SOME ASPECTS OF THE TOPOGRAPHY AND GLACIERIZATION OF ADELAIDE ISLAND

By G. J. DEWAR

ABSTRACT. Some features of the topography and glacierization of Adelaide Island are described, and particular attention is given to planed surfaces occurring at three main levels. Planed surfaces at the intermediate level, between 2,400 and 3,250 ft. (730 and 990 m.) a.s.l., have not previously been described on the Antarctic Peninsula, although ones similar to the high planed surfaces on the mountain summits, and the low ones inferred below coastal ice piedmonts, have been mentioned by many previous authors. The origins of the platforms at all three levels are discussed, and it is suggested that those at intermediate levels are parts of the one inferred below the Fuchs Ice Piedmont which have been elevated in an episode of block-faulting. Evidence that block-faulting has taken place has been found on Adelaide Island. The origin of the low platforms is not known, but the origins proposed by Holtedahl (1929) and Fleming (1940) are compared. Some of the evidence found on Adelaide Island seems to suggest that the ice piedmonts have not cut strandflat platforms in the manner suggested by Holtedahl.

WHILE the geology of Adelaide Island was being investigated in 1961–63, the writer was able to make some observations on the topography and glacierization of the island. The topography was found in part to reflect the structure of the rocks which lie beneath the thick snow cover masking much of the area. Adelaide Island (Fig. 1) extends approximately between lat. 67°45′ and 69°40′S. and between long. 67°40′ and 69°00′W.; its length is about 87 miles (140 km.) and it has a maximum width of about 25 miles (40 km.). The island is one of the largest close to the western coast of the Antarctic Peninsula and it is elongated parallel to it. Although the area of the island is approximately 1,430 sq. miles (3,700 km.^{2}), it is separated from the nearest part of Graham Land by only a narrow steep-walled channel (The Gullet) at the northern end of Laubeuf Fjord. A high mountain chain forms much of the eastern coast of the island, but its western side is covered by the Fuchs Ice Piedmont which extends north of the mountains as an ice cap with a gently undulating surface penetrated only by four widely spaced nunataks. A comparatively narrow ice foot fringes the mountainous eastern coast but it broadens to a small ice piedmont on Square Peninsula between Ryder Bay and Stonehouse Bay (Fig. 1).

THE MOUNTAINS AND THE VISIBLE PLANED SURFACES

The mountain range on the eastern side of Adelaide Island is 50 miles (80 km.) long and it has a maximum altitude of about 9,190 ft. (2,800 m.) (Mount Gaudry). It is completely divided only by the steep-walled valley of Shambles Glacier, which flows eastwards into Stonehouse Bay from the central part of the Fuchs Ice Piedmont; this range is also almost completely divided in the south by the valley of Sloman Glacier. To the north and south of the valley of Shambles Glacier, which is 10 miles (16 km.) wide, the steep and markedly linear walls of the range (Fig. 2) rise from the eastern and southern coasts and from the Fuchs Ice Piedmont; they have been locally embayed by cirque formation. A very few isolated nunataks have survived the erosion in the cirques but, except on Square Peninsula, no nunataks occur outside the former straight lines of the mountain walls.

The summits of the mountains are mostly over 5,580 ft. (1,700 m.) a.s.l. They are in many cases the local high points of gently undulating platforms (Figs. 3–7) on which accumulated snow forms ice caps which are the sources of frequent avalanches on both sides of the range (Figs. 3 and 4). These surfaces, which contrast with the steep mountain walls, have a low relief with rounded summits that are exceptionally up to about 1,475 ft. (450 m.) above their general level. They are similar to descriptions (Holtedahl, 1929; Nichols, 1960; Linton, 1964, figs. 7–11) of the high plateau on the mountainous central spine of Graham Land, which rises from just over 3,280 ft. (1,000 m.) a.s.l. in northern Graham Land to 6,560–8,860 ft. (2,000–2,700 m.) a.s.l. south of the latitude of Adelaide Island (Nichols, 1960, p. 1423).

Three extensive flat-lying areas on the western sides of the mountains form steps backed by the mountain walls and fronted by their steep linear boundary scarp walls, which descend to the Fuchs Ice Piedmont. Two of the platforms with well-preserved scarp walls are west of Mount Mangin (Fig. 7) and Sloman Glacier (Fig. 5); their snowy surfaces slope very gently

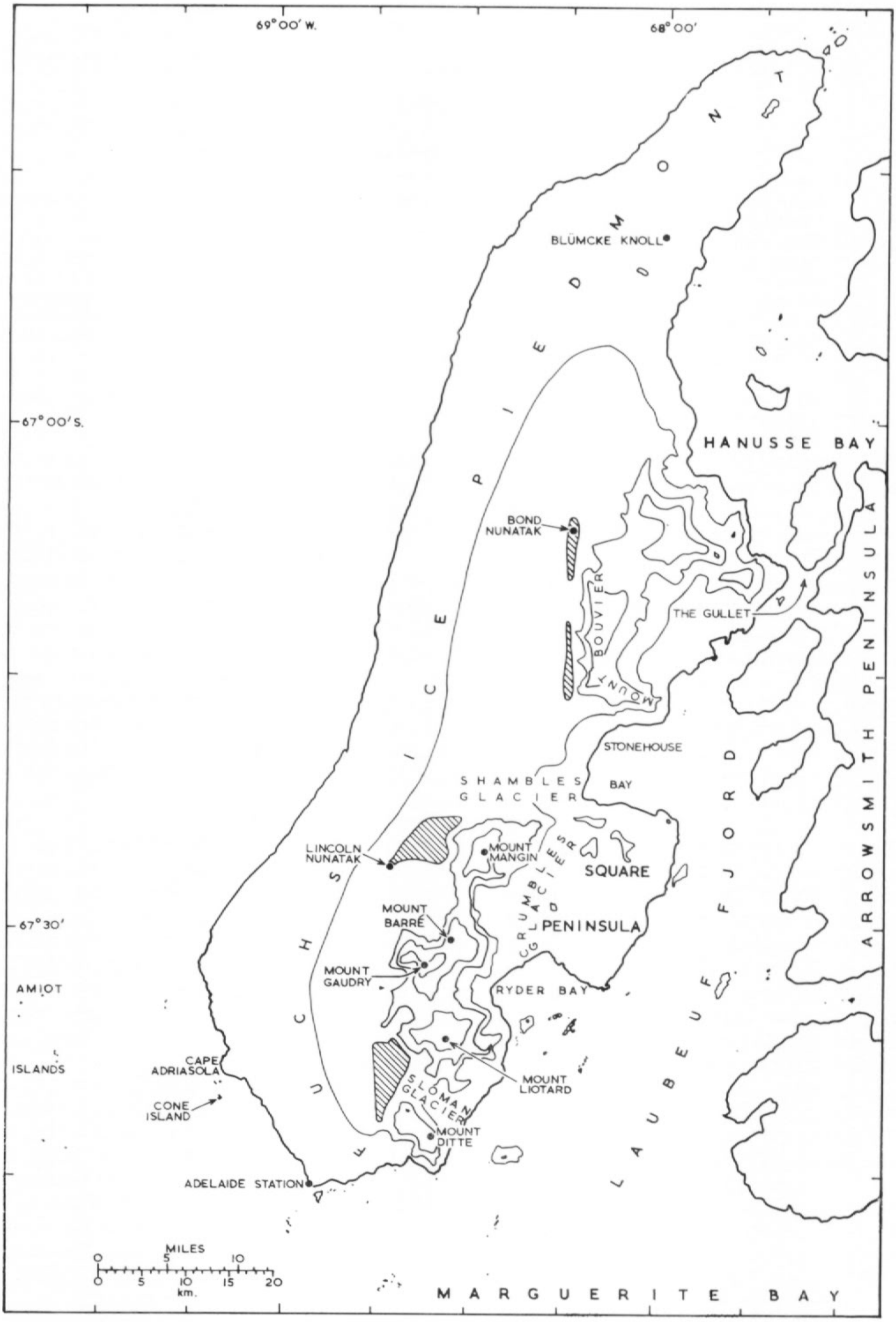

Fig. 1. Sketch map of Adelaide Island showing the positions of topographic features mentioned in the text. The shaded areas are the planed surfaces between 2,400 and 3,250 ft. (730 and 990 m.) a.s.l. The contour interval is 1,640 ft (500 m.).

Fig. 2. Aerial view of the western side of Mount Bouvier from the north-west. The scarp on the western side of Bond Nunatak (foreground) is on the same straight line as the ends of the western ridges of Mount Bouvier. The largest ridges have planed summits, particularly the most southerly one (in the distance at the right). A high platform east of the summit of Mount Bouvier is just distinguishable (upper left centre) behind the summit of the mountain. There is a pronounced hollow in the surface of the Fuchs Ice Piedmont immediately west of Bond Nunatak.

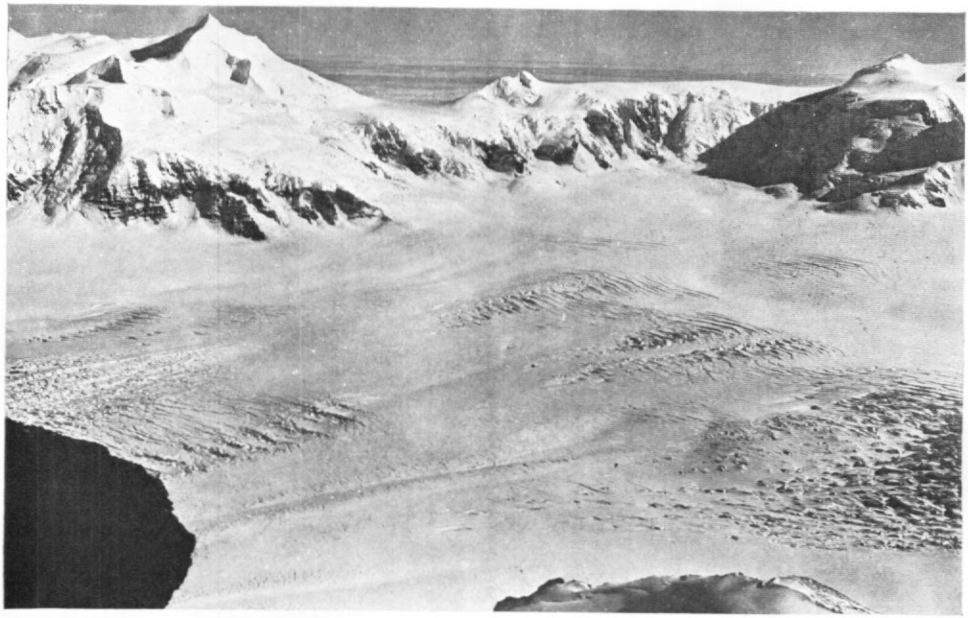

Fig. 3. Oblique air photograph of Mount Barré (upper left) and southern Mount Mangin from the east. Near the mountain summits are distinct platforms (upper left and centre) which are at almost the same altitude. The large cirque in south-eastern Mount Mangin (right centre) is thought to have been cut into the fault scarp of the mountain walls, on the left and right sides of the photograph. Avalanche debris is piled below the mountain walls (left). Crevasses in the surface of Crumbles Glacier, which flows into Ryder Bay (lower left) show that most of the ice movement takes place in ice streams.

Fig. 4. Detail view from the air of the back of the large cirque and the flat-lying surface on southern Mount Mangin; these features are also visible in Fig. 3. The photograph shows the sharp transition between the ice-covered platform and the steep mountain walls, on which exposures are of massive volcanic rocks. Disturbed snow near the foot of the walls shows where avalanches have fallen from the mountains.

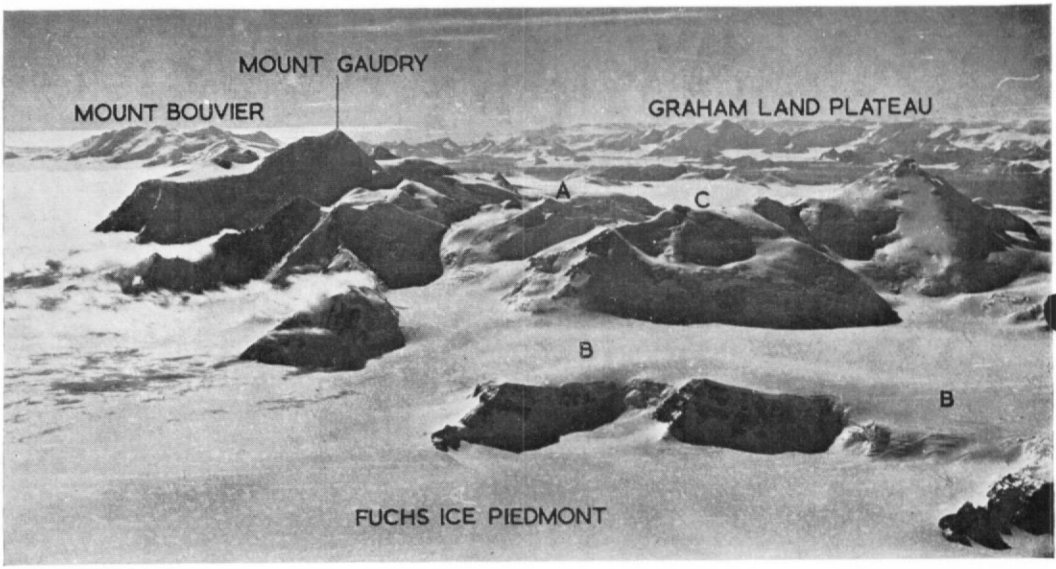

Fig. 5. Oblique air photograph from the south-west, showing planed surfaces close to and east and west of the summit of Mount Gaudry. Another extensive high planed surface (A) is on eastern Mount Barré (Fig. 3). In the foreground, the scarp west of Sloman Glacier separates the Fuchs Ice Piedmont from a flat-lying slightly higher surface (B). Ice falls emphasized by windscoops indicate the southward flow of the Fuchs Ice Piedmont past the small ridges on the scarp. In the background are the Mount Bouvier massif, the ice piedmont on Square Peninsula (C) and the plateau surface and the mountains of Graham Land.

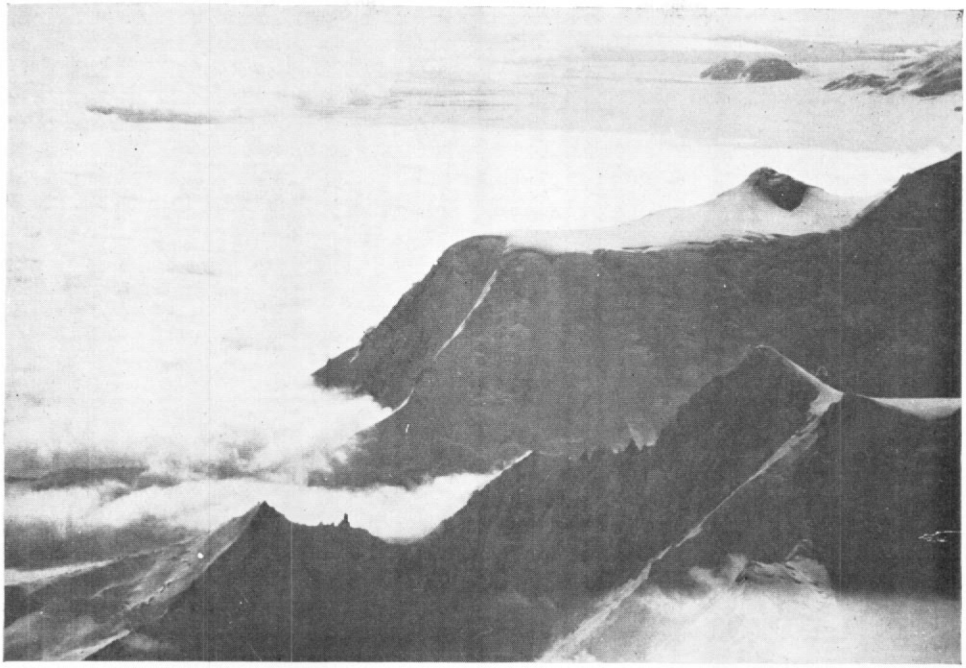

Fig. 6. Air photograph from the south of the high platform west of the summit of Mount Gaudry; the direction of view is similar to that of Fig. 5. The contrast in relief between the mountains and the Fuchs Ice Piedmont is well shown. Low cloud covers most of the Fuchs Ice Piedmont but Bond Nunatak and western Mount Bouvier are visible at the upper right. The peak and ridge in the foreground are of granodiorite which has weathered to *aiguilles*, and these are clearly visible in this photograph.

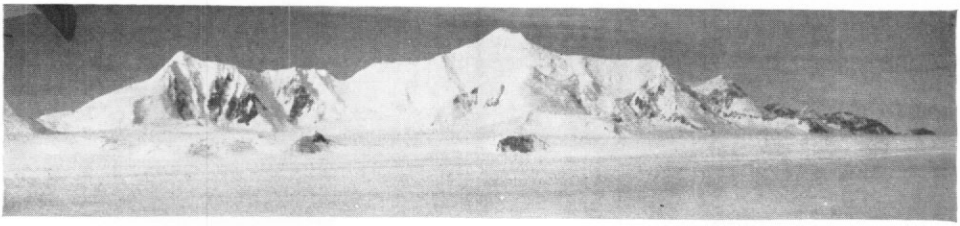

Fig. 7. Oblique air photograph of Mount Gaudry (centre) and Mount Barré (upper left), showing the high platforms on Mount Gaudry. The scarp west of Mount Mangin (nunataks, centre) separates the uniform surface of the Fuchs Ice Piedmont (foreground) from a similar higher surface close to the mountains. The line of the scarp continues southwards in the collinear ends of the western ridges of the mountains, and it extends to the scarp west of Sloman Glacier (extreme right).

eastwards towards the mountains. The third platform is deeply eroded but it is clearly exposed in the planar ends of remnant ridges west of Mount Bouvier (Fig. 2). This platform appears to be essentially horizontal. The platforms west of Mount Bouvier and Mount Mangin are erosion surfaces; the former is cut discordantly across gently dipping strata and the latter is cut into intrusive rocks. Although the platform west of Sloman Glacier (Fig. 5) is extensive, it may have been formed by erosion down to a single bedding plane. Because its surface slope is very close to that of the dip of the underlying bedded rocks, it may merely simulate a gently tilted surface of planation.

The Ice Piedmonts and the Inferred Planed Surfaces

The Fuchs Ice Piedmont, which extends for the whole length of Adelaide Island on its western side, is from 2 to 10 miles (3 to 16 km.) wide in different areas, and it is about 900 sq. miles (2,300 km.^{2}) in area. Its snow surface rises towards the mountain walls from its terminal ice cliffs on the southern and western coasts of Adelaide Island (Fig. 8), and it reaches 2,855 ft. (870 m.) a.s.l. near Bond Nunatak. Its maximum overall gradient is about 1 : 20 west of Lincoln Nunatak. The ice piedmont on Square Peninsula is comparatively small, because the whole peninsula is only about 100 sq. miles (250 km.^{2}) in area and nunataks fringe its northern and southern coasts. These nunataks rise to about 1,640 ft. (500 m.) above the snow surface. The ice piedmont is mostly contained between these coastal nunataks; it descends to the coast of Laubeuf Fjord with an overall gradient near to 1 : 28 from about 1,475 ft. (450 m.) a.s.l. near Mount Mangin.

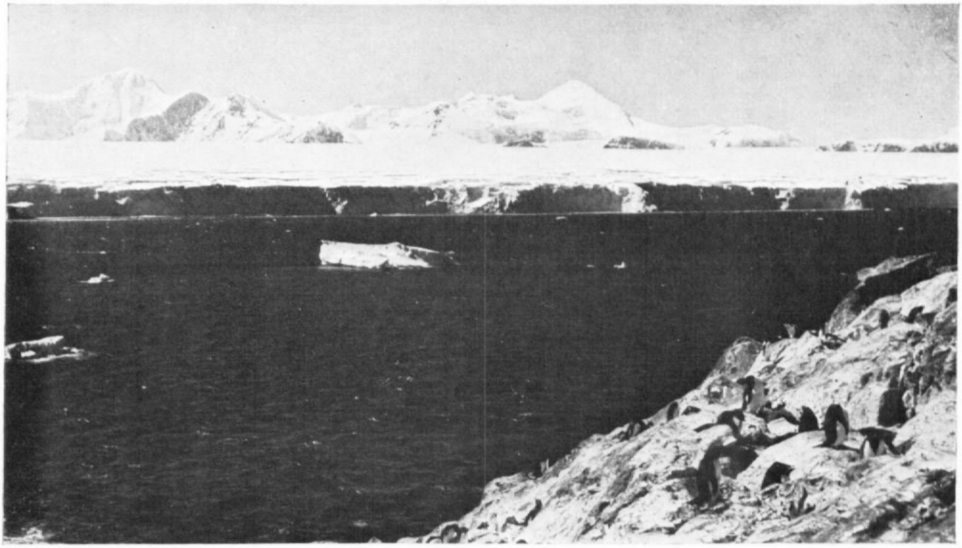

Fig. 8. View to the east-north-east from the summit of Cone Island towards Adelaide Island. Mount Gaudry (left), Mount Liotard (centre) and the flat-topped scarp west of Sloman Glacier (right) show above the Fuchs Ice Piedmont and its terminal ice cliffs.

The terminal ice cliffs of the ice piedmonts are generally parallel to their mountainous headwalls (Fig. 1). Those on the west coast of Adelaide Island (Fig. 8) were estimated correctly by Charcot (1910, p. 87) as being near to 100 ft. (30 m.) in height, but the cliffs on other coasts are lower and locally pass into ice ramps where the ice, landward of coastal reefs, is nearly stagnant. Rock exposures are visible in places below the ice cliffs of the southern and eastern (Laubeuf Fjord) coasts, where raised beaches and platforms show that the land has been elevated relatively recently, but such exposures have not been found elsewhere. The wastage of the ice cliffs in the calving of icebergs from them is balanced to some extent by outward movement of the piedmont ice (p. 43).

The surfaces of the ice piedmonts are not uniformly convex nor planar, but they show quite pronounced swells and hollows. These are found not only near the mountains but also at some distance from them. Often, but not invariably, swells occur opposite the ridges on the mountains, suggesting that the ice-surface relief may reflect the sub-ice topography to a certain extent (Holtedahl, 1929, p. 122). Such surface relief, however, has been observed on much thicker ice masses such as the Antarctic Ice Sheet, where the sub-ice topography bears no relationship to the ice-surface contours. The ice piedmont on Square Peninsula has a more pronounced relief than the Fuchs Ice Piedmont (see above).

Regime

The snow which feeds the ice piedmonts on Adelaide Island comes from mountain-valley glaciers, avalanching down the mountain walls (Figs. 3 and 4) and the high annual precipitation received by the area (Bryan, 1965). Precipitated snow is the only source of nourishment of the northern ice cap. The high precipitation was initially suspected because sledge travel was constantly hampered by deep soft snow, and it has been confirmed subsequently by the digging of pits at a number of places on the island. 4·85 m. of semi-compacted snow (1,965 mm. water equivalent) were found in October 1962 overlying the layer of ice formed on the snow surface during the previous summer at Blümcke Knoll. The highest average annual precipitation known from records in Graham Land appears to be 1,169 mm. water equivalent at the Argentine Destacamento Melchior off Anvers Island (Schwerdtfeger and others, 1959).

The high annual accumulation does not appear to be seasonal. It has made the surface of the Fuchs Ice Piedmont almost completely free from visible crevasses above the 820 ft. (250 m.) contour, which roughly coincides with the firn line. The only crevasses visible close to the mountains are the largest ones formed where valley glaciers flow into the ice piedmonts, and all of them are at least partially filled by drifted snow (Fig. 4). Many wide crevasses at lower altitudes have been exposed by melting of accumulated snow in times of unusually high average temperature.

On the Fuchs Ice Piedmont south of the latitude of Cape Adriasola, accumulation is lower than elsewhere. On this part of the ice piedmont, snow brought by the prevailing northerly winds appears to drift down the lee slope into Marguerite Bay. Surfaces on the southern end of the Fuchs Ice Piedmont tend to be more icy and melting of snow is noticeable in summer. In the extreme south, a glacier flowing westwards from Mount Ditte has talus exposed on its surface each summer and it appears to have a negative budget. The regime of the southern end of the Fuchs Ice Piedmont might be compared with that of the Marr Ice Piedmont (Holtedahl, 1929) on the west coast of Anvers Island which probably suffers more intense ablation than Adelaide Island because it is farther north. The northern part of the Fuchs Ice Piedmont, where snow accumulation is very rapid and surface talus has not been found, is probably more similar to the Marr Ice Piedmont when it was more widespread in former times of more intense glacierization.

Thickness and ice movement

A thickness of up to 490 ft. (150 m.) of ice must be actively moving outwards near the western terminal ice cliffs of the Fuchs Ice Piedmont and the northern ice cap, because sea depths up to 195 fathoms (120 m.) have been recorded close to them. However, the ice piedmont is believed to be considerably thicker farther inland, because ablation is much more pronounced at low levels. That the ice is moving is shown by the presence of minor ice falls round the ends of rock ridges near the southern end of the Fuchs Ice Piedmont, the obvious movement of the moraine-covered ice stream west of Mount Ditte and the frequently observed calving of icebergs from the terminal cliffs. Crevasses visible near the coasts (Fig. 3) show that outward movement occurs predominantly in ice streams flowing between slower-moving ice masses to the terminal ice cliffs. These ice cliffs show neither promontories nor embayments at the ends of the ice streams. The ice piedmont on Square Peninsula moves in the same way but its lower terminal ice cliffs show that it is probably not as thick as the Fuchs Ice Piedmont. Holtedahl (1929, p. 14) has suggested that the Marr Ice Piedmont of Anvers Island in its present state probably rests everywhere on bedrock, and soundings made off south-western Adelaide Island show that this is also substantially true of the southern part of the Fuchs Ice Piedmont. Holtedahl (1929, p. 28) has suggested that the Marr Ice Piedmont was once more extensive, and that it may at that time have been supported by the sea in places. That the Fuchs Ice Piedmont was once thicker and more extensive is shown by the evidence given in Table I.

Sub-ice topography

The rock surfaces below the ice piedmonts of Adelaide Island must have topographic reliefs which are insignificant compared with that of the mountain chain. The ice piedmonts and the northern ice cap are believed to mask planed surfaces (Holtedahl, 1929). These sub-ice surfaces are thought to slope away from the mountains less steeply than the upper surfaces of the ice piedmonts, which are thought to be thicker in inland areas.

TABLE I. EVIDENCE FOR THE RECESSION AND DIMINUTION IN THICKNESS OF THE FUCHS ICE PIEDMONT

Location	*Evidence*
South-western Mount Liotard; scarp west of Sloman Glacier	Ice-smoothed walls well above the surface of the ice piedmont
Bond Nunatak	Striae 400 ft. (122 m.) above the ice-piedmont surface
Cone Island (2 miles (3·2 km.) distant from the terminal ice cliffs of the Fuchs Ice Piedmont)	Striae on island summit 147 ft. (45 m.) a.s.l.; Fig. 9
Islets around south-western Adelaide Island, including Amiot Islands 11 miles (17·6 km.) offshore	Typical glaciated surfaces; "strandflat" topographies

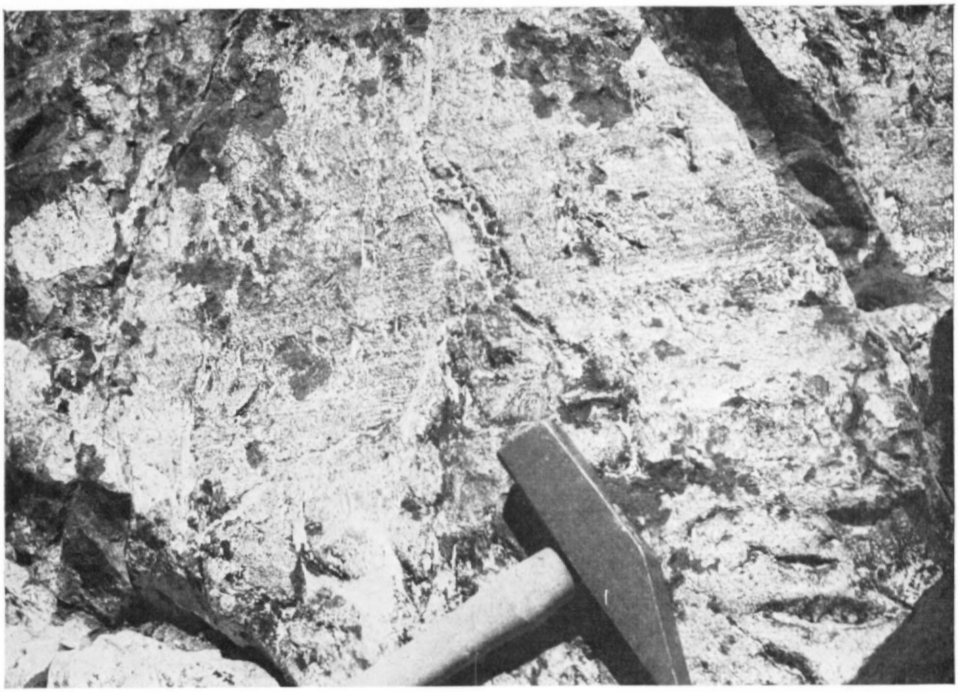

Fig. 9. Glacial striae and a chattermark cut into the flat surface of fine-grained massive volcanic rock on the summit of Cone Island at 147 ft. (45 m.) a.s.l. The head of the hammer is 8 in. (20 cm.) long.

The unpublished results of hydrographic survey work indicate that the sea bed off south-western Adelaide Island is very uneven in detail. Low hummocky bedrock masses are separated by rough shallow channels that may have been cut by ice moving preferentially along ice streams in the Fuchs Ice Piedmont which once covered this surface. Near the Adelaide scientific station, where there are many low islands near the shore, the local relief is up to 245 fathoms (150 m.); near Cone Island it is over 410 fathoms (250 m.); and 6·2 miles (10 km.) from the coastal ice cliffs near Cone Island, the presence of a deep steep-walled trench raises the local relief to over 985 fathoms (600 m.). Wide tracts of the sea bed, although they are uneven, are generally at depths of 165–330 fathoms (100–200 m.), so that the rock surface here and probably the one still covered by the Fuchs Ice Piedmont appear to have been planed at least as thoroughly as those below the ice piedmont on Square Peninsula (p. 42) (off which no soundings have been made) and below the ice caps on the high and low platforms on the mountains (p. 37). The sub-ice topographies of the mountain platforms are seen only in cliff sections (Figs. 3–7). Topographies similar to that below the sea off south-western Adelaide Island have been described by Holtedahl (1929, p. 146) in his discussion of exposed mature strandflats up to 6·2 miles (10 km.) in width in Scandinavia.

FORMATION OF THE PLANED SURFACES

The preceding descriptions of the topography known from exposed rocks and inferred below snow cover on Adelaide Island show that planed surfaces occur at three distinct levels:

i. On the mountain summits at heights ranging approximately from 4,900 to 5,900 ft. (1,500 to 1,800 m.) a.s.l.
ii. On the western sides of the mountains between 2,400 and 3,250 ft. (730 and 990 m.) a.s.l.
iii. Below the ice piedmonts at heights which are unknown but which range at most from −390 to 1,640 ft. (−120 to 500 m.) a.s.l. The sub-ice surfaces are thought to be planar and generally near to sea-level, or to slope very gently away from the mountains.

Effect of block-faulting on the lowest planed surfaces

The most facile explanation for the occurrence of planed surfaces at three different levels on Adelaide Island is that they have been differentially uplifted by faulting from a single planed surface. Block-faults with substantial throws surround the mountains of Adelaide Island and they have been mapped during the geological investigation of the island. They trend parallel to the almost linear mountain walls (p. 37) and they are marked especially by the steep scarp faces west of Mount Bouvier, Mount Mangin and Sloman Glacier. This block-faulting is thought to have been instrumental in the elevation of the mountains relative to the surrounding terrain, and it has been reported in other parts of the Antarctic Peninsula (Stephenson and Fleming, 1940; Goldring, 1962; Hooper, 1962; King, 1964; Curtis, 1966).

This explanation for the occurrence of planed surfaces at these different levels is not sufficient, however, because it is known that the surfaces between 2,400 and 3,250 ft. (730 and 990 m.) a.s.l. have not been very greatly displaced relative to the mountains and to the planed surfaces on the mountain summits. The rocks exposed on the scarp faces west of these terraces can be correlated with those at similar heights on the mountain walls nearby. These correlations indeed suggest that at least part of the platform west of Mount Bouvier has been elevated relative to the mountain through a height of 1,970–2,950 ft. (600–900 m.). The platform west of Sloman Glacier is not thought to have been displaced at all. The one west of Mount Mangin is cut into intrusive rocks only, and correlations cannot be made between the rocks forming its scarp and those of adjacent exposures on the mountain.

Block-faulting is, however, thought to be responsible for the situation of the planed surfaces between 2,400 and 3,250 ft. (730 and 990 m.) a.s.l., because there is evidence that both the surfaces and the mountains have been faulted upwards relative to the sub-ice platform beneath the Fuchs Ice Piedmont. These terraces are in fact believed to be parts of the planed surface which underlies the ice piedmont (p. 43) and that they have been elevated by the block-faults which partially elevated the mountains. The height through which the terraces and the mountains have been elevated can only be guessed, because it is dependent on the height of the planed surface below the Fuchs Ice Piedmont close to the mountains. If the platforms beneath the ice piedmonts are horizontal, the elevation would be of the order of the heights above sea-level of the terraces, i.e. 2,400–3,250 ft. (730–990 m.), but if it slopes away from the mountains the elevation must have been less than this. It was greater than 985 ft. (300 m.), because the exposed scarp walls are of this height in places.

Because the planed surfaces at intermediate levels are considered as originally being parts of that below the Fuchs Ice Piedmont, only two of the surfaces listed at three levels need be considered in a discussion of the origin of the flat-lying platforms. The planed surfaces on the summits of the mountains must be regarded as having an origin different from those below the ice piedmonts, because the two types are believed to have been formed at levels which differ by at least 3,280 ft. (1,000 m.). The highest surfaces have not been faulted up from the lower ones.

Formation of the highest surfaces

Other writers have discussed the origin of the high plateau of Graham Land which is similar in form and height to the planed surfaces on the mountain summits of Adelaide Island. Nichols (1960) and Linton (1964) have agreed with Holtedahl (1929) that the mid- to late Tertiary surface is a peneplain with a rolling topography which has been cut into all the rocks that crop out on it. It is not a surface of deposition. It has also been suggested that the plateau is an uplifted plain of marine denudation, a surface of cryoplanation (Peltier, 1950) or a strandflat (Holtedahl, 1929).

Formation of the sub-piedmont surfaces

It is believed that the planed surfaces at intermediate levels on the western sides of the mountains of Adelaide Island have been faulted upwards from a planed surface beneath the Fuchs Ice Piedmont (p. 45). The origin of the sub-piedmont surfaces of the island should therefore be the same as that of the terraces at intermediate levels.

Holtedahl's theory of strandflat formation. Holtedahl (1929, p. 17), after investigating the Marr Ice Piedmont of Anvers Island, proposed that the masses of foreland glacier ice on the exposed coasts of Graham Land are strandflat glaciers that have cut and are cutting planed surfaces (strandflats) at a level controlled by the sea. He regarded the Marr Ice Piedmont, the Fuchs Ice Piedmont and, on Alexander Island, the Handel and Mozart Ice Piedmonts as mature strandflat glaciers which have eroded all nunataks they may have surrounded, and have almost completely cut away their mountain headwalls in areas such as northern Adelaide Island. The strandflats were not cut on the less-exposed coasts, because the fjords were filled by stagnant ice whose full cutting power was not developed. Hooper (1962, p. 5) has agreed that this mechanism formed the skaergaard islands around the Marr Ice Piedmont and the planed surface below it.

Fleming's theory of ice-shelf margins. In a discussion of the "fringing glacier" or ice foot found on most of the coast of western Graham Land, Fleming (1940) concluded that it is the land-supported margin of a coastal ice shelf, the sea-borne part of which has broken up and been lost from the area in comparatively recent years. He considered that the thick ice caps on many of the smaller islands on which fringing ice cliffs are comparable to those of the fringing glaciers were once also continuous with this ice shelf, and he proposed that the extensive ice piedmonts on the islands west of the Antarctic Peninsula formed a land-supported part of the ice shelf. Fleming did not explain the platforms at sea-level on which the fringing glaciers and ice piedmonts rest, but he concluded that they had a glaciated origin, because subaerial and marine processes were not competent to form them in Graham Land. He disagreed with Holtedahl's proposed theory, because he found no evidence that the fringing glaciers eroded their own platforms; indeed, they have been found (Fleming, 1940, p. 98) resting on, but not eroding, unconsolidated beach deposits. Also, englacial moraine is never visible in ice-cliff sections of fringing glaciers, even where bedrock is visible between the ice and the sea.

Application of Holtedahl's and Fleming's theories to Adelaide Island. Some observations made on Adelaide Island seem to indicate that Holtedahl's theory of strandflat formation may not completely explain the occurrence of widespread planed surfaces below the ice piedmonts of the island, although it is the most comprehensive theory so far proposed. Just as Fleming observed no englacial moraine in ice piedmonts moving over their platforms, none was observed in the ice of the piedmonts of Adelaide Island where they could be studied resting on rock surfaces. There is no direct evidence that the ice piedmonts are eroding the rock on which they rest, and this is also true of the higher platforms on which the erosional process can be more easily studied. The ice cover is believed to be predominantly protective at all levels (Linton, 1964, p. 64) except possibly beneath major ice streams. According to Holtedahl and others, the plateau of Graham Land and the high platforms on the mountains are thought to have formed before the planed surfaces at lower levels, and hence they must have been protected while the lower platforms were being cut. If the origin suggested by Holtedahl for the surfaces beneath the ice piedmonts is correct, this then means there are great differences in the cutting powers of moving ice at different altitudes. Koerner (1964) has suggested that the ice piedmonts of northern Graham Land rest on pre-glacial pavements, because he considered that the regular linearity of the mountain walls behind the ice piedmonts could not have been produced by a strandflat-cutting glacier which had eroded its pavement for as great a distance as 6·2 miles (10 km.) from the coast. The Fuchs Ice Piedmont is up to 10 miles (16 km.) wide in places (p. 41) and this point is therefore even more significant.

The flat-lying rock surface which underlies the ice piedmont on Square Peninsula is unlikely to be a strandflat, because its situation is one where it would be unlikely for a strandflat to be formed if Holtedahl's theory is correct. According to Holtedahl (1929, p. 20), during the most intense period of glacierization of the Adelaide Island area, Laubeuf Fjord was covered by a great thickness of comparatively immobile ice, which was later reduced to deep-cutting valley glaciers. Therefore, at no time during this glacierization would the accumulated ice be able to cut a strandflat surface on Square Peninsula.

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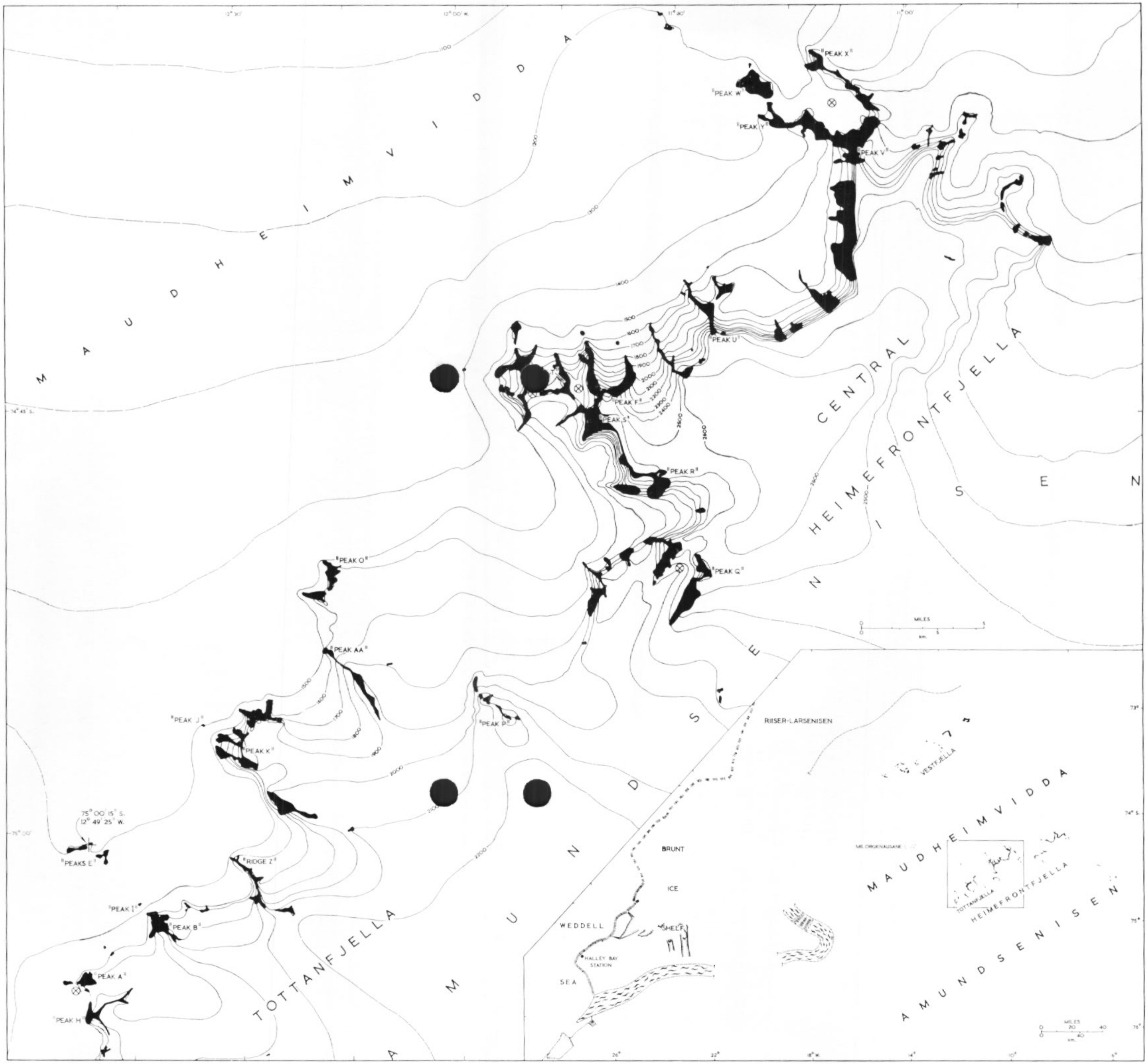

Fig. 1. Topographical sketch map of Tottanfjella and the central block of Heimefrontfjella, showing the position of the first sun-fix, the physiography and place-names. The contour interval is 100 m. (305 ft.) and the rock outcrops are shown in black. Blue ice-fields are indicated by crosses (⊗). The inset shows the location of Heimefrontfjella in relation to the Halley Bay station.