BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD

RECORD NO. 1985/38

MUNDARING GEOPHYSICAL OBSERVATORY

ANNUAL REPORT 1984

by

P.J. Gregson, E.P. Paull, V.F. Dent, G. Woad & B.J. Page

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SUMMARY

Basic programmes in geomagnetism, ionospherics and seismology continued at the Mundaring Geophysical Observatory during 1984. The main instruments were an Eschenhagen normal-run magnetograph, an IPS type 4B ionosonde, a Worldwide Standard Seismograph, and a Seismic Research Observatory.

Seismographs were operated at Ballidu, Kalgoorlie, Rocky Gully, Kununurra, Marble Bar, Meekatharra, Mundaring, Nanutarra, Narrogin and Warburton. A regional seismograph was installed at Morawa on 21 June.

The annual earthquake (ML>2) list shows details of 148 Western Australian earthquakes, 75 of which occurred in the southwest seismic zone. More than 400 minor earthquakes (ML<2.0) were recorded in the Southwest Seismic Zone.

1. INTRODUCTION

The Mundaring Geophysical Observatory opened on 18 March 1959, and now controls seismological recording at Ballidu, Kalgoorlie, Kellerberrin, Kununurra Marble Bar, Meekatharra, Morawa, Mundaring, Nanutarra, Narrogin Rocky Gully and Warburton; magnetic recording at Gnangara and ionspheric recording at Mundaring. The seismograph at Narrogin is a Seismic Research Observatory (SRO) and is operated in co-operation with the United States Geological Survey.

Descriptions of the Observatory and an outline of activity there to the end of 1983 have been given in previous records (e.g. Gregson, et al 1985) and principal events in the observatory's history are given in the appendix.

P.J. Gregson, E.P. Paull, V.F. Dent, G. Woad and B.J. Page have contributed to this report.

2. STAFF AND VISITORS

1984 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 attended and addresses given, in Table 4. P.J. Gregson was a member of the Geophysics Advisory Committee, Western Australia Institute of Technology and the seismological data base sub-committee of the Accreditation Technical Experts Natural Disasters (ATEND).

V.F. Dent assisted with the first order magnetic survey for one week in May.

E.P. Paull acted as Observer In-Charge from 22 October to 14 December while P.J. Gregson was acting Manager of the Geomagnetism Section in Canberra.

Two temporary part-time technical assistants (Mrs P.S. Trew and Mrs H.L. Masters) were employed, each for 20 hours/week from 11 October to 14 December. They assisted with the additional work load resulting from technical trials related to monitoring nuclear blasts (see later).

Visitors to the observatory during 1984 are listed in Table 5.

3. GEOMAGNETISM

An Eschenhagen 20mm/hr magnetograph operated continuously at Gnangara recording the three components D,H, and Z. The installation of an Elsec automatic digital magnetograph (ADM) commenced in the latter part of 1983 was suspended for reasons described below.

Eschenhagen magnetograph

The magnetograph operated satisfactorily throughout the year. Twenty-four hours of record (0.3%) were lost owing to the recorder drum not translating. A further 24 hours of record had no timemarks when the 24V charger was returned to the workshop for repair.

As in previous years, the Z scale value drifted during the year. It changed

from 6.20 nT/mm in April to a peak in August of 6.82n T/mm; the drift reversed between August and November. There were two unexplained jumps in the Z scale value of about 0 .20nT/mm each in June and July.

The Z baseline values changed abruptly by about 10 nT on three occasions in May, June and July. Two of these changes coincided with the abrupt changes in the Z scale value. There was no apparent reason for the change in May.

There were no abrupt changes in either H and D scale or baseline values.

Adopted scale and baseline values for 1984 are given in Tables 8 and 9 respectively.

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

Element	Baseline value	Scale value
D	1.4 nT (0.20 min)	-
H	1.4 nT	0.02 nT/mm
Z	1.0 nT	0.04 nT/mm

Values were similar to those obtained in previous years.

Eschenhagen magnetograph tests

Temperature coefficients. Values of qH = 0.0 nT/°C and qZ = 3.2 nT/°C derived from 1981 data and confirmed from 1982 and 1983 baseline plots were used throughout 1984.

The drift in Z scale value showed a good correlation with temperature. Least-squares analysis gave the following relation:

$SZ = SZ_o - 0.05(t-20)$ nT/mm
where SZ_o is the scale value at 20°C.

Orientation. No orientation tests were made during the year.

Parallax. No tests were performed during 1984 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 D scale value was not determined during 1984.

Automatic digital magnetograph

Installation of an Elsec automatic digital magnetograph (ADM) commenced in the latter part of 1983, was suspended. Successive readings were scattered and digital information recorded onto magnetic tape was garbage. The scatter in readings was reduced by better earthing of all control units, reducing the ripple on the 24V DC supply and adjusting the sensor orientation. Useful digital data could not be obtained even though both the tape controller (XMA3) and Kennedy tape recorders were replaced.

A decision was made in December to suspend the installation of a digital magnetometer at Gnangara until an EDA fluxgate as used at Charters' Towers and proposed for Learmonth, became available. This would work towards the

standardisation of magnetic digital magnetometers operated by the BMR. This decision was later reversed and installation recommenced in 1985.

Magnetometers

Absolute observations for D, H, and Z values were made at weekly intervals. An Askania magnetometer (S/N 309319, circle 580135) was used throughout the year for D observations. A proton vector magnetometer (PVM B/5/Z) was used for combined observations of F and Z values (cancellation method). The PVM consisted of Elsec vector coils (set B), an MNS-2 proton-precession magnetometer (S/N 5) and sensor (S/N Z). H values were calculated from F and Z values.

Preliminary corrections used during the year were:
(a) PVM B/5/Z : H 0 nT, Z 0 nT
(b) Askania declinometer 509319 (circle 580135) : +0.5 minutes.

Comparisons. H comparisons were made through baseline values between the Gnangara PVM (pier NM) and the Gnangara QHM 293 (pier NE). The pier difference is negligible.

April 18

H.PVM B/5/Z - H.293 = -14.8 +/- 1.4 nT (5 observations)

Mean H was 23250 nT

Reference Marks

The relative angles between reference marks were not checked in 1984.

Accessory equipment

The Askania H visual variograph at Mundaring office was operated throughout the year with minor record losses.

A magnetic pulsations tape recorder was operated at the Weir site for the University of Newcastle.

First order magnetic survey

Mr V.F. Dent occupied the first order magnetic stations at Augusta and Albany in May. The results will be reported separately.

Data reduction and publication

Magnetograms and reduction data were prepared in monthly batches about six weeks after the end of the month and sent to headquarters for reduction to mean hourly values.

Adopted scale values and baseline values are listed in Tables 8 and 9 respectively.

Monthly and annual mean values of H, D, Z, F and K-index for 1984 are listed in Table 6. The field values were derived from the five local quiet days each month by scaling a mean ordinate for each component from each magnetogram. The F value was calculated from H and Z values. Annual values and secular variation for all components since 1974 are shown in Table 7. Apart from D, recent trends in secular variation continued during 1984 with H decreasing by 27nT, Z decreasing in magnitude by 16 nT and the calculated mean value of F rising by 4 nT during 1984. The mean value of D remained approximately the same as for 1982.

The routine distribution and publication of data is listed in Table 10. Components of K-index are stored on magnetic tape at headquarters.

Checked data for rapid variations, solar flare effects, and principal magnetic storms for 1983 were prepared for the IAGA Bulletin.

Requests for geomagnetic data attended to during the year are listed in Table 16.

4. IONOSPHERICS

A quarter-hourly sounding schedule was continued throughout the year using a model 4B ionosonde. Five minute soundings were made from 22 to 24 November to monitor effects caused by a solar eclipse. The ionosonde spare components and film were supplied by the Ionospheric Prediction Service (IPS), Department of Science and Technology.

Record loss was 1.2% almost entirely caused by film jamming in the cassette and running out of film.

There were no technical problems during the year, and only some slight adjustments to the the picture frame size were necessary.

Data distribution and publication

The F2 layer critical freqency at each six hours UT and local noon were scaled. The six-hourly values were sent to IPS for distribution internationally and the monthly median of the noon values was telexed to the International Radio Consultative Committee (Geneva) for the determination of the index IF2. The weekly film was sent to IPS Hobart for scaling of the remaining parameters. Hourly values of all parameters are published in the IPS Series D and are distributed internationally. Ionograms are available on loan within Australia from IPS and internationally through the WDC-A.

5. SEISMOLOGY

Seismograph stations

Permanent seismograph stations were operated throughout 1984 at Ballidu (BAL), Kalgoorlie (KLG), Kellerberrin (KLB), Kununurra (KNA), Marble Bar (MBL), Meekatharra (MEK), Mundaring (MUN), Nanutarra (NAU), Narrogin (NWAO), Rocky Gully and Warburton (WBN).

A station was installed at Morawa (MRWA) on 21 June and a local operator contracted to attend the equipment daily. Seismograms are posted to Mundaring three times a week.

An insensitive seismograph was operated in the Mundaring office.

The number of earthquakes reported from each station in 1984 were:

BAL 685; KLB 751; KLG 330; KNA 1368; MBL 983; MEK 1258;
MRWA 406 (7 months); MUN 960; NAU 1043; NWAO 914; RKG 377; WBN 1396;
TOTAL: 10471

A summary of seismograph calibration data used during 1984 for all stations is given in Table 12.

Some of the EMI clocks used at the outstations have been in service for about 15 years. These clocks provide both time control and synchronous power to operate the seismographs. The faults developing with the clocks are becoming more numerous and frequent. To ensure reliable operation of outstations over the next few years it will be necessary to have more spare clocks on hand. Two spare clocks from HQ alleviated the position slightly and two spare units can now be held in the workshop.

Descriptions of individual station operations during 1984 are given below and a summary of record losses in Table 11. At least one service visit was made to all outstations. Modifications were made to standardise configurations of control equipment. All seismographs were re-calibrated and magnifications were consistent with previous calibrations (except where indicated below). The polarities of all components were checked. Although the ultimate directions on the seismograms were correct there were differences in cabling and individual units. These were all standardised with the exception of Kununurra.

Ballidu (BAL). This station continued to run well. The seismometer was relocated on 5 April onto solid rock which reduced microseismic noise caused by tree movement on windy days. The seismograph was recalibrated and the magnification curve was consistent with the previous calibration other than for periods less than 0.15s. The difference was attributed to errors in setting the function generator and measuring the small amplitude deflections.

Kellerberrin (KLB). A discriminator change on 12 January resulted in an overall increase in the seismograph sensitivity of about 25%. The major causes of record loss was Telecom line outage.

Kalgoorlie (KLG). Noise from the Mt Charlotte ore crusher continued to be a major problem. A quieter site, 4 km north-west of Kalgoorlie was selected and it is proposed to resite the seismometer at that site and telemeter the signals back to either the existing recording site or to the Mundaring office. Late record changing was the only cause of record loss (1.2%).

Kununurra (KNA). Several changes of operators during the year resulted in increased record loss due to operator errors. Over 3% of record was lost because of late or no change of records.

It is proposed to convert the seismograph from photographic to visual recording early in 1985.

Although the polarities of the three components were checked in March there is still an inconsistency as the first motion of blasts are recording as down yet the directions of locals are consistent with their location.

The vertical component only was operated prior to 18 June because of the shortage of paper. The EW component was not in operation from 8 December as the seismometer was returned to Mundaring for tests.

Marble Bar (MBL). Some problems continued to be experienced with trace drift but it was not as excessive as the previous year and could be tolerated. A visit to the station in March failed to solve the problem although it is thought that the problem is associated with temperature changes in the recording room affecting the discriminator stability. Line outage generally caused by lightning strikes was the main cause of record loss (2.4%). The automatic remote calibrator (PC-100) was not in operation for most of the year.

Meekatharra (MEK). This station ran well with the major record loss being due to late or missed record changes.

Morawa (MRWA). A permanent short period vertical seismograph was installed at the Agricultural High School at Morawa on 21 June. Table 13 shows station parameters. Details of the response curve are shown on Table 12 and Figure 1. The station is operated by staff from the school. Clock failure and AC power resulted in minor loss of record.

Mundaring (MUN). The WWSSN seismograph continued to operate exceptionally well. The only loss of record was caused by blown globes on the SP-E component (total 31 hours). Six system tests were performed during the year with only one adjustment required to the LP-N seismometer free period.

The supplementary seismograph also ran well with minimum record loss. The three channel insensitive seismograph ran well apart from some drift in the trace. As the recorder amplifiers are old valve types this problem is difficult to overcome.

Nanutarra (NAU). Operator performance improved considerably from 1983 although late or no change of record resulted in about 2% of record loss. Pen damage due to overheating and failure of the recorder translation motor were the main causes of record loss. The recorder was returned to Mundaring to rectify the latter fault.

Narrogin (NWAO). This station continued to run exceptionally well. The major reason for record loss was again Telecom line outage (less than 1%). The remote site batteries were replaced in June. The teletype was replaced in October with a digital line printer. This gave some trouble with random messages and was eventually replaced with a complete printer from the Albuquerque Seismological Laboratory (ASL). No visits were made by personnel from ASL.

Warburton (WBN). The seismometer recorder cable broke on two occasions, resulting in about 9% record loss. Apart from this the seismograph ran well.

Accelerographs

Two MO2 accelerographs were operated in the Southwest Seismic Zone, both near Meckering. The State Public Works Department (PWD) operated a Kinemetrics SMA-1 accelerograph at Mundaring Weir. Telecom operated three SMA-1 accelerographs in the Wellington St. Telephone Exchange, Perth. The Telecom instruments were serviced by observatory staff.

There were no triggerings during 1984.

Seismicity

Table 14 lists 148 earthquakes of magnitude ML = 2.0 or greater which occurred in Western Australia in 1984. Epicentres of those with magnitude ML = 3 or greater are shown in Figure 2.

Southwest Seismic Zone. During 1984 there were 75 earthquakes with ML >2 located in the Southwest Seismic Zone (see fig. 3). The activity was widely spread throughout the zone ranging from Latham in the North to Merredin in the east and Mt Barker in the south. The largest earthquake was near Cadoux on 28 March with magnitude ML = 4.2. Twenty five other tremors were recorded in the Cadoux area. This compares with 57 for 1983. About 350 minor tremors occurred in the zone (Table 15).

Kununurra. During 1984, six small tremors (ML range 2.0-2.3) occurred

within 100 kms of Kununurra. Three were in an area about 80 km south of the town; one was 58 km south, one 30 km SSW and the other 93 kms ESE. The Ord River Dam lies 37 km south of Kununurra.

Offshore. 24 earthquakes were located offshore during 1984; (See Table 14) the largest being of magnitude ML = 5.2, 350 km NNE of Broome on 16 March. This was also the largest earthquake for the year overall. There were no real concentrations of earthquakes in any area, the activity being more or less evenly spread along the coastline.

Other areas. 37 earthquakes were located on land, apart from the areas mentioned above (see Table 14). The largest, with magnitude ML = 4.5 occurred on 7 July in the Great Victoria Desert, 225 km south of Warburton.

Stress measurements

Assistance was rendered to CSIRO to take fracture impressions at three existing measurement sites at Wongan Hills, Goomalling and Clackline. A tripod was constructed with pulley and winch rope and three man days were spent in the field.

Nuclear monitoring

The observatory participated in the Group of Scientific Experts Technical Tests (GSETT) designed to test the transmission of seismic data via the Global Telecommunication Service (GTS).

Level 1 data from the Seismic Research Observatory station at Narrogin (NWAO) for the period 15 October-14 December was used for the tests. Data was prepared daily and transmitted each week day to the BMR HP computer in Canberra via CSIRONET. The BMR re-transmitted data via the GTS to International Centres.

During the two month trial period there were 281 events, 1580 arrivals and 5008 parameters reported from the Narrogin station. Additional man hours required for the tests were: analysis of data - 92 hours; data handling - 23 hours; i.e. 13 hours/week.

Data distribution, publication and requests

Preliminary monthly lists of Western Australian earthquakes were distributed to 13 recipients.

Requests for seismological data attended to during the year are listed in Table 16. Narrogin tapes were sent to ASL vis the US Consulate (Perth). Mundaring WWSS seismogram were sent to the WDC-A for copying.

6. ACKNOWLEDGEMENTS

The assistance of the daily attendants listed in Table 2 and the co-operation of Australia Post and Telecom for housing the seismograph at Marble Bar is hereby acknowledged. Remote seismometers and telemetry equipment were located on the properties of K. Quartermaine (Narrogin), V. Wright (Kellerberrin) and T. Maley (Ballidu).

7. REFERENCE

GREGSON, P.J., PAULL, E.P., DENT, V.F., WOAD, G. and PAGE, B.J., (1985) - Mundaring Geophysical Observatory, Twenty-fifth year. *Bureau of Mineral Resources Record*, 1985/37.

APPENDIX
PRINCIPAL EVENTS
MUNDARING GEOPHYSICAL OBSERVATORY 1957-1984

1957 May	Geomagnetic recording commenced at Gnangara (La Cour)
1959 Mar 18	Transfer of observatory from Watheroo to Mundaring
1959 Apr 03	Ionospheric recording commenced (Type 2 ionosonde)
1959 Jul 30	MUN seismograph recording commenced (Benioff)
1960 Mar-Oct	Atmospheric noise recording (for CSIRO)
1960 Apr 30	Eschenhagen normal magetograph replaced La Cour at Gnangara
1960 May 01	Cossor ionosonde replace Type 2
1960 Jun 22	Absolute magnetic observations commenced in new absolute house
1962 Jun	WWSS system commenced recording at MUN
1963 Apr19-Dec 17	GRV seismograph operation
1963 May 30-Dec 19	NGN seismograph operation
1964 Nov 06	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 February 1972
1967 Feb	Fremantle Region Upper Mantle Project
1967 Oct 26	MEK SP-Z seismograph recording commenced
1968 Oct-Nov 26	Field seismograph operation at Meckering
1968 Nov 16-1971 Dec 31	AFMAG recording at Mundaring
1970 Jan 01	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 01	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) at Kununurra
1973 Jan 31	Mobile SP-Z recording at various sites in SW seismic zone started
1973 Mar 01	MEK reduced to 3 component SP
1973 Mar 30	KLG reduced to SP-Z
1973 May 23	MUN 2 Wood Andersons installed
1973 May 25	MUN Benimore SP-Z withdrawn; Benioff SP-Z started
1974 Apr 01	Proton vector coils introduced for Z baseline control
1974 May 01	Proton vector coils introduced for H baseline control
1974 Jun 17-31	Riometer recording at Mundaring during solar eclipse
1974 Sep-1978 Jun	GLS SP-Z recording
1975 Jul 18-Nov 19	Earthtide recording at Mundaring
1975 Mar	Magnetic pulsation recording commenced at Mundaring
1975 Mar 19-Aug 15, Dec 18, 1981 Jul 20	SWV SP-Z recording
1975 Sep 02-1976 Feb 05	NWAO SP-Z recording
1976 Mar 27	NWAO Seismic Research Observatory commenced
1976 Jun	MBL SP-Z recording commenced
1976 Sep-1977 Nov 27	XMI SP-Z recording
1976 Oct	Special ionospheric sounding, solar eclipse (23 Oct)
1977 Nov 28	A third MO2 accelerograph installed at Meckering
1978 Feb	A fourth MO2 accelerograph installed at Meckering
1978 Jun 27	WBN SP-Z recording commenced

APPENDIX 1 (Cont.)

1980 Jun 19	NAU SP-Z recording commenced
1981 Aug 07-1982 Mar 27	BAL SP-Z recording
1981 Sep 23	KLB SP-Z recording commenced
1981 Nov 19-1982 Jun 27	Walpole SP-Z field recording
1982 Aug 26	BAL SP-Z recording commenced
1983 Aug 03	RKG SP-Z recording commenced
1984 Jun 21	MRWA SP-Z recording commenced

AS

TABLE 1
OBSERVATORY STAFF 1984

Officer	Designation
P.J. Gregson	Geophysicist Class 3
E.P. Paull	Geophysicist Class 2
V.F. Dent	Geophysicist Class 2
G. Woad	Senior Technical Officer Gr. 1
B.J. Page	Technical Officer Grade 2
M.A. Bousfield (Mrs)	Clerical Assistant Grade 3
H.L. Masters (Mrs)	Technical Assistant Grade 2 (20 hrs part time 11 Oct-14 Dec)
P.S. Trew (Mrs)	Technical Assistant Grade 2 (20 hrs part time 11 Oct-14 Dec)

TABLE 2
ASSOCIATED PERSONNEL 1984

Name	Nature of Duties
B. Carling	Daily attendant, Gnangara
G. McLauchlan	Daily attendant, Kalgoorlie
D. Ardnt	Daily attendant, Marble Bar (to 30 Jun)
A. Mead	Daily attendant, Marble Bar (from 1 Jul)
A. Riach	Daily attendant, Meekatharra
L. Makin	Daily attendant, Kununurra
M. Fitzgerald	Daily attendant, Nanutarra
J. Capps	Daily attendant, Warburton
S. Cameron	Daily attendant. Rocky Gully
W. Briggs	Ground maintenance (to 13 Jun)
K. Furmage	Ground maintenance (from 14 Jun to 5 Aug)
B. Bussau	Ground maintenance (from 6 Aug)
L. Page	Cleaning
N. Fenttiman	Relief Clerical Assistant (31 days)
J. Mason	Work experience May 28-Jun 8 (Eastern Hills Senior High School)
D. Gasmire	Work experience Aug 6-17 (Eastern Hills Senior High School)

TABLE 3
OBSERVATORY STAFF ABSENCES 1984

Nature of absences	No. of man-days
Sick leave	16
Special leave	1
Furlough	13
Military leave	19
Attendance at outstations and field operations	58
Temporary transfer	53
Conferences and training	5
Total	165 *

* Clerical assistant relief was available for 31 days

TABLE 4
CONFERENCES, ADDRESSES AND TRAINING, 1984

Officer	Date	Conference
P.J. Gregson	Aug 13-17	OIC's meeting, Canberra
		Addresses
E.P. Paull	Nov 16	Cunderdin Rotary Club, "Earthquakes"
		Committees
P.J. Gregson		Geophysics Advisory Committee, Western Australian Institute of Technology
P.J. Gregson		Seismological data base sub-committee of the Accreditation TechnicalNatural Disasters (ATEND)

TABLE 5
VISITORS 1984

Visitor	Institution
C. Lynam	University of Queensland
J. Richards	Teledyne Geotech (Melbourne)
J. Smith	Teledyne Geotech
Students (60)	Lesmurdie High School
I.B. Everingham	Dept of Mineral Resources, Fiji
K. Leadbetter	State Emergency Service
M. McElhinny	BMR
J. Enever	CSIRO, Melbourne
Students (26)	Bunbury High School
P. Milligan	ex. Flinders University
J. Ayres	State Emergency Service
Students (14)	Kalamunda High School
Students (26)	Mt. Helena Primary School
Officers (12)	State Emergency Service
P. Wright	State Emergency Service

TABLE 6

PRELIMINARY MONTHLY MEAN GEOMAGNETIC VALUES AND K-INDICES, 1984

Month	D(West)	H,nT	Z,nT	F,nT	K
	° '				
January	3 19.2	23291	53745	58575	2.15
February	19.0	280	747	572	2.26
March	19.6	275	743	567	2.92
April	18.8	268	750	570	2.60
May	18.7	267	745	565	2.12
June	19.3	268	756	576	2.02
July	19.1	269	762	581	2.25
August	18.8	271	734	557	2.24
September	19.0	267	758	577	2.58
October	18.8	274	759	581	2.62
November	18.9	272	763	584	2.77
December	18.9	270	761	581	2.63
Mean	19.0	273	752	574	2.41

TABLE 7

GEOMAGNETIC ANNUAL MEAN VALUES (AND SECULAR CHANGE) 1974-1984

Year	D	I	H,nT	X,nT	Y,nT	Z,nT	F,nT	Notes
	° '	° '						
1974	3 09.9	66 09.0	23642	23606	-1304	53477	58470	C
	(-1.6)	(-2.3)	(-34)	(-35)	(-10)	(-19)	(+ 2)	
1975	11.5	11.3	608	571	-1314	496	474	C
	(-0.9)	(-2.9)	(-48)	(-41)	(- 4)	(-32)	(+12)	
1976	12.4	14.2	567	530	-1318	528	486	C
	(-0.8)	(-2.8)	(-49)	(-39)	(- 6)	(-29)	(+11)	
1977	13.6	17.0	528	491	-1324	557	497	C
	(-1.5)	(-2.5)	(-47)	(-48)	(- 8)	(-39)	(+17)	
1978	15.1	20.5	481	443	-1332	596	514	C
	(-0.6)	(-2.6)	(-37)	(-38)	(- 7)	(-28)	(+11)	
1979	16.5	23.1	444	405	-1339	624	525	C
	(-1.3)	(-2.6)	(-33)	(-35)	(- 7)	(-28)	(+11)	
1980	17.8	25.7	409	370	-1346	652	536	C
	(-2.1)	(-3.2)	(-45)	(-45)	(-12)	(-33)	(+14)	
1981	19.9	28.9	364	325	-1358	685	550	D
	(+0.4)	(-3.0)	(-43)	(-43)	(+5)	(-29)	(+ 8)	
1982	19.5	31.9	321	282	-1353	714	558	D
	(+0.2)	(-1.8)	(-27)	(-27)	(+ 3)	(-16)	(+ 4)	
1983	19.3	33.7	294	255	-1350	730	562	D
	(+0.3)	(-1.6)	(-21)	(-21)	(+ 4)	(-22)	(+14)	
1984	19.0	35.3	273	234	-1346	752	574	D

Notes: C Preliminary values = Mean daily values, 10 days
D Preliminary values = Mean daily values, 5 days

TABLE 8

ADOPTED SCALE VALUES, GNANGARA MAGNETOGRAPH 1984

Date from	UT h	UT m	Scale Value	Explanation
HORIZONTAL INTENSITY			So (nT/mm)	
Jan 01	00	00	2.42	
DECLINATION			SD (min/mm)	
Jan 01	00	00	1.09	
VERTICAL INTENSITY			SZ nT/mm)	
Jan 01	00	00	6.08	
Mar 01	00	00	6.10	Drift due to
Mar 11	00	00	6.12	temperature through
Mar 21	00	00	6.14	to May 25
Apr 01	00	00	6.16	
Apr 11	00	00	6.18	
Apr 21	00	00	6.20	
Apr 27	00	00	6.22	
Apr 29	00	00	6.24	
May 01	00	00	6.26	
May 03	00	00	6.28	
May 05	00	00	6.30	
May 07	00	00	6.32	
May 09	00	00	6.34	
May 11	00	00	6.36	
May 13	00	00	6.38	
May 15	00	00	6.40	
May 17	00	00	6.42	
May 19	00	00	6.44	
May 21	00	00	6.46	
May 23	00	00	6.48	
May 25	00	00	6.50	
Jun 21	00	00	6.64	Unknown
Jul 11	00	00	6.82	Unknown
Sep 01	00	00	6.80	Drift due to
Sep 06	00	00	6.78	temperature through
Sep 11	00	00	6.76	to November 21
Sep 16	00	00	6.74	
Sep 21	00	00	6.72	
Sep 26	00	00	6.70	
Oct 01	00	00	6.68	
Oct 03	00	00	6.66	
Oct 05	00	00	6.64	
Oct 07	00	00	6.62	
Oct 09	00	00	6.60	
Oct 11	00	00	6.58	
Oct 13	00	00	6.56	
Oct 15	00	00	6.54	
Oct 17	00	00	6.52	
Oct 19	00	00	6.50	

TABLE 8 (Contd)

Oct 20	00	00	6.48
Oct 21	00	00	6.46
Oct 22	00	00	6.44
Oct 23	00	00	6.42
Oct 24	00	00	6.40
Oct 25	00	00	6.38
Oct 26	00	00	6.36
Oct 28	00	00	6.34
Oct 30	00	00	6.32
Nov 01	00	00	6.30
Nov 03	00	00	6.28
Nov 05	00	00	6.26
Nov 07	00	00	6.24
Nov 09	00	00	6.22
Nov 11	00	00	6.20
Nov 13	00	00	6.18
Nov 15	00	00	6.16
Nov 17	00	00	6.14
Nov 19	00	00	6.12
Nov 21	00	00	6.10

TABLE 9

ADOPTED BASELINE VALUES (UNCORRECTED) AT 20°C
GNANGARA MAGNETOGRAPH 1984

Date 1983	UT h	m	Baseline Value	Explanation
HORIZONTAL INTENSITY			BHs (nT)	
Jan 01	00	00	23241	
Feb 01	00	00	23240	
Feb 11	00	00	23239	
Feb 21	00	00	23238	
Mar 01	00	00	23237	
Mar 11	00	00	23236	
Mar 21	00	00	23235	
Nov 11	00	00	23234	
Nov 21	00	00	23233	
Dec 01	00	00	23232	
DECLINATION			BD (W) ° ,	
Jan 01	00	00	3 03.5	
Jul 01	00	00	3 03.4	
Sep 01	00	00	3 03.3	
Oct 01	00	00	3 03.2	
Oct 21	00	00	3 03.3	
Oct 26	00	00	3 03.4	
Dec 01	00	00	3 03.5	

TABLE 9 (Cont)

VERTICAL INTENSITY			BZs (nT)	
Jan 01	00	00	53396	
Feb 01	00	00	53395	
Mar 01	00	00	53396	
Mar 05	00	00	53397	
Mar 11	00	00	53398	
Mar 16	00	00	53399	
Mar 21	00	00	53400	
May 21	00	00	53388	Unknown
May 23	00	00	53389	
May 25	00	00	53390	
May 27	00	00	53391	
May 29	00	00	53392	
May 31	00	00	53393	
Jun 02	00	00	53394	
Jun 04	00	00	53395	
Jun 06	00	00	53396	
Jun 08	00	00	53397	
Jun 10	00	00	53398	
Jun 12	00	00	53399	
Jun 14	00	00	53400	
Jun 21	00	00	53392	Unknown
Jul 11	00	00	53385	Unknown
Sep 16	00	00	53386	
Sep 21	00	00	53387	
Sep 26	00	00	53388	
Oct 01	00	00	53389	
Oct 04	00	00	53390	
Oct 07	00	00	53391	
Oct 09	00	00	53392	
Oct 11	00	00	53343	
Oct 13	00	00	53394	
Oct 15	00	00	53395	
Oct 17	00	00	53396	
Oct 19	00	00	53397	
Oct 21	00	00	53398	
Oct 23	00	00	53399	
Oct 25	00	00	53400	
Oct 27	00	00	53401	
Oct 29	00	00	53402	
Oct 31	00	00	53403	
Nov 02	00	00	53404	
Nov 04	00	00	53405	
Nov 06	00	00	53406	
Nov 08	00	00	53407	
Nov 11	00	00	53408	
Nov 14	00	00	53409	
Nov 17	00	00	53410	
Nov 21	00	00	53411	

TABLE 10

ROUTINE DISTRIBUTION OF GEOMAGNETIC DATA

Weekly	K-indices
Carpentaria Exploration Pty Ltd, SA	Basic Aerosurveys Pty Ltd, Guildford
Carpentaria Exploration Pty Ltd, Perth	Aerodata McPhar Pty Ltd, Subiaco
Scintrex Pty Ltd, West Perth	Esso Minerals, Nedlands
Geopeko, Gorden NSW	Hamersley Exploration Pty Ltd, Tom
Broken Hill Pty Ltd, Perth	Seltrust Mining Co. Pty Ltd, Perth
Uranerz Australia Pty Ltd, Subiaco	Duval Mining Co. Australia Ltd, Perth

Monthly	K-indices	Rapid variations	Principal storms	Preliminary mean values	Magnetogram 16mm copy
BMR, Canberra	*1	*1	*1	*1	
IPS, Sydney	*	*			
WDC A, Washington	*	*	*		*
WDC C1, Denmark	*	*	*		
WDC C2, Kyoto	*	*	*		
Observatory de Elbo		*2			
Institute de Physiques du Globe	*				

Data published

1. Geophysical Observatory Report, Bureau of Mineral Resources, Geology and Geophysics

2. IAGA Bulletin, Geomagnetic data

TABLE 11
SEISMOGRAPH RECORD LOSS, 1984

Photographic Recorders	MUN (WWSSN) SP-Z	SP-N	SP-E	LP-Z	LP-N	LP-E	MUN SUP Z	N	E	KNA Z	N	E
Late/no change										21	21	21
Paper fogging										24	24	24
Paper off drum/ reversed										26	26	26
Drum translation	67	67	67							177	177	177
Recorder failure										1290	1290	1290
DC power										174	174	174
AC power							17	17	17			
Clock										223	223	223
Recorder lamp	31	12	29				37		13	32		
Total hours	98	79	96	0	0	0	54	17	30	1967	1935	1935
Percentage	1.1	0.9	1.1	0	0	0	0.6	0.2	0.3	22.4	22.1	22.1

Visual Recorders	NWAO SP-Z	LP-Z	LP-N	LP-E	KLB	BAL	RKG	KLG	MEK	WBN	NAU	MBL
Late/no change			2		16	4		44	32	1	1908	
Pen translation	2				2	7		12	24			
Pen broke	12	12	2	4			73	8	26	10		55
Recorder failure												
Recorder amplifier									3			
DC power						64						
AC power	11	11	11	11	1	1	52	4		94		
Pre amplifier					133							585
Clock	8	8	8	8						6		
Line outage	41	41	41	41	31	24						
+/- 12V power												
Maintenance						12	8				10	
Total hours	74	72	64	74	183	112	133	68	82	111	1918	64
Percentage	0.8	0.8	0.7	0.8	2.1	1.3	3.7	0.8	0.9	1.3	21.9	0.7

TABLE 12

SEISMOGRAPH CALIBRATION DATA 1984

MAGNIFICATION (x1000)

SHORT PERIOD

PERIOD (Second) STATION	0.1	.15	0.2	.25	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
BAL Z	273	381	334	270	233	172	127	95	75	56	44	34
KLB Z (to 12 Jan)	160	208	190	155	130	95	71	55	42	33	25	21
KLB Z (Fm 13 Jan)	200	260	240	194	160	120	89	69	52	41	31	26
KLG Z		10	174	270	238	184	144	112	87	66	54	43
KNA Z	80	145	165	155	130	90	70	47	35	27	21	18
KNA N,E	25	32	34	34	32	27	22	18	15	12	10	7.8
MBL Z	1260	940	800	610	460	240	130	88	54	40	26	24
MEK Z	449	452	402	348	305	236	192	156	126	98	75	60
MGO	2.60	3.03	2.98	2.97	2.97	2.87	2.59	2.25	1.89	1.70	1.40	1.11
MRWA Z (fm 21 Jun)	662	730	731	655	570	434	349	274	216	177	130	103
MUN**Z,N,E	3	6	10	14.5	20	31	39	41	40	36	31	25
MUN HGZ	406	380	338	324	326	318	207	101	55	31	21	14
MUN WA	2.05		2.05		1.98	1.83	1.68	1.50	1.35	1.21	1.06	0.95
NAU Z		27	340		432	318	222	150	92	57	38	28
NWAO*Z	30	110	193	238	260	242	190	150	120	90	70	50
RKG Z fm 04 Aug	136	158	154	135	102	62	40	26	17	12	8	6
RKG Z fm 13 Dec	272	316	308	270	204	124	80	52	34	24	16	12
WBN Z	444		639		460	320	231	161	119	86	64	48

LONG PERIOD

PERIOD (Second) STATION	8	9	10	15	20	25	30	40	50	60	80	100
MUN**Z,N,E	.31	.34	.36	.375	.34	.28	.25	.18	.14	.11	.08	.06
NWAO*Z,N,E	.32	.50	.82	2.3	4.1	5.0	5.0	4.0	3.3	2.0	1.0	.50

* Seismic Research Observatory
** World Standard Seismograph

TABLE 13

MORAWA SEISMOGRAPH STATION DETAILS

Code

MRWA

Co-ordinates

Latitude	29° 13.08' S
Longitude	115° 59.76' E
Elevation	300 m
Foundation	Alluvium/granite

Parameters

Component	SP-Z
To	1.0s
Magnification	130K at 1.0s 730K at 0.2 (peak)
Recording speed	60mm/min

Instrumentation

Seismometer	Willmore Mk2
Pre-amplifier	Geotech 42/50
Recorder	Geotech RV301B
Recorder amplifier	Geotech AR311
Power and time	EMI clock

Installation date

21 June 1984

TABLE 14

EARTHQUAKES IN THE REGION OF WESTERN AUSTRALIA 1984

DATE 1984	ORIGIN UT	LAT °S	LONG °E	DEP KM	MAG	LOCALITY	N	A
JAN 01	183920.4	33.00	114.00	10G	2.4 ML	155KM WNW BUNBURY	5	C
02	054950	33.93	118.16	10G	2.0 ML	15 KM E GNOWANGERUP	4	C
03	031829	26.32	126.85	10G	3.2 ML	30KM SE WARBURTON	3	D
04	161810.6	15.67	126.86	10G	2.8 ML	205KM W KUNUNURRA	2	D
08	115303	24.67	115.70	10G	3.2 ML	60KM NE GASCOYNE	3	C
09	082927	26.77	131.49	10G	3.4 ML	160KM SSE AYERS ROCK,	4	C
15	042030.9	29.82	116.50	10G	2.1 ML	8KM SE LATHAM	3	C
15	190504.1	29.82	116.50	10G	2.0 ML	8KM SE LATHAM	2	C
15	214545.5	29.82	116.50	10G	2.4 ML	8KM SE LATHAM	4	C
18	012037.0	29.16	115.62	10G	2.3 ML	16KM E MINGENEW	3	C
24	144136	22.04	129.87	10G	3.2 ML	80KM E LAKE MACKAY, NT	6	B
26	143320.3	32.22	116.88	10G	2.1 ML	19KM NW BROOKTON	4	A
28	062547	28.29	121.02	10G	2.6 ML	70KM NNW LEONORA	6	C
28	164552	30.73	117.10	10G	2.8 ML	5KM NW CADOUX	7	A
28	164805.0	31.82	117.97	10G	2.0 ML	16KM WNW BRUCE ROCK	4	B
29	195302.1	32.52	116.94	10G	2.0 ML	13KM W PINGELLY	5	A
30	024411.3	32.52	116.94	10G	2.5 ML	13KM W PINGELLY	6	A
31	050134.6	29.48	115.51	10G	2.0 ML	12KM W ARRINO	4	B
31	021206.4	30.70	117.16	10G	2.0 ML	8KMM NNE CADOUX	4	A
FEB 03	150243	34.37	119.57	10G	3.3 ML	15KM E BREMER BAY	7	C
07	221643.1	31.47	117.15	10G	2.0 ML	20KM NE MECKERING	3	A
07	232258	31.47	117.15	10G	2.2 ML	20KM NE MECKERING	4	A
13	172025.5	32.38	117.92	10G	2.0 ML	6KM SE CORRIGIN	5	B
15	182514	29.25	113.69	10G	2.1 ML	100KM WSW GERALDTON	5	D
21	055915	31.82	122.72	10G	3.7 ML	25KM N FRAZER RANGE	10	C
21	055951	31.82	122.72	10G	4.2 ML	25KM N FRAZER RANGE	10	C
MAR 02	050157	17.66	122.42	10G	4.1 ML	40KM NE BROOME	5	C
02	100805.1	30.70	117.13	10G	2.0 ML	7KM N CADOUX	3	A
14	040350.1				2.2 ML	174KM FROM MEEKATHARRA	1	
16	034606.0	14.95	123.38	37R	5.2 ML	350KM NNE BROOME	10	B
17	141100.4	30.72	117.13	10G	2.0 ML	5KM N CADOUX	3	A
18	110559.4	34.55	117.23	10	2.0 ML	23KM ESE ROCKY GULLY	3	B
22	195840.0	31.70	117.06	10G	2.3 ML	10KM SE MECKERING	5	A
23	193814	21.29	125.52	19	4.0 ML	TOBIN LAKE	8	B
24	073546.6	25.42	122.43	10	3.2 ML	65KM NW CARNEGIE	5	B
27	072639.3	29.82	116.50	10G	2.1 ML	5KM SW LATHAM	4	C
28	145333.7	30.72	117.08	10G	4.2 ML	7KM NW CADOUX	9	A
28	165233.8	16.65	120.29	37R	4.0 ML	250KM NW BROOME	6	B
30	101526.0	27.14	124.55	10G	3.3 ML	225KM WSW WARBURTON	8	C
31	123747.9	30.72	117.08	10G	2.4 ML	CADOUX	5	A
31	224617.0	32.22	116.91	10G	2.0 ML	12KM S OF BEVERLEY	5	A
APR 01	193322.0	16.27	128.82	10G	2.2 ML	58KM S KUNUNURRA	2	C
02	161154.5				2.2 ML	96KM FROM MEEKATHARRA	1	
04	093705.2	30.70	117.10		2.2 ML	6KM N CADOUX	3	B
10	145552.3	33.39	117.73	7	2.0 ML	8KM S DUMBLEYUNG	5	A
10	150149.1	33.39	117.73	7	2.3 ML	8KM S DUMBLEYUNG	5	A
11	135421.0	15.48	119.34	10	4.3 ML	190KM NW BROOME	8	B
12	204640	19.6	130.0		3.5 ML	NT	4	C
17	032652.0	29.20	113.94	10	3.2 ML	80KM SW GERALDTON	7	B

TABLE 14 (Contd)

DATE 1984	ORIGIN UT	LAT °S	LONG °E	DEP KM	MAG		LOCALITY	N	A
APR	23 135947.8	19.54	126.00		3.0	ML	LAKE TOBIN	4	B
	28 231731	33.38	117.82	10G	2.4	ML	10KM SE DUMBLEYUNG	4	B
MAY	17 041200.5	21.37	123.06	15	3.6	ML	330KM E MARBLE BAR	7	C
	17 202119.6	27.78	115.84	30	3.0	ML	160KM E KALBARRI	5	B
	20 024751	37.48	111.80	10G	3.0	ML	450KM SW AUGUSTA	4	D
	22 185220.0	24.63	110.74	37R	3.8	ML	290KM W CARNARVON	10	C
	24 021628.1	30.72	117.08	10G	2.3	ML	7KM NW CADOUX	3	A
JUN	02 135448.0	31.70	117.06	10G	2.0	ML	10KM SSE MECKERING	5	A
	02 153636.0	22.75	113.38	10	3.4	ML	35KM SW POINT CLOATES	6	B
	07 225451	36.45	122.59	10G	3.0	ML	300KM SSE ESPERANCE	6	D
	09 070426	30.75	121.53	0G	2.5	ML	NEAR KALGOORLIE	4	C
	10 155925.9	32.23	117.37	10G	3.0	ML	20KM NE ALDERSYDE	6	A
	11 072817.3	30.78	117.06	10G	2.8	ML	7KM WSW CADOUX	5	A
	11 132144.5	26.28	122.51	10G	4.2	ML	65KM SW CARNEGIE	10	B
	11 133100	26.28	122.51	10G	3.3	ML	65KM SW CARNEGIE	2	C
	12 195707	23.97	112.42	10G	3.0	ML	160KM NW CARNARVON	2	D
	15 174303.3	32.23	117.37	10G	2.3	ML	20KM NE ALDERSYDE	4	A
	17 191344.2	32.23	117.37	10G	2.1	ML	20KM NE ALDERSYDE	4	A
	17 191357.4	32.23	117.37	10G	2.1	ML	20KM NE ALDERSYDE	4	A
	18 221436.1	30.67	117.14	10G	2.3	ML	10KM N CADOUX	4	A
	21 045252.0	32.23	117.37	10G	2.2	ML	20KM NE ALDERSYDE	4	A
	22 083327.3	30.77	117.16	10G	2.5	ML	10KM NNE CADOUX	4	A
	22 110813.7	32.23	117.37	10G	2.1	ML	20KM NE ALDERSYDE	4	A
	24 124924.0	32.23	117.37	10G	2.8	ML	20KM NE ALDERSYDE	7	A
	24 172455.8	30.70	117.14	10G	2.8	ML	7KM N CADOUX	7	A
	27 072425.3	30.69	117.15	10G	2.2	ML	8KM N CADOUX	4	A
	27 201244.6	30.69	117.15	10G	2.0	ML	8KM N CADOUX	4	A
	29 020454.4	32.23	117.41	10G	3.4	ML	21KM NE ALDERSYDE	7	A
	29 051346.7	32.23	117.41	10G	2.4	ML	21KM NE ALDERSYDE	5	A
	29 055824.1	32.23	117.41	10G	2.4	ML	21KM NE ALDERSYDE	5	A
	29 180947.2	32.14	117.16	10G	2.4	ML	23KM E BEVERLEY	5	A
JUL	03 015543	20.02	116.38	37R	4.1	ML	75KM NW DAMPIER	8	C
	07 043906	28.21	126.63	10	4.5	ML	225KM S WARBURTON	12	B
	07 230104.8	31.75	117.06	10G	2.2	ML	15KM SSE MECKERING	6	A
	08 231413	25.84	113.90	10G	2.7	ML	110KM SSE CARNARVON	3	D
	15 112017.6	18.61	113.25	10G	3.4	ML	370KM NNW EXMOUTH	3	D
	16 152527	33.58	118.22	10G	2.4	ML	8KM ESE NYABING	4	B
	16 180751	33.58	118.22	10G	2.5	ML	8KM SSE NYABING	4	B
	20 015048.7	16.50	128.58	10G	2.0	ML	30KM SSW KUNUNURRA	2	B
	31 164548	26.88	107.01	37R	4.5	ML	700KM W KALBARRI	11	C
AUG	06 173206	36.70	123.70	37	4.4	ML	350KM SSE ESPERANCE	12	C
	07 205115	15.81	127.42	10	3.5	ML	80KM SSW WYNDHAM	5	B
	07 232533	22.98	129.69	10G	2.7	ML	80KM SE L MACKAY (NT)	3	C
	08 152458.1	19.61	119.34	10G	3.0	ML	100KM NW PORT HEDLAND	3	C
	10 134813.7	33.98	117.30	5G	2.6	ML	20KM SE KOJONUP	7	B
	16 172728.9	34.73	117.44	10G	2.0	ML	22KM SW MOUNT BARKER	3	B
	18 140758	22.00	126.49	19	3.2	ML	40KM E LAKE TOBIN	6	B
	19 201139.1	33.34	117.28	10G	2.6	ML	9KM E WAGIN	6	B
	19 203607	22.08	126.51	10G	3.0	ML	50KM SSE TOBIN LAKE	5	B
	20 011051.1	30.74	117.11	10G	2.7	ML	3KM NW CADOUX	6	A

TABLE 14 (Cont)

DATE 1984	ORIGIN UT	LAT S (°)	LONG E (°)	DEP KM	MAG	LOCALITY	N	A
AUG	28 202425.3	30.68	117.10	10G	2.3 ML	10KM NNW CADOUX	5	A
	31 151630.9			10G	2.0 ML	80KM FROM KUNUNURRA	1	
SEP	01 225550	27.14	113.32	10G	3.0 ML	100KM NW KALBARRI	5	C
	03 120538.5	16.42	128.72	10G	2.3 ML	75KM S KUNUNURRA	2	B
	09 092217.6	31.60	117.10	10G	2.6 ML	8KM E MECKERING	9	A
	10 015422	20.09	123.25	10G	3.3 ML	GREAT SANDY DESERT	7	C
	10 075118	31.59	123.55	10G	3.3 ML	60KM S ZANTHUS	6	B
	12 210217	21.92	126.50	10G	4.0 ML	40KM E LAKE TOBIN	11	B
	13 194822	26.46	111.31	10G	3.1 ML	310KM NW KALBARRI	3	C
	15 100240	22.05	126.55	10G	3.7 ML	50KM SSE TOBIN LAKE	10	B
	15 162341	26.18	131.08	10G	3.4 ML	90KM S AYERS ROCK (SA)	8	D
	18 002402.7	30.72	117.14	10	2.3 ML	6KM NNE CADOUX	5	A
	21 023643.2	30.76	117.10	10G	2.0 ML	2KM NW CADOUX	4	A
	21 202005.1	16.10	129.56	10G	2.0 ML	93KM ESE KUNUNURRA	2	C
	22 203630.9	26.42	127.07	10G	2.8 ML	54KM ESE WARBURTON	3	C
	23 210200	21.91	126.48	10G	3.2 ML	40KM E TOBIN LAKE	6	B
	25 212856.1	31.35	118.27	10G	2.1 ML	15KM N MERREDIN	5	B
	26 214704.5	31.37	118.35	10G	2.4 ML	15KM NNE MERREDIN	7	B
	27 011820.8	33.25	117.19	10G	2.0 ML	16KM WNW WAGIN	4	B
	27 042713.8	33.24	117.13	10G	2.0 ML	22KM WNW WAGIN	4	B
	27 234132.7	31.35	118.33	10G	2.1 ML	17KM NNE MERREDIN	5	B
	27 234300.3	31.37	118.35	10G	2.1 ML	15KM NNE MERREDIN	4	B
	28 011411.3	31.35	118.33	10G	2.0 ML	17KM NNE MERREDIN	3	B
	29 213704.0	30.68	117.09	10G	2.7 ML	10KM NNW CADOUX	4	A
	29 213720.0	30.68	117.09	10G	3.0 ML	10KM NNW CADOUX	4	A
	30 054515.6	30.64	117.13	10G	2.0 ML	15KM N CADOUX	4	A
	30 141458.9	30.64	117.13	10G	2.4 ML	15KM N CADOUX	4	A
	30 181906.0	28.30	120.69	10G	3.2 ML	90KM NW LEONORA	9	C
OCT	01 154744	18.76	126.83	10G	3.6 ML	95KM E CHRISTMAS CREEK	4	B
	02 002347.0	32.00	117.35	10G	2.0 ML	5KM WNW QUAIRADING	4	A
	03 083454.3	30.75	117.10	10G	2.2 ML	4KM NW CADOUX	5	A
	15 003209.9	16.49	128.79	10G	2.2 ML	80KM S KUNUNURRA	2	C
	16 135702	10.35	131.63	10G	3.3 ML	250KM NNE DARWIN	3	C
	27 184624	23.56	114.30	10G	3.0 ML	155KM NNE CARNARVON	4	C
NOV	03 200643	11.66	124.88	10G	3.9 ML	350KM NW KALUMBURU	4	C
	18 211927	17.67	122.89	37R	3.4 ML	75KM ENE BROOME	6	C
	21 042808	21.39	112.39	10G	3.3 ML	190KM WNW EXMOUTH	5	D
	23 160223.5	30.64	117.12	10G	2.1 ML	14KM N CADOUX	4	A
	29 233340	21.68	107.56	37R	4.6 ML	670KM W EXMOUTH	10	C
DEC	05 182654.9	30.89	117.14	10G	2.2 ML	13KM S CADOUX	3	A
	06 011737.1	29.43	114.34	10G	2.5 ML	60KM WSW DONGARA	5	C
	07 160023	18.63	123.25	10G	3.2 ML	130KM SE BROOME	5	B
	11 210236.4	30.75	117.11	10G	2.4 ML	3KM NW CADOUX	5	A
	13 164813.0	26.25	124.91	10G	3.2 ML	160KM W WARBURTON	5	C
	15 105032	23.55	129.46	10G	3.0 ML	NT, 110KM SW L.MACKAY	4	C
	22 225903	27.70	124.32	10G	2.7 ML	NEAR LAKE THROSSELL	4	C
	25 071738.2	34.11	117.21	10G	2.0 ML	28KM S KOJONUP	4	C
	28 214851	19.27	125.81	10	3.5 ML	45KM S CHRISTMAS CREEK	6	C
	28 215305.6	23.78	114.59	10G	3.2 ML	150KM NE CARNARVON	4	C

TABLE 15

MINOR EARTHQUAKES IN THE SOUTHWEST SEISMIC ZONE

DATE 1984	TIME UT	MAG ML	LOCALITY	REMARKS
Jan 01	2025	0.6	Ballidu	
08	1217	0.7	Cadoux	
10	1011	1.9	Cadoux	
10	1426	1.4	Cadoux	
11	1259	1.0	Cadoux	
11	2110	1.2	Cadoux	
11	2159	1.1	Cadoux	
12	0533	1.7	Cadoux	
12	0702	0.8	Cadoux	
12	2338	1.2	Cadoux	
13	0430	1.4	Cadoux	
15	0903	1.0	Cadoux	
17	0417	0.9	Cadoux	
17	0948	0.9	Cadoux	
17	1216	0.9	Cadoux	
17	1914	1.2	Meckering	
17	2015	1.1	Cadoux	
17	2016	1.2	Cadoux	
17	2135	1.3	Cadoux	
17	2137	1.3	Cadoux	
17	2138	1.0	Cadoux	
17	2151	0.8	Cadoux	
17	2155	1.2	Cadoux	
17	2212	1.4	Cadoux	
17	2232	0.8	Cadoux	
18	1524	1.6	Cadoux	
18	1550	0.9	Cadoux	
18	1739	0.7	Cadoux	
18	1841	1.1	Cadoux	
18	1954	0.9	Cadoux	
18	2209	0.7	Cadoux	
19	0754	0.6	?	
20	1943	1.1	Cadoux	
21	0650	0.5	Ballidu	
21	1112	0.5	Cadoux	
21	1140	0.5	Cadoux	
21	1239	0.9	Cadoux	
21	1245	1.0	Cadoux	
25	0409	1.3	Cadoux	
25	0743	1.3	Cadoux	
25	1303	0.7	Cadoux	
25	1649	0.5	Cadoux	
25	2004	1.1	Cadoux	
27	1610	1.7	Latham	
28	2223	1.6	Latham	
29	1426	1.0	Cadoux	
30	0644	0.9	Cadoux	
30	1413	1.2	Cadoux	
31	0502	1.5	Ballidu	
31	0542	0.9	Cadoux	

TABLE 15 (Contd)

DATE	TIME	MAG	LOCALITY	REMARKS

TABLE 15 (Contd)

DATE 1984	TIME UT	MAG ML	LOCALITY	REMARKS
Feb 01	0753	1.0	?	
03	1105	0.9	Cadoux	
06	1106	0.5	Cadoux	
09	0538	1.3	Cadoux	
09	2222	0.9	Cadoux	
10	0619	0.5	Ballidu	
11	2013	1.7	Cadoux	
12	1440	1.6	Cadoux	
12	1509	1.0	Cadoux	
13	0625	1.8	Cadoux	
13	1247	0.9	Cadoux	
13	1607	1.6	Cadoux	
14	0115	0.9	Cadoux	
14	1148	1.5	Cadoux	
14	1252	1.4	Cadoux	
14	2308	1.8	Cadoux	
17	0012	0.4	Ballidu	
17	1017	1.3	Cadoux	
19	0826	1.0	Cadoux	
19	1344	0.7	Cadoux	
20	1548	0.5	Ballidu	
21	0311	1.0	Cadoux	
21	1039	1.3	Cadoux	
22	0000	0.9	Cadoux	
24	1107	0.9	Cadoux	
26	0620	1.9	Cadoux	
26	0736	1.8	Cadoux	
26	0816	1.7	Cadoux	
26	0817	1.0	Cadoux	
Mar 01	1635	0.8	Cadoux	
01	1701	0.7	Ballidu	
02	1040	1.3	Cadoux	
02	1053	1.7	Cadoux	
03	1020	1.3	Cadoux	
03	1032	1.2	Cadoux	
04	1021	0.7	Cadoux	
04	1248	0.7	Cadoux	
04	1358	1.0	Cadoux	
04	1548	1.0	Cadoux	
10	2020	1.0	Cadoux	
14	0919	0.9	Cadoux	
14	1621	1.1	Cadoux	
16	0820	1.4	Cadoux	
16	1812	0.9	Cadoux	
20	0917	0.8	Ballidu	
20	1749	0.8	Ballidu	
20	2035	1.0	Ballidu	
22	1008	1.3	Meckering	
22	1509	1.1	Dowerin	

TABLE 15 (Contd)

DATE 1984	TIME UT	MAG ML	LOCALITY	REMARKS
Mar 24	0848	1.2	Cadoux	
25	0203	1.3	Cadoux	
25	1435	1.0	Cadoux	
26	0922	0.9	Cadoux	
28	0101	1.4	Cadoux	
28	0235	1.1	N of Ballidu	
28	1500	1.8	Cadoux	
28	1503	0.9	Cadoux	
28	1503	1.4	Cadoux	
28	1508	1.1	Cadoux	
28	1511	1.5	Cadoux	
28	1519	1.9	Cadoux	
28	1604	1.3	Cadoux	
28	1632	1.6	Brookton	
28	1825	0.3	Cadoux	
28	1835	1.7	Cadoux	
28	1848	0.9	Cadoux	
28	1850	1.7	Cadoux	
28	1923	1.2	Cadoux	
28	2306	0.7	Cadoux	
29	1146	1.2	?	
30	0226	1.1	Cadoux	
30	0740	1.2	Cadoux	
30	1430	1.1	Cadoux	
30	1501	1.2	Cadoux	
31	1051	1.0	Cadoux	
31	1241	1.6	Cadoux	
31	1558	1.3	Cadoux	
31	1947	0.1	Cadoux	
Apr 02	0712	0.9	Cadoux	
02	0719	0.7	Cadoux	
02	1717	0.5	Cadoux	
03	1939	1.0	N of Ballidu	
03	2254	0.6	Cadoux	
06	0223	1.4	Cadoux	
09	0544	1.1	Cadoux	
09	0749	0.8	Cadoux	
09	1246	0.8	Cadoux	
09	1655	0.9	Cadoux	
10	0438	0.7	Cadoux	
10	1637	0.9	Cadoux	
11	2339	1.8	Cadoux	
12	1847	1.3	Cadoux	
13	1841	1.1	Cadoux	
14	1631	0.9	Cadoux	
15	0632	1.4	Cadoux	
18	2034	1.1	Cadoux	
19	0340	1.4	Cadoux	
19	2328	0.9	Cadoux	
20	0525	1.2	Cadoux	

TABLE 15 (Contd)

DATE 1984	TIME UT	MAG ML	LOCALITY	REMARKS
Apr 21	2200	0.2	Rocky Gully	
22	0510	1.4	Meckering	
22	0558	1.1	Meckering	
22	1830	1.3	Wyalkatchem	
25	0829	1.5	Cadoux	
30	0341	1.9	Quairading	
May 01	1831	1.4	Quairading	
02	1002	1.7	Cadoux	
02	1221	1.3	Cadoux	
02	1459	1.4	Cadoux	
03	2218	1.1	Cadoux	
04	0130	1.0	N of Ballidu	
04	2245	0.8	Cadoux	
05	0600	1.5	Cadoux	
05	1338	1.3	Cadoux	
05	1851	1.2	Cadoux	
11	0043	1.5	Cadoux	
11	0246	1.0	Bodallin	
16	0525	1.8	Cadoux	
16	0819	1.6	?	
17	2022	1.9	?	
17	0341	1.2	Cadoux	
22	1806	1.2	Cadoux	
24	0303	1.5	Cadoux	
24	0353	1.5	Cadoux	
25	1658	1.0	Cadoux	
26	0240	1.4	Meckering	
26	0543	1.1	Meckering	
27	1304	1.7	Brookton	
27	0915	1.1	Cadoux	
29	0658	1.6	Cadoux	
30	0322	1.5	Cadoux	
30	0424	1.9	Cadoux	
30	0450	1.6	Cadoux	
30	0451	1.7	Cadoux	
31	2128	1.1	Cadoux	
31	2206	1.4	Cadoux	
Jun 02	0104	1.3	Cadoux	
03	0005	1.9	Cadoux	
07	0016	1.4	Bencubbin	
09	0705	1.8	Bencubbin	
11	0728	2.8	Cadoux	
13	0615	1.4	Cadoux	
14	0518	1.0	Cadoux	
14	1858	1.4	Meckering	
15	1127	1.6	Cadoux	
17	0211	0.8	Cadoux	
17	2235	1.7	Aldersyde	
18	0514	1.6	Cadoux	
18	0656	0.9	Cadoux	

TABLE 15 (Contd)

DATE 1984	TIME UT	MAG ML	LOCALITY	REMARKS
Jun 18	0909	0.7	Cadoux	
19	1455	0.6	Cadoux	
20	0850	1.3	Cadoux	
21	0102	1.0	Cadoux	
22	0210	1.2	Cadoux	
22	1108	1.5	Aldersyde	
22	1738	1.0	Cadoux	
22	1929	1.0	Cadoux	
22	2114	1.4	Cadoux	
22	2301	1.1	Cadoux	
23	2232	1.3	Cadoux	
24	1032	0.9	Cadoux	
24	1757	1.3	Cadoux	
24	1855	1.8	Cadoux	
24	1907	1.4	Cadoux	
25	0733	1.3	Cadoux	
25	1716	1.3	Cadoux	
26	1220	1.1	Cadoux	
27	1836	1.0	Cadoux	
29	1715	1.5	Aldersyde	
30	1038	1.4	Aldersyde	
Jul 01	2127	1.2	Cadoux	
01	2332	1.3	Cadoux	
02	0431	1.4	Aldersyde	
03	0828	1.4	Aldersyde	
05	1715	1.0	Meckering	
08	1050	1.4	Cadoux	
11	1655	0.9	Cadoux	
11	2358	1.5	Wyalkatchem	
13	0610	0.9	Cadoux	
13	1342	0.9	Cadoux	
14	0530	1.3	Cadoux	
16	1527	1.9	Nyabing	
16	1535	1.2	Cadoux	
16	2036	1.3	Cadoux	
18	0811	0.8	Cadoux	
22	2347	1.1	Cadoux	
25	0555	0.9	N of Ballidu	
25	0903	0.9	Cadoux	
25	1125	1.1	Cadoux	
28	0921	1.0	Kellerberrin	
30	1104	0.7	?	
Aug 04	1026	0.7	Cadoux	
04	1127	1.0	Cadoux	
04	2314	1.0	Cadoux	
06	0011	1.0	Meckering	
06	0224	0.9	Cadoux	
08	0911	1.6	Cadoux	
08	1205	1.2	Cadoux	
08	1217	1.5	Cadoux	

TABLE 15 (Contd)

DATE 1984	TIME UT	MAG ML	LOCALITY	REMARKS
Aug 12	1633	1.4	Cadoux	
12	1814	1.3	Cadoux	
12	2204	1.4	Bencubbin	
13	1954	0.9	Cadoux	
21	0245	1.0	?	
21	0509	1.0	Cadoux	
21	2045	1.0	Cadoux	
Sep 01	1936	0.1	Kellerberrin	
02	0857	1.2	Cadoux	
02	0912	0.4	Cadoux	
02	2232	1.1	N of Ballidu	
05	0007	1.4	Wyalkatchem	
06	0608	1.3	Cadoux	
07	2305	1.6	Merredin	
08	1041	1.4	Cadoux	
10	0913	1.2	Cadoux	
10	2107	1.1	Cadoux	
11	0648	0.9	Cadoux	
11	0928	1.7	Cadoux	
13	0029	1.4	Wyalkatchem	
13	0130	0.4	Kellerberrin	
13	0212	0.9	Cadoux	
14	2134	1.7	Meckering	
15	1642	1.2	Cadoux	
15	1836	1.0	Cadoux	
16	0338	1.1	Cadoux	
16	0916	0.7	Cadoux	
16	0917	1.1	Cadoux	
16	0929	0.9	Cadoux	
16	0958	1.5	Cadoux	
16	1026	1.2	Cadoux	
16	1026	1.7	Cadoux	
16	1049	0.9	Cadoux	
18	1924	0.8	Cadoux	
21	0136	1.8	Cadoux	
21	1637	1.8	Cadoux	
21	1638	1.5	Cadoux	
23	0021	0.9	Cadoux	
23	2107	1.0	Cadoux	
25	2306	1.8	Merredin	
27	2157	1.0	Cadoux	
27	2221	1.0	Cadoux	
28	0208	0.7	Cadoux	
29	1518	1.4	Cadoux	
30	0512	1.2	Cadoux	
30	0809	1.7	Cadoux	
30	0937	1.0	Cadoux	
30	1651	1.6	Cadoux	
30	2243	1.2	Cadoux	
Oct 01	0905	0.8	Cadoux	

TABLE 15 (Contd)

DATE 1984	TIME UT	MAG ML	LOCALITY	REMARKS
Oct 02	0751	1.0	Cadoux	
02	1024	1.0	Cadoux	
06	1039	1.8	Cadoux	
07	1826	1.6	Cadoux	
09	2214	1.7	Cadoux	
14	0910	1.4	Cadoux	
17	2221	1.2	Cadoux	
20	0906	0.5	Ballidu	
21	0641	0.8	Ballidu	
22	0137	1.2	?	
22	1621	1.6	Cadoux	
24	2243	1.4	Cadoux	
25	0341	1.4	Cadoux	
27	1107	1.4	Rocky Gully	
27	1649	1.0	Rocky Gully	
27	2253	1.3	Cadoux	
29	0339	1.4	Cadoux	
30	0856	1.3	Kalannie	
31	1207	1.3	Cadoux	
Nov 05	1524	1.0	Ballidu	
05	1621	1.9	Cadoux	
06	0636	1.0	Cadoux	
07	0902	0.4	Kellerberrin	
08	1051	1.2	Cadoux	
09	0825	1.6	?	
12	0838	1.0	Cadoux	
12	0926	1.1	Cadoux	
13	0633	1.8	Cadoux	
15	2247	0.9	Cadoux	
16	1122	1.2	Cadoux	
16	1704	1.0	Cadoux	
17	0831	0.5	Kellerberrin	
18	1835	1.0	Quairading	
23	0742	0.8	Cadoux	
23	0743	1.0	Cadoux	
Nov 23	2259	1.1	Cadoux	
24	1449	1.3	Cadoux	
25	0934	1.1	Cadoux	
26	0743	1.4	Cadoux	
27	0136	1.5	15km NNE of Calingiri	
28	0231	1.3	Cadoux	
Dec 02	1830	0.8	Kellerberrin	
03	0722	1.3	Cadoux	
03	2208	1.1	Cadoux	
03	2210	1.6	Cadoux	
03	2218	1.0	Cadoux	
04	0119	1.1	Cadoux	
04	0644	1.1	Cadoux	
04	0913	0.9	Cadoux	
04	0917	1.0	Cadoux	

TABLE 15 (Contd)

DATE 1984	TIME UT	MAG ML	LOCALITY	REMARKS
Dec 04	0947	1.6	Cadoux	
04	1944	0.9	Cadoux	
06	1718	1.0	Cadoux	
07	0959	1.4	30 NE Kalannie	
07	1700	1.1	Cadoux	
09	1759	1.0	Cadoux	
09	1823	0.3	Ballidu	
12	0856	1.4	Cadoux	
13	0049	1.2	Cadoux	
13	0400	1.2	Cadoux	
18	0322	1.1	Cadoux	
23	1735	1.4	150 from Rocky Gully	
23	1844	1.5	150 from Rocky Gully	
23	2247	0.9	Cadoux	
25	2027	1.0	Cadoux	
28	1721	1.4	150 from Rocky Gully	
30	0223	1.3	Cadoux	

TABLE 16
REQUESTS FOR DATA 1984

INSTITUTION	TYPE OF DATA	NO
University of California	seismogram copies	18
University of WA	seismogram copies	6
Meteorological Research Institute, Japan	seismogram copies	2
World Data Centre A	seismogram copies	6
North Western University, Illinois	seismogram copies	14
Lamont-Doherty Observatory	seismogram copies	9
California Institute of Technology	seismograp copies	3
International Institute of Seismology & Earthquake Engineering, Japan	seismogram copies	6
Bureau of Mineral Resources (M. Lieba)	seismogram copies	10
Bureau of Mineral Resources (D. Denham)	seismogram copies	10
Cornell University, New York	seismogram copies	1
Geomaxim Australia, consulting geologist	earthquake risk map	1
Western Colleries	earthquake risk map	1
Hoyle, Mundaring	earthquake risk map	1
City of Cockburn	earthquake risk map	1
Western Colleries	isoseismal maps	8
L. Sabitay, consultant	isoseismal maps	5
Dept of Conservation & Environment	isoseismal maps	8
Dept of Meteorology, Jakarta	earthquake data	2
Bureau of Mineral Resources (M. Lieba)	earthquake data	several
Bureau of Mineral Resources (B. Gaull)	earthquake data	several
Nedlands Anglican Church	earthquake data	1
Northam Shire Care Centre	earthquake data	1
Resident, Bencubbin	earthquake data	1
Resident, Quairading	earthquake data	1
Resident, Jerramungup	earthquake data	1
U.S. Geological Survey	earthquake data	1
Dept of Army	earthquake data	1
Dept of Mineral Resources, Fiji	earthquake data	1
Bureau of Mineral Resources (T. Jones)	blast data	several
PDM John Perry, consulting engineers.	earthquake risk, Thailand	2
WA Police Dept	earthquake risk	
Jet Propulsion Laboratory, Pasadena	Meckering fault photos	3
General Public & Insurance Co	earthquake data (phone) (phone)	numerous
J. McCoy & Assoc., consulting engineers	earth current data (Watheroo)	1
British Geological Survey	magnetic values	1
Australian Mines & Metals	magnetogram copies	4
PP. Milligan (Flinders University)	magnetogram copies	27
Academy of Science, USSR	annual mean values (5 years)	1
Ionospheric Prediction Service	ionograms	123

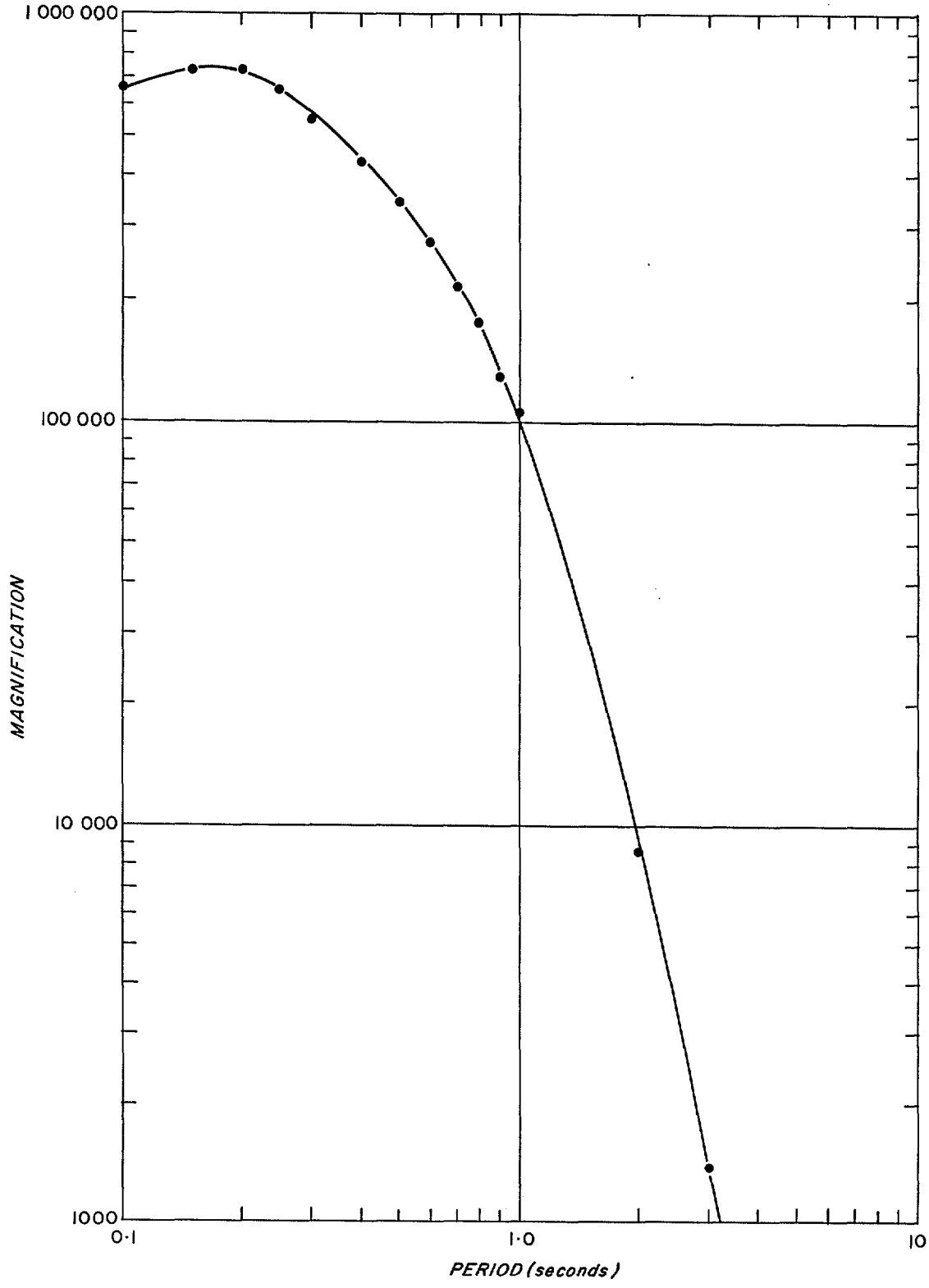

Fig. 1 Calibration curve, Morawa seismograph

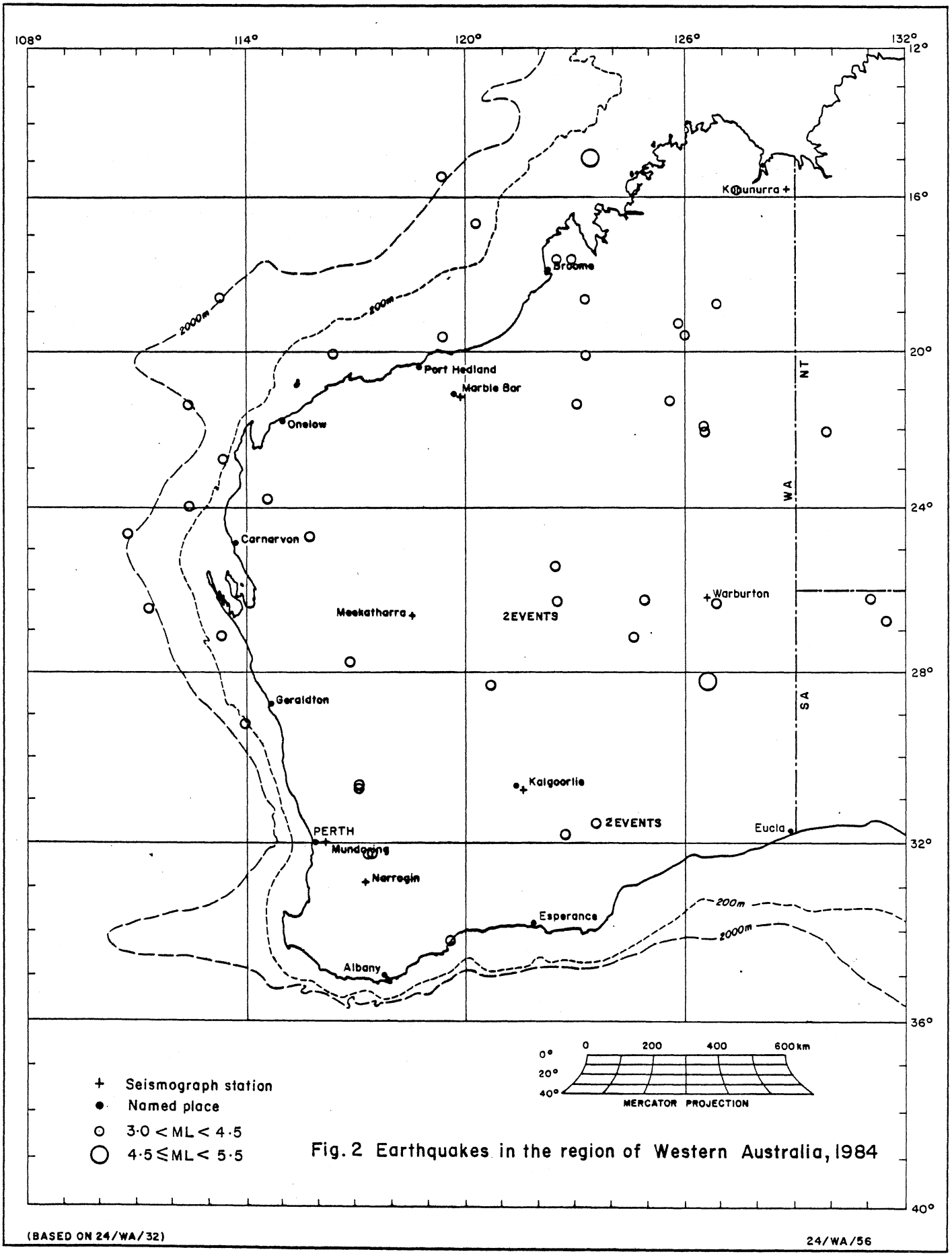

Fig. 2 Earthquakes in the region of Western Australia, 1984

(BASED ON 24/WA/32)

24/WA/56

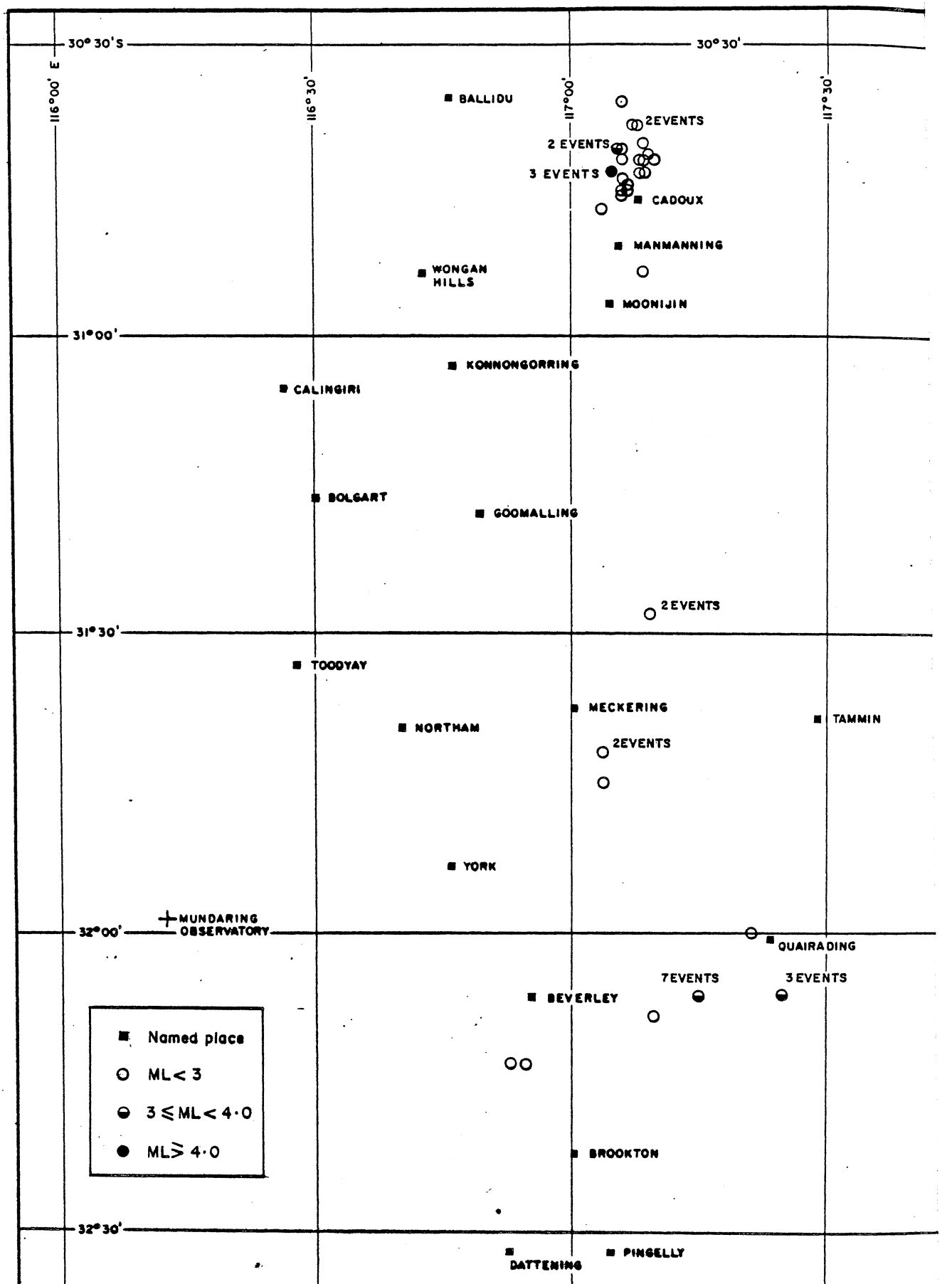

Fig.3 Earthquakes in the region 30.5°-33.0° S and 116.0°-117·5°E, 1984