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RECORDS 1960 No. 114

WILKES GEOPHYSICAL OBSERVATORY WORK
ANTARCTICA 1959

by

R. Underwood.

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ABSTRACT

The author was resident geophysicist at Wilkes Station, Antarctica, during 1959. This report describes the running of the magnetic and seismic observatories and gives practical details of the problems encountered. Tabulated results of the year's work will be published later in a printed report.

1. INTRODUCTION

Wilkes Station was constructed during the late summer of 1957 as part of the United States Navy's "Operation Deepfreeze II" for use as the Knox Coast base of the United States International Geophysical Year Programme. The magnetic observatory was set up and run by R.J. Berkley of the U.S. Coast and Geodetic Survey, and the seismograph station was set up and run by G. Dewart of California Institute of Technology.

In February 1959 the control of the base was taken over by the Antarctic Division of the Australian Department of External Affairs, and responsibility for the magnetic and seismic observatory work was entrusted to the writer, who was seconded to the Antarctic Division by the Bureau of Mineral Resources. Equipment and materials, however, continue to be supplied by the United States Antarctic Research Project.

2. STRUCTURES AND MAINTENANCE

Magnetic structures

No major structural work was done during 1959, but necessary maintenance included tightening and locking the outside panel clamps of both the variometer and the absolute buildings, and re-locating the wedges in several places where the building panels had been assembled wrongly. The interior roof clamps of the variometer building were tied to the aluminium lattice beams with copper wire in such a way as to prevent either the clamps from loosening or the roof from lifting under wind load. The joints between panels were cleared of tar and "plastic wood" which had previously been used as caulking. "Vulcatex", an asbestos-silicone caulking compound designed to remain flexible, was forced into the joints and cracks, and the sealed joints of the roof and the end panels of the east face of the Variometer room were painted with a dark green paint. A blizzard tore off a piece of canvas from the corridors connecting the buildings; it was later tacked back into place.

The strong blizzard winds from the east caused some scouring of the pebbles at each end of the east face of the variometer building; heavy boulders were rolled into position to stop this. A collection of rubbish within about 200 ft of the magnetic huts yielded 179 lb of ferrous objects, including 7½ lb of shrapnel from the explosives used to excavate for the piers; an examination of this shrapnel led to the conclusion that there is still at least 3 lb of steel pieces beneath the building.

Seismic structures

The panel clamps were tightened and locked, the roof joints were cleared of tar, caulked with "Vulcatex" and painted with "Proofcote" (a semi-liquid rubber solution intended to form a harder skin over the soft caulking compound), and the whole roof and as much of the wall area as was accessible were painted white. The purpose of using a white paint was to help the building reflect solar heat, which was believed to affect the instruments within. The albedo of the roof after painting was measured as about 0.5. A "thermidor" (heated tube or corridor for pipes, etc) carrying an air heating tube was removed from the north wall of the seismic vault, and the holes where it had passed through the wall were patched and sealed. The wiring for power, time mark, D.C. lamps and A.C. recorder drive were rewired from the science building control panels as opportunity offered.

In December the behaviour of the seismic instruments suggested that the floor of the hut was touching the pier and was causing spurious vibrations; the floor and beams were cut back about $\frac{1}{2}$ in. all around. From the start of December, thaw water, partly formed by melting of the snow around the heated hut and partly run-off from beneath the snow and structures to the east, began to accumulate beneath the floor. A $\frac{1}{4}$-h.p. portable electric pump was used several times each day to drain a sump beside the eastern wall of the hut. Unfortunately this operation had a very disturbing effect on instruments, notably on the least stable (E-W) seismometer. As the season progressed, water, which oozed and then froze over the floor of the corridor connecting the hut to the "E.M. Quarters", formed a dangerous ice slope.

Science building

The interior of the geophysical office was painted during the year. The control panel for the seismic and magnetic power, lamps, and timing supplies was reorganised. The seismic and magnetic time-marking systems were combined as outputs from the Simplex programme machine, which was controlled by a single chronometer. The time-signal radio failed twice during the year; a power supply and two audio output tubes had to be replaced, and part of the audio H.T. rewired. The receiving-aerial wire was requisitioned by the radio section, and a shorter aerial had to be erected to replace it.

Darkroom

The interior of the darkroom used by the author was painted. The print-drying machine was operated and maintained. A seizure of its gear box was corrected by proper lubrication. A print drying service was provided throughout the year. The sink outlet was cleared of blockages several times during the year.

3. MAGNETIC WORK

Absolute observations

The absolute instruments, consisting of the Field Magnetometer-Earth Inductor set (No. 28) of the Carnegie Institution of Washington, gave no mechanical trouble. The instruments are however not particularly suitable for polar observatory work. They have been superseded since February 1960 by QHMs and a BMZ, but the magnetometer is still used for measuring declination.

The following details concerning the Carnegie instrument as a declinometer are of interest. The telescope cannot be focussed very clearly on the graticule, and the contrast of the graduations on the field of view is not very good. The horizontality of the trunnion axis and the verticality of the crosshairs were not tested, as the azimuth mark was very nearly in the same horizontal plane as the instrument. The spindle of the lens which views the torsion disc was very loose, and the lens kept dropping down into the line of sight. The torsion-head rack which raises the magnet is very worn and loose at the height normally used with the present fibre. The column is evidently not perpendicular to the plane of the deflection bar, and east deflections are up to $1\frac{1}{2}$ degrees smaller than west deflections.

The field view of magnet 28L, which is used for measuring declination, is dirty, but the erect-minus-inverted value is stable at 14 or 15 minutes of arc. This magnet is slightly loose on the locating pin of the stirrup.

Magnetic instruments require periodic checking against the instruments of other observatories to ensure the world-wide uniformity of magnetic results. For this reason the following intercomparisons were made with instruments standardised at Toolangi observatory :-

Date		Instrument	Element Measured	No. of Sets
1959 Jan.	26	DTM CIW 16	D	1
"	28	"	D	1
"	28	"	H	1
"	31	"	I	1
1960 Feb.	12	BMZ 221A	Z	16
"	13	Askania 509320	D	8
"	14	H.T.M. 5010154	H	8
"	15	QHM 492	H	2
"	16	"	H	2
"	17	"	H	4

Scale values

Scale-value determinations were made once a week by the Helmholtz-Gaugain coil method. Trouble was experienced in August and again in December, when the applied currents would not settle to a steady value. The trouble was traced to loose connections to the coils round all variometers; it disappeared when the terminals were tightened.

Variation instruments

This account of the variation instruments is not complete and is intended only to point out work done and troubles encountered during the year. The final analysis of both the results and the performance of the instruments is in hand.

(a) Orientations tests

Tests were carried out by the magnet method during change-over 1959 and again in June, and no indications were found that the instruments were not acceptably adjusted. However, it was noticed that the stops which locate the magnet box for rapid-run D & H tests were loose, and that the box would not sit in the standard stops because of a protruding screw head on the stop plate. The corners of the magnet box were bevelled so that they would clear this. Further, the magnet within the orientation box is loose and can be heard to rattle. The test results probably do not mean much, because of these imperfections, and an examination of the abstracted results of tests since installation confirms this.

(b) Standard variometers

The Z variometer appeared to be the least satisfactory one. Following the technique of the previous observer, the Z levels were checked at each record change and whenever the room was entered, and if the instrument was more than one or 1½ bubble divisions out of level, it was relevelled. This usually had to be done two or three times a month, and was necessary because the instruments are mounted on a plywood table which apparently warps with varying temperature and humidity. Also following the technique of the previous observer, the Z movement was lifted from its seating with the clamping device, and very carefully replaced. This operation (known as "cageing") was performed at each record change and at other times when there was cause to believe that the movement had been disturbed; for instance, after explosion of demolition charges nearby. The recording lamp was left burning during levellings and cageings so that the disturbance to the Z trace and baseline could be observed.

The baseline trace of the Z variometer is derived from an image of the recording lamp thrown by a mirror fixed to the body of the variometer, and is the reference line from which all measurements of Z are taken. This should of course remain fixed. However, on several occasions the baseline trace shifted as much as one millimetre during 24 hours when there was a sudden change of temperature (indicated by the trace from a thermograph incorporated in the instrument).

When demolition charges were exploded, notably for excavation of the loading ramp to Frogmans Beach, the Z trace and occasionally also the Z baseline were observed to undergo sudden shifts of up to several millimetres; these shifts were usually corrected by subsequent cageing. It is presumed that the explosive shock jars the movement and shifts the positions of the knife edges on the agate plates; if so, there is a strong possibility that the knife edges will suffer damage if more charges are exploded in the vicinity.

During the middle of June, and again at the start of September, the Z traces and sometime the Z baseline jumped by amounts up to 1 mm. This was attributed to some effect of the long spells of very cold weather experienced about these two times, probably "frost heaving" of the foundation, because the instrument room was heated and the piers were set into permanently frozen ground.

Investigation of the final adopted baselines for D and H reveals that an "annual wave" of baseline values occurs, to the extent of 63 gammas in H and 16 minutes in D; this is attributed to warping of the pier top and tilt of the wooden piers. If the H variometer tilted enough to allow the recorder magnet to move 1 mm from the intersection of the magnetic axes of the sensitivity and temperature-control magnets, the recorded H value could change as much as 270 gammas; this would show as a change in baseline value. It is believed that such a tilt could easily result from seasonal affects on the pier top and the pier itself. The D baseline, however, would imply several millimetres displacement of the D recorder magnet, and this is probably not possible without the suspension fouling some part of the variometer body.

It is concluded that concrete piers and a slate pier top should be installed.

(c) Rapid-run variometers

The remarks which have been made about the standard Z variometers apply equally to the rapid-run Z variometers. Levelling and cageing behaviour, and jumps after explosions and during the cold spells, all occurred, but bending of the baselines with temperature was not detected because temperature is not recorded and moreover the baselines are only two hours long instead of twenty-four. The D & H rapid-run variometers were also subject to mislevelling due to warping, but this took the form of a deflection of the image of the illuminating lamp reflected from the baseline mirror on to the recorder slit. This image deflected either upwards or downwards until the baseline disappeared entirely from the record. The trouble was corrected by relevelling "fore and aft" until the baseline spot appeared at the same level as the magnet spot (the "bullseye" levels on the bodies of the H & D instruments were not sufficiently sensitive to show when the instrument was returned exactly to its correct attitude).

At times of severe disturbance, for example during the storms of July 1959, the number of reserve spots on the rapid-run D variometer was insufficient to maintain a record when the declination value exceeded about 86°W. In December 1959 the mirror supplying the most westerly spot was readjusted and one more mirror was added outside this, but in the storm of December 27th even these measures proved insufficient, and the last spot was lost at 87° 40'W. This loss of rapid-run trace will continue, and even get worse, as the secular change makes declination progressively more westerly.

Accessory equipment

At the beginning of the year, the time marks for both standard and rapid-run magnetic records were provided from a Simplex programme machine driven by Bliss chronometer No. 3162, the rate of which was adjusted, by tilting, to keep the correction within 0.5 seconds. The seismic time marks were imposed by Hamilton chronometer No. 2E11658, also tilted to keep the correction within 0.5 second; and manual time marks were also placed 3 times a day, with an estimated accuracy of ± 0.1 seconds.

Later, after reorganisation of the geophysical office, the third channel of the Simplex programme machine was brought into service as a seismic time marker, and Hamilton chronometer 2E11658 was used to drive the Simplex. A delay of 0.6 seconds between the minutes tick of the chronometer and the flow of current in the seismic time mark relays circuit was found to occur, and the chronometer was run 0.6 seconds fast, with the rate adjusted by tilting. Presumably a delay of the same amount occurs before the lamp flash of the magnetic time markers. The chronometer correction was determined each 24 hours, to 1/10 second, using the National 183C radio receiver provided, and as a check the flow of current in the relay circuit was timed against the radio signal with a stop watch when manual time marks were being put on.

The rapid-run recorder drive failed once during the year owing to drying of the oil in the bearings of the first layshaft; this was cleared and an oil hole was drilled to prevent further trouble. The recorders did not give any other trouble. The optics and illumination were satisfactory, except that the standard Z spot tended to be too weak and was occasionally invisible at fast writing speeds if the lamp voltage had been allowed to fall. This was attributed to the Z instrument being the farthest from the lamp and recorder, and to an imperfect projection lens. Also, the rapid-run time lamp was not properly adjusted for several months and required excessive current to give a clear time-mark.

The two sets of magnetographs are in adjacent rooms within the variation building, and thermostats for the special non-magnetic glass radiant panel heaters are located in each room, near the interconnecting door which was usually left open. The mercury switch of one thermostat failed and had to be replaced by the spare.

Earth Currents

The possibility of recording rapid fluctuation of earth currents was investigated. A true E-W line about 300 yds long was surveyed and at the west end a copper wire net was buried in moraine debris, with caustic waste to lower the resistance to earth. The east electrode was made from a galvanized steel rod driven 3 ft into moraine and wetted with salt solution. Wires were strung along the ground to the science building and also over the roofs to the meteorology building. When a recording millivoltmeter from the meteorology office was connected, it was found that only wind vibration effects were being picked up, and the experiment was discontinued.

4. SEISMIC WORK

Seismometers

The E-component seismometer was the least satisfactory of the set, because it generated an irregular trace which also showed occasional "bays", i.e., sudden excursions followed by a damped return to equilibrium. In May this component was entirely rebuilt, without very much improvement, and later a blanket was draped over the case, to help exclude draughts. This made some improvement. When thaw water had to be pumped from under the vault, the sump could only be located near the E-component, which was much disturbed by the pumping. It is possible that the concrete pier, or the "bedrock" under this corner, may be cracked.

Early in the year the Z-component was found to be transmitting only the strongest motions. Dry joints in the wiring were found and remade, and after this the trace was troubled only by galvanometer drift.

The N-component behaved well throughout.

All components were calibrated for free period each month from April, by open-circuiting the output coil, pushing the boom, and following its oscillation with a microscope constructed by the author for this purpose. When necessary the period was readjusted.

Galvanometers

The galvanometers consist of 2 main assemblies, the magnet base with levelling screw and sub-base, and the "tube" containing the suspension, coil, mirror, helix, torsion head and clamp, electrical connections, and ferrox slug. At various times during the year, tubes were taken out of service and repaired, or replacement tubes inserted, but the magnet bases remained in position in front of their respective recording drums throughout. The traces given on the westerly drum, with various tubes and when various seismometers were connected, were always temperature sensitive, and would drift for several hours when temperature changed. Early in the year, a thermostat was used to control the temperature of the seismograph shelter, but the differential was 5°F which was still enough to throw all traces off; consequently the thermostat was set at so high a temperature that it could not operate. Later, the heater was connected permanently to the line, and a small internal fan disconnected. The idea was to allow heated air to rise to the roof, and air cooled in contact with the pier, which was always cold, to remain near the floor, so that a stable non-convective system was established. However, this equilibrium was disturbed at record change each day, and trace was lost until the instruments settled down again. During the winter, when snow entirely covered the building, there was little diurnal temperature variation within. But the long sunny days and cold clear nights of summer produced a diurnal temperature range of 5°F at the level of the instruments in the uncovered building. Under these conditions galvanometers, especially the one most westerly in the building, drifted severely; the traces spread farther apart as the temperature started to rise, say from 8 a.m. to 3 p.m. local time, and crowded together when the temperature was at its peak, from 5 p.m. to 8 p.m.

Five galvanometer tubes were rebuilt during the year; one could not be adjusted and was returned to Australia for despatch to Caltech.

Calibration of galvanometers was performed monthly from April; it was done by suddenly passing a current of a few microamps from a high-impedence network through the three galvanometers in series, and allowing the free oscillations to be recorded. The current was then suddenly interrupted and the resulting oscillations recorded also. The difference in mean positions is a measure of the galvanometer current sensitivity, and was expressed with respect to one volt imposed at the terminals of the network. The seismometers were then clamped and connected to their galvanometers, and the voltages again applied, so that the damping could be recorded from the oscillations produced.

Pier and foundations

It has been mentioned that the E-component trace especially was unstable and much affected by the pumping of thaw water from beneath the floor. Immediately the electric pump started, the traces would deflect about 4 cm in an easterly sense, about 4 cm in a northerly sense, but not at all on Z. When the pump was turned off about 20 minutes later, the E-trace would stay deflected and not recover, and would produce evenly spaced records from the new position. But the N-trace would soon return to its previous level and produce evenly spaced traces from there. The Z-trace would continue undisturbed. Now, the signal generated by a seismograph coil moving in a permanent magnet field is proportional to the velocity with which the coil moved relative to the field; thus if the seismometers were tilted, only a transient with a period of no more than a few minutes would deflect the galvanometers, to produce a record similar to the "bays" which often occurred on the records. Consequently the described effect on the traces of pumping is not associated with tilt of the seismometers, but with the galvanometers. In the line-up finally adopted, the E-component recorded through the centre galvanometer, the N-component through the easterly galvanometer and the Z-component through the westerly galvanometer. Then it would be expected that the traces would be disturbed by pumping from a sump east of the room in the order of increasing severity:- westerly, centre, easterly. In fact the trace from the centre galvanometer was most disturbed. From which it is concluded that a simple foundation tilt is not the explanation.

Alternatively, it is possible that the electric pump caused an electrical disturbance. Possibly some A.C. current was picked up and rectified in one of the circuits, building up on the suspensions of the affected galvanometers a static charge which only slowly leaked to earth through the bleeder resistor fitted to one terminal of each galvanometer.

Recording

The optical system involves crossed cylindrical lenses, and only minor focussing adjustments could be made without moving the whole galvanometer, base, and height adjusting assembly, followed by re-levelling and height adjustment. The centre spot was found to be blurred because the front surfacing of the upper mirror was rubbed rough. To overcome this failing, the lamp beam was collimated with a slit about 1 mm wide which excluded much of the blurring reflection. In previous years, the drive wheel of the drum had been serrated to afford a better grip on the axle; during the present year a new, smooth wheel was installed, and no slip was experienced. The friction clutch worked loose once during the year and had to be retightened. The time-mark relays sometime failed to function properly. Most of the year the centre spot was not deflected far enough to provide a good time mark, but towards the end of the year the easterly spot became worse and the centre spot improved.

Miscellaneous

The clearance between the floor and the pier was suspect, as mentioned earlier, so the floor was cut all around the pier, and the floor beams were hacked away. The gap was filled with strips of rubberised horsehair to allow independent movement without draught.

Temperature control was attempted by painting white as much of the outside of the building as possible, to reflect sun heat and reduce radiation on cold clear nights. All the wiring was replaced during the year, and the variously routed cables brought into one bundle. The old armoured flexible power cable for the heater was removed from the roofs. The switch of the seismic lamp circuit was modified so that when the seismic lamps were turned off, an equal resistance was switched on; in this way the current drain from the D.C. supply was kept constant and the lamps for the magnetic recorders were not affected.

5. MISCELLANEOUS WORK

To relieve the engineer from some of his work load, various small routines and maintenance jobs were undertaken by the author. The water filters, for instance, were replaced as necessary, and odd sink and waterpipe blockages cleared. The washing and drying machines were maintained. Following the take-over from the United States party, a stocktake and a stocklisting of all items were undertaken.

6. RECOMMENDATIONS

These do not include many of the suggestions made to the incoming geophysicist (W.K. Jones) on small and continuing problems, but mainly on matters of concern to the Melbourne office.

Seismic

It is recommended that a short-period, vertical-component seismograph be provided at Wilkes. The present instruments are not ideal for the determination of epicentres; the P-phase and its reflections, being usually of short period, often do not record well, if at all. This would be corrected if a vertical, 1-second-period seismograph were installed.

The present building is inadequate, and as described, the foundation of the pier is suspect. A new seismograph, as recommended above, could not easily be fitted into the existing structure. Further, the blizzard wind vibrates the building and causes a visible disturbance of the trace.

It is recommended that a new site be chosen for the seismic installation, preferably in a place where a concrete vault-like structure could be fully or mainly buried under rock, rubble, or even permanent snow. It should have good foundations and not be too close to human activity, but must have electric power supplied.

It is recommended that means for very precise temperature control of the seismic installation, either old or new, be investigated and supplied for 1961.

Magnetic

It is recommended that non-magnetic cables and fittings be supplied to hold down the variometer building during the blizzard winds, which strike the top half of the east face with great force. An exterior white paint of good quality should be supplied to paint the panels, some of which are scoured by wind, and the roof, which leaks at the joints. The cribbing, notably under the north side of the absolutes building and the corridor, needs to be repacked with gravel and covered with boulders.

As described, the variometers are mounted on plywood tables, which warp. It is recommended that slate or marble pier tops be provided, or that magnetically tested gravel, sand, and cement be despatched to Wilkes so that concrete slabs can be cast on the site.

An instrument to observe the rapid fluctuations of magnetic field would be interesting; some type of visual recording instrument would certainly be useful, particularly for showing whether conditions are suitable for absolute and scale-value determinations.

A gravity tie back to Australia would be valuable, as the site read by Sparkman with the La Coste-Romberg gravity meter during the I.G.Y. is available. The tie flown from McMurdo Sound by Thiell in December 1959 was to a station on the snow at S.1 ice-cap site; the elevation is uncertain and the station can no longer be reoccupied exactly.

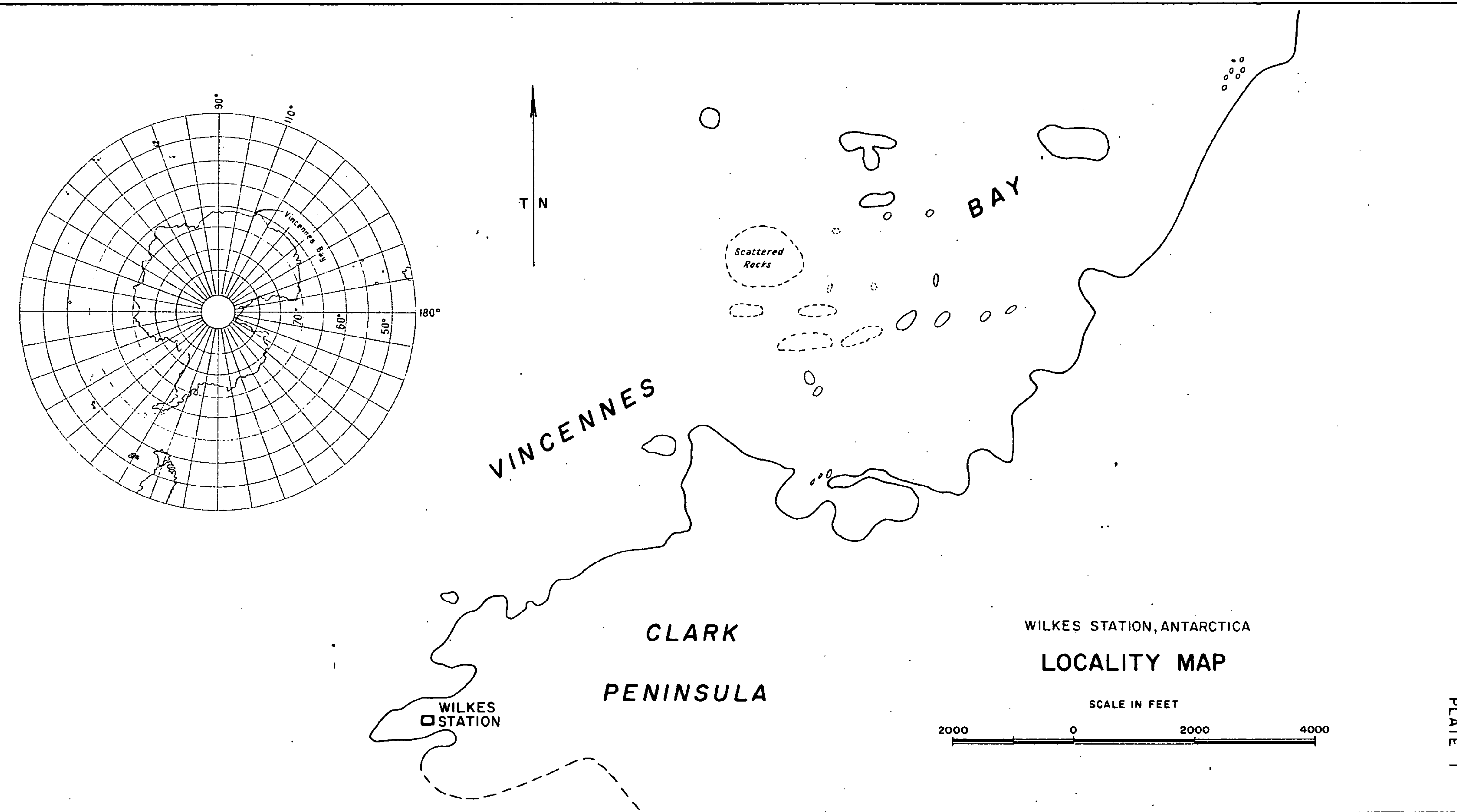

PLATE I

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.

G364-11

TO ACCOMPANY RECORDS 1960, No. 114

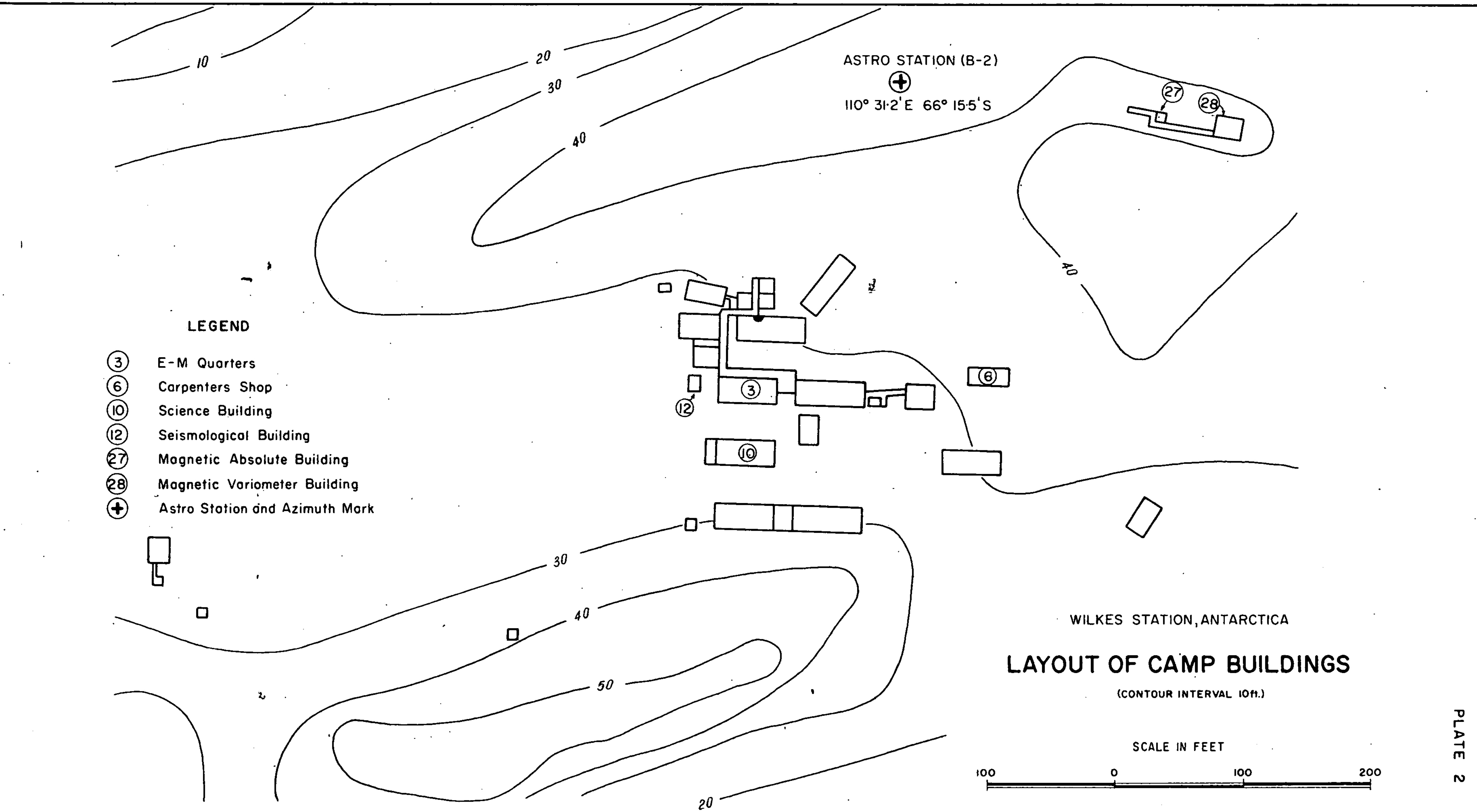

PLATE 2

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G364-12

TO ACCOMPANY RECORDS 1960, No. 114