DEPARTMENT OF NATIONAL RESOURCES

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1977/7

MUNDARING GEOPHYSICAL OBSERVATORY
ANNUAL REPORT 1976

by

P.J. Gregson

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SUMMARY

Basic programs in geomagnetism, ionospherics, and seismology were continued at the Mundaring Geophysical Observatory during 1976. The main instruments were an Eschenhagen normal-run magnetograph, an IPSD Type IIIE ionosonde, and a Worldwide Standard Seismograph. A 'sensor house' was erected at Gnangara in preparation for the installation of an Automatic Magnetic Observatory.

Seismographs were operated at Swan View, Kalgoorlie, Meekatharra, Marble Bar and Giles, and accelerographs at Meckering and Kununurra. The seismograms from the seismograph at Kununurra owned by the WA Government, were analysed. A Seismic Research Observatory was installed with the sensor at Narrogin and digital and visual recording in the Mundaring office.

The annual earthquake list shows details of 47 Western Australian earthquakes, 21 of which occurred in the southwest zone; the largest, near Meckering had a magnitude ML = 4.7 and felt-reports data showed it had a maximum intensity of MM V.

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, Marble Bar, Giles, Kununurra, and Swan View (seismological recording). In co-operation with the United States Geological Survey, a Seismic Research Observatory (SRO) was installed in March with the sensor at Narrogin and digital and visual recording at the Mundaring office. Routine recording commenced on 27 March 1976. Preparations were commenced for the installation of an Automatic Magnetic Observatory at Gnangara. Descriptions of the observatory and an outline of activity there to the end of 1975 have been given in previous records (e.g. Gregson & Smith, 1976); and principal events in the observatory's history are given in the Appendix. Discussion of non-routine projects is brief, as details will be reported separately.

STAFF AND VISITORS

Observatory staff is 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 summarised in Table 3, and conferences and training sessions attended, or addresses given, in Table 4.

Mr R.S. Smith was promoted to Geophysicist Class 3 and transferred to Canberra headquarters on 19 August; Mr E.P. Paull remained on temporary transfer to the Toolangi Observatory Group until 30 October, when he returned to Mundaring as Geophysicist Class 2.

Two geophysicists, Messrs K.D. Wake-Dyster and M.J. Sexton, were given training in observatory practice from July to September in preparation for Antarctic duty in 1977.

Visitors to the observatory are listed in Table 5.

GEOMAGNETISM

Normal magnetograph

The Eschenhagen 20 mm/h magnetograph continued in operation at Gnangara.

The records for 5 March and 27 July were completely lost owing to operators' errors, viz. the recording lamp being left off and the recorder shutter left closed respectively. Partial loss occurred on 9 and 10 June and 4 October as a result of fogging. The duty operator loaded the recording paper with the reverse side out from 7 to 12 January, but the records were still readable. Three hours of record were lost on each of 11 and 12 April when the battery supply failed. The normal lead accumulators were replaced with two 12V Faure-x cells designed for low-current trickle charging.

All the control equipment operated well throughout the year with the exception of the magnetograph calibration (see later). The time-mark foot switches in the absolute hut were rewired and an extra switch was installed near the proton precession magnetometer.

No unexplained changes in baseline or scale values occurred during 1976.

On 8 February (1144 UT) the H variometer temperature-compensating magnet shifted slightly. This resulted in the recording trace value moving 21 mm. The compensating magnet was adjusted on 24 February (0100) to bring the recording trace back to its original position. The same adjustment reduced the variometer scale value from 2.65 nT/mm to 2.52 nT/mm. The Z scale value rose from a minimum of 5.70 nT/mm in January to 6.20 nT/mm in August.

The Z variometer temperature-compensating magnet was lowered 5 mm on 31 August (0600 UT) to reduce the Z temperature

coefficient. The poise on the recording magnet was also adjusted then, and again on 8 September, to relevel the magnet and bring the recording trace back to its original position. This adjustment reduced the Z scale value to 5.7 nT/mm.

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

Element	Baseline value	Scale value
D	0.24 min	-
H	1.1 nT	0.01 nT/mm
Z	1.2 nT	0.04 nT/mm

Magnetograph tests

Temperature coefficients. Least-squares analysis of H baseline data obtained after the adjustment of the temperature-compensating magnet on 24 February gave a value of qH = 0.0 nT/^{o}C. The value determined for the 1975 data, qH = 0.4 nT/^{o}C, was used until 24 February.

The 1975 value of qZ = 3.9 nT/^{o}C was used until the adjustment of the Z temperature-compensating magnet on 31 August. A value of 4.3 nT/^{o}C was determined using least-squares analysis but this value was not used as the difference was small. The adjustment improved the temperature compensation considerably and a preliminary coefficient of qZ = 0.0 nT/^{o}C was used for the remainder of the year.

Orientation. Orientation tests were made on the Z variometer on 15 June and on 8 September after the adjustment of the compensating magnet; the H and D magnets were tested on 31 August. Orientations of the recording magnets in the mean magnetic field were:

H:	E 1.0°N	31 August (ordinate 18 mm)
D:	N 0.3°W	31 August (ordinate 20 mm)
Z:	N 0.0°	15 June (ordinate 36 mm)
Z:	N 0.1° Down	8 September (ordinate 39 mm)

These results are compatible with those of previous years.

Parallax. No tests were performed during 1976 and it was assumed that the parallax remained unchanged from previous years. During 1973 it had been found that the parallax on variation trace time-mark spots (but not on baseline spots or hour lines) was zero on all components. The parallax for other time-marks can be measured from the trace time-marks.

Scale values. A magnetograph calibrator MCO2 was used in conjunction with Helmholtz coils to determine H and Z scale values once weekly. The current delivered by the calibrator varied significantly before April. The variation was eliminated by replacing the reference diode with a high-precision temperature-compensated zener diode.

The D scale value was determined to be 1.09'/mm on 31 August using the Helmholtz coil method.

Magnetometers

Instruments used during the year for weekly control observations were Askania declinometer 509319 and PVM B/116/B. The latter comprised Elsec vector coils set B, Elsec proton precession magnetometer, S/N 116 and sensor set B.

Difficulty was encountered in turning and levelling the PVM coils on several occasions. Tests with various lubricants continued until April when a slight coating of "stalube" white grease was applied to the mating surfaces of the cone bearing. This proved satisfactory for the remainder of the year. The

vector coil pier (NM) was replaced in September by a pier with larger area (600 mm x 600 mm) to improve the stability of the coil level.

Comparisons. A set of intercomparison observations was performed between the Gnangara PVM (B/116/B) and the QHM 460 series from 11 May to 1 June. Comparisons were made through baseline values because the PVM polarising current (pier NM) affected the QHMs (pier NE) and prevented simultaneous observations. Each QHM was read eight times. The H differences found were:

H. 460 - H. B/116/B = 3.4 ± 0.9 nT)
H. 461 - H. B/116/B = 7.3 ± 0.8 nT) Note: these differences are not reduced to a common pier.
H. 462 - H. B/116/B = 3.8 ± 0.9 nT)

An F pier difference was measured on 11 May between piers NM and NE. Observations were taken simultaneously using a Geometrics PPM (S/N 1365, W.A.I.T.) at a site about 30 metres south of the absolute house, and PPM 116 on pier NM and then on pier NE. Ten observations were made on each pier. The derived station difference was:

NM - NE = 1.6 nT (F).

BMZ 120 was compared with PVM (B/116/B) on 10 and 11 August. The Z difference found was:

Z. 120 - Z. B/116/B = +227 nT.

Preliminary corrections used throughout the year were:

(a) PVM B/116/B: H nil.
(b) Askania declinometer 509319 (circle 508135): + 0.5 minutes.
(c) PVM 116: Z nil.

D standardisation. A series of D observations was made with the Askania declinometer (509319) from May to July to determine the effects of magnetic material in either the circle base or the declinometer head. These tests were part of the HQ program to establish an Australian Magnetic Standard. Two sets of observations were made:

1. Base rotation. Observations were made with the base in three orientations 120^{o} apart. Two observations were made in each position on each of five separate days. With footscrew A in the positions shown, the mean observed baseline values were:

N =	2^{o} 50.9' $\pm$ 0.3'
SE -	2^{o} 51.1' $\pm$ 0.3'
SW -	2^{o} 50.8' $\pm$ 0.3'
Mean	2^{o} 50.9' $\pm$ 0.3'

The mean baseline value is the same as the baseline value from normal observations (footscrew A N), within the limits of error. It is therefore concluded that the magnetic effect of the base is zero for normal observations.

2. Head rotation. Observations were made with the declinometer head rotated through 180^{o} and viewing the magnet mirror with the telescope to the north instead of the normal south position. Two observations were made in both the normal and reverse positions on each of six days. Differences in baseline observations were:

D(N) - D(S) = 1.6 minutes.

The copper damping plates were removed on 29 June and the above test repeated. The difference D(N) - D(S) = 1.5 minutes. This indicates that the majority of any magnetic impurity is in the declinometer head. The damping plates were reinstalled.

Automatic Magnetic Observatory

Preparations commenced for the installation of an Automatic Magnetic Observatory (AMO). A new insulated concrete-block house was built to house the sensors. The position of the building is shown in Plate 5.

Accessory equipment

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

Magnetic pulsation tape-recording equipment was operated at the Weir site for the University of Newcastle. Apart from minor losses due to the failure of the tape drive and breaking of the signal cables, recording was continuous.

Data reduction and publication

Mean hourly value reduction data were prepared in monthly batches about three months after recording. Magnetograms and reduction data were sent to Canberra HQ for the derivation of hourly values. As a check on these values, the first and thirteenth hours of H, D, and Z were hand scaled and mean values calculated at Mundaring for direct comparison.

Monthly and annual mean values of H, D, Z, and F and mean K-index values at Gnangara for 1976 are listed in Table 6. The field values were derived from the ten local quiet days of each month by scaling a mean ordinate for each component from each magnetogram. Annual values for all components since 1966 are shown in Table 7. Recent trends in secular variation continued with H decreasing by about 41 nT; D became more westerly by 0.9 minutes and Z increased in magnitude by about 30 nT. The mean value for F rose by about 12 nT during 1976.

The distribution and publication of data continued as previously (for details see Record 1975/143).

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

IONOSPHERICS

Equipment

The quarter-hourly sounding schedule was continued throughout the year using a model 3E ionosonde; the ionosonde and components and circuit boards were supplied by the ionopheric Prediction Service (IPS), Department of Science. 240 hours (2.7%) of record was lost during the year. Losses were due to component failure (95 hours) and the film jamming or breaking (145 hours).

Special soundings were made at 5-minute intervals for the period 13 October to 5 November covering the solar eclipse on 23 October; 1-minute soundings were made on 23 October from 0400 UT to 1000 UT.

Data distribution and publication

The scaling, distribution, and publication of data continued as previously (for details see Record 1976/48).

SEISMOLOGY

Seismograph stations

Permanent stations were operated throughout 1976 at Mundaring (MUN), Kalgoorlie (KLG), Meekatharra (MEK), Kununurra (KNA), Swan View (SWV), and Giles (GLS). Marble Bar (MBT) was closed in February; the seismometer was resited and the station reopened in June as MBL. A Seismic Research Observatory (SRO) was installed at Narrogin/Mundaring (NWAO).

The numbers of events reported from each station in 1976 were:

MUN 637; KLG 485; MEK 724; KNA 1733; MBT (one month) 5; MBL (six months) 477; NWAO (nine months) 445; NWA (two months) 64;
SWV 431; GLS 1491.
TOTAL: 6562.

A summary of record losses from all seismograph stations is given in Table 8.

Mundaring. The erratic behaviour of the WWSSN timing system which began on 13 December 1975 continued until June. An EMI clock was used for time control during this period. Replacement units including the crystal, divider, strobe and programmer from Albuquerque Seismological Laboratory did not improve the clock performance, and the problem was eventually tracked down to excessive ripple (3V) on the output of the battery charger. This in turn was resulting in excessive ripple on the 25V regulator. The ripple on the charger output was reduced by reducing the charger output current and the timing system became stable again. The short-period recorder motor was replaced in July.

The supplementary seismograph ran well and the seismograms were used extensively in microearthquake studies. The main cause of record loss was again the failure of the recorder lamps. A mask in the optical path of the high-gain vertical-component was removed in December. This allowed the lamp intensity to be reduced and should reduce the frequency at which the lamps burn out.

Kalgoorlie. This seismograph was converted from a photographic recorder to a visual recorder (helicorder) in August. By using 0.75 Hz and 5.0 Hz cut-off much of the background and industrial noise was eliminated. This enabled the peak magnification to be increased from 21K to 60K. The magnif-

ication was later doubled on 9 November to give a peak magnification of 120K. The seismograph calibration curve is shown in Plate 4.

Meekatharra. This seismograph continued to operate as a single vertical component throughout the year. The battery charger was modified to reduce RF noise by the addition of a small capacitor (0.047 uF) across one of the amplifier transistors (Q4) and increasing the value of the output filter capacitor (C3). All other battery chargers of this type constructed at Mundaring were subsequently modified.

Marble Bar. Helicorder and EMI clock problems resulted in the closure of this station (MBT) in early February. As it was planned to resite the seismometer later in the year, repairs were left until then.

In June the seismometer was positioned at Marble Bar airport and data were telemetered on a Telecom line into the town. The recording and control console was shifted from the Shire Office to the Post Office where there is an airconditioned room. The seismometer was shifted to eliminate the artificial seismic noise generated in the townsite and to place it on more consolidated rock. The peak magnification was increased from about 100K to 400K at 0.15 seconds, with an increase from 19K to 70K at 1 second.

Co-ordinates and details of instruments are given in Table 10.

There is no power at the seismometer site. To supply power for the telemetry amplifier (Geotech AS330) a 12V lead accumulator was installed. A solar cell is used to keep the accumulator charged and a locally produced DC to DC converter provides $\pm$ 12V for the telemetry amplifier. Plate 6 shows details of the remote power supply. Some problems occurred during hot weather in December. The charging rate of the solar

cell dropped below that required to keep the battery charged. The battery had to be removed twice for recharging. This accounted for about half of the record loss. It may be necessary to increase the remote charging capacity by adding a second solar cell.

Full details of the Marble Bar seismograph are given in Page & Smith (in prep.).

Kununurra. This station continued to operate exceptionally well with only minor record losses, resulting from operator errors. Occasional problems occurred with time control when the EMI clock display jumped. The clock was replaced in August.

Swan View. This station operated throughout the year with the exception of the period 8-30 August when the telemetry amplifier was used at Kalgoorlie. From March, power and time control was provided from the seismic Research Observatory console. Mains power was used from 26 November to 4 December when diodes and a voltage sensing relay failed in the SRO power supply.

The seismograms proved valuable in providing data to locate earthquakes in the southwest seismic zone and also for providing preliminary data about overseas and larger Australian earthquakes.

Giles. The operation of this station improved considerably. Time control was a problem in May when the time correction shown in the operator log differed from that determined from the recorded radio pips. The clock rate increased drastically to about half a second per day in July. These types of problems take time to rectify because records are received only in fortnightly batches.

Eleven days' record was lost in August when the station ran out of recording paper.

Transportable. This unit was operated for a short period only in November during explosion tests (see later).

Seismic Research Observatory

In the early 1960s, the United States Government established the World Wide Standard Seismograph Network (WWSSN) comprising about 115 stations in more than 50 countries. This world network has been the principal source for a general-purpose data base for global seismological investigations and research. By employing the advances in electronic and instrumental technology made since 1960, the data base can be greatly improved, and with this objective the United States Defence Advance Research Projects Agency (ARPA) in co-operation with the U.S. Geological Survey (USGS) initiated the Seismic Research Observatory (SRO) project.

The USGS, in co-operationn with participating countries, is in the process of installing thirteen SROs around the world, so that with similar seismographs installed in recent years there will be about 25 digital-recording observatories to complement the WWSSN. Mundaring Observatory was selected in 1974 as the centre of one of the SROs (see Record 1974/174, p. 97). Routine recording commenced on 27 March.

Details of the SRO are given by Smith, Woad & Gregson (in prep.): an installation report by the contractors also provides technical information (Shaw, undated).

Accelerographs

Four MO2 accelerographs were in service until December, two at Kununurra and two at Meckering, sites B and C. No seismic events were recorded. All the accelerographs were returned to Mundaring in December for a general overhaul.

Explosion seismology

Seismic waves from mining explosions at Newman, Tom Price, Goldsworthy, Shay Gap, Sunrise Hill, Parburdoo and Koolyanobbing were recorded regularly by some Western Australian seismographs. The mining companies involved continued to cooperate by supplying monthly summaries of explosion times. A catalogue of signatures of the explosions recorded at various seismograph stations was made to assist in differentiating between explosions and local or regional earthquakes.

A large mining explosion at Tom price on 11 August was recorded at MBL, MUN, NWAO, KLG, MEK, ASP, MTN, and STK. The Pn velocity between MEK and MUN was calculated to be 8.35 km/s; compared with a value of 8.44 km/s determined in 1975 (Gregson & Smith, 1976).

From July, waves from explosions at Collie (Griffin Mining Co.), were recorded on numerous occasions at Mundaring, Swan View, and Narrogin. Further recordings at sites between Collie and Mundaring are planned for 1977.

The Navy, in conjunction with the Weapons Research Establishment (WRE), exploded about thirty 50-kg depth charges about 100 km off the west coast on 22 November. Attempts were made to record the waves at sites 10 km west and 10 and 20 km east of Swan View, and at Boddington (70 km west of Narrogin), but the charges were too small to record.

Stress measurements

Six sites in the southwest seismic zone, which were selected in 1975, were drilled by the CSIRO for in situ stress measurements in January and February. This project was part of the program of the BMR Regional Crustal Suryeys Group (see Record 1976/91, p. 71); observatory staff provided local liaison with the drilling contractor. Stress measurements were made by an

overcoring method. Site localities and results are given by Alexander, Denham & Worotnicki (1977).

Seismicity

Table 9 lists Western Australian earthquakes of magnitude ML = 2.0 or greater which occurred during 1976 and for which locations are available; 47 events are listed, of which 21 occurred in the southwest seismic zone.

Epicentres were initially determined graphically. For larger earthquakes not in the southwest seismic zone, which were recorded at four or more Australian stations, epicentres were redetermined by the headquarters group using a computer program for the relocation of earthquakes. Better results were obtained for earthquakes in the southwest seismic zone by using distance and azimuth from Mundaring. A program using a Sharp 365P calculator was developed for determining origins in the southwest seismic zone using S-P times from MUN, SWV, and NWAO. From April, this program was used when applicable.

Plates 1 and 2 show epicentres of Western Australian earthquakes (with magnitudes mB = 4 or greater) and those in the southwest seismic zone respectively.

Southwest zone. Activity in this zone was lower than in 1975; there were only two earthquakes with ML greater than 2.9. The largest, ML = 4.7, occurred on 29 October 3 km south of Meckering. Three small events occurred 13 km north-northwest of Rocky Gully on 8 August.

Kununurra area. The Kununurra area was the most active other than the southwest zone during 1976. Twelve earthquakes were recorded between 33 km south and 180 km southwest of Kununurra. The largest, ML = 4.5, occurred on 7 November and was located 33 km south-southwest of Kununurra. Two other small events occurred also in November in the same place, within 10 km of the Ord River Dam wall.

Other areas. Several isolated earthquakes with magnitude mB greater than 4 occurred during the year. These are shown in Plate 2.

Earthquake intensities

One hundred and eighty questionnaires were distributed for the Meckering earthquake which occurred on 29 October; 75% of them were returned. An isoseismal map was prepared and is shown in Plate 7; It is difficult to fit smooth isoseismals but the data indicate that the maximum intensity was upper V at Meckering, the radius of the isoseismal for intensity IV was approximately 120 km, and the earthquake was felt up to 240 km from the epicentre.

Data distribution and publication

Seismic data were distributed as previously (for details see Record 1975/143). A punched-tape telex machine was installed in the office in January to facilitate sending preliminary data from all stations to the US National Earthquake Information Service.

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

NOTES ON WORKS PROJECTS

Minor repairs and maintenance were carried out on the observatory buildings. A 3 m x 4 m insulated concrete-block building was built at Gnangara to house the sensor coils for the proposed Automatic Magnetic Observatory.

ACKNOWLEDGEMENTS

The assistance of the daily attendants listed in Table 2 is hereby acknowledged. The co-operation of the Pilbara Shire

Council (until June) and the Marble Bar Post Office (from June), for housing the Marble Bar seismograph is also acknowledged. Punching of ISC cards was carried out by the Australian Bureau of Statistics (Perth) by arrangement with the Deputy Commonwealth Statistician. We also acknowledge Hamersley Iron Pty Ltd, Mount Newman Mining Co. Pty Ltd, and Goldsworthy Mining Ltd, for preparing monthly summaries of explosion times for their mining operations.

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TABLE 1

OBSERVATORY STAFF 1976

Officer	Designation
P.J. Gregson	Geophysicist Class 3
R.S. Smith	Geophysicist Class 2 (until 19 August)
E.P. Paull	Geophysicist Class 2 (from 1 November)
B.A. Gaull	Geophysicist Class 1 (from 27 January)
J. Silic	Geophysicist Class 1 (until 13 February)
G. Woad	Technical Officer Grade 2
B.J. Page	Technical Officer Grade 1
Y.M. Moiler (Mrs)	Typist Grade 1
T.E. Creaser	Assistant Grade 1

TABLE 2

ASSOCIATED PERSONNEL 1976

Name	Nature of duties
K.D. Wake-Dyster	Antarctic trainee (16 July - 24 September)
M.J. Sexton	Antarctic trainee (6 September - 1 October)
B. Carling	Daily attendant, Gnangara
R. Kruger	Daily attendant, Kalgoorlie
D. Richardson	Daily attendant, Meekatharra (until 22 December)
B. Harvey	Daily attendant, Meekatharra (from 23 December)
G. Edwards	Daily attendant, Marble Bar (until 31 January)
J. Bailey	Daily attendant, Marble Bar (from 25 June)
J. Roberts	Daily attendant, Kununurra
Observer-in-Charge Weather Station	Daily attendant, Giles

TABLE 3

OBSERVATORY STAFF ABSENCES 1976

Nature of absence	No. of man days
Sick leave	30
Military leave	15
Attendance at outstations and field operations	26
Furlough	11
Temporary transfer	208
	290

TABLE 4

CONFERENCES, ADDRESSES AND TRAINING

Officer	Date	Address
P.J. Gregson	Sep 13	Midland Business Men's Association

TABLE 5

VISITORS

Visitor	Institute
Mr R. Thompson	CSIRO)
Mr I. Hulls	CSIRO) (Stress measurements)
	)
Mr L. Alexander	CSIRO)
Mr S. Shaw	Unitech)
Mr R. Reynolds	Unitech) (SRO)
Mr H. Butler	United States Geological Survey)
Mr J. Bailey	Marble Bar Post Office
Mr B. Fereday	Department of National Resources (Canberra)
Mr D. Blair	Kalgoorlie School of Mines
Mr E. Edmiston	Department of National Resources (Perth)
Mr H. Lauchland	Department of National Resources (Canberra)
Mr D. Rock	Albuquerque Seismological Laboratory (SRO)
Mr B. Harvey	Department of Transport, Meekatharra
Mr J. Hoare	Westrail
Mr B. Mitchell	Westrail
Students	Darlington Primary School
Trainee teachers	Churchlands Teachers College

TABLE 6

PRELIMINARY MONTHLY MEAN GEOMAGNETIC VALUES AND K-INDEX

1976

Month	D(West)	H, nT	Z, nT	F, nT	K
January	03° 12.2'	23589	53510	58479	2.17
February	12.0	582	514	480	2.52
March	12.2	571	520	481	2.66
April	12.0	567	526	485	2.26
May	12.6	569	526	485	2.03
June	12.3	568	527	486	1.67
July	12.0	566	529	487	1.95
August	12.4	562	530	486	1.79
September	12.4	555	537	490	2.17
October	12.2	559	535	490	1.86
November	12.7	557	540	493	1.50
December	13.2	557	542	495	1.93
Mean	03° 12.4	23567	53528	58486	2.05

TABLE 7

GEOMAGNETIC ANNUAL MEAN VALUES 1966-1976

Year	D	I	H, nT	X, nT	Y, nT	Z, nT	F, nT	Notes
1966	-2°52.6'	-65°56.2'	23890	23860	-1199	-53499	58591	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
1973	07.8	06.2	686	651	1292	460	472	2C
1974	09.9	09.0	642	606	1304	477	470	2C
1975	11.5	11.3	608	571	1314	496	474	2C
1976	12.4	14.2	567	530	1318	528	486	2C
Mean annual change	-1.98	-1.80	-32.3	-33.0	-11.9	2.9	-10.5	

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

TABLE 8

1976 SEISMOGRAPH RECORD LOSSES

HOURS

Cause	MUN WWSSN SP Z	MUN WWSSN SP N	MUN WWSSN SP E	MUN WWSSN LP Z	MUN WWSSN LP N	MUN WWSSN LP E	MUN SUP Z	MUN SUP N	MUN SUP E	NWAO SP Z	NWAO LP Z	NWAO LP N	NWAO LP E	SWV Z	KLG Z	MEK Z	MBL Z*	KNA Z	KNA N	KNA E	GLS Z
OPERATOR																					
Late change										1	1	1	1		135	225	37	1	1	1	70
Drum not reset	24	24	24															24	24	24	
Paper reversed			24																		
Poorly loaded							20	19								53					10
Fogged																73		41	41	41	
Paper supply																					264
POWER FAILURES																					
Mains															52						
Battery														32			106				
RECORDER FAULTS																					
Blown lamp	36	87					82	35	32						103					16	
Helicorder										27			5				146				
Optics																5					
CONTROL EQUIPMENT																					
Clock																		24	24	24	
Discriminator																					
SRO remote													32								
SRO local										26	4	4	4								
Equipment elsewhere														604							
LINE OUTAGE										42	42	42	42								
MAINTENANCE																					
Preventative	8	8	8	8	8	8				138	138	138	138	4	71		5				
TOTAL	68	119	56	8	8	8	102	54	32	234	185	185	222	640	361	356	294	90	90	106	344
Percentage	0.8	1.4	0.6	0.1	0.1	0.1	1.2	0.6	0.4	3.5	2.8	2.8	3.3	7.3	4.1	4.1	5.8	1.0	1.0	1.2	3.9
Mean percentage				0.5%				0.7%			3.1%								1.1%		

* Not operating for 5 months.

TABLE 9

WESTERN AUSTRALIAN EARTHQUAKES 1976

Date 1976	Origin Time U.T.	Lat. °S	Long. °E	ML	mB	Remarks	No. of Stations
Jan 20	03 34 15.3	31.86	116.97	1.9		27 km S Meckering, felt.	2
Feb 11	14 14 45.5	30.75	116.80	2.4		30 km NW Manmanning.	2
19*	02 32 05.3	19.41	114.30		5.6	250 km NW Onslow.	8
22	17 38 22.8	31.70	116.99	2.8		8 km S Meckering.	3
Mar 01	06 53 29.1	31.60	117.00	2.1		2 km N Meckering.	2
04	16 09 03.9	30.9	117.0	2.0		10 km SW Manmanning.	1
04	21 07 38.5	30.62	116.67	2.5		10 km SW Ballidu, felt MM IV.	3
15*	15 38 35.9	32.34	125.47		5.2	South Coast.	16
17	22 51 42.1	30.5	116.77	2.5		10 km N Ballidu.	1
22	05 32 44.2	31.66	117.01	2.5		4 km S Meckering.	4
28	07 35 34.9	17.0	127.6	2.7		180 km SW Kununurra.	1
29	01 26 03.4	16.9	127.7	2.7		170 km SW Kununurra.	1
31*	21 26 48.4	38.22	113.50		4.7	South Coast.	5
Apr 12	15 24 27.0	16.4	128.1	2.2		100 km SW Kununurra.	1
18*	19 50 10.0	22.2	126.58		4.6	Lake Mackay	7
May 08	00 54 34.8	30.72	116.62	2.3		200 km SW Ballidu, felt.	3
11	09 26 49.0	30.90	117.09	2.5		5 km S Manmanning.	3
11	10 28 58.7	30.68	116.60	2.3		15 km SW Ballidu.	3
11	10 54 13.5	30.7	116.6	2.6		15 km SW Ballidu.	3
21	05 43 31.7	16.45	128.25	2.5		95 km SW Kununurra.	1
21	05 48 13.4	16.5	128.2	2.0		90 km SW Kununurra.	1
24	22 56 56.2	33.13	118.01	3.1		75 km ESE Narrogin.	3
Jun 11*	04 27 24.5	18.67	125.25	3.8		50 km S Fitzroy Crossing.	6

Date 1976	Origin Time U.T.	Lat. °S	Long. °E	ML	mB	Remarks	No. of Stations
Jul 01	14 03 42.0	33.70	117.90	2.6		20 km E Broomhill.	3
23	16 11 46.9			2.3		143 km from Marble Bar.	1
27*	17 56 59.5	20.0	113.9		4.4	50 km N North West Cape.	6
Aug 08	03 10 28.9	34.40	116.93	2.9		13 km NNW Rocky Gully, felt.	2
08	09 28 54.7	34.40	116.93	2.7		13 km NNW Rocky Gully, felt.	2
08	12 20 41.0	34.40	116.93	2.6		13 km NNW Rocky Gully, felt.	2
10	19 05 17.7	33.40	118.10	2.4		10 km NW Broomhill.	2
11	04 36 14.2	23.40	119.70			Newman explosion.	9
Sep 14	14 15 12.9	16.4	128.0	2.1		115 km SW Kununurra.	1
15	19 49 50.3	31.88	116.98	2.3		29 km S Meckering.	3
27	02 17 54.1	16.53	128.72	2.0		89 km S Kununurra.	1
Oct 10	12 18 12.2	16.56	128.42	2.4		91 km SSW Kununurra.	1
16	18 11 59	27.0	112.0	4.0		400 km NW Geraldton.	3
21	11 12 21	19.4	114.0		4.9	NW Shelf.	3
29	06 04 48.2	31.64	117.00	4.7		3 km S Meckering, felt MM V.	11
Nov 07*	03 47 27.6	16.05	128.82	4.5		33 km SSW Kununurra, felt MM V.	7
07	09 58 19.6	16.02	128.64	2.0		33 km SSW Kununurra.	2
09	20 48 33.2			1.7		31 km from Marble Bar.	1
10	05 27 42.6	16.02	128.64	2.1		33 km SSW Kununurra.	1
20	08 18 18.8	16.02	128.64	2.5		33 km SSW Kununurra.	1
24	11 47 50.2			2.1		135 km from Marble Bar.	1
25	11 11 50.3	31.62	117.11	2.6		10 km E Meckering.	3
28*	18 34 12.6	18.26	122.06		4.4	100 km S Broome.	8
Dec 04	20 27 13	17.1	128.1	3.0		160 km SSW Kununurra.	1

*Relocated using headquarters computer program.

TABLE 10

MARBLE BAR (MBL) SEISMOGRAPH DATA

Code

MBL

Co-ordinates

Latitude:	21° 09.6'S
Longitude:	119° 50.0'E
Elevation:	200 metres
Foundation:	Archaean Basic Igneous

Parameters

Component:	SP-Z
Ts:	1.0 seconds
Magnification	
at 1.0 sec.	70K
0.15 sec.	428K
Recording speed:	60 mm/min

Instruments

Seismometer:	Johnson Matheson	S/N 332
Telemetry amplifier:	Geotech AS330 (6 db)	S/N 450
Discriminator:	Geotech XD410	S/N 454
Recorder:	Geotech RV301	S/N 252
Recorder amplifier:	Geotech AR311 (24 db)	S/N 326
Clock:	EMI	S/N 843
Radio:	Labtronics	S/N 419

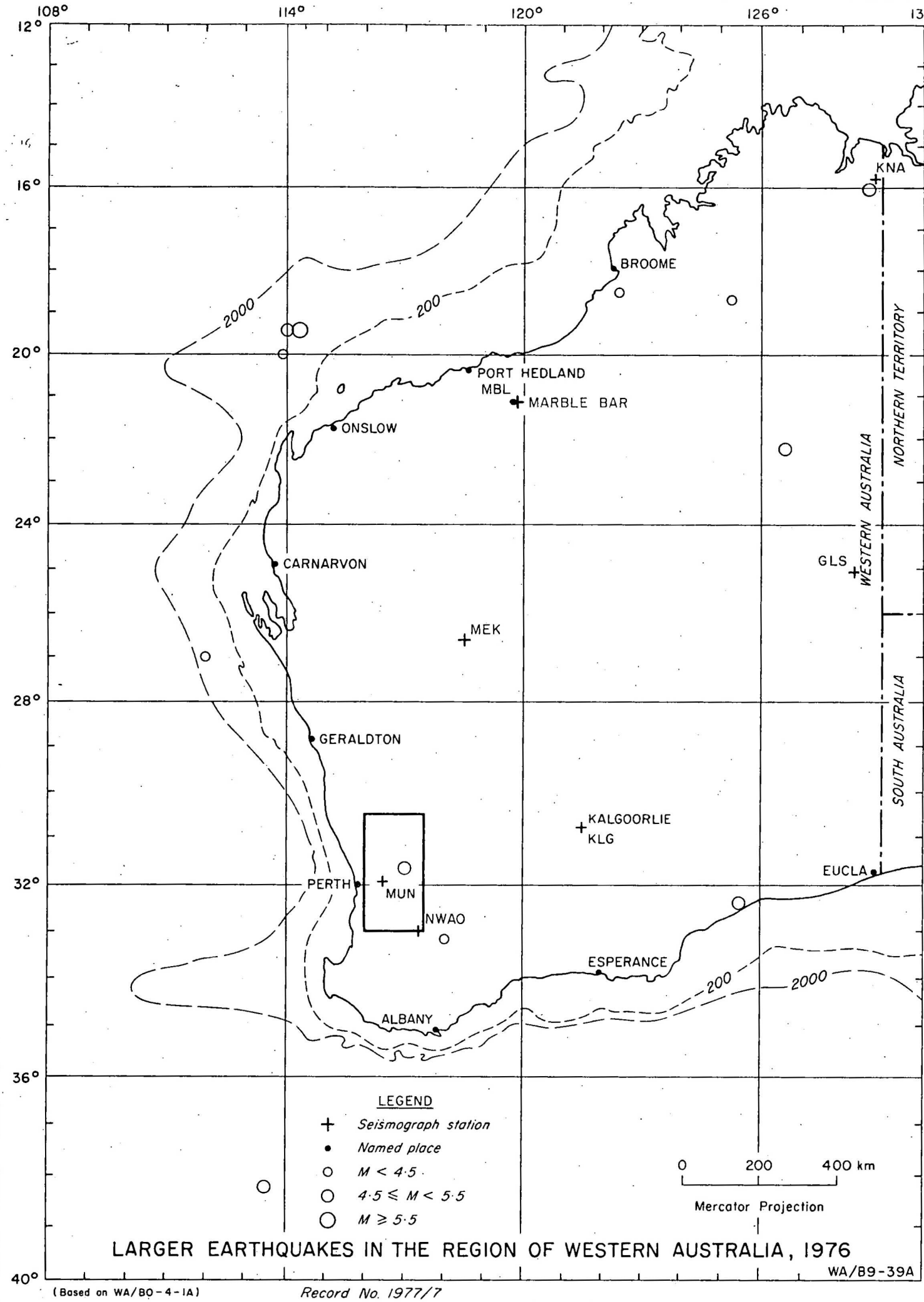
APPENDIX

PRINCIPAL EVENTS

MUNDARING GEOPHYSICAL OBSERVATORY 1957-1974

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 Jun 22	Absolute magnetic observations commenced in new absolute house.
1962 Jun	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 Jun 27	Proton scalar magnetometer introduced for Z baseline control.
1972 Oct 12-1975 Feb	MBT SP-Z seismograph recording.
1972 Nov 16	MO2 accelerograph (PWD) installed at Kununurra.
1973 Jan 31	Mobile SP-Z recording at various sites in SW seismic zone started.
1973 Mar 30	KLG - reduced to SP-Z.
1973 May 1	MEK - increased to 3-component SP.
1973 May 23	MUN - 2 Wood Andersons installed.
1973 May 25	MUN - Benimore SP-Z withdrawn; Benioff SP-Z started.

1974 Apr 1	Proton vector coils introduced for Z baseline control.
1974 May 1	Proton vector coils introduced for H baseline control.
1974 June 17-31	Riometer recording at Mundaring during solar eclipse.
1974 Sep	GLS - SP-Z recording commenced.
1975 Jul 18 - Nov 19	Earthtide recording at Mundaring.
1975 Mar 19 - Aug 15, Dec 18	SWV - SP-Z recording.
1975 Sep 2-1976 Feb 5	NWA - SP-Z recording.
1976 Mar 27	NWAO - Seismic Research Observatory commenced.
1976 Jun	MBL SP-Z recording commenced.
1976 Oct	Special ionospheric sounding, solar eclipse (23 Oct)

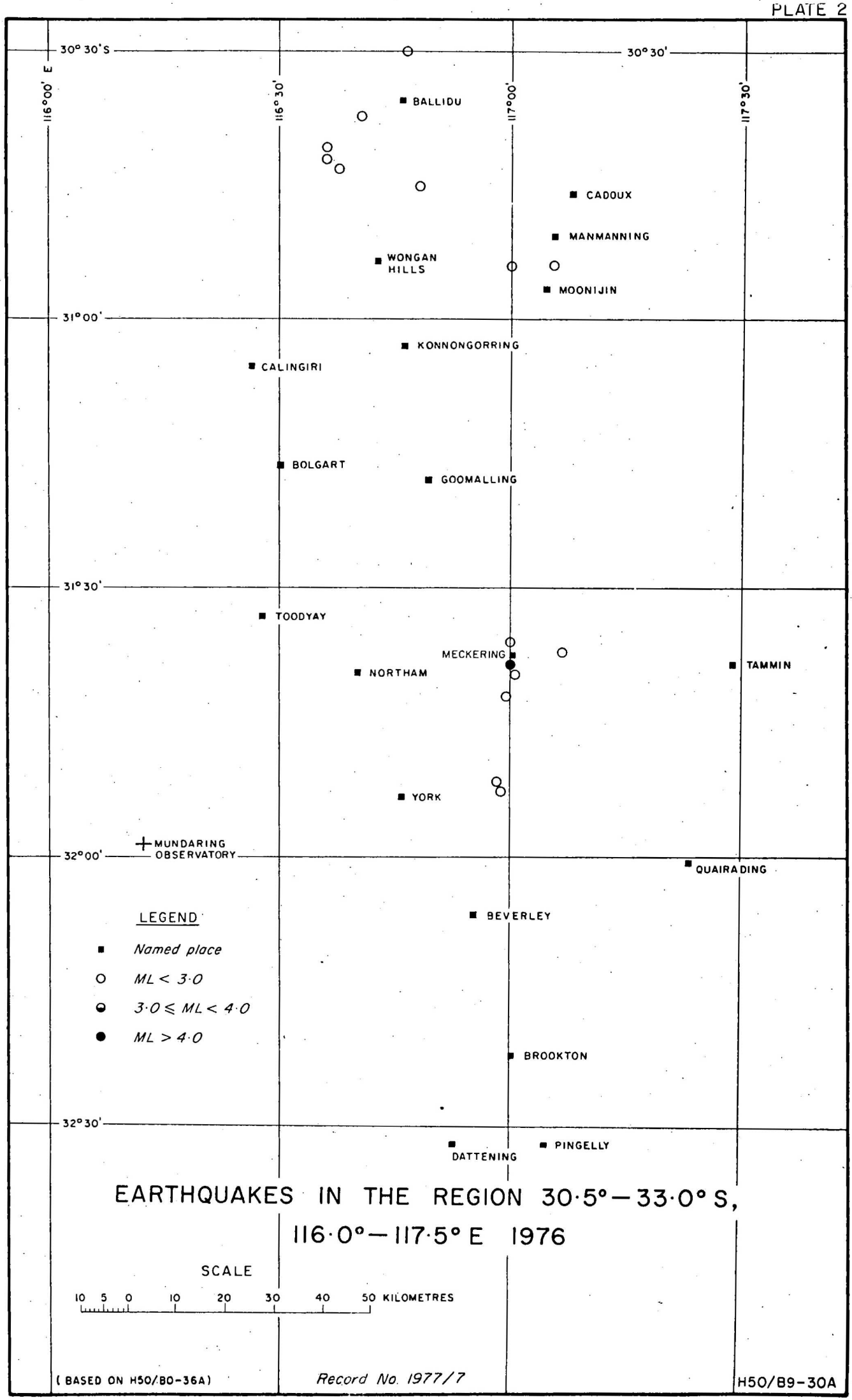


LARGER EARTHQUAKES IN THE REGION OF WESTERN AUSTRALIA, 1976

WA/B9-39A

(Based on WA/BQ-4-1A)

Record No. 1977/7



EARTHQUAKES IN THE REGION 30·5° — 33·0° S, 116·0° — 117·5° E 1976

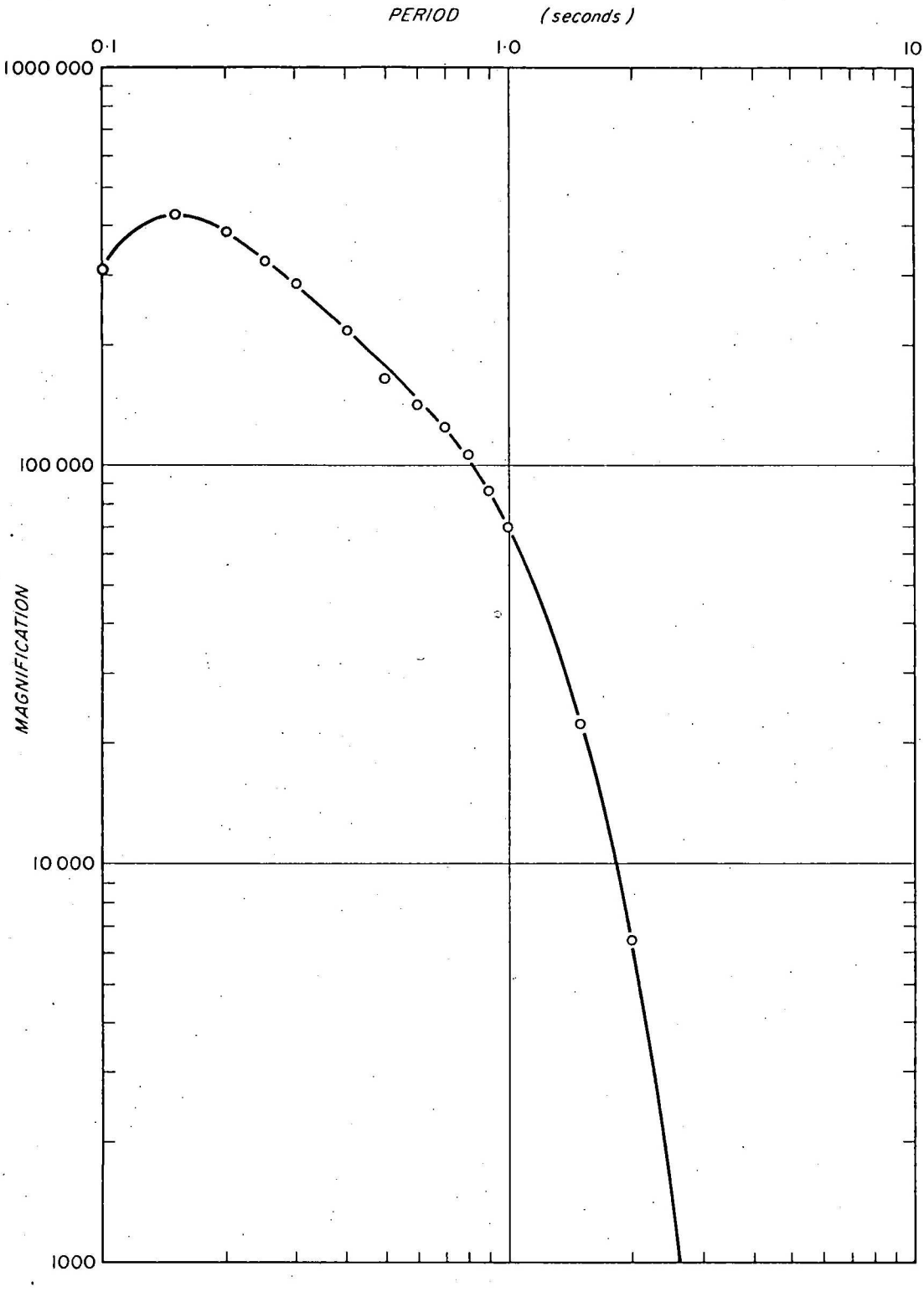
SCALE

10 5 0 10 20 30 40 50 KILOMETRES

(BASED ON H50/80-36A)

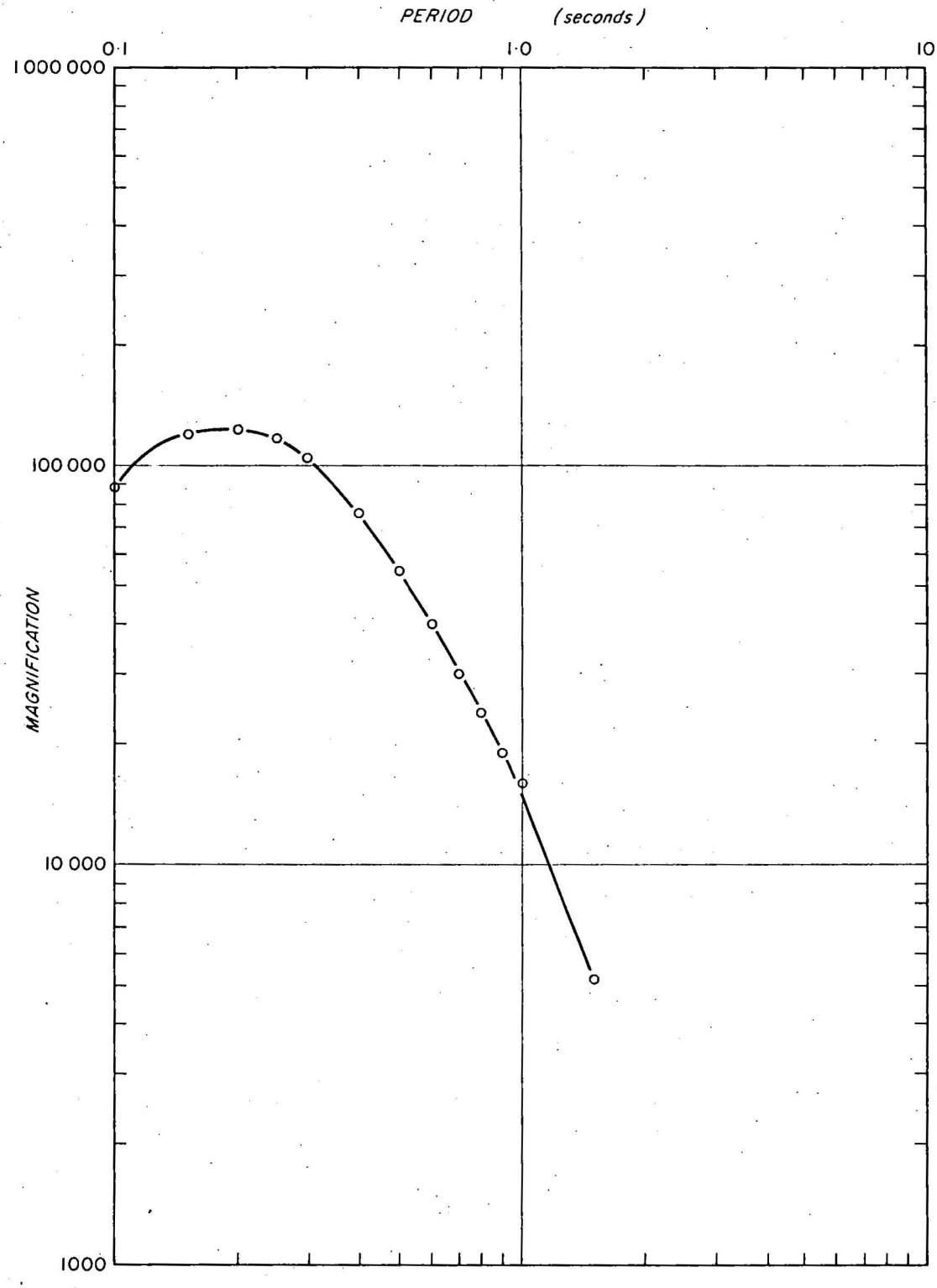
Record No. 1977/7

H50/89-30A



CALIBRATION CURVE MARBLE BAR Z SEISMOGRAPH

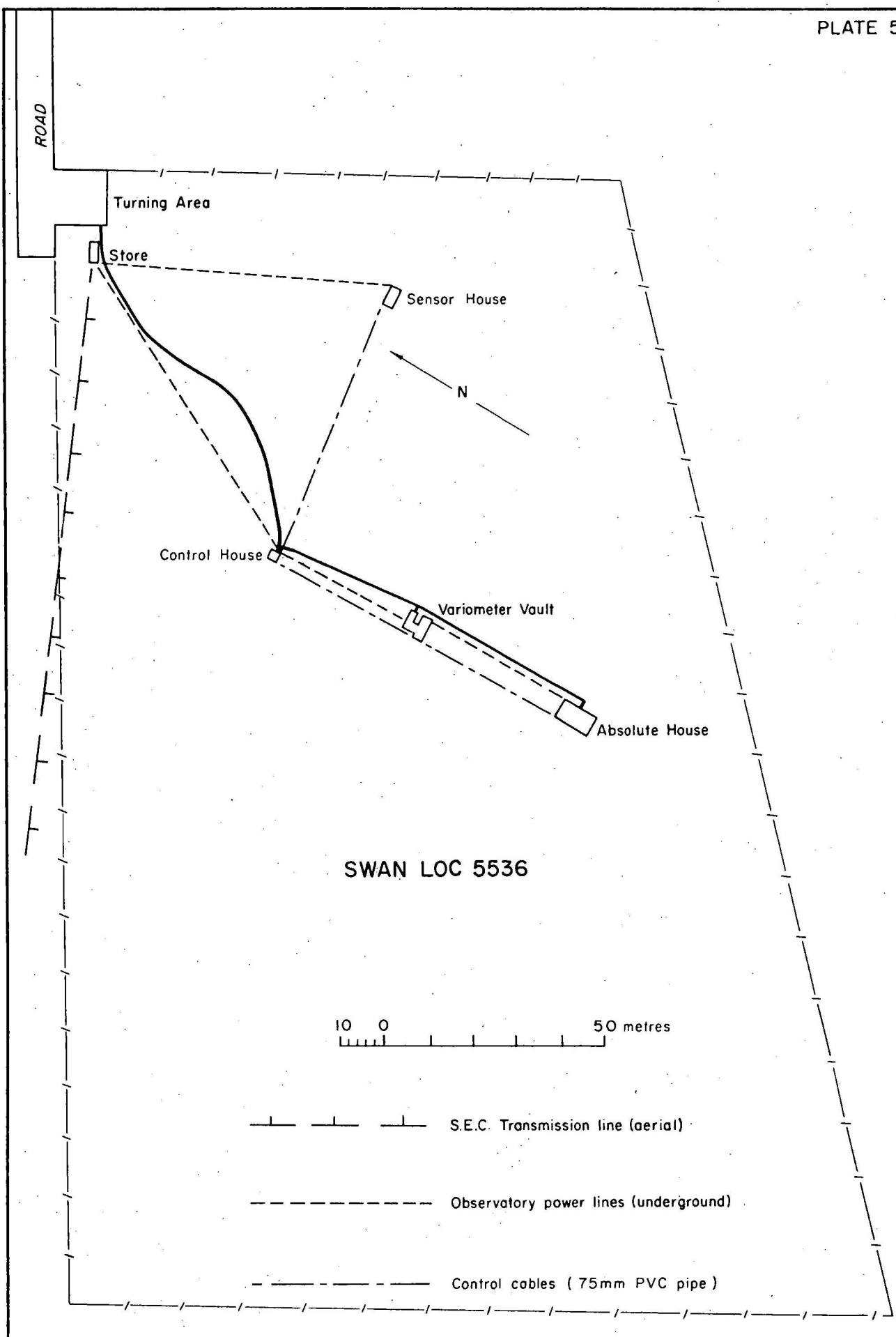
FROM 21 JUNE 1976



CALIBRATION CURVE KALGOORLIE Z SEISMOGRAPH

FROM 9 NOVEMBER 1976

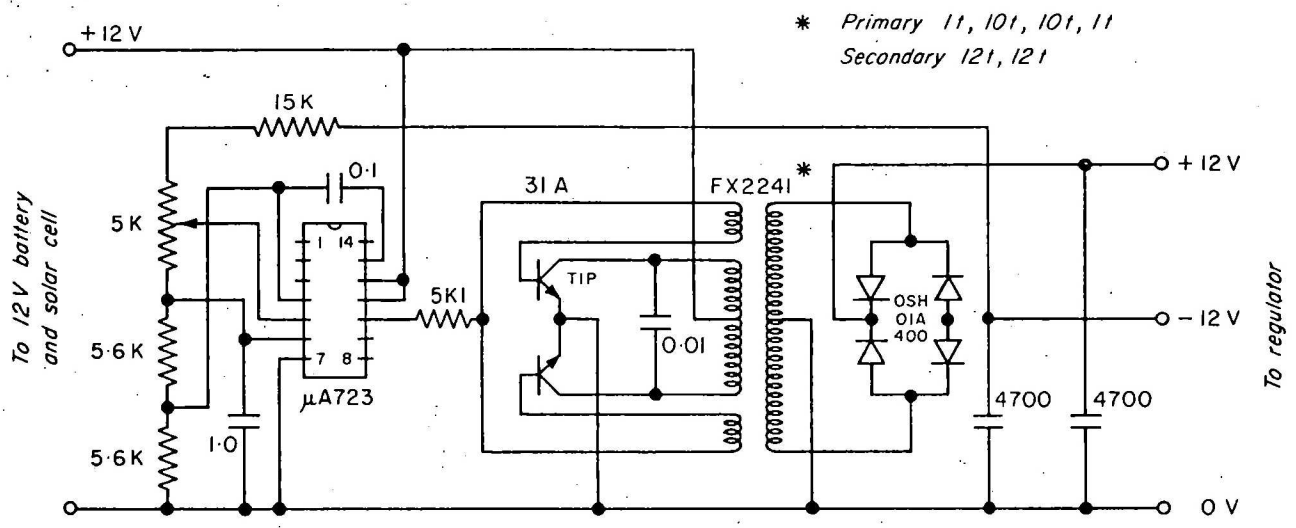
PLATE 5



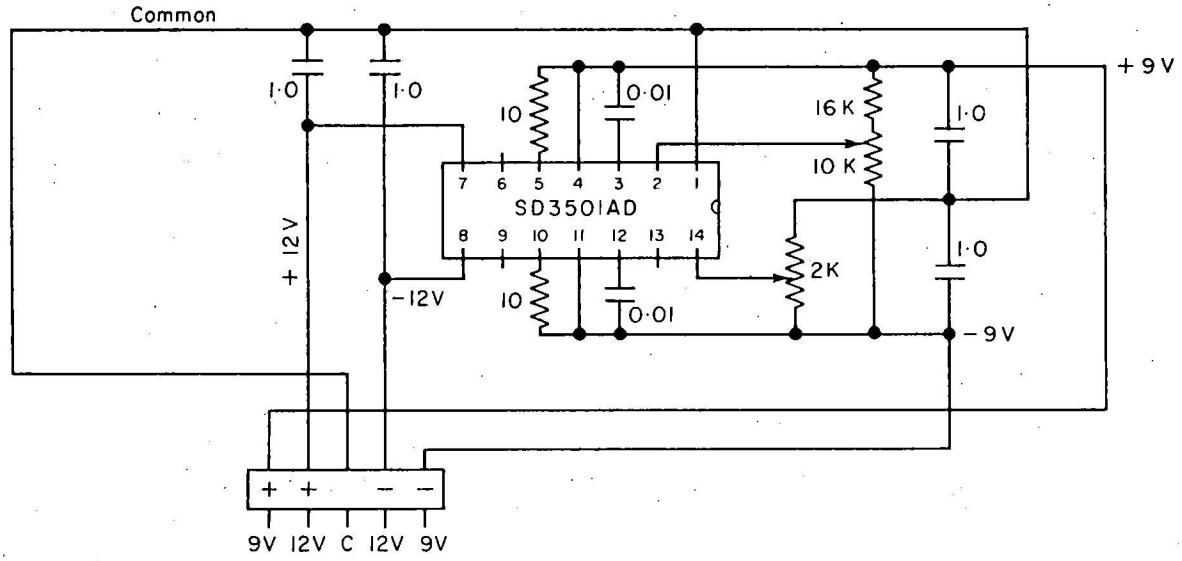
LOCATION OF SENSOR HOUSE, GNANGARA

Record No. 1966/35 and Record No. 1977/7

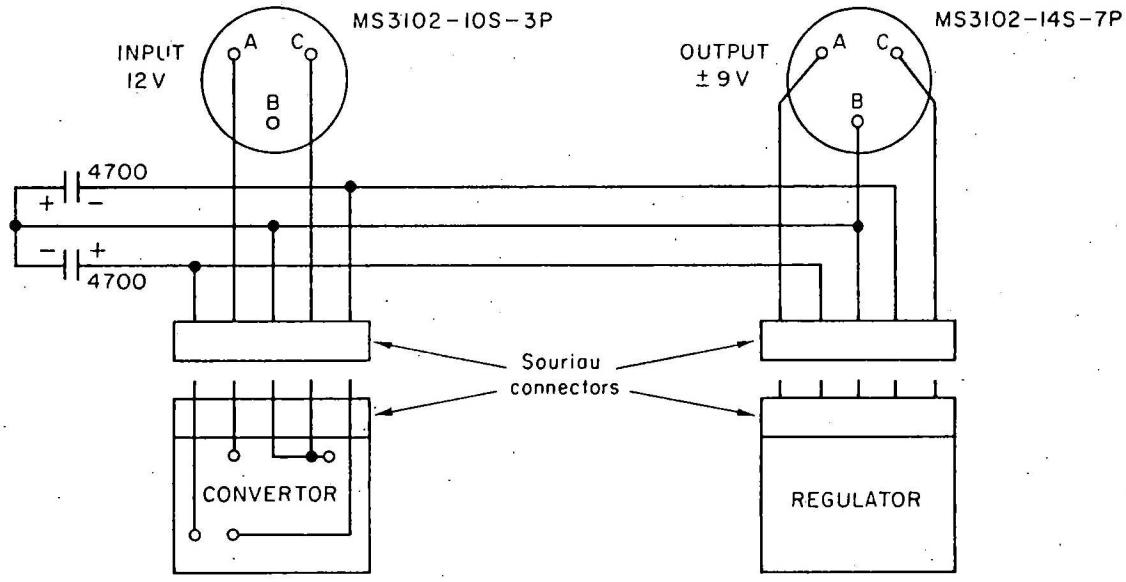
H50/B9-31A



DC to DC CONVERTOR

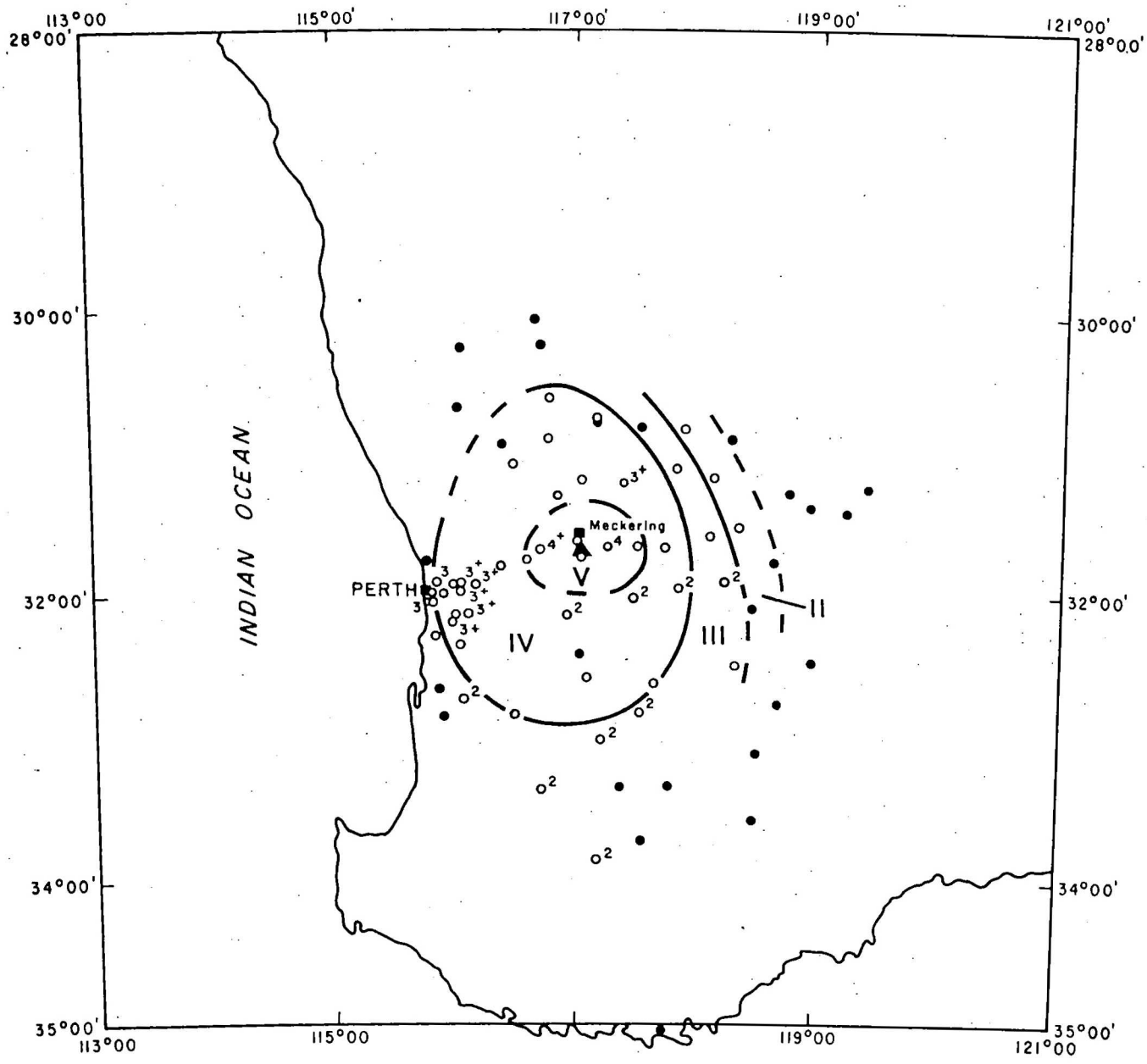


± 9V REGULATOR



CONNECTING WIRING

MARBLE BAR REMOTE POWER SUPPLY



ISOSEISMAL MAP OF MECKERING EARTHQUAKE 29 OCTOBER 1976

KILOMETRES

100 0 100 200 300 400

DATE : 29 OCTOBER 1976
TIME : 06:04:48·2
MAGNITUDE: 4·7ML, 4·9mB
EPICENTRE: 31·64°S 117·00°E

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

Small figure beside open circle indicates intensity is different from zone designation