USE OF ANEROID BAROMETERS FOR HEIGHT DETERMINATIONS ON THE LARSEN ICE SHELF

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NUMEROUS aneroid barometer readings were taken on the Larsen Ice Shelf and adjoining parts of the east coast of Graham Land (Fig. 1) during the course of geophysical and topographical survey work in the Antarctic summer of 1963–64. The heights of geophysical stations are normally obtained by levelling from a known datum, usually sea-level, but such methods are impracticable in a reconnaissance survey where time is limited and the seaward edge of the ice shelf is at a minimum distance of 60 miles (97 km.) from the working area. The only practical method is to use aneroid barometers. The technique employed differs somewhat from that normally adopted by large field parties working under similar conditions, so a full description of the technique and the expected accuracy is given here.

Throughout most of the survey, four Walker aneroid barometers were read at each station, except during a period on the northern part of the ice shelf where only three were used. The air temperature at the time of the observation was also noted. In addition, readings were taken when making and striking camp.

REDUCTION AND ACCURACY OF RESULTS

In the reduction of aneroid readings, extensive corrections must be made for the external influence of atmospheric pressure changes. Many previous parties engaged in this type of work in the Antarctic have had access to a local static barograph, or have used the "leapfrog" method of correction, whereby simultaneous barometer readings are taken by two sections of the party travelling several miles apart. Neither method was feasible in the present case, owing to the smallness of the party and the need for mobility over a wide area. The best source of information available was the series of pressure charts compiled by the Meteorological Office in Port Stanley, Falkland Islands. These were drawn up three or four times daily from sea-level pressure data submitted by the various observing stations in the Antarctic and South America. The nearest meteorological stations to the working area were the British ones at the Argentine Islands and Adelaide Island (both on the west coast), and the Argentine station "Teniente Matienzo", at the Seal Nunataks (120 miles (193 km.) north-east of Churchill Peninsula). The charts were contoured at 4 mb. intervals and thus allowed interpolation of the theoretical sea-level pressure at any part of the working area at the times to which they applied. A graph of pressure changes throughout the day was then drawn, based upon these fixed points and supplemented with additional information on the local trend in atmospheric pressure derived from reading the aneroids at camps.

Under ideal conditions, where observing stations are close to the working area and aneroids can be frequently checked for calibration changes and "jumps", the average aneroid reading at a field station is simply subtracted from the interpolated sea-level pressure for the same point. The result, duly corrected for temperature differences and other minor effects, then gives directly the height of the station above sea-level. In the present survey, aneroid calibration against a mercury barometer was only possible at the beginning of the three-month working period. The working area was a considerable distance from the observing stations and no direct estimate of the accuracy of the meteorological charts could be obtained. Severe local pressure changes are common in Graham Land, especially in coastal areas, and it is probable that on many days the local pressure conditions bear little relation to the regional pattern. Under such circumstances, the estimated heights can be up to several hundred feet in error. Initially, therefore, the interpolated pressure curves were used only to provide an indication of relative external changes during local work on the peninsulas and glaciers adjacent to the ice shelf. Heights of stations were thus calculated relative to starting and finishing points on the nearby ice shelf rather than directly to sea-level.

The expected overall accuracy of this method should be obtainable by comparing the interpolated curves of pressure variation with actual pressure changes recorded by the aneroids

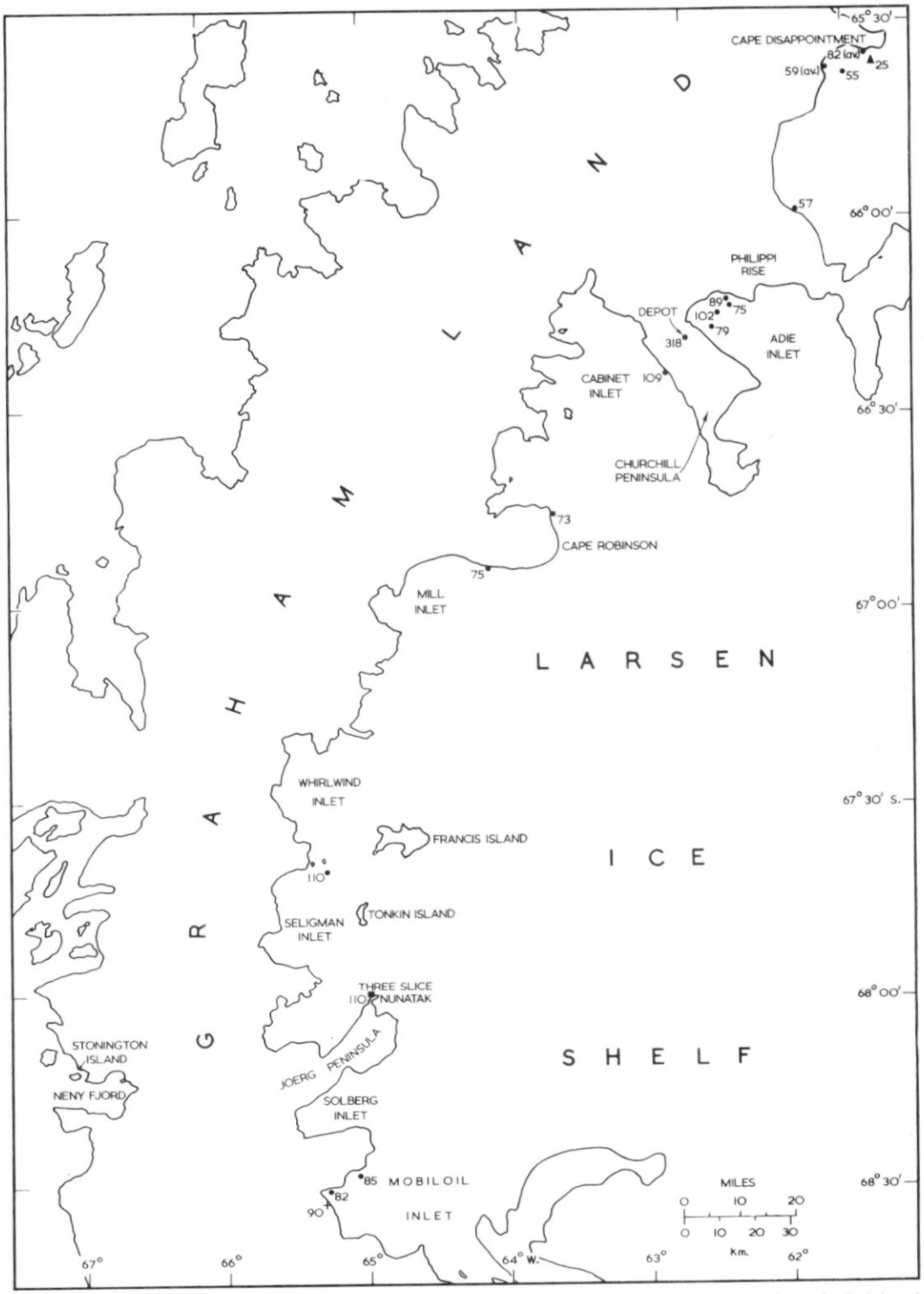

Fig. 1. Map of the northern part of the Larsen Ice Shelf, showing the positions of stations where the height of the ice shelf above sea-level was estimated. Heights are given in metres.

- ● From the author's observations.
- ▲ From Fleet (1965).
- ■ From Mason (1950).
- + From observations by Gibbs and Forster in 1958.

during prolonged stays in one place. With this aim, half-hourly readings were taken at the Churchill Peninsula depot on 4 November and during 11 to 16 December 1963. The results, which are shown in Fig. 2, have been corrected for the calibration error of the aneroids determined at the start of the field work. There is considerable variation in the absolute comparison between the measured curve and the interpolated one but, considering only the shape of the curves on a day to day basis, the correlation is fairly good. The maximum divergence is of the order of $\pm 0{\cdot}07$ in. ($\pm 2{\cdot}4$ mb.), equivalent to about ± 65 ft. (± 20 m.) in altitude. The accuracy of heights determined by short runs up from the ice shelf can therefore be expected to lie within these limits. This was confirmed by repeated measurements of the altitude differ-

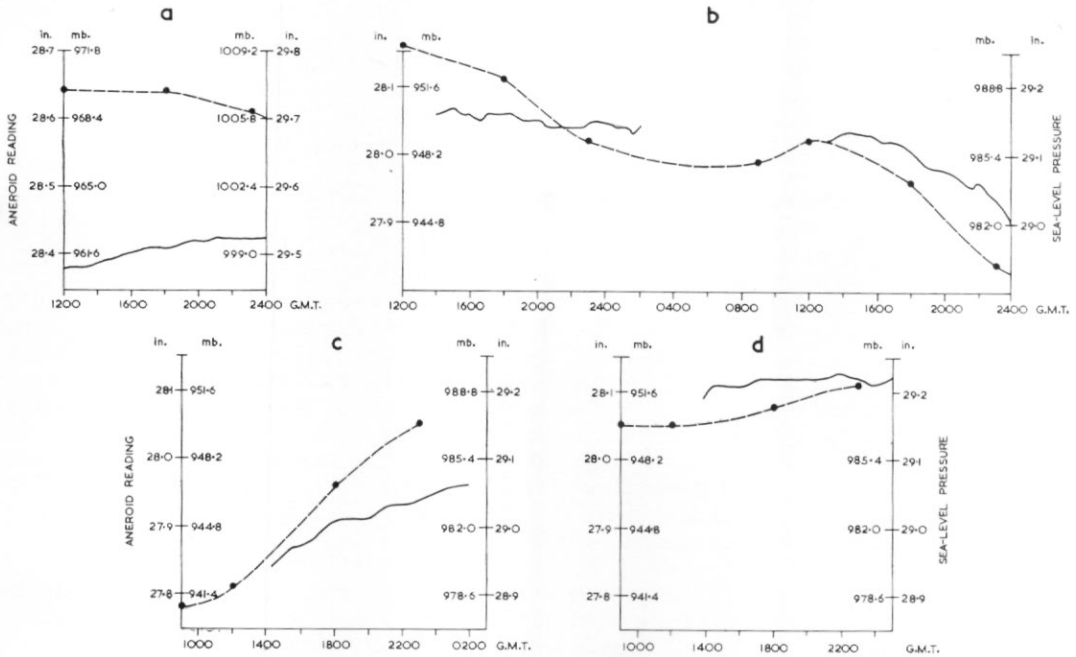

Fig. 2. Correlation of aneroid barometer readings (solid line) with interpolated sea-level pressure (pecked line) at Churchill Peninsula.

a. 4 November 1963.
b. 11–12 November 1963.
c. 13–14 November 1963.
d. 15–16 November 1963.

ence between two stations and ice-shelf level, enabling standard deviations to be calculated. The mean of four determinations at the Churchill Peninsula depot was 852 ± 32 ft. (260 ± 10 m.) above ice-shelf level. At the other point, on Jason Peninsula, a value of 631 ± 8 ft. (192 ± 2 m.) was obtained from three separate runs. In each case, a different starting point on the ice shelf was used, so the low standard deviation suggests that the method is more accurate than was expected and also that the ice shelf in Cabinet and Adie Inlets is extremely flat.

Height of Ice Shelf above Sea-Level

In spite of the apparently poor absolute correlation between the pressure curves, an attempt was made to calculate the height above sea-level of the Larsen Ice Shelf itself by direct correlation of the aneroid readings at ice-shelf stations with the interpolated sea-level pressure. In all, 16 stations at well-distributed intervals between Mobiloil Inlet and Cape Disappointment (Fig. 1) were observed on the ice shelf. The average height obtained was 261 ± 56 ft. (79 ± 17 m.). Heights in the area between Philippi Rise and Cape Disappointment appear to be consistently less than average, being of the order of 216 ± 41 ft. (66 ± 12 m.).

The relatively low standard deviation is again surprising. In addition to errors of correlation there is also the problem of the undulating nature of the surface of the ice shelf, which would be expected to produce a greater scatter in the altitude values. No serious work has yet been done on these height variations on the Larsen Ice Shelf but in some parts they are estimated to be of about 100 ft. (30·5 m.) amplitude. The bigger undulations appear to be concentrated in the south of the area; in the northern part, where most of the height determinations were made, they are less marked. Another factor which may contribute to the small standard deviation is that most of the readings were made on the apparently level part of the ice shelf immediately before the dip which usually marks the junction between the land ice and the ice shelf.

The absolute altitude of the Churchill Peninsula depot was also calculated by comparison between the two curves shown in Figs. 2a, b, c and d at two-hourly intervals. A height of 1,046±53 ft. (318±16 m.) above sea-level was obtained. Assuming that the depot is 852 ft. (260 m.) above the ice-shelf level, the height of the ice shelf in the vicinity of Churchill Peninsula is then 194 ft. (59 m.).

Independent evidence of the height of the ice shelf is available from several sources. The work described here was the continuation of a sledge traverse across Graham Land from a sea-level station at Stonington Island. Information about changes in atmospheric pressure was again obtained from the meteorological charts, supplemented by overnight readings at camps and by observations made by the personnel at the Stonington Island station. Unfortunately, steep pressure gradients prevailed during the crossing of the plateau and the expected accuracy of the heights is only ±100 ft. (±30·5 m.). However, the height determinations made during this traverse are in close agreement with those of Gibbs and Forster in 1958, and shown on the 1 : 200,000 map of the area (D.O.S. 610, 1963). Their nearest spot height to the ice shelf gave a height of 90 m. at the junction between the Mercator Ice Piedmont and the ice shelf of Mobiloil Inlet itself. This agrees well with a value of 269 ft. (82 m.) measured during the present work on the ice shelf slightly farther to the east.

Mason (1950) has stated that the height of the Larsen Ice shelf in lat. 67°S. and about 5 miles (8 km.) from the coast is 300–400 ft. (91–122m.), derived by observing on to points of detail on the mainland which had previously been fixed by a barometric traverse. He has also described the results of aneroid readings on the ice shelf at Three Slice Nunatak, which gave a height of 360 ft. (110 m.). Considering the whole of the Larsen Ice Shelf, Mason has stated that it is higher to the north of lat. 68°S. than to the south. However, when the heights obtained during the present survey are taken into account, it appears that the ice shelf is at its highest near lat. 68°S. and then decreases slightly in altitude to the north. In the discussion of Mason's paper, it was supposed that the accumulation rate was higher in the north of the area than in the south, but snow-pit measurements by R. Tindal (personal communication) have demonstrated that the reverse is true and that the annual accumulation at Three Slice Nunatak is many times greater than in the Churchill Peninsula area.

Fleet (1965) has described a series of rifts in the ice shelf south of Cape Disappointment and he has suggested that the bases of the rifts are at sea-level. On this assumption, he has estimated that the level of the ice shelf in the immediate vicinity of the rifts is 82 ft. (25 m.) above sea-level. No aneroid barometer measurements were made at the site of Fleet's observations but the average of several height determinations a short distance away on the ice shelf southwest of Cape Disappointment is 216±41 ft. (66±12 m.). The discrepancy between this estimate and Fleet's figure is greater than would be expected from the size of the standard deviation of the aneroid barometer values. It would seem most likely, therefore, that Fleet's altitude is only applicable locally to the surface of the ice shelf near the rifts, which must be abnormally depressed in comparison with the rest of the area.

MS. received 3 September 1964

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