ICE-MOVEMENT MEASUREMENTS IN THE THERON MOUNTAINS

By C. M. WORNHAM

ABSTRACT. Ice-movement and snow-accumulation measurements were made over a 12-month period at a number of points in the Theron Mountains. Velocities up to 183 m./yr. were observed on an ice stream at the foot of the mountains.

THE Theron Mountains are situated on the north-eastern borderlands of the Filchner Ice Shelf in lat. 79°S. (Fig. 1). They are bounded by a 110 km. long north-west-facing escarpment of cliffs and ice falls (Fig. 2). The cliffs form the edge of an elevated plateau extending to Parry Point (Fig. 3), the most southerly rock outcrop, where they turn south-east and continue as an ice-covered scarp forming the northern boundary of Slessor Glacier. Mount Faraway, the highest peak of the Theron Mountains, has a height of 1,140 m. above sea-level. The highest of the cliffs reach about 600 m. above the level of the snow to the north-west. Behind, and in general above the cliffs, there are nunataks, ice-covered hills and ice falls. These give way at distances of up to 25 km. from the cliffs to gently undulating snow areas at a height of about 1,250 m. above sea-level.

There are three principal valley glaciers: Goldsmith Glacier, Jeffries Glacier and a southernmost un-named glacier near Mount Faraway. Jeffries Glacier is the steepest and most well defined, being 22 km. in length with an eastern boundary of truncated spurs separated by snow-filled cirques and a western boundary of snowfields and ice falls in its upper section and vertical dolerite cliffs near its mouth. Goldsmith Glacier is the longest of the three, being of the order of 30 km. The upper part is bounded by small ice falls and hills which diminish in size southwards, the lower part by generally rising ground and a few small nunataks.

"Southern Glacier" is small by comparison, being about 12 km. in length with an ice fall half-way down. It is bounded by Mount Faraway to the west and by nunataks and ice falls to the east. The ice divide on the plateau is set back some distance from the frontal line of cliffs. Snowfields south of the divide drain towards Slessor Glacier and the Filchner Ice Shelf, while those north of the divide drain into glaciers of the Theron Mountains.

ICE-SURFACE REGIME

Accumulation

Table I shows the mean value of the snow accumulation measured at several stakes in each of a number of areas over various periods. Where accumulation over the winter period was not measured, it has been estimated on the basis of the ratio of winter to summer accumulation observed in an area around 35 km. north of stake 18. The prevailing north-east wind, which appears from measurements of sastrugi height and direction to extend about 25 km. north of the range, gives way to an area of comparative calm. The considerable increase in accumulation at this distance may be due to a lessening of surface deflation by wind.

Ablation

The bare-ice ablation areas are shown in Fig. 1. These lie close to areas of exposed rock where localized warming of the surrounding air is marked. Considerable deposits of rock dust found nearby indicate that it is one of the factors causing local ablation. Dust was found about 400 m. from the cliffs and it extended at intervals over the whole length of the range.

There are pronounced snow ridges at the confluence of Jeffries Glacier and the ice stream into which it flows. Bare ice was found on the crests and north-facing slopes while there was snow in the valleys between the ridges. Simultaneous measurements of air temperature and wind speed (Table II) were taken on the bare ice and on the snow to see whether significant differences were present that could contribute to the ablation. Observations were made 30 cm. above the surface on a typical sunny, windy day.

The 20 per cent increase in wind velocity on the crest and the slightly higher air temperature indicate that these are contributory factors affecting ablation on the crests and slopes of the ridges. The bare-ice parts of the ridges, however, are found on north-facing slopes of about 5°; aspect may therefore be of greater significance to the ablation than are wind speed and air temperature.

Ice Movement

Aluminium alloy stakes were drilled into the three glaciers and into the ice stream at the foot of the mountains (Fig. 1). Stake positions were determined by intersection or resection using rock control points. Angles were measured with a Tavistock theodolite to a mean square

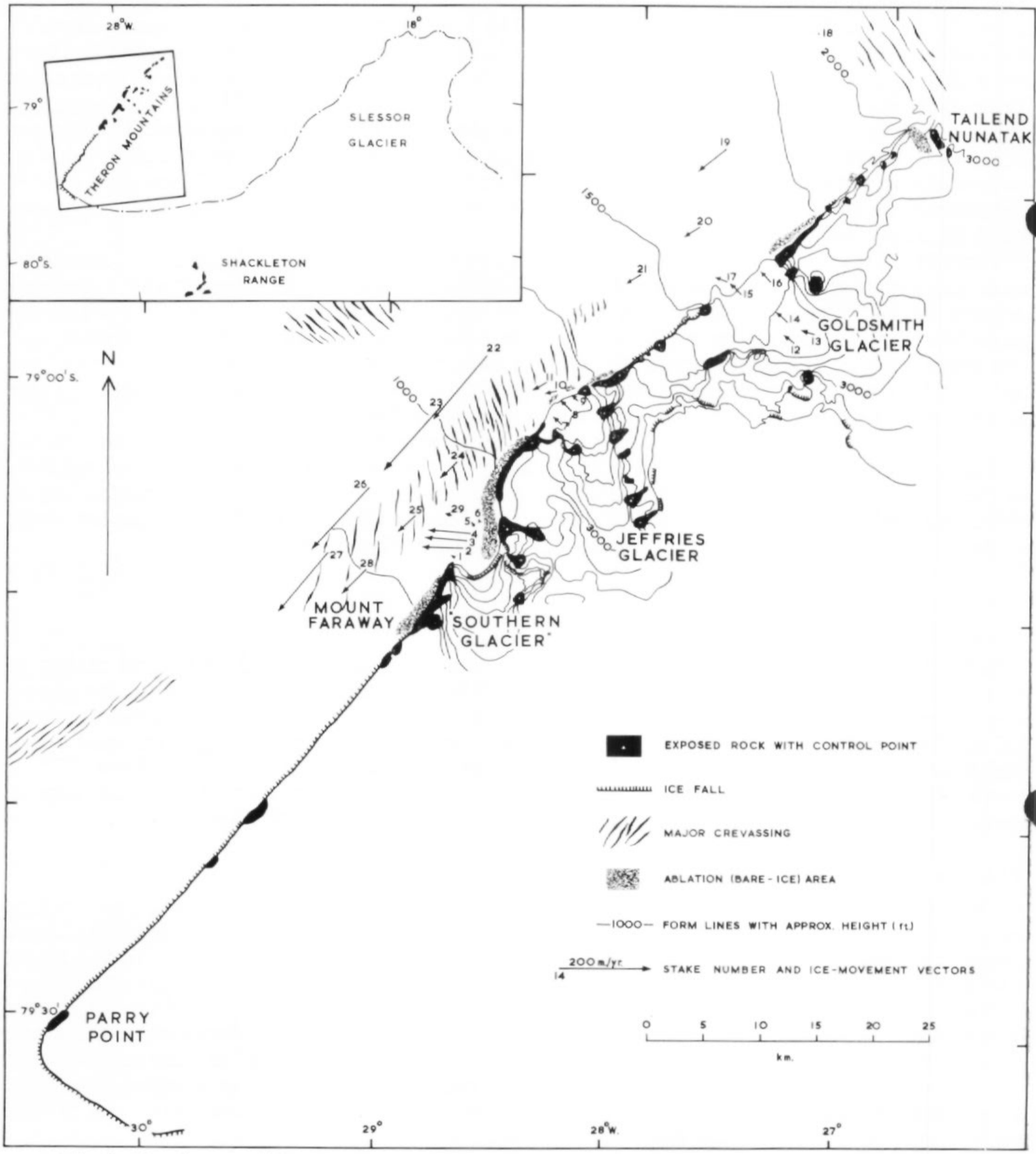

Fig. 1. Sketch map of the Theron Mountains, showing the amount and direction of ice movement.

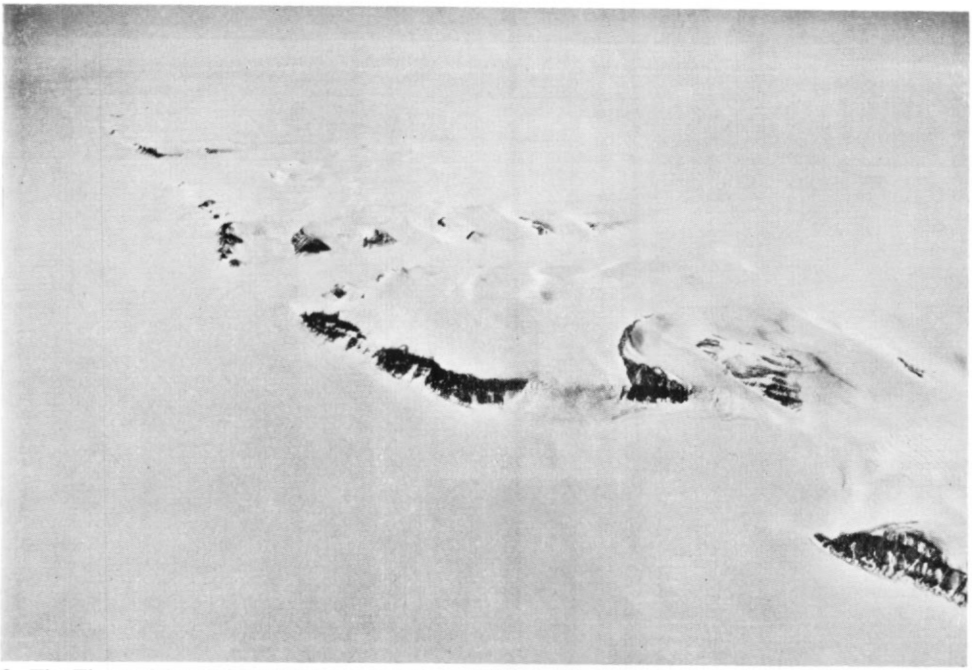

Fig. 2. The Theron Mountains; air photograph from 8,000 m. above sea-level, facing east. "Southern Glacier" is at the lower right. (Photograph by U.S. Navy for U.S. Geological Survey.)

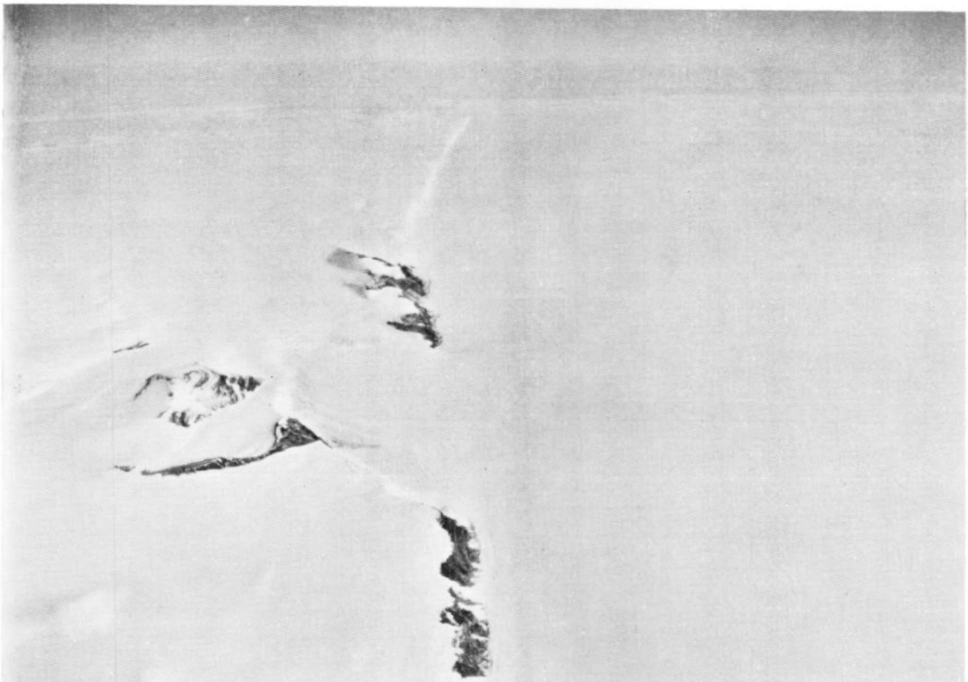

Fig. 3. The western end of the Theron Mountains; air photograph from 8,000 m. above sea-level, facing south-west. "Southern Glacier" is at the left centre and Parry Point is at the distant end of the escarpment. (Photograph by U.S. Navy for U.S. Geological Survey.)

TABLE I. NET ACCUMULATION (cm. snow)

Area	Observed			Estimated
	December 1966 to February 1967	*December 1966 to November 1967*	*February to November 1967*	*February to November 1967*
Stake 28	—	14	—	11
"Southern Glacier"	—	—	13	
Stake 24	—	11	—	9
Stake 11	—	19	—	15
Lower Jeffries Glacier	—	—	20	
Mid Jeffries Glacier	—	36	—	28
Upper Jeffries Glacier	—	50	—	39
Stake 21	—	—	15	
Lower Goldsmith Glacier	—	22	—	17
Mid Goldsmith Glacier	—	22	—	17
Stake 18	—	15	—	12
6 km. north of stake 18	3	14	11	
32 km. north of stake 18	10	46	36	

error of ±4 sec. of arc. Resections were calculated on the University of Cambridge "Titan" computer. To assess the accuracy of the method, the geographical coordinates of four of the rock control points were chosen and one of these was treated as a resected point. The spread of these points was such that they formed the largest possible triangle so that errors in converting from geographical to plane coordinates would be a maximum. The difference, in this case, between surveyed and computed coordinates was 10 cm. As far as possible, resections were re-observed using the same control points. In some cases this was not possible as some rock cairns had fallen during the intervening winter. Where this occurred a check with a fourth point was made. The distance between the two resected positions was in no case greater than 25 cm.

TABLE II. SIMULTANEOUS WIND-SPEED AND AIR-TEMPERATURE MEASUREMENTS

On crest		*In valley*	
Wind speed (m./sec.)	*Air temperature* (°C)	*Wind speed* (m./sec.)	*Air temperature* (°C)
8·5	−12·2	7·9	−12·4
9·0	−12·3	7·0	−12·4
9·6	−12·3	7·3	−12·5
9·6	−12·3	7·4	−12·6
8·2	−12·3	7·3	−12·6

The observed ice movements and directions of movement are given in Table III, and they are also plotted in Fig. 1.

TABLE III. OBSERVED ICE MOVEMENT TOGETHER WITH ESTIMATED ERRORS

Stake number	*Movement* (m./yr.)	*Direction**
1	5·4±1·4	289°
2	89·5±1·4	273°
3	89·9±1·4	275°
4	89·8±1·4	275°
5	11·0±1·4	328°
6	7·2±1·4	357°
7	20·1±0·9	318°
8	30·2±0·9	321°
9	16·5±1·4	315°
10	22·5±1·4	265°
11	30·5±0·9	241°
12	25·5±1·6	308°
13	30·8±1·6	286°
14	29·8±1·6	314°
15	23·4±0·9	318°
16	26·4±1·4	320°
17	23·4±1·4	290°
18	Not observed	
19	80·8±0·9	222°
20	38·7±0·9	238°
21	34·7±0·9	238°
22	175·4±0·9	220°
23	181·9±0·9	222°
24	74·1±0·9	224°
25	51·9±0·9	228°
26	183·0±0·9	224°
27	169·1±0·9	220°
28	48·8±0·9	224°
29	12·4±0·9	288°

* In each case ±2°.

Conclusion

The ice flowing from the valley glaciers does not noticeably increase the rate of movement of the ice stream at the foot of the range. No strand cracks were seen and it is not known at what point the ice stream joins the Filchner Ice Shelf. Snow accumulation at the foot of the range during a 12-month period in 1966–67 was about 15 cm. Lichen coverage was sparse and no trim lines were seen to indicate former ice levels. Comparison between photographs taken in 1958 by the Trans-Antarctic Expedition and those taken in 1967 by the U.S. Navy show identical features, indicating no change in the position of the ice margin during this period.

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