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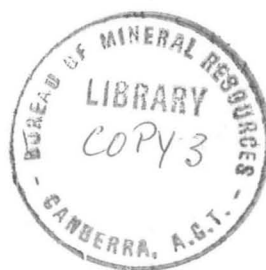
DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

052917

Record No. 1971/40

Information on Western Australian
Earthquakes Which Occurred During
the Periods 1849-1900 and 1923-1960



by

I. B. Everingham and L. Tilbury

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INFORMATION ON WESTERN AUSTRALIAN EARTHQUAKES
WHICH OCCURRED DURING THE PERIODS
1849-1900 AND 1923-1960

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SUMMARY

To complement published data on the seismicity of Western Australia, earthquake data for the period 1849-1900 are summarized and data for the period 1900-1961 are reassessed. The pre-1900 results show that the Geraldton, Barrow Range, and Roebourne regions have a history of past seismic activity.

Epicentres and magnitudes (in the range M_L 3.9 - 5.8) are determined for sixteen earthquakes during the period 1923-1961; most of these occurred in the Yandanooka-Cape Riche Lineament, an active zone east of Perth.

A body-wave magnitude (mb) of 7.1 is determined for the 1941 Meeberrie earthquake.

1. INTRODUCTION

A description of the seismicity of Western Australia (Everingham, 1968) reveals an inadequate knowledge of earthquakes which occurred in the period prior to 1960. As that report points out, the details of only one earthquake in Western Australia (at Meeberrie in 1941) were known prior to 1960, whereas over two hundred were located during the relatively short 1960-1965.5 period. No details of seismicity prior to 1900 were given.

In order to improve knowledge of earlier events further investigations were carried out, with the result that additional information was found to be available from three main sources. These were (a) newspaper and Bureau of Meteorology reports of events which happened prior to 1900; (b) seismograms of the Milne-Shaw seismograph which operated at the Perth Observatory during the period 1923-1961; and (C) intensity data contained in the Perth Observatory files covering the period 1923-1961.

Only a few years of the old Milne-Shaw seismograms for the period 1904-1922 could be located. Their quality was so poor, however, that the missing one would probably have been of little use for the investigation of events prior to 1923.

2. DATA FOR THE PERIOD PRIOR TO 1900

The earliest known reference to Western Australian seismicity is a legend to be found in a book of aboriginal legends named "An Attempt to Eat the Moon", by Buller-Murphy (1958). The legends pertain to the area in the vicinity of Busselton, and the one of interest here, entitled "The Great Shaking", gives a vivid description of earthquake (and perhaps volcanic and weather) effects which were accompanied by changes in the topography and sea level. The existence of the legend suggests that a major earthquake which occurred unknown centuries ago was impressive enough to be permanently recorded in the legends of the local population.

The only list of data on earthquakes that occurred before 1900 appears to be that published by the Bureau of Meteorology (1929) in a volume entitled "Rainfall observations in Western Australia (for all years of record up to 1927)". The volume gives very brief descriptions of earthquake reports during 1849-1927, those for the 1900-1927 events being much the same as descriptions extracted from Perth Observatory files by Everingham (1968). The first known map of earthquake reports in Western Australia also appears here. Although the first earthquake listed took place in 1849, the Bureau pointed out that the information was accumulated only after 1878 so that further reports of 1829-1878 tremors may be discovered in the future.

The authors searched newspapers for references to events listed by the Bureau of Meteorology and extracts from these references are listed in the Appendix. Where a newspaper report of a listed earthquake could not be discovered, the details given by the Bureau of Meteorology are used.

Descriptions of three events not listed by the Bureau of Meteorology are also given in the Appendix; of particular interest is the description contained in a log of Earnest Giles' inland exploration journey of 1873.

For this study no attempt was made to search for earthquake reports in every newspaper published before 1900. To locate reports in this manner would be extremely time-consuming and probably inefficient because of the difficulty in reading the archival microfilm copies of the newspapers and because of the haphazard way in which reports were included in these newspapers. Even when the dates of events were known, the authors often found it difficult to locate the reports in the newspapers.

The earthquakes that perhaps caused the highest intensities (probably MM6) prior to 1900 were at Barrow Range (1873) and Geraldton (1885). A one-metre drop in sea level reported to have been associated with the Geraldton event should be further investigated by reference to historical papers from that town.

Localities of the earthquake reports listed in the Appendix are shown in Plate 1.

3. DATA FOR THE PERIOD 1923-1961

Intensity data used for location of epicentres

Because of the experience gained in recent years, it was possible to determine epicentres of most of the Western Australian earthquakes recorded on the Milne-Shaw seismograph by scrutinizing the Perth Observatory files of earthquake reports and newspaper cuttings. For example Carrigy and Main of the University of Western Australia sent out a number of intensity questionnaires for earthquakes that occurred at Bolgart (1952), Yericoin (1955), and Gabalong (1955), and replies to these questionnaires clearly indicated the epicentral regions; in other examples the similarity of reports with those from areas which have been active since 1960 gave a good lead to the epicentral position. Moreover, it was possible to use the S-P time on the Milne-Shaw seismograms converted to epicentral distance (using recently determined travel-times) to confirm epicentres determined from the felt reports.

Fortunately many epicentres could be determined fairly accurately because: (a) most of the events recorded at Perth were in the most closely populated farming region not far east of that city and were large enough to be felt clearly; (b) the focal depths of local events are generally very shallow so that maximum intensities are felt in very localized areas; and (c) reports of frequent loud explosive sounds caused by aftershocks and foreshocks are commonly made from areas within a few kilometres of the epicentre of the main shock.

In some instances the Perth Observatory wrongly reported that a local felt earthquake was recorded on the seismogram, e.g. a distant event recorded at the time a local tremor was felt at Albany on 2 February 1937 was assumed to have caused the shaking at that town. In other instances recordings were weak or indecipherable and did not provide any additional information.

The epicentres are listed in Table 1. Except for the 1946 event to the west of Yallingup all events were in the area east of Perth, and the positions of these epicentres are shown in Plate 2.

Magnitude determinations

Magnitudes were determined in two ways: (a) from intensity information discussed above; and (b) from the Milne-Shaw seismograms. Typical seismograms are shown in Plate 3.

Where there was sufficient information the felt intensities for a given earthquake were compared with those experienced in recent earthquakes of known magnitudes, and for which isoseismal maps have been drawn (see Everingham & Parkes, in prep.). Four magnitudes determined in this manner are included in Table 1 under the heading ML*.

Because the periods of ground motions could not be measured on the Milne-Shaw recordings, the trace amplitudes could not be converted to standard Wood-Anderson amplitudes for determination of local magnitude values. However, using the maximum trace amplitude registered on the Perth Milne-Shaw seismogram and the nomogram of Gutenberg and Richter (1942), relative local magnitudes (ML) of eighteen events were determined. The level of these magnitudes was then adjusted so that the mean value of the four determinations from isoseismals equalled the mean value of the relevant four determinations using the Milne-Shaw records. Results are listed in Table 1. Magnitude values are probably accurate to 0.5 units.

In addition to the above determinations, a body-wave magnitude for the 1941 Meeberrie earthquake was found for comparison with magnitude values found from surface waves and isoseismal data (Everingham & Parkes, in prep.). Results are given in Table 2. The magnitudes determined from the body waves and from the intensity data are greater than those from the surface waves, which tends to confirm Everingham & Gregson's (1969) assumption that the surface-wave magnitude determination ($M_S = 6.8$) was low because the depth of the event was greater than normal.

It is unfortunate that for the one event (3 October 1959) which was recorded at both Mundaring and Perth Observatories before the Milne-Shaw seismograph at Perth was closed down, the recording from Perth was spoilt by traffic noise, and a comparison of magnitudes determined from each instrument could not be made.

4. CONCLUSIONS

As a result of careful inspection of seismic records, newspaper cuttings, and Perth Observatory files for the period 1923-1961, both the epicentres and earthquake magnitudes at 16 previously undetermined epicentres in the zone of seismicity to the east of Perth were determined with reasonable accuracy; also a body-wave magnitude was obtained for the Meeberrie (1941) earthquake.

The zone to the east of Perth is a recognized zone of seismicity along what is known as the Yandanooka-Cape Riche Lineament (Everingham, 1968). Within this zone most of the centres that were active during the period 1923-1961 (shown in Plate 2) have also been active since 1961 (Everingham, 1968).

Pre-1900 newspaper reports of pronounced shaking of the earth at Geraldton (1885), Barrow Range (1873), and Roebourne (1888-1893) are interesting because there has been practically no evidence of activity in these regions since 1900. In earthquake risk analysis, these areas should be considered as active areas.

The 1849 report of shaking in Perth is the earliest known report of a tremor, and in Perth the intensity (MM5?) experienced then was probably not exceeded until 1968, when the Meckering earthquake caused intensities of MM6.

5. ACKNOWLEDGEMENTS

The authors' attentions were drawn to the reports of the 1873 earthquakes in Giles' diary by Dr J. Daniel of the W.A. Geological Survey, and to the Bureau of Meteorology (1929) publication by Mr D. Walker of the Bureau of Meteorology. Their assistance and the services of the archival section of the Library Board of W.A. are gratefully acknowledged.

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TABLE 1

SOUTHWESTERN AUSTRALIAN EARTHQUAKES RECORDED AT PERTH
OBSERVATORY 1923-1961

Year	Date	Approx. Origin Time G.M.T.	Place	Epicentre		Magnitude	
				Lat °S	Long °E	ML*	ML
1940	Dec 18	2145	Beverley- Brookton	32.2	117.2		4.2
1946	Apr 19	2113	West of Yallingup?	(33.5)	(114.5)		5.7
1946	Sep 17	1512	Pingelly?	(32.5)	(116.9)		4.5
1949	May 02	1000	Yericoïn	30.9	116.4		5.1
1949	May 07	1709	Yericoïn	30.9	116.4		4.1
1952	Mar 11	0609	Bolgart	31.3	116.5	4.6	5.1
1954	Nov 27	0836	Talbot Brook?	(32.0)	(116.7)		3.9
1955	Apr 29	0914	Yericoïn	30.9	116.4	5.1	4.7
1955	Apr 29	1949	Yericoïn	30.9	116.4		4.4
1955	Aug 29	0609	Gabalong	30.7	116.4		5.3
1955	Aug 30	1352	Gabalong	30.7	116.4	5.5	5.8
1955	Aug 30	1407	Gabalong	30.7	116.4		4.7
1955	Aug 30	1656	Gabalong	30.7	116.4		4.6
1956	Feb 24	0627	Yericoïn?	(30.9)	(116.4)		4.5
1956	Apr 05	2313	Yericoïn?	(30.9)	(116.4)		4.5
1958	Mar 20	0303	Beverley- Brookton	32.2	117.2	5.2	4.8

NOTES: ML relative determinations from maximum trace amplitude on
NS Milne-Shaw recording at PERTH

ML* magnitude from intensity data

32.2 Accuracy $\pm 0.25^\circ$

(33.5) Accuracy $\pm 0.5^\circ$

(5.7) Magnitude less accurate

TABLE 2

MEEBERRIE (1941) EARTHQUAKE BODY-WAVE MAGNITUDE DETERMINATIONS

Date	Epicentre		T (sec)	Log $\frac{A}{T}$	mb	Magnitude	
	Lat°S	Long°E				M'S	MS
1941 Apr 29	26.8	116.1	4	4.1	7.1	7.3	6.8

mb = $mb(MUN) + 0.4$, where $mb(MUN)$ is determined using Everingham's (1968) curve B for attenuation function

M'S = derived from $M'S = 1.59 \text{ mb} - 3.97$

MS = Gutenberg and Richter's (1954) determination

A = ground amplitude

T = period

APPENDIX

EARTHQUAKE FELT REPORTS, 1849 - 1900

1849 AUGUST 4, PERTH

Inquirer, 8 August 1849. Page 3, Column 1, Para. 3.

'On Saturday last, about a quarter past four o'clock a.m., several of the inhabitants of Perth were awakened by what they conceived to be a slight shock of an earthquake; it was momentary, but quite sufficient to make the glasses ring, and to shake the articles of furniture in the rooms, such as the bedsteads etc. The same phenomenon was observed at Fremantle and Guildford. This is the first time such an occurrence has been noticed in Western Australia, which bears no trace of having been recently a volcanic country, and is not therefore liable to those disturbances of the earth's surface felt in existing volcanic regions. If this were a slight shock, it will most probably be found to be nearly simultaneous with one of greater severity that has happened elsewhere, some great distance away, of which it was a prolongation and perhaps the terminative effect. We cannot hear that any damage was effected, or indeed that any trace of its visit has been left to substantiate the fact of a shock having occurred. The weather at the time was perfectly calm, although there were several heavy showers during the night, and some thunder and lightning'.

Perth Gazette, 10 August 1849. Page 2, Column C.

'Early on the morning of Saturday last, shortly after four o'clock several persons in Perth, Fremantle and Guildford, were aroused from their slumbers by what is supposed to have been a slight shock of an earthquake, but whatever nature the mysterious visitant was of, a motion of the earth was very perceptible, and sufficiently strong to shake the houses and the articles of furniture in them, particularly the bedsteads, which appear to have been special articles of visitation, causing some of the occupants to quit them in haste; report says that one gentleman looked under his bed to see if the earthquake was there, and that another peeped out of his window to see which way it was going'.

1873 DECEMBER 15, BARROW RANGE

Giles's Diary, Vol. 1. Ch. V. pp. 240-242.

'I was in a state of bewilderment at the thought of the water having so quickly disappeared, and I was wondering where I should have to retreat to next, as it appeared that in a day or two there would literally be no water at all. I felt ill again from my morning's walk, and lay down in the 110° of shade, afforded by the bough gunyah which Gibson had formerly made.

I had scarcely settled myself on my rug when a most pronounced shock of earthquake occurred, the volcanic wave, which caused a sound like thunder, passing along from west to east right under us, shook the ground and the gunyah so violently as to make me jump as though nothing was the matter with me. As the wave passed on, we heard up in the glen to the east of us, great concussions, and the sounds of smashing and falling rocks hurled from their native eminences rumbling and crashing into the glen below. The atmosphere was very still today, and the sky clear except to the deceitful west.

Gibson is still so ill that we did not move the camp. I was in a great state of anxiety about the water supply, and Tietkens and I walked first after the horses, and then took them up to the glen, where I was enchanted to behold the stream again in full flow, and the sheets of surface water as large and as fine as when we first saw them. I was puzzled at this singular circumstance, and concluded that the earthquake had shaken the foundations of hills, and thus forced the water up; but from whatsoever cause it proceeded, I was exceedingly glad to see it. To-day was much cooler than yesterday. At three P.M., the same time of day, we had another shock of earthquake similar to that of yesterday, only that the volcanic wave passed along a little northerly of the camp, and the sounds of breaking and falling rocks came from over the hills to the north-east of us.

Gibson was better on the 17th, and we moved the camp up into the glen where the surface water existed. We pitched our encampment upon a small piece of rising ground, where there was a fine little pool of water in the creek bed, partly formed of rocks, over which the purling streamlet fell, forming a most agreeable little basin for a bath'.

1873 DECEMBER 23, BARROW RANGE

Giles's Diary. Chapter VI, p. 247

'... rocks above us so that he and Jimmy had need to defend themselves with firearms. Our bough-house was a great protection to them, and it appeared also that these wretches had hunted all the horses away from their feeding ground, and they had not been seen for three days, and not having come up to the water all the time we were away. At four P.M., we had our afternoon earthquake, and Gibson said the shock had occurred twice during our absence'.

1878 MARCH 17, NORTHAM

Northam

'A slight earthquake shock was felt here and for a few miles north of the town at 4 p.m.'

1885 JANUARY 5, GERALDTON

Morning Herald, 7 January 1885, Page 3, Column F.

'I have to report that a slight shock of earthquake occurred here last night, somewhere about 10 o'clock. The ground was sensibly shaken and all the windows and doors of our houses by their rattling, slamming and shaking indicated that an earthquake was occurring. The sensation produced resembled very much that which is occasioned by the rattling of the wheels of a vehicle or the still more rumbling noise of a succession of railway carriages in motion'.

Victoria Express, 7 January 1885. Page 3, Column A.

'About five and twenty minutes past ten on Monday evening the inhabitants of Geraldton were startled - many from their slumbers - by a severe shock of earthquake. The shock appeared to travel from a north-easterly direction and was preceded by a peculiar subterranean murmur lasting some seconds. This was followed by a tremor of the earth, which shook buildings and their contents in a most alarming manner. The shock from its first premonitory murmur to its complete subsidence must have lasted fully twenty seconds, and was of exceptional severity. Walls rocked,

casements, and the contents of rooms rattled loudly, and a gentleman informs us that his bird was thrown off its perch. It aroused almost everybody in the town and for a time caused considerable consternation. There was no electrical disturbance in the air, the night being clear, calm and chilly for the time of year. Shortly after the shock the sea subsided fully three feet in a quarter of an hour, but there was no subsequent rush of the tide, the water rising gradually. According to the cable news we publish in another column the earth appears to have been in a state of great disturbance during the past few days in Europe, and we anticipate receiving further intelligence of a very heavy earthquake in some parts of the world not very remote from ourselves.

Further particulars are to hand concerning the shock, and we learn from one of the men in charge at Point Moore Lighthouse that the shock was so severely felt there that he was almost thrown off his feet. Mr du Boulay informs us that the shock was also felt with much severity at his residence at Woorrie. A correspondent at Northampton telegraphs to us that the houses in the town were violently shaken and that a number of people were greatly frightened but no damage was done.

The shock does not appear to have been felt at the Gascoyne as our Carnarvon correspondent reports nothing unusual has occurred here, and the weather is fine and considering the season moderately cool. Up to the time of going to press we had received no information from Perth as to whether the shock was felt there'.

West Australian, 7 January 1885

'A severe shock of earthquake occurred here about half past ten o'clock last night, preceded by a strange subterranean rumbling, and lasting about ten seconds. Houses were violently shaken by the tremor and walls rocked, causing much consternation. The sea, also, subsided about three feet in the course of a quarter of an hour, and then gradually returned to its ordinary level. The weather at the time was clear and the temperature cold'.

West Australian, 12 January 1885

'From Geraldton a correspondent writes: - "At about 10.45 p.m. on the 5th instant, we were all greatly astonished by an earthquake shock which lasted for fully 30 seconds. So great was the alarm excited that one lady fainted, others shrieked, and many persons rushed into the streets in great consternation. I, with others, was in Hosken's Hotel at the time; the building

was shaken from top to bottom, and I must confess I was really startled, while the amazement depicted upon the countenances of my companions was a sight to see. We hastened to the outer door whether persons rushed from all parts of the house to inquire the cause of the extraordinary vibration of the building. The shock seemed to come from a north easterly direction and some people declare that it was preceded by a rumbling noise. There is no doubt the shock has been generally felt in this district, and we may expect to hear of volcanic disturbances of some magnitude elsewhere''.'

1885 MARCH 17, TABLE MOUNTAIN (UPPER GASCOYNE)

A slight but distinct earthquake shock occurred at 7.40 p.m. A rumbling sound like distant thunder was audible for nearly 10 seconds.

1885 MAY 8, GERALDTON, DONGARA, GREENOUGH

West Australian, 11 May 1885

'A very heavy shock of earthquake took place at six o'clock this morning and lasted fully three quarters of a minute, in the direction of East to West. Persons were thrown from one side of their bed to the other, houses rocked violently and the disturbance altogether was of an extraordinary and alarming kind. The weather was very overcast and threatening. It is reported from Greenough that the shock was very heavy there, displacing plaster at the police station. Giles of the eastern valley reports that this house rocked tremendously and was nearly thrown down'.

Morning Herald, 11 May 1885. Page 3, Column B

'If we are destined to chronicle more of earthquakes in our colony similar in character and duration to the one just reported to have occurred at Dongara, our colony will be gaining for itself the reputation that New Zealand has for earthquakes. The last earthquake reported as having taken place at Dongara, on the 8th instant, is said to have been the most severe and alarming of any that have yet taken place in or about that locality'.

Victoria Express, 16 May 1885. Page 3, Column B

'Mr L.C. Burgess of Oakabella writes, "On Friday morning about 6 a shock of earthquake occurred travelling apparently from the S.S.E. I at first thought it was the cook coming in with my coffee the door being shaken as if by someone's hand. I was dressing at the time, and the sundries on my dressing table and wash stand rattled violently. Several persons on my station felt the shock''.'

'Mr Logue also writes in informing us that the shock of earthquake was felt with alarming distinctness and from all quarters we hear of its severity'.

1887 APRIL 24, YORK

A slight shock was experienced at York at 9.20 p.m. Residents stated that the buildings shook perceptibly. In Perth many people noticed a rumbling and trembling about the same time. The shock was also felt to the coast.

1888 SEPTEMBER, COSSACK

An earthquake shock occurred.

1888 SEPTEMBER 27, NORTHAM

West Australian, 28 September 1888. Page 3, Column G.

Northam, 27 September

'A slight but distinct shock of an earthquake was felt here on Tuesday about 2 p.m. accompanied by a loud report. Windows were distinctly heard to rattle and the vibration was apparent to many outlying farmers who confirm the report'.

1890 DECEMBER 7, COSSACK, ROEBOURNE

West Australian, 9 December 1890. Page 3, Column F

'The shock of an earthquake was felt about half past two yesterday afternoon over Roebourne and Cossack. News has been received that it was also felt thirty miles to the eastward, and twenty miles to the westward. Most likely it was felt all over the district. The shaking lasted for half a minute, and was followed by a rumbling sound lasting for a minute. The sound increased to a loud roar, then died away again. It resembled the approach of a passing train. It woke several people who were sleeping at the time.

(The Colonial Secretary has received the following telegram from the weather observatory station at Cossack. "Cossack, Dec. 8, shock as if caused by an earthquake felt here about 2.30 p.m. yesterday. Doors and windows of dwellings considerably shaken. Shock felt for about 50 seconds. Direction of report, N.W. to S.E.")'.

1893 APRIL 27, ROEBOURNE

North West Times, 29 April 1893. Page 2, Column D.

'An earthquake shock of about twenty seconds duration, occurred on Thursday morning a few minutes after 6 o'clock.'

West Australian, 29 April 1893. Page 3, Column O.

'A shock of earthquake was experienced here yesterday morning at a few minutes after six o'clock, lasting about twenty seconds.'

1896 APRIL 20, KARRIDALE

West Australian, 21 April 1896. Page 4, Column G.

'The Inspector of telegraphs (Mr W.E. Snook) last evening received the following message from the postmaster at Karridale: - "At 8.15 this evening a loud explosion was heard in a north-westerly direction. The explosion was accompanied by earth tremors. The buildings shook very perceptibly.'

West Australian, 22 April 1896. Page 5, Column A.

'A severe earth tremor, accompanied by violent explosions, was felt here about eight o'clock last night, and caused much alarm among the inhabitants. The shock seemed to travel from south to north and lasted for about fifty seconds.

(The gist of this telegram appeared in our "News and Notes" column yesterday morning. - Ed.).'

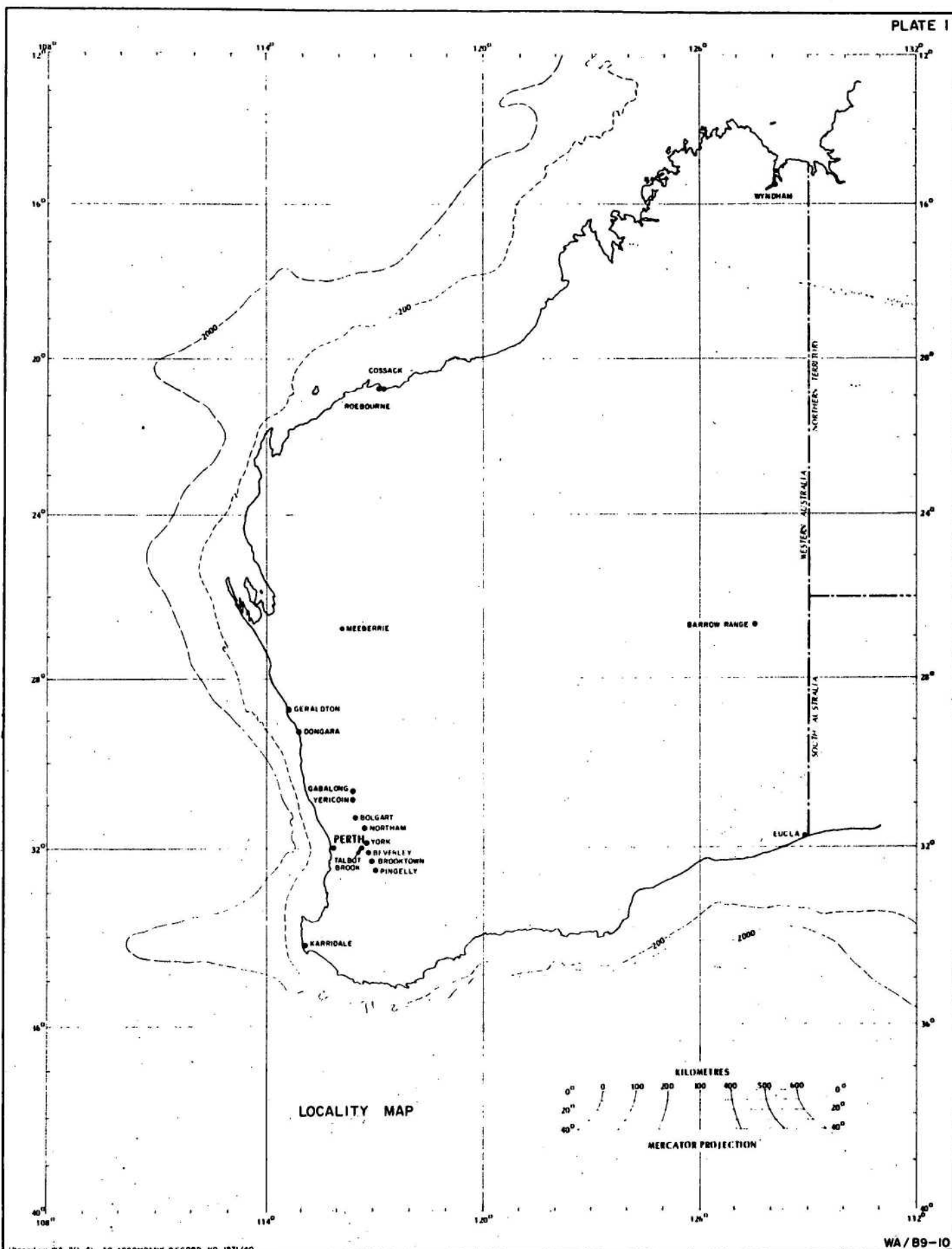
1896 JULY 3, EUCLA

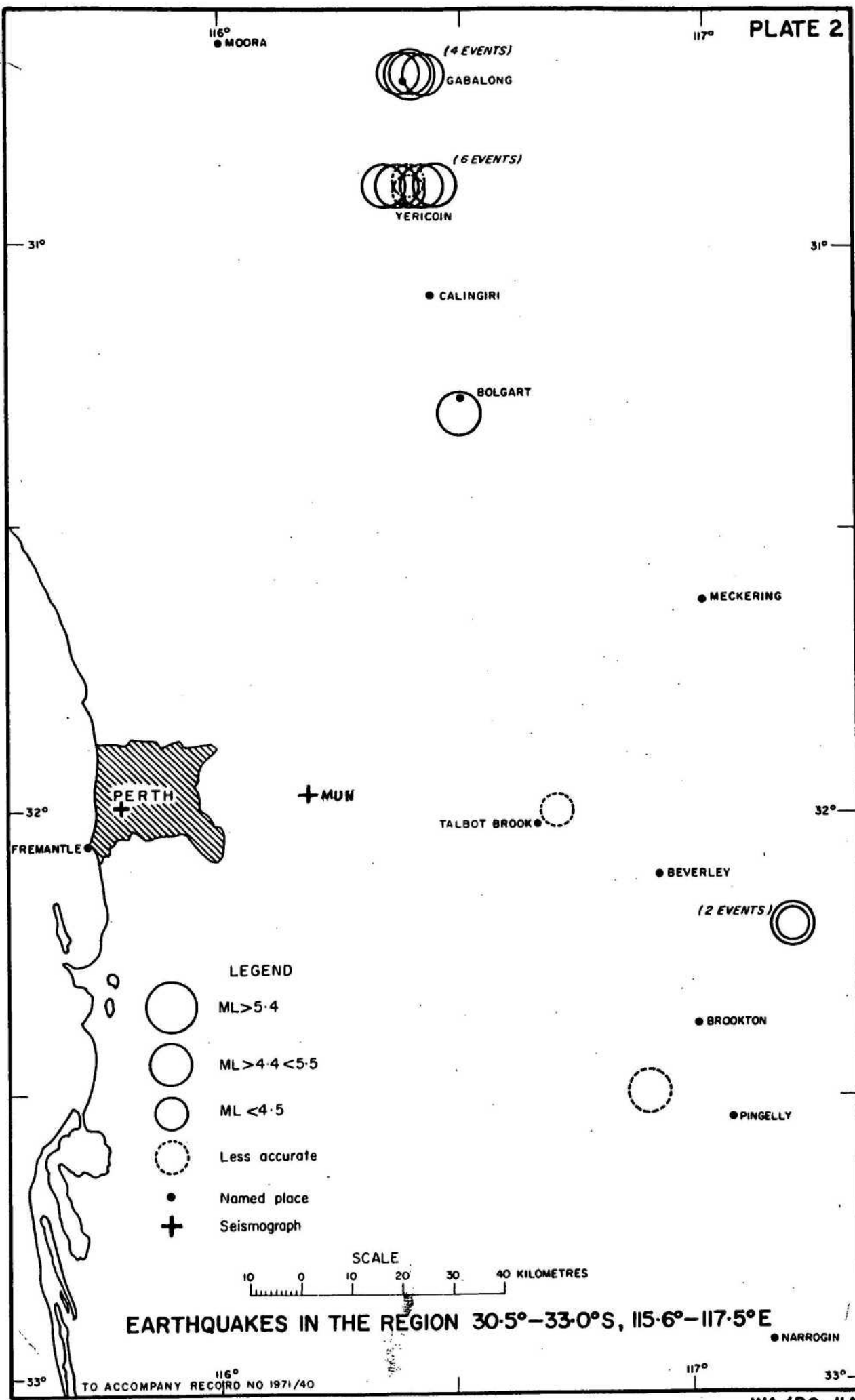
A slight earthquake shock was felt about 8 p.m. and lasted 60 seconds; the telegraph station was severely shaken.

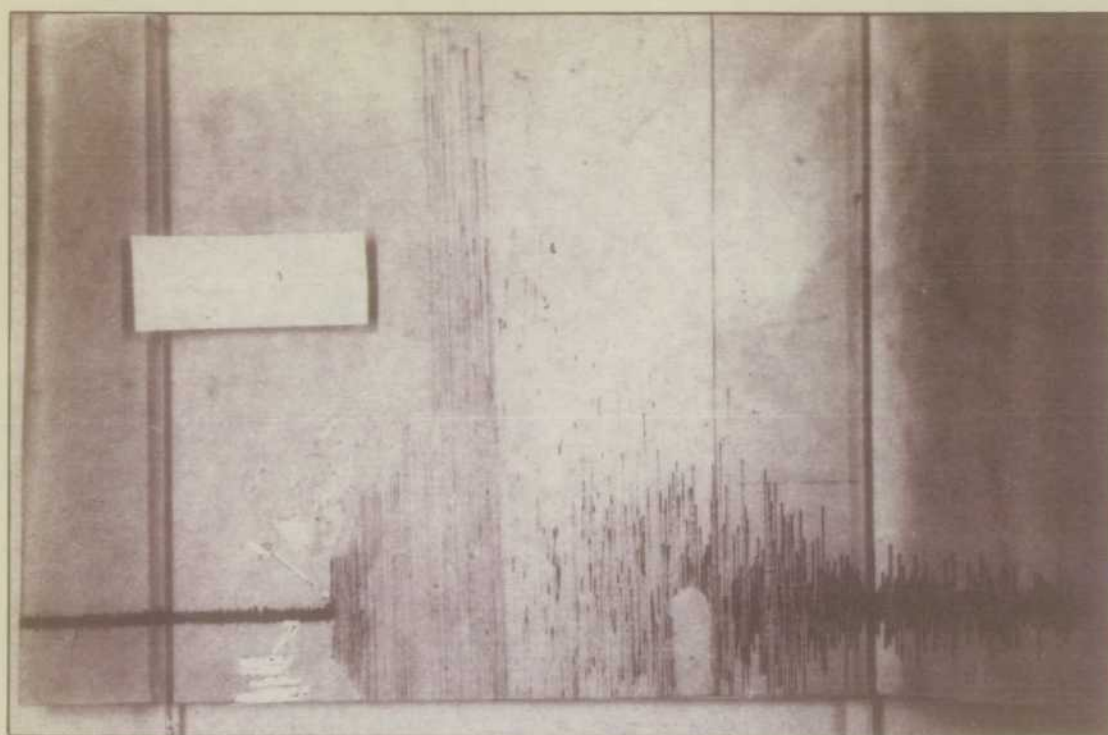
1897 OCTOBER 14, WYNDHAM

West Australian, 15 October 1897..Page 5, Column 1

'A telegram was received at the Perth Observatory yesterday from the resident Magistrate at Wyndham stating that at about 2 o'clock that morning a shock of earthquake took place in that town. The vibrations of the earth travelled East to West and lasted about ten seconds. No rumbling was noticed.'

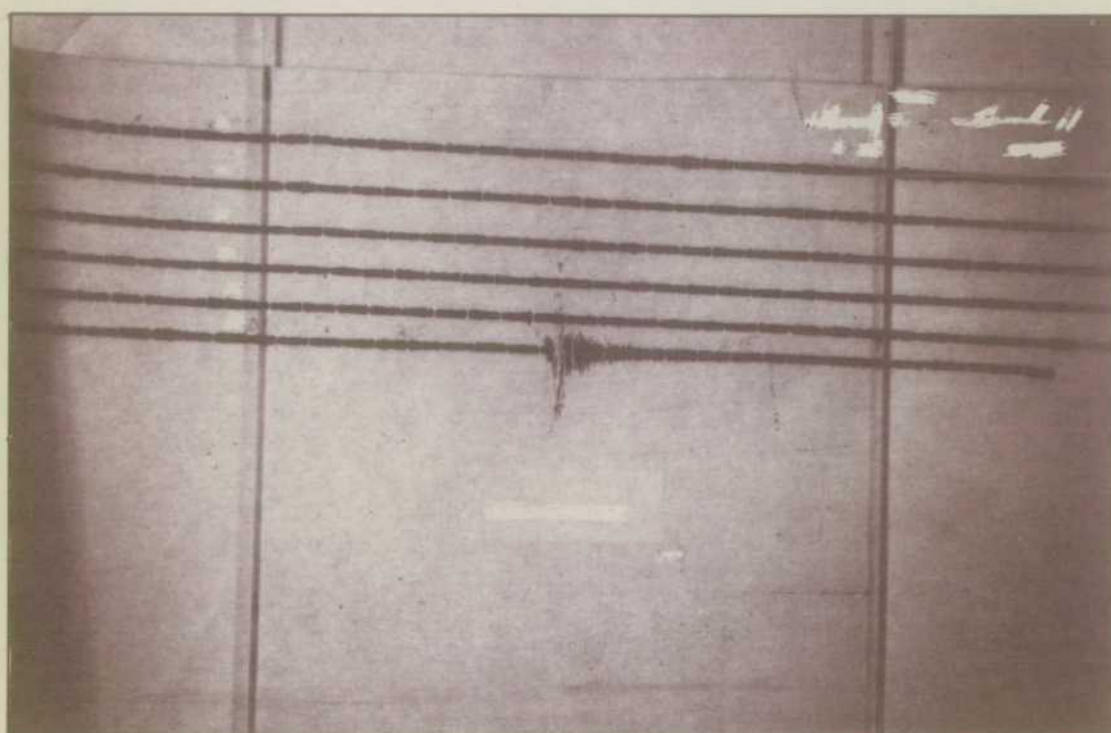






29 April 1941

$\Delta = 575$ km



11 March 1952

$\Delta = 100$ km

TYPICAL MILNE-SHAW RECORDS