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GEOPHYSICAL WORK AT MACQUARIE ISLAND, 1954

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C O N T E N T S

I L L U S T R A T I O N S

ABSTRACT

The geophysical programme carried out on Macquarie Island in 1954 was a continuation of the magnetic and seismological observatory work carried out in the previous two years. This record gives a general account of the year's work and includes a description of the condition of the observatories and the behaviour of the equipment during the year. It gives also an outline of the non-routine work performed and describes several innovations to the daily routines. It does not include the actual scientific results; these are presented in separate reports.

1. INTRODUCTION.

Macquarie Island lies in the Southern Ocean, 900 miles south-east of Tasmania. It is about twenty miles long and two to three miles across. The climate is cool and humid and there are frequent high winds. Scientific work is carried out annually by a party of about fourteen men at an establishment set up by the Australian National Antarctic Research Expedition near the northern end of the island.

Studies are made of the ionosphere, cosmic rays, the aurora, terrestrial magnetism and seismology, the last two subjects being the responsibility of the Bureau of Mineral Resources, Geology and Geophysics. As an officer of the Bureau the writer was geophysicist at Macquarie Island from December, 1953, to December, 1954, in charge of the magnetic and seismological observatories.

The proximity of the island to the southern auroral zone and its situation near the southern end of the circum-Pacific seismic belt make it very suitable for investigations into terrestrial magnetism and seismology.

2. MAGNETIC OBSERVATORY.

A. Housing.

The magnetic instruments are housed in two huts, both of which have been described in earlier reports (Oldham, 1953 and McGregor, 1954). The huts were in good order on the writer's arrival in December, 1953, and excepting for painting, required little attention during the year. The huts are built on the crest of a slight rise with one hundred yards of open sand and shingle beach on the windward side, and as a result of strong winds in May and June the paint on the western sides of the huts was almost sand-blasted off. These sides were given a thick coat of red lead during the winter and two coats of paint when the huts were re-painted later in the year.

The battery box, a short distance from the variometer hut, was almost blown over in September and had to be reinforced with heavy wooden supports. The batteries, wiring and battery clips were replaced during the year.

B. Equipment.

(i) Magnetographs.

As in previous years, the low-sensitivity La Cour variometers with 15 mm/hour recorder were maintained in continuous operation and gave very little trouble during the year.

The only loss of record occurred through fading of the trace during periods of 100 per cent humidity. This loss amounted to only a few hours, and at no time were records of all three trace elements lost at once. The fading occurred despite the continued use of an anti-dimming compound, and was always at the beginning of very humid periods accompanying north winds. It is attributed to condensation when warmer, humid air from the north came into contact with the glass surfaces of the recording system, the trace returning to normal when the temperature of the instruments rose to the new atmospheric temperature.

(ii) Pendulum Clock.

Time marks were occasionally lost from the magnetograms through faulty working of the pendulum clock contacts, but the wiring to the contacts was overhauled, and the contacts appear to be satisfactory if cleaned periodically.

Further trouble was experienced with the clock while the writer was absent from the main camp in November. This trouble occurred because the clock was accidently knocked slightly out of its vertical position. Time marks were not made when the clock stopped. Further, the clock's rate was rather erratic for several days afterward while readjustment was being effected.

(iii) Scale Value Circuit.

As in previous years, it was found difficult to obtain smooth, steady increases in the Helmholtz coil currents; this was attributed to the effect of the moist, salt-laden atmosphere on the potentiometers and switch contacts, and no further alterations to the equipment were considered worthwhile. The best remedy appeared to be to clean the potentiometers and switch contacts with methylated spirits and to manipulate them frequently before actual use.

(iv) Time Marking System for Absolute Observations.

During the year, it was suggested by J.A. Brooks that a system for placing time marks on the magnetogram during absolute determinations, by operating a switch in the absolute hut, should be installed as at Heard Island. The purpose of this system is to simplify and make more accurate the scaling of the magnetograms during absolute computations, as the exact times of reading the absolute instruments could be indicated by time spots on the record. After discussion with C. A. Van der Waal and J. A. Brooks by radio, work on this system was begun in July.

Essentially, this involved the burying of a heavy, lead-sheathed, two-line copper cable between the two magnetic huts, the connecting of it to the clock contacts and switchboard in the variometer hut and to a switchboard and switches on the instrument piers in the absolute hut (Plate 1, Fig.1).

After numerous experiments and minor adjustments had been carried out, the system proved very successful and was used for absolute determinations from September onwards.

(v) Clock Comparison Signal Lamp.

Advantage was taken of the existence of the above-mentioned lead-sheathed line between the two magnetic huts to simplify the daily comparison of the pendulum clock with station WWVH. As the time signal from WWVH could not usually be received in the morning, a special journey had to be made to the variometer hut from the geophysicist's office each afternoon with a pocket chronometer in order to compare the magnetograph pendulum clock with WWVH. This entailed a return journey of some 900 yards, usually made unpleasant by the island's inclement weather, and occupied about 30 minutes.

In July, however, a 240-volt lamp was installed near one of the windows of the absolute hut so that when lighted it could be seen from the window of the geophysicist's office. This lamp was switched on and off by a six-volt, 100-ohm relay which was actuated each time the pendulum clock five-minute contacts were closed. The lamp was left on at all times except during absolute determinations, so that the magnetograph clock could at any time be directly checked against the radio in the geophysicist's office merely by looking out of the office window. The light was visible nearly always in the daytime and could readily be seen at night even in thick fog, so that any defect in the working of the clock or contacts could easily be detected from the geophysicist's office. The switchboard in the absolute hut was arranged so that during absolute determinations the lamp relay was disconnected, and the clock contacts could be short-circuited through a 4.5-volt globe by means of the switches on the instrument piers.

The use of the clock comparison lamp resulted in a saving of several hours per week.

(vi) Absolute Magnetic Instruments.

The (semi) absolute magnetic instruments consisted of Q.H.M. Nos.178 and 179, and B.M.Z. No.64.

Q.H.M. No.178 was intercompared with instruments at Toolangi in November, 1953, and Q.H.M. No.179 was brought back to Melbourne for intercomparison when the writer returned in January, 1955. There is at present no known I.M.S. correction for B.M.Z. No. 64, as its range prevented its use at Toolangi Observatory, and no suitable instrument has yet been available for intercomparisons at Macquarie Island.

C. Magnetic Programme, 1954.

(a) Routine Work.

The following routine, carried out by the two previous geophysicists, was continued during 1954.

(i) Daily changing and photographic processing of the La Cour magnetograms. It was found essential to expose the magnetogram paper to the atmosphere on the day preceding its use on the drum, otherwise the paper usually expanded considerably while in use.

(ii) Scaling mean hourly values of each magnetic element : Horizontal Intensity (H), Vertical Intensity (Z) and Declination (D).

(iii) Semi-absolute determinations of H, D and Z four times per month.

(iv) Determination of H and Z scale values four times per month in conjunction with (iii).

(v) Calculation of provisional monthly mean values of H, D and Z (transmitted to Melbourne for publication a day or two after the end of each month).

(vi) Determination of K-Index for each three-hourly period (transmitted monthly to Melbourne for publication).

(vii) Daily determination of chronometer rates anc corrections to standard time.

(viii) Periodic maintenance and parallax tests on the recorder.

(ix) Abstracting of all monthly mean, absolute, baseline, scale value and K-Index data so that a complete record remained on the island when the originals were returned to Melbourne.

(b) Intercomparisons.

In March and December, the Q.H.M. were intercompared for both horizontal intensity and declination observations. These determinations showed that the I.M.S. difference between the two instruments remained substantially the same throughout the year.

(c) Azimuth Determinations.

(i) Absolute Hut Azimuth Marks.

The azimuths used to date were obtained in 1952 by transference of known azimuths from station A to the eastern pier in the absolute hut (McGregor, 1954). Sunshots were taken by P. B. Tenni in 1953 to check these azimuths, but he did not regard his results as conclusive and advised the writer to carry out further checks during 1954.

However, the theodolite was available at the main camp for sunshots during October and part of November only, and the weather prevented a complete series of observations being obtained on a single day. Nevertheless, six sets of observations in close agreement were obtained, the observations being spread over four days. Values obtained for the azimuths in the past few years are tabulated below :-

Observer	North Mark	Post Mark
P. M. McGregor 1952	353°40.9'	176°59.2'
P. B. Tenni, 1953	353°41.1'	176°59.7'
C. S. Robertson, 1954	353°39.5'	176°57.8'

The writer also repeated the transference of azimuths from station A to the absolute hut as a check; the result, although not as reliable as the series of sunshots, confirmed the writer's view that the azimuths were somewhat lower than the values previously used. It appears that further field work will be necessary to clarify the position.

(ii) Caroline Cove Azimuth Mark.

In 1952, P. M. McGregor carried out absolute determinations at Caroline Cove near the magnetic station occupied by Webb and Kennedy in 1911 (McGregor, 1954). He was unable to determine the azimuth of the mark used for declination, and, as an attempt by P. B. Tenni in 1953 to determine this azimuth was not very successful because of the weather, further attempts were made by the writer in 1954.

The theodolite (Watts No.14548) was left near the southern end of the island by the members of the 1953 Expedition and was first examined by the writer at the Hurd Point Hut in May, 1954. It was found to be in very poor condition after use in a field survey down the length of the island and was badly out of adjustment. This condition was partly rectified at Hurd Point, but bad weather prevented final adjustment.

On three days when the weather looked promising, the arduous journey was made over the 1000 ft. high plateau from Hurd Point Hut to Caroline Cove, but bad weather and poor adjustment of the theodolite prevented satisfactory results being obtained. The theodolite was then carried some 26 miles back to the main camp for adjustment and use there. A second journey was made to Hurd Point with it in November.

Cloudless skies are rare on Macquarie Island, and two further trips to Caroline Cove were necessary before a series of sunshots was obtained.

The magnetic station set up at the Cove by McGregor in 1952 was easily located, and the azimuth rock was taken to be the first low, dome-shaped rock on the horizon to the right of the centre of the cove mouth (Plate 1, Fig.2). However, it was seen through the telescope that, instead of a single highest point as described by McGregor, the rock had two surmounting points of about the same height. For a reference mark the sharpest point was used, i.e. the southern point (to the right as viewed through the telescope). The angle between the two points was found to be 2.2. minutes.

The mean of five values for the azimuth was $343^{\circ}02.0' \pm 0.5'$. This is in fairly close agreement with the value of $343^{\circ}04.9'$ obtained by P. B. Tenni, as it is probable that he used the more northerly point on the rock.

Accuracy of the observations was limited mainly by the unstable nature of the ground where the station is situated, as this is a peaty bench which vibrates when walked upon. Walking from one side of the theodolite to the other considerably altered the position of the levelling bubble.

(d) Miscellaneous.

During the year the writer collected some of the auroral, cosmic-ray and ionospheric data obtained on the island for possible correlation with the magnetic data. On both trips to the southern end of the island he assisted in the work on paralactic photographs of the aurora.

Investigations were made into the possibility of constructing a rough declination variometer which would record by electrical instead of photographic means. Such an instrument would be invaluable on the island for the direct correlation of aurora displays with magnetic disturbances and also in indicating whether particular days are sufficiently undisturbed to allow successful absolute determinations to be made. Experiments using variable inductance, the secondary coil being attached to the moving magnet system, proved quite successful, but lack of a recording A.C. milliameter prevented the scheme from being fully tested.

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3. SEISMIC OBSERVATORY.

A. Housing.

A seismological observatory is situated about 45 feet above sea level on the side of Wireless Hill and overlooking the main camp. It consists of a concrete seismograph room built into the basalt hillside, an adjoining wooden building comprising an office and darkroom and a small iron building which serves as a workshop and store (Plate 1, Fig.3). These buildings were in fairly good condition on the writer's arrival, although the wooden building required painting and the concrete building had to be repaired with cement along the junction of the roof and the western wall. As in previous years water leaked in between the two buildings during heavy rain. This was remedied by the application of P.C.49, which needs to be applied periodically. An additional ventilator was installed in the western wall of the office.

B. Equipment.

A new set of short-period, Wood-Anderson type seismometers was taken to the Island and installed by the writer in December, 1953. They were set up to record east-west and north-south components.

As these seismometers were somewhat shorter than the previous ones, some difficulty was experienced in installing them in conjunction with the old light sources as these could not be lowered as much as required. The seismometers proved insufficiently stable when placed on slate slabs on the cement pier, but by tilting the light sources downwards a satisfactory focus of the light spots on the drum was obtained without the slabs.

The setting-up and adjustment of the instruments were made more difficult because the inertia masses apparently contained a small amount of magnetic material; consequently, when the damping magnets were swung into position, the masses moved slightly, rotating the attached mirror.

When finally set up, the seismometers operated satisfactorily and were a considerable improvement on the previous instruments, whose damping magnets were too weak to give adequate damping. The damping co-efficients and periods of the new seismometers were maintained at 0.85 and 1.0 seconds respectively. The light sources were overhauled at the beginning of the year, and better focussing of the spots resulted.

Apart from the new seismometers and a new six-volt accumulator that were installed, the equipment used was the same as in previous years.

Several days' records were missed during the year due to failures of the light source globes, the power line to the observatory and the motor driving the drum.

During the year a new aerial for the A.W.A. receiver was put up between Wireless Hill and Camp Hill, high above the geophysicist's office. This considerably improved the reception of time signals from WWVH.

C. Seismological Programme, 1954.

The routine seismological programme was :-

(i) Daily changing and photographic processing of the seismograms. A successful method of preventing the seismogram from curling up when dry was discovered. This consisted of wiping the emulsion surface, but not the back of the seismogram, with a solution of glycerine and wetting agent before finally drying.

(ii) Preliminary scaling and interpretation of all shocks recorded. Jeffreys and Bullen seismological tables were used for the interpretation.

(iii) Scaling of period and amplitude of microseisms on both components at 0, 6, 12 and 18 hours G.M.T.

(iv) Determination of free periods and damping coefficients several times during the year.

In addition to the scaling of microseisms, weather information was obtained from the weather officer during periods of maximum microseismic activity, and a close relationship was established between atmospheric depressions and microseisms.

Damping Tests.

Damping tests presented some difficulty at first as the high damping coefficient recommended (h = 0.85) required that the initial deflection had to be large to produce a measurable deflection on the other side of the zero position.

For the east-west component, the light beam was deflected about 15 cm. on to the cylindrical lens of the north-south component by blowing air through a tube in the top of the instrument on to the mirror. The light intensity of the spot in the deflected position had to be as great as possible because of the reduced amount of light reaching the fixed mirror, but a screen was placed over part of the east-west cylindrical lens to cut down the intensity in the undeflected position.

As it was impossible to get the north-south component spot to deflect in the direction of the east-west lens without replacing the metal blowing tube, the spot was deflected off the drum on to a cardboard scale, and the amount of deflection was observed visually and noted. The resulting deflection on the other side of the zero position was recorded photographically in the normal manner. Deflections of the

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order of 30 cm. were used, and the process was repeated several times in any determination of the damping ratio.

4. GRAVITY OBSERVATIONS.

During the changeover periods in December, 1953, and December, 1954, gravity readings were taken at intervals on the station established previously in the meteorological store. A Worden gravity meter was used on each occasion. Results of these observations are included in a separate report (Williams, 1957).

5. EXPEDITION DUTIES.

In addition to geophysical work the writer was required to carry out several camp duties. The job of cook's assistant entailed at least 35 hours every twelfth week, and that of duty cook occupied five whole days during the year. Other tasks did not occupy more than a few hours per week.

The writer was requested to act also as official photographer for the expedition from March onwards. Considerable time was spent in this capacity taking photographs, processing films and printing them for expedition members and the official album.

6. RESULTS.

As already stated, many of the results of immediate value obtained during the year were radioed to Australia and were subsequently published in the monthly bulletins issued by the Bureau of Mineral Resources. These results were the provisional monthly mean magnetic values, geomagnetic K-Indices and preliminary analyses of earthquakes.

The results of the year's investigations, including final mean hourly values of the magnetic elements, lists of "sudden commencements", principal magnetic storms and final analyses of earthquakes, are contained in a report by Robertson (1957).

7. CONCLUSIONS.

As far as the routine observatory work is concerned, the year was successful because very little record was lost and several improvements were made. However, the programme proved a very full one for one geophysicist, requiring him to work a 56-hour week, and leaving little time for original research, for which there are good opportunities on the island.

It is considered that, in order to reduce the amount of routine geophysical work, the abstracting of results to be left on the island should be confined in future to SQ data, monthlymean values, baseline values and scale values. Moreover, the scaling of microseisms should be done only on internationally selected days.

8. ACKNOWLEDGEMENTS.

The writer's thanks are due in particular to K. Stibbs and K. Short for valuable assistance in obtaining the azimuth of the Caroline Cove mark, to J. Jones and K. Stibbs for carrying on the observatory routine while the writer was at the south end of the island, and to K. Short for general assistance in observatory work.

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PLATE 1.

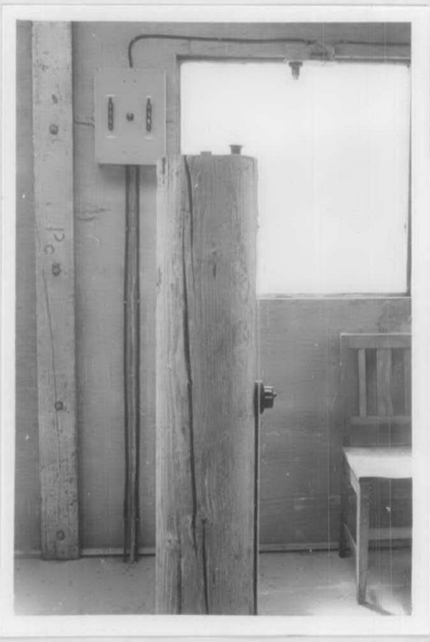

Fig. 1 Manual time-marking system for absolute determinations, and clock comparison signal lamp.

Fig. 2 Caroline Cove, with the azimuth rock on the horizon slightly to the right of the centre.

Fig. 3 Situation of the seismological observatory and office.

Fig. 4 A.N.A.R.E. Station, Macquarie Island, from the seismological observatory.