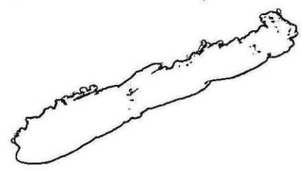

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DEPARTMENT OF NATIONAL DEVELOPMENT

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GEOLOGY AND GEOPHYSICS

RECORDS 1953, No. 134

GEOPHYSICAL WORK AT HEARD ISLAND, 1951-1952

ESTABLISHMENT OF SEISMOLOGICAL AND MAGNETIC OBSERVATORIES AND INITIAL RESULTS

by

H. A. DOYLE

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ILLUSTRATIONS

ABSTRACT

The establishment of seismological and magnetic observatories at Heard Island is described. Brief descriptions and photographs of the huts and instruments are given.

Earthquake phases recorded between April 1951 and February 1952 are listed, as are absolute magnetic observations made between July 1951 and January 1952.

Although Heard Island has two active volcanic craters, the region is not very active seismically. Only two near earthquakes were recorded, both probably $2^{\circ}.9$ distant along the Kerguelen ridge.

The absolute magnetic observations showed that the high rate of secular change in declination and horizontal intensity is continuing.

1. INTRODUCTION

During the 1947-48 summer season the Australian National Antarctic Research Expedition (A.N.A.R.E.) established scientific observing stations at Heard and Macquarie Islands. Seismological and magnetic observatory work is part of the planned programme of scientific work. This geophysical work is being carried out by the Bureau of Mineral Resources, Geology and Geophysics, of the Department of National Development, in co-operation with the Antarctic Division, Department of External Affairs.

The seismological and magnetic observatories at Heard Island are valuable additions to the world network of stations, as there is a considerable gap in this net work in southern latitudes. The island is in a region of rapid secular magnetic change, and is close to the maximum auroral zone. Also, there is the possibility of local seismic activity, as the island is of volcanic origin and has two active craters. Seismological stations on oceanic islands are of particular value, as the study of near earthquakes there can aid in elucidating sub-oceanic crustal structure.

2. WORK PRIOR TO 1951.

A geophysicist from the Bureau accompained H.M.A.S. Labuan on its first voyage to Heard Island in December 1947. While the vessel was at the island a preliminary survey was made with a field vertical-component variometer to select a site for the magnetic station. The first absolute magnetic observations were then carried out (Chamberlain, 1952; see also Jacka, 1953).

This preliminary work was continued during the relief operations in February 1950. The magnetic station was reoccupied by Schaefler and Doyle (Jacka, 1953), and Bunbury extended the variometer survey to aid the selection of the magnetic observatory site. Also, the site for the seismological observatory hut was chosen and the concrete foundations were laid. Later in 1950 the Heard Island party erected this hut and constructed two concrete piers in the instrument room.

3. OPERATIONS IN 1951/52.

The observatories were established and recording was begun between February 1951 and February 1952, during which time the writer was the geophysicist with the 1951 Heard Island party.

(a) The Seismological Observatory.

This is housed in an insulated prefabricated hut (see Plates 2 & 3). The hut sections are made of "onozote" insulator, 2½ inches thick, covered with plywood. These sections were bolted to a heavy framework fixed to the concrete foundations, and these in turn were laid on the basaltic lavas which outcrop near the camp. The observatory is 890 feet from the camp and it is safely distant from the diesel generator, movement of the tractor, etc, and well protected from easterly winds, but unfortunately not from the prevailing westerlies. The wave-battered cliffs of Rogers Head Peninsula are unfavourably close. These latter two drawbacks are unfortunately unavoidable as no better site is available.

Before installation of the instruments some finishing work on the huts and piers was necessary. This work comprised isolation of the piers from the floor, waterproofing the roof against the heavy summer rains, making a waterproof well for the recording drum driving weight, and installing electric wiring. A power line from the camp was also constructed.

As can be seen in Plate 2 provision was made for the future accommodation of additional instruments. The instrument room was kept dry by a 750-watt strip heater. This is necessary as the humidity is always very high in these regions and would otherwise cause expansion of the recording paper. The clock room, which also housed the short-wave radio receiver, was kept warm and dry by a 100-watt globe enclosed in a light-tight tin.

The instrument installed was a two-horizontal-component Wood-Anderson type seismograph designed and constructed by officers of the Bureau. The components were aligned so that N-S and E-W components of ground motion were recorded. A weight-driven recording drum with an air governor was used so as to be independent of electric power, if necessary. The air governor has the advantage of being easily adjusted to different drum speeds.

The governor was damaged during the rough voyage from Australia and had to be repaired before installation.

At first, one component was operated with the normal 0.75 second suspension, and the other with an experimental long-period suspension, the period of which was varied between 5 and 10 seconds. The first trial recordings were begun in April, and in July the long-period suspension was replaced by a normal 0.75 seconds suspension. The long-period instrument was a failure, owing to the excessive amplitudes of the microseisms and to instrumental difficulties. The period of the normal suspension was varied between 0.6 and 1.25 seconds and finally left at 0.75 secs. At 1.25 seconds the group microseisms were recorded too strongly. Damping was adjusted to be nearly critical, and the static magnification of the short period instrument was 2,800.

(b) The Magnetic Observatory.

The magnetic observatory is at West Bay, about one mile from the camp (see Plate 1). The variometer surveys carried out previously had revealed large variations in the magnetic field in the camp area, caused by the magnetic volcanic rocks which extend down from the old craters near Roger and Corinth Heads. Further, the beaches at Atlas Cove and Corinthian Bay are unsuitable for an observatory site as they are unstable and flooded occasionally. However, at West Bay the magnetic field is satisfactorily uniform over small areas, and the sand cover stable and sufficiently high to escape flooding from rain or heavy surf.

The absolute and magnetograph huts were prefabricated from materials similar to those used in the seismological hut, but they are of improved design and, of course, contain no magnetic material. With the aid of a diagram and numbered panels, a party unskilled in carpentryhad little trouble in erecting the huts once the foundations were levelled (see Plates 5 and 6). The panels were bolted together without a framework. Strips of non-porous rubber sponge between the panels, and a sheet of lead capping along the ridge of the huts made them almost air tight. This is necessary because of the heavy rain in summer and fine drifting snow in winter. The main part of the construction was completed in a few days during the relief operations. Finishing work, such as placing the lead ridge capping and painting, was done later. Because of the high winds which are common in these regions both huts were tied down with rope to heavy railway sleepers buried in the sand.

(i) The Absolute Magnetic Hut.

The absolute magnetic instruments used during 1951 were a modified Kew pattern magnetometer made by Elliott Bros. and a Cambridge dip-circle No. 226. A pier was constructed for each of these instruments by cementing two earthenware pipes, one above the other, to concrete bases under the floor (see Plate 4). This was facilitated by the design of the huts which allowed removal of the

floor panels. Because the sand on the island is magnetic, normal beach sand was taken from Australia for use in these piers. Wooden pegs were set in concrete under the floor for the tripod of the Q.H.M. and B.M.Z. instruments which have been used since 1951.

(ii) The Magnetograph Hut.

This hut was placed 100 ft. magnetic north of the absolute hut (see Plate 1). A plan of the hut is shown in Plate 4.

A La Cour continuous recording magnetograph with declination, horizontal intensity, and vertical intensity variometers was installed in the instrument room. These instruments did not arrive in Melbourne until after the departure of H.M.A.S. Labuan. However, together with Q.H.M. (Nos. 172, 173 and 174) and B.M.Z. (No. 62) semi-absolute instruments, they were taken to the island by R.R.S. Discovery II, which called there in early September 1951. Four earthenware piers surmounted by slate slabs were set up for the magnetograph, and lighting, time marking, and calibration instruments were installed (Plate 6). Auxiliary equipment kept in this hut included a pendulum clock, two Helmholtz coils, a calibration control board made on the island, and accumulators to supply light and instrument current. A motor-driven battery charger was housed in a small hut about one hundred yards away.

The variometers comprising the magnetograph were unpacked and tested in the camp before being installed at West Bay. The chief difficulty encountered was the unreliable minute mark obtained from the clock. This was finally remedied by substituting contact leaves of a new type which were brought to the island on the relief ship M.V. Tottan in February 1952. Trial recordings were begun on 2nd January, 1952, for the Z variometer, on 7th January for the D variometer and on the 17th January for the H variometer. The scale values were 0.912/mm for D, 10.1 gammas/mm for H, and 14.4 gammas/mm for Z. The normal drum speed of 15mm/hr was used. During the installation the various adjustments were made during the day and then a recording made over-night. The magnetograms were developed at the camp.

The writer was relieved in February 1952 by Mr. L. Ingall, geophysicist with the 1952 Heard Island relief party. In the change-over period Mr. C.A. van der Waal, Mr. L. Ingall, and the writer carried out intercomparisons between the Q.H.M.'s, the B.M.Z., the Elliott Magnetometer, and other instruments brought temporarily to the island for this purpose. During the return voyage to Australia a visit was made to the French party at Isles de Kerguelen, and the opportunity taken to reoccupy the magnetic station at Port Jeanne d'Arc.

(c) Auroral Work.

The high average cloud cover at Heard Island (about seven-eighths), and the fact that Big Ben mountain covers a large area of the southern sky, make conditions for observing aurorae poor. However, whenever possible, visual observations, including the azimuths and altitudes of some of the forms, were recorded with the occasional help of other members of the party.

4. OBSERVATIONS AND DISCUSSION.

(a) Seismology.

(i) Recorded Earthquakes.

Earthquakes recorded during the 1951/52 period are listed in Appendix 1. They comprise five distant earthquakes and two

near ones, which analysis with the Jeffreys-Bullen Tables shows to be 2°.9 away.

In addition to these definite earthquakes numerous small tremors are indicated on practically every daily record. There is little doubt that the great majority of these were produced by large falls of glacier ice. Most of the island is covered by glacier ice which meets the sea in high ice-cliffs. Huge slabs of ice undercut by wave-action fall into the sea, and the resulting sound can often be heard in the camp. At its closest point the Baudissen glacier is only $\frac{5}{4}$ mile from the seismological observatory. (see Plate 1). The times of some icefalls were noted and found to coincide with the times of recorded tremors. However, it is possible that some small local true earthquake recordings have been passed over, owing to their similarity to those resulting from icefalls.

The active Mawson volcanic crater is at the summit of Big Ben mountain (9,005 ft.). On the rare occasions when the summit was out of cloud, small plumes of steam were sometimes observed, and glow reflected off cloud could be seen at night. On one occasion there was a very voluminous outpouring of steam, and on another a lava flow. Steam and a glow from a previously unrecorded active vent on the western side of the Big Ben massif were observed during the year. There are extinct craters near the camp (see Plate 1), on Laurens Peninsula, and at points near the coast.

An important reason for using a seismograph of short period was the possibility of recording near earthquakes associated in a broad way, with this volcanic activity. However, the only near earthquakes known to have been recorded were those about 2°.9 (320 kms) distant (Appendix 1). The N-S component was not clearly recorded, but the record shows that the amplitudes of the two components were approximately equal. Possibly therefore the epicentre lay on the Kerguelen submarine ridge which extends south-east from Isles de Kerguelen to Heard Island, BANZARE Rise, Gribb Bank, and then to the coast of the Antarctic continent, near the Gaussberg crater. Members of the French party at Isles de Kerguelen have mentioned the occurrence of tremors there.

The two near earthquake records are of interest because analysis shows that there are probably three P phases and three S phases present as in continental near earthquakes. They may correspond to granitic, intermediate, and ultrabasic layers in the Kerguelen ridge. There is another phase present after the "Pg" which may be a fourth P phase or LQ, the Love surface wave.

Heard Island is a very difficult place for earthquake recording. Long-period records are spoilt by the large amplitudes of the microseisms and there is little local seismic activity to give interest to short-period records. The records obtained so far indicate that there is little local seismic activity in this region. It is hoped to install later a vertical component seismograph of short period and higher sensitivity, which would add to the number of teleseisms recorded.

(ii) Microseisms.

Although an obstacle in earthquake recording, microseisms of small amplitude are of great interest in their relation to atmospheric low pressure systems and other weather phenomena.

The microseisms recorded can be divided into three classes, (a) the well known group microseisms with periods of 2 to 7 seconds, (b) fairly continuous but irregular microseisms of period about 1 second, which were probably caused by surf, and (c) a very short-period type which varied with wind velocity and was obviously caused by hut vibrations (see Plate 7).

The amplitude of the group microseisms varied with the proximity to the island of atmospheric low pressure systems. Usually these "lows" approach from the north-west, pass south of the island and move off to the south-east, but because of the lack of observing stations the tracks and intensities of these "lows" or cyclones are not known accurately. Also, the slow rate of change of group microseism amplitude and marking by the short-period microseisms make it difficult to correlate them with weather phenomena. However it was noticed that the times of the maxima tended to occur after the "low" had passed the island. This has been confirmed by the succeeding geophysicist (Ingall, 1953). The largest of the group microseisms recorded had a ground amplitude of about 20-30 microns for each horizontal component.

The second type of microseism reached ground amplitudes of about 1-2 microns on each component. They occurred when a large surf was running, with or without a high wind. It is very likely that they were produced by wave action upon the steep cliffs which closely surround the observatory (see Plate 1). Another possible cause is standing ocean waves produced between incoming and reflected waves just off the coast (Longuet-Higgins & Ursell, 1948).

The hut vibrations are due to the action of the prevalent high winds, sometimes reaching over 100 mph, and to the unavoidably exposed position of the seismological hut. A heavier building, preferably of concrete, would have been more suitable, but of course much more difficult to construct in such a locality.

(b) Terrestrial Magnetism.

The results of absolute magnetic observations are given in Appendix 2. Comparison with the results of earlier years shows that large secular changes were still occurring in declination and horizontal intensity. The readings obtained at Isles de Kerguelen are also given.

Magnetograph recording was begun in January 1952, but as instrument adjustments were being made up to the time of relief, no results are given here.

(c) Auroral Observations.

The results of the auroral observations will be included in a report being prepared by officers of the Antarctic Division, Department of External Affairs.

5. ACKNOWLEDGEMENTS.

The author wishes to acknowledge the assistance obtained from Mr. C.A. van der Waal and Mr. R.E. Ervin, officers of the Bureau, and Mr. P.G. Law, Director of the A.N.A.R.E., in the preparations for the expedition; and also the assistance of various members of the 1951 Heard Island party in the work on the island.

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Jacka, F., 1953 - Magnetic Observations at Heard and Macquarie Islands, 1947-51, A.N.A.R.E. Reports, Series C, Vol. 1.

Longuet-Higgins, M.S. & Ursell, F., 1948. - Sea Waves and Microseisms, Nature, 30 Oct. 1948, p. 700.

NOTE: Reports by A. Bunbury and G.F. Schaefler on magnetic observations at Heard Island, are in preparation.

(H. A. DOYLE)

May, 1954.

APPENDIX 1.

Earthquake Phases

Period: 0.75 seconds

Damping: critical

Magnification: 2,800

Jeffreys-Bullen tables and notations used throughout.

No.	Date	Phase	Time	A_N (μ)	A_E (μ)	T_e (sec.)	Remarks
	1951						
1	Oct. 21	eS	21 57 55	12	-6	6	Formosa(U.S.C.G.S.)
2	Dec. 8	iP	04 03 31	-3.0	+2.3	1.5	900 miles S.E. of
		ipP	04 03 39	+2.0	-2.2	1.0	Madagascar, 34°S,
		eLQ	04 07 20	+840	+1130	16	56°SE depth about
		M		1940	170	15	100km (U.S.C.G.S.)
	1952						
3	Jan. 11	iP	04 12 10	1.0	+1.0	1.0	Eastern New Guinea (U.S.C.G.S.)
4	Feb. 10	iP	07 09 48	+1.8	1.3	1.5	Δ = 56°3
		iS	07 16 47	-5	-5	4	Java Sea, 6°S, 110°E depth 700 km (U.S.C.G.S.)
5	Feb. 14	iP	03 48 45	1.0	0.8	1.0	Flores Sea
		iS	03 57 23	-12	-17	6	(U.S.C.G.S.)
6	Feb. 26	iPn	12 17 46	-	-0.5	1	Δ = 2°.9 (320km)
		iP*	12 17 52	-	0.8	1	
		iPg	12 17 59	-	0.9	1	
		i(P or LQ?)	12 18 07		1.8	1	
		iSn	12 18 24	-	1.7	1	
		iS*	12 18 28	-	1.7	1	
		iSg	12 18 32	-	2.0	1	
7	Feb. 26	iPn	13 14 52	-	0.6	0.7	Δ = 2°.9 (320km)
		iP*	13 14 56	-	1.0	0.7	Replica of previous
		iPg	13 15 02	-	0.9	0.7	shock.
		i(P or LQ?)	13 15 11		0.9	0.7	Both the latter
		iSn	13 15 28	-	3.2	0.7	tremors possibly on
		iS*	13 15 32	-	6.4	0.7	the Kerguelen ridge.
		iSg	13 15 39	-	5.7	0.7	

APPENDIX 2.

Absolute Magnetic Observations at Heard and Kerguelen Islands

(i) Heard Island

DATE	HORIZONTAL INTENSITY (Gammas)	DECLINATION	INCLINATION
27-7-51		-49° 40.'3	
30-7-51			-69° 34.'5
31-7-51		-49° 43.'9	
17-8-51			-68° 33.'9
18-8-51	18467		
4-10-51			-68° 37.'5
6-10-51	18460	-49° 48.'4	
21-11-51	18462	-49° 44.'1	-68° 35.'7
22-1-52	18483	-49° 46.'8	-68° 33.'1

(ii) Isles de Kerguelen

5-3-52	18208	-48° 34.'0	

PLATE 1

Jacka Glacier

VANHOFFEN BLUFF

Sheer rock cliffs with extensive talus slopes

Sheer cornice

RAZORBACK
295

MT AUBERT DE LA RUE
407

W E S T B A Y

ROGERS HEAD
477'

BALANCED ROCK
312'

CRATER
318'

CRATER

CORINTH HEAD
592'

Lava cliffs 50–100' high

CORINTHIAN BAY

73 23 07 5E

53 01 11 55S

Seismological Observatory

A.N.A.R.E. STATION AREA

Gravity Station

Survey initial point

Wharf Point

Landing beach

A T L A S C O V E

Flat sandy area subject to flooding

Magnetic Station
1947-48
53° 01·9′ S
73° 21·9′ E

Battery Charging Hut

Variometer Hut

Absolute Hut

MT ANDREE
461

Sheer

CAVE

BAY

S O U T H W E S T B A Y

Raised flat sandy area approximately 10' above sea level

MT DRYGALSKI
690

767'

Baudissen Glacier

Schmidt Glacier

73 23 07 5E

A.N.A.R.E. STATION AREA

HEARD I.

LA PLATA

SANTIAGO

CAPE TOWN

WELLINGTON

MACQUARIE ISLAND

HEARD I.

KERGUELEN ISLAND

MELBOURNE

RIVERVIEW SYDNEY

ADELAIDE

PERTH

WATHEROO

Declination 5½° True North

LOCALITY DIAGRAMS

SKETCH MAP
SHOWING LOCATION OF

MAGNETIC AND SEISMOLOGICAL OBSERVATORIES, AT HEARD ISLAND

Reference:	*Survey Initial Point (Camp Area) 53 01′ 11″·58 73 23 07″·5E*
Control:	*Based on Triangulation Control Survey by R.Dovers 1948.*
Detail:	*Sketched in from uncontrolled ground photography based on known stations by K.Summons and I.Mather, 1950.*
Reliability:	*Reliable sketch.*

0 0.25 0.50 0.75 1 MILES

0 500 1000 1500 2000 YARDS

SCALE

VERTICAL INTERVAL 100 FEET

LEGEND

Cliffs

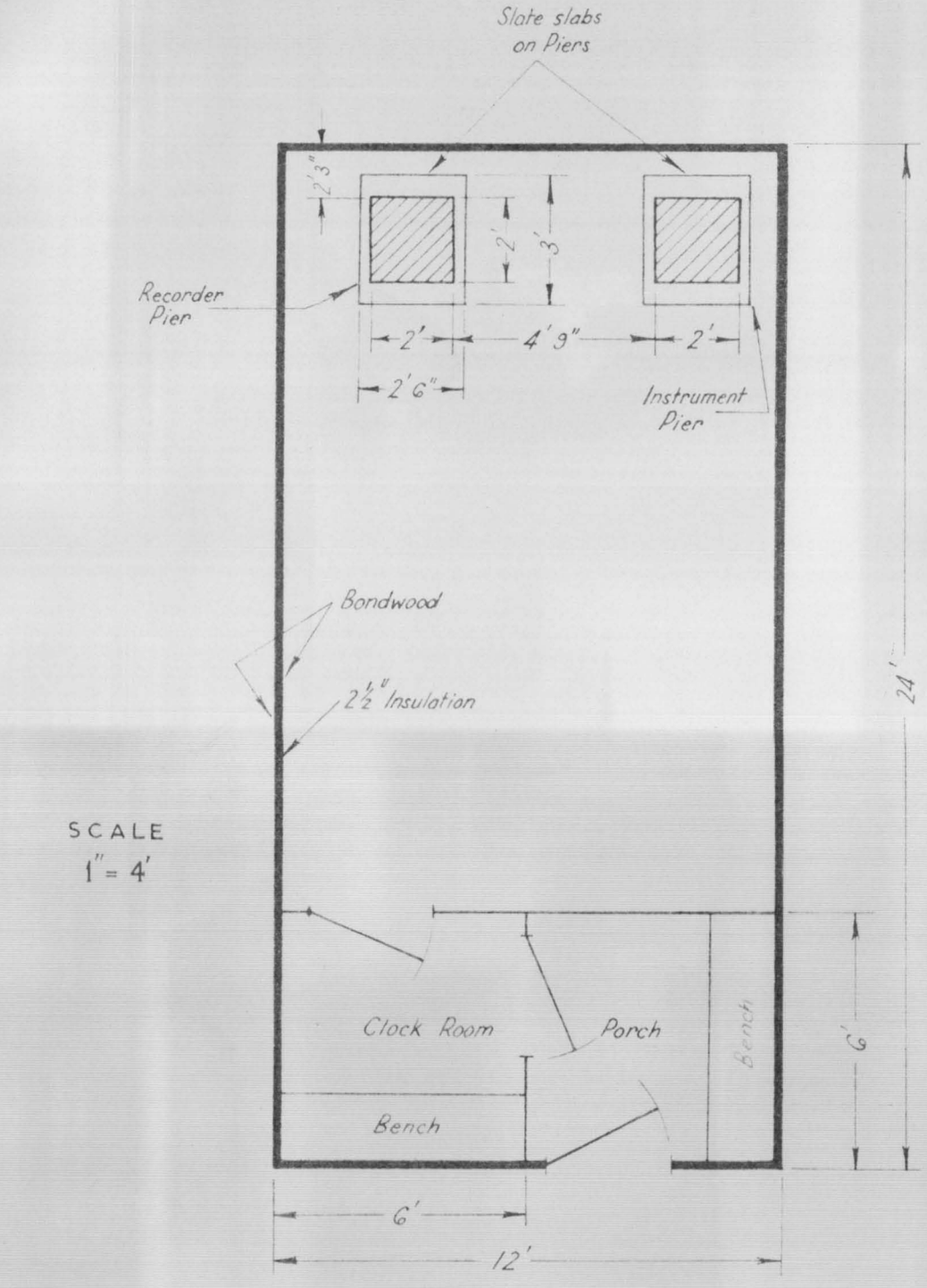
Contours

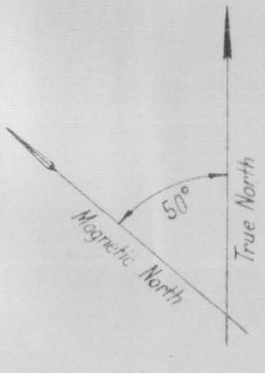
Spot heights

G 21-20

Compiled and drawn by Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics. 1950

PLATE 2





FLOOR PLAN

SEISMOLOGICAL HUT HEARD ISLAND

G 21 - 19

Geophysical Section, Bureau of Mineral Resources, Geology & Geophysics

SEISMOLOGICAL HUT AND INSTRUMENTS

(a) Seismological Hut with "Big Ben" in background

(b) Seismological Hut and the camp on the shores of Atlas Cove.

(c) Wood-Anderson type horizontal component seismographs with recording drum.

PLATE 4

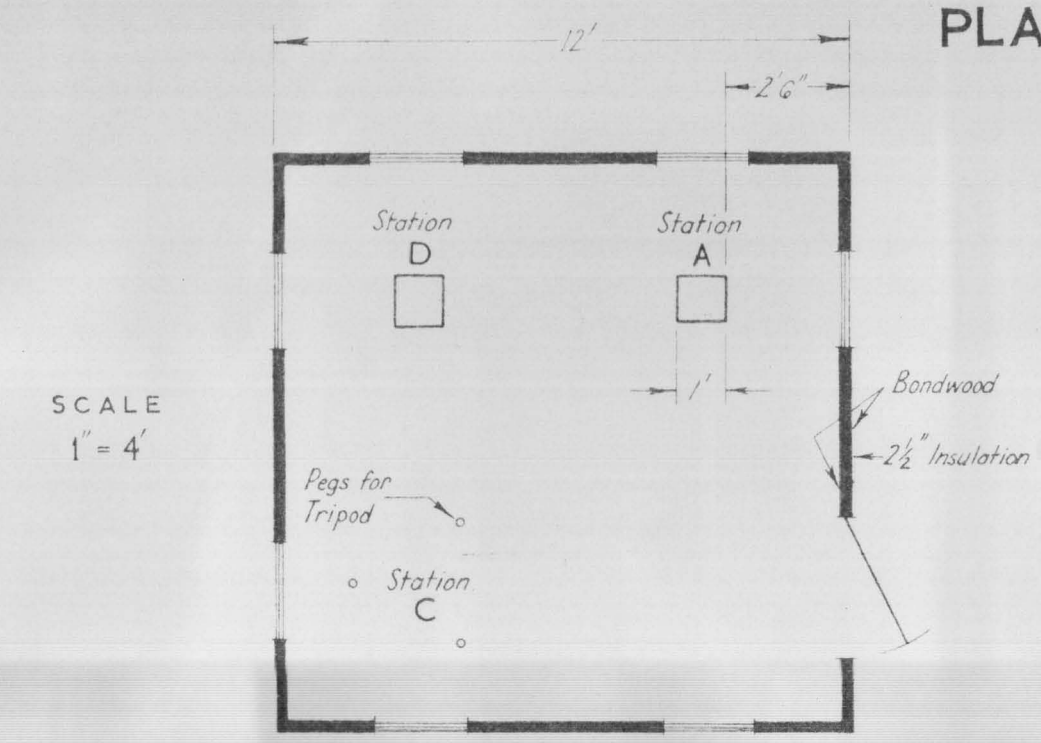


fig. 1
FLOOR PLAN
ABSOLUTE HUT

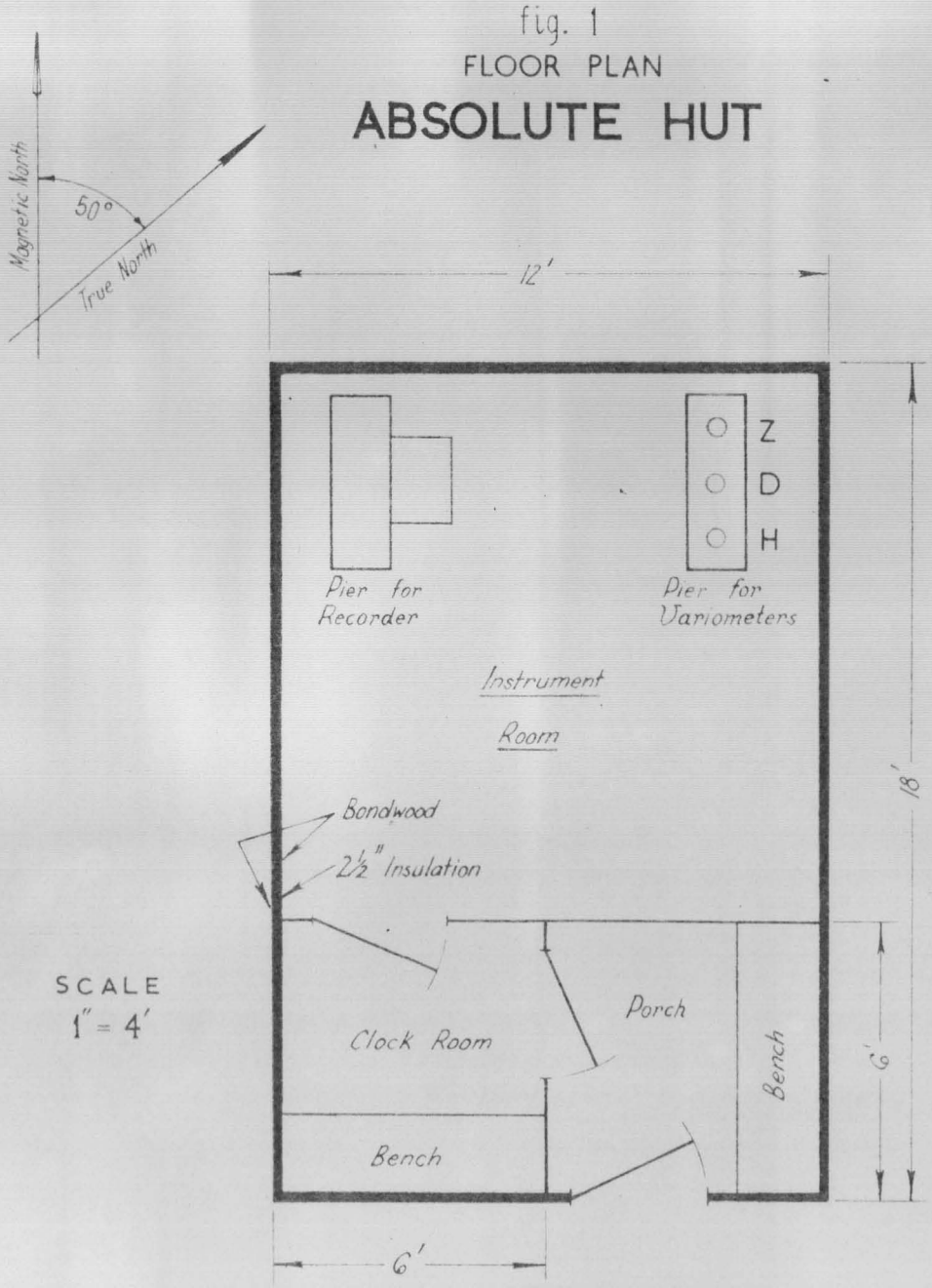


fig. 2
FLOOR PLAN
MAGNETOGRAPH HUT
HEARD ISLAND

G 21-18

Geophysical Section, Bureau of Mineral Resources, Geology & Geophysics.

ABSOLUTE HUT AND INSTRUMENTS

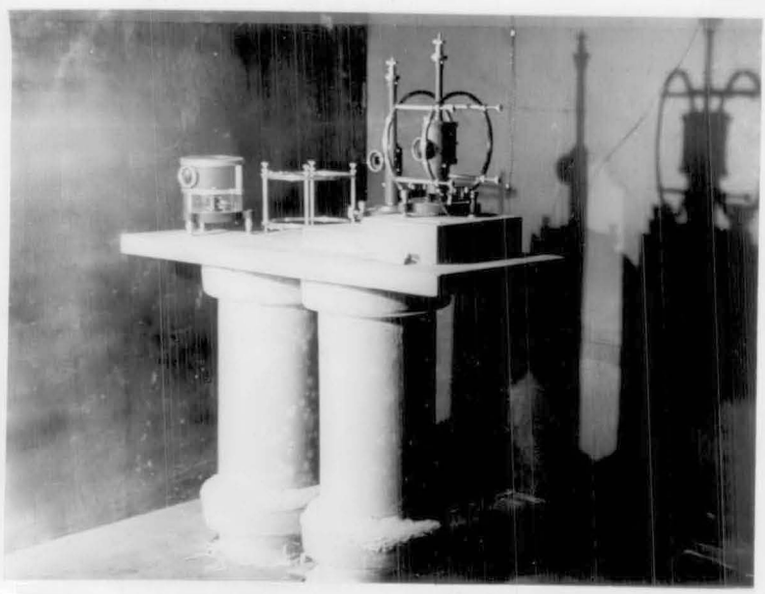
(a) Magnetic observatory huts, West Bay, Mt. Olsen in background.

(b) Absolute hut, looking towards camp, Corinth Head in background.

(c) Dip-circle and magnetometer on the piers in the absolute magnetic hut.

MAGNETOGRAPH HUT AND LA COUR MAGNETOGRAPH

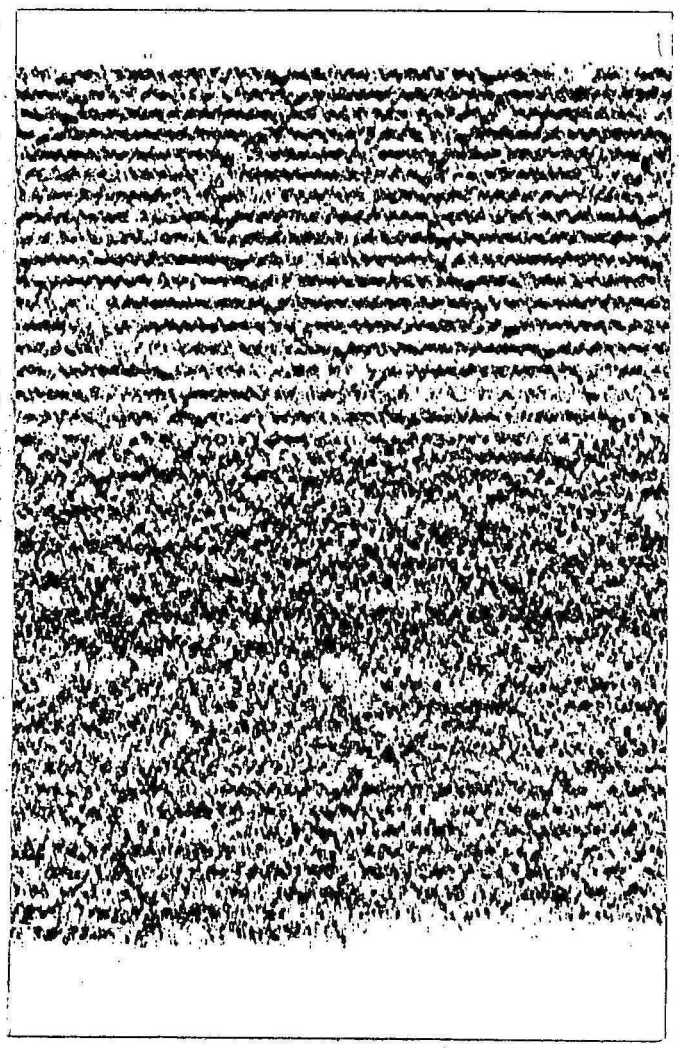
(a) Fitting the roof panel.



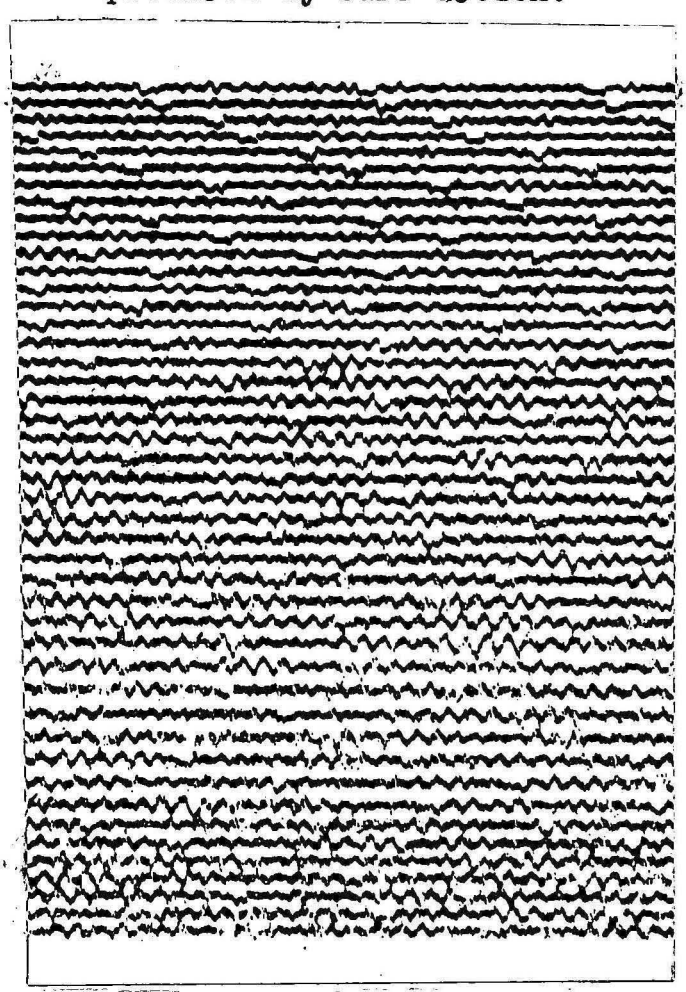
(b) The three variometers and the two Helmholtz coils of the La Cour magnetograph.

(c) The recorder and the prism rack.

TYPES OF MICROSEISMS RECORDED



(a) Short period microseisms, possibly produced by surf action.



(b) Normal long-period microseisms associated with atmospheric low-pressure system.