BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD

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MACQUARIE ISLAND GEOPHYSICAL OBSERVATORY ANNUAL REPORT, 1976

by

P.R. Gidley

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1. SUMMARY

The operation of the geomagnetic RAPID-RUN and NORMAL variometers and the two vertical seismographs was continued throughout 1976 at Macquarie Island.

Attempts to increase the signal-to-noise ratio of the primary seismograph were made by testing the background noise at several sites and installing electronic filters. A calibration system was constructed to monitor changes of signal-to-noise ratio. The secondary seismograph was modified to record horizontal N-S ground motion.

2. INTRODUCTION

This Record describes the operation of the Macquarie Island Geophysical Observatory while the author was Observer-in-Charge; the author succeeded Mr J. Silic on 25 November 1975 and remained until 15 March 1977. Although the normal term of duty is one year, from 23 November 1976 until 15 March 1977 the author assisted and trained the relieving geophysicist, Mr M. Sexton.

The Bureau of Mineral Resources, Geology and Geophysics (BMR), has carried out seismological and geomagnetic recordings at Macquarie Island since 1950 and 1951 respectively, as part of the operations of the Australian National Antarctic Research Expedition (ANARE): the Antarctic Division of the Department of Science provided accommodation and logistic support for this work.

The operation of the observatory in earlier years is described in annual BMR records (e.g. McMullan 1974; Hill 1974; Silic 1979) and the station's history is given in the 1980 annual report (Davies, in prep.).

3. GEOMAGNETISM

Two continuously-recording magnetographs were in operation during 1976. These were:

(1) La-Cour NORMAL (20 mm/hr) three-component magnetograph.

(2) La-Cour RAPID-RUN (180 mm/hr) three-component magnetograph.

The following absolute instruments were used for baseline control observations:

Horizontal Intensity (H): QHMs 177, 178 and 179
Declination (D): Askania declinometer (DEC 505) S/N 640505 with circle S/N 640620
Vertical Intensity (Z): BMZ 236
Total Intensity (F): Elsec PPM 421

Preliminary corrections used throughout the year were:

QHM 177	:	- 10nT
QHM 178	:	- 3nT
QHM 179	:	- 0nT
BMZ 236	:	- 48nT (Z negative)
DEC 505	:	- 0.0'

NORMAL magnetograph

A 15 mm/hr magnetic recorder was replaced by a 20 mm/hr recorder in April 1975 (Silic, 1979) and ran reliably through 1976. Minimal record loss resulted. Record quality was improved by cleaning prisms and lenses when required. Trace lamp intensities varied at times but this was corrected by rewiring the lamp circuit. Correct light spot intensities were achieved by masking the lenses. Adopted baseline values, preliminary monthly means, K-Indices, and annual mean values are given in Tables 1, 2 and 3. Scale values and the standard deviations of the adopted scale values and baseline values are given in Table 4.

RAPID-RUN magnetograph

This instrument performed well and only about 60 hours were lost owing to lamp failures or the light carriage becoming jammed.

A new Z-trace long mirror was installed because the silvering on the original mirror showed signs of corrosion. It is recommended some reserve prisms be replaced as these also show signs of corrosion.

Magnetograph calibrator

A BMR magnetograph calibrator (MCO-1) was used to provide the constant current source for determining routine scale value measurements. Both currents and voltages were monitored throughout the year. A digital multimeter was used for current outputs and was accurate to one part in two thousand. The calibrator consistently produced a current 0.15% higher than indicated by the calibrator switches. New batteries and a new temperature-compensating zener diode were installed, resulting in a slightly improved performance.

Azimuth check

Before carrying out the 1976 orientation tests, a check was made of the azimuth line within the variometer hut; the azimuth line had previously been checked by Meath (1971). Using the spacer bars permanently mounted in the hut, the same technique was used as described by Meath. This involved siting by theodolite through a hole in the variometer wall to a vertical filament lamp placed on the spacing bar, which was referenced to a second backsighted-theodolite on the standard Pier E. This pier has a known reference meridian to the North Mark (checked November 1975 by Division of National Mapping). The process was repeated three times to assess the accuracy of the observations. A mean reference azimuth of $24^{\circ}11.5'$ was obtained. This differs from Meath's azimuth by 5.4', but is still within the accepted 0.1° error required for orientation measurements.

Orientation tests

One set of orientation tests was carried out on each magnetograph about mid-year. The NORMAL H and D variometers had their respective Helmholtz coil azimuths checked against the measured reference azimuth inside the variometer room. Measured coil orientations were 28.5° E for D, and 118.5°E for H. These results agree with those of Hill (1974) and McMullan (1974) but differ from the original installation values of 29.0°E and 119.0°E respectively (Meath, 1971).

The orientation tests for the NORMAL H and D variometers use an external battery, MCO-3, and a 1000 ohm potentiometer and ammeter as described by Silic (1979). This arrangement was used because the required current of 300 mA was not available on the routine calibrator (MCO-1). The NORMAL Z variometer orientation test was done using a bar magnet with moment 7595 $\pm$ 50 CGS units at a distance of 115 cm between magnet centres.

For the RAPID-RUN orientation tests, the scale value coils had to be rotated by 90° because no orthogonal coils were present. The currents required (60MA for H and D) were supplied by the MCO-1 calibrator. A supplementary BMZ magnet (700 $\pm$ 10 CGS units) was used for the Z variometer test.

The results of the tests are given in Table 5.

Pier Corrections

Two piers were used for absolute measurements. Pier E was used for H and D measurements and Pier W was used for Z and F. Pier measurements of F were determined monthly, and inter-pier differences (also determined monthly) were found to be less than 1 nT.

During November 1976, a new set of declinometer circle feet (tested non-magnetic material) were placed on pier E to standardise the reading procedure with that of other observatories.

Thermographs

The NORMAL Z variometer temperature trace was used with a sensitivity of 1.4^{o} C/mm. Temperature coefficients are shown in Table 4. The temperature scale values were calculated by a least-squares fit to the data obtained from daily temperature readings and the corresponding ordinates of the NORMAL Z temperature trace.

4. SEISMOLOGY

When the author arrived at Macquarie Island in November 1975, two vertical component seismographs were operating. Both systems were recording data photographically in a lightproof vault at the base of Wireless Hill.

Analysed seismic results were routinely telegraphed to BMR Melbourne Office and then to the US National Earthquake Information Service (NEIS) for preliminary epicentre determinations. A total of 598 earthquakes was reported to the International Seismological Centre at Edinburgh after final analysis.

Primary seismograph

A Willmore Mk II seismometer was installed on the southeastern corner of the Wireless Hill plateau, approximately 110 m above MSL. An FM telemetry system was used to transmit signals 400 m via a coaxial cable to the recording site in the vault; this system is described by McMullan (1974) and Hill (1974). The hill top location of the seismometer was chosen as a result of a seismic noise survey (Silic, 1979). Data was recorded using a 60 mm/min single channel Geotech photographic drum recorder, installed during 1975, with a Benioff 0.2 s short period galvanometer.

Calibration equipment was constructed to test the seismometer system, and the seismometer was temporarily installed in the seismometer vault from 7-13 May, 1976 to simplify the testing procedure. On 3 May 1976, the seismometer was removed from Wireless Hill and re-installed in the seismometer vault.

Filtering investigations

The Macquarie Island seismographs are primarily designed to record mid-oceanic teleseisms which have predominant periods within the range of 0.8 to 1.2 s. However, the records are noisy because strong microseisms with

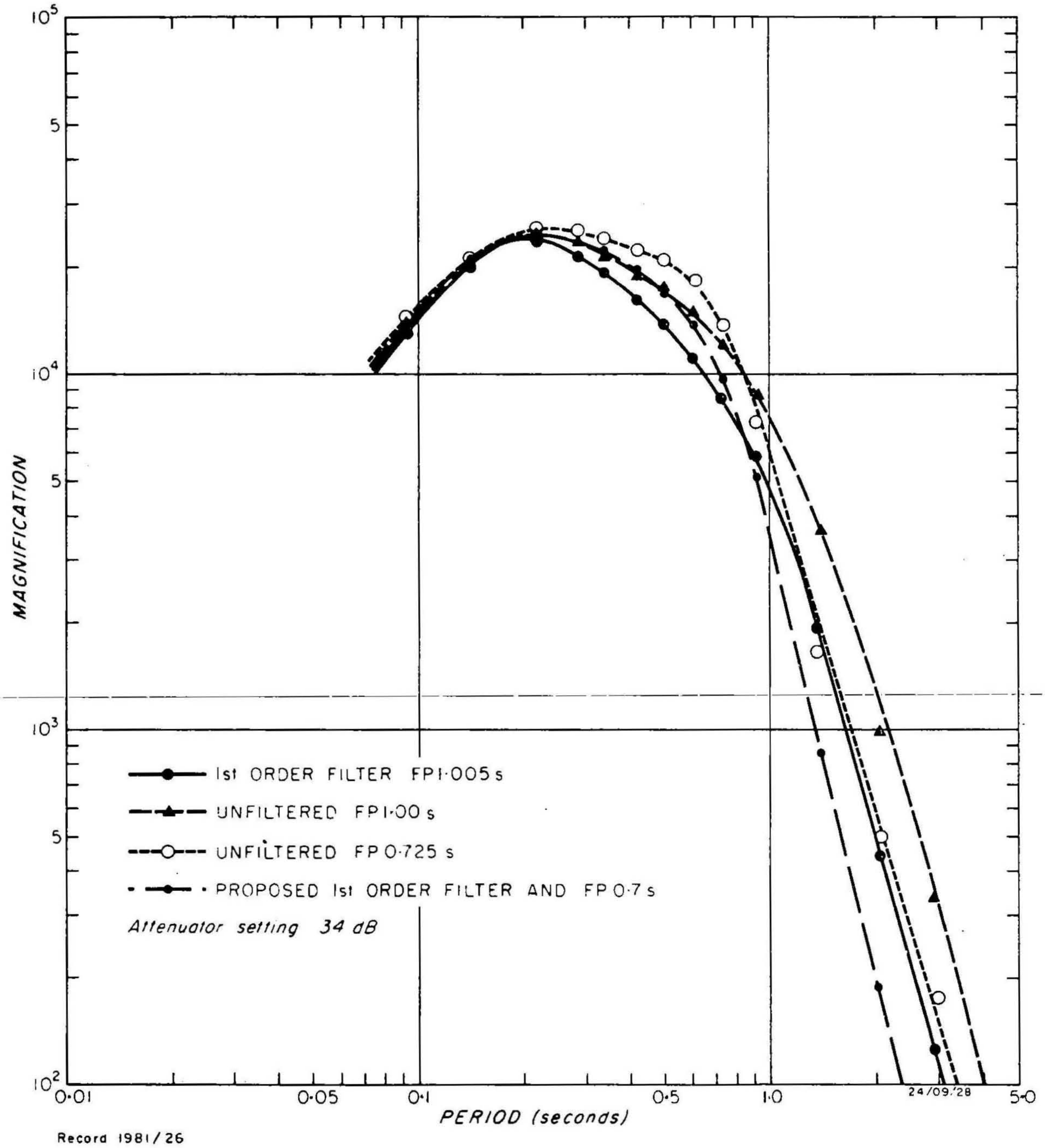

Fig. I Vertical Seismograph Calibration Curves, MCQ, 1976 a 2-3 s period are generated by local surf. Accordingly, filtering techniques were employed with the aim of reducing magnifications in this range without decreasing the signal at teleseismic periods.

The first technique involved reducing the seismometer free-period from 1.0 s to 0,7 s. This had the effect of flattening the magnification curve (see Fig. 1) between 0.2 s and 0.7 s but reducing the magnification between 1.0 s and 5.0 s. This reduction appeared desirable because the 2-3 s noise was significantly reduced; however it also caused a drop in the magnification of about 2400 at 1.0 s period relative to the unfiltered, 1.0 s free period, curve.

A second method of improving the signal-to-noise ratio involved the construction of electronic filters which were placed in-line after the telemetred signal had been demodulated. The initial design was a first-order, high-pass filter with attenuation factor of 6db/octave below 1.1 Hz. Since the input impedance of the galvonometer network was much lower than the series resistor of the filter a buffer was required. A voltage follower was incorporated with a 741 operational amplifier and drive voltages obtained from the nearby Geotech amplifier power supply. The filter effectively halves magnifications with periods greater than 1.1 s but its effect becomes noticeable at a period of about 0.4 s (Fig. 1). The maximum magnification at 0.2 s remains approximately the same for both filtered and unfiltered signals.

Attempts to attenuate 0.3 s to 0.5 s wind-generated noise were carried out by inserting a notch filter. This band-rejection filter attenuated 3db of signal between 0.35 s to 0.5 s, but its value was evident only in high wind (particularly easterly) conditions. In other conditions, its use was not warranted, so a switching system was incorporated to include the filter when necessitated by the prevailing weather conditions.

Conclusions from the filtering investigations

The choice of instrument and filter setting should be made using the criteria of highest signal-to-noise ratio with the greatest magnification in the frequency range of teleseismic events. From the magnification curves a compromise had to be reached. Although the signal-to-noise ratio in the 2.0 s to 3.0 s period range was higher for the filtered signals relative to the unfiltered, its teleseismic recording capability was reduced. This applied with both the 1.0 s and 0.7 s seismometer free period (FP). The unfiltered 0.7 s FP curve has a substantially higher magnification than its 1.0 s FP counterpart between 0.3 - 0.7 s period. The effect of the filter on the 0.7 s FP curve would be similar to that of the 1.0 s FP curve. Its attenuation effect in the 2.0 - 3.0 s noise range would be substantially higher than for any other arrangement. It is recommended that this configuration be tested further.

Calibration tests

Although a discussion of the seismograph tests has previously been given for Macquarie Island (Hill, 1974), the tests are described again here because equipment has been constructed and permanently set up for calibration on site for the first time.

The frequency (magnification) response of the primary seismograph was determined by a series of three separate procedures:

(a) Weight-lift test: two masses (0.122 gm and 0.042 gm) were placed upon the seismometers' 4.75 kg mass pointer and then rapidly lifted off. The deflections on the record were related to the calculated forces.

(b) Pulse test: the motor constant (G) for the calibration system involved a current step to induce a force on the seismometer mass. A calibration magnet used for the test was constructed and coupled with the calibration coil, as described by Stewart & Sutton (1967).

(c) Dynamic test: a low-frequency (0.2 to 16.4 Hz) sine-wave generator was used to induce a sinusoidal motion into the seismometer mass through the calibration coil. The peak-to-peak current, frequency, and recorded deflections were observed, and the magnification was calculated using an adopted value for the motor constant (G). A sine-wave generator of the frequency required was not available and had to be constructed. The adopted design used a Wien bridge incorporating an operational amplifier (741) as the oscillator, with a second 741 as a DC follower. A bank of 15 resistor pairs were selected to balance the bridge with a switching system to allow the necessary output frequencies to be used. Discrete switching was used rather than a continuous-range potentiometer as no frequency meter was routinely available. The 15 frequencies were determined accurately at installation, checked routinely from the records, and always monitored while testing was underway. The power for both pulse and signal generator was provided by four 6V dry cells. Current and voltages appeared to remain stable over long periods of operation.

Secondary seismograph

This instrument, which acted as a backup, also recorded the vertical component using a Willmore Mk I seismometer (FP = 0.9 s), a short-period (0.2 s) galvanometer, and a 30 mm/min BMR photographic recorder. The system was operated as described until 12 August, when it was decided to convert the drum to the standard 60 mm/min recording speed.

The conversion to 60 mm/min recording was made by doubling the diameter of the drive roller upon which the recording drum rests. Once the recorder was operational, the seismometer was placed in a horizontal cradle and oriented N-S. Its free period was 1.2 s. The recordings made on the horizontal seismograph were a worthwhile addition to the MCQ system and often detected phases that were not apparent on the vertical seismograph record.

5. POWER AND TIMING

The central power and timing system described by Silic (1979) proved reliable throughout 1976. Minor faults which developed through corrosion or design were easily remedied.

Timing system

Primary timing was obtained from an EMI crystal-controlled clock which, along with a time-mark programmer unit (TMU-2), sent time-marks to both seismic and magnetic recorders. Mercer chronometers were used as standby time pieces should the EMI clock fail. Time marks could also be sent directly to the seismic and magnetic systems if the TMU-2 failed. Routine time mark pips at 1 s intervals were placed on the records by a time-signal receiver tuned to either VNG or NWVH radio timing stations.

During the summer the EMI clock was troublesome, owing to poor connections and a faulty internal power supply. A replacement clock with an average diurnal drift of 5 to 10 ms was installed in February 1976 and proved reliable.

Power system

Primary or secondary power for the recorder motors was supplied by a 24-240 V 250 VA Saunders inverter which operated either synchronously or asynchronously. The synchronising pulse was a 50 Hz 3-4 V square wave from the EMI clock.

The inverter drew its 24 V supply from two heavy duty batteries which were constantly charged, so that during a mains failure the batteries continued to supply the inverter. The power to the seismic vault was transmitted via a buried coaxial cable which also carried timing pulses. Should the cable or the inverter fail a changeover relay switches to a mains-driven standby inverter. An indicator lamp was installed in the office to monitor the continuity of this cable.

Power to the magnetograph lamps, MCO-3 PPT-1, TMU-2, and NTO-1 relay was supplied by a regulated power supply. The unit, in normal operation, operated off station mains power, but during mains power failures, power was derived from an 18 V battery supply.

6. OTHER DUTIES

The author acted as stand-in physicist for short periods. Assistance was also given in general station duties including slushy duty, aiding the building program, and assisting meteorological observations. Assistance was also given to the biology and surveying programs when the author was away from the main station. Geophysics buildings were maintained by external painting of parts of all buildings plus grey-wire replacements of the magnetograph huts. Aerial maintenance and waterproofing of buildings were also occasionally required.

7. ACKNOWLEDGEMENTS

Thanks must go to all members of the 1976 expedition for their support, both moral and technical, and for their good company throughout the year. Special thanks go to Tony Bulcock and Peter Stanimerovic for maintaining the equipment during the author's absence on field trips. Diesel mechanic Terry Heggerty's aid was invaluable in modifying the secondary seismic recorder and the OIC, and Peter MacKenzie was reponsible for the high morale and well-being of the camp throughout 1976.

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TABLE 1. ADOPTED BASELINE VALUES, NORMAL RUN MAGNETOGRAPH

1976

DATE		TIME UTC	BASELINE	REMARKS
MON:	DAY:	HOUR		
HORIZONTAL INTENSITY				
Jan	01	00	12638 nT	
May	01	00	12640	Adoption
Jul	01	00	12642	Adoption
Sep	01	00	12640	Adoption
Nov	01	00	12638	Adoption
Dec	01	00	12636	Adoption
DECLINATION				
Jan	01	00	26°28.8'E	
Feb	09	1200	26°27.6'E	Earthquake
Apr	22	00	26°28.0'E	Earthquake
Jun	01	00	26°28.4'E	Adoption
Sep	12	00	26°28.8'E	Adoption
Nov	20	00	26°28.4'E	Adoption
Dec	10	00	26°27.8'E	Adoption
VERTICAL INTENSITY				
Jan	01	00	63784 nT	
to				
Dec	31	2400	63784	

TABLE 2

PRELIMINARY MONTHLY MEAN GEOMAGNETIC VALUES AND K INDEX

1976

Month	D(EAST)	H, nT	Z, nT	F,nT	K
January	27°48.0'	12838	-63901	65178	3.11
February	27°47.7'	12826	-63893	65168	2.92
March	27°49.4	12822	-63905	65179	3.07
April	27°49.6	12820	-63912	65185	2.42
May	27°50.5	12822	-63899	65173	1.95
June	27°51.3	12824	-63907	65181	1.60
July	27°52.7	12822	-63894	65168	1.62
August	27°53.0	12820	-63881	65154	1.64
September	27°53.8	12817	-63882	65155	2.33
October	27°54.5	12814	-63876	65148	2.02
November	27°54.4	12821	-63876	65150	1.98
December	27°54.2	12821	-63869	65143	2.12
Mean	27°51.6	12822	-63891	65165	2.23

TABLE 3

GEOMAGNETIC ANNUAL MEAN VALUES 1966-1976

YEAR	D	I	H	X	Y	Z	F
	° '	° '	nT	nT	nT	nT	nT
1966	26 37.6	-78 26.7	13121	11729	5881	-64175	65503
1967	26 46.5	-78 28.5	13084	11681	5894	-64166	65486
1968	26 54.7	-78 29.7	13053	11639	5908	-64132	65447
1969	27 2.3	-78 30.8	13026	11602	5921	-64099	65409
1970	27 9.6	-78 32.1	12996	11563	5932	-64078	65383
1971	27 13.3	-78 33.3	12963	11527	5930	-64032	65331
1972	27 22.1	-78 34.4	12937	11489	5947	-64008	65302
1973	27 27.6	-78 35.8	12905	11451	5951	-63985	65273
1974	27 34.3	-78 37.6	12865	11404	5955	-63956	65237
1975	27 43.2	-78 38.2	12847	11373	5976	-63926	65204
1976	27 51.6	-78 39.1	12822	11336	5992	-63891	65165
ANNUAL MEAN CHANGE	+9.40'	-1.24'	-29.9	-39.3	+11.1	+28.4	-33.8

TABLE 4

ORIENTATIONS OF VARIOMETER MAGNETS

DATE	COMPONENT	MAGNET	ORIENTATION	N POLE
NORMAL RUN VARIOMETERS				
07 JUL 76	H	E	0.1°	S
07 JUL 76	D	N	1.1°	E
07 JUL 76	Z	N	0.5°	DOWN
RAPID RUN VARIOMETERS				
10 JUL 76	H	W	0.4°	S
10 JUL 76	D	N	0.6°	E
12 JUL 76	Z	S	0.9°	DOWN

REFERENCE MERIDIAN 27.8°E

REFERENCE PRIME VERTICAL (PV = 90° + 27.8°) = 117.8°E

REFERENCE H FIELD = 12 822 nT

REFERENCE Z FIELD = -63 906 nT

TABLE 5. MAGNETOGRAPH PARAMETERS

COMPONENT	MEAN OBSERVED SCALE VALUE	ADOPTED SCALE VALUE	STANDARD DEVIATION Scale Value	STANDARD DEVIATION Baseline	TEMP COEFF nT/^{o}C
Normal-run					
H	19.5	19.5	0.06	2.2	+ 3.0
D	2.38	2.38	0.03	0.7	-
Z	20.9	20.9	0.07	3.1	0.0
Rapid-run					
H	5.24	5.24	0.05	-	-
D	1.00	1.00	0.01	-	-
Z	6.46	6.45	0.09	-	-

D scale values and standard deviations are in minutes/mm

H and Z scale values and standard deviations are in nT/mm