

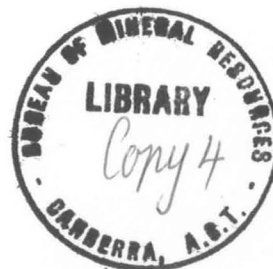
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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record No. 1971/77



## Mundaring Geophysical Observatory, Annual Report, 1970

by

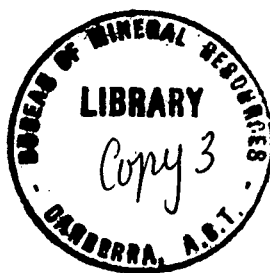
*P. J. Gregson*

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RECORD NO. 1971/77



MUNDARING GEOPHYSICAL OBSERVATORY,

ANNUAL REPORT 1970

by

P.J. GREGSON

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## SUMMARY

During 1970, basic observatory programs were continued in geomagnetism, ionospherics, and seismology at the Mundaring Geophysical Observatory, the main instruments being the Eschenhagen normal-run magnetograph, an IPS IIIIE ionosonde, and a Worldwide Standard Seismograph system.

Seismographs were operated continuously at Kalgoorlie and Meekatharra. Interpretation of seismograms from the State owned seismograph at Kununurra was commenced on a routine basis.

Epicentres of approximately 180 Western Australian earthquakes were determined and annual lists were completed. The level of earthquake activity in the southwest of Western Australia was considerably reduced compared with the 1969 level but still higher than the pre-Meckering level. A small fault scarp resulted from an earthquake near Calingiri on 10 March.

Considerable earthquake activity has occurred in the Lake Mackay region following a magnitude  $m = 6$  earthquake on 24 March.

Recordings of the Ord River blast (21 June) were obtained at the permanent seismograph stations, and a temporary station was set up at Dampier for the event.

## 1. INTRODUCTION

The Mundaring Geophysical Observatory came into being on 18 March 1959 and now controls operations at Mundaring (seismological and ionospheric recording), Gngara (magnetic recording), Kalgoorlie and Meekatharra (seismological recording). Descriptions of the Observatory and an outline of activities there to the end of 1969 have been given in previous records, (e.g. Everingham and Gregson, 1971). The present Record summarises the work during the calendar year 1970. Discussion of non-routine projects is brief, as details are reported separately elsewhere.

## 2. STAFF AND VISITORS

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

P. Gregson continued to act as Observer-in-Charge at the Port Moresby Observatory until 3 April; I.B. Everingham was transferred to Port Moresby as Observer-in-Charge on 7 April; A. Parkes, who joined the observatory at Watheroo with the Carnegie Institution of Washington on 1 May 1945, retired on 3 July.

Visitors to the observatory are listed in Table 5.

## 3. GEOMAGNETISM

### Normal magnetograph

The Eschenhagen 20mm/hour magnetograph continued in operation at Gngara. Two days recordings were lost because of fogging; twenty hours because of recorder drive failure; and twenty two hours due to the recorder shutter being left closed.

As a result of the earthquake at Calingiri on 10 March the H, D and Z baseline values changed abruptly by +4 gammas, +1.0 minutes and +4 gammas respectively. The H baseline value increased by three gammas when the pendulum clock was removed from the vault on 30 July. The H ordinate was increased by 90 gammas on 11 November to reduce the large number of negative ordinates. All traces were moved 20 mm down the magnetogram on 18 November to allow more space at the top of the magnetogram for recording H. Other baseline and scale value changes made during the year were small.

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

<u>Element</u>	<u>Baseline value</u>	<u>Scale value</u>
D	0.32 minutes	-
H	2.2 gammas	0.01 gammas/mm
Z	3.4 gammas	0.02 gammas/mm

During October a 75mm PVC pipe was installed between the control hut, vault and absolute house. This was in preparation for heavier wiring which will be required when new lamps are installed in the magnetograph.

The MCO scale value calibrator required attention in February, August and December. In the first instance the reference voltage began to drift from about January 1; in the last two, there was no output current.

The La Cour pendulum clock failed on 29 July and was not repaired because of its age. It was replaced by a simple locally built programmer operating from minute pulses either from an EMI clock or chronometer. The programmer gives ten minute and hour time marks.

#### Magnetograph tests

Temperature coefficients. Least squares analysis carried out on the 1970 baseline data gave coefficients slightly different from those in use.

$$QH = 0.4\gamma/^{\circ}C \quad (1.2\gamma/^{\circ}C, 1969)$$

$$QZ = 3.2\gamma/^{\circ}C \quad (2.5\gamma/^{\circ}C, 1969)$$

Orientation. Tests made on the Eschenhagen magnetograph on 4 November indicated that the orientation of the H, D, and Z variometer magnets were E  $0.4^{\circ}$  N, N  $0.4^{\circ}$  W and N  $0.1^{\circ}$  UP respectively. The reference meridian was  $003.0^{\circ}$  T and the value of H was 23,784 gammas. These results are compatible with the results of 6 September 1967 (Everingham and Gregson, 1969) after allowing for secular variation. No adjustments were made.

D scale-value. One observation using a Helmholtz coil was made on 4 November. The value determined was 1.076 minutes/mm.

#### Magnetometer comparisons and corrections

QHM's 291, 292 and 293 were compared through baselines with QHM's 305 and 306 from 15 to 27 May.

Mean QHM (305 and 306) = QHM 291 -24 gammas (5 observations)  
(uncorrected) = QHM 292 -31 gammas (5 observations)  
= QHM 293 - 6 gammas (5 observations)

A check was made on the instrument corrections in use by comparing the total force calculated from adopted Z and H baseline values and ordinates and ten values of F measured using an Elsec proton magnetometer (S/N 416) between 2 and 16 December.

F computed - F proton = -1 gamma (10 observations).

Mean observed QHM differences for 1970 were:

QHM 291 - QHM 293 = 16 gammas

QHM 292 - QHM 293 = 24 gammas

Preliminary corrections. Those used throughout the year were:

- (a) QHM 291, -20 gammas; QHM 292, -30 gammas; QHM 293, 5 gammas;
- (b) BMZ 120, +300 gammas.
- (c) Askania declinometer 509319, (circle 508135), + 0.5 minutes.

#### Accessory equipment

The Mundaring Askania visual recorder continued to operate throughout the year.

Induction loop recordings were made continuously from 18 February to 31 March using a 100 second period galvanometer. Recording was suspended pending further tests, when the galvanometer became unstable. Continuous recordings recommenced on 14 December using a 14 second galvanometer.

An AFMAG recording instrument was operated throughout the year at Mundaring Weir for the metalliferous group.

#### Data reduction and publications

Data distribution and mean hourly value reduction continued as for 1969. The distribution of the weekly K-indices and storm data letter increased from fifteen to twenty one, to meet requests from prospecting groups.

From July the values of the first and thirteenth hours for H, D, and Z were hand scaled from each Gwangara magnetogram. These values are used as a check on the values computed for all hours at headquarters.

Monthly and annual mean values of H, D, and Z at Gwangara for 1970 are listed in Table 6. Until September the values were derived from magnetogram hourly ordinates on the five local days of each month. From October the values were derived from the ten local quiet days by scaling a daily mean ordinate for each component. The latter is the procedure carried out in other BMR observatories. The annual mean values and the monthly mean K-index value from 1961 to 1970 are listed in Table 7 and 8 respectively.

Recent trends in secular variation for H and D continued, with H decreasing by about 30 gammas and D becoming more westerly by about 2.0 minutes. The numerical by decreasing trend in Z is confirmed by a decrease of about 10 gammas. (see Plate 1.)

Miscellaneous requests attended to were primarily for magnetogram copies (K. Lloyd, Weapons Research Establishment, Adelaide; Dr C.U. Wagner, Central Institute for Solar Terrestrial Physics, Potsdam; D. Pridmore, University of Adelaide; V.P. St John, B.P. Australia) and information on the geomagnetic field in Western Australia. Magnetograms and constants were supplied to the US Navy Project Magnet, which flew a calibration run over Gwangara on 10 March.

#### 4. IONOSPHERICS

##### Equipment

The quarter-hourly sounding schedule was continued throughout the year. The Cossor 7562C ionosonde was replaced with a Model 3E IPS ionosonde, installed by the Ionospheric Prediction Service Division (IPSD) and put into operation on 26 February.

Nearly 600 hours of records were lost during the year owing to four main causes:

- (a) Breakdown of components at high operating temperatures, 130 hours.
- (b) Station 250V power failures, 130 hours.
- (c) The breakdown of the 50V power unit resulting in an output of 70V blowing several transistors. 168 hours record were lost while replacement parts were sent from Sydney.
- (d) Film jamming on several occasions resulted in 150 hours of records being lost.

### Data distribution and publications

Scaling procedures continued as for 1969. Hourly values of  $f_{min}$ ,  $fEs$ ,  $fbEs$ ,  $foF2$ ,  $M(3000)F2$ ,  $FxI$  and  $M(3000)I$  are published by IPSD for BMR in the form of the IPS-D series.

In addition monthly medians and f-plots of  $F2$  and  $M(3000)F2$  are currently being published by the U.S. Department of Commerce in their Ionospheric Data series CRPL-FA.

Commencing from August monthly medians of  $foF2$  were sent by telegram to the International Radio Consultative Committee (Geneva) for the determination of the index  $IF2$ . Back data from February 1947 to July 1970 were also sent to the committee.

Several requests (mainly from IPSD) for ionograms were received during the year.

## 5. SEISMOLOGY

### Seismograph stations

Stations and instruments in operation on 31 December are listed in Tables 9 and 10.

Mundaring. Seismographs at this station ran satisfactorily throughout the year with very little loss of record.

The periods of the short-period Z, N and E seismometers and the long-period N galvanometer were adjusted on 28 January. The latter was replaced on 12 February as it appeared to be short circuited.

The phase shifter unit was used for most of the year in place of the strobe as the a.c. output of the latter unit was low. Replacement parts from U.S.A. did not rectify the fault. The WWSSN primary power and timing failed twice during June owing to a fault in the phase shifter. An EMI clock was used for time marks while the phase shifter was being repaired.

Kalgoorlie. The Kalgoorlie seismograph continued to operate as two components (Z and SW) as the defocussing of the NW galvanometer experienced during 1969, could not be fixed. On July 9 the Benioff recorder was returned to Mundaring for overhaul and modification as listed below:-

- (a) Several long mirrors were replaced.
- (b) The recorder was completely rewired.
- (c) Plug in attenuators were fitted.

- (d) Cannon plugs (MS3102-14S-7S) were fitted for the seismometer inputs, making them standard with other equipment.
- (e) The original 115V motor was replaced by a 250V Philips motor (AU5300) and gear box (AU5300/80DM, modified from 4 rev/min to 8 rev/min by the BMR workshop).
- (f) The power supply was rebuilt, to replace the existing 250Vac/115Vac motor drive, 115Vac/12Vac timemark power and 250Vac/6Vac regulated lamp supply by a 250Vac/12Vdc and 6Vac supply. The original lamp transformer drew more than the 50 W supplied by the EMI clock.
- (g) The drum drive and clutches were overhauled.
- (h) The galvanometer mounting of one channel was modified slightly (because of focus) to accept a U.E.D., 0.75 second galvanometer. Two U.E.D. 0.25 galvanometers were fitted without modification.

The recorder with three new U.E.D. galvanometers was reinstalled at Kalgoorlie on 4 September, in a new seismograph hut. Plates 5 and 6 show the hut design, and its location. The remainder of the seismograph was upgraded as follows:-

- (a) An EMI clock was installed for timing and drum drive.
- (b) UED electromagnetic calibrators were fitted to both Benioff horizontal seismometers.
- (c) Signal output plugs (cannon MS3102-14S-7S) and calibration plugs (cannon MS3102-12S-3S) were fitted to both Benioff horizontal seismometers.
- (d) The coil configuration of both Benioff seismometers were rearranged so they are identical with the WWSSN short-period seismometers.
- (e) The vertical Willmore (MK I) seismometer was replaced with a MK II seismometer.
- (f) Standby 24V batteries for the EMI clock, battery charger, calibration unit and radio filter unit (STA 3) were installed, but will not be described as it is intended to modify these with the object of standardising accessory equipment at all outstations.

The seismograph was calibrated (see Plate 2). The sensitivity of the horizontal components was reduced by half on 14 October.

Meekatharra. This station ran extremely well throughout the year with very little loss of record. The Eddystone radio receiver required overhaul and was replaced by a Labtronics time signal receiver in July.

One visit was required on 5 August when the drive of the 115V recorder motor became erratic. This motor was replaced by a Philips motor and gear box as for Kalgoorlie.

Kununurra. This station is owned and operated by the Western Australian Public Works Department. Records are interpreted at the Mundaring Observatory.

The Mercer chronometer was reinstalled at the station on 9 January after repairs. Chronometer corrections were rather erratic so a filter unit (STA 3) was lent to the station for recording radio time pips once a day (May).

From May seismic events which had impulsive P phases or were of particular interest were analysed and reported in the Mundaring Seismological Bulletin.

An EMI clock was lent to the station from September following continued erratic behaviour of the chronometer resulting in uncertain timing. From this date the reliability of Kununurra improved immensely.

Broome. Operator and instrumental problems together with the unsatisfactory site (maximum magnification about 3000 due to background noise) resulted in this station being dismantled in favour of establishing a seismograph at Dampier.

Dampier. Preliminary site tests were carried out in June. Four sites were tested at Dampier airport, Karratha townsite, Dampier townsite, and near the Hamersley Iron Pty Ltd offices. All but the last were satisfactory seismic sites for medium gain operation, but only the Dampier townsite has a reliable power and source of operators. There were no temporary sites available in Dampier. Temporary accommodation may be available at the Public Works Department offices in Karratha.

30 day recorder. This recorder was operated twice for short periods at Southern Cross and Calingiri. Both times recording ceased because the film winding mechanism failed. Repairs were completed in October and the recorder was installed 2 miles north of Meckering on 15 October. The galvanometer suspension broke early in November resulting in the curtailing of operations for the remainder of the year. Between 15 and 28 October over 200 tremors ranging between ML = 0 and 3 at distances between 1 and 20 kilometres were recorded.

## Seismicity

Earthquake lists. 1970 Western Australian earthquakes are listed in Tables 12 to 15.

The larger earthquakes are those that were well recorded at more than one station and generally have a magnitude  $ML = 3.0$  (mb approximately 4.0) or greater. They have been listed in two Tables, those in the Lake McKay region ( $22.0^{\circ}S$ ,  $126.0^{\circ}E$ ) and those in other areas of the state (Tables 13 and 12 respectively). Because of the small amount of data available, epicentres given for Lake McKay earthquakes are accurate to only  $\pm 0.5^{\circ}$ . Earthquake epicentres listed in Table 12 are given to one or two decimal places of a degree and are accurate to  $\pm 0.1^{\circ}$  and  $\pm 0.01^{\circ}$  respectively. The minor earthquakes have been listed in two tables as for the larger earthquakes. Table 13 lists those in the southern part of the state and were generally only recorded at Mundaring, with magnitude less than  $ML = 3.0$ . Table 15 lists those in the Lake McKay region, the majority of which were recorded at both Meekatharra and Warramunga. The magnitude mb listed is calculated from relative amplitudes of the P phase as recorded at Meekatharra.

All larger W.A. earthquakes are plotted on Plate 3.

Earthquakes in the south western part of the state. 1970 earthquakes for this region are plotted in Plate 4.

Activity in the central part of the Yandanooka - Cape Riche zone of seismicity was considerably reduced from the 1969 level (Everingham and Gregson, 1971). There were 14 earthquakes with  $ML = 2.9$  compared with 194 recorded in 1969. The level of activity is still at least double that prior to the large Meckering earthquake of 14 October 1968. The number of minor tremors (60) is still considerably higher than the pre-Meckering level.

An earthquake magnitude  $m = 6$  occurred on 10 March at 17 15 11.2 UT near Calingiri ( $31.11^{\circ}S$ ,  $116.47^{\circ}E$ ). This event had a maximum intensity of  $MM = 6$  and was felt over an area of 250km radius. It caused an arcuate, shallow, east - dipping thrust fault over a distance of about 5 km, with a maximum uplift of 30 cm. An isoseismal survey was carried out and the results are given by Everingham and Tilbury (1971).

Earthquakes in the Lake McKay region. The largest earthquake magnitude  $m = 6$ , recorded in Western Australia during 1970 occurred in this region on 24 March at 10 53 07 UT ( $21.6^{\circ}S$ ,  $126.7^{\circ}E$ ). The maximum known intensity was  $MM = 5$  at Fitzroy Crossing, 500 km from the epicentre. The earthquake was also felt in Perth 1500 km from the epicentre. This was the first earthquake recorded in this region and has been followed by about 160 aftershocks with magnitude  $mb = 3.4$  or greater (see Tables 13 and 15).

### Ord River explosion

On 21 June 500,000 kg of TNT was detonated near the Ord River damsite to provide rock fill for the dam. Seismic waves from the explosion were recorded at Mundaring (2166 km), Kalgoorlie (1785 km), Meekatharra (1569 km), Kununurra (42 km), and a temporary field station at Dampier (1363 km). Ten other Australian stations recorded the blast. The results will be published separately.

### Data distribution and reports

Extraction and distribution of Mundaring, Meekatharra and Kalgoorlie data continued with only minor changes. Data from Kununurra was distributed on a routine basis from May.

Reports of seismological interest were prepared during the year by Gregson and Paull (1971), Everingham and Gregson (1971), Everingham and Tilbury (1971) and Everingham and Parkes (1971).

## 6. NOTES ON OPERATIONS

The following repairs, maintenance, new works and alterations were carried out during the year:

- (a) Maintenance to the Weir site access road (April).
- (b) All fire extinguishers were checked by the Fire Brigade (2 February and 19 November).
- (c) Three trees were lopped in the office grounds (April).
- (d) A new seismic hut was completed at Kalgoorlie (September).
- (e) A 75mm PVC cable pipe was installed at Gngangara between the control hut, vault and absolute house (October).
- (f) The office was reorganised so that all seismic analysis and storage could be carried out in the one room.

## 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 B. Page of Meekatharra is hereby acknowledged. The co-operation of Mr S. Gunson of the Western Australian Institute of Technology in lending a proton magnetometer is greatly appreciated.

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EVERINGHAM, I.B. and TILBURY, L., (1971) - Information on Western Australian earthquakes which occurred during the periods 1849-1900 and 1923-1960. Ibid. 1971/40 (unpubl.).

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TABLE 1  
Observatory Staff 1970

Officer	Designation
I.B. Everingham	Geophysicist Class 3 (until 6 April).
P.J. Gregson	Geophysicist Class 3 (from 6 April).
Vacant	Geophysicist Class 2.
E.P. Paull	Geophysicist Class 1.
A. Parkes	Technical Officer Grade 2 (retired 3 July).
G. Woad	Technical Officer Grade 2.
Vacant	Technical Officer Grade 1.
Y.M. Nardini (Miss)	Typist (from 19 January).
T. Creaser	Assistant Grade 1.

TABLE 2  
Associated Personnel 1970

Name	Position
J.J. Petkovic	Antarctic trainee (March-September).
M.I. McDowell	Antarctic trainee (May-September).
J. Silich	Antarctic trainee (from December 16).
J.W. Murray	Vacation student 1969/70, 1970/71.
L. Tilbury	Vacation student 1969/70.
T. Pryor	Vacation student 1970/71.
P. Johannsen	Daily attendant, Gwangara (until June 10).
B. Carling	Daily attendant, Gwangara (from June 10).
D.C. Allen	Daily attendant, Kalgoorlie.
P.J. Page	Daily attendant, Meekatharra (until 9 December).
K. Baird	Daily attendant, Meekatharra (from 9 December).

TABLE 3

Observatory Staff Absences 1970

Nature of absence	No. of man-days
Sick, special, repatriation	116
Military	22
Attendance at outstations and field operations	18
Other Geophysical Branch surveys	75 ?
Conferences	8
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TABLE 4

Conferences and Addresses

Officer	Date	Conference
P.J. Gregson	September 27 - October 2	Canberra - Observers'-in-Charge meeting.
G. Woad	September 30 - October 2	Sydney - I.P.S. Operators' conference.
		<u>Addresses</u>
P.J. Gregson	June 27	Apex Club, York on W.A. earthquakes.
P.J. Gregson	September 8	Pingelly Diners Club on W.A. earthquakes.

TABLE 5

Visitors

Visitor	Institution
Hon R.W.C. Swartz	Commonwealth Parliament - Minister for National Development.
Dr N.H. Fisher	BMR - Director.
L.W. Williams, Miss B. Wood	BMR
J. Bennett, A. Dixon	National Development.
R.F. Gorden	Geological Survey W.A.
P. Alekna, J. Pyke, V. Solaga	Ionospheric Prediction Service.
E. Edmiston	Department of Supply (Perth).
D. Woodward	DSIR New Zealand.
M. Kurzeme, D. Andrews	CSIRO Soils Division.

TABLE 6  
Preliminary monthly mean values  
of geomagnetic elements, 1970

Month	H, gammas	D (W)	Z, gammas
January	23,801	2°58.8	-53.484
February	808	58.9	477
March	791	59.1	483
April	786	58.9	481
May	793	59.7	474
June	783	59.1	481
July	781	59.8	474
August	771	59.8	469
September	779	59.9	470
October	784	3°00.2	466
November	780	00.4	472
December	782	01.3	474
Mean	23,786	2°59.6	-53,475

TABLE 7  
Preliminary annual mean values of geomagnetic  
elements 1961-70

Year	H, gammas	D (W)	Z, gammas
1961	23,952	2°53.3	-53,491
1962	945	52.8	490
1963	931	52.3	497
1964	916	51.7	501
1965	906	51.7	496
1966	889	52.4	499
1967	868	54.1	499
1968	843	55.7	494
1969	820	57.5	488
1970	786	59.6	475

TABLE 8  
Monthly mean K-index 1961-1970

Month	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
January	2.01	1.89	2.12	1.98	1.42	1.52	2.21	2.28	1.76	1.39
February	2.20	2.21	1.67	2.09	1.76	1.82	1.86	2.35	2.31	1.30
March	2.13	1.82	1.87	1.89	1.54	1.57	1.53	2.42	2.53	1.86
April	2.05	2.11	1.86	2.12	1.26	1.39	1.62	2.02	2.39	1.84
May	1.91	1.41	1.96	1.58	1.33	1.33	2.34	2.02	2.29	1.48
June	1.65	1.80	1.95	1.35	1.37	1.26	1.59	2.27	1.89	1.60
July	2.52	1.95	2.01	1.57	1.38	1.51	1.43	1.63	1.44	1.92
August	1.61	2.49	2.25	1.42	1.63	1.89	1.88	1.76	1.63	1.50
September	1.67	2.68	2.95	1.62	2.02	2.58	2.25	2.24	1.88	1.78
October	1.73	2.98	2.09	1.93	1.54	1.82	2.09	1.92	1.40	1.75
November	1.65	2.28	2.34	1.97	1.57	1.98	2.05	2.21	1.69	2.00
December	1.97	2.33	1.98	1.53	1.76	2.18	2.51	2.02	1.47	1.68
Annual Mean	1.92	2.16	2.08	1.75	1.52	1.74	1.95	2.09	1.88	1.68

TABLE 9

Seismograph Station locations

Station	Code	Lat. S	Long. E	Elevation	Foundation
Mundaring	MUN	31° 58.7'	116° 12.5'	253	Precambrian granite.
Kalgoorlie	KLG	30° 47.0'	121° 27.5'	350	Alluvium over basic metasediments.
Meekatharra	MEK	26° 36.8'	118° 32.7'	515	Precambrian sediments.
Kununurra	KNA	15° 45.0'	128° 46.0'	55	Unweathered sandstone.

TABLE 10

Seismograph parameters

Station	Component	Ts (Sec)	Ts (Sec)	Magnification	Recording speed
MUN	Z, N, E.	1.0	0.75	25000 at 1 s.	60mm/min
	Z.	1.0	0.04	20000 at 1 s.	120mm/min
	Z.	15.0	100	750 at 15s.	15mm/min
	N, E.	15.0	100	375 at 15s.	15mm/min
KLG	Z.	1.0	0.75	16000 at 1 s.	60mm/min
	NE, SE.	1.0	0.25	18500 at 1 s.	60mm/min
MEK	Z.	1.0	0.25	10000 at 1 s. (approx)	60mm/min
KNA	Z.	1.0	0.25	21000 at 1 s.	60mm/min

TABLE 11  
Seismograph Station Instruments

Component	Seismometer	Galvanometer	Recorder	Power supply	Clock	Radio
<u>Mundaring</u>						
SP-Z	Benioff Model 1051 S/N 264	Geotech Model G10 S/N 2780	UED 3ch. Model DR273 S/N 41	WWSSN	Console	No. 44
SP-N	Benioff Model 1101 S/N 243	Geotech Model G10 S/N 2847				
SP-E	Benioff Model 1101 S/N 255	Geotech Model G10 S/N 2898				
LP-Z	Sprengnether Model 201 S/N 2267	Lehner-Griffith Model G13 S/N 70	UED 3ch. Model DR275 S/N 49			
LP-N	Sprengnether S/N 2240	Lehner-Griffith Model G13 S/N 148				
LP-E	Sprengnether S/N 2250	Lehner-Griffith Model G13 S/N 147				
SP-Z	Benioff Model 1051	Willmore S/N 89637 and 88192	Willmore S/N 184806 and 128146	250V Mains	WWSSN	Console No. 44

Component	Seismometer	Galvanometer	Recorder	Power supply	Clock	Radio
<u>Kalgoorlie</u>						
SP-Z	Willmore Mark 2 S/N 240299	Geotech Model G10 S/N 5205	Benioff 3ch. S/N	250V Mains 24V DC standby	EMI S/N 579	Eddystone Model 680X S/N
SP-NE	Benioff Model 1101 S/N	Geotech Model G10 S/N 4340				
SP-SE	Benioff Model 1101 S/N	Geotech Model G10 S/N 4405				
<u>Meekatharra</u>						
SP-Z	Willmore Mark 2 S/N 240297	Geotech Model G10 S/N 15362	Benioff 3ch. 60mm/min S/N	250V Mains 24V DC standby	EMI S/N 580	Labtronics Model 21 S/N 52
<u>Kununurra</u>						
SP-Z	Willmore* Mark 1 S/N 150112	Willmore* S/N 139952	Willmore* S/N 136970	250V Mains	EMI S/N 844	National* R317

\* Equipment belongs to P.W.D. (W.A.)

TABLE 12  
1970 LARGER WESTERN AUSTRALIAN EARTHQUAKES  
EXCLUDING THOSE IN THE LAKE MCKAY REGION

Date 1970	H (U.T.)	Lat. °S	Long. °E	Dist (MUN) km	Magnitude (see footnotes)					Remarks (see footnotes)
					ML	m <sup>1</sup>	mb MUN	mb KLG	m	
Jan 07	03 39 35.8	31.62	116.82	77	3.2	4.1	3.5		3.8	Felt Meckering.
" 12	23 56 04.5	23.03	115.03	1042	3.4	4.3	4.3		4.3	Felt Wagoola.
Feb 01	18 40 56.1	20.3	118.5	1297			5.1	5.1	5.1	20km W Port Hedland.
" 08	16 31 28.5	27.89	125.38	1008			4.3	4.5	4.4	5km W Amy rocks, 7R.
" 16	21 20 22.5	20.0	111.0	1430			5.7	5.3	5.5	600km W Dampier.
Mar 10	17 15 11.2	31.11	116.47	99	5.1	5.5	6.5		6.2	Felt over an area of approx. 250km radius. MM = 6 at Calingiri. 5km overthrust fault 30cm high. Depth 1km. Reported by USCGS (29 stations).
Jul 19	16 38 02	31.18	116.71	101	3.8	4.6	4.7	4.3	4.5	4km E Northam.
Aug 27	22 02 05.7	31.59	117.04	90	3.4	4.3	4.7	4.4	4.5	5km NE Meckering.
Oct 02	06 08 56.7	31.78	117.01	80	3.1	4.1	4.1	4.1	4.1	17km S Meckering.
" 04	16 03 32.6	31.80	117.05	83	3.2	4.1	3.8	4.2	4.1	20km S Meckering. Felt Meckering, Northam.
" 05	13 30 36.4	31.08	115.46	101	3.1	4.1	4.1		4.1	Calingiri.
" 24	02 35 56.2	31.78	116.89	69	3.5	4.4	3.4		4.2	5km SE Quellington. Felt Meckering
" 24	02 36 06	31.8	116.9	69					(4.2)	
Nov 01	05 37 24.0	31.75	116.99	78	3.2	4.1	3.4		4.0	15km S Meckering.
" 26	20 41 06.8	31.72	117.00	81	3.3	4.2	4.1		4.2	16km S Meckering. Felt Meckering.
Dec 26	18 25 51.0	31.08	116.31	102	4.0	4.7	4.4	4.7	4.6	5km W Calingiri.
"	18 32 40.3	31.06	116.32	104	3.2	4.1	3.8	4.4	4.1	5km NW Calingiri.
"	21 57 55.2	31.09	116.31	101	3.0	4.0	3.8	4.1	3.9	3km W Calingiri.

TABLE 13  
LARGER EARTHQUAKES IN THE LAKE MCKAY REGION, 1970

Date 1970	H (U.T.)	Lat. °S	Long. °E	Dist. (MUN) km	Magnitude (see footnotes)					Remarks (see footnotes)	
					ML	m <sup>9</sup>	mb				m
							MUN	KLG	MEK		
Mar 24	10 35 07.5	21.6	126.7	1524			5.9		5.9	Felt in Perth, 1500km from epicentre. Maximum known intensity MM = 5 at Fitzroy Crossing 500km from epicentre. Reported by USCGS (138 stations)	
" 24	11 18 41.5	21.7	126.3	1499				4.9	4.9		
" 24	11 34 11.3*	22.2*	126.7*						4.6*	Reported by USCGS (5 stations)	
" 24	12 10 36.3	22.1	126.4	1489			5.5	5.0	4.9	DAR. Reported by USCGS (5 stations)	
" 24	13 08 10.4	21.7	126.1	1519			4.4	4.4	4.6		
" 24	14 14 40.9	21.9	126.5	1499			4.5	4.6	4.5		
" 24	14 26 01.2	21.6	126.1	1489			4.5	4.4	4.1		
" 24	15 01 23.9	21.9	126.2	1499			4.4	4.4	4.1	DAR.	
" 24	16 09 41.4	21.9	126.7	1529			4.8	4.9	4.4	DAR. Reported by USCGS (5 stations)	
" 24	16 22 06.7	21.4	126.4						4.2		
" 24	17 15 12.8	22.0	126.5	1489			4.4	4.4	4.4		
" 24	20 02 44.9	21.7	126.1	1467			4.4	4.4	4.1		
" 24	20 23 10.3	21.8	126.4	1509			5.0	4.7	4.6		
" 24	20 37 35.4	21.8	126.5					4.3			
" 24	23 00 49.2	21.7	126.4						4.0		

Date 1970	(U.T.)	Lat. °S	Long. °E	Dist. (MUN) km	Magnitude (see footnotes)					Remarks (see footnotes)	
					ML	m <sup>v</sup>	mb				m
							MUN	KLG	MEK		
Mar 24	23 32 42.4	21.8	126.2	1499		5.0	4.9		4.9		
" 25	00 31 48.5	21.9	126.3	1479		5.1	5.1		5.1	DAR.	
" 25	01 18 23.2	22.0	126.5	1499		4.7	4.7		4.7		
" 25	01 54 25.4	22.2	126.5	1469		4.7			4.7		
" 25	05 08 52.8	21.8	126.4	1449		4.7	4.7		4.7		
" 25	06 32 35.8	22.1	126.4	1479		4.9	4.7		4.8		
" 25	10 30 26.2	22.1	126.5	1494		4.8	4.8		4.8		
" 25	12 39 39.1	22.2	126.4	1489		4.6	4.7		4.6		
" 25	16 21 29.1	21.9	126.2	1464		4.7			4.7		
" 26	00 48 56.1	21.8	126.2	1474		(4.4)		4.1	4.2		
" 26	02 35 10.1	22.0	126.5	1479		(5.0)	4.9	4.8	4.9		
" 26	02 42 51.4	22.2	126.5	1459		(4.8)		4.4	4.5		
" 26	11 38 12.4	21.9	126.3	1474		4.9	(5.0)	4.8	4.9	DAR. Reported by USCGS (6 stations).	
" 26	12 19 16.9	21.9	126.4	1502		4.7	4.7	4.6	4.7	DAR. Reported by USCGS (5 stations).	
" 26	13 09 48.7	22.0	126.5			4.5		4.4	4.4		
" 27	00 52 01.3	21.9	126.5	1499				4.0	4.0		
" 27	10 10 41.1	22.5	126.8	1489				4.0	4.0		
" 29	18 48 35.4	22.5	126.7	1449			3.9	4.0	4.0		
" 29	19 33 51.7	22.2	126.7	1469			4.0	3.9	3.9		
" 30	01 06 44.2	21.9	126.3	1469			4.2	4.1	4.1		

Date 1970	H (U.T.)	Lat. °S	Long. °E	Dist. (MUN) km	Magnitude (see footnotes)					Remarks (see footnotes)	
					ML	m°	mb				m
							MUN	KLG	MEK		
Apr 01	16 12 00.4	21.8	126.2	1503			5.0	5.0	4.9	4.9	DAR. Reported by USCGS (5 stations).
" 03	11 13 39.0	22.1	126.3	1449			(4.4)	4.1	4.1	4.1	
" 03	23 42 40.1	22.0	126.4	1500				4.4	4.4	4.4	
" 04	14 09 35.1	21.9	126.6	1504			5.4	5.3	4.9	5.2	DAR. Reported by USCGS (17 stations).
" 04	19 49 22.2	21.8	126.3	1489			4.1	4.1	3.9	4.0	
" 06	19 19 04.2	22.5	126.7	1469			4.0		4.0	4.0	
" 07	10 33 22.6	22.1	126.6				4.1		4.1	4.1	
" 14	01 53 29.2	21.9	126.4	1489				4.2	4.1	4.1	
" 14	05 34 29.1	21.7	126.3					4.0	3.9	3.9	
" 16	18 44 21.8	21.9	126.3					4.2	4.4	4.4	
" 18	08 58 06.5	21.9	126.3						4.8	4.8	
" 25	22 50 20.5	22.0	126.5					4.1	4.1	4.1	
May 05	23 56 37.8	21.6	126.3	1534					4.1	4.1	
" 08	19 26 49.5	21.6	126.2	1504				4.2	4.1	4.1	
" 10	18 42 34.8	21.5	126.2	1514				4.6	4.4	4.5	
" 14	14 37 14.6	21.5	126.2	1514			(4.7)		4.4	4.5	
" 15	09 31 48.0	21.6	126.3	1509					4.0	4.0	
" 20	07 32 13.3	21.7	126.1	1509					4.8	4.8	
" 20	10 42 39.5	21.8	126.1	1489					4.4	4.4	
" 22	15 54 07.1	21.6	126.3						4.1	4.1	
" 23	18 53 42.4	21.5	126.0	1509					4.6	4.6	
" 24	04 50 43.5	21.6	126.1	1499					4.1	4.1	
" 25	10 33 24.8	21.8	126.3	1489					4.0	4.0	

Date 1970	H (U.T.)	Lat. °S	Long. °E	Dist. (MUN) km	Magnitude (see footnotes)					Remarks (see footnotes)	
					ML	m'	mb				m
							MUN	KLG	MEK		
May 26	10 35 15	21.7	126.0	1499					4.0	4.0	
" 27	04 42 42	22.1	126.5	1489					4.2	4.2	
" 31	02 46 07	21.8	126.2	1499			4.0				4.0
" 31	10 20 53	21.8	126.2	1489			4.2				4.2
Jun 09	22 20 29	21.7	126.2	1489				4.2	4.1		4.1
" 11	11 47 29	21.8	126.4	1499					4.0		4.0
" 11	18 59 35	21.6	126.2	1479					4.0		4.0
" 23	05 54 45	21.5	126.3						4.1		4.1
" 29	07 32 10	21.8	126.4						4.4		4.4
" 30	19 49 20	21.8	126.2						4.1		4.1
Jul 17	08 24 16.9	21.9	126.6					4.1	4.1		4.1
" 20	16 01 45	22.1	126.3					4.8	4.5		4.6
" 20	19 08 42	22.3	126.7						4.0		4.0
" 22	00 32 39	22.5	126.9	1499					4.1		4.1
" 22	18 59 59	21.5	126.3	1509					4.1		4.1
" 30	05 19 01	21.7	126.3	1499					4.1		4.1
Aug 04	21 21 02	21.7	126.3	1499					4.1		4.1
" 04	22 10 30	21.2	126.0	1539					4.4		4.4
" 05	08 59 55	21.7	126.3					4.6	4.9		4.8
" 07	08 17 33	21.9	126.4	1489					4.4		4.4
" 23	20 50 29	22.1	126.5	1489					4.1		4.1
" 29	19 42 57	22.3	126.6	1479					4.1		4.1
Oct 03	02 18 49								4.6		
" 04	19 42 06	21.7	126.3	1509					4.1		4.1

Date 1970	H (U.T.)	Lat. ° S	Long ° E	(MUN) km	Magnitude (see footnotes)					Remarks (see footnotes)	
					ML	m <sup>0</sup>	mb				m
							MUN	KLK	MEK		
Oct 23	03 45 59	22.5	126.9	1499					4.1	4.1	
" 29	02 36 22	22.2	126.8						4.0	4.0	
Dec 23	21 27 25	21.7	126.1	1504					4.1	4.1	

TABLE 14

1970 Minor Earthquakes in Western Australia  
Excluding Those in the Lake Mealy Region

Date 1970	H U.T.	ML	mb	Distance km from MUN	Bearing ° <sub>T</sub>	Remarks
Jan 19	04 23 08	2.8	3.7	96	(045)	15km E Goomalling
" 28	18 45 48	2.4	3.6	79	045	Jennacubbine
" 30	18 11 01	2.6	3.8	111	028	5km SW Konnongorring
Feb 01	18 47 15	2.4	3.3	91	135	Dattening
" 01	22 14 28	2.6	3.5	91	135	Dattening
" 09	20 33 48	2.5	4.1	82	(060)	Meckering
" 21	16 04 59	2.6	3.6	111	022	15km Konnongorring
Mar 01	03 16 44	2.0	3.4	91	(015)	Near Calingiri
" 10	17 47 33	2.2	3.1	93	(015)	Near Calingiri
" 10	18 15 32	2.5	3.4	93	(015)	Near Calingiri
" 13	07 56 12	2.2	3.1	96	(015)	Near Calingiri
" 13	18 07 37	2.3	3.2	97	(015)	Near Calingiri
" 14	01 22 59	2.1	3.0	95	(015)	Near Calingiri
" 20	13 01 10	2.0	2.9	95	(015)	Near Calingiri
May 18	18 34 12	2.5	3.2	82	076	20km S Meckering
Jun 03	14 56 43	2.5	4.0	99	061	12km NE Meckering
" 17	04 00 34	2.4	3.4	94	016	8km S Calingiri
" 26	12 03 45	2.6	3.7	156	(015)	12km SW Balidu
" 28	19 13 56	2.5	-	128	019	5km W Wongan Hills
" 28	23 31 54	2.5	3.2	85	059	5km NW Meckering

Date 1970	H U.T.	ML	mb	Distance km from MUN	Bearing °T	Remarks
Jul 11	05 35 23	2.6	3.5	74	-	Meckering
" 11	15 15 45	2.6	4.3	81	062	5km W Meckering
" 14	07 49 40	2.4	3.1	80	076	20km S Meckering
" 14	18 21 15	2.7	3.9	78	066	8km SW Meckering
Aug 09	16 56 20	2.5	3.7	78	067	8km SW Meckering
" 18	05 51 03	2.4	3.7	87	078	25km SW Meckering
" 24	14 00 35	2.2	3.1	75	063	10km SW Meckering
" 24	16 53 30	2.5	3.4	101	(090)	10km E Mawson
" 26	10 11 36	2.6	3.5	78	080	20km N Mawson
" 30	13 47 13	2.2	3.1	97	(015)	Near Calingiri
" 30	15 11 32	2.0	2.9	96	(015)	Near Calingiri
" 31	04 50 30	2.2	3.1	99	(015)	Near Calingiri
Sep 02	04 50 39	1.9	2.8	94	(015)	Near Calingiri
" 02	10 12 36	2.2	3.4	85	(090)	Mawson
" 03	04 00 11	2.0	3.3	78	(090)	12km W Mawson
" 06	07 45 24	2.5	3.7	85	073	15km S Meckering
" 17	01 00 33	2.8	3.6	100	013	Calingiri
" 17	01 16 14	2.2	3.1	102	018	10km E Calingiri
" 18	00 12 58	1.8	3.7	85	072	15km S Meckering
" 18	01 46 39	2.6	3.8	102	007	6km NE Calingiri
" 18	06 43 19	2.2	3.5	81	062	5km W Meckering
" 24	09 08 51	1.7	3.3	75	079	18km SW Quellington
" 25	07 22 07	1.7	3.4	81	078	21km SW Quellington
" 25	13 38 06	1.8	2.5	95	(000)	Near Calingiri

Date 1970	H U.T.	ML	mb	Distance km from MUN	Bearing °T	Remarks
Sep 27	04 02 32	2.2	3.5	103	007	7km NE Calingiri
" 30	10 08 55	2.8	4.0	72	078	15km S Meckering
Oct 01	05 48 56	2.1	3.0	80	027	8km E Wattening
" 01	15 15 53	2.3	3.3	80	061	15km SSE Meckering
" 05	11 35 15	2.6	3.6	88	066	5km SE Meckering
" 13	02 46 21	2.7	3.9	82	063	5km SW Meckering
" 25	06 30 48	1.8	2.6	81	059	8km NW Meckering
Nov 03	15 33 34	2.5	3.7	77	066	10km SW Meckering
" 06	19 33 53	1.5	2.8	85	072	15km S Meckering
" 09	02 52 41	2.0	3.6	98	(000)	Near Calingiri
" 11	23 57 00	2.3	3.1	81	066	8km SW Meckering
" 16	20 11 10	2.0	2.9	77	090	12km W Mawson
" 22	20 13 04	2.2	3.4	83	072	14km S Meckering
" 30	00 35 38	2.6	3.0	101	105	30km SW Beverley
" 30	07 28 13	2.3	2.5	91	072	15km SW Meckering
Dec 12	01 22 06	(2.9)		(109)	073	30km E Meckering
" 17	05 36 33	2.1	3.7	94	034	5km W Goomalling
" 17	14 21 07	2.0	3.3	102	(000)	Near Calingiri
" 17	16 26 26	1.9	3.3	81	073	15km S Meckering
" 25	20 23 25	2.4	3.4	105	020	12km E Calingiri

TABLE 15Minor Earthquakes in the Lake McKay Region

Date 1970	H (U.T)	Lat. °S	Long. °E	mb MEK
Mar 24	11 11 09	21.9	126.5	3.9
" 24	11 42 42	20.7	125.5	3.9
" 24	11 51 45	21.6	126.3	3.5
" 24	14 39 24	21.8	125.8	3.6
" 24	15 22 05	21.9	126.4	3.9
" 24	15 31 02	22.0	126.7	3.7
" 24	16 03 32	22.1	126.7	3.6
" 24	17 40 39	21.8	126.5	3.7
" 24	18 13 52	21.7	126.6	3.4
" 24	19 16 30	21.7	126.2	3.9
" 24	19 40 09	21.7	126.7	3.4
" 24	21 35 48	21.3	126.1	3.7
" 25	00 23 27	21.6	126.3	3.7
" 25	07 45 40	21.6	126.3	3.6
" 25	08 29 30	22.2	126.6	3.7
" 25	10 52 02	21.6	126.4	3.9
" 25	17 16 31	21.8	126.3	3.7
" 25	22 37 02	22.1	126.6	3.6
" 25	23 14 59	21.7	126.4	3.6
" 26	00 29 11	21.4	126.2	3.7
" 26	04 51 27	22.1	126.6	3.9
" 26	09 53 36	21.6	126.3	3.6
" 26	14 29 54	21.7	126.5	3.7
" 27	00 49 06	21.8	126.5	3.5
" 27	22 41 54	22.6	126.9	3.9
" 27	23 46 55	21.9	126.6	3.6
" 30	21 31 11	21.8	126.4	3.5
" 30	22 48 43	21.8	126.6	3.5
" 31	21 19 07	21.7	126.3	3.6

Date 1970	H (U.T)	Lat. °S	Long. °E	mb MEK
Apr 01	12 11 21	22.2	126.6	3.9
" 01	16 49 07	21.9	126.5	3.6
" 02	05 36 17	22.1	126.4	3.4
" 02	16 30 35	21.6	126.4	3.4
" 06	14 30 25	21.8	126.6	3.4
" 09	12 14 57	21.6	126.3	3.4
" 13	14 24 22	21.9	126.4	3.9
" 14	01 06 01	21.6	126.3	3.9
" 16	16 03 33	21.7	126.3	3.5
" 17	05 50 44	21.7	126.2	3.8
" 17	09 28 35	21.7	126.0	3.9
" 18	09 30 39	21.9	126.4	3.8
" 18	11 29 22	21.8	126.5	3.4
" 21	10 03 03	21.7	126.5	3.4
" 23	04 23 20	21.5	126.2	3.5
" 24	06 11 20	22.2	126.5	3.9
" 26	14 19 42	22.1	126.7	3.4
May 02	21 48 41	21.9	126.5	3.4
" 03	02 45 48	21.6	126.4	3.4
" 04	08 22 26	22.0	126.5	3.9
" 06	11 57 11	21.6	126.2	3.4
" 11	08 41 07	21.4	126.3	3.5
" 11	14 07 15	21.3	126.1	3.8
" 14	15 12 10	21.6	126.4	3.8
" 15	11 16 43	21.6	126.2	3.4
" 25	21 35 17	21.9	126.7	3.4
" 29	08 30 33	21.7	126.5	3.4
" 30	02 34 35	21.7	126.5	3.7
June 03	01 44 57	21.5	126.0	3.7
" 05	17 08 41	22.1	126.7	3.9
" 14	02 26 01	21.4	126.1	3.4
" 20	04 28 26	21.6	126.5	3.4
" 30	14 12 37	21.7	126.3	3.7

Date 1970	H (U.T)	Lat. ° S	Long. ° E	mb MEK
Jul 02	11 59 36	21.5	126.4	3.4
" 05	07 48 49	21.5	126.4	3.4
" 12	18 22 55			4.0
" 16	22 44 46	21.4	126.2	3.6
Aug 07	17 23 36	21.6	126.1	3.4
" 21	00 15 13	22.0	126.7	3.7
" 23	20 00 39	22.0	126.4	3.5
" 27	16 21 03	21.3	126.9	3.7
Sep 15	15 29 36	21.5	126.1	3.4

NOTES FOR TABLES 11-14

Events in table 11 were generally recorded at MUN, KLG and MEK.

Events in table 12 were generally recorded at MUN, KLG, MEK and WRA.

Events in table 13 were generally recorded at MUN only.

Events in table 14 were generally recorded at MEK and/or WRA only.

DAR - Darwin

ML - Determined at MUN

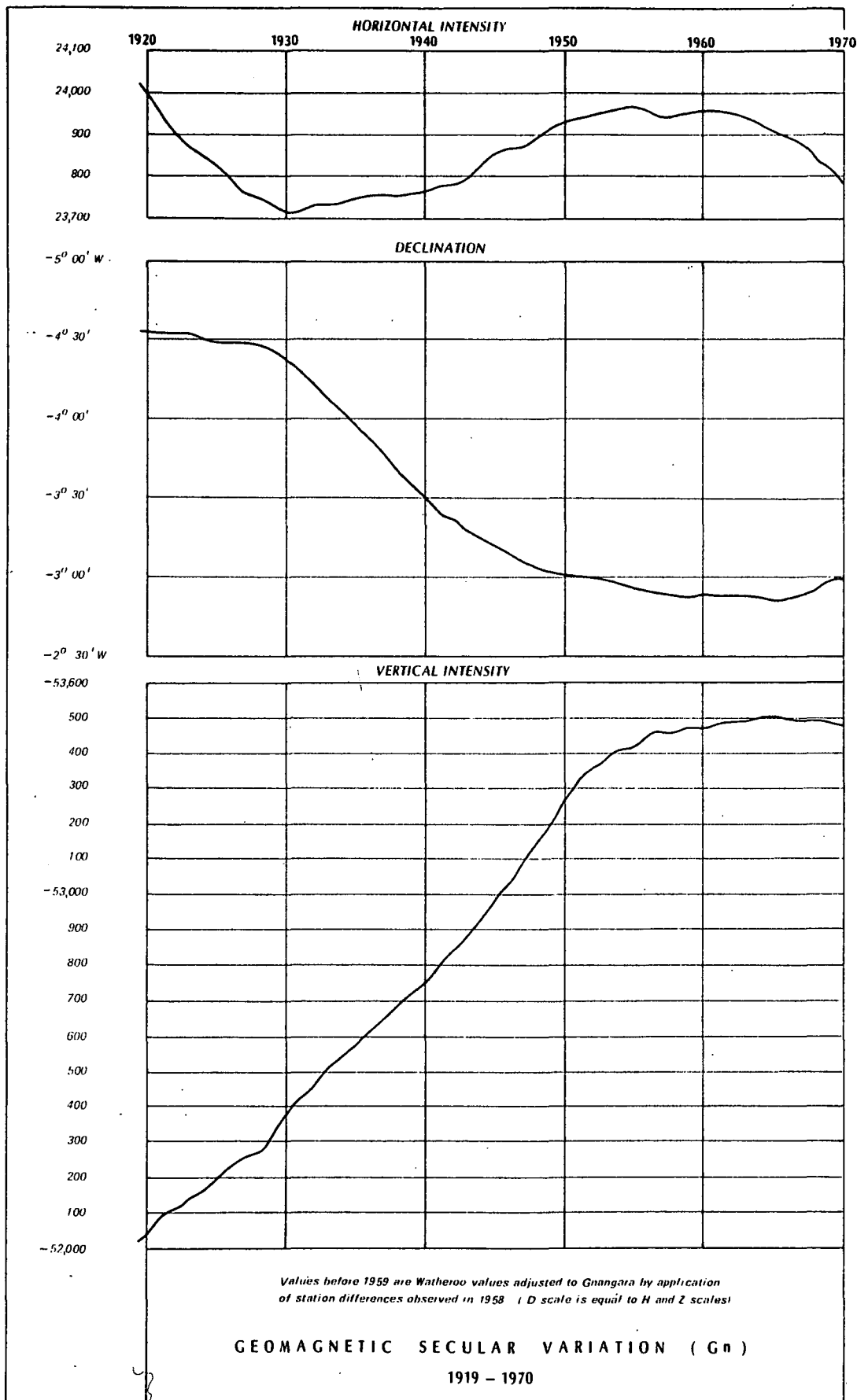
$m'$  - Derived from  $m = 1.8 + 0.73ML$

$mb$  - Derived from  $mb = \log A/T + A_0 + 0.4 = mb(MUN) + 0.4$   
 $A_0$  from Everingham (1968) curve B

$m$  - Unified magnitude (weighted mean of  $m'$  and  $mb$ ) values for MUN and KLG or MEK

( ) - Less accurate value

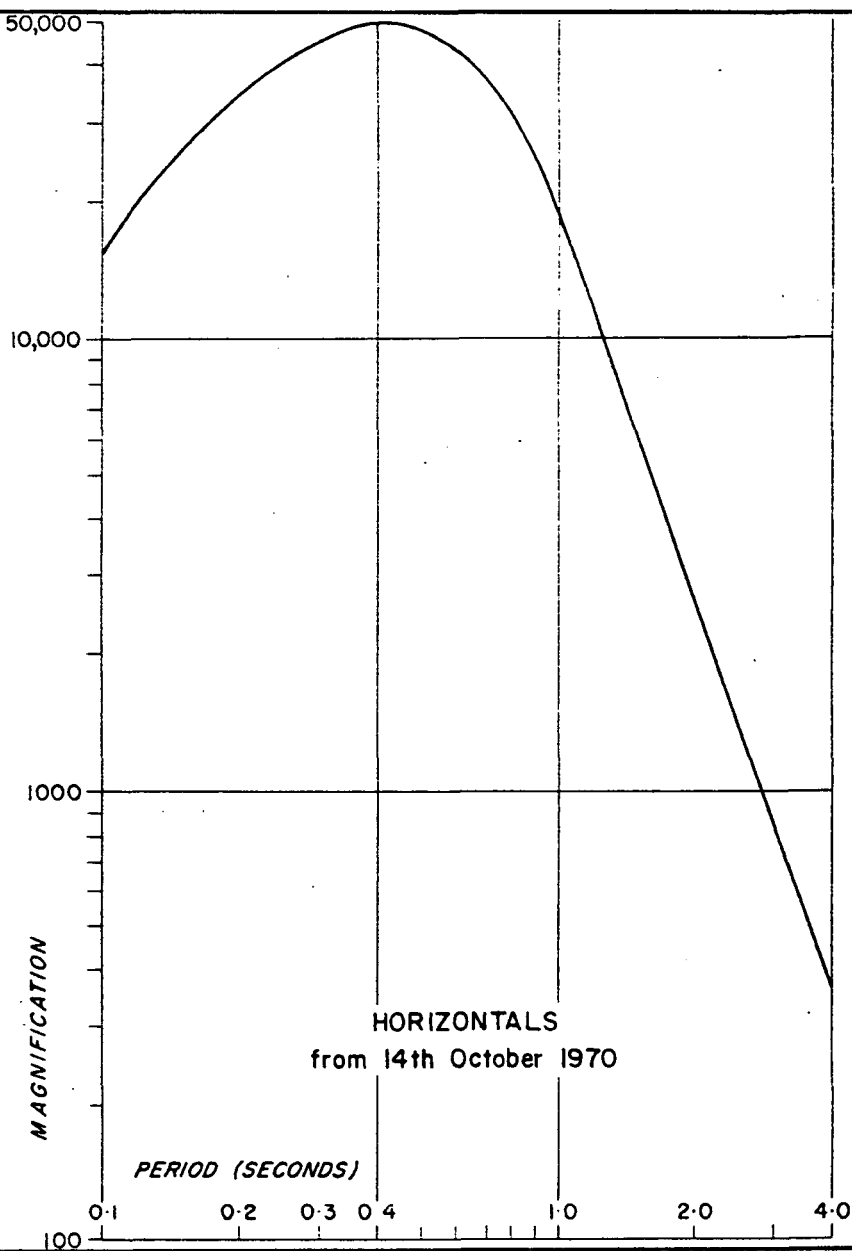
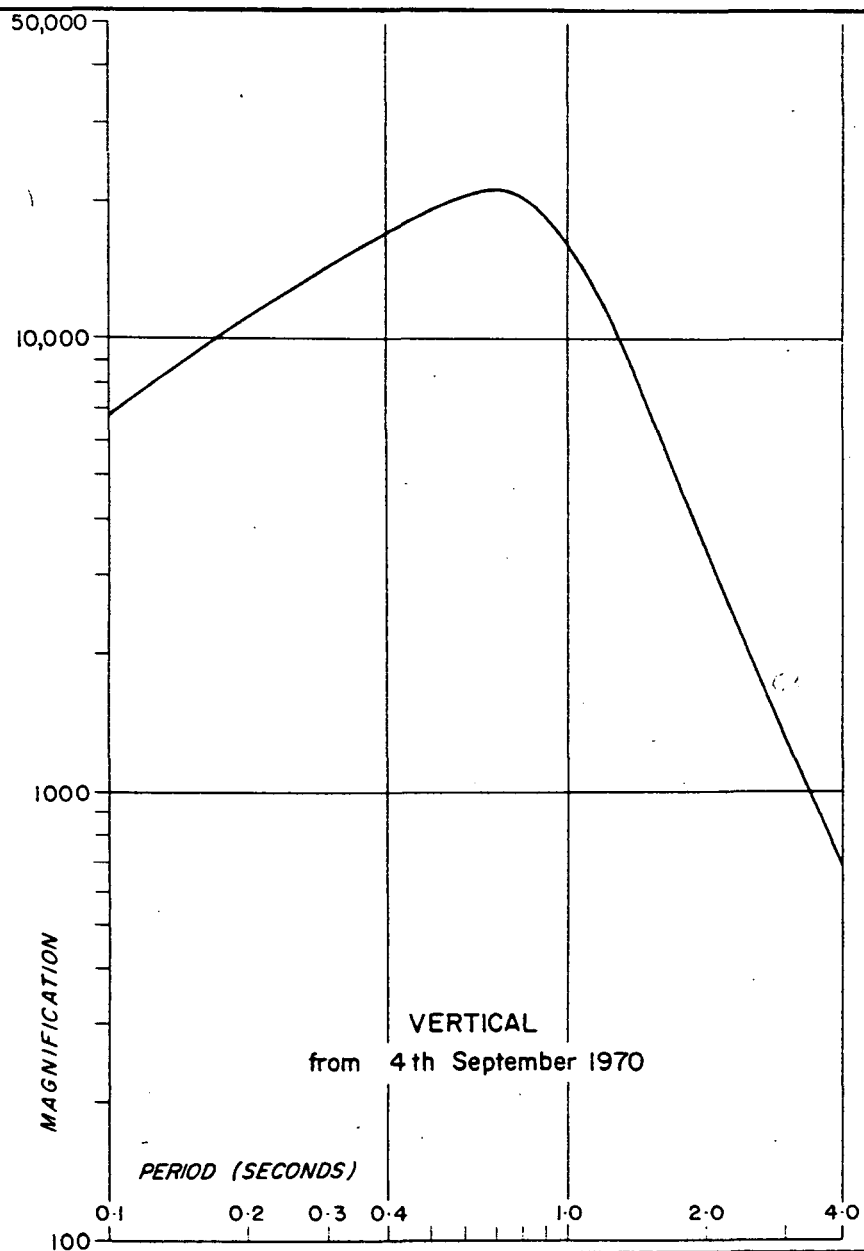
\* - USCGS determination.

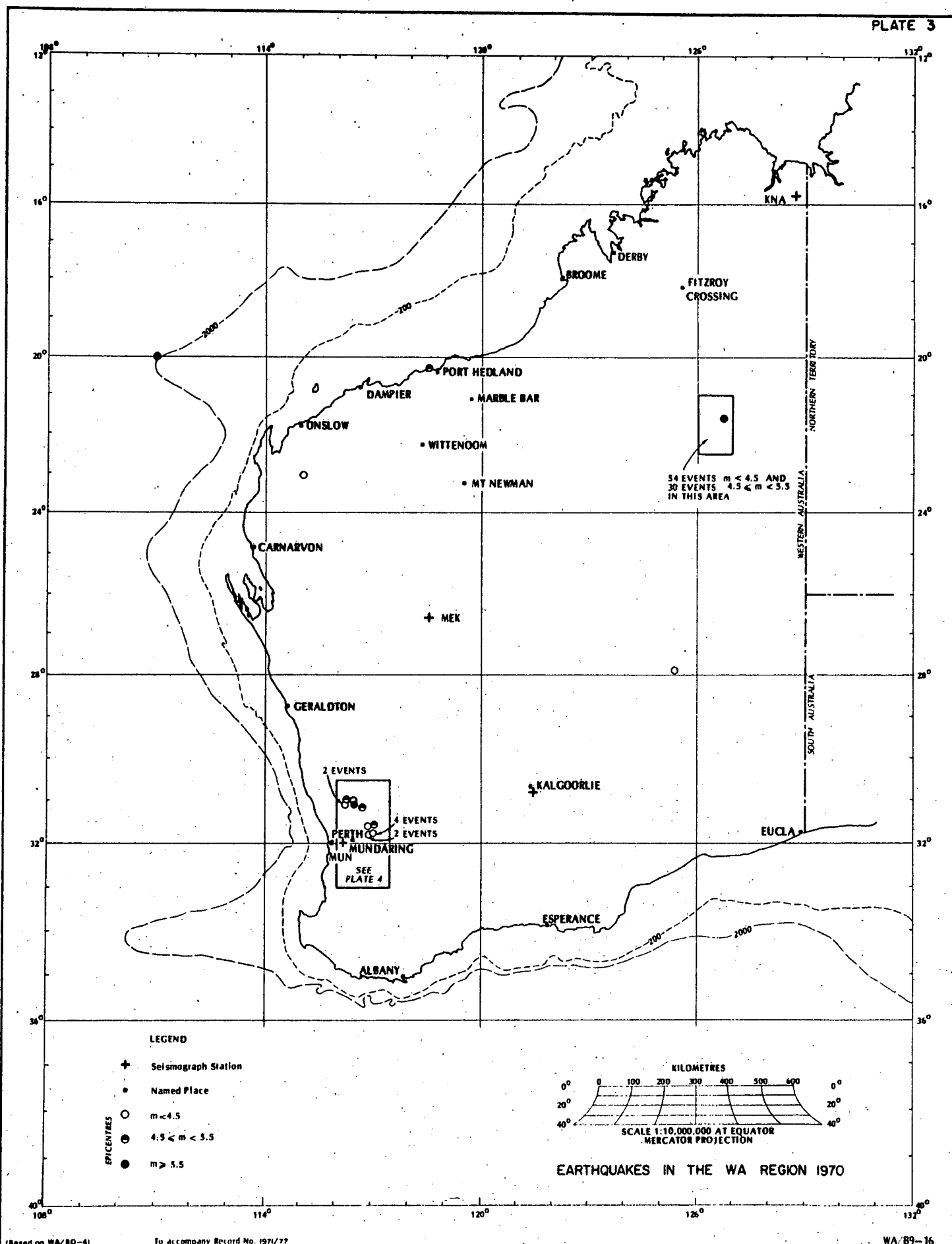


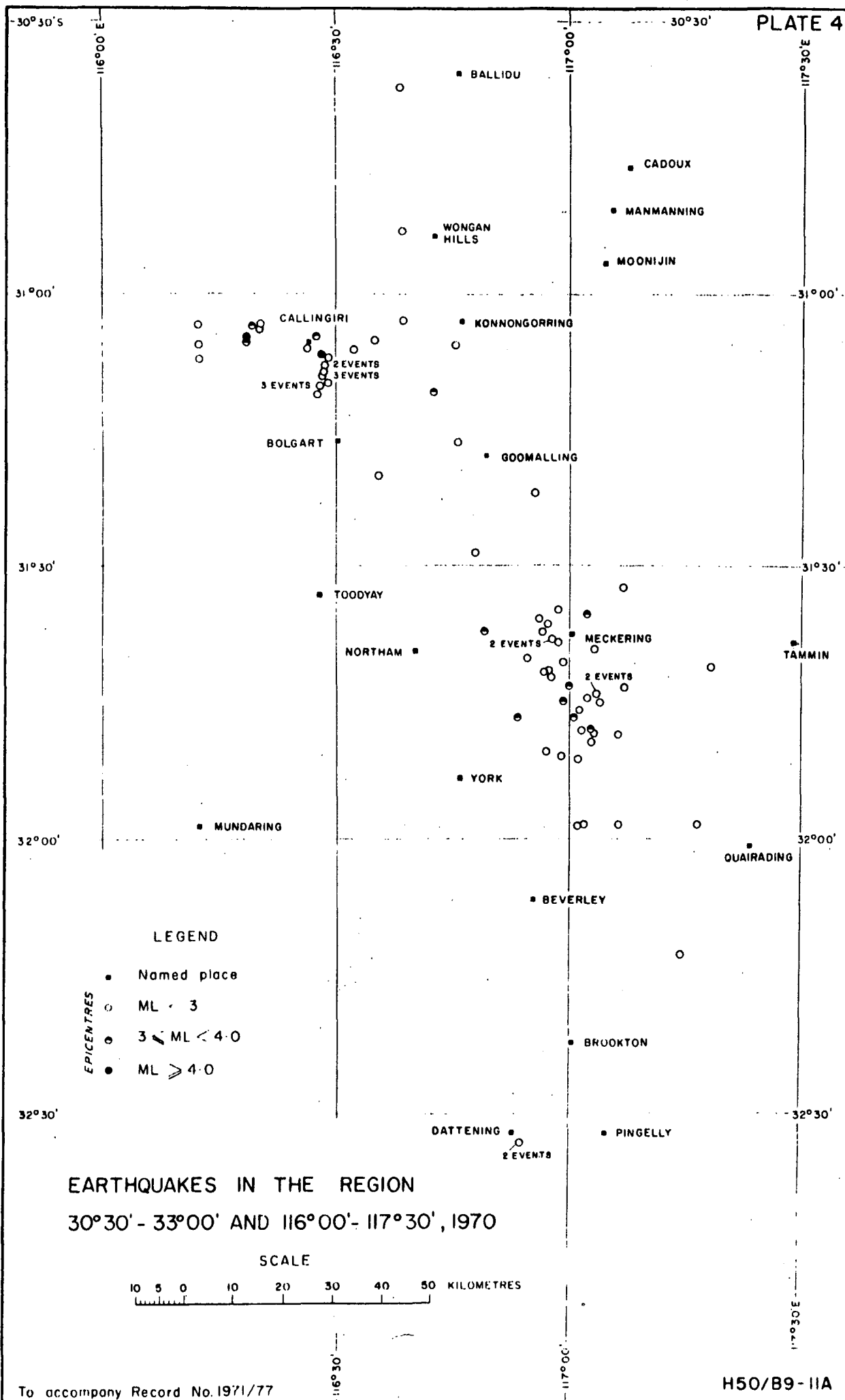
# KALGOORLIE SEISMOGRAPH CALIBRATION CURVES

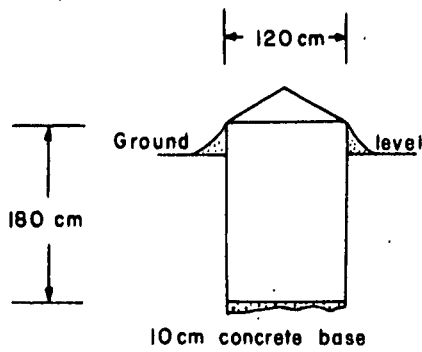
To accompany Record No.1971/77

G82/3-149A



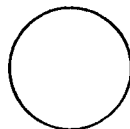




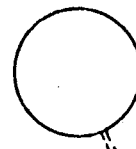
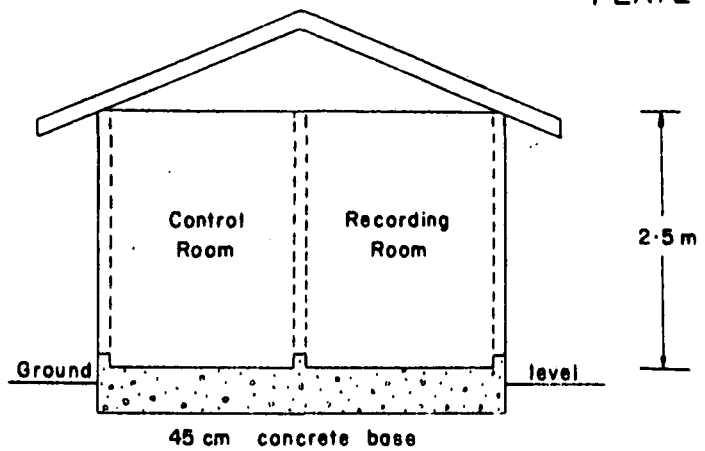


SECTION

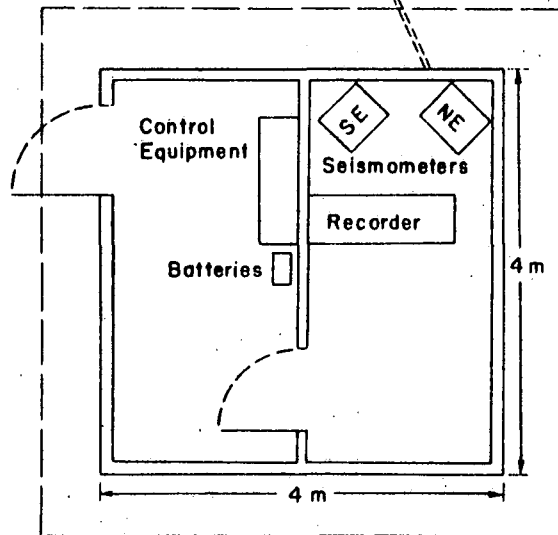
Seismometer Vault



PLAN



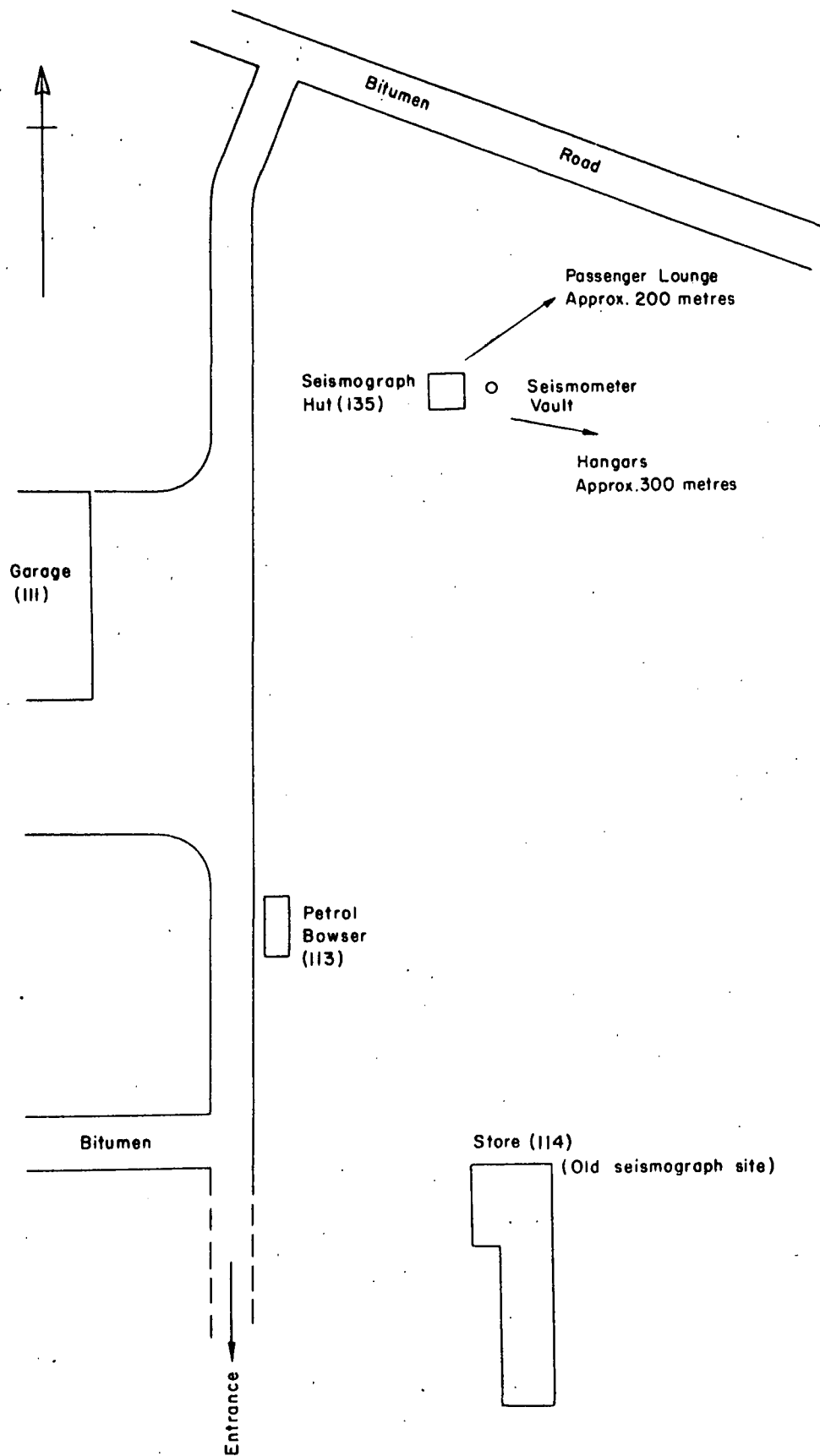
75mm P.V.C. pipe to seismometer pit



PLAN

# KALGOORLIE SEISMOGRAPH HUT AND VAULT





LOCATION OF SEISMOGRAPH,  
KALGOORLIE AIRPORT