DEPARTMENT OF
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

1975/143

MUNDARING GEOPHYSICAL OBSERVATORY

ANNUAL REPORT 1974

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 1974. The main instruments were an Eschenhagen normal-run magnetograph, and IPSD Type IIIE ionosonde, and a Worldwide Standardized Seismograph System. A Proton Vector Magnetometer was introduced in April to replace the semi-absolute magnetometers for the measurement of horizontal and vertical intensity.

Seismographs were operated at Kalgoorlie, Meekatharra, and Marble Bar. The seismograms from the seismograph at Kununurra, owned by the W.A. Government, were analysed. Accelerographs were operated at Meckering and Kununurra.

The annual earthquake list shows details of 97 Western Australian earthquakes, 82 of which occurred in the southwest zone. A series of small tremors occurred in the Brookton area; activity reached a peak in February-March.

Intensity data were collected for three earthquakes with magnitudes greater than 4 from the southwest zone. The extent of intensity IV was defined for each earthquake. Microtremor analysis, commenced in 1973, was extended to include data from July 1967.

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, and Kununurra (seismological recording). The operation of a seismograph station at Giles commenced in September. Descriptions of the observatory and an outline of activities there to the end of 1973 have been given in previous records (e.g. Gregson & Smith, 1974); 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 summarized in Table 3, and conferences attended or addresses given are listed in Table 4.

E.P. Paull was temporarily transferred to the Toolangi Observatory Group on 28 June for the remainder of the year.

Visitors to the observatory are listed in Table 5.

GEOMAGNETISM

Normal magnetograph

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

The magnetic buildings were broken into on 26 May, resulting in fogging of about 7 hours of record. Fortunately none of the scientific equipment was damaged, and only some minor attractive items were stolen. The records for 2 and 3 October were partly fogged during processing, resulting in about 50% loss. Records for 11-13 November were also found to be partly fogged. This was apparently caused by the intruders in May and tests of the paper stocks at the time had not revealed the damaged paper.

The EMI clock stopped on 28 August, resulting in no timemarks for 22 hours. From 12-30 April, some timemarks were displaced owing to a jump in the display of the EMI clock and to malfunction of the counter relay.

No abnormal changes in H and D baseline values and scale values were noted during 1973. The Z scale value rose from a minimum of about 5.72 nT/mm in March to a maximum of about 6.22 nT/mm in August, then fell to about 5.74 nT/mm in December. This behaviour is almost identical to that which occurred during 1973. The Z baseline value rose from 53320 nT in January to a maximum of 53325 in April, fell to a minimum of 53315 in August, and rose again to 53323 by December. This seasonal variation disappeared after the application of a revised temperature coefficient.

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

Element	Baseline value	Scale value
D	0.15 min	-
H	3.3 nT	0.01 nT/mm
Z	2.0 nT	0.03 nT/mm

Magnetograph tests

Temperature coefficients. Preliminary values used were $qH = 0.4$ nT/$^{\circ}$C and $qZ = 3.2$ nT/$^{\circ}$C. Least-squares analysis of the 1974 H and Z baseline value data gave values of $qH = 0.5$ nT/$^{\circ}$C and $qZ = 3.9$ nT/$^{\circ}$C. However, there was considerable scatter in the H values so $qH = 0.4$ nT/$^{\circ}$C was retained. The value of $qZ = 3.9$ nT/$^{\circ}$C was adopted and 1974 Z baseline values recalculated. Baseline values at temperature were all within 1 nT of the old ones and differences resulted mainly from the turning points in temperature corrections occurring on different days.

Orientation. No orientation tests were performed during 1974. Orientations of the recording magnets (N poles) in the mean magnetic field as at December 1974, estimated from previous results were as follows:

H: E 0.8°N

D: N 0.3°W

Z: N 0.2° DOWN.

Parallax. No tests were performed during 1974 and it was assumed that the parallax remained unchanged from the previous year. During 1973 it was found that the parallax on variation trace timemark spots (but no on baseline spots or hour lines) was zero on all components. The parallax for other timemarks can be measured from the trace timemarks.

Scale values. A magnetograph calibrator MC02 was used in conjunction with Helmholtz coils to determine H and Z scale values once weekly. The calibrator failed on 16 April and required the replacement of integrated circuit A2. On 23 April it was reinstalled and the current output adjusted to 5.00 mA; the output required another adjustment from 4.95 to 5.00 mA on 18 June. A Schlumberger digital meter was calibrated at the WA Institute of Technology (WAIT) in June and used as a reference standard. It was noticed that when correctly adjusted to deliver 5.00 mA, the load of the meter on the 5.00 V test points caused the output to change to 5.04 mA whilst the meter read 5.04 V. The calibrator failed again on 10 October. A dirty potentiometer or dry joint was suspected, but no fault was found. It was reinstalled and adjusted on 15 October to deliver 5.00 mA. However, on 23 October and 31 October it was again checked and found to be delivering 5.02 mA on each occasion. During November, the scale value current was monitored weekly and found to vary by ± 0.02 mA.

The D scale was not determined during 1974.

Magnetometers

Instruments in use during the year were Askania declinometer 509319, QHM 291, QHM 292, QHM 293, BMZ 120 and PPM 116.

The Elsec vector coils were reinstalled on NM pier on 26 February and used with PPM 116 to form the Proton-Vector-Magnetometer (PVM), for measurements of H and Z. The coils became very difficult to rotate, so they were dismantled on 12 June. The base was stripped and the bearing surface cleaned. After reassembly on 18 June, the bearing remained satisfactory. Considerable difficulty was experience in achieving the required level stability. The coils were again dismantled and the base returned to Mundaring on 27 November for tests on a stable foundation. The trouble still remained and the coils were reinstalled on 4 December for further testing.

H baseline values were controlled by QHM measurements, but until the end of April when QHM readings were discontinued, and thereafter by PVM measurements. However, weekly PVM (H) readings were commenced on 26 February in order to determine QHM corrections.

Baseline control for Z until the end of April was maintained by combining observed values of F with H values derived from the magnetograms to calculate Z values. From the beginning of May, weekly F readings were discontinued and the PVM determinations of Z used for baseline value control. However, weekly PVM (Z) readings were commenced on 2 April in order to compare the two methods of determining Z baseline values.

F measurements

Plate 6 illustrates F standards at Gnangara. Total intensity (F) was measured to 19 March on pier NW using a toroidal sensor (T) and from 26 February on pier NM also, using a cylindrical sensor (C) in the PVM. On 19 March the two PPM sensors were compared on pier NW by interleaving readings using PPM 116. The PVM coils remained on pier NM. A small difference only (C-T = 0.6 nT) was found so a zero sensor difference was assumed at that time.

After the installation of the vector coils and the change in pier and sensor, an increase in F readings and hence Z baseline values was evident. The cylindrical sensor (C) in the PVM on pier NM, and the toroidal sensor (T) on pier NW were compared on 24 September by interleaving readings with PPM 116. The difference was:

NM (C) - NW (T) = 4.9 nT.

Tests were conducted to discover the reason for the large difference and it was found that the coil frame bolts and washers were slightly magnetic so they were replaced on 5 November.

During December an extensive series of comparison readings was made using PPM 116 and PPM 416 (from WAIT) to determine any remaining effect of the vector coils on F readings made with either the toroidal or cylindrical sensors. Differences were observed sinultaneously at remote sites approximately 15 m south and east of the absolute house and at either the piers NM or NW. The sensors and PPMs were swapped and some readings were taken with the PVM coils removed.

It was found that whilst no difference was found between the two cylindrical sensors (C and W: WAIT), the toroidal head (T) produced readings slightly low (0.2 to 0.3 nT) on PPM 416 and between 1.0 and 1.7 nT low on PPM 116. The signal level using the toroidal sensor was lower and readings more scattered than those from the cylindrical sensors, and the effect of the nearby PVM coils was greater on the toroidal than the on cylindrical sensors.

It was concluded that readings using the toroidal sensor were unreliable, particularly when using PPM 116 and the PVM coils. An approximate correction of +1.4 nT to F (+1 nT to Z) readings should be applied for the period 20 October 1973 to 26 February 1974 when the toroidal sensor was in use with PPM 116. Likewise a correction of -2.3 nT to F (2 nT to Z) should be made for the period 26 February to 5 November 1974 before the PVM coils were demagnetised.

Adopted F differences in nT are summarized below:

BEFORE INSTALLATION OF PVM COILS

PIER DIFFERENCE:	NM - NW = -1.4	
SENSOR DIFFERENCE:	C - W = 0	
SENSOR DIFFERENCE:	C - T = 1.4	

AFTER INSTALLATION OF PVM COILS

PIER DIFFERENCE:	NM - NW = 2.1	(SENSOR C)
PIER DIFFERENCE:	NM - NW = 1.5 to 2.0	(SENSOR T)
SENSOR DIFFERENCE:	C - T = 0.6 to 1.1	(PIER NM)
SENSOR DIFFERENCE:	C - T = 0.5 to 0.6	(PIER NW)

The new F standard using sensor C on pier NM in the PVM is 0.5 nT higher than the original F standard using a cylindrical sensor on pier NW before the installation of the PVM. No change was adopted in H and Z baseline values as the effect on H and Z measurements is small.

Comparisons

A set of intercomparison observations was performed between PPM 339 (ex. Mawson) and the Gnangara PPM 116 on 29 January. Two piers were used, reading each PPM alternately for 10 readings each, before changing piers. The differences found were:

PPM DIFFERENCE	116 - 339 = -3.8nT.
PIER DIFFERENCE	NM - NW = -0.4 nT.

However these results are suspect and have been ignored as the toroidal sensor was used throughout. The PVM coils were on the floor of the absolute house in the near vicinity, and the pier difference derived differs from that measured in December.

The oscillator of PPM 116 was checked on 6 February and found to read 5.449728 MHz instead of 5.449750 MHz. This would given an F reading only about 0.25 nT high at Gnangara.

Comparison of the Gnangara QHMs were made between 26 February and 30 April by interleaving QHM and PVM readings. Assuming no correction to PVM 116, corrections determined were as follows:

QHM 291, -31 nT

QHM 292, -37 nT

QHM 293, -3 nT

Comparison of the QHMs 460, 461 and 462 (from Canberra HQ) were made during July by interleaving QHM and PVM readings. Assuming no corrections to PVM 116, corrections determined were:

QHM 460, -3.3 nT

QHM 461, -5.2 nT

QHM 462, -3.8 nT

Preliminary corrections used throughout the year were:

(a) QHM 291: -30 nT; QHM 292: -36 nT; QHM 293: 0 nT

(b) BMZ 120: +226 nT (not used for baseline value control).

(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.

Data reduction and publication

Mean hourly value reduction data were prepared in monthly batches about three months after recording. Magnetogram mean hourly ordinates of each component (H, D and Z) were digitized at headquarters and used with the reduction data to compute mean 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 D, H, Z, and F and mean K-index values at Gnangara for 1974 are listed in Table 6. The field values were derived from the ten local quiet days of each month by scaling an ordinate for each component from each magnetogram. Annual values for all components since 1964 compiled by the Headquarters Group are shown in Table 7. Recent trends in secular variations for H and D continued with H decreasing by about 40 nT and D becoming more westerly by about 2 minutes. Mean values for Z increased sharply by 30 nT from the numerical minimum in January and February to a maximum in July then fell slightly to level off at near the maximum value. Mean values for F reached a minimum in February, then rose to near the mean for 1973.

The distribution and publication of data are shown in Table 11.

Miscellaneous requests were attended to, mainly for magnetogram copies and information on the geomagnetic field in Western Australia. A magnetogram copy and control data for 19 May were supplied to Project Magnet as a check for several aerial runs over Gnangara.

IONOSPHERICS

Equipment

The quarter-hourly sounding schedule was continued throughout the year using a model IIIE ionosonde, supplied by the Ionospheric Prediction Service (IPS), Department of Science & Consumer Affairs. Components and circuit boards continued to be supplied by IPS.

80 hours (1%) of record were lost during the year. This was a considerable improvement over the previous year (463 hours). Losses were due to component failure, 50 hours; film jamming, 23 hours; and operator error, 7 hours. Circuit modifications to the triggering unit (S-board) to prevent surges to transistors was the main reason for the reduced record loss.

A Collins communications transceiver was installed during August. A regular schedule was established with IPS on Wednesday mornings for the transmission of ionospheric data. The link also facilitates equipment maintenance where consultation with IPS staff is required.

A riometer and receiver (tuned to 18.8 MHz for determining variations in signal strength from a Hobart transmission) were installed by IPS officers at Mundaring Weir on 17 June to monitor effects due to the solar eclipse on 20 June. The equipment was operated until 30 June. One-minute and five-minute ionospheric soundings were made for intervals of a few hours and a day respectively either side of the solar eclipse.

Data distribution and publications

The scaling, distribution and publication of data continued as previously (for details see Record 1974/103).

SEISMOLOGY

Seismograph stations

Permanent stations were operated throughout 1974 at Mundaring (MUN), Kalgoorlie (KLG), Meekatharra (MEK), Marble Bar (MBT), and Kununurra (KNA). A station was installed by

Headquarters Staff at Giles (GLS) in September (Robertson & Zeitlhfer in prep.). Routine operation and record analysis became the responsibility of the Mundaring staff after installation. Maintenance visits and equipment replacement remained the responsibility of Headquarters. A transportable seismograph was operated at Talbot Brook and Bally Bally; station details are summarized in Table 9.

The number of events reported from each station were: MUN 874; KLG 790; MEK 945; MBT 844; KNA 1985; GLS 18; WA4 24; Total - 5480.

A summary of record losses for all seismograph stations is given in Table 8. The purpose of the summary is to indicate the areas where attention is required to significantly improve continuous recording. It is hoped that steps taken will be reflected in the summary for 1975.

Mundaring. The WWSSN seismograph continued to run satisfactorily. The SP recorder motor was replaced in April. Several of the switches in the galvanometer control boxes were either replaced or cleaned during May and June after record losses due to poor switch contacts. The LP seismometer heaters and calibrators were rewired in July. This eliminated drift in the LP-Z system.

Masks were fitted to the optical system of the supplementary seismograph recorder to improve the relative intensity of large deflections.

Kalgoorlie. One routine maintenance visit was made in May. During the visit minor modifications were made to the power distribution to standardize it with other stations.

Meekatharra. One routine maintenance visit was made in June. A BMR calibrator was installed during the visit.

Recording was reduced from three short-period components to a single vertical component on 1 October. The horizontal components had not been producing useful information.

Marble Bar. A mains power surge on 2 March resulted in damage to the helicorder amplifier (AR311) and the ± 12V regulated power supply for the pre-amplifier. Numerous other problems ranging from mains power failures, operator errors, and delays in diagnosing faults continued to make this the most unsatisfactory station during the year.

Kununurra. This station operated exceptionally well.

Swan View. A seismograph was installed in a disused railway tunnel at Swan View on 2 August. An Australian Post Office circuit is used to telemeter signals to the Mundaring Office. Vandals hroke into the seismometer housing on 3 August and damaged the seismometer and telemetry amplifier (AS330) beyond repair. No further recording was made during the year pending repair and strengthening of the housing doors.

Giles. Shortly after installation in September, problems were experienced with insufficient time control. This situation remained till the end of the year. Although the seismograms could not be used to report P arrival times, several valuable S-P times were obtained for earthquakes in the east Canning Basin region.

Transportable. This unit was extremely useful in recording a series of tremors near Brookton in February and March (see Table 9). The unit was withdrawn from service in June because of mechanical faults in the recorder.

Field tape recorder. A crustal studies field tape recorder was operated near Brookton from 20 February to 6 March to record a series of tremors from the area.

Accelerographs

Two accelerographs were in operation for most of the year at Kununurra. One of the three units at Meckering was returned to Mundaring for service in March. During service, the block was turned on its side and oilddamaged the mirror surfaces. A second unit was returned in October as it had a sticky trigger. Both units are awaiting repairs.

None of the accelerographs was triggered during the year.

Seismicity

Table 10 lists Western Australian earthquakes of magnitude ML = 2.0 or greater which occurred during 1974 and for which locations are available. 97 earthquakes are listed, of which 82 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 re-determined by the Headquarters Group using a computer program for the relocations of earthquakes. Better locations were obtained for earthquakes in the southwest seismic zone by using distance and azimuth from Mundaring.

Plates 1 and 2 show epicentres of Western Australian earthquakes and those located in the southwest seismic zone, respectively. Those shown in Plate 1 had magnitudes mB 4 or greater.

Kununurra area. Previous activity in the Kununurra area has been south to southwest and at least 90 km from Kununurra. Four small tremors with epicentres approximately south to southwest and about 50 km from Kununurra have been recorded since the Ord River Dam filled in December 1973; their magnitudes ranged from ML 1.0 to 1.9.

Southwest zone. Activity in the zone was considerably higher than in 1973. There were thirteen earthquakes with ML greater than 2.9. Earthquakes occurred on 4 September near Manmanning, 9 July and 19 November near Meckering, and had magnitude ML = 4.5, 4.3, and 4.0, respectively. Activity was more widespread than usual, and occurred over the entire length of the known zone (Plate 2).

Brookton area. A series of tremors occurred about 20 km northeast of Brookton commencing in December 1973. A peak in activity was reached during February and March. Over 500 tremors were recorded at Mundaring, and ranged between magnitude 0.9 and 3.7; the largest occurred on 25 February. A crustal study tape recorder seismograph and the transportable film recorder were installed in the area on 20 and 21 February, respectively.

During the eight days examined, 550 tremors were recorded on the tape recorder. The lowest magnitude recorded was ML = -0.5. This was determined by comparing amplitudes of tremors recorded on both the tape recorder and at Mundaring. Approximately 60 tremors were recorded on all three seismographs over a fivedays period. Using travel-times determined from the Geotraverse project (Gregson & Paull, 1971) hypocentres were determined for these tremors. Good solutions were obtained for most of the tremors, and indicated depths between 5 and 8 km. The areal extent of tremors located was less than 5 km in diameter.

A detailed analysis will be presented elsewhere.

Narrogin area. About 40 tremors occurred about 20 km northwest of Narrogin between 22 January and 28 June. Their magnitudes (ML) ranged from 1.0 to 3.9.

Other areas. Activity continued in the east Canning Basin in the Bone described by Denham, Everingham, & Gregson (1974). Earthquakes were also recorded from: the Marble Bar area; 200 km north of Port Hedland; 270 km east-northeast of Kalgoorlie; 540 km west-northwest of Carnarvon; 120 km southwest of Meekatharra; and 200 km southwest of Geraldton (Table 10).

Microtremors

The analysis carried out in 1973 of microtremor activity in the southwest seismic zone was extended to include tremors from July 1967 to June 1969. The results of this analysis will be presented elsewhere.

Earthquake intensities

Earthquake questionnaire forms were distributed for earthquakes which occurred on 9 July, 4 September, and 19 November. Isoseismal maps are shown in Plates 3 to 5.

The extent of the MM 4 isoseismal for the two Meckering earthquakes is comparable, considering the relative magnitudes. By comparison, the area over which the Manmanning earthquake (4 September) was felt is surprisingly small. This small area and the maximum intensity of 6 near the hypocentre suggests that the event was very shallow. Mr. W. Shankland reported -"At 7.17 a.m. a very loud explosion - right under the kitchen table - vibrations and rumbling, so much so that the six of us at breakfast ran for it. At 7.20 a.m., as before we ran outside - have experienced tremors before but never as this terrifying experience". Mr. Shankland also felt tremors at 8.40 a.m. and 2.20 p.m. The magnitudes of the first three tremors were ML = 4.5, 3.9, and 1.5, respectively. The last tremor was not recorded at Mundaring.

Magnitude comparisons

A three-component seismograph, supplementary to the WWSSN seismograph has been in operation at Mundaring for just over eighteen months. It consists of a high-gain vertical-component and two standard Wood-Anderson components. Combined with the WWSS, a wide range of magnitudes for earthquakes occurring in the southwest seismic zone can be determined at Mundaring, as shown in the following table.

Seismograph	Magnification 0.2 s	Magnification 0.3 s	Magnitude range
High-gain vertical	340 000	326 000	1.0 to 3.5
WWSS	10 000	20 000	2.0 to 4.5
Wood-Anderson	2 040	2 040	3.0 to 5.5

The magnitudes (ML) determined from the Wood-Anderson seismographs and the WWSS were compared for 30 earthquakes from the southwest seismic zone. Epicentres were near Meckering, Bolgart, Brookton, Manmanning, and Narrogin and magnitudes ranged between 2.4 and 3.7.

As the static magnification of the modern Wood-Anderson seismograph (model TS220) is 2040 compared with 2800 for the original seismograph, a correction of + 0.1 is applied when determining Richter magnitudes from the Gutenberg and Richter nomogram. The method for determining Richter magnitude from the WWSS records was as outlined by Everingham (1968).

The mean relation between the magnitudes determined was

WWSS + 0.13 - Wood-Anderson.

It may not be valid to use the static magnification in determining the Wood-Anderson magnitudes as the response of the new Wood-Anderson may not be the same as for the original seismograph. We cannot confirm this.

Data distribution and publication

Selected preliminary data were sent three times a week to the National Earthquake Information Service, US Geological Survey, via the American Embassy Canberra. Preliminary monthly bulletins were distributed to the organizations listed in Table 12. The amount of data reported from outstations was reduced from October because of staff shortage. Punched cards containing data from final analyses were prepared for data from July 1973 to July 1974 inclusive, and forwarded to Canberra headquarters for inclusion in the Australian data tapes sent to the International Seismological Centre, Edinburgh.

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

Reports of seismological interest were prepared or published during the year by Denham, Everingham, & Gregson (1974) and Denham, Small, Cleary, Gregson, Sutton, & Underwood (1974).

NOTES ON WORKS PROJECTS

The following works were carried out during the year:

(a) Work was completed on additions to the workshop (May).

(b) A seismograph housing was constructed in the Swan View Tunnel (May). Repairs are continuing after vandalism in August.

(c) Repairs and maintenance to assets at Gnangara, Mundaring Weir, and the Mundaring Office were carried out during October-December.

ACKNOWLEDGEMENTS

The assistance of the Regional Director and staff of the Department of Manufacturing Industries is acknowledged. Their long association with the administrative activities of the Observatory since its establishment at Mundaring concluded in April with the establishment of a Regional Office of the Department of Minerals and Energy in Perth.

Assistance by Department of Transport Officers (for outstation operation), Messrs J. Grant of Kalgoorlie and E. Tromans of Meekatharra is hereby acknowledged. The assistance of the Pilbara Shire for housing the Marble Bar seismograph is greatly appreciated. The assistance of Mr G. Edwards in changing records at 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.

REFERENCES

DENHAM, D., EVERINGHAM, I.B., & GREGSON, P.J., 1974 - East Canning Basin earthquake, March, 1970.- J. Geol. Soc. Aust., 21(3), 353-8.

DENHAM, D., SMALL, G.R., CLEARY, J.R., GREGSON, P.J., SUTTON D.J., & UNDERWOOD, R., 1974 - Australian earthquakes (1897-1972). Bur. Miner. Resour. Aust. Rec. 1974/102 (unpubl.).

EVERINGHAM, I.B., 1968 - Seismicity of Western Australia. Bur Miner. Resour. Aust. Rep. 132.

GREGSON, P.J., & PAULL, E.P., 1971 - Refraction recording of geotraverse explosions 1969 - operational report. Bur. Miner. Resour. Aust. Rec. 1971/75 (unpubl.).

GREGSON, P.J., & SMITH, R.S., 1974 - Mundaring Geophysical Observatory annual report 1973. Bur. Miner. Resour. Aust. Rec. 1974/103 (unpubl.).

ROBERTSON, M.J.M. & ZEITLHOFER, L. (in prep.) - Giles seismograph installation. Bur. Miner. Resour. Aust. Rec.

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).
1969 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 June 27	Proton scalar magnetometer introduced for Z baseline control.
1972 Oct 12	MBT SP-Z seismograph recording commenced.
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 only.
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 magnetometer introduced for Z baseline control.
1974 May 1	Proton vector magnetometer introduced for H baseline control.
1974 Jun 17-31	Riometer recording at Mundaring during solar eclipse (for IPS).
1974 Sep 30	GLS SP-Z recording commenced.

TABLE 1

OBSERVATORY STAFF 1974

Officer	Designation
P.J. Gregson	Geophysicist Class 3
R.S. Smith	Geophysicist Class 2
E.P. Paull	Geophysicist Class 1 (Temporary transfer to Toolangi from 28 June)
G. Woad	Technical Officer Grade 2
B.J. Page	Technical Officer Grade 1
Y.M. Moiler (Mrs)	Typist
T.E. Creaser	Assistant Grade 1
J. Silich	Geophysicist Class 1 (29 July-30 September)
W.J. Byrne (Mrs)	Technical Officer Grade 2 (6 December-11 December)

TABLE 2

ASSOCIATED PERSONNEL 1974

Name	Nature of duties
C. Blyth	Vacation student 1973/74
B. Carling	Daily attendant, Gnangara
J. Grant	Daily attendant, Kalgoorlie
E. Tromans	Daily attendant, Meekatharra
G. Edwards	Daily attendant, Marble Bar
J. Roberts	Daily attendant, Kununurra
T. Mitchell	Daily attendant, Giles
R. Calver	Vacation student 1974/75

TABLE 3

OBSERVATORY STAFF ABSENCES 1974

Nature of absence	No. of man days
Sick leave	16
Military service	20
Attendance at outstations and field operations	13
Conferences and training	27
Furlough	36
Temporary transfer	126
	238

TABLE 4

CONFERENCES AND ADDRESSES

Officer	Date	Conference
P.J. Gregson	Sep 16-18	Canberra, O.I.C.s meeting
G. Woad	Oct 17-19	Sydney, IPS Operators' conference
		Addresses
P.J. Gregson	Apr 02	Standard Association, seminar on Earthquake Engineering - "W.A. Seismicity"
		Training
G. Woad	Apr 29-May 10	Perth, P.M.G. Logic Course
G. Woad	Oct 20-Nov 01	Canberra, Headquarters retraining

TABLE 5

VISITORS

Visitor	Institute
P.M. McGregor	BMR (Supervisor)
C. Ling	Ionospheric Prediction Service
P. Davies	Ionospheric Prediction Service
G. Webster	Ionospheric Prediction Service
D.C. Allen	Department of Transport
J. Grant	Department of Transport
J. Peterson	Albuquerque Seismological Centre
D. Batson	Unitech, Houston, U.S.A.
A. Sabitay	Consulting Geologist
R. Fraser	CSIRO, Melbourne
Geology students	Leederville Technical College
Geophysics students	University of W.A.

TABLE 6

PRELIMINARY MONTHLY MEAN GEOMAGNETIC VALUES AND K INDEX

1974

Month	D(West)	H, nT	Z, nT	F, nT	K
January	$3^{\circ}09.1'$	23671	-53457	58463	2.56
February	09.6	664	457	461	2.34
March	09.6	651	467	464	2.90
April	09.7	650	472	469	2.78
May	09.4	642	480	473	2.52
June	09.8	639	481	472	2.54
July	09.9	630	487	474	2.70
August	09.8	636	486	476	2.74
September	10.5	627	484	470	2.84
October	10.0	630	484	471	2.91
November	10.6	633	483	472	2.56
December	10.4	630	484	471	2.71
Mean	$3^{\circ}09.0'$	23642	-53477	58470	2.68

TABLE 7

GEOMAGNETIC ANNUAL MEAN VALUES 1964-1974

Year	D ° '	I ° '	H nT	X nT	Y nT	Z nT	F nT	Notes s
1964	- 2 51.7	-65 54.6	23917	23887	-1194	-53506	58608	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
1973	07.8	06.2	686	651	1292	460	472	2C
1974	09.9	09.0	642	606	1304	477	470	2C
Mean annual change	-1.82	-1.44	-27.5	-28.1	-11.0	+2.9	-13.8	

NOTES: 2. Preliminary value

B. Mean of hourly values, 5 IQ days

C. Mean of daily values, 10 Q days

TABLE 8

1974 SEISMIC RECORD LOSSES

All components unless shown

HOURS

Cause	MUN WWSSN	MUN SUP	KLG	MEK	MBT	KNA
OPERATOR						
Late change			192	18	249	3
Drum not reset			21	2		24
Paper reversed						N 24 E 24
Paper off drum		S 42		E 23		
Switching	LP					
Lamp intensity			73			
POWER FAILURES						
Mains			8		139	
Batteries						28
RECORDER FAULTS						
Drum translation	SP 41		50			
Lamp connections						Z 16 N 17
Blown lamp	SP-N 26	Z 47		Z 18		
	SP-E 56	S 14		N		
		E 25		E 13		
Optics				N 300		
Helicorder*					939	
CONTROL EQUIPMENT						
Switches	SP-Z 22					
	LP-N 48					
	LP-E 42					
Clock					3	
AR311*					71	
TOTAL	286	128	344	374	1401	112
%	3.3%	1.5%	3.9%	4.3%	16.0%	1.3%

* Includes replacement time.

TABLE 9

TRANSPORTABLE SEISMOGRAPH DATA

DISPOSITION 1974

Place Code	Talbot Brook WA3	Bally Bally WA4
Co-ordinates		
Latitude	$32^{o}03.1'$ S	$32^{o}10.9'$ S
Longitude	$116^{o}38.6'$ E	$117^{o}09.1'$ E
Elevation	276 m	280 m
Foundation	Precambrian granite	Precambrian granite
Date of operation		
From	16 Nov 1973	21 Feb 1974
To	20 Feb 1974	22 Jun 1974
Parameters (all places)		
Component	Sp-Z	
Ts (Seconds)	1.0	
Tg (Seconds)	0.1	
Magnification*	1.8K at 1.0S 13 K at 0.1S	
Recording speed*	15 or 30 mm/min	
Instruments (all places)		
Seismometer	Willmore Mk 2; S/N 213862	
Galvanometer	Geotech (G10); S/N 4483	
Recorder	Geotech RF220; S/N 110	
Power supply	250V mains with 24V d.c. standby	
Clock	EMI	
Radio	Labtronics	

* Recording is on 70 mm film which can be enlarged x 10 for record analysis.

TABLE 10

WESTERN AUSTRALIAN EARTHQUAKES 1974

Date 1974	Origin time U.T.	Lat. °S	Long. °E	ML	mB	Remarks
Jan 04	09 25 09.0	33.5	117.7	2.4	3.5	25 km N Kantanning
18	02 10 32.2	31.70	117.02	2.1	3.3	8 km S Meckering
21	22 53 54.3	32.84	116.99	2.3	3.5	20 km NW Narrogin
23	02 43 01.0	32.84	116.99	3.9	4.8	20 km NW Narrogin
23	20 11 33.3	32.84	116.99	2.0	3.2	20 km NW Narrogin
24	15 49 53.9	32.84	116.99	2.2	3.1	20 km NW Narrogin
24	21 12 12.9	32.83	116.93	2.4	3.7	20 km NW Narrogin
Feb 05	09 02 05.8	32.31	117.18	2.0	3.6	20 km NE Brookton
06	06 26 13.4	31.7	116.9	2.2	2.5	9 km SW Meckering
08*	12 43 08.4	11.99	119.82		4.7	700 km NW Broome
09	02 10 24.4	32.34	117.20	2.4	3.7	18 km ENE Brookton
10	01 33 00.7	32.28	117.21	2.3	3.6	24 km NE Brookton
13	04 28 39.0	32.35	117.18	2.3	3.8	16 km ENE Brookton
13	16 59 18.4	32.28	117.23	2.7	4.1	23 km NE Brookton
15	00 59 12.9	32.35	117.20	2.1	3.8	22 km ENE Brookton
15	04 18 17.2	32.30	117.21	3.3	4.4	22 km ENE Brookton
16	20 42 23.6	27.16	117.62		4.0	120 km SW Meekatharra
21	03 09 25.6	32.30	117.20	2.8	4.6	20 km ENE Brookton
21	03 11 08.2	32.29	117.22	3.0	4.6	20 km ENE Brookton
21	03 34 01.8	32.35	117.18	2.4		18 km ENE Brookton

Date 1974	Origin time U.T.	Lat. °S	Long. °E	ML	mB	Remarks
Feb 21	22 28 37.0	32.34	117.21	2.8		20 km ENE Brookton
23	05 25 24.6	32.32	117.24	2.7	4.6	20 km ENE Brookton
25	05 43 00.3	32.23	117.26	2.4	3.6	24 km NE Brookton
25	05 47 29.4	32.35	117.20	2.0	3.3	18 km E Brookton
25	06 43 41.3	32.29	117.22	2.0	3.4	22 kn ENE Brookton
25	13 07 04.3	32.30	117.23	3.7	4.6	22 km ENE Brookton, felt
28	23 17 55.1	32.23	117.26	2.5	3.6	28 km NE Brookton
Mar 05	07 45 29.1	32.30	117.25	2.4	4.0	20 km NE Brookton
08	12 00 06.4	17.2	128.5	2.7	4.1	170 km S Kununurra
09	09 16 13.6	31.68	116.93	2.4	3.5	10 km SW Meckering
13	08 33 21.3	31.7	117.0	2.1	2.9	10 km SW Meckering
14	10 46 01	31.6	117.0	2.1		Meckering
19	05 52 25.8	32.33	117.21	2.0	3.5	19 km ENE Brookton
19	18 05 30.5	32.30	117.23	2.1	3.5	23 km ENE Brookton
20	02 11 15.9	32.30	117.23	2.6	4.2	22 km ENE Brookton
25	16 44 46.7	32.35	117.16	2.0	3.7	24 km E Brookton
28	08 11 38.0	32.36	117.20	2.1	3.3	18 km E Brookton
28	09 47 19.8	32.33	117.27	2.1	3.7	25 km ENE Brookton
28	23 53 22.6	32.30	117.20	2.0	3.2	20 km ENE Brookton
Apr 01	19 47 05.6	32.3	117.2	2.1		20 km ENE Brookton
01	22 49 13.3	32.3	117.2	2.2		20 km ENE Brookton
04	22 28 17	30.9	118.3	2.4	3.0	Mukinbudin
09	00 03 04	23.0	109.0		4.5	540 km WNW Carnarvon

Date 1974	Origin time U.T.	Lat. °S	Long. °E	ML	mB	Remarks
Apr 15	02 37 36	31.1	118.5	2.8	4.1	37 km E Mukinbudin
15	19 24 15.9	31.67	117.11	2.4	3.5	11 km SE Meckering
16	09 42 52	22.0	116.5	2.5	3.3	150 km S Roebourne
17*	07 21 26.2	29.61	123.82	4.8	5.3	270 km ENE Kalgoorlie
29	14 40 16.1	30.2	116.5	3.3	4.4	18 km WNW Dalwallinu
May 02	23 00 57.0	31.68	116.98	3.1	3.6	6 km S Meckering
03	14 25 23.6	31.64	117.00	2.3	3.4	2 km S Meckering
04	08 32 38.9	31.6	117.0	2.0	3.3	7 km S Meckering
08	01 49 48.1	(16.2)	(128.7)	2.0		50 km S Kununurra
12	15 49 46.3	30.83	117.01	2.7	3.9	8 km WNW Manmanning
23	03 38 58.5	32.26	117.31	2.3	3.9	30 km ENE Brookton
26	11 52 56.2	32.33	117.20	2.8	4.2	19 km ENE Brookton
31	13 42 59.9	31.62	117.01	2.6	3.3	1 km E Meckering
Jun 08	02 58 01.5	31.67	116.97	2.7	3.7	6 km SSW Meckering
15	16 42 24.2	32.35	117.23	2.6	3.8	20 km E Brookton
18	14 21 56.4	31.56	116.93	2.4	3.8	10 km NW Meckering
20	17 07 17.4	33.5	118.5	2.8	4.0	Pingrup
27	22 57 44.7	31.59	116.92	2.2	3.8	10 km NW Meckering
28	13 11 32.5	31.73	116.95	2.0	3.0	15 km SW Meckering
Jul 02	04 30 04.3	31.56	116.88	2.4		14 km NW Meckering
02	19 09 48.8	31.72	117.03	2.8	3.6	11 km S Meckering
09	10 46 47.4	31.65	117.00	4.3	5.3	4 km S Meckering, felt
14	11 32 32.8	(16.2)	(128.7)	1.8		54 km S Kununurra

Date 1974	Origin time U.T.	Lat. °S	Long. °E	ML	mB	Remarks
Jul 15	08 25 51.7	32.40	117.16	2.8		15 km E Brookton
15	09 19 42.7	32.35	117.20	3.2	4.5	18 km NE Brookton
15	11 45 13.6	32.44	117.18	2.4		12 km SE Brookton
18	16 08 11.9	32.37	117.17	2.4		15 km E Brookton
25	05 43 40.0	32.75	117.00	2.5	3.8	20 km NW Narrogin
Aug 01	18 15 05.7	(16.2)	(129)	1.0		50 km S Kununurra
04	23 49 19.7				3.8	140 km from Marble Bar
07	16 51 05.6	(16.1)	(128.9)	1.9	2.9	53 km S Kununurra
13	05 59 23.1	31.7	116.9	2.1		10 km SW Meckering
15	19 17 23.6	31.63	117.04	2.3		3 km E Meckering
16	04 37 25	21.0	114.1		3.8	120 km N North-West Cape
17	15 59 43.0	31.2	116.4	2.3		10 km NW Bolgart
25	15 41 19.1	30.2	116.5	2.2	3.6	20 km WNW Dalwallinu
Sep 03	08 28 42.3			3.1		143 km from Marble Bar
04	23 17 42.4	30.79	116.97	4.5	5.8	13 km NW Manmanning
04	23 20 30.4	30.79	116.97	3.9	4.6	13 km NW Manmanning
05	21 31 37.1	30.76	116.91	2.7	4.3	20 km NW Manmanning
06	23 01 52.3	31.68	117.08	2.8	3.9	10 km SE Meckering
07	08 00 16	16.6	128.5	1.9		96 km SSW Kununurra
07	12 23 56.4	30.82	116.97	2.3		12 km NW Manmanning
09	09 42 05	30.8	117.0	2.2		10 km NW Manmanning
15	04 51 32.6	16.3	128.6	1.7		60 km SSW Kununurra

Date 1974	Origin time U.T.	Lat. °S	Long. °E	ML	mB	Remarks
Sep 21	16 05 15.9	16.6	128.9	2.2		170 km S Kununurra
26	16 38 01.8	17.24	128.13	3.7		170 km SSW Kununurra
30*	03 32 19.0	30.3	112.8	5.1	5.0	220 km SW Geraldton depth 30 km
Oct 03	04 12 27.2	30.77	116.96	2.9	4.2	13 km NW Manmanning
03	20 41 49.3	30.78	116.97	3.1	4.3	12 km NW Manmanning
Nov 03	03 18 28.4	30.8	118.4	2.3		Mukinbudin
04	17 45 20.1	31.22	117.06	2.6		5 km E Meckering
05	20 24 50.1	30.65	117.16	3.1		12 km N Cadoux
07*	01 53 31.5	18.16	118.65		5.3	200 km N Pt. Hedland
14*	21 14 09.1	22.07	126.66		4.7	Lake McKay
17*	14 53 44.37	22.00	126.53		5.1	Lake McKay
19	03 27 12.5	31.71	117.08	(2.6)	3.7	12 km SE Meckering
19	09 30 22.6	31.63	117.03	4.0		3 km SE Meckering
30	17 16 49.0	31.58	117.07	2.2	3.5	7 km NE Meckering
Dec 09	11 05 32	31.90	117.17	2.4		12 km N Mawson
21	00 59 17.9	31.76	117.10	2.6	3.8	17 km SE Meckering
31	22 24 10	31.6	117.0	2.0		Meckering

* Relocated using headquarters computer program.

TABLE 11

GEOMAGNETIC DATA DISTRIBUTION

Weekly

K-Indices and storm advice to:

Carpentaria Exploration, Kalgoorlie	Adastra Hunting Geophysics, Mascot
Foster Harris & Associates, Boulder	Professor G.R. Ellis, Hobart
Sampey Exploration, Midland	Basic Aerosurveys, Kewdale
International Nickel, West Perth	Westfield Minerals, Perth
Scintrex Pty. Ltd., West Perth	Alcoa of Australia, East Perth

Monthly

	K-Indices	Rapid Variations	Principal Storms	Prelim. Monthly Means	Magnetograms 35 mm copy
BMR, Canberra	X[1]	X[1]	X[1]	X[1]	
IPS, Sydney	X	X			
WDC C1, Denmark	X	X			
WDC C2, Kyoto	X				
WDC A, Washington	X		X		X
ISGI, De Bilt	X[2]*	X			
DSB, Melbourne*	X				
Dr. Mayaud, Paris	X				

* Components of K-Indices included.

* Defence Signals Branch

Annual

BMR, Canberra	Preliminary annual and monthly mean values
Dr. Pushkov, IZMIRAN, Moscow.	Preliminary annual and monthly mean values
WDC-2, Kyoto	Preliminary annual and monthly mean values
IAGA, Commission on magnetic variations	Checked data for rapid variations[2]
WDC-A	Checked data for principal magnetic storms[2]

Data published

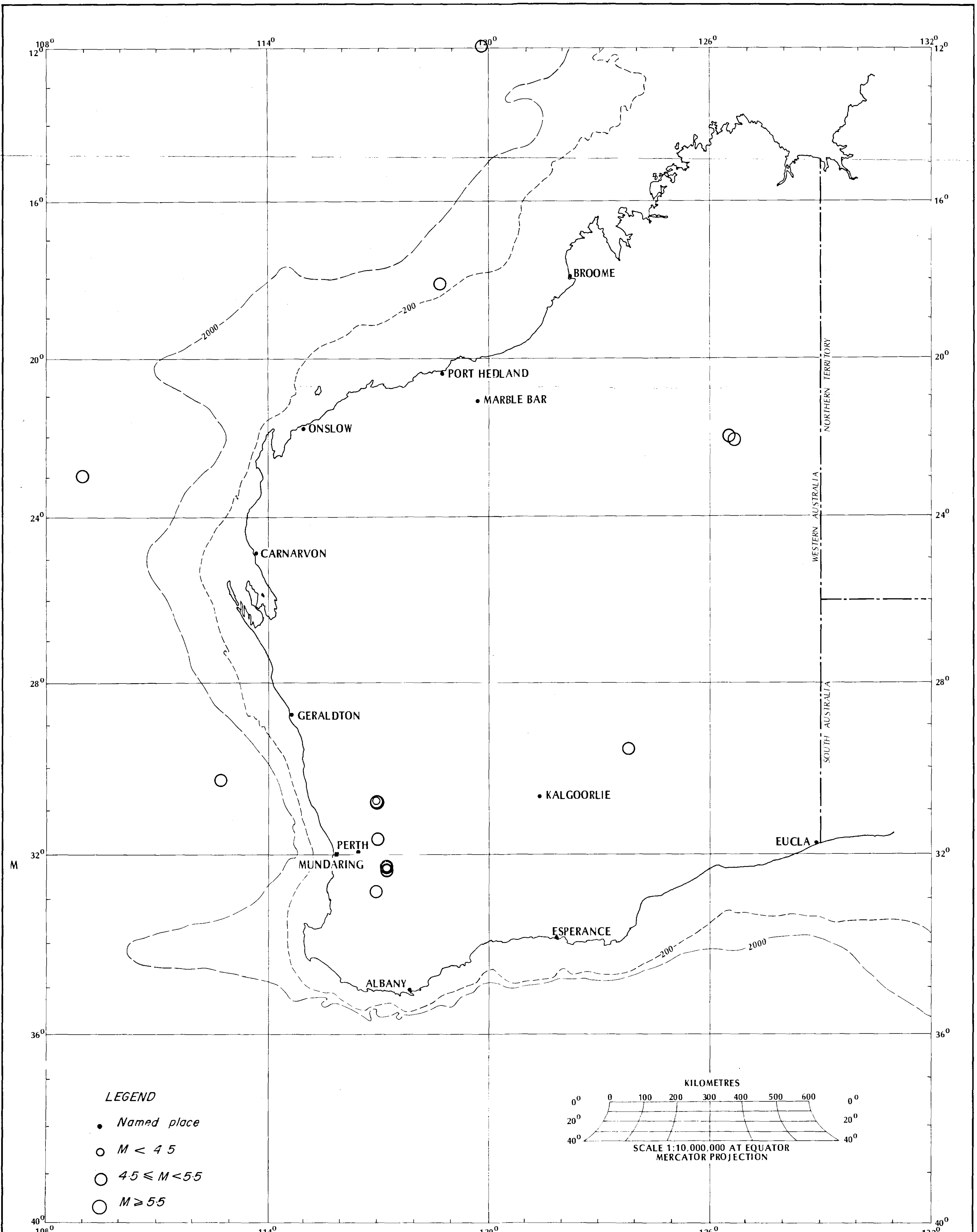
1. Geophysical Observatory Report, Bureau of Mineral Resources, Geology and Geophysics.
2. IAGA Bulletin, Geomagnetic data.

TABLE 12

PRELIMINARY SEISMOLOGICAL DATA DISTRIBUTION

Preliminary monthly bulletins of phase data are distributed to:

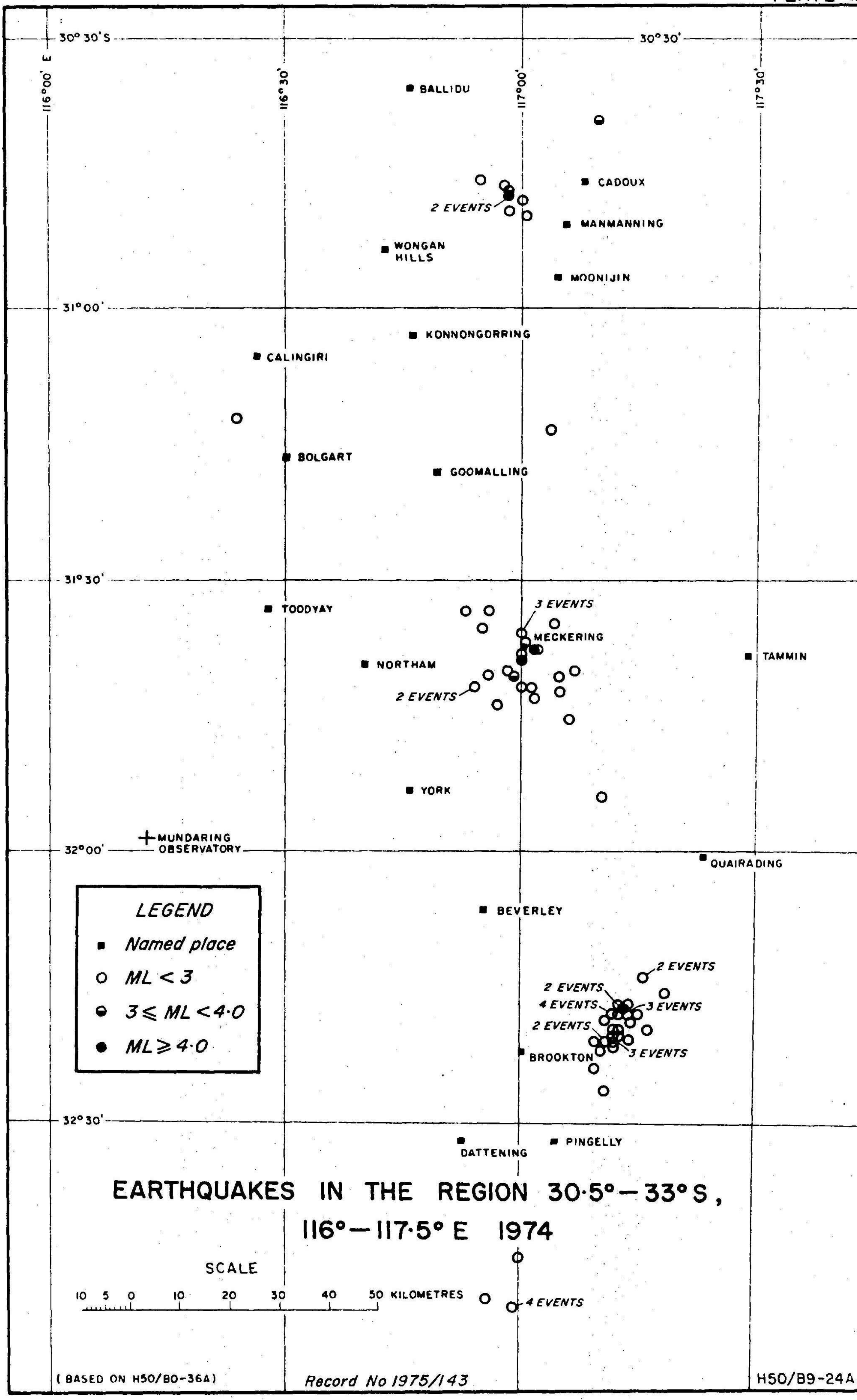
BMR, Canberra
BMR, Darwin
BMR, Melbourne
BMR, Port Moresby
Australian National University, Canberra
University of Queensland, Brisbane
University of Adelaide, Adelaide
University of Tasmania, Hobart
Riverview College Observatory, Lane Cove
Volcanological Observatory, Rabaul
Seismological Observatory, New Zealand
University of Tokyo, Tokyo
U.S. Geological Survey, Colorado
Seismological Laboratory, California
University of California, California
Apia Observatory, Western Samoa
Tohoku University, Japan
Ciudad Universitaria, Mexico
University of British Columbia, Canada
Observatoire de Tananarive, Madagascar
S.N. Mitra, India
International Central Seismological Bureau, France
World Data Centre B2, U.S.S.R.
Instituto Geofisica de Hyancayo, Peru
Meteorological & Geophysical Institute, Indonesia



LARGER EARTHQUAKES IN THE REGION OF WESTERN AUSTRALIA, 1974

(Based on WA/BO-4) Record No 1975/143

WA/B9-36



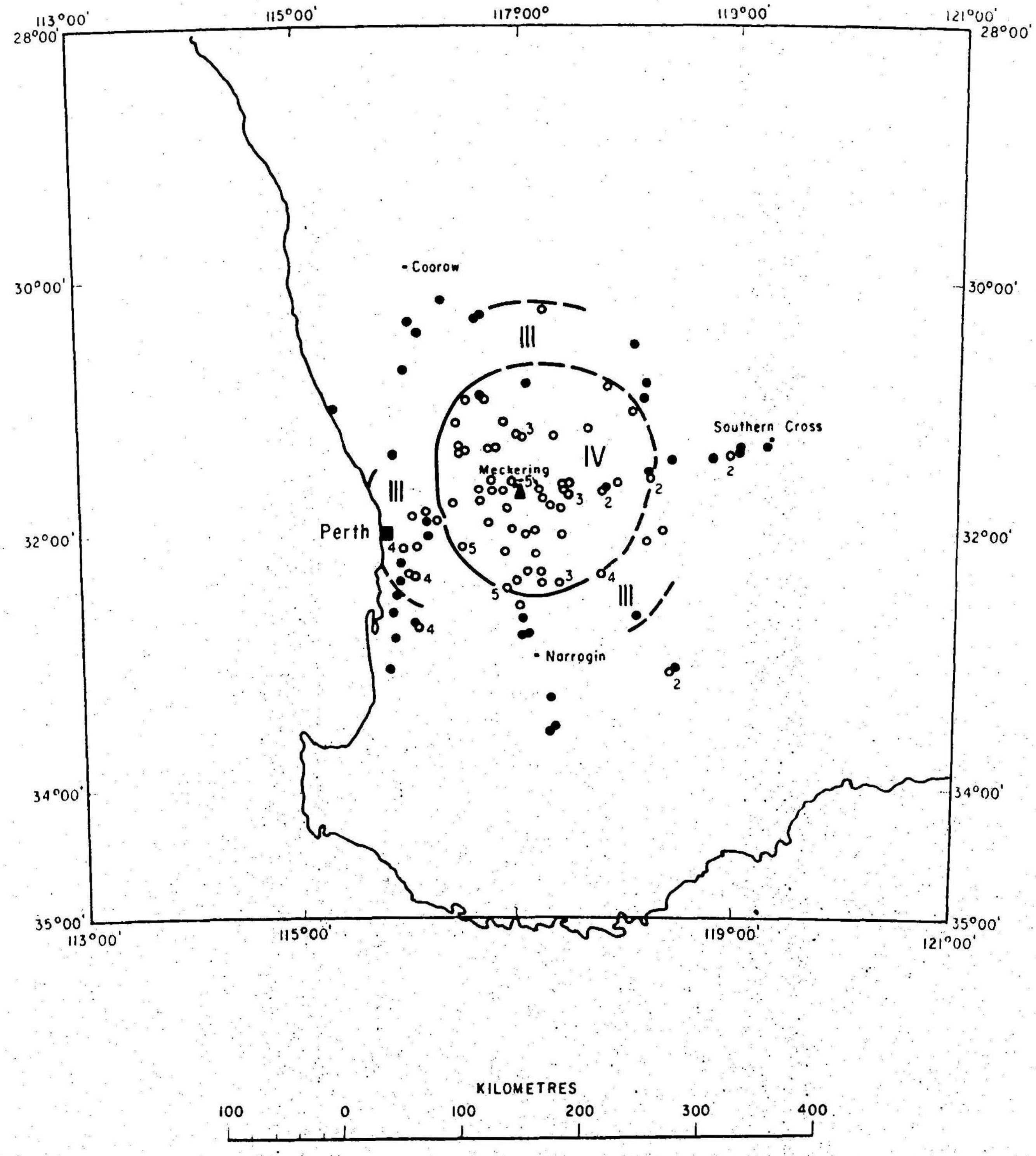
EARTHQUAKES IN THE REGION 30·5°—33°S, 116°—117·5° E 1974

Record No 1975/143

H50/B9-24A

ISOSEISMAL MAP OF A MECKERING EARTHQUAKE WA

PLATE 3



DATE : 9 JULY 1974

TIME : 10:46:47·4 UT

MAGNITUDE : 4·3 ML, 5·3 mB

EPICENTRE : 31·65°S 117·00°E

▲ EPICENTRE

o EARTHQUAKE WAS FELT

● EARTHQUAKE WAS NOT FELT

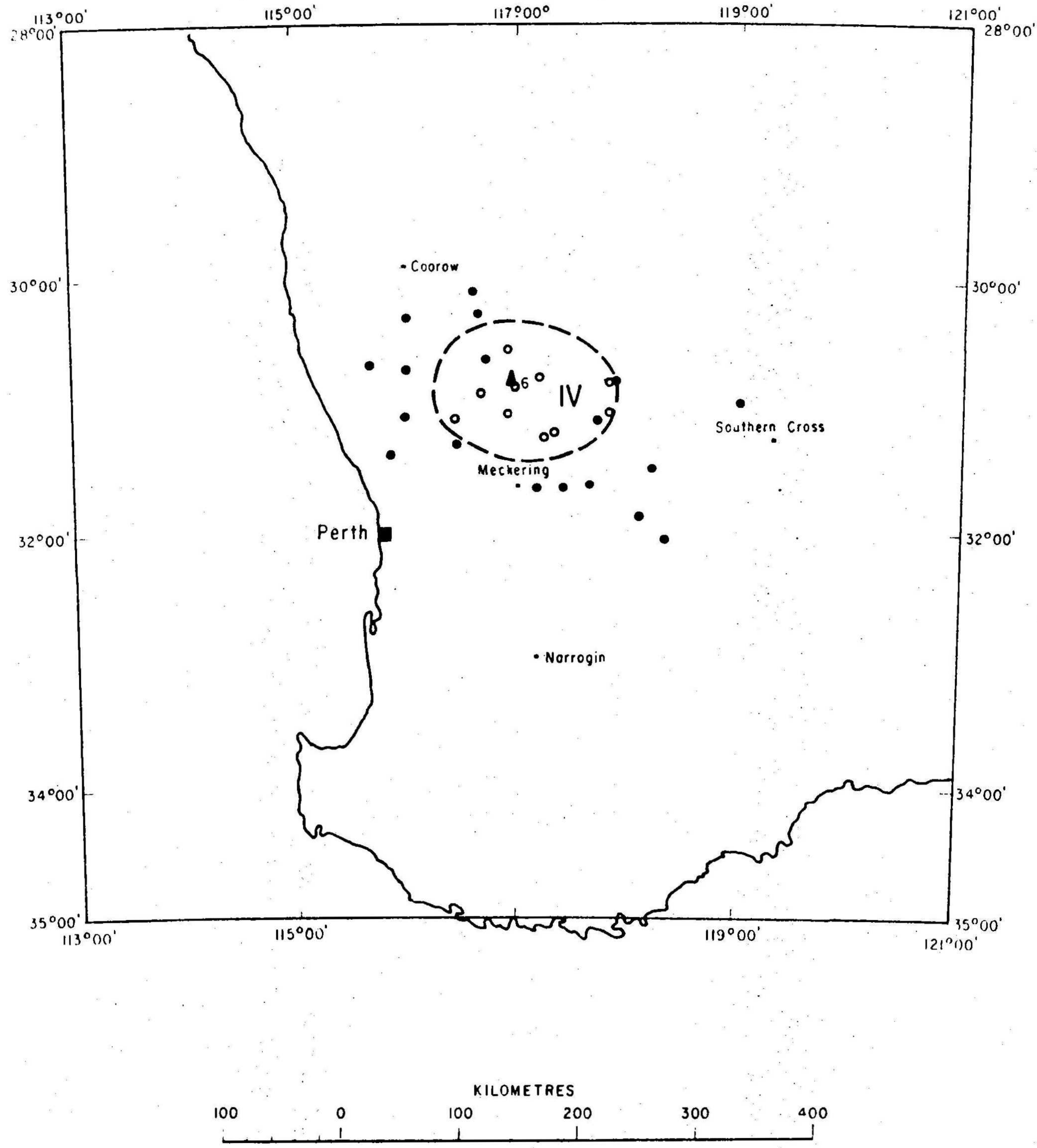
IV ZONE INTENSITY DESIGNATION (MM)

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

(BASED ON WA/BO-18A) *Record No 1975/143* H50/B9-20A

PLATE 4

ISOSEISMAL MAP OF A MANMANNING EARTHQUAKE WA



DATE : 4 SEPTEMBER 1974
TIME : 23:17:42·4 UT
MAGNITUDE : 4·5 ML, 5·8 mB
EPICENTRE : 30·79°S 116·97°E

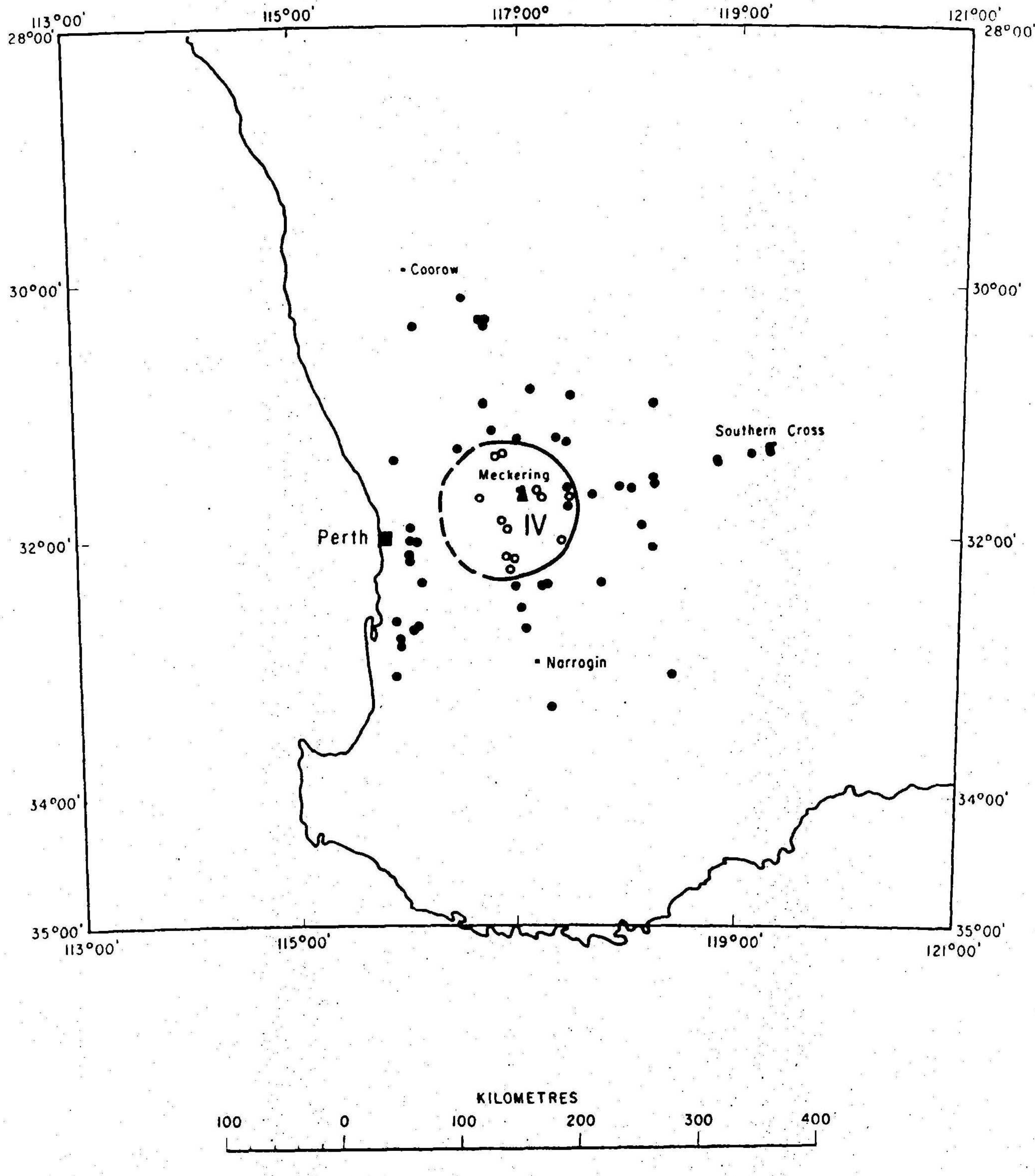
▲ EPICENTRE
o EARTHQUAKE WAS FELT
● EARTHQUAKE WAS NOT FELT
IV ZONE INTENSITY DESIGNATION (MM)

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

(BASED ON WA/B0-18A) *Record 1975/143* H50/B9-21A

PLATE 5

ISOSEISMAL MAP OF A MECKERING EARTHQUAKE WA



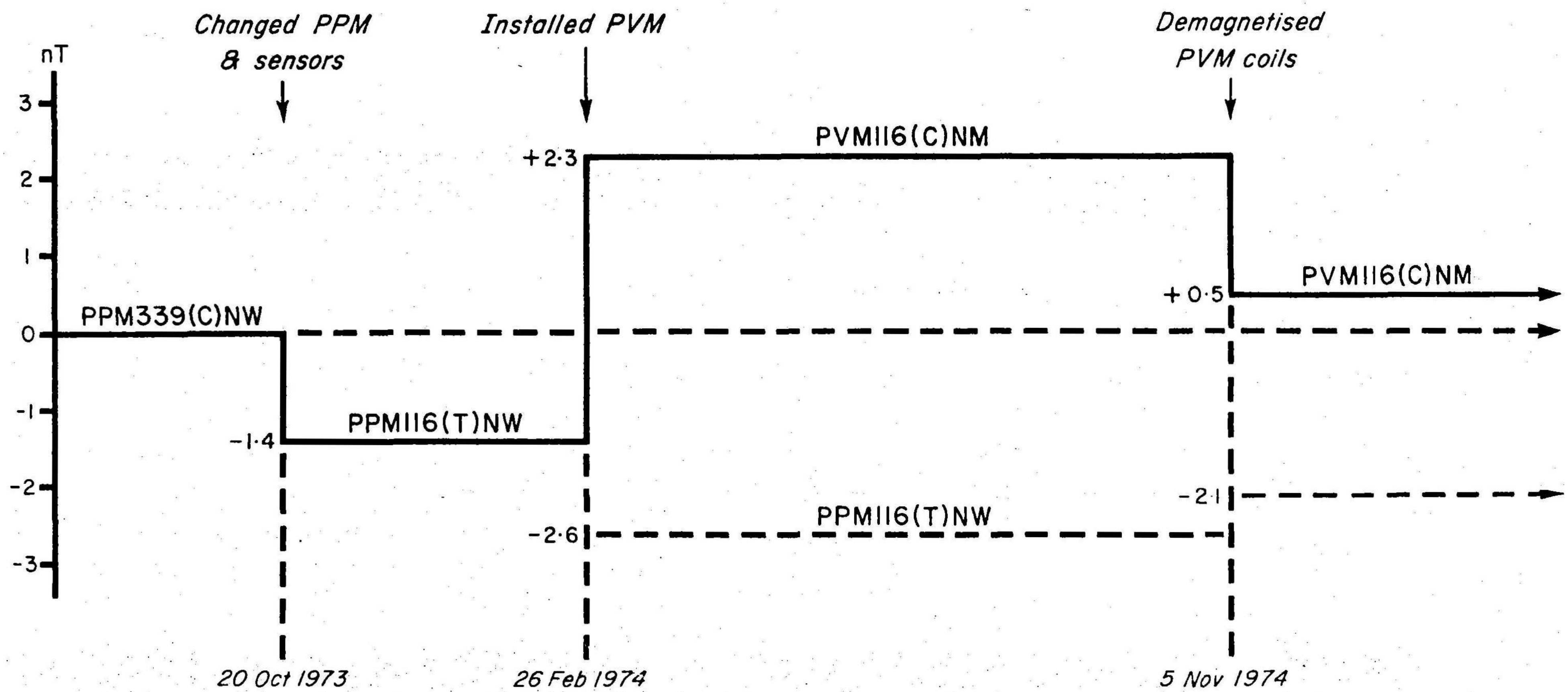
DATE: 19 NOVEMBER 1974
TIME: 09:30:22·6 UT
MAGNITUDE: 4·0ML
EPICENTRE: 31·63°S 117·03°E

▲ 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

(BASED ON WA/BO-18A) *Record No 1975/143* H50/B9-22A

Gnangara F Standards



C = cylindrical sensor
T = toroidal sensor
NM = Pier NM
NW = Pier NW

PPM339 = Elsec proton precession magnetometer No. 339
PVM116 = Elsec proton vector magnetometer No. 116