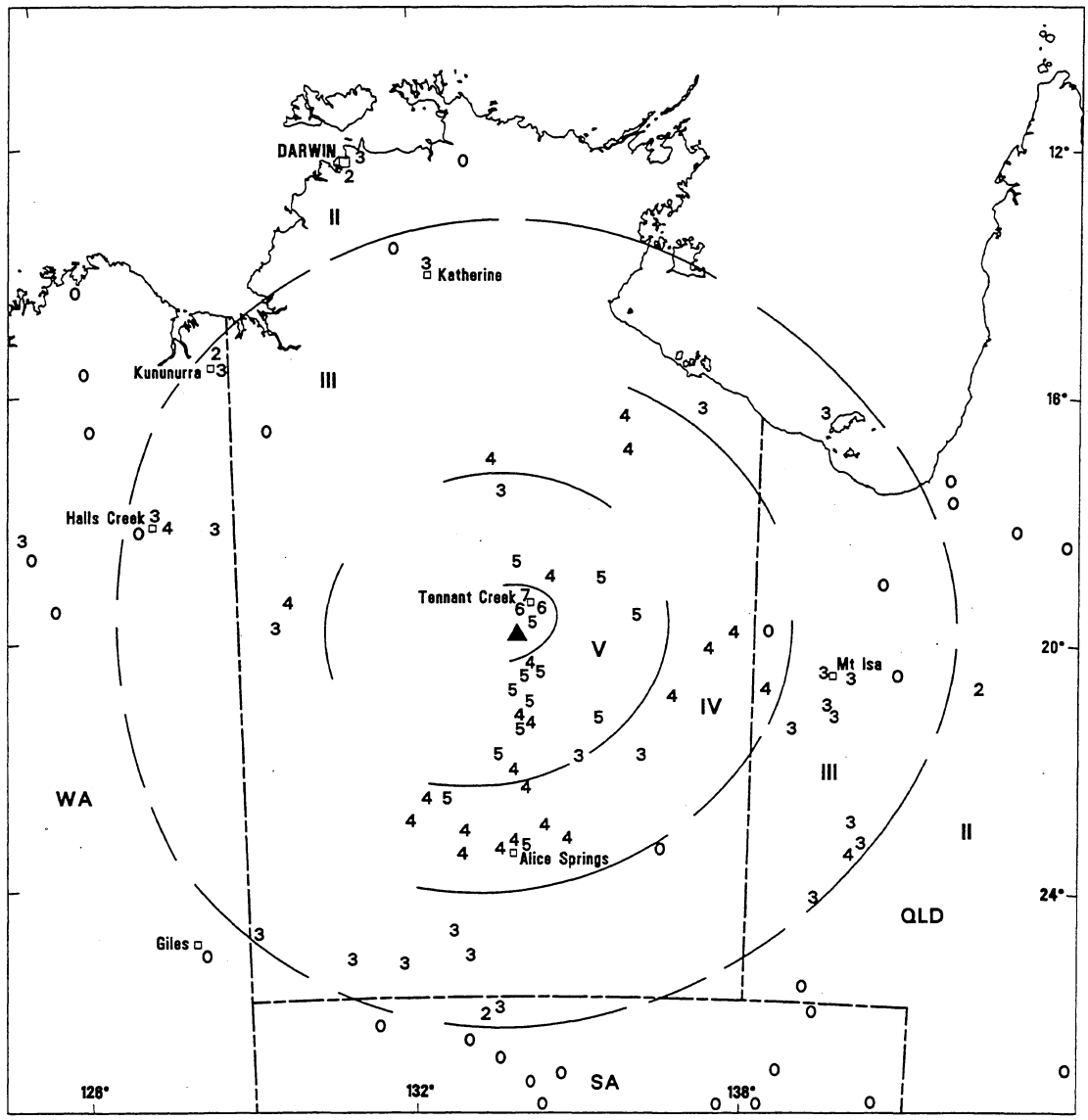
Isoseismal Map of the Tennant Creek earthquake Northern Territory - 22 January 1988

A year-long earthquake sequence which commenced on 5 January 1987 near Tennant Creek, NT had all but petered out when a large earthquake occurred at 00:36 UTC on 22 January 1988, about 40 km southwest of the township. Peace had hardly settled when another even larger earthquake shook the region at 03:57 UTC, causing minor damage (intensity MMVII) in Tennant Creek. Damage in the town was surprisingly small so close to such large earthquakes. After the first earthquake, the NTGAS company flew an inspection of the nearby buried natural gas pipeline supplying gas to Darwin from the Palm Springs field in Central Australia, but they found no ground surface disruption (Jones & others, 1991).

Isoseismal questionnaires were distributed that same day from the ASC and preparations made for a field trip by seismologists Trevor Jones (ASC), Gary Gibson and Tony Corke (PIT) and Roger Bowman (ANU). Jones, Gibson and Corke installed a set of 9 portable seismographs around the fault scarps in the first few days after the earthquakes and recorded hundreds of aftershocks.

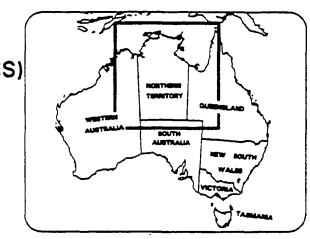
Contributors: This map was compiled by Peter Gregson with data solicited by Trevor Jones, Jerry Vahala and Mary Douch.

ISOSEISMAL MAP OF THE FIRST & SECOND TENNANT CREEK EARTHQUAKES, NORTHERN TERRITORY, 22 JANUARY 1988



DATE: 22 January 1988
TIME: 00:36 UTC & 03:57 UTC
MAGNITUDE: 6.3 MS (USGS) & 6.4 MS (USGS)
EPICENTRE: 19.88°S, 134.00°E & 19.85°S, 134.07°E

▲ *Epicentre*
IV *Zone intensity designation*
4 *Earthquake felt (MM)*
0 *Earthquake not felt*



24/A/103

Isoseismal Map of the third Tennant Creek earthquake
Northern Territory - 22 January 1988

The largest earthquake of the series, magnitude Ms 6.7, occurred at 12:05 UTC (10:35 pm local time the same day) and a second aerial inspection by NTGAS at first light discovered a surface ground rupture crossing the pipeline. On advice from the seismologists as to the likely mechanism of faulting, the mild steel 300 mm diameter pipeline was carefully unearthed. It was intact though crimped at a welded joint, and shortened by nearly one metre where it crossed the fault.

This earthquake was distinctly felt at Darwin and as far away as Cairns in North Queensland, but seems to have caused little damage in Tennant Creek. A water tank burst and minor damage was caused to domestic dwellings in an aboriginal community 20 km west of the surface faulting. Members of the community later abandoned their homes for several months. Some residents of Tennant Creek are reported to have left permanently as a result of the earthquake.

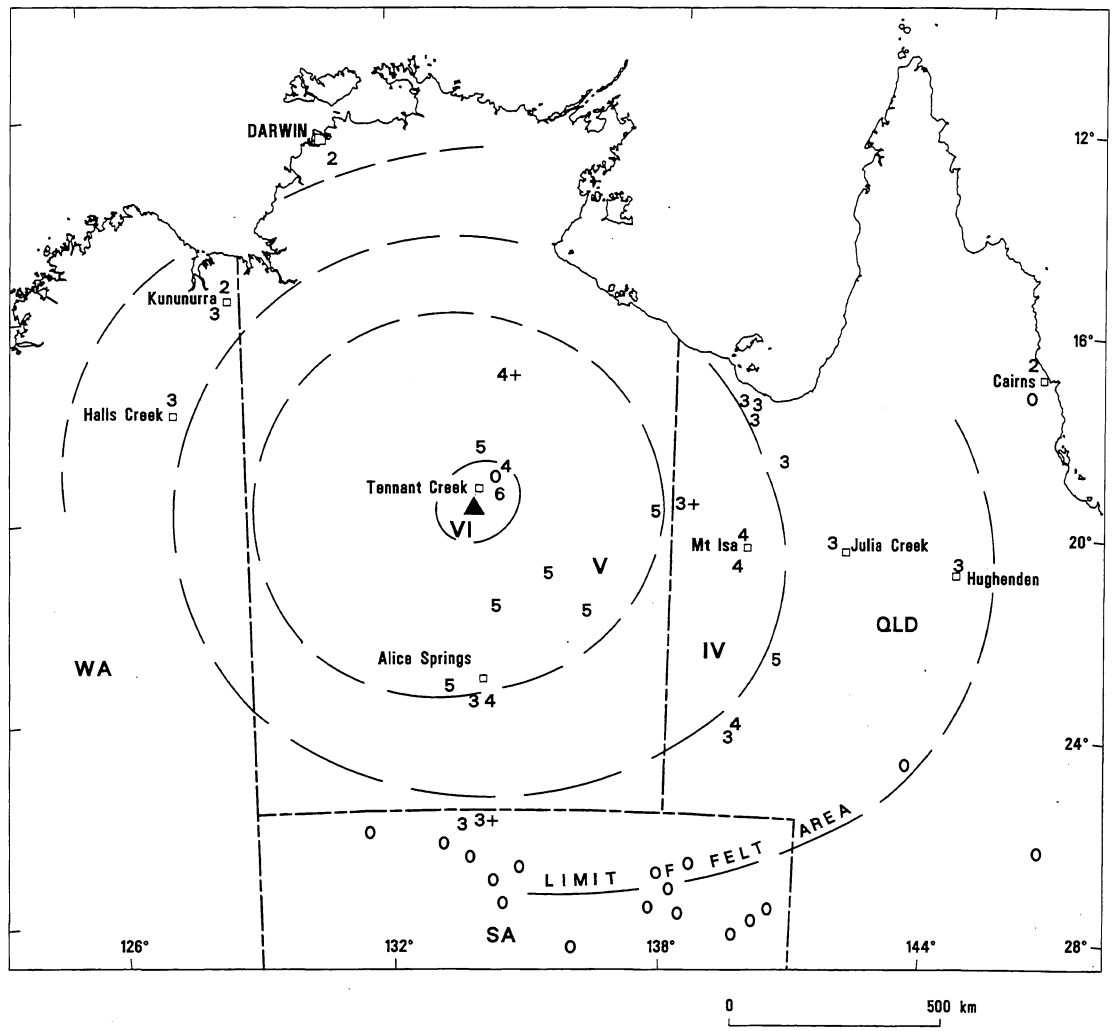
Extracts from an interesting letter sent by Kay Rose to Trevor Jones give some indication of the effects of the earthquakes in Tennant Creek.

> At approximately 10.00 am, I was seated in the office at our Reception building... I heard the drink bottles in the shop refrigerator begin to rattle and my chair seemed *uneasy*. Remembering the slight tremors of last year I ran outside, and could see the brick wall on the police flats nearby ripple...
> There was no damage to stock in the shop at that quake. At approximately 2.30 pm I was in the Westpac bank, Paterson Street when another sizeable quake shook the town. The staff abandoned the customers (and the money) and ran to the strong-room to shelter. A small child screamed and the customers jammed in the door in semi-panic, attempting to get outside. Once outside, I could see the overhead powerlines swaying...
>
> When I arrived back at the Park, I found some damage and extremely frightened teenage children and their friends. Quite a considerable amount of stock in the shop had been flung to the floor - glass bottles were broken, and packaged groceries were all over the place. Drinks in the refrigerator had been knocked over. Portion of a brick wall on the house had been knocked down - broken bricks all over the back verandah...
>
> At 10.30 pm visitors from A.S. had just arrived when the most severe shock happened. We were getting quite blase about them by this time. Keith made 3 of us stay to hold the inside brick wall in the house which is not connected to the ceiling. It moved quite significantly during the earlier shocks. As Sarah went out the large sliding glass door to the back verandah, it bounced off the tracks and she was left bleating for help and holding the door. It was saved. A second brick wall came down onto the verandah. As we stood on the lawn, I had the feeling of being giddy, and felt the ground rise up. The water main to the front of the block split ... and one of the large water storage tanks in the Amenities block had the base shaken out. Perhaps the worst of it all was the noise.

The Chief Minister of the Northern Territory visited Tennant Creek to inspect the damage and oversee relief operations. One of the first decisions he made at that time was to cancel plans to build an intractable waste disposal unit at Tennant Creek.

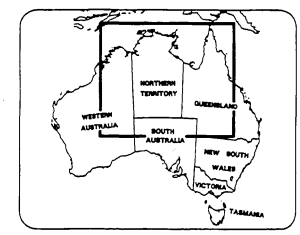
Contributors: This map was compiled by Kevin McCue with data solicited by Trevor Jones, Jerry Vahala and Mary Douch.

ISOSEISMAL MAP OF THE THIRD TENNANT CREEK EARTHQUAKE, NORTHERN TERRITORY, 22 JANUARY 1988



DATE: 22 January 1988
TIME: 12:05:00 UTC
MAGNITUDE: 6.7 MS (USGS)
EPICENTRE: 19.9°S, 134.1°E
DEPTH: 5 (±5)km

▲ *Epicentre*
IV *Zone intensity designation*
4 *Earthquake felt (MM)*
0 *Earthquake not felt*



24/NT/4

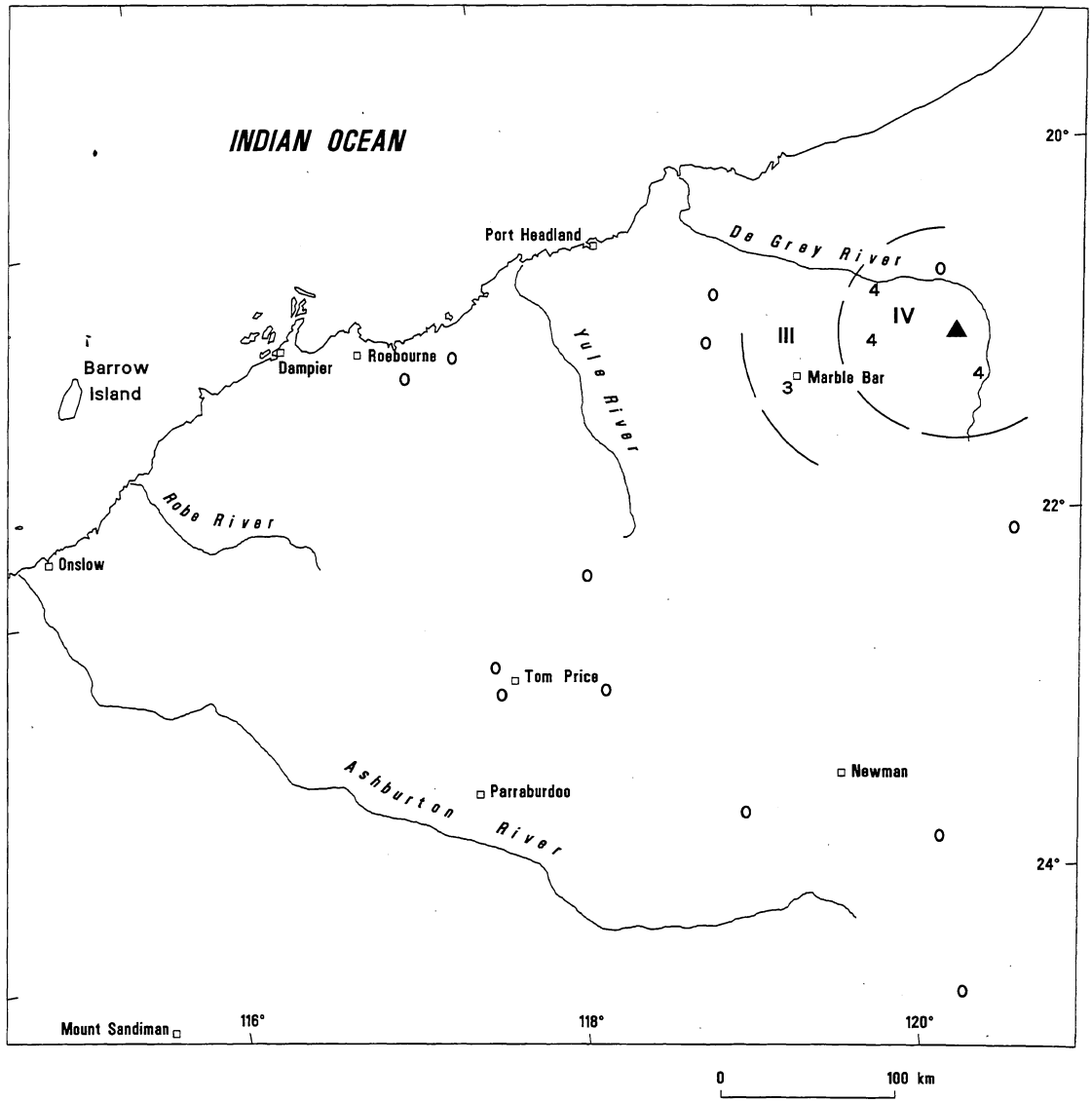
Isoseismal Map of the Marble Bar earthquake
Western Australia - 28 January 1988

Three sizeable earthquakes occurred in quick succession on 28 January with epicentres approximately 90 km east of Marble Bar. The first (magnitude ML 4.8) was at 09:46 local time, the second (ML 4.6) at 09:49 and the third and largest (ML 5.0) occurred at 09:56.

Questionnaires were distributed, but owing to the remoteness of the area, only four reports were received that the earthquakes were felt. The maximum intensity was MM IV; at Marble Bar it was MM III.

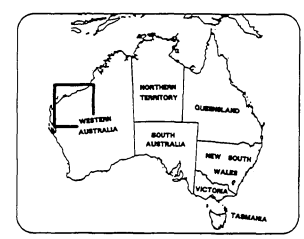
Contributors: This map was compiled by Peter Gregson.

ISOSEISMAL MAP OF THE MARBLE BAR EARTHQUAKE, WESTERN AUSTRALIA, 28 JANUARY 1988



DATE: 28 January 1988
TIME: 01:56:17.5 UTC
MAGNITUDE: 5.0 ML (MUN)
EPICENTRE: 21.05°S 119.60°E
DEPTH: 5 km

▲ *Epicentre*
IV *Zone intensity designation*
0 *Earthquake felt (MM)*
4 *Earthquake not felt*



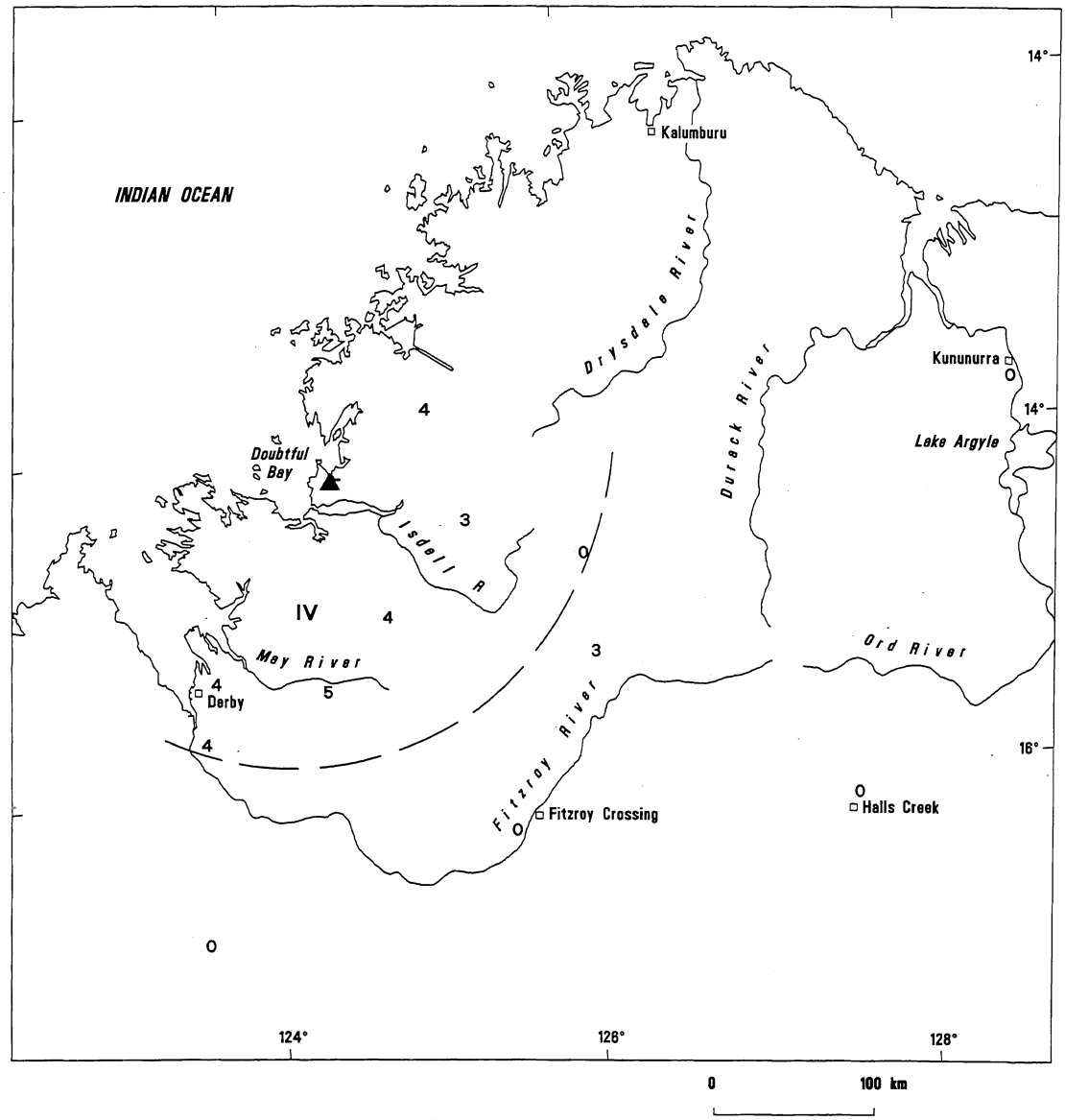
24/150/7

Isoseismal Map of the Doubtful Bay earthquake
Western Australia - 6 February 1988

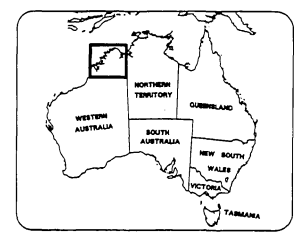
This magnitude ML 5.7 earthquake on 6 February was the largest to occur in WA during 1988. The epicentre near Doubtful Bay, 150 km northeast of Derby, is in a remote area of the Kimberleys. Questionnaires were distributed but only six of the respondents felt the earthquake. At Derby the intensity was MM IV.

Contributors: This map was compiled by Peter Gregson.

ISOSEISMAL MAP OF THE DOUBTFUL BAY EARTHQUAKE, WESTERN AUSTRALIA, 6 FEBRUARY 1988



DATE: 6 February 1988
TIME: 05:23:58 UTC
MAGNITUDE: 5.7 ML (MUN)
EPICENTRE: 16.18°S 124.51°E



▲ *Epicentre*
IV *Zone intensity designation*
4 *Earthquake felt (MM)*
0 *Earthquake not felt*

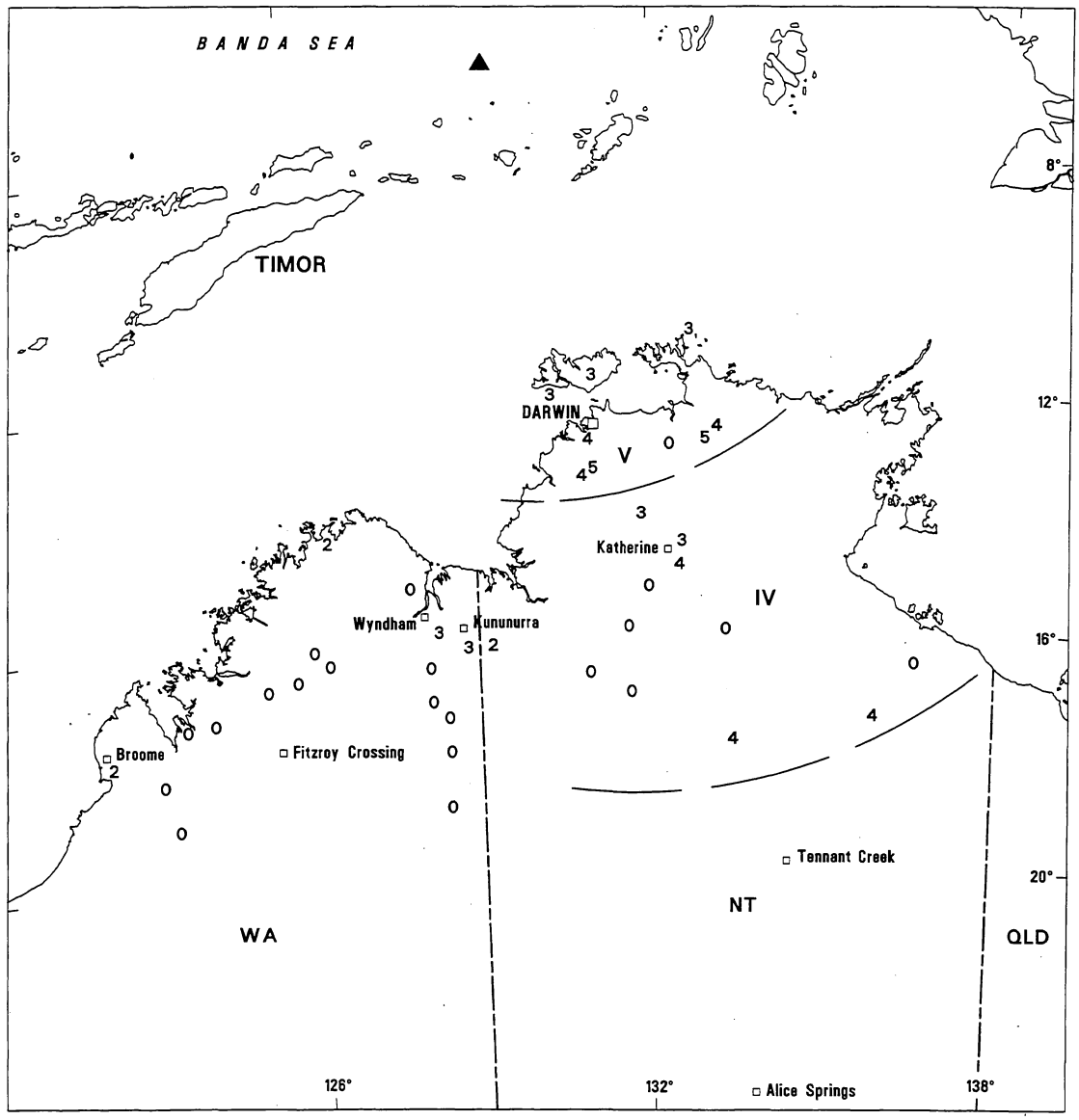
24/E51/2

Isoseismal Map of the Banda Sea earthquake Indonesia - 30 May 1988

This large (Mb 6.5) shallow earthquake northeast of Timor on 30 May was strongly felt in northern Western Australia and the Northern Territory. It was felt as far away as Broome Western Australia and Tennant Creek, Northern Territory, both about 1600 km from the epicentre. An intensity of MM V was reported from Batchelor, and at three cattle stations east of Darwin. Both Darwin and Katherine reported an intensity of MM IV. There were no reports that Timor or other near-epicentre islands in Indonesia suffered damage.

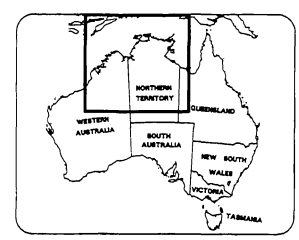
Contributors: This map was compiled by Peter Gregson.

ISOSEISMAL MAP OF THE BANDA SEA EARTHQUAKE, INDONESIA, 30 MAY 1988



DATE:	30 May 1988
TIME:	21:11:11.3 UTC
MAGNITUDE:	6.5 MB (USGS)
EPICENTRE:	7.50°S 128.32°E
DEPTH:	86 km

▲	*Epicentre*
IV	*Zone intensity designation*
4	*Earthquake felt (MM)*
0	*Earthquake not felt*



24/OA/33

Isoseismal map of the Bunnaloo earthquake
New South Wales - 3 July 1988

This small earthquake occurred at 08:23 UTC on 3 July. Only two of the 65 questionnaires returned to the ASC indicated that this earthquake had been felt. Staff at the Seismology Research Centre made a number of telephone calls and conducted personal interviews in the epicentral region, which provided sufficient additional information to draw up the isoseismal map. Cracks in a farmhouse 7 km from the epicentre drew the highest assigned intensity, MM VI.

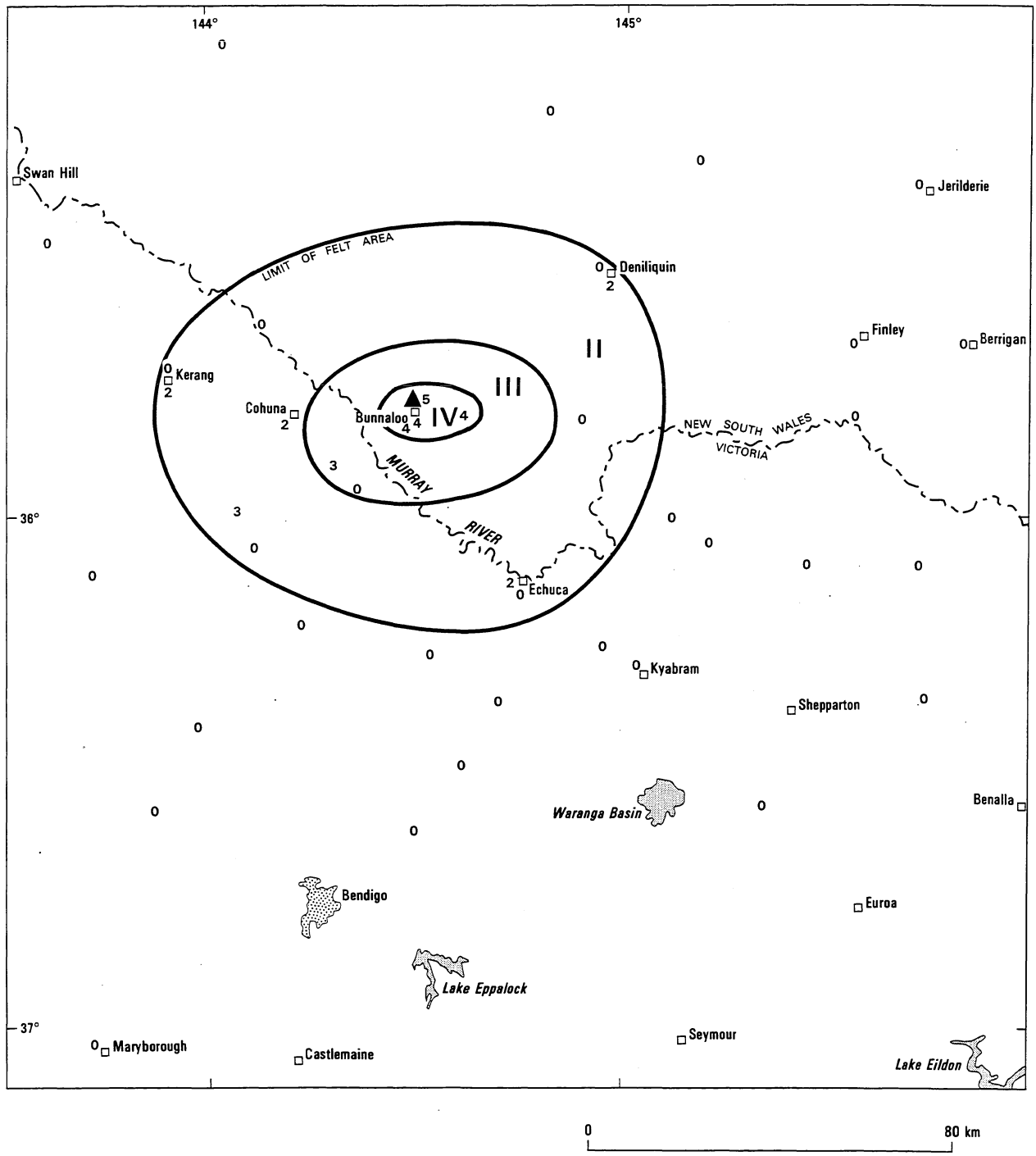
In a brief personal report on the earthquake Gary Gibson commented:

> We visited every farm within about 10 km of the epicentre. We noted intensity 5 in this limited area west of Bunnaloo, including; paintings being displaced, being felt outdoors, and doors opening or closing. Near the epicentre there were two houses where items fell off shelves and one of these had minor cracks in newly painted walls..... None of the people I spoke to in Echuca, Mathoura, Deniliquin, Barham, or Kerang felt or heard anything.

The well distributed 'not felt' reports provide good constraint on the felt area which is commensurate with an earthquake of this small size. The magnitude derived from the radius of perceptibility of 50 km is ML(I) 4.1, in good agreement with that computed from the recorded amplitudes of seismic waves on regional seismographic stations.

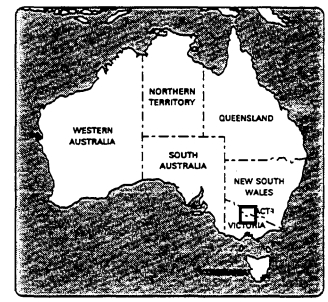
Contributors: This map was compiled by Kevin McCue and Jerry Vahala with intensities assessed by Gary Gibson, Seismology Research Centre, Victoria and the ASC.

ISOSEISMAL MAP OF THE BUNNALOO EARTHQUAKE, NEW SOUTH WALES, 3 JULY 1988



DATE : *3 July 1988*
TIME : *08:23:12 UTC*
MAGNITUDE : *4.0 ML (BMR)*
EPICENTRE : *35.73°S, 144.49°E*
DEPTH : *10 km*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



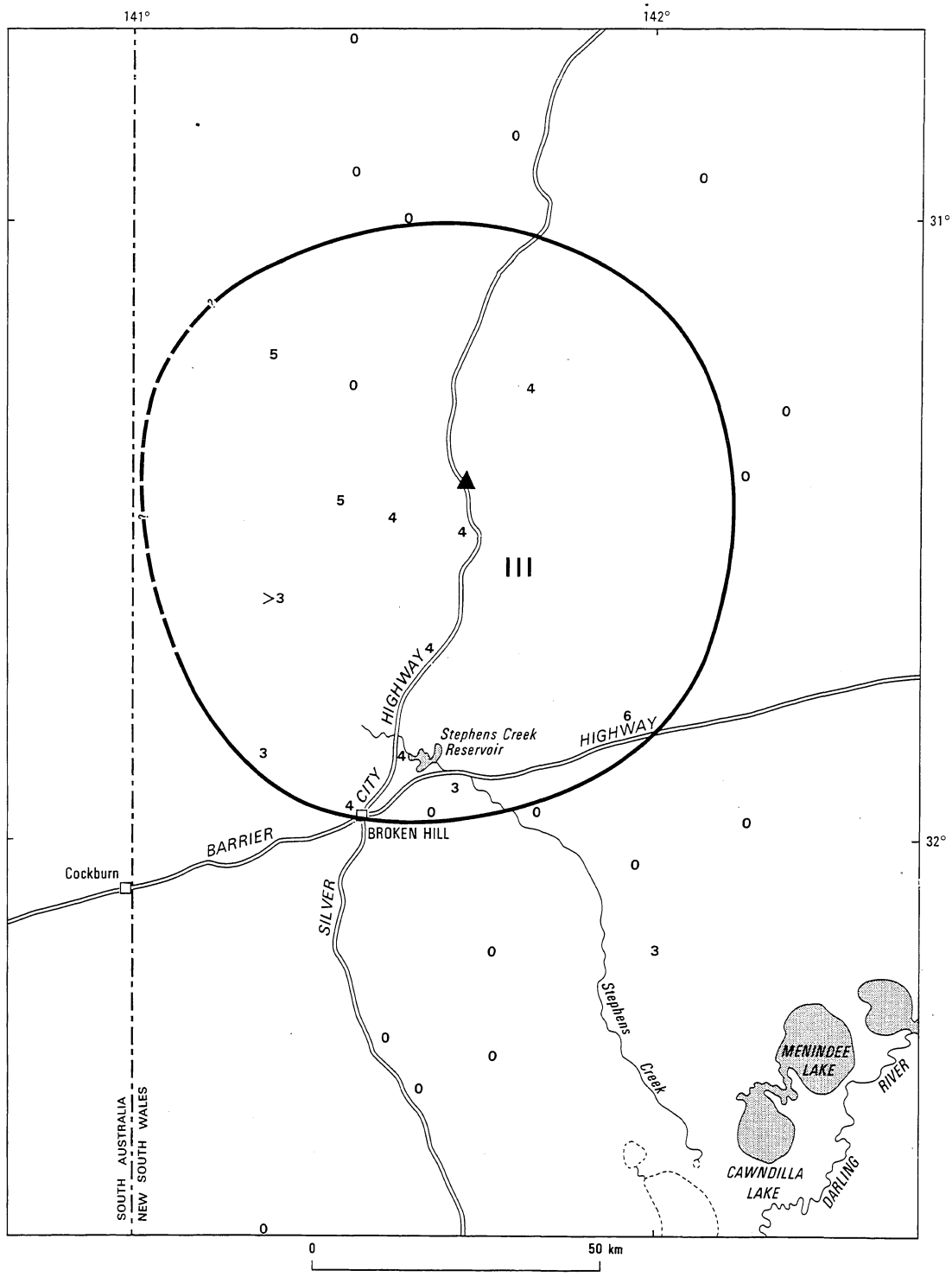
24/N/36

Isoseismal map of the Barrier Range earthquake
New South Wales - 7 September 1988

There was some confusion in Broken Hill at 07:07 UTC (05:37 pm local time) on 7 September as to whether the noise and shaking were caused by an earthquake, a rockburst or a blast in the nearby large underground lead and silver mine. The epicentre and waveform on ASC seismograms confirmed the cause to have been an earthquake with a magnitude ML 3.9. Minor damage was reported at a homestead 50 km from the epicentre, but none in the vicinity of the epicentre or at Broken Hill. Most of the reports used to compile the isoseismal map were solicited by telephone and about half the people contacted did not feel the small earthquake.

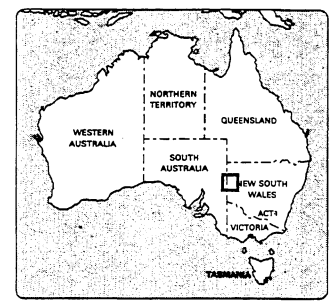
Contributors: This map was compiled by Kevin McCue, Jerry Vahala and Trevor Jones.

ISOSEISMAL MAP OF THE BARRIER RANGE EARTHQUAKE, NEW SOUTH WALES, 7 SEPTEMBER 1988



DATE : *7 September 88*
TIME : *07:07:42 UT*
MAGNITUDE : *3.9 ML (BMR)*
EPICENTRE : *31.43°S, 141.64°E*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/H54–15/1

Isoseismal map of the West Wyalong earthquake
New South Wales - 5 January 1989

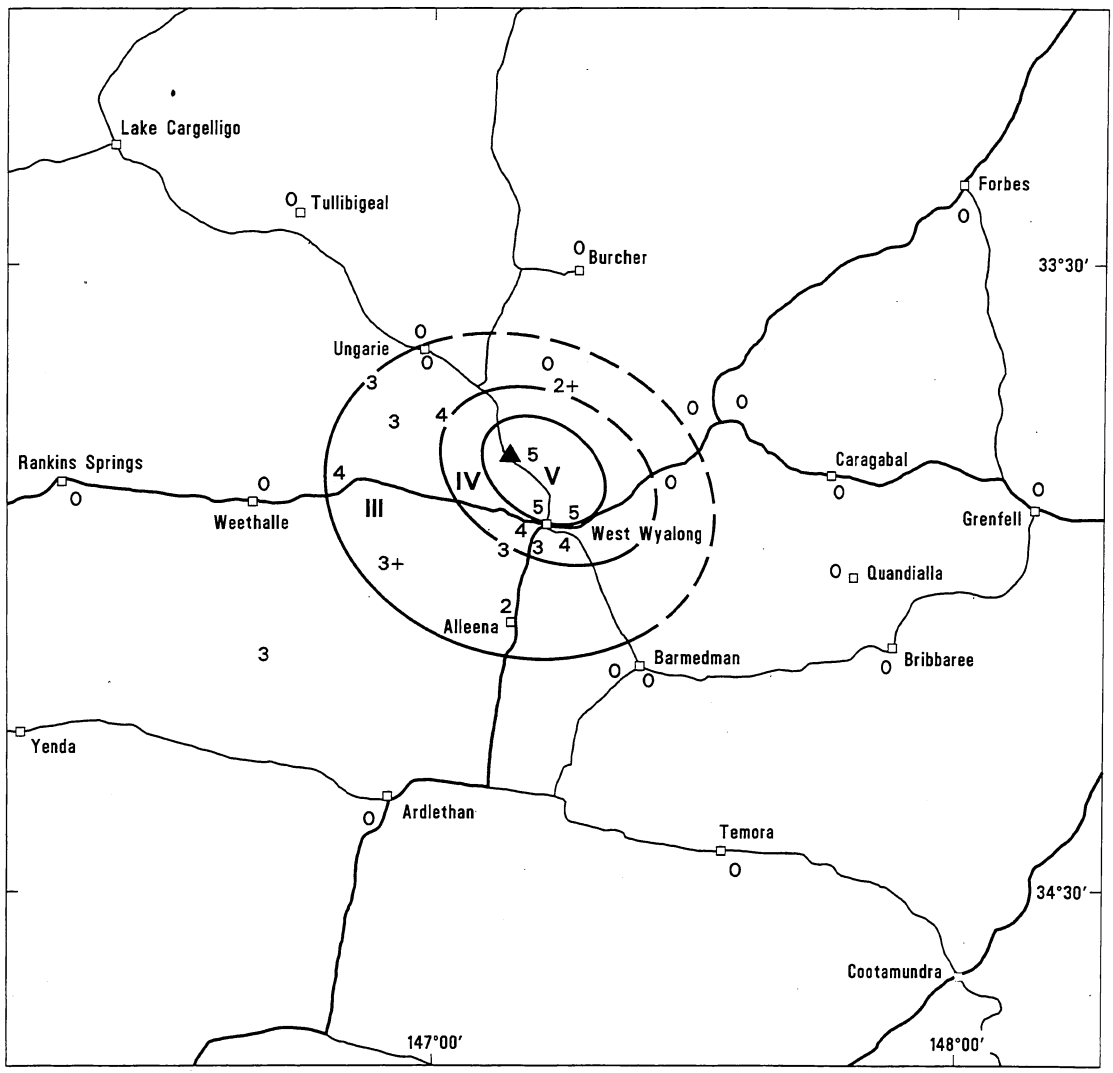
The earthquake occurred on 5 January 1989 at 20.48 UTC (6 January at 07:48 local time) and was recorded by the majority of seismographic stations of the Eastern Australian Network.

Intensities used to plot the isoseismal map were reported on the returned questionnaires distributed to residents within a 100 km radius of West Wyalong. Other observations were solicited by telephoning residents on selected properties surrounding the epicentre. Intensities ranging from MMIII to MMV were observed in West Wyalong while the nearby town of Wyalong experienced intensities of MMIV and MMV although there were people in both towns who did not feel the earthquake. Only a few instances of minor damage were reported, mostly cracks in plaster and concrete. Many people stated that small objects had been shifted and others mentioned hearing loud earth noises.

The magnitude of ML 3.9 has been derived using records from 10 stations and times from 23 seismographs were used to compute the earthquake epicentre. This was the largest earthquake recorded near West Wyalong since 26 November 1982 when a magnitude ML 4.6 earthquake occurred there (Denham & others, 1984).

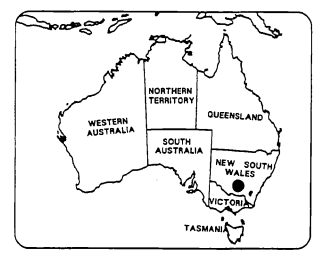
Contributors: This map was compiled by Kevin McCue, Trevor Jones and Jerry Vahala.

ISOSEISMAL MAP OF THE WEST WYALONG EARTHQUAKE, NEW SOUTH WALES, 5 JANUARY 1989



DATE: 5 January 1989
TIME: 20:48:27 UTC
MAGNITUDE: 3.9 ML
EPICENTRE: 33.82°S 147.12°E
DEPTH: 5 km

▲ *Epicentre*
IV *Zone intensity designation (MM)*
4 *Earthquake felt (MM)*
0 *Earthquake not felt*



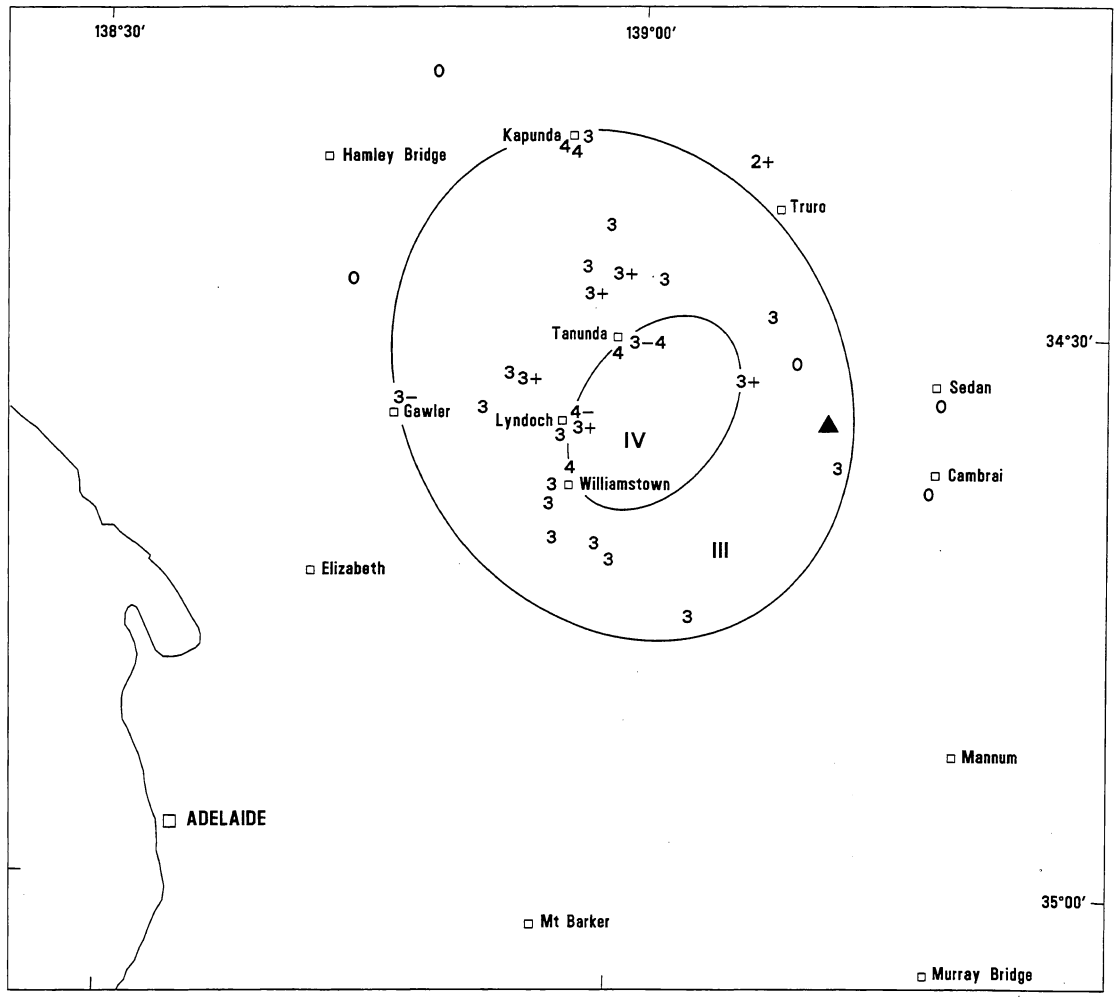
24/155/31

Isoseismal map of the Tanunda earthquake
South Australia - 27 February 1989

A small magnitude ML 2.9 earth tremor shook the Barossa Valley at 8:05 pm (local time). Minor effects such as rumbling and windows rattling were noticed by many people in this well populated area. The isoseismal map was produced from a phone survey by SADME seismologists.

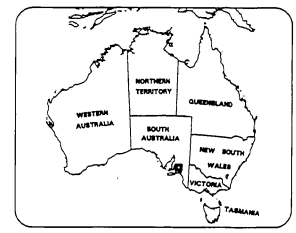
Contributors: This map was compiled by David Love from the South Australian Department of Mines and Energy

ISOSEISMAL MAP OF THE TANUNDA EARTHQUAKE, SOUTH AUSTRALIA, 27 FEBRUARY 1989



DATE: 27 February 1989
TIME: 06:45 UTC
MAGNITUDE: 2.9 ML (I)
EPICENTRE: 34.60°S 139.21°E
DEPTH: 15 km

▲	*Epicentre*
IV	*Zone intensity designation*
4	*Earthquake felt (MM)*
0	*Earthquake not felt*



24/J54-9/1

Isoseismal map of the Jindabyne earthquake
New South Wales - 18 April 1989

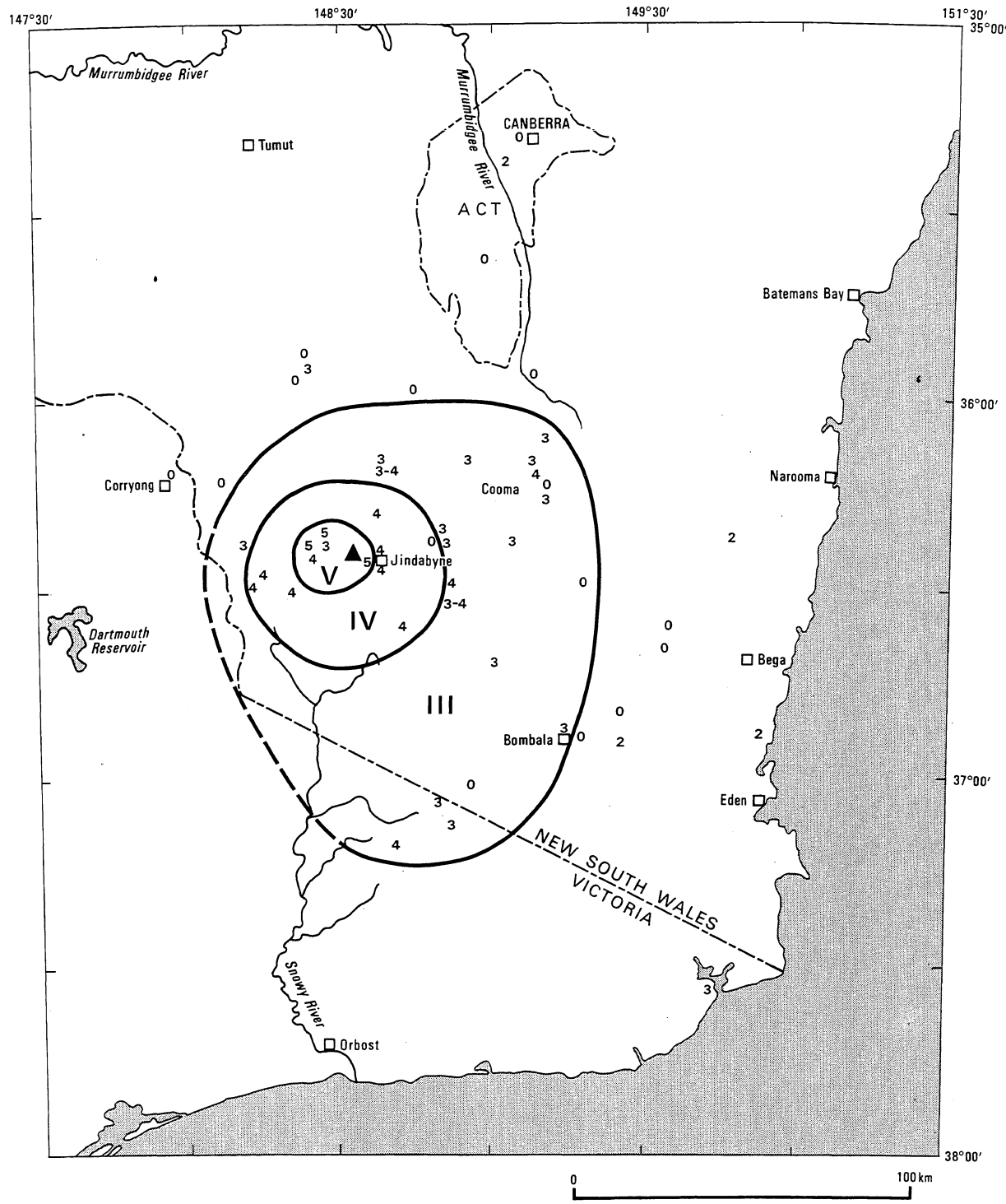
Operators of the 'Blue Cow' ski resort rushed to the end of the SKITUBE fearing that the train had crashed through the end barrier; such was the jot and noise in the office that accompanied the earthquake. Reports were phoned in from as far as Mallacoota on the Victorian coast and a southern suburb of Canberra but no damage was reported in the epicentral region. Snowy Mountains Authority engineerings in the Geehi tunnel reported feeling the earthquake as did a road construction gang at Bunyan, south of Cooma.

Seismic energy seems to have been preferentially propagated to the southeast although there are few reporting points to the northwest and none in the mountains to the southwest.

The epicentre is on the Crackenback fault, a 45 km long, ENE trending fault linking the Jindabyne and Berridale Thrust fault and Long Plain-Indi fault. Previous earthquakes in the same region include the 1885 and 1959 Berridale earthquake (Everingham & others, 1982; Rynn & others 1987).

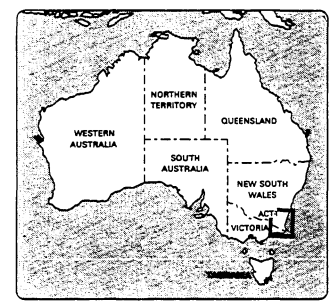
Contributors: This map was compiled by Kevin McCue.

ISOSEISMAL MAP OF THE JINDABYNE EARTHQUAKE, NEW SOUTH WALES, 18 APRIL 1989



DATE : *18 April 1989*
TIME : *03:51:34 UT*
MAGNITUDE : *3.7 (± 0.1) ML (BMR)*
EPICENTRE : *36.40°S, 148.57°E*
DEPTH : *14 (±7) km*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24 / J55 / 25

Isoseismal map of the Mt Olga earthquake
Northern Territory - 28 May 1989

Questionnaires were distributed in the Mt Olga region, Central Australia following the earthquake on 28 May. From the responses, letters and interviews an isoseismal map was drawn which indicates that the earthquake was felt over a sparsely populated elliptical area of approximately 156 000 km^2. The following newspaper extract is from *The Northern Territory Times* on 29 May 1989 (page 2)

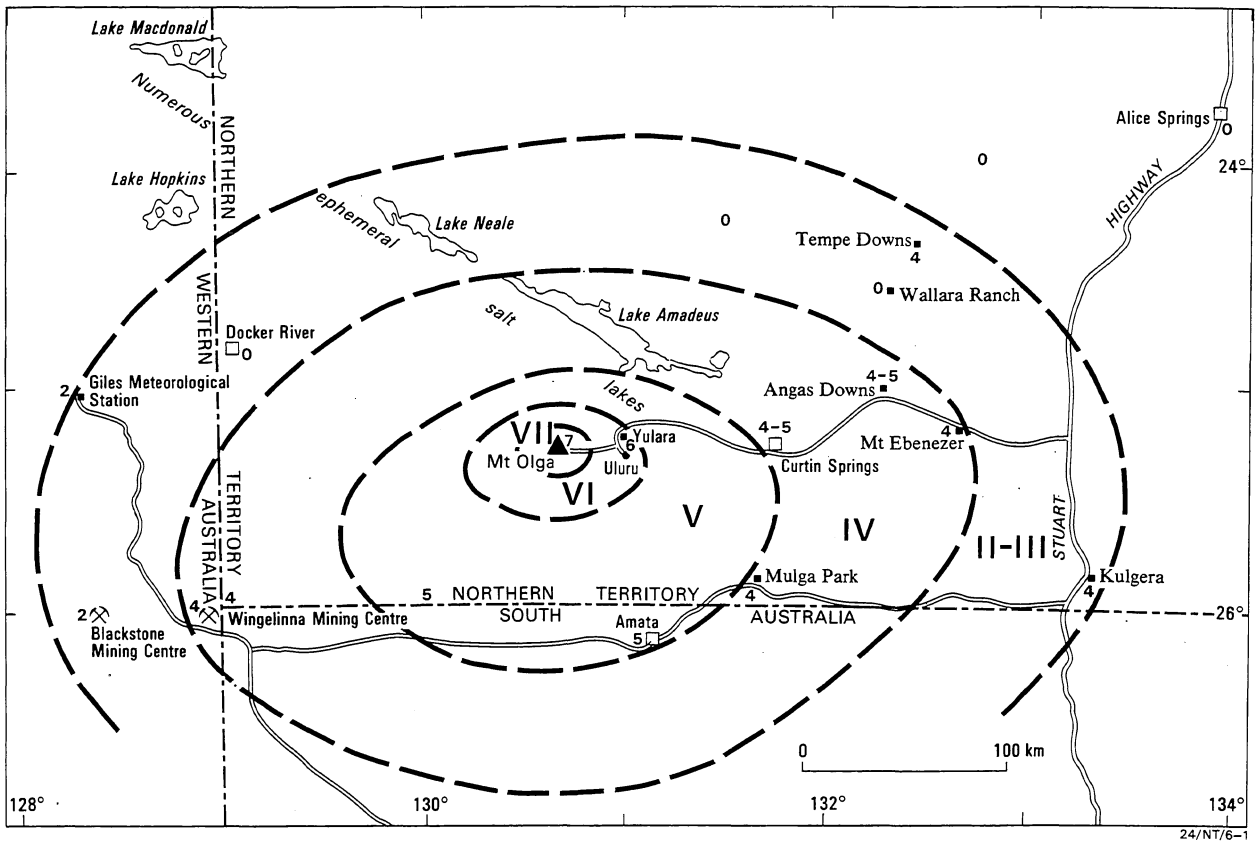
> Startled guests and staff watched a 'ripple effect' on glass walls and saw waves in a hotel pool during a 20-second earthquake at Uluru National Park's Yulara resort yesterday.
> The quake struck Uluru and surrounding areas about 12:25 pm, with an epicentre about 60 km north-west of the resort township. The park superintendent, Mr Terry Piper, said it was believed to be one of the strongest known quakes in the area, and the first tremor of any kind for many years.
> He said people on Uluru (Ayers Rock) had said they felt the tremor. A number of people at the base of the rock said they had been taken aback by 'a thunder-like roll, followed by a loud crack'.
> At the resort, which contains two hotels and a number of flats, maisonettes and a large resident living quarters, staff and guests ran to the safety of a concourse area in the centre of the township..... A preliminary search by engineers and staff failed to reveal any new structural damage to any of the buildings. The resort's Sheraton Hotel recently closed almost 100 of its rooms following damage caused by the area's heaviest recorded rains.

Later reports indicated that minor cracks occurred in brick walls of the modern hotel and tourist complex at Yulara, the closest modern structure to the computed epicentre.

No fault scarp was found and no aftershocks were recorded on portable seismographs deployed by BMR, SADME and ANU seismologists in the epicentral region a few days after the earthquake.

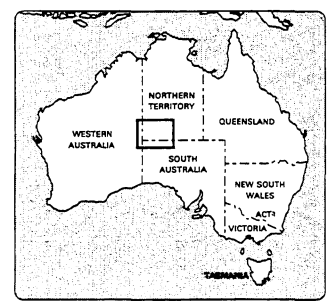
Contributors: This map was compiled by Marion Michael-Leiba and Jerry Vahala.

ISOSEISMAL MAP OF THE MT OLGA EARTHQUAKE, NORTHERN TERRITORY, 28 MAY 1989



DATE : 28 MAY 1989
TIME : 02.55:17.8UT
MAGNITUDE : 5.4 ML(BMR)
EPICENTRE : 25.275°S,130.667° E
DEPTH : 5km

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/NT/6

Isoseismal map of the Margaret River earthquake Western Australia - 20 July 1989

This earthquake was located offshore about 10 km west of Prevelly Park. The maximum intensity felt was MM IV at the seaside resort of Cowaramup Bay and at the towns of Margaret River and Witchcliffe. There were no felt reports beyond 25 km from the epicentre.

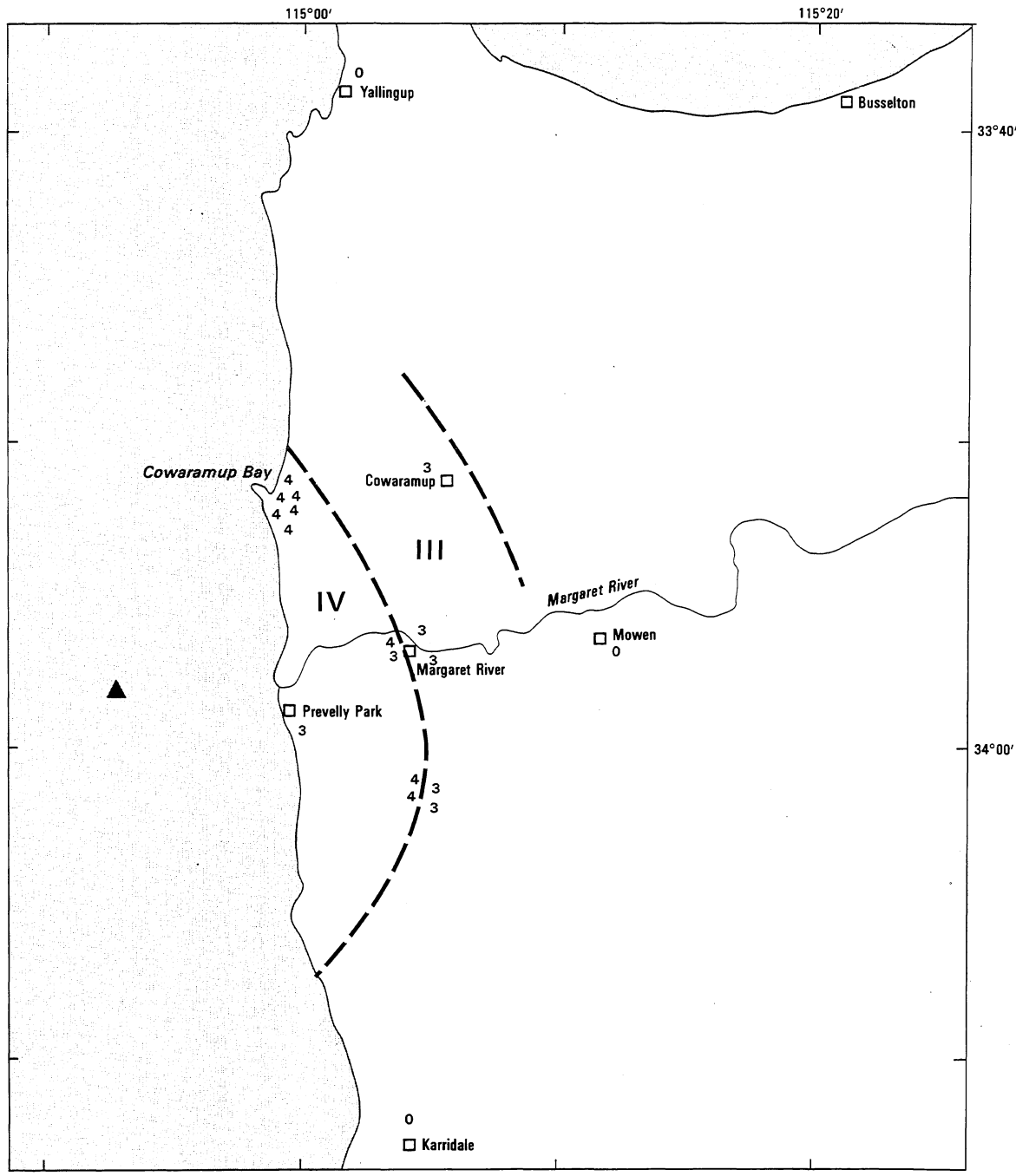
Four small tremors occurred within the 10 hours prior to the main shock and ten afterwards, all in the magnitude range of 2.0 to 2.4. At least five of them were felt in the Cowaramup Bay area.

Other earthquakes in the area in recent times were:

1978, 09 June, 12 km E of Mowen, ML 3.0
1986, 15 January, 24 km SW of Augusta, ML 3.8

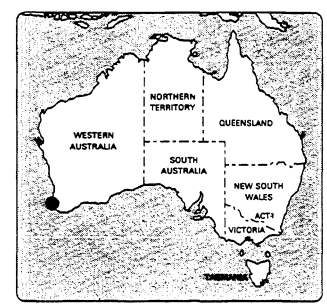
Contributors: This map was compiled by Peter Gregson.

ISOSEISMAL MAP OF THE MARGARET RIVER EARTHQUAKE, WESTERN AUSTRALIA, 20 JULY 1989



DATE : *20 July 1989*
TIME : *09:29:24.5 UT*
MAGNITUDE : *3.2 ML (MUN)*
EPICENTRE : *34.0°S 114.9°E*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



24/150/6

Isoseismal map of the Darwin earthquake
Northern Territory - 23 July 1989

More earthquakes are felt in Darwin than in any other city in Australia, due to the frequent large earthquakes on the Australian/Eurasian plate boundary in the Banda Arc, 500 km to the north of the city. For a local earthquakes to shake Darwin is a relatively rare event but shake it did on 24 July at 6:11 am CST. Many Darwin resiodents were woken by earthquake noises 'like an aeroplane taking off' or like the sound of heavy traffic. People in all suburbs also reported buildings shaking for up to 30 seconds, but there was no damage.

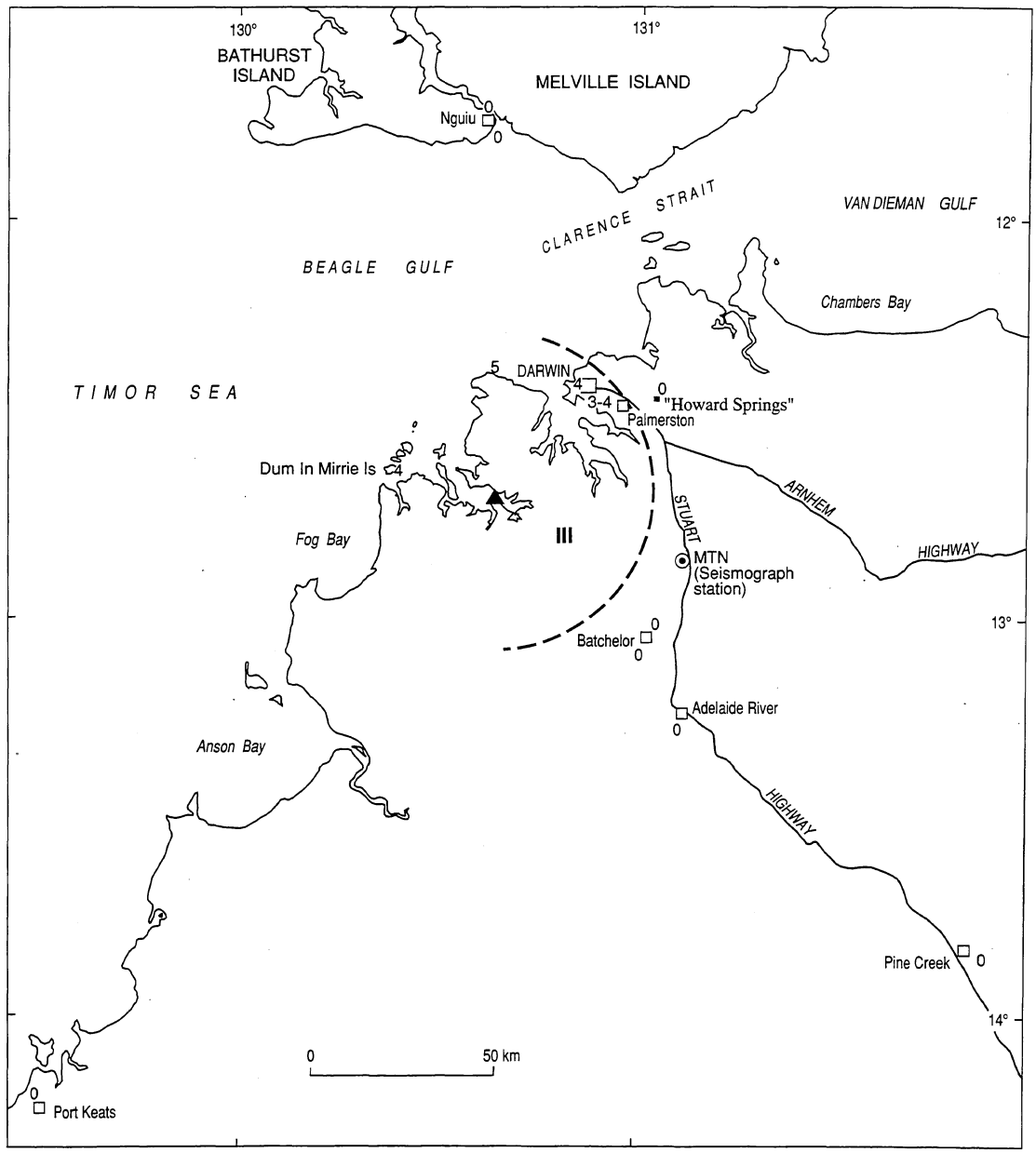
Residents of Quail and Dum In Mirrie islands reported very strong shaking (their verbatim comments unprintable) as did two workers at the Channel Island Power Station near Palmerston, a three storey brick building on rock foundations:

> Vibrations in the administration building incorporating the main control centre were quite noticeable, and the noise and tremor, not unlike a jet plane breaking the sound barrier....

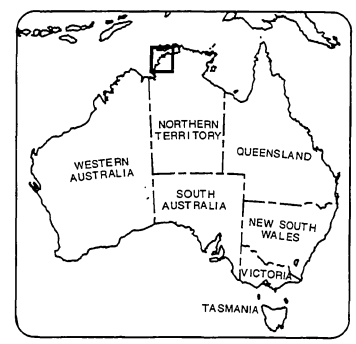
The magnitude 3.7 earthquake was felt over a radius of about 45 km but there were too few reports to draw up a detailed map.

Contributors: This map was compiled by Kevin McCue using information collated by Trevor Jones.

ISOSEISMAL MAP OF THE DARWIN EARTHQUAKE, NORTHERN TERRITORY
23 JULY 1989



24/NT/20



DATE: 23 JULY 1989
TIME: 20:41:22 UTC
MAGNITUDE: 3.7 ML
EPICENTRE: 12.70°S 130.63°E

▲	*Epicentre*
IV	*Zone intensity designation*
4	*Earthquake felt (MM)*
0	*Earthquake not felt*

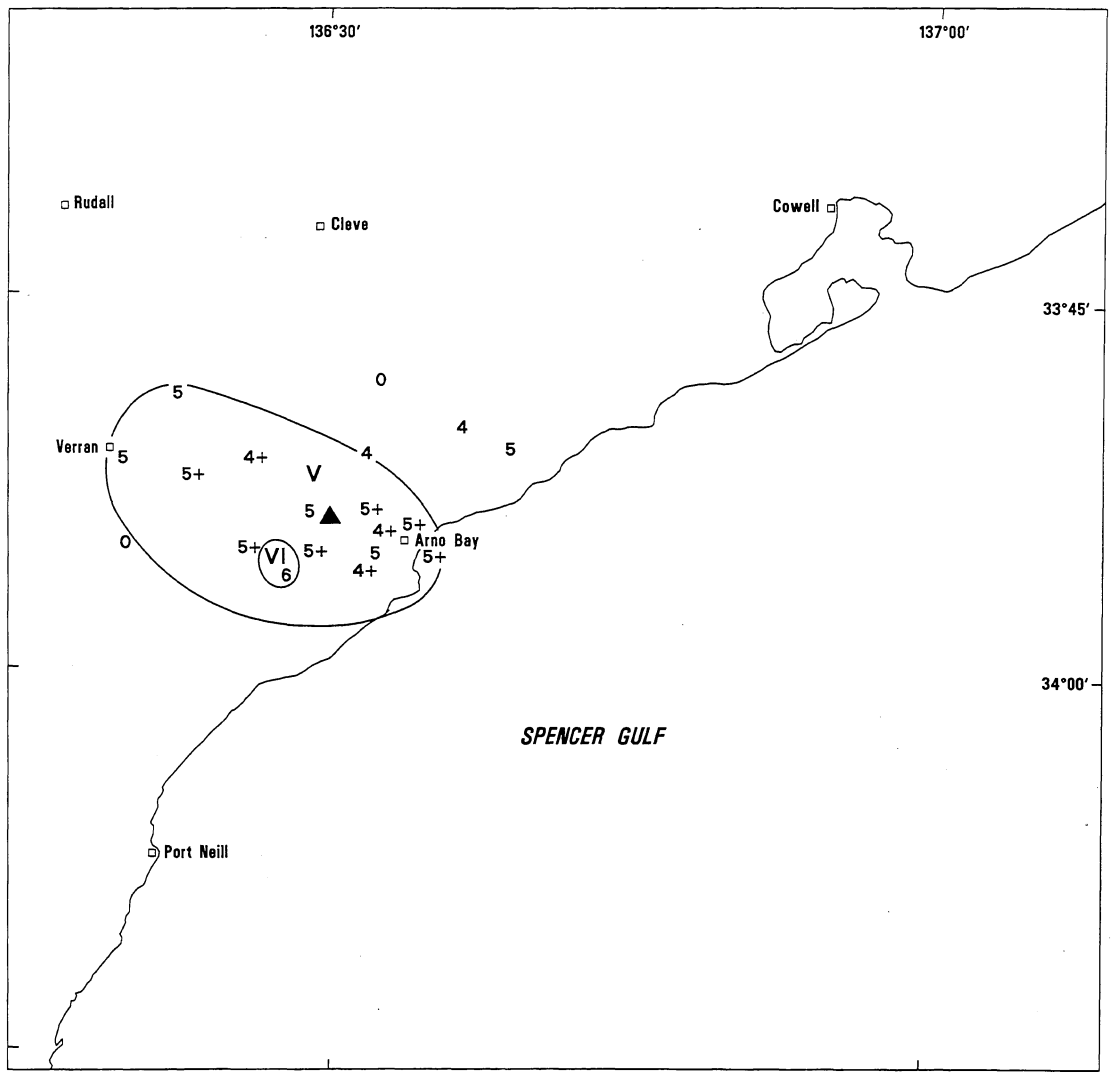
Isoseismal map of the Arno Bay earthquake
South Australia - 13 August 1989

At 4:47 am on Monday 14 August (local time), Arno Bay residents were woken by a small close magnitude ML 3.1 earthquake. Because of the early hour, intensities below IV could not be gauged, but a number of people near the epicentre described moderate intensities. There were 22 replies from 31 questionnaires distributed and some noted minor damage, mainly slight plaster cracks. In one case a planter pole overbalanced and crashed through a window.

This was the largest of many events that occurred in 1989 on Eyre Peninsula. Most of them were slightly east of Arno Bay, and five were felt on one day in April.

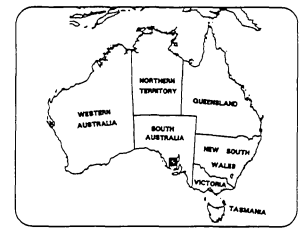
Contributors: This map was compiled by David Love from the South Australian Department of Mines and Energy

ISOSEISMAL MAP OF THE ARNO BAY EARTHQUAKE, SOUTH AUSTRALIA, 13 AUGUST 1989



DATE:	13 August 1989
TIME:	19:17:43.3 UTC
MAGNITUDE:	3.1 ML
EPICENTRE:	33.85°S 136.45°E
DEPTH:	12.1 km

▲	*Epicentre*
VI	*Zone intensity designation*
4	*Earthquake felt (MM)*
0	*Earthquake not felt*



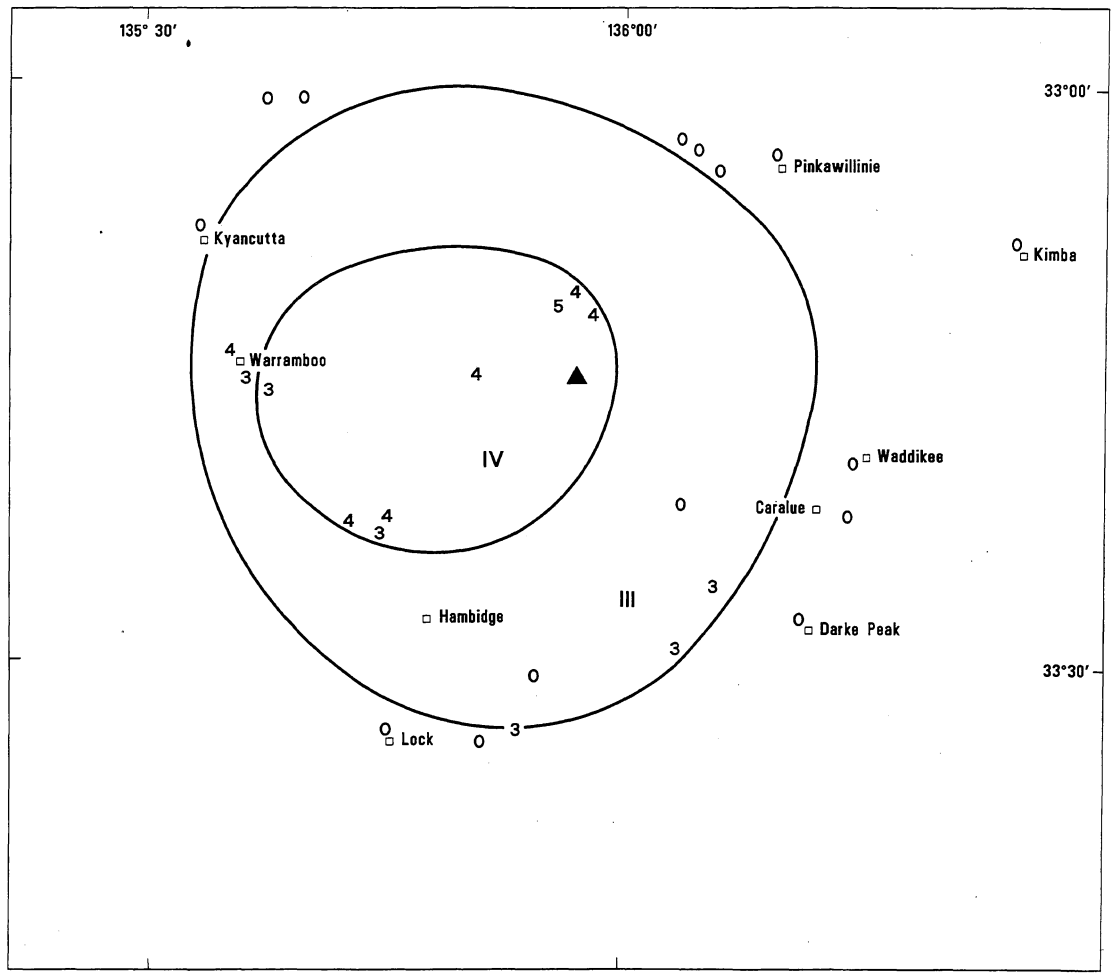
24/153-8/1

Isoseismal map of the Hambidge earthquake
South Australia - 7 September 1989

On this Thursday at 5:38 pm (local time) a small ML 2.9 earthquake shook the central Eyre Peninsula. The effects were fairly minor, being limited to loud noises, and rattling dishes. The area is sparsely and unevenly populated with Hambidge Conservation Park in the middle. SADME staff distributed 26 questionnaires and the map was produced from 20 replies and a number of phone calls.

Contributors: This map was compiled by David Love from the South Australian Department of Mines and Energy

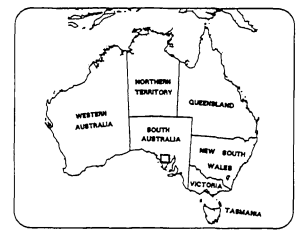
ISOSEISMAL MAP OF THE HAMBIDGE EARTHQUAKE, SOUTH AUSTRALIA, 7 SEPTEMBER 1989



0 20 km

DATE: 7 September 1989
TIME: 08:08:29.7 UTC
MAGNITUDE: 2.9 ML
EPICENTRE: 33.55°S 135.92°E
DEPTH: 21.1 km

▲ *Epicentre*
IV *Zone intensity designation*
4 *Earthquake felt (MM)*
0 *Earthquake not felt*



24/153-7/1

Isoseismal map of the Broome earthquake
Western Australia - 13 October 1989

At 09:59 UTC (5.59 p.m. local time) on 13 October, an earthquake was felt over a wide area between Broome and Cape Leveque. Its magnitude was ML 5.4 and the epicentre was 42 km north-east of Broome.

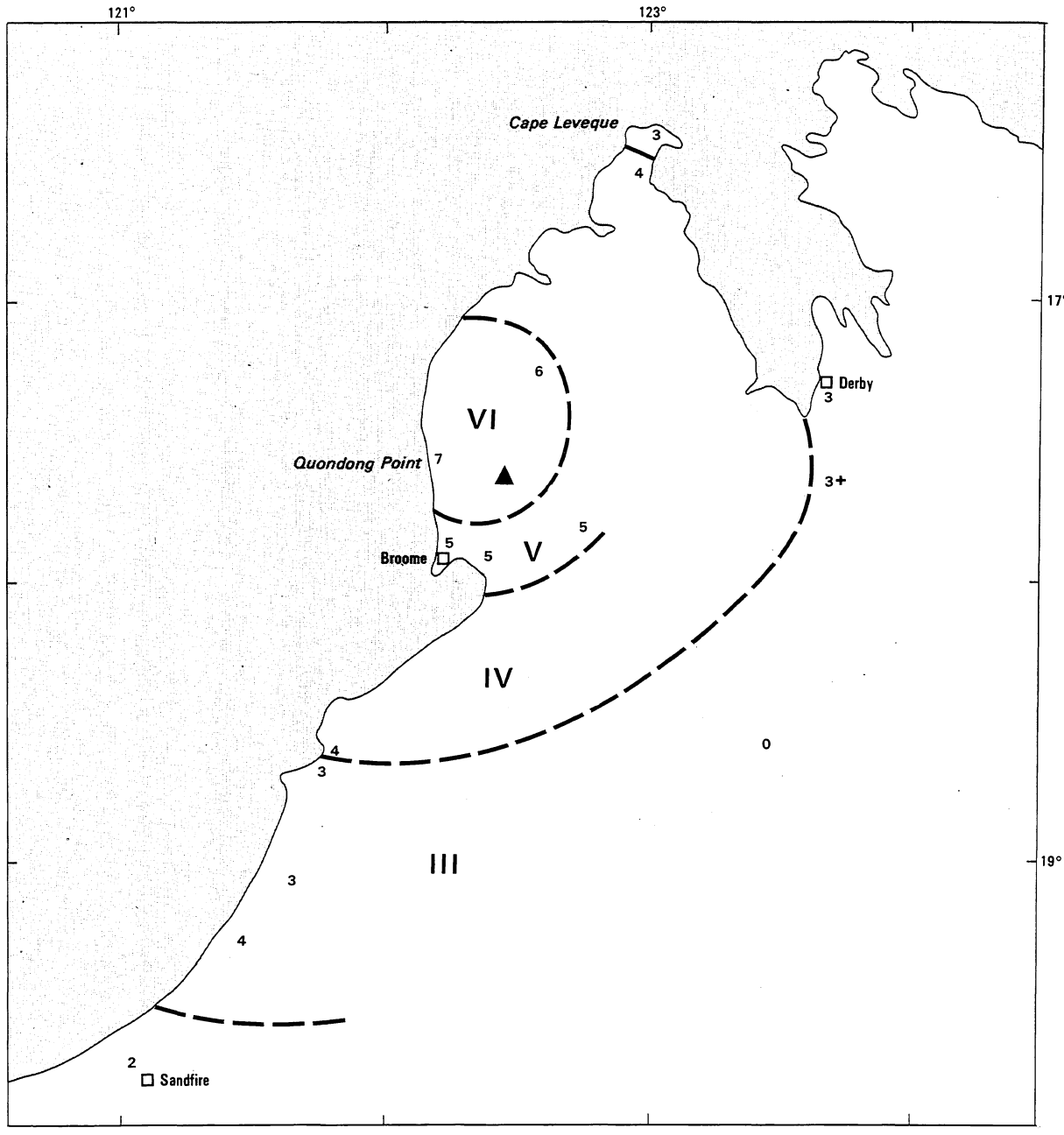
The maximum intensity experienced, MM VII, was at Quandong Point, 27 km west of the epicentre, is colourfully described by David Mayhew:

> `Fortunately Broome was 40 km south of the epicentre, but guess where I was? You have guessed it, 50 km north of Broome sitting on the very edge of the epicentre; at Kadalikan (Pt Quandong).
>
> I was the only camp here at the time and was lying down waiting for the news to come on and they had just announced the time at 1759 hours, when the wooshing, rattling and banging commenced; seemed to come in from the north-east; next instant the sand surface was jiggling like a jelly and I was being jolted up and down. The durin (wild plum tree) which measures eight feet in circumference was gyrating from side to side at crazy angles and also being projected upwards at the same time by the convulsions of the ground surface. I was fully convinced the ground would crack apart and take the lot including me, it was frightening, I can assure you.
>
> From the first indications to the last rattle was about 15/20 seconds but that is not too reliable as the thoughts whizzing through my mind during the tremor were not given to documenting time but astonishment turning to a sort of bewilderment as the tremor intensified; was it a nuclear attack? no bright light yet! must be an earthquake! will the ground open up?
>
> When the shaking and cracking sounds subsided I rose from the swag and looked out to sea and inland across the scrub but nothing stirred'

Broome was the closest town and experienced intensities of MM V. The earthquake was felt (MM II) as far as Sandfire 280 km from the epicentre with the radius of the MM IV isoseismal being 130 km.

Contributors: This map was compiled by Peter Gregson

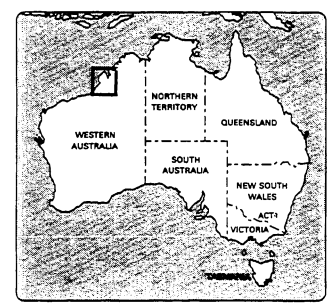
ISOSEISMAL MAP OF THE BROOME EARTHQUAKE, WESTERN AUSTRALIA, 13 OCTOBER 1989



0 100 km

DATE : *13 October 1989*
TIME : *09:59:14.6 UT*
MAGNITUDE : *5.4 ML (MUN)*
EPICENTRE : *17.6°S 122.4°E*
DEPTH : *Crustal*

▲ *Epicentre*
IV *Zone Intensity Designation*
4 *Earthquake Felt (MM)*
0 *Earthquake Not Felt*



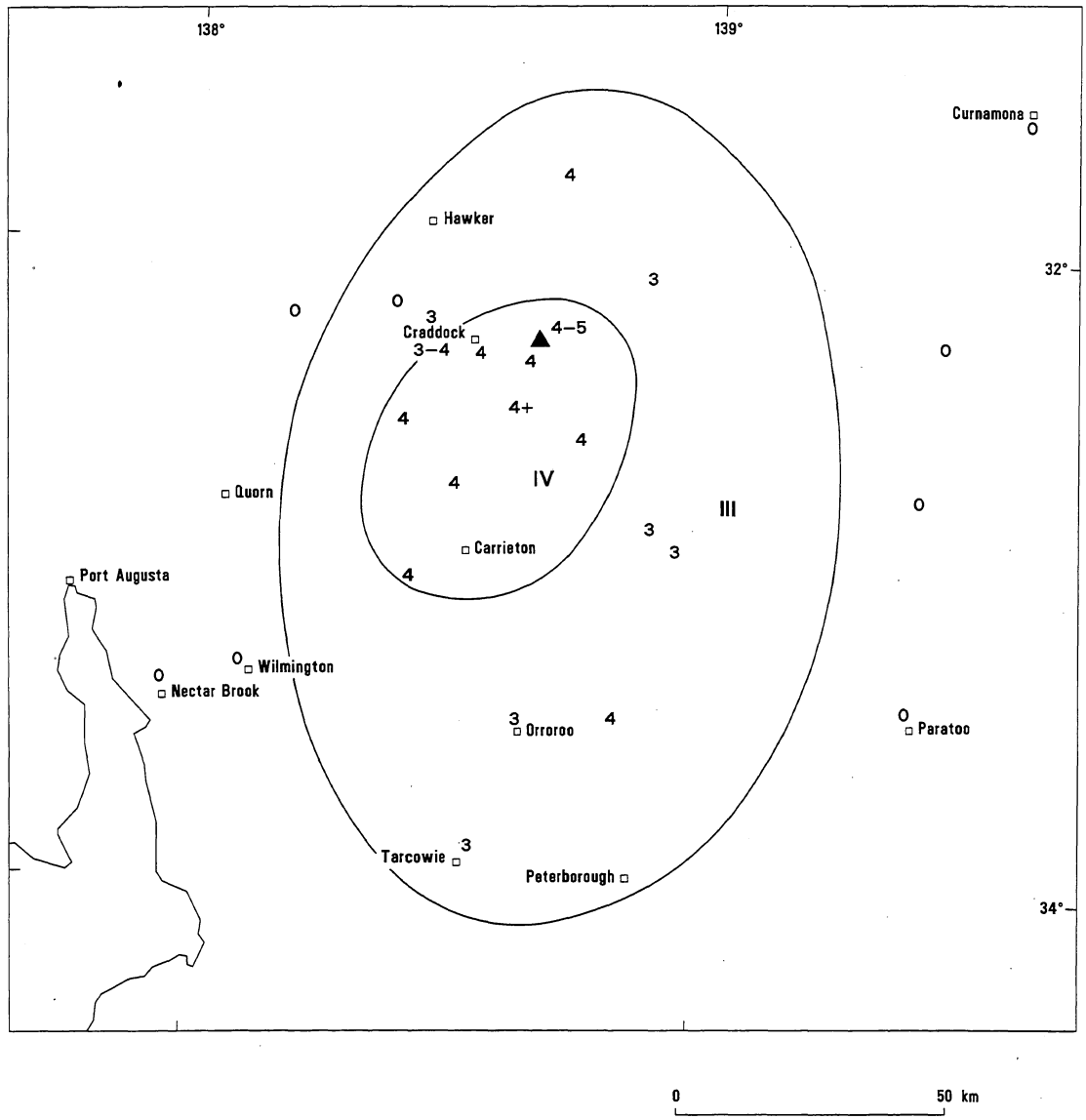
24/E51/1

Isoseismal map of the Craddock earthquake
South Australia - 15 October 1989

At 9:05 pm (local time) on Sunday 15 October, a small ML 3.1 earthquake occurred in the Flinders Ranges. It was noticed from Tarcowie to Warcowie (130 km), but did little more than rattle bottles, ornaments and leave pictures askew. The area is not well populated, but 34 questionnaires were distributed, and a reasonable map was drawn by SADME seismologists from 24 replies.

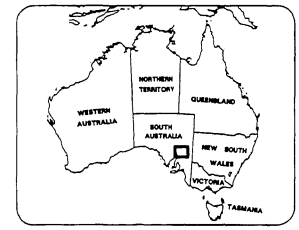
Contributors: This map was compiled by David Love from the South Australian Department of Mines and Energy

ISOSEISMAL MAP OF THE CRADDOCK EARTHQUAKE, SOUTH AUSTRALIA, 15 OCTOBER 1989



DATE:	15 October 1989
TIME:	11:35:07.1 UTC
MAGNITUDE:	3.1 ML
EPICENTRE:	32.27°S 138.67°E
DEPTH:	15.0 km

▲	*Epicentre*
IV	*Zone intensity designation*
4	*Earthquake felt (MM)*
0	*Earthquake not felt*



24/154–1/1

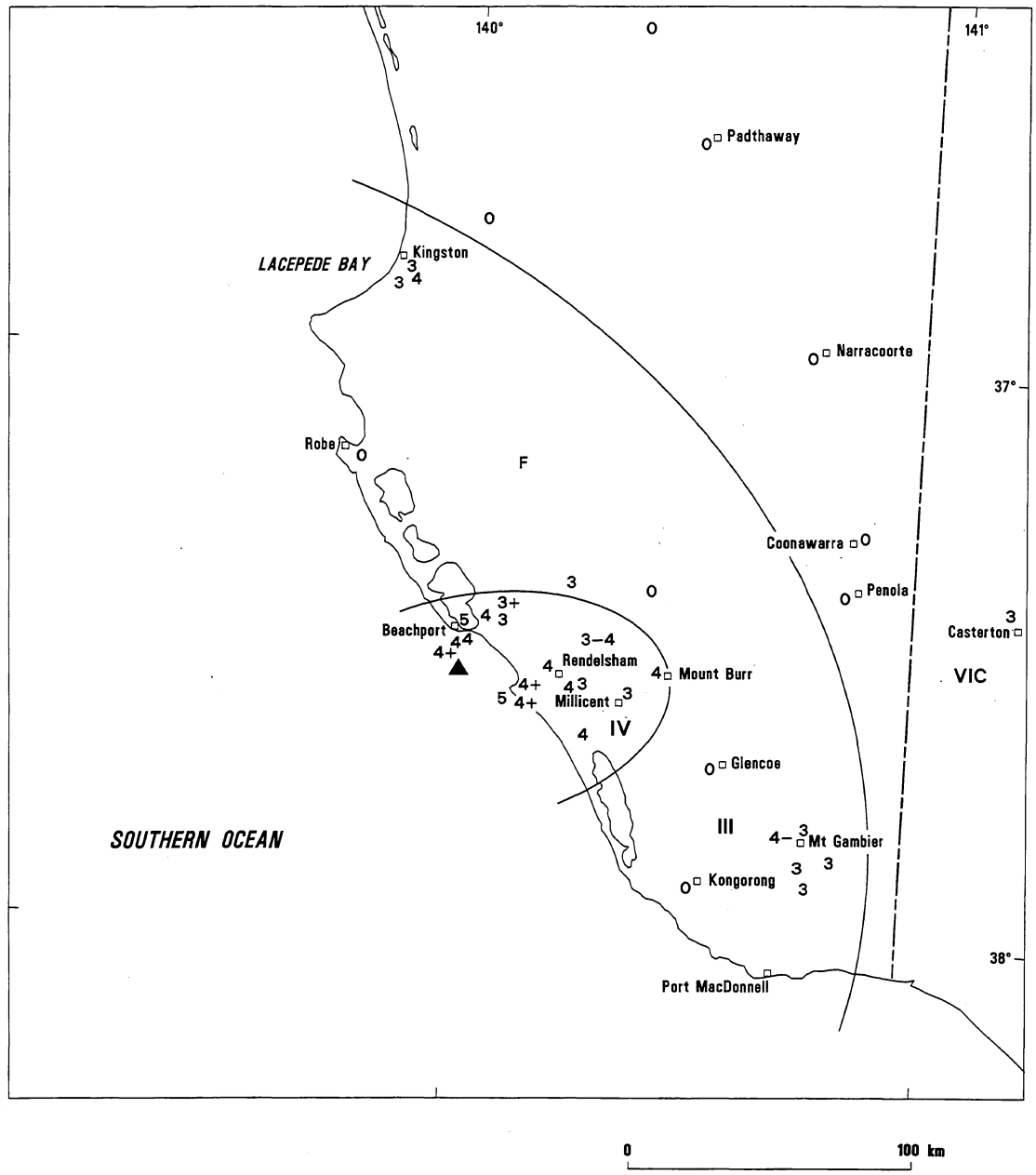
Isoseismal map of the Beachport earthquake
South Australia - 8 November 1989

On Wednesday 8 November at 3:36 pm local time, coastal towns in the South-East were shaken by an ML 3.9 earthquake. At Beachport and Southend near the epicentre, some small objects were upset and light kitchen furniture appeared to jump. One group of people reported a sensation of being on a wave.

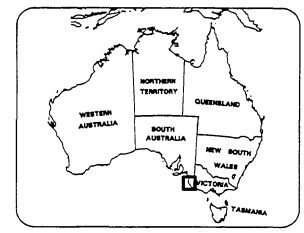
SADME distributed 63 questionnaires and the isoseismal map was produced from the 52 replies. A peak intensity of MM V was assigned. Two small aftershocks in the following three hours were felt by a few people at Southend.

Contributors: This map was compiled by David Love from the South Australian Department of Mines and Energy

ISOSEISMAL MAP OF THE BEACHPORT EARTHQUAKE, SOUTH AUSTRALIA, 8 NOVEMBER 1989



DATE: 8 November 1989
TIME: 05:06:30.7 UTC
MAGNITUDE: 3.9 ML
EPICENTRE: 37.55°S 140.06°E
DEPTH: 13.3 km



▲ *Epicentre*
IV *Zone intensity designation*
4 *Earthquake felt (MM)*
0 *Earthquake not felt*
F *Felt*

24/J54-6/1

Isoseismal Map of the Newcastle earthquake New South Wales - 27 December 1989

Questionnaires designed to assess the felt intensity were distributed by Jerry Vahala and the returned forms were used to compile the BMR isoseismal map. Other `fill-in' data were obtained by onsite observation and radio and telephone interviews. The maximum intensity is assessed at MMVIII (McCue & others, 1990; Melchers, 1990). Modern structures in the epicentral region and downtown Newcastle suffered considerable damage including the Pasminco zinc refinery, the then unopened John Hunter hospital, Newcastle Technical College and Junction Motel. Of course special reasons can be found for their failure, and many other structures were undamaged but the ground motion was undeniably strong.

Other authors who briefly visited the area rated the intensty as only MM VII (Tiedemann, 1990; Pappin & others, 1991), though Rynn (1991) assigned it intensity IX and prepared an isoseismal map using the BMR and other data. The detailed map of the city area is similar to that prepared by the Institution of Engineers, Australia and shows a high correlation between the areas of alluvial fill and the intensity VIII contour. This region is 15 km from the epicentre at Booleroo where the intensity was only VI. Boolaroo was itself about 11 km from the focus.

The difference of two intensity units between the epicentral region and the city amounts to at least a fourfold magnification of peak ground velocity which is attributed to the alluvial fill underlying a large area of inner Newcastle. Such effects are commonly observed in areas where earthquakes are more frequent. The October 1989 Santa Cruz or Loma Prieta earthquake was a classic example; intensities in San Francisco, 100 km from the epicentre, were rated similar to those in the epicentral region and the cause was attributed to ground motion amplification in the bay muds.

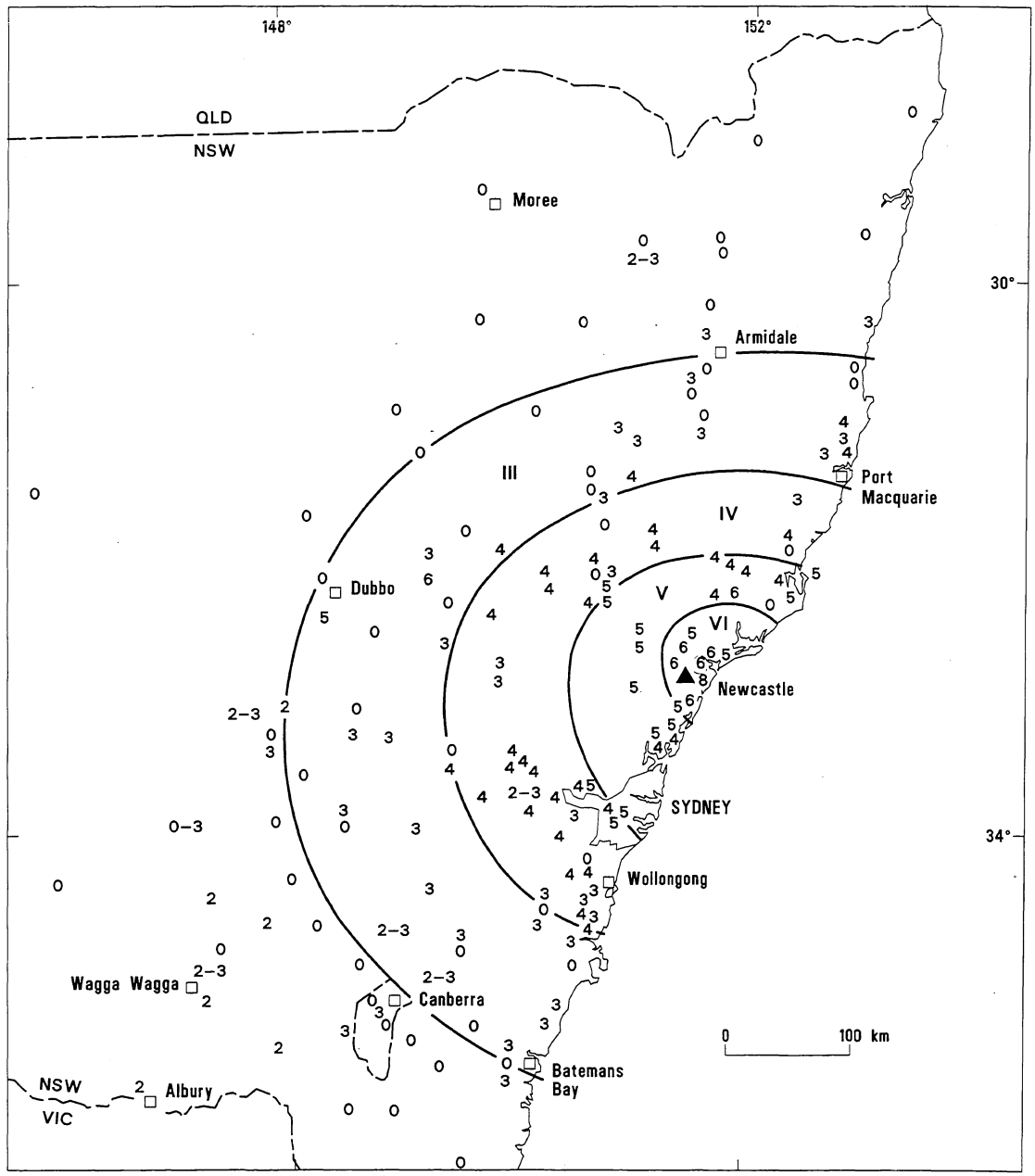
The Newcastle earthquake was felt at intensity IV-V in Sydney and clearly in Canberra, especially in tall buildings (one janitor rang to ask if another earthquake was likely, and if so he would evacuate the building).

The radius of perceptibility was about 310 km, corresponding to a magnitude of ML(I) 5.6. The shape of the contours is similar to those of other Hunter Valley earthquakes in 1868 and 1925 but the 1989 earthquake is obviously the largest of the three since it was felt over a wider area.

In the meizoseismal region, the rapid attenuation of intensity would normally indicate that the focus was very shallow but in this case the focal depth is well constrained at 11.5 (±2 km) by P wave reflections from the underside of the Earth's surface recorded on Alice Springs and Tennant Creek seismographic array stations and the Eskdalmuir seismographic array in Scotland.

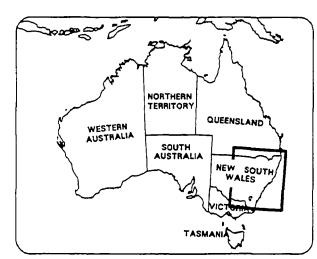
Contributors: This map was compiled by Kevin McCue.

ISOSEISMAL MAP OF NEWCASTLE EARTHQUAKE, NEW SOUTH WALES
27 DECEMBER 1989



DATE:	27 DECEMBER 1989
TIME:	23:26:58 ±1.5s UTC
MAGNITUDE:	5.6 ML
EPICENTRE:	32.95°S 151.61°E
DEPTH:	11.5 ±1.0 km

▲	*Epicentre*
IV	*Zone intensity designation*
2	*Earthquake felt (MM)*
0	*Earthquake not felt*



24/156/14-1

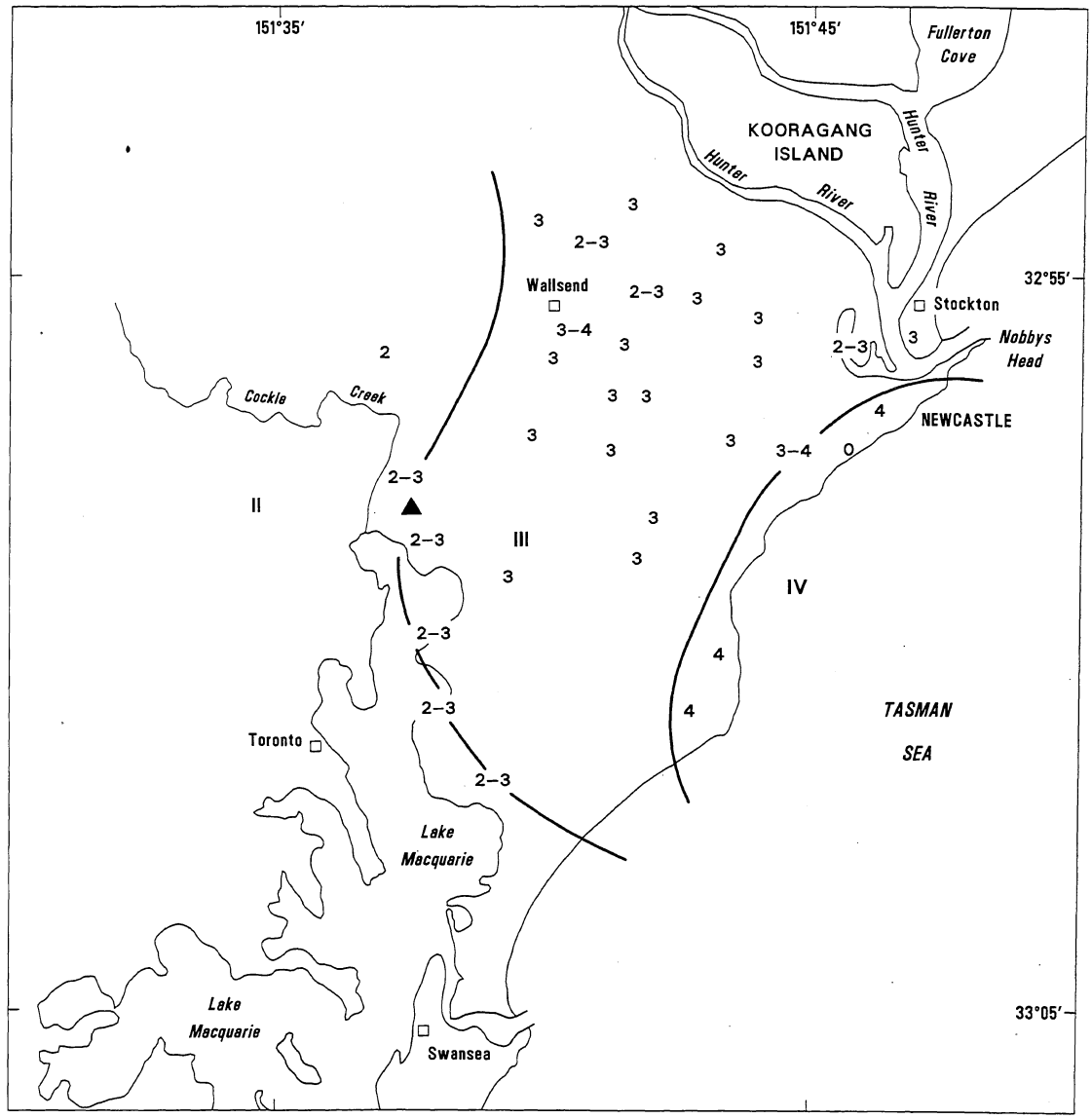
Isoseismal map of the Newcastle aftershock New South Wales - 29 December 1989

As one of the team of seismologists who had just completed installing the temporary network around Newcastle, I (McCue) was sitting on the steps of the cellar housing the Merewether seismograph, a portable MEQ-800 recorder, giving a media briefing on our days activities when the phone rang and a concerned police officer at the Newcastle CBD headquarters informed me that an earthquake had been felt there and at Hamilton. On rotating the recorder drum I was able to confirm that an aftershock had indeed occurred but none of the ten or so people in the room had felt it. Later we ascertained that it had been felt at Adamstown too.

Rynn (1991) compiled this isoseismal map which is not at all constrained by 'not-felt' reports nor a single report, felt or otherwise, west of the epicentre. This lack of coverage prevents any comparisons between the felt areas of the mainshock and aftershock and severly limits conclusions on the correlation between the felt area and the aftershock location which is well constrained by seismographic data.

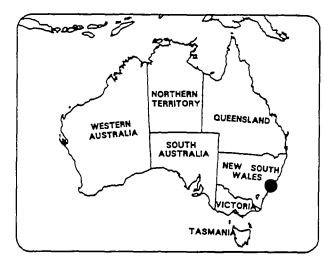
Contributors: This map was compiled by Dr Jack Rynn CERA.

ISOSEISMAL MAP OF NEWCASTLE EARTHQUAKE, NEW SOUTH WALES
29 DECEMBER 1989



DATE: 29 DECEMBER 1989
TIME: 09:08:11 UTC
MAGNITUDE: 2.1 ML
EPICENTRE: 32.96°S, 151.63°E
DEPTH: 13 km

▲ *Epicentre*
IV *Zone intensity designation*
3 *Earthquake felt (MM)*
0 *Earthquake not felt*



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