DEPARTMENT OF
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1973/154

MUNDARING GEOPHYSICAL OBSERVATORY ANNUAL REPORT 1972

by

P.J. Gregson and R.S. Smith

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SUMMARY

Basic programs in geomagnetism ionospherics and seismology were continued at the Mundaring Geophysical Observatory during 1972. The main instruments were an Eschenhagen normal-run magnetograph, and IPSD Type IIIE ionosonde, and a Worldwide Standardized Seismograph system.

Seismographs were operated at Kalgoorlie and Meekatharra; the seismograph at Karratha was withdrawn in August and a new seismograph installed at Marble Bar in October. The seismograms from the seismograph at Kununurra owned by the WA Government were analysed. Three accelerographs were operated intermittently, at Mundaring (1) and Meckering (2).

The annual earthquake lists show details of 105 Western Australian earthquakes; 85 occurred in the southwest zone, but the increase there was not significant. Activity continued, for the third year, in the Lake Mackay region.

The observatory provided 3 field seismograph parties as a contribution to the Trans-Australian Seismic Survey in October.

1. INTRODUCTION

The Mundaring Geophysical Observatory opened on 18 March 1959 and now controls operations at Mundaring (seismological and ionospheric recording), Gnangara (magnetic recording), Kalgoorlie, Meekatharra, and Marble Bar (seismological recording). Descriptions of the observatory and an outline of activities there to the end of 1971 have been given in previous records, (e.g. Gregson 1972); and principal events in the observatory's history are given in Appendix 1. Discussion of non-routine projects is brief, as details will be reported separately.

2. STAFF AND VISITORS

Observatory staff are listed in Table 1, and other personnel associated with the observatory's operations in Table 2. Staff absences, for reasons other than recreation leave, are summarized in Table 3, and conferences attended or addresses given in Table 4.

P.J. Gregson was appointed to the Western Australian Earthquake Advisory Committee in May.

R.S. Smith recommenced duty on 6 July after extended leave while holding an appointment as Production Assistant with the International Seismological Centre (ISC), Edinburgh. E.P. Paull acted as Geophysicist Class 2 during Mr. Smith's absence.

M.J. Robertson and J.A. Major, Geophysicists Class 1, relieved for short periods during the year (Table 1).

Visitors to the observatory are listed in Table 5.

3. GEOMAGNETISM

Normal magnetograph

The Eschenhagen 20 mm/hour magnetograph continued in operation at Gnangara. Twenty hours of recording trace were lost owing to a break in the recording lamp circuit. There were several days when traces were faint early in the year. This was caused by a faulty potentiometer in the lamp control circuit.

Adjustments were made to the H and D variometers on 17 February to reduce the parallax between the normal time marks and the hour lines. As a result of the adjustments the H ordinate increased by 65 nT, and the D ordinate decreased by 14 minutes. The H ordinate was decreased by 58 nT on 8 March as the trace was too near the top of the magnetogram. There were no other large H and D baseline or scale value changes during the year.

An adjustment was made to the Z variometer on 17 February to increase the trace ordinate in order to reduce the number of negative ordinates. After an abrupt trace shift of 8 nT on 27 February it was suspected that the variometer prism was loose. On 8 March the variometer was opened and the prism support tightened. During this work the recording magnet was bumped and the scale-value increased from 5.6 to 7.0 nT/mm. Adjustments were made on 13 and 15 March during which the scale-value was reduced to 6.1 and 5.1 nT/mm respectively. Both adjustments were accompanied by baseline value changes.

From then until mid-July the scale-value drifted to 5.8 nT/mm and the baseline value decreased numerically by about 35 nT. The recording magnet was removed and the agates cleaned on 7 June in an effort to stop the drift and both parameters became stable after about mid-July.

The standard deviations of the observed baseline and scale values from adopted values were:

Element	Baseline value	Scale value
D	0.23 minutes	
H	2.6 nT	0.02 nT/mm
Z	1.5 nT	0.05 nT/mm

Z values between 17 February and 21 July were not used in calculation of the standard deviation because of the erratic behaviour of the z variometer and BMZ 120 during this period.

Magnetograph tests

Temperature coefficients. Least-squares analysis of the 1972 H and Z baseline data confirmed the coefficients in use (QH = 0.4 nT/°C and QZ = 3.2 nT/°C).

Orientation. Tests made on the Eschenhagen magnetograph in February showed that the orientation of the H and D magnets (N poles) were E 0.4° and N 0.3° W respectively. The reference meridian was 03.1°T and the value of H was 23572 nT. These results were compatible with 1971 results.

The Z magnet N pole was 0.2° up (above the horizontal) which was compatible with 1970 results. A further test was made on the Z variometer on 15 March after adjustments. The magnet N pole was 0.2° down.

Scale values. A magnetograph calibrator was used in conjunction with Helmholtz coils to determine H and Z scale values once per week. From 9 February to 8 March the calibrator was out of service owing to a component failure. One observation of the D scale value using the calibrator and a Helmholtz coil was made in February. The value determined was 1.07 minutes/mm.

Magnetometers

Magnetometers in use throughout the year were Askania declinometer 509319, QHM 291, QHM 292 and BMZ 120; QHM 293 was returned to service in June after repairs at Rude Skov.

Baseline values calculated from readings of BMZ 120 suddenly decreased numerically by about 40 nT from 3 May. As no sudden changes were evident on the variograph traces it was assumed that a change had occurred in the BMZ readings. Damage may have been caused when the BMZ was moved at this time during intercomparison measurements, but if so the damage was not obvious.

From 27 June total intensity (F) measurements, using an Elsec proton precession magnetometer (PPM 329) were made weekly. The values of F were combined with H values derived from the magnetograms to keep a check on Z baseline values derived from BMZ 120. The PPM results confirmed that a large change had occurred in the correction to BMZ 120. Accordingly baseline values for the period 1 May to mid-July were ignored and a linear drift of baseline values was assumed. From mid-July the BMZ readings became consistent and the correction had stabilized at the pre-May value (see preliminary corrections).

Comparisons

Comparisons between the observatory QHMs and the BMR standard 460 series were made in March. The observatory QHM 292 was compared with QHM 293 when the latter was returned from Rud Skov in June.

13-16 March:	Simultaneous observations	
	H.460-H.292 = -35 ± 2.4 nT	(4 observations)
	H.461-H.292 = -30 ± 0.5 nT	(4 observations)
	H.462-H.292 = -34 ± 1.8 nT	(4 observations)
	H.460-H.291 = -28 ± 0.7 nT	(4 observations)
	H.461-H.291 = -24.5 ± 1.1 nT	(4 observations)
	H.462-H.291 = -28.5 ± 1.7 nT	(4 observations)
7-19 June:	Simultaneous observations	
	H.293-H.292 = -35 ± 1.0 nT	(8 observations)
	H.293-H.291 = -26 ± 2.1 nT	(8 observations)

The regional magnetic field instruments QHM 305 and BMZ 211 were compared with observatory instruments, and QHM 306 (returned from Rude Skov after replacement of fibre).

5-9 May:	Simultaneous observations	
	H.292-H.306 = +34 ± 1.7 nT	(6 observations)
	H.291-H.306 = +26 ± 2.1 nT	(6 observations)
19-27 June:	Baseline value differences	
	H.305-H.306 = +2 ± 2.2 nT	(10 observations)
	H.291-H.306 = +25 ± 1.2 nT	(10 observations)
	Z.120-Z.211 = -86 nT	(4 observations)

Elsec proton magnetometers 271 and 416 (from the WA Institute of Technology) were compared on three days in January. The difference in average count was less than one.

Preliminary corrections. Those used throughout the year were:

(a) QHM 291: -23 nT; QHM 292: -32 nT;
QHM 293: 0 nT; (from June).

(b) BMZ 120: +226 nT.

(c) Askania declinometer 509319 (circle 508135): + 0.5 minutes.

Accessory equipment

The Askania horizontal intensity visual recorder at the Mundaring office was operated throughout the year.

A normal-run La Cour variograph was installed at Mundaring by Antarctic trainees and operated for short periods as part of their training program.

Data reduction and publication

Data distribution and mean hourly value reduction continued as for 1971.

Monthly and annual mean values of H, D, Z, and F, and mean K-index values at Gnangara for 1972 are listed in Table 6. The field values were derived from the ten local quiet days of each month, by scaling one ordinate for each component from each magnetogram. Annual values of all components since 1962 compiled by the HQ Group are shown in Table 7.

Recent trends in secular variation for H, D, and Z continued with H decreasing about 35 nT, D becoming more westerly by about 3 minutes, and Z decreasing numerically by about 5 nT.

Miscellaneous requests attended to were primarily for magnetogram copies and information on the geomagnetic field in Western Australia.

4. IONOSPHERICS

Equipment

The quarter-hourly sounding schedule was continued throughout the year using a model 3E ionosonde supplied by the Ionospheric Prediction Service Division (IPSD), Department of Science.

Nearly 460 hours of record were lost during the year. Component failure (410 hr) continued to be the main cause. Other causes were: film jamming and operator error, 30 hours; and installation of aerial platform, 15 hours.

Data distribution and publications

Scaling procedures continued as for 1971. Hourly values and monthly median values of fmin, fEs, fbEs, M(3000)F2, FxI, and M(3000)I were computer-listed for BMR by the IPSD. These listings are continuous with the IPS-D series.

In addition, monthly median and f-plots of F2 and M(3000)F2 were published currently by the U.S. Department of Commerce in their Ionospheric Data Series CRPL-FA.

Monthly medians of the noon value of foF2 were sent by telegram to the International Radio Consultative Committee (Geneva) for the determination of the index IF2.

5. SEISMOLOGY

Seismograph stations

The Western Australian network of seismograph stations was extended by the establishment of a station at Marble Bar on 12 October 1972. Details of instruments and position are given in Table 8. This station replaced the low gain station at Karratha which was dismantled on 31 July 1972.

The State Public Works Department (PWD) station at Kununurra (KNA) was upgraded by the installation of a three component short-period seismograph on 28 February. Details of instruments are given in Table 9. KNA seismogram analyses were continued by the Observatory.

Changes in instruments at other stations were confined to control equipment replacements.

The numbers of events reported by each station were:

MUN 1132; KLG 819; MEK 1122; KAA 237 (7 months);
KNA 1843 (10 months); MBT 233 (3 months); Total - 5386.

Mundaring. Seismographs at this station ran satisfactorily throughout the year and very little record was lost.

The WWSSN frequency standard had to be replaced in June; otherwise the control console continued to operate well and faults were minor. The long-period north-south galvanometer broke on 8 February and was replaced. Repairs were made to the heater regulator for the long-period seismometer, and the mirror in a timemark assembly was re-cemented in place.

The Benimore seismograph continued to operate satisfactorily except during two short intervals when the drive assembly needed attention.

Kalgoorlie. The three-component seismograph operated throughout the year. Radio reception continued to be a problem and plans are being made to install a more effective aerial.

Failures in three EMI clocks were the main cause of record loss. Prolonged mains power failures resulted in record loss on two occasions.

Meekatharra. Apart from intermittent 50 Hz interference on the galvanometer for a few days, this station ran very well.

Karratha. Microseisms made seismogram interpretation difficult from time to time. The station was dismantled on 31 July as the PWD required the room in which the seismograph was housed.

Marble Bar. The seismograph operated satisfactorily although some difficulty was experienced with variations in the power supply for the recorder drive, probably owing to an overload of the EMI clock output. The fault was corrected by running the recorder amplifier directly from the mains. The seismograph was calibrated at installation (Pl. 1).

Kununurra. The three-component seismograph operated well from February till October when a change in operators resulted in considerable loss of record, and the seismograph became grossly out of adjustment.

Normal operation recommended on 15 November after adjustments by observatory staff. Operating procedures were demonstrated to PWD staff.

The seismograph was calibrated at installation (Pl. 2).

30-day recorder. This instrument did not operate satisfactorily during the year. The galvanometer was returned in March after being repaired in U.S.A. However, the equipment was plagued with faults ranging from mechanical failures in the recording equipment to overheating in the control equipment. A small air conditioner was installed in the recording cab to overcome the latter problem.

The recorder was ready for field use by the end of December.

Explosion seismology

On 25 October 80 t. of explosives was detonated near Kunanalling and Mount Fitton (S.A.) as part of the Trans-Australia Seismic Survey (Drummand & Finlayson, in prep.). The seismic waves from the blasts were recorded at Western Australian seismograph stations and field stations. The Kunanalling blast was recorded at Mundaring (484 km), Kalgoorlie (39 km), Meekatharra (513 km), and Sandstone (341 km). The Mount Fitton blast was recorded at Mundaring (2237 km), Meekatharra (2092 km), and Sandstone (1984 km). Marble Bar, Kununurra, and Kumarina, which were recording during both blasts, did not show any phase arrivals. Observatory staff recorded the shot instant of the Kunanalling blast.

Accelerographs were set up at distances of 100, 200, and 400 metres from the Kunanalling blast. Recordings were made on all three instruments. Unfortunately an attempt to manually trigger the accelerographs five seconds before the blast failed and they were triggered by the first arrival. The internal time source also failed and operated only intermittently during the recording.

Accelerographs

Two accelerographs were operated at Meckering and one at Mundaring intermittently during the year. Several repairs were made to a faulty clutch, and a jamming cassette; a pin hole had to be enlarged.

All three accelerographs were removed from normal service at the beginning of September to prepare them for the Kunanalling blast. Two were returned to service at Meckering on 22 November.

Two MO2 accelerographs were installed for the PWD at the Ord River Dam (Kununurra) on 29 February and 16 November. One was installed on the top of the dam wall and the other at its base.

Details of all accelerographs are given in Table 10.

Apart from those of the Kunanalling blast no useful accelerograms were obtained during the year.

Seismicity

Earthquake lists. 1972 earthquakes are listed in Tables 11 and 12.

The larger earthquakes (Table 11 and Pl. 3) are those that were well recorded at more than one station and generally have a magnitude ML = 3.0 (mB about 4) or greater. Epicentres are given to one or two decimal places of a degree according to their accuracy. Some of the epicentres in the northwest are shown in brackets as their accuracy is less than 0.1° because of the uncertainty in travel times in this area.

Epicentres were initially determined graphically. Where an earthquake was recorded at four or more Australian stations, epicentres were determined by the HQ Group using a computer program for the relocation of earthquakes.

Earthquakes in the southwestern part of the State

All earthquakes which had ML = 2.0 or greater and which occurred in the southwest, plotted in Plate 4 zone of seismicity are listed in Table 12.

Activity in the central part of the zone was slightly but not significantly higher than in the previous two years. There were nine earthquakes with ML greater than 2.9 and about 75 minor tremors.

Earthquakes in the northern part of the state. Activity continued in the Lake McKay region. Five earthquakes with ML greater than 3.3 were recorded.

Activity was evident in the Marble Bar/Port Hedland region. Insufficient data were available to determine epicentres except for one significant earthquake which occurred on 12 April (20.9S, 120.4E) with magnitude m = 5.2.

An earthquake, m = 5.4, occurred 30 km northeast of Gascoyne Junction on 21 October. The area is sparsely populated and the maximum intensity felt was MM = 5, 70 km from the epicentre.

Microtremors

Microtremors were reported from Ongerup and Dumbleyung. Areas which have previously reported microtremors are Mukinbudin, Talbot Brook, Pingelly, Mawson, and Jacobs Well.

These tremors are very localized, shallow, and may have magnitudes less than zero. Often they occur for periods of several weeks. Although small they can cause considerable concern to the nearby residents. They are often associated with large rock outcrops.

Seismic coverage

The area of Western Australia from which seismic events of low magnitude can be detected was increased considerably during the year. This increase was the result of the establishment of stations at Marble Bar, and Manton (N.T.). McGregor & Zeitlhofer, in prep.), and by the upgrading of Kununurra.

Plates 5 and 6 show areas in Western Australia from which seismic events of magnitude (ML) = 3.0 could clearly be detected, as at 1 January and 31 December, 1972 respectively. The radii of perception for each station was determined using the following guidelines:

(a) Phases are recorded clearly enough for the first arrival to be picked routinely during preliminary analysis.

(b) The minimum centre-to-peak trace amplitude is 1 mm.

(c) The working magnitude for the station is that at 0.5 s.

(d) The Richter magnitude formula and attenuation factors apply.

The area of perception common to three stations is less than 1% of Western Australia.

There are several deficiencies in station distribution evident from Plate 6. The most significant of these are:

(a) Almost total lack of perception capabilities for the large area on the eastern side of the state from the north to the south coast. This includes the Lake McKay and Broome regions.

(b) The lack of perception in the area of N.W. Cape and Carnarvon. Events in this area are not uncommon.

(c) Insufficient control in the important southwest zone.

The following program for 1973 is expected to reduce these deficiencies:

(a) The installation of a high-gain short-period station at Giles (headquarters group).

(b) The installation of a short-period station near Wagin.

(c) The resiting of the Kalgoorlie short-period vertical component to enable the sensitivity to be increased.

(d) The transfer of the Kalgoorlie short-period horizontal seismometers to Meekatharra.

(e) The resiting of the Marble Bar seismometer to enable the sensitivity to be increased.

Area of Perception of Events ML = 3.0

Western Australia

	1 Jan 1972	31 Jan 1972	Anticipated 31 Dec 1973
3 stations	1%	1%	4%
2 stations	7%	15%	27%
1 station	38%	50%	52%
TOTAL	46%	66%	83%

Data distribution and publication

Data distribution continued as for 1971 until August. From September preliminary data were distributed monthly instead of weekly, and the distribution of a final monthly bulletin ceased. All recipients previously receiving the final monthly bulletin are receiving the preliminary monthly bulletin if they so desire.

From January, punched cards containing data from final analyses were prepared in Perth in lieu of headquarters. The punched cards were sent to headquarters for the preparation of an Australian time sorted bulletin and for transmission on magnetic tape to the International Seismological Centre (ISC), Edinburgh. At 31 December, data to the end of June 1972 were completed.

Miscellaneous requests for seismogram copies, phase data, and information on W.A. seismic activity were attended to.

Reports of seismological interest were prepared during the year by Denham, Simpson, Gregson & Sutton (1972); Gregson, Everingham & Denham (in prep.) and Gregson, McCue & Smith (1972).

6. NOTES ON WORKS PROJECTS

The following new works were carried out during the year:

(a) A six-foot cyclone wire security fence and gates were erected across the entrance to the Weir site (January).

(b) Automatic BCF fire extinguishers were installed in the seismic valut control room, ionospheric hut, Gnangara control hut, Kalgoorlie seismic hut (January), and power house (June).

(c) An inspection platform was installed at the top of the ionospheric mast (February).

(d) A 10KVA standby generator was installed at the Weir site (May).

(e) Floor tiles were laid in the equipment room at the office and in the Gnangara control hut (October).

7. ACKNOWLEDGEMENTS

The assistance of the Regional Director and staff of the Department of Supply, Perth and Department of Civil Aviation officers (for outstation operation) - Messrs. D. Allen of Kalgoorlie, and E. Tromans of Meekatharra - is acknowledged. The assistance of the State Public Works Department and the Marble Bar Shire for housing the Karratha and Marble Bar seismographs is greatly appreciated. The assistance of Mr H. Ausburn and G. Edwards in changing records at Karratha and Marble Bar is acknowledged. Punching of ISC cards was carried out by the Bureau of Census and Statistics (Perth) by arrangement with the Deputy Commonwealth Statistician.

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APPENDIX 1

PRINCIPAL EVENTS

MUNDARING GEOPHYSICAL OBSERVATORY
1957-1972

1957	May		Geomagnetic recording commenced at Gnangara (La Cour).
1959	Mar	18	Transfer of observatory from Watheroo to Mundaring.
1959	Apr	3	Ionospheric recording commenced (Type 2 ionosonde).
1959	Jul	30	MUN seismograph recording commenced (Benioff).
1960	Mar	- 1960 Oct	Atmospheric noise recording (for CSIRO).
1960	Apr	30	Eschenhagen normal magnetograph replaced La Cour at Gnangara.
1960	May	1	Cossor ionosonde replaced Type 2.
1960	June	22	Absolute magnetic observations commenced in new absolute house.
1962	June		WWSS system commenced operation at MUN.
1963	Apr	19-1963 Dec 17	GRV seismograph operation.
1963	May	30-1963 Dec 19	NGN seismograph operation.
1964	Nov	6	KLG SP seismograph recording commenced.
1965	Nov	29-1966 Aug 24	LVS seismograph operation.
1965	Nov		KNA SP-Z seismograph recording commenced; operation intermittent till Feb 1972.
1967	Feb		Fremantle Region Upper Mantle Project.
1967	Oct	26	MEK SP-Z seismograph recording commenced.
1968	Oct	- 1968 Nov 26	Field seismograph operation at Meckering.
1968	Nov	16-1971 Dec 31	AFMAG recording at Mundaring.
1970	Jan	1	Routine analysis of KNA seismograms commenced.

1970	Feb	26	IPS IIIE ionosonde replaced Cossor.
1971	Feb	10-1972 Jul 31	KAA SP-Z seismograph operation.
1971	Nov	30	Two MO2 accelerographs installed at Meckering.
1972	Feb	29	KNA seismograph upgraded to 3 components.
1972	Mar	1	MO2 accelerograph (PWD) installed at Kununurra.
1972	Oct	12	MBT SP-Z seismograph recording commenced.
1972	Nov	16	MO2 accelerograph (PWD) installed at Kununurra.

TABLE 1

OBSERVATORY STAFF 1972

Officer	Designation
P.J. Gregson	Geophysicist Class 3
R.S. Smith	Geophysicist Class 2
E.P. Paull	Geophysicist Class 1
G. Woad	Technical Officer Grade 2
B.J. Page	Technical Officer Grade 1
Y.M. Nardini (Miss)	Typist
T.E. Creaser	Assistant Grade 1
M.J. Robertson	Geophysicist Class 1 (9 February to 17 April, and 12 June to 31 July)
J.A. Major	Geophysicist Class 1 (1 July to 27 July)

TABLE 2

ASSOCIATED PERSONNEL 1972

Name	Nature of duties
J. Silich	Antarctic Trainee (till 31 January)
R.A. Almond	Antarctic Trainee (April to September)
P.J. Hill	Antarctic Trainee (April to September)
T. Pryor	Vacation student, 1971/72, 1972/73
B. Carling	Daily attendant, Gnangara
D.C. Allen	Daily attendant, Kalgoorlie
E. Tromans	Daily attendant, Meekatharra
H. Ausburn	Daily attendant, Karratha (till 31 August)
J. King	Daily attendant, Kununurra (till October)
W. Till	Daily attendant, Kununurra (from October)
G. Edwards	Daily attendant, Marble Bar (from 10 October)

TABLE 3

OBSERVATORY STAFF ABSENCES 1972

Nature of absence	No. of man days
Sick leave	13
Military Service	28
Attendance at outstations and field operations	30
Other branch surveys	50
Conferences	26
Furlough	22
	169

TABLE 4

CONFERENCES AND ADDRESSES

Officer	Date	Conference
P.J. Gregson	May 29-June 2	Sydney - Conference on the Ionosphere.
B.J. Page	May 22-23	Perth - Industrial safety.
P.J. Gregson	Aug 14-18	Canberra - OICs meeting.
B.J. Page	Nov 9-10	Sydney - Ionospheric operators conference.
G. Woad	Dec 4-15	Perth - PMG transistor course.
		Addresses
P.J. Gregson	Sep 23	Civil Defence Group (Northam) on earthquakes.
P.J. Gregson	Oct 18	W.A. Institute Technology on the MGO program.

TABLE 5

VISITORS

Visitor	Institute
Mr I. Nakamura	Tokyo Earthquake Research Institute.
Mr J. Faichney	State Mines Department.
Mr A. Ibbotson	State Mines Department.
Mr R. Goldsmith	Ionospheric Prediction Service.
Mr P. Alekna	Ionospheric Prediction Service.
Mr H. Enright	National Development.
Mr Charles	State Electricity Commission.
Mr P. Mann	Bureau of Mineral Resources.
Mr A. Parkes	Retired (BMR).
Mr K. Grant	CSIRO (Melbourne).
Mr E. Krinitzsky	US Army
Mr C. Bubb	Department of Works (Melbourne).
Mr K. McCue	Imperial College London.
Amateur Radio Operators	

TABLE 6

PRELIMINARY MONTHLY MEAN GEOMAGNETIC VALUES AND K INDEX

Month	D(West)	H, nT	Z, nT	F, nT	K
January	3°04.1'	23752	53461	58500	2.04
February	04.2	739	465	498	1.75
March	04.2	738	465	498	1.71
April	04.3	732	457	488	1.68
May	04.7	732	446	478	1.64
June	04.7	724	449	478	1.80
July	05.3	720	447	474	1.41
August	05.6	709	450	472	2.25
September	05.7	713	449	473	1.71
October	05.8	719	447	474	1.82
November	06.3	713	455	479	2.01
December	06.9	727	462	491	1.92
Mean	3°05.2'	23726	53454	58483	1.81

TABLE 7

GEOMAGNETIC ANNUAL MEAN VALUES 1962-1972

Year	D	I	H	X	Y	Z	F	Notes
	° '	° '	nT	nT	nT	nT	nT	
1962	-2°52.8	-65°53.0	23946	23916	-1203	-53492	58607	2B
1963	52.3	54.1	931	901	1199	503	611	2B
1964	51.7	54.6	917	887	1194	506	608	2B
1965	51.7	55.8	907	877	1194	500	599	2B
1966	52.6	56.2	890	860	1199	499	591	2B
1967	54.2	57.3	869	838	1209	499	582	2B
1968	55.7	59.0	846	815	1217	494	568	2B
1969	57.6	59.6	822	790	1230	487	552	2B
1970	59.6	-66°01.0	790	758	1242	474	527	2B
1971	-3 02.3	02.0	764	730	1260	459	503	2B
1972	05.2	04.0	726	692	1278	454	483	2C
Mean Annual Change	- 1.24	- 1.10	-22.0	-22.4	-07.5	+03.8	-12.4	

Notes: 2. Preliminary value
B. Mean of hourly values, 5IQ days
C. Mean of daily values, 10Q days

TABLE 8

MARBLE BAR SEISMOGRAPH

Code		
MBT		
Co-ordinates		
Latitude	21° 10.2'S	
Longitude	119° 44.5' E	
Elevation	200 m	
Foundation	Archean basic igneous	
Parameters		
Component	SP-Z	
Ts (seconds)	1.0	
Magnification	20K at 1.0 s 100K at 0.2 s	
Recording speed	60 mm/min	
Instruments		
Seismometer	Willmore Mk 2;	S/N 240310
Amplifier	Geotech EA310;	S/N 122
Recorder amplifier	Geotech AR311;	S/N 326
Recorder	Geotech RV301;	S/N 252
Power supply	250V mains with 24V d.c. standby	
Clock	EMI;	S/N 840
Radio	Labtronics 21B;	S/N 419

TABLE 9

KUNUNURRA SEISMOGRAPH

Code			
KNA			
Co-ordinates			
Latitude	15° 45.0' S		
Longitude	128° 46.0' E		
Elevation	55 m		
Foundation	Unweathered sandstone		
Parameters			
Component	SP-Z	SP-N	SP-E
Ts (seconds)	1.0	1.0	1.0
Tg (seconds)	0.75	0.25	0.25
Magnification			
at 1.0 s	20K	8K	8K
at 0.4 s	34K		
at 0.2 s		36K	36K
Recording speed	60 mm/min		
Instruments			
Seismometer	Geotech S-13	Geotech S-13	Geotech S-13
	S/N 411	S/N 413	S/N 412
Galvanometer	Geotech (8430)	Geotech (8430)	Geotech (8430)
control	S/N 468	S/N 469	S/N 467
Galvanometer	Geotech (G10)	Geotech (G10)	Geotech (G10)
	S/N 8333	S/N 4350	S/N 4351
Recorder	Geotech (model R11) three component		S/N 024
Clock	EMI; S/N 864		
Radio	Eddystone EC10 Mk2		

TABLE 10

WESTERN AUSTRALIAN ACCELEROGRAPHS

Station & Ownership	Co-ordinates & Date installed	Elevation (m)	Foundation	Serial Nos MO2	Serial Nos Block	Scale values (g/cm)* Ia	Scale values (g/cm)* Ib	Scale values (g/cm)* Ic
Not yet installed (BMR)				290	1196	0.590	0.560	0.394
Meckering A (BMR)	31.594S 116.991E 30 November 1971	250	Alluvium over Precambrian granite	289	1166A	0.582	0.584	0.348
Meckering B (BMR)	31.694S 116.982E 30 November 1971	200	Alluvium over Precambrian granite	291	1462A	0.609	0.597	0.417
Ord River Dam (PWD)	16.113S 128.738E 1 March 1972	120	Rock fill 3m, clay core 90 m, quartzite	245				
Ord River Abutment (PWD)	16.113S 128.737E 16 November 1972	60	Phyllite	244				

BMR: Bureau of Mineral Resources, Mundaring Geophysical Observatory.
PWD: Public Works Department, W.A.
* g = acceleration due to gravity

TABLE 11

LARGER WESTERN AUSTRALIAN EARTHQUAKES 1972

Date 1972	H U.T.	Lat. °S	Long. °E	Depth KM	ML	m'	mB					m	Remarks
							MUN	KLG	MEK	KAA	KNA		
Jan 08	17 04 46.0	30.82	121.53	1 G	3.0	4.0	3.8	3.7				3.9	Kalgoorlie rockburst.
08	17 05 00.2	30.82	121.53	1 G	3.4	4.3	4.1	4.1				4.2	Kalgoorlie rockburst.
16	03 43 24.0	31.0	124.0	0 S	3.3	4.0[a]		3.9				3.9	Fraser fault.
18	10 33 37.5	22.98	126.58	0 S			4.7	5.3	4.7			4.9	Lake McKay region.
25	17 37 54.6	29.85	117.10	0 S	3.0	4.0	4.2	4.4	4.6			4.3	Manmanning.
29	04 10 25.0	21.0	124.5	0 S	3.8[c]	4.5[c]				4.1		4.3	SE Marble Bar.
Feb 05	16 20 38.9	27.07	125.61	0 S			4.4	(4.3)	4.4			4.4	NE Leonora.
07	19 10 11.7	31.70	116.99	0 S	3.2	4.1	4.3	4.0	4.0			4.1	Meckering, felt.
16	12 11 05.4	22.07	126.58	0 S				5.3	5.1	5.5		5.3	Lake McKay region.
26	11 15 40	30.81	117.02	0 S	3.3	4.2	3.9					4.0	Manmanning.
Mar 28	00 35 11	31.85	116.93	0 S	3.1	4.1	3.8					4.0	E York, felt.
Apr 07	22 08 39.0	18.29	124.90	0 S			4.6		4.5	4.7		4.6	Lake McKay region.
08	07 51 00.0	23.14	126.80	0 S							4.5	4.5	Lake McKay region.
12	22 13 46.2	20.62	120.00	0 S			4.9	4.9		5.0	4.6	4.9	Marble Bar.
22	13 47 17.2	30.76	118.37	0 S	3.3	4.2	4.1	4.3	4.5			4.4	Mukinbudin.

Date 1972	H U.T.	Lat. °S	Long. °E	Depth KM	ML	m'	mB					m	Remarks
							MUN	KLG	MEK	KAA	KNA		
May 20	03 47 14	28.1	124.6	0 S			4.1	3.9	4.0			4.0	Wilkinson Range.
28	13 59 36.0	16.5	128.6	0 S	3.0[d]						4.0	4.0	South of Kununurra.
Jun 27	12 40 25.6	22.04	126.65	0 S			4.3	4.9	4.6	4.4	4.9	4.6	Lake McKay.
Jul 01	19 41 46.6	31.70	116.93	0 S	3.3	4.2	(4.7)	4.4	4.7			4.5	Meckering.
03	07 28 57.2	31.41	116.75	0 S	3.4	4.3	4.3	4.3	4.0			4.2	Meckering.
07	16 03 21.0	22.03	126.52	0 S			4.6	4.7		4.8	4.3	4.6	Lake McKay region.
22	04 19 56.3	27.98	126.70	0 S			4.5	(4.7)	5.0		4.5	4.7	NE Kalgoorlie
25	02 43 54.0	22.73	119.05	0 S			4.3	(4.5)	3.9		(4.3)	4.2	SE Wittenoom.
26	04 31 00.4	31.19	111.91	0 S			4.4	4.8	4.1			4.3	W of Perth.
Aug 12	05 53 18.0	31.52	117.02	0 S	3.7	4.5	3.6	4.2	4.5			4.4	Meckering.
Oct 21	02 33 42.8	24.88	115.55	0 S	5.2	5.6	5.6	5.1	5.2	5.4		5.4	Gascoyne.
23	15 46 20.2	31.60	116.92	0 S	3.2	4.1	4.0					4.0	Meckering.
Nov 08	22 54 48.8	30.9	117.2	0 S	3.0	4.0	3.7	4.2	4.2			4.0	Manmanning.
Dec 07	07 44 24	18.1	120.6	0 S						4.2	4.1	4.2	W of Broome.
21	13 43 02	30.7	124.3	0 S				4.2	4.1			4.2	N of Kitchener.

ML determined from MUN seismograms unless shown as:

a, KLG; b, MEK; c, KAA; d, KNA.

$m' = 1.8 + 0.73\ ML$

mB = log (A/T) + Ao + 0.4 (Ao from curve B - Everingham, 1968)

m = unified magnitude (weighted mean of m' and all available mB)

S Depth restrained to surface

G Depth restrained by geophysicist.

TABLE 12

EARTHQUAKES IN THE SOUTHWEST SEISMIC ZONE

1972

DATE	ORIGIN TIME UT	LAT. °S	LONG. °E	ML	mB(MUN)	REMARKS
Jan 06	05 58 14	31.72	117.13	2.4	3.4	16 km SW Meckering.
12	06 33 04	31.70	117.10	2.7	3.8	12 km SE Meckering.
21	23 24 07	31.85	117.04	2.8	3.7	20 km NW Mawson.
25*	17 37 54.6	29.85	117.10	3.0	4.2	Manmanning.
28	05 38 45	31.57	116.92	1.9	3.2	11 km NW Meckering.
30	01 01 42	31.70	116.90	2.1	3.4	8 km S Meckering.
30	02 10 25	30.89	116.98	2.4	3.8	13 km W Manmanning.
Feb 01	04 15 28	30.90	117.06	2.7	3.7	7 km SW Manmanning.
01	14 59 19	31.8	118.3	2.1	3.2	40 km SE Mukinbudin.
02	18 20 34	30.90	117.06	2.0	3.2	7 km SW Manmanning.
03	04 22 19	31.78	117.03	2.1	3.4	16 km S Meckering.
04	17 49 22	31.68	117.03	2.2	-	6 km S Meckering.
07*	19 10 11.7	31.70	116.99	3.2	4.3	10 km S Meckering, felt.
15	16 59 52	31.62	117.02	1.9	3.2	3 km E Meckering.
18	07 58 43	30.84	116.88	2.9	3.9	20 km W Manmanning.

DATE	ORIGIN TIME UT	LAT. °S	LONG. °E	ML	mB(MUN)	REMARKS
Feb 18	08 23 52	30.83	116.89	2.3	3.5	20 km W Manmanning.
Cont 24	02 16 22	30.86	116.98	2.2	3.4	10 km W Manmanning.
24	06 51 32	30.90	117.05	2.4	3.7	7 km SW Manmanning.
24	14 37 16	30.90	117.05	2.2	3.5	7 km SW Manmanning.
26*	11 15 40	30.81	117.02	3.3	3.9	8 km NW Manmanning.
Mar 01	15 01 50	31.08	117.26	1.9	3.2	30 km SE Manmanning.
05	19 44 49	31.84	117.13	2.2	3.5	15 km N Mawson.
12	02 20 22	31.67	116.98	2.3	3.3	6 km SW Meckering.
13	14 43 03	31.75	117.03	2.2	3.5	14 km S Meckering.
14	03 55 36	31.52	116.87	2.1	3.4	17 km NW Meckering.
15	16 26 11	30.75	116.68	2.2	3.2	20 km SW Ballidu.
19	07 11 57	31.14	116.92	2.8	3.4	18 km NE Goomalling.
26	11 44 57	31.55	116.85	2.1	-	16 km NE Meckering.
28*	00 35 11	31.85	116.93	3.4	3.8	18 km E York, felt.
Apr 01	15 37 18	30.85	116.98	2.1	3.3	10 km W Manmanning.
02	23 45 08	30.85	116.98	2.1	3.3	10 km W Manmanning.
03	09 40 38	31.59	117.02	2.5	2.9	3 km N Meckering.
13	09 24 47	31.65	116.97	2.2	2.6	5 km SW Meckering.
20	10 22 14	31.79	117.00	2.4	3.1	21 km S Meckering, felt.

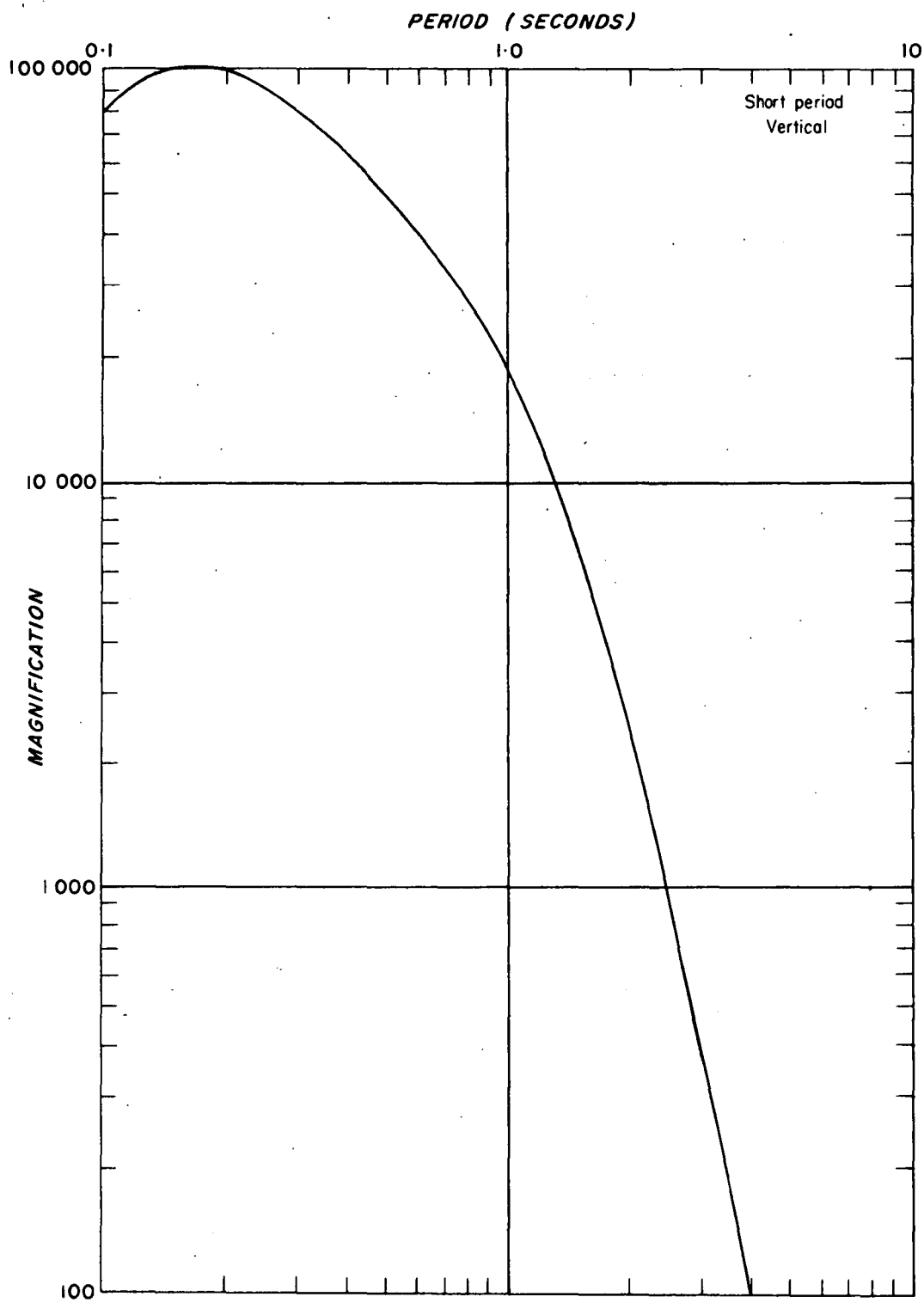
DATE	ORIGIN TIME UT	LAT. °S	LONG. °E	ML	mB(MUN)	REMARKS
Apr 22	07 56 02	31.8	118.3	2.5	3.4	40 km SE Mukinbudin.
Cont 22*	13 47 20	31.8	118.3	3.3	4.1	40 km SE Mukinbudin.
22	14 08 00	31.8	118.3	2.3	3.4	40 km SE Mukinbudin.
23	06 16 28	31.8	118.3	2.4	3.4	40 km SE Mukinbudin.
29	15 44 45	31.54	116.92	2.2	3.2	11 km NW Meckering.
May 02	11 54 02	31.79	117.00	2.2	3.2	18 km S Meckering.
02	11 54 42	31.79	117.00	2.0	3.0	18 km S Meckering.
02	22 04 09	31.70	116.98	2.3	3.8	8 km S Meckering.
03	06 24 04	31.76	116.99	2.1	2.9	16 km S Meckering.
08	15 26 53	31.70	116.99	2.9	3.9	8 km S Meckering.
18	02 55 04	31.88	117.00	2.0	3.0	23 km E York.
19	22 43 36	31.88	117.00	2.1	3.3	23 km E York.
22	16 37 50	31.71	116.90	2.5	3.4	14 km SW Meckering.
Jun 05	21 26 18	31.72	117.01	2.2	3.3	10 km S Meckering.
07	16 26 16	30.9	118.4	2.2	3.4	40 km SE Mukinbudin.
08	00 28 15	30.9	118.0	2.0	3.1	40 km SE Mukinbudin.
08	02 30 24	32.10	116.99	2.2	3.4	6 km E Beverley
12	07 16 41.0	32.23	117.25	1.8	3.1	22 km NE Brookton.
20	23 10 55	31.69	116.99	2.3	3.7	7 km S Meckering.

DATE	ORIGIN TIME UT	LAT. °S	LONG. °E	ML	mB(MUN)	REMARKS
Jun 29	00 17 57	30.8	118.0	2.7	(3.3)	30 km SE Mukinbudin.
Cont						
Jul 01*	19 41 46.6	31.70	116.93	3.3	(4.7)	18 km S Meckering.
03*	07 28 57.2	31.41	116.75	3.4	-	16 km S Meckering.
15	23 26 56.9	31.67	116.93	2.6	3.6	9 km SW Meckering.
18	13 04 57.7	31.7	117.0	2.2	3.4	10 km S Meckering, felt Northam.
18	14 27 01.9	31.7	117.0	2.1	3.0	10 km S Meckering.
26	09 27 17.0	31.77	117.24	2.6	4.4	20 km SE Meckering.
Aug 10	05 33 27.2	32.10	117.19	2.1	3.7	10 km S Mawson.
12*	05 53 18.0	31.52	117.02	3.7	3.6	12 km N Mawson.
14	21 50 06.3	31.66	117.00	2.2	3.0	4 km S Meckering.
15	11 05 27.6	31.26	116.81	2.0	3.6	20 km E Bolgart.
26	10 52 53.3	31.60	117.03	2.2	3.6	2 km E Meckering.
31	09 10 26.2	31.3	116.3	1.8	3.1	24 km W Bolgart.
Sep 14	02 50 39.2	31.25	116.63	2.8	3.8	12 km E Bolgart.
14	02 57 26	31.20	116.50	2.2	3.4	8 km N Bolgart.
14	03 32 35.1	31.20	116.50	2.6	3.5	8 km N Bolgart.
25	21 42 44.8	31.75	117.06	2.2	3.1	14 km SE Meckering.

DATE	ORIGIN TIME UT	LAT. °S	LONG. °E	ML	mB(MUN)	REMARKS
Sep 27	03 04 18.0	31.80	116.96	2.2	2.5	19 km S Meckering.
Cont 28	13 07 17.9	31.80	117.02	2.2	-	20 km S Meckering.
Oct 05	11 29 30.8	31.73	117.00	2.1	3.4	12 km S Meckering.
07	01 47 32.2	31.62	117.07	2.8	3.0	6 km E Meckering.
19	21 47 06.3	31.72	117.08	2.6	3.4	12 km SE Meckering.
19	21 47 09.2	31.72	117.08	2.9	2.9	12 km SE Meckering, felt Southern Brook.
23	15 46 02.7	31.64	116.93	2.3	3.6	8 km SW Meckering.
23*	15 46 20.2	31.60	116.92	3.2	4.0	8 km W Meckering.
23	15 46 28	31.6	116.9	2.8	3.9	8 km W Meckering.
Nov 08*	22 54 48.8	30.9	117.2	3.0	3.7	10 km SE Manmanning, felt.
09	21 11 39.5	30.9	117.2	2.7	3.5	10 km SE Manmanning.
26	04 49 56.7	(31.7)	(117.0)	2.6	(3.6)	10 km S Meckering.
27	06 45 00.0	31.0	117.2	2.2	3.3	15 km SE Manmanning.
Dec 09	08 29 16.0	31.7	117.8	2.3	3.7	20 km S Kellerberrin.
26	06 58 22.3	32.32	117.13	2.5	3.5	13 km NE Brookton.

* Earthquakes also listed in Table 10.

PLATE I



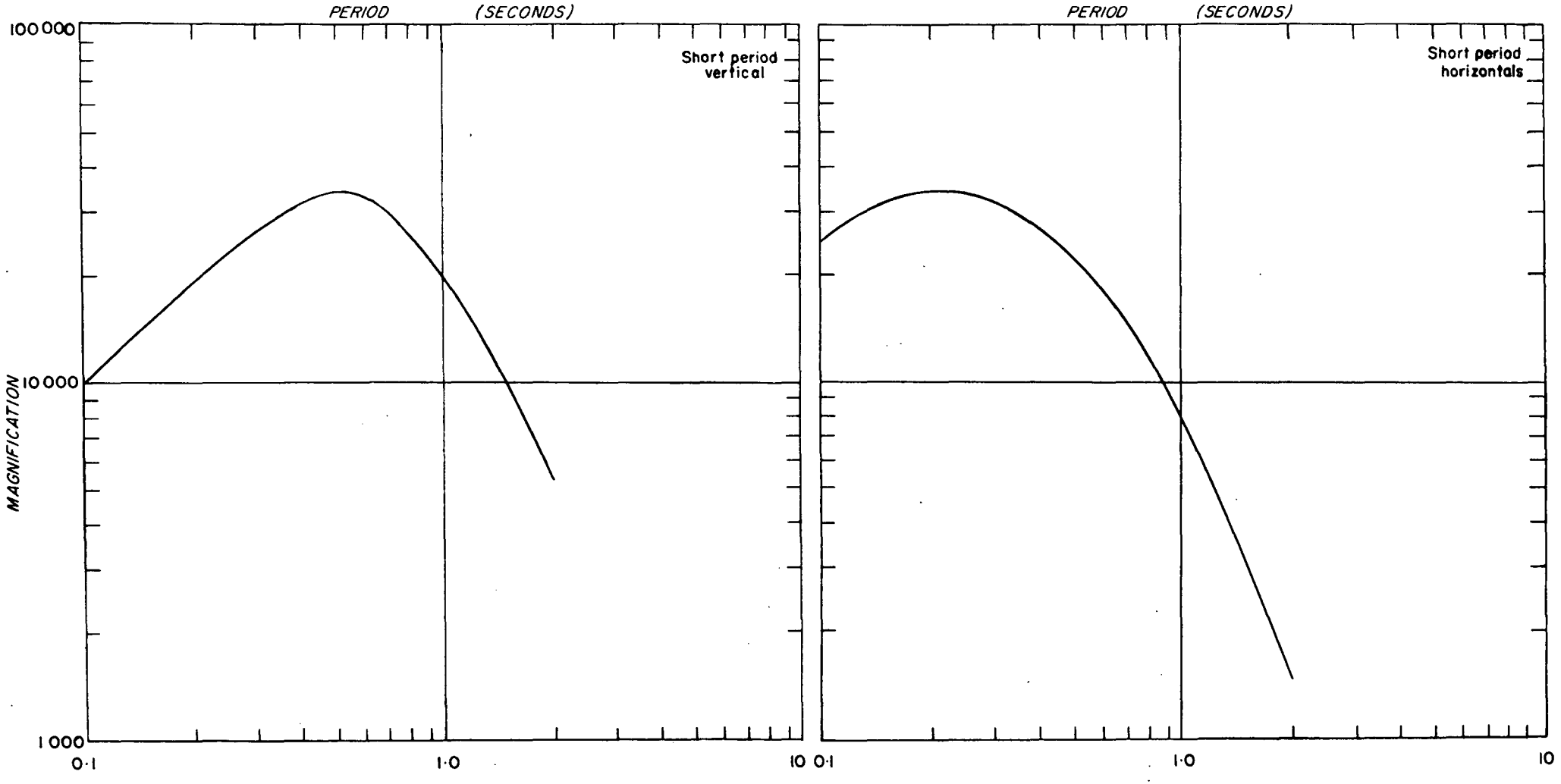
CALIBRATION CURVE

MARBLE BAR TOWN SEISMOGRAPH

To Accompany Record No. 1973/154

F50/B9-3A

To Accompany Record No 1973/154



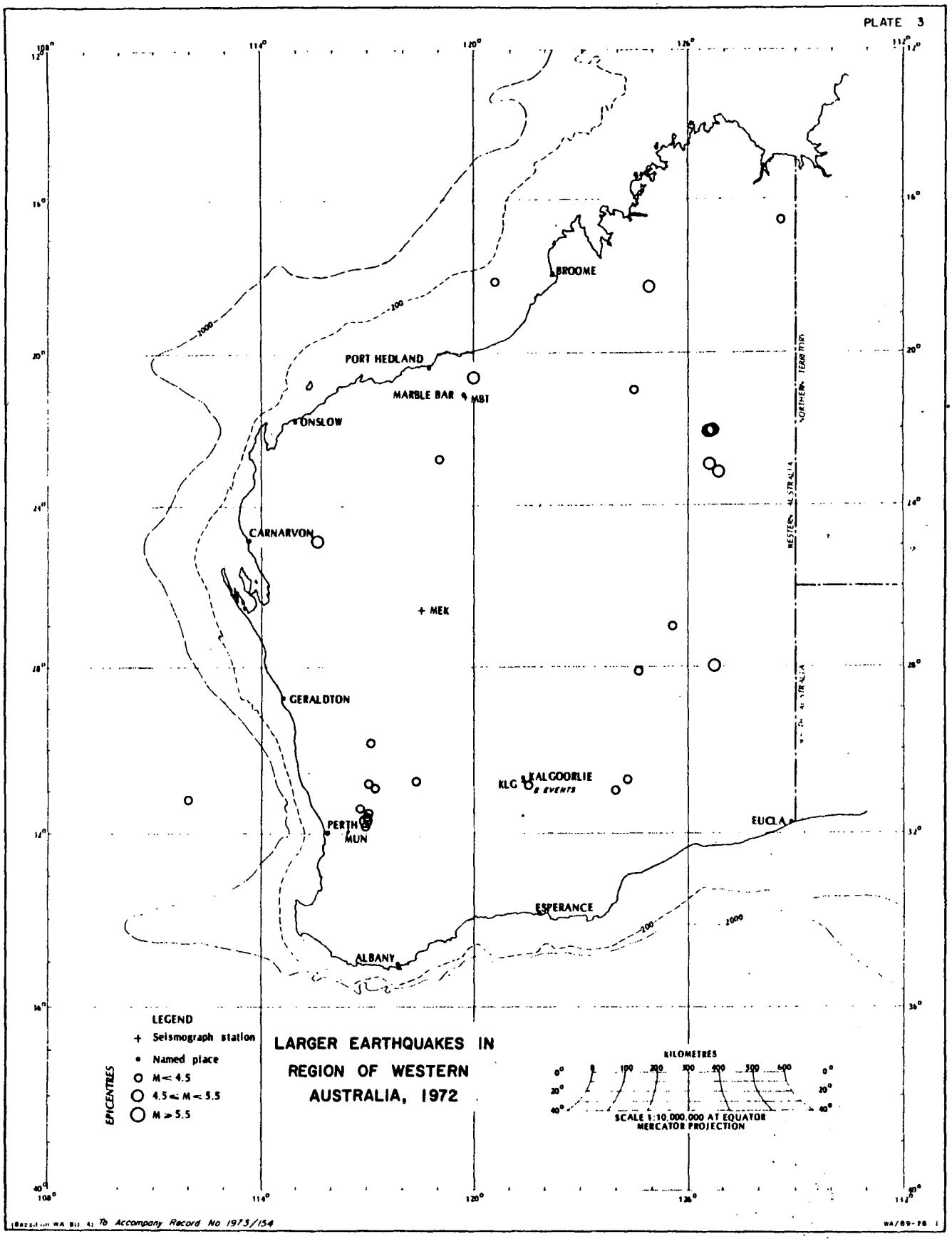
CALIBRATION CURVE

KUNUNURRA SEISMOGRAPH

PLATE 2

D52/89—12A

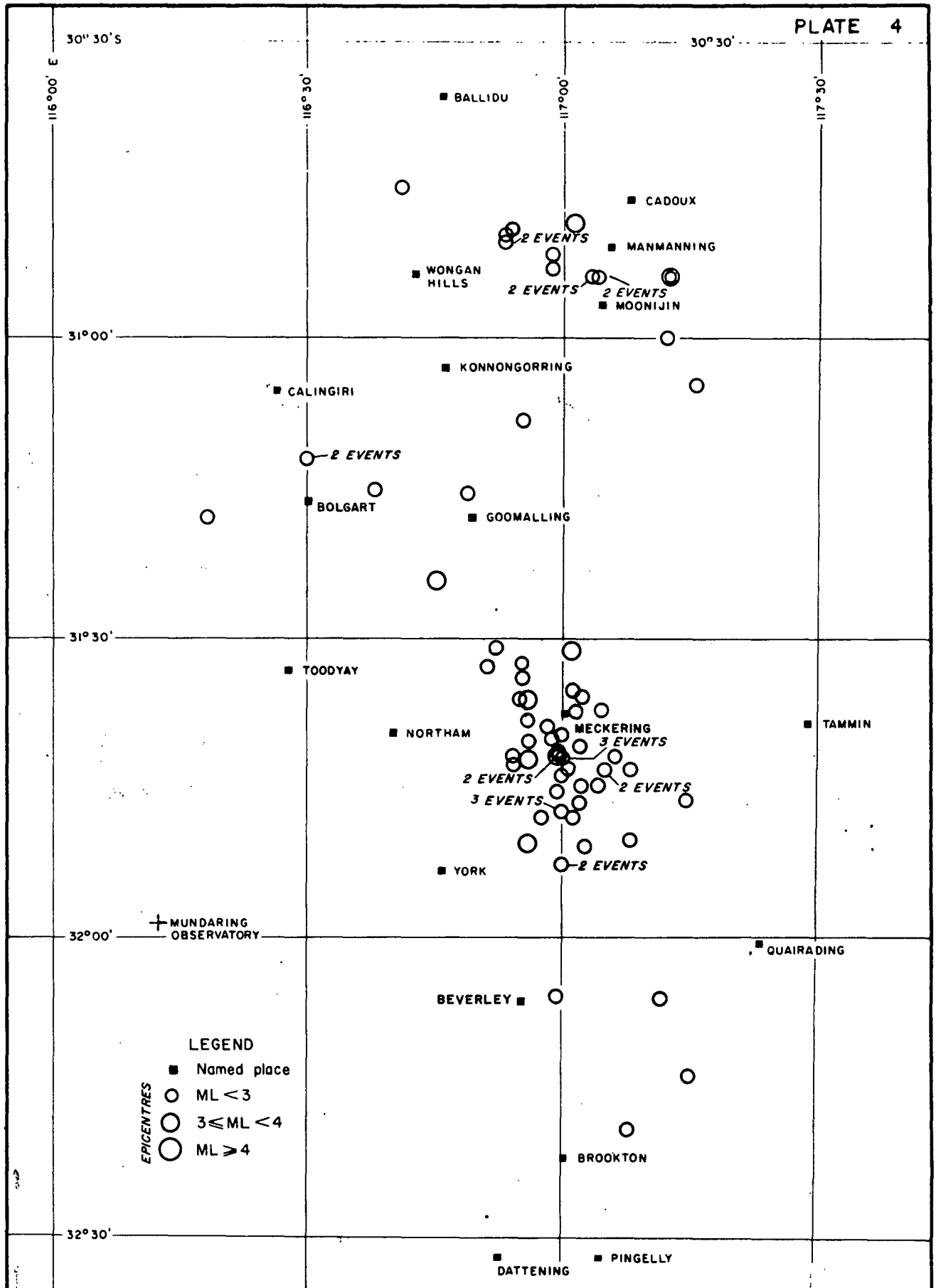
PLATE 3



(Bureau WA 811 4) To Accompany Record No 1973/154

WA/69-78

PLATE 4

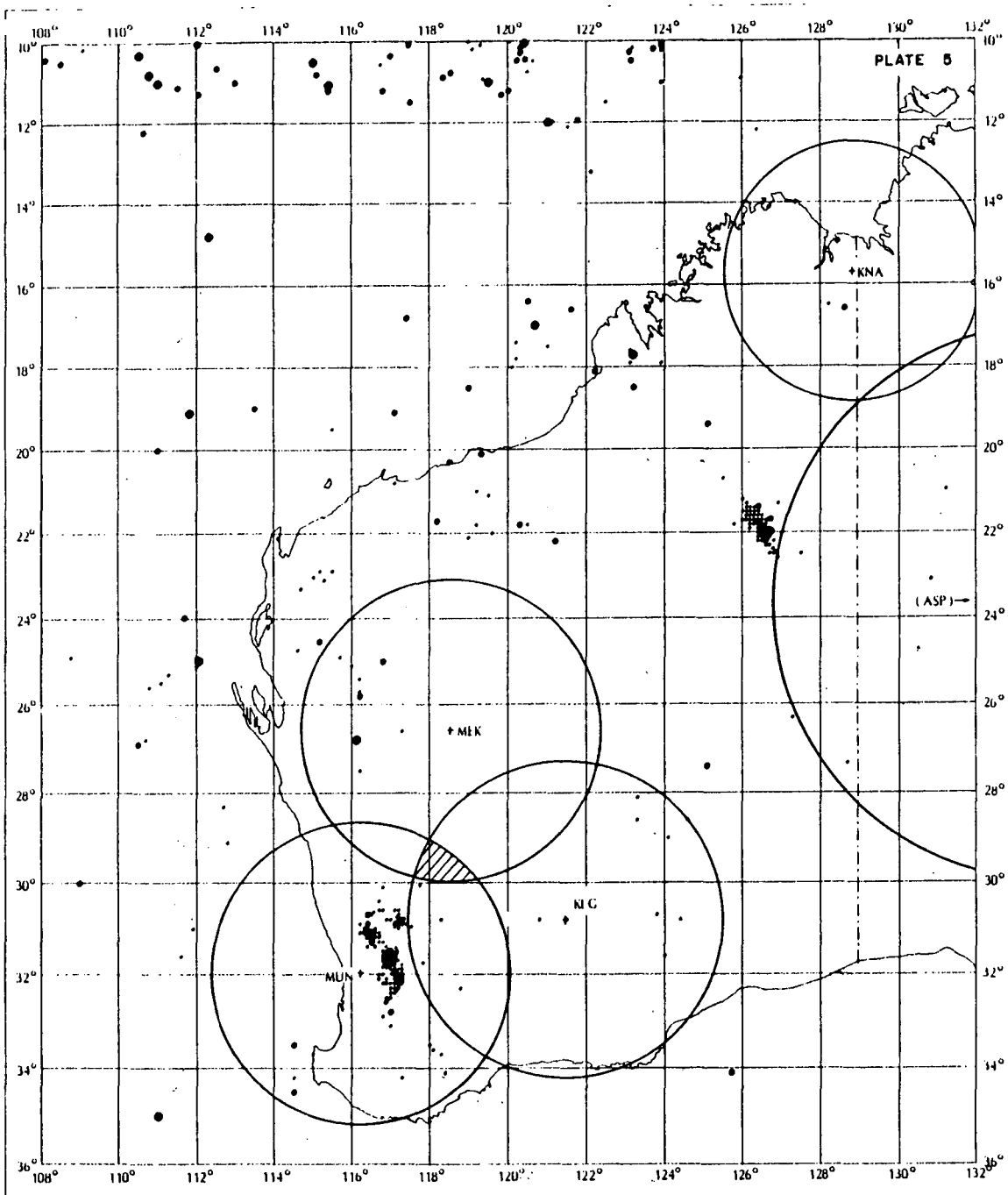


EARTHQUAKES IN THE REGION 30°30'–33°00'S AND 116°00'–117°30'E, 1972

SCALE

10 5 0 10 20 30 40 50 KILOMETRES

(BASED ON H50/80-36A) *To Accompany Record No. 1973/154* WA/B9-27-1A



LEGEND

+KLG Seismograph station

Circles round each station represent maximum radii for detection of earthquakes with ML = 3.0

//// Three station coverage

• • • Located earthquake

KILOMETRES

0 100 200 300 400 500 600

0° 20° 40°

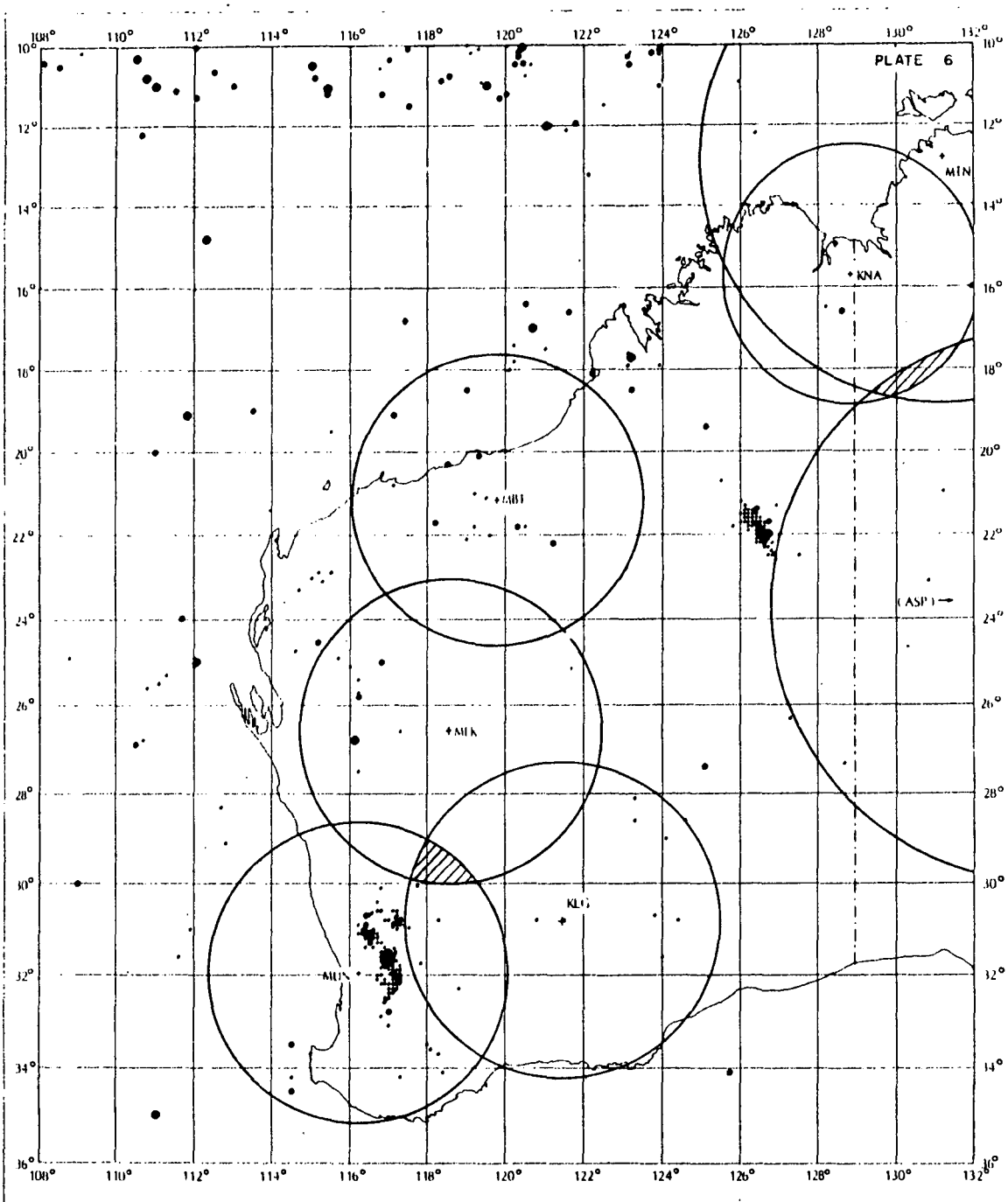
SCALE 1:10,000,000 AT EQUATOR
MERCATOR PROJECTION

SEISMIC COVERAGE OF WESTERN AUSTRALIA

AT 1 JANUARY 1972

(Based on WA/89-86 i) To Accompany Record No 1973/154

WA/89-30



LEGEND

+KLG Seismograph station

Circles round each station represent maximum radii for detection of earthquakes with ML = 3.0

Three station coverage

Located earthquake

KILOMETRES

0 100 200 300 400 500 600

SCALE 1:10,000,000 AT EQUATOR
MERCATOR PROJECTION

SEISMIC COVERAGE OF WESTERN AUSTRALIA

AT 31 DECEMBER 1972

(Bxxx - WA/BS 48-1) To Accompany Record No 1973/154

WA/BS - 1