COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

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GEOPHYSICAL WORK AT HEARD ISLAND, 1954

by

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ABSTRACT

This record gives a general outline of the geophysical programme carried out at Heard Island in 1954. It includes a summary of the condition of the geophysical huts, the routine procedure and the behaviour of the equipment.

The geophysical programme was a continuation of that begun in 1951 by Doyle and continued in 1952 by Ingall and in 1953 by Brooks.

The closure of the station on 31st October, 1954, the dismantling of the buildings and the transfer of buildings and equipment to a new site at Mawson is outlined. The record does not include the scientific results as these are published in a separate report.

1. INTRODUCTION.

Heard Island lies about 2,400 nautical miles south-west of Perth in latitude 53.0°S. and longitude 73.5°E. A base was established on the island by the Australian National Antarctic Research Expedition in 1948, and biological, auroral, meteorological, magnetic and seismological investigations have been carried out on the island since then.

The operation of the magnetic and seismological observatories was the responsibility of the Bureau of Mineral Resources, Geology and Geophysics, until the closing of the station in March, 1955 (the scientific programme ended on 31st October, 1954). Reports on the operation of the observatories during the preceding years have been written by Chamberlain (1952), Doyle (1953), Ingall (1953) and Brooks (1955).

2. BUILDINGS.

(a) Magnetic Observatory.

The absolute and variometer huts were in excellent condition when the writer took over duties at Heard Island. The absolute hut had just been painted inside and out, and the variometer hut was painted on the outside. It had been suggested that malthoid strips be placed over the eaves, but none of these were available. However, no trouble was experienced during the year and no deterioration occurred in the eaves.

Icing up of the doors on both huts occurred from time to time during the winter, but little could be done to prevent this, except to clear the snow and ice from the door jambs with a metal strip before closing the door each day. The door of the variometer hut leaked around the edges despite the rubber packing, but no effective preventive measures could be taken. The small amount of snow that penetrated was shovelled out each day. This problem did not arise very often with the absolute hut, as it faced the east and snowstorms from the east were very rare.

The tripod holes in the absolute hut were filled with cotton waste, although little snow came up through them before this was done.

Except for painting the eaves and replacing a door handle, very little work was necessary during the year. The complete painting of each hut, which is usually done about November, was not necessary this year as the two huts were to be dismantled and sent to Mawson for re-erection.

The variometer hut was dismantled in November and was found to be in reasonable condition, considering the weather conditions at Heard Island. Although they were well covered with paint, the walls and roof were saturated with water. This was unavoidable, as the weather conditions at Heard Island would not permit the drying out of the wood after the old paint had been scraped off; consequently, new paint had to be applied over wet wood. The aluminium brackets were badly corroded, and as the brass screws could not be removed with a screw driver because of this corrosion and the damp wood, they had to be levered out. The wood dried out during the voyage to Mawson, and on arrival there the hut was considered to be in good condition.

The absolute hut was dismantled in January 1955, and was in similar condition to the variometer hut. The plate glass windows were left in place because the screws were difficult to remove from the damp wood; several glass panes were broken during the voyage to Mawson.

The piers in the variometer hut had to be demolished so that the floor sections could be removed. The piers were made from earthenware pipes, and replacements were available for Mawson. The slate slabs were despatched to Mawson. The two piers in the absolute hut were left standing as they did not interfere with the dismantling of the hut. If the station is reoccupied, these piers could be used again because they are firmly set into the ground.

The battery charging hut, used this year for storage of tools, was weatherproof except for snow coming from the east. The door, which faces east, could not be made weatherproof with the materials available.

Valuable equipment stored in the hut during 1953, such as a motor-driven generator used for charging batteries and a radio transceiver used for checking chronometers at the magnetic observatory against a time signal from station WWV, was returned to the main camp early in 1954. When the station was closed down, the hut was left secured but was not as weatherproof as desirable.

(b) Seismological observatory.

The seismological hut was in good condition, although the north-west wall had begun to deteriorate when it was dismantled in November. The cover strips were of compounded ply wood and, towards the end of the year, showed signs of lifting. The door, though facing south, was weatherproof, and except for having to ensure that no snow had fallen into the jamb, the hut required very little maintenance. Condensation raised no problems, but it was apparent that there had been some trouble previously, as all bolt holes were covered with cotton wool and tarred paper. When the hut was dismantled, the wood was quite wet despite the cover of paint. The hut came apart easily, although the bolts were very tight in the wet wood.

3. DETERMINATION OF AZIMUTH.

Sun observations for azimuth were carried out at noon three times during the winter, when the sun was at a low altitude. The azimuth measured was within 0.2 minutes of the adopted value. During October, an attempt to check the reading with an extra meridian observation of the sun was unsuccessful because of low cloud. As the observer's finger was badly crushed during the dismantling of the seismological observatory, no further sun observations could be taken.

4. INSTRUMENTS.

(a) Continuous recording variometers.

No adjustments were made to the variometers during the year. Base-line determinations of H and D were constant, and, although Z showed some apparent fluctuation with a general upward trend, the cause is almost certainly to be found in the B.M.Z. The Z trace showed a continuous decrease in ordinate during the year, and would have needed adjustment had not the observatory been closed at the end of the year.

Gaps on some of the magnetograms were at first attributed to fogging of the lenses, but, after enquiries from Melbourne, were found to be due to dampness rendering the paper insensitive; the trouble disappeared when silica gel was placed with the photographic paper when a new box was opened, and the damp-proof wrapper had been removed. The short time each sheet of paper was exposed to damp conditions in the recorder was not long enough to affect the sensitivity of the paper.

(b) Magnetograph recorder.

Only minor and routine troubles were experienced with the recorder. A spring in the pawl holding one of the drive weights had to be replaced. This trouble caused no loss of record, except for a short period one day when the pawl slipped.

Cleaning the escapement caused some trouble at first, but this was due mainly to doing it too quickly. Initially, carbon tetrachloride was used as a cleaning fluid, and because of its poisonous nature, it was not advisable for the observer to be exposed to the vapour for very long. After the initial failure, in which some record was lost, white spirit was used as a cleaning fluid, and from then on there was no more trouble.

(c) Scale-value wiring system.

The scale-value wiring system was replaced in February 1954, and a new five-position ceramic switch was installed. A new sub-standard ammeter was used for the scale-value determinations. The wiring system was satisfactory until June, when sudden surges of current commenced and a steady reading of the ammeter was unobtainable. Much time was spent in trying unsuccessfully to trace the fault. Eventually, all joints, including terminals, were soldered. There was no more trouble after that, except that some of the dry cells had become damp and had to be replaced.

An instantaneous time-mark system had been installed in 1952 for marking the exact time on the record when an absolute observation was made. This system worked well throughout the year. When the pendulum clock failed in May this system provided the only time scale on the records for part of the year.

The permanent wires installed in 1953 between the absolute and variometer huts, and used in the instantaneous time-marking system, were maintained in the early part of the year. The wires proved to be too light during the winter, when snow and ice accumulated on them, and they were often broken by the extra weight and sometimes by strong winds. The strong three-wire cable made by Ingall in 1952 was installed permanently in August and proved satisfactory.

(d) Absolute and semi-absolute instruments.

Q.H.M.'s 173 and 174, the instruments used in 1953, were used to determine H in 1954 at station D, and Q.H.M. 172 was left in Melbourne.

The clamping device on the Q.H.M. circle did not grip Q.H.M. 173 properly, and a brass shim was used to tighten the grip. This did not make any noticeable difference in the readings obtained. During August, this instrument appeared to give several false readings. The first was thought to be an error in reading, but the same error was found at the next reading. The shim was found to be bent on the bottom and had caused the instrument to seat slightly off level. After this was rectified, the readings returned to normal. Later, Q.H.M. 173 gave further false readings, for which no explanation can be offered. No trouble was experienced with Q.H.M. 174.

Elliott Magnetometer No. 18 was used to determine D on station A. Base-lines obtained were constant.

B.M.Z. No 62 was used at station D to determine the Z base-line, three readings being taken for each determination. The base-lines showed a general increase of about 40 gammas during the ten months from January to October, with some fluctuations of about 10 gammas. According to Brooks, resident geophysicist at the island during 1953, a similar inconsistency also occurred during that year. Temperature variations appeared to cause these changes, but the relationship was not simple because the readings showed an increase during the colder months and did not return to the original value as the temperature increased.

The scale zero position of B.M.Z. No. 62 was checked every four months; the reading was constant for the whole year.

On 4th November, 1954, a series of readings was taken with B.M.Z. No.62 while the temperature was raised by lighting candles inside the closed absolute hut. The results were compared with the baseline of the Z variometer, but little useful information was gained regarding the variation of the baseline value with temperature. To examine the base-line variations effectively the temperature should have been decreased, but this, unfortunately, was not possible.

(e) Seismological instruments.

(i) Wood-Anderson long period seismographs and recorder.

The short-period Wood-Anderson suspensions, which were used in the seismographs during 1953, were replaced in February, 1954, by long-period suspensions designed and constructed in the Bureau's geophysical workshop, Melbourne. Periods of nine seconds were used in both horizontal components; when longer periods were tried, the instruments were found to be unstable. There was some drift, which was attributed to changes of temperature and general strain on the tungsten wire. Drift was corrected each time the record was changed.

The recorder used with the Wood-Anderson seismographs was a weight-driven apparatus controlled by the air resistance to a vaned governor. J.A.Brooks, the preceding geophysicist at the island, suggested that the apparatus be cleaned and oiled every two or three weeks to prevent it stopping and thus losing part of a record. The adjustment of the cogs of the governor was difficult and the loss of trace due to this maladjustment was considerable. It was decided, therefore, not to clean the apparatus as a routine procedure, but to clean it only if it stopped. During the several remaining months before the station was closed, the apparatus gave no trouble.

The Mercer chronometer, which operated the time-marking circuit of the recorder, had a contact mechanism built on its face to short out the minute-mark impulse made on the hour. Early in the year, this contact often shorted out all the minute impulses. Investigation showed that there was no need for the mechanism on the chronometer face, but that, after proper adjustment of the contacts built into the chronometer, the minute impulse on the hour could be prevented, leaving all the other minute marks unaffected.

Microseisms were very large on Heard Island when there were heavy swells; these were often, but not always, accompanied by strong winds. J.A. Brooks had spent some time during the previous year examining the relation of the seismograph piers to the hut; he was convinced that there was a contact between the two and that the heavy microseisms were produced when the wind shook the hut and the vibration was transmitted to the pier. The writer is inclined to believe that the cause was the proximity of the station to the sea and the pounding surf, combined with the fact that the Southern Ocean is an area of intense barometric disturbance. A vibration produced by wind shaking the hut would have a short period (less than a second), whereas the activity taken by the writer to be microseisms had a period of about six seconds.

The light source of the north-south component used to burn out frequently, and the reason was thought to be the intermittent shorting of the screw-in socket holding the globe. The light source of the vertical seismograph recorder gave the same trouble. It is suggested that this type of globe socket, a flimsy piece of metal with a minimum of insulation, be replaced by a more substantial fitting for any future use of these light sources. The trouble was intermittent, and months might elapse between the periods when several globes had to be replaced at short intervals.

The minute marks were hard to see during periods of heavy microseismic activity, as there was insufficient contrast between the sudden movement of the light spot at minute intervals and the movement of the light spot due to microseisms. The deflection of the light spot could not be increased because confusion would arise in the interpretation of each line on the seismograph record. One method of overcoming this is to have a complete break in trace on the minute and not merely a deflection. As the minute deflection lasted four seconds, the interruption in the record due to a corresponding break would be considerable. A preferable method is to increase the pitch of the drum progression screw, thus giving greater space for each line on the record. This would prevent the intermingling of the lines on the record, and it is suggested that, in future, when seismograph records are taken where microseismic activity is intense, wider spacing of the trace should be adopted; the records would then be much more valuable than those taken at Heard Island in 1954.

(ii) <u>The Grenet vertical seismograph and recorder</u>.

The Grenet vertical seismograph was installed during February, and some records were obtained. The period of the instrument was about 1.2 seconds, and the weights and spring could not be adjusted to give a shorter period than this. The most troublesome part of the Grenet equipment was the recording apparatus. The light used was supplied by a large 8-volt globe, and as this was not strong enough it was replaced by a $4\frac{1}{2}$-volt globe of the same type as those used in the horizontal seismograph. This entailed alteration to the fixtures in the light source to fit the new, small, screw-in bulb. The light from this new system was brighter but could not be focussed properly. Several different lenses were tried in front of the galvanometer, but despite this improvisation and the alteration of distance between the galvanometer and recorder, the spot was never exactly in focus. Head Office advised that the inability to focus properly was due to a bent galvanometer mirror.

The windscreen wiper motor, which was used to drive the recorder, was too fast when using a 6-volt battery and too slow when using a 4-volt battery, giving in the first case no record for the last few hours in the day and in the latter case a heavy unreadable black line. An attempt was made to control the voltage across the motor with a variable resistor, but the heat dissipation in the resistor was so great that it was a fire danger, and the attempt was abandoned. Battery trouble eventually curtailed all further experimentation with this recorder, because the drain through the motor was too much for the failing batteries during the period at night when no power was generated.

(f) <u>Pendulum clock for magnetograph time marks.</u>

The pendulum clock caused much trouble during the year. A stoppage during March was corrected by an adjustment in the level. The clock operated satisfactorily during April, except for an occasional duplication of time marks about the half hour, probably due to a bend in the contact arm. As the mechanism was very sensitive, this fault was not adjusted at the time. The clock stopped again in May for no apparent reason and could not be re-started. The movement of the gears and the friction with the plates were checked, the gears and bearings were cleaned, and the bearings oiled, but the clock did not respond.

The suspension for the pendulum was broken during subsequent handling and had to be replaced. The clock started again towards the end of May and continued at a normal rate until the middle of June, when it stopped once more and did not go again, except for odd hours at an unknown rate. For some time the pendulum was suspected to be the cause of the stoppages. As the joint in the middle was not firm and could not be tightened, it was soldered. The bob was loose on the shaft, and this was firmly attached with a close-fitting guide soldered on to the bob. These repairs did not succeed in getting the clock to operate. It was concluded that the escapement must be faulty, probably due to wear and tear. The tick was quite even at times, then for no apparent reason it would become uneven and stop. Levels were checked and the clock fixed more firmly to the wall; then varying angles of the clock case were tried, but all to no avail. Shaking of the hut wall by wind may have been enough to upset a worn escapement wheel. Nothing that was done produced the desired result and at no time during the latter part of the year was the clock reliable enough to trust or to rate. Consequently, there are no time marks on the magnetograms after the middle of June, and for scaling one has to rely on the regular speed of the drum drive and the time at which the records were put on and taken off. Fortunately, the drum speed appears to have been reasonably constant, and errors in the times of magnetic disturbances should be less than $\pm$ 5 minutes.

(g) Batteries.

There were eight lead-acid accumulators on Heard Island, of which four were used in the seismological hut as follows: two on charge, one on time marks and one on light sources. One battery on charge was also feeding the electric motor drive of the Grenet recorder. The other four batteries were used in the magnetic observatory. Two at a time were brought from the main camp where they were charged; each was used for a week and they were then replaced by the two which had been on charge. Charging the batteries at the main camp in preference to the observatory was undoubtedly the easiest and most efficient routine.

In June, several traces were lost when the batteries in use in the magnetic observatory lost their charges; the two used to replace them were little better. Two batteries were borrowed from the seismological observatory during this period, and experiments with the vertical seismograph recorder had consequently to be stopped. The four magnetic observatory batteries were emptied of electrolyte and recharged with new acid, but only slight improvement was obtained. The two seismological observatory batteries were then filled with new acid and charged, and the magnetic observatory thereafter functioned on these two batteries.

The breakdown of the four batteries used in the magnetic observatory can probably be attributed to fair wear and tear accelerated by cold weather and the transport, which was sometimes rough, by tractor from the main camp to the magnetic observatory at West Bay. The batteries were subsequently written off by a Board of Survey in January, 1955.

5. OBSERVATORY ROUTINE.

(a) Magnetic observatory.

The record at the magnetic observatory was changed daily at 0300 hours G.M.T. (0800 hours L.M.T.), that is at the same time as during the previous year, until the end of March. At the begining of April the time was changed to 0600 hours G.M.T. (1100 hours L.M.T), because during the winter months it was dark at 0800 L.M.T. The walk from the camp to West Bay was a long one and it was easy to lose one's way during the dark in adverse weather conditions. The main disadvantage of the new time was that it interfered with the routine of the day.

Time signals were taken once a week on the day that absolute measurements were made. Scale-value determinations for the H and Z variometers were usually done on the same day. The scale-value of the D variometer was checked three times during the year.

Maintenance of equipment and buildings was done when necessary, after the trace was changed.

Records, both seismological and magnetic, were developed, on an average, once per week. The necessary washing of the records was a very inconvenient process. Early in the year one of the records was lost between the dark room and the small lake of fresh water where the records were washed. After that, water was carried in buckets to the dark room, except when there had been heavy rain and fresh water was available in the storage tanks. The capacity of the storage tanks was small, however, and the water supply was not sufficient for washing twenty-one records per week. The records were washed in the sea at one stage, but seaweed stains were noticed and this practice was discontinued. Moreover, the salt of the sea water was almost as difficult to remove as the fixer and a considerable amount of fresh water was still required. The salt also made the records sticky in the moist atmosphere of the island. The magnetic records were processed in glycerine after washing, as this diminished shrinkage.

Base-lines and provisional values were calculated each month and K-indices were scaled. These results for the period after May need some revision and consideration, as the clock failed and the time marking system was unreliable.

(b) Seismological observatory.

The record was changed daily at 1200 hours G.M.T., and any adjustments required were made to the instruments after the change. Power was available from the main supply and adjustments to the equipment could therefore be made at night.

If possible, time signals were taken every day during the early part of the year, but the radio eventually became unserviceable. As there was no replacement, the chronometer was checked against a watch carried from camp after the watch had been compared with a time signal broadcast from station WWV.

The records were examined each week, and any earthquakes recorded were scaled. No ice falls or local disturbances were recorded on the long-period instruments, and teleseisms were few. With the help of the United States Coast and Geodetic Survey Cards, it is hoped to find teleseisms that were masked by microseisms.

Hut maintenance was done when necessary.

(c) Geophysicist's office.

The office was in the old biology hut, with the dark room adjoining, and the working space and storage room were adequate.

6. GENERAL ACCOUNT OF THE CLOSING OF HEARD ISLAND OBSERVATORIES.

Continuous recording at the observatories ceased on 31st October 1954, and instruments were dismantled and packed during November and December.

In early November, the seismological instruments were packed for return to Australia, and preparations were made for the dismantling of the seismological hut which was to go to Mawson.

Check readings were taken on damping periods and distances from seismometer to recorder before dismantling.

During the dismantling of the seismological hut one of the writer's fingers was severely injured, and the dismantling of the magnetic instruments was hampered, With the help of Dr. Budd, however, they were eventually dismantled without mishap by the end of November, and were carefully packed for shipment to Mawson.

Weekly absolute magnetic observations were continued until early January, 1955, when the absolute hut had to be dismantled. The Oregon piers and the reference objects for declination readings were left intact so that the station could be reoccupied at any time.

Most of the serviceable auxiliary equipment was shipped to Mawson and a few items were returned to Melbourne. Unserviceable equipment was returned to Melbourne.

The library was transferred to Mawson, with the exception of some special books which were returned to Melbourne.

7. GRAVITY OBSERVATIONS.

During January, 1955, gravity observations were made with Worden Gravimeter No.169. The results, together with readings taken at other locations in Antarctica, are published in a separate report (Williams, 1957).

8. RESULTS.

Immediate results of K-indices and monthly mean values of the three magnetic elements were sent by radio to the Head Office of the Bureau in Melbourne each month, and were published in the monthly Geophysical Observatory Report. Preliminary analyses of earthquakes were also reported.

A more comprehensive report, including final results, will be published by the Bureau at a later date. No results are included in this record.

9. CONCLUSIONS.

The immediate geophysical results for the year were disappointing because of frequent failure of the recording equipment. However, the value of the results will be enhanced when they are more carefully analysed. The necessary data for final analysis was accumulated and accurate reports of magnetic and seismological data will be published later.

In any normal year, the geophysical programme on Heard Island is a full one; during 1954, the expedition party was reduced in number, with the result that the writer had to carry out more general camp duties and complete evaluation of the records could not be carried out.

10. ACKNOWLEDGEMENTS.

Thanks are due to Mr. L. Gardner for his help and advice during the trouble with the lead-acid accumulators, and for changing the trace during the writer's absence on a short field trip; to Dr. Budd for his assistance in dismantling and packing the magnetic variometers and also for changing the magnetic trace from time to time; also to Messrs. Henderson and Walsh who changed the seismograph trace during the writer's absence on short field trips.

The thanks of the writer go also to J.A. Brooks, the preceding geophysicist, who organised the observatory routine so that it could be efficiently carried out with the minimum of effort.

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