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ICE SHELF AND FIORD ICE PROBLEMS IN DISRAELI FIORD NORTHERN ELLESMERE ISLAND, NWT

by

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ABSTRACT

The distribution of ice shelf and fiord ice in Disraeli Fiord is briefly described. The ice shelf forms a barrier between the surface water of the fiord and the Arctic Ocean with the result that the fiord ice is of fresh-water origin. This situation has existed for not more than 3000 years, according to the radiocarbon age of driftwood previously collected from the shores of the fiord. In the summer of 1972 an extensive collection of driftwood was made from the fiord for taxonomic and radiocarbon analyses, which it is hoped will lead to deductions on changes in concentration of Arctic Ocean ice with time and on the genesis of ice shelf.

RÉSUMÉ

Une brève description est faite sur la distribution de la plateforme de glace et la glace de fiord dans le fiord Disraeli. Cette plateforme dresse une barrière entre l'eau du fiord et celle de l'océan Arctique de telle sorte que la glace du fiord est formée à partir d'eau douce. Cette situation a existé depuis environ 3000 ans d'après l'âge, détecté au radiocarbone, des débris de bois ramassés sur les bords de ce fiord. Au cours de l'été 72, une bonne quantité de ce bois a été ramassé en vue d'analyses taxonomiques et au radiocarbone, qui on l'espère permettront de faire des déductions sur les changements avec le temps de la concentration de la glace de l'océan Arctique et sur la génèse de la plateforme de glace.

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NORTHERN ELLESMERE ISLAND, NWT

INTRODUCTION

The Ward Hunt Ice Shelf forms a floating barrier across the mouth of Disraeli Fiord and thus causes oceanographic conditions of peculiar interest within the fiord (Fig. 1). South of Ward Hunt Island the ice shelf extends up the fiord for 20 km and then gives place to fiord ice and (in summer) very limited open water up to the glacier tongue at the head of the fiord, a further 25 km. Milne Fiord is the only other fiord whose near-surface waters are blocked from the ocean by an ice shelf, and in this case the ice shelf completely fills the fiord and is contiguous with the glacier at its head. The surface waters of the neighbouring Markham, M'Clintock and Ayles fiord were blocked off in a similar manner, until the partial disintegration of the Ward Hunt Ice Shelf in 1961-62 and the almost complete disintegration of the M'Clintock and Ayles ice shelves since 1962 (Hattersley-Smith, 1963; 1967).

Disraeli Fiord thus presents an oceanographic situation that is unique in the Canadian Arctic and probably anywhere else in the Arctic. The ice shelf effectively dams the surface water layer of the fiord to a depth of about 44 m (the approximate thickness of the ice shelf), while allowing free interchange with the Arctic Ocean at greater depths. This surface layer is almost fresh and is derived from melt-water runoff from the shores of the fiord (Keys and others, 1969).

The question of when the ice shelf formed across the mouth of Disraeli Fiord has not yet been resolved. Driftwood that has been collected from the shores of Disraeli Fiord can have been deposited only when the fiord was open to the Arctic Ocean. From radiocarbon dates on driftwood Crary (1960) concluded that the Ward Hunt Ice Shelf was initiated not more than 3000 years ago. However, Lyons and Mielke (1972) have suggested that the ice shelf was initiated about 4000 years ago and that Disraeli Fiord retained a surface connexion with the Arctic Ocean until about 3000 years ago.

From 23 July to 6 August 1972, G. Hattersley-Smith and A. Davidson carried out field work in Disraeli Fiord. They arrived there by Twin Otter aircraft from the DREO camp at Lincoln Bay _via_ Alert, and were evacuated by Alouette helicopter at the end of their stay, during which they traversed the entire shore on both sides of the fiord in its upper 30 km and made three excursions up to 10 km inland. The work provided further information on the unique ice regime in the fiord, but the principle objective was the recovery of further samples of driftwood from the shores and river deltas for taxonomic identification and radiocarbon dating. A large collection of driftwood was made from various points, and this has been passed to the Geological Survey for analyses. When these analyses are completed, it is hoped to make deductions on changes in concentration of Arctic Ocean ice with time and to form a more accurate assessment of the period when Disraeli Fiord became sealed off by the Ward Hunt Ice Shelf. Collections of marine shells were also made at various levels up to 50 m above sea level. These also have been passed to the Geological Survey for radiocarbon dating in order to provide further information on the rate of postglacial uplift in the area.

FIORD ICE AND ICE SHELF

To the south of the ice shelf the ice cover of Disraeli Fiord is more or less perennial and, as indicated above, of virtually freshwater origin. It has the characteristics of lake ice, that is to say, the crystals are large with c-axes vertically aligned. In summer the ice presents a typically candled surface from which melt water drains along the crystal boundaries. Melting snow drains off rapidly in this way.

The part of the Ward Hunt Ice Shelf that occupies the outer part of the fiord is separated by a moat of fresh water varying in width from a few metres to a kilometre at the southern end of the ice front. The lake ice that forms on this moat is of more or less seasonal duration. However, in cool summers the ice may not melt completely, so that more than one generation of lake ice may be demarcated in air photographs. South of the ice shelf the moat continues as a narrow body of water separating the shore from the main body of lake ice in the fiord. Here again the ice on the moat is more or less seasonal, the width of open water in summer varying from a few metres to a few hundred metres opposite river mouths,with more than one generation of ice present. The moat was established before the cooler summers of about the last decade; it is for this reason that it contains ice of more than one age. There is a similar moat around the shore of the small unnamed island.

In its recent history the ice shelf has calved periodically from its southern front as shown by the air photographs. It is not known how long this calving process has been going on, nor is it known how much of the fiord was formerly covered by ice shelf that has since disintegrated. It is possible that the ice shelf formerly covered the whole fiord right up to the glacier tongue at the southern end in a situation similar to that obtaining in Milne Fiord. At the present time the upper 20 km of the fiord is completely clear of bergs calved from the ice shelf. However, to the west of the small unnamed island there are two large bergs which have been in essentially the same position at least since 1947, when the first air photographs became available. In the same area there are also numerous smaller bergs that have moved around since that time. A selection of air photographs shows the situation to the west of the small island. These photographs were taken on 24 April 1947 (Figs. 2 and 3), 24 June 1950 (Fig. 4) and 11 August 1959

(Fig. 5). The last two photographs are shown on roughly the same scale. For further comparison a panoramic photograph taken by J.E. Keys from the summit of the small island on 7 August 1972 is available (Fig. 6).

It is evident from these photographs that between 1947 and 1959 many of the small bergs between the largest berg and the ice front drifted away, but they did not drift to the south of the island, nor did they drift over to the east side of the fiord. Their disappearance cannot be accounted for by melting, and it is concluded that they drifted northwards into the moat between the ice shelf and the land on the west side of the fiord. The apparent lack of movement of the two large bergs suggests that they were aground, but the bathymetry of this part of the fiord as far as it is known (Keys and others, 1969) makes this unlikely. The fact that they did not move, or moved only very slightly, is probably due to the considerable inertia of the bergs and to the very short period (say, from 15 July to 1 September in the warmest summer) when movement is possible. But the evident movement of the small bergs implies open water or break-up conditions near the southwestern front of the ice shelf, conditions that have not been observed by field parties operating in the fiord each summer since 1966. Furthermore, between 1959 and 1966 (Figs. 5 and 6), the gap between the two large bergs widened considerably, and two small bergs drifted southwards - one to a position about 0.5 km west of the mid-point of the island (Figs. 6 and 7) and the other to a point about 2 km due south of the island (Fig. 6). In Fig. 7 the fiord ice is seen to carry gravel and boulders that can only have been deposited by streams when the ice lay close to shore. Thus, at some time between 1959 and 1966 there was open water or break-up conditions for some way south of the island. Measurements near the island by J.E. Keys and H. Serson since 1966 have shown thicknesses of 2.75 to 3 m for the fiord ice, and for the most part the ice appears to have frozen over in a single sheet without any older ice frozen in. In 1966 the ice surface appeared remarkably smooth, as if it was of relatively young formation, but since that time it has become rougher and more undulating. Towards the head of the fiord the ice surface presents progressively further stages of roughness and undulation, as if this ice had been subject to ablation weathering for a much longer period. The inference is that the ice in the southern part of the fiord has been perennial for many years, while near the island the fiord has been open much more recently. On the other hand, the moat ice around the fiord is relatively young and has remained smooth; it thus provides the best landing areas for aircraft and can be used for this purpose right through the summer in a cool season.

There is a sharp distinction between the crystal structure of the ice shelf and that of the fiord ice. An examination of a 3.5 m vertical face of the berg south of the island revealed an upper section composed entirely of iced firn, except for a 0.5 m lens of lake ice 2.5 m below the surface. There was a heavy dirt layer on the surface of the berg and a light dirt layer at the horizon of the lake ice, which represented a buried erosion surface of unknown age. Renewed build-up led to the deposition of the upper 2.5 m of iced firn and this was followed by the current period of net ablation, in progress at least since 1909 (Hattersley-Smith and others, 1955) and formation of the heavy surface dirt layer. Lyons and others (1971) mapped the ice type of this part of the ice shelf as predominantly basement ice, defined as ice formed from brackish water under special conditions at the underside of the shelf. The ice exposed in the berg was formed by surface accretion; no basement ice was seen, although it may well be a major component of the ice shelf in Disraeli Fiord. The surface topography of the ice shelf is related in a complex manner to the crystal structure. It is suggested that the lake ice of the fiord,by reason of its crystal structure, would never develop a similar topography through ablation weathering.

DRIFTWOOD

Radiocarbon ageing of a widespread assemblage of driftwood from the Queen Elizabeth Islands shows the oldest samples dating from 8500-8000 years ago, numerous samples from the period 6500 to 4500 BP, a sharp decrease in samples from the period 4500 to 500 BP, and an increase again in the last 500 years (Blake, 1972). The period 4500 to 500 BP is correlated with the onset of more severe ice conditions and the development of ice shelves, especially along the north coast of Ellesmere Island (Blake, 1972).

Four driftwood samples collected by E.W. Marshall from 3 m above sea level in Disraeli Fiord in 1954 were assigned the following radiocarbon ages: 3000 ± 200, 3400 ± 150, 5740 ± 200 and 6120 ± 150 yr BP (Hattersley-Smith and others, 1955; Crary, 1960; L254D, L254A, L254B and L254C). Three further samples were collected by J. van der Leeden in 1967: one of these (from the genus Larix) was dated 6280 ± 140 yr BP (Mielke and Long, 1969; SI-568) and the other two (from the genera Larix and Picea) were dated at more than 35000 yr BP (Mielke and Long, 1969; SI-566, 567) or outside the range of radiocarbon dating. These samples were all found rather casually; before 1972 no systematic effort to collect driftwood from the fiord had been made. It therefore seemed worthwhile to make a thorough search for driftwood and to concentrate efforts on finding wood from the lowest levels, since only wood younger than c. 3000 yr BP could provide new information on the genesis of the ice shelf. In other words it was hoped to narrow down the age of the ice shelf and thus to refine ideas on climatic change in the last few thousand years, particularly in the effects on Arctic ice shelves and sea ice.

A total of 27 samples of wood were collected from the shores of the fiord; twenty-one of these were collected from less than 1 m above sea level, and the remainder from 1, 2, 2.5, 8, 9 and 23 m above sea level. The extensive delta on the west side of the fiord and southwest of the island provided nineteen of the samples and the delta opposite on the east side provided a further four. Localities for the remaining three samples are shown on the map (Fig. 1). The sample from an elevation of 23 m above sea level lay fully exposed on the surface of delta gravels and is clearly very old. It has been identified as belonging to the genus Larix. Many of the samples from lower levels have doubtless been brought down by stream action and solifluction from higher levels. Whether the wood is very old or only a few thousand years old -- and it is impossible to tell by visual inspection -- it could be expected to be most abundant on deltas and tidal flats near river mouths. Elsewhere much of the shore is steep-to and provides very little lodgement. One sample lay on vegetated ground, and had clearly been redeposited from elsewhere in the fiord comparatively recently.

CONCLUSION

This note is essentially a progress report, since the main conclusions on the significance of the driftwood must await taxonomic and radiocarbon analyses by the Geological Survey. In addition to the radiocarbon dates of driftwood cited above, dates of samples collected from Cape Richardson and Clements Markham Inlet on the north coast of Ellesmere Island by G. Hattersley-Smith in 1953 refer to 980 ± 100 and 2190 ± 150 yr BP (Crary, 1960; L261A and L261B), and driftwood has been observed on the pack ice of the Arctic Ocean and in the channels of the Queen Elizabeth Islands in recent years. For example, H. Serson recovered a large log from the ice in Nansen Sound in 1970. Thus driftwood from the north coast of Ellesmere Island could date from any time within the last few thousand years. If driftwood can be shown to have reached the shores of Disraeli Fiord less than 3000 years ago, it would be necessary to reassess the time of onset of the climatic deterioration leading to the formation of ice shelves along the north coast of Ellesmere Island.

REFERENCES

Blake, W. 1972. Climatic implications of radiocarbon-dated driftwood in the Queen Elizabeth Islands, Arctic Canada in Vasari, Y. (Ed.) Climatic change in Arctic areas during the last 10,000 years. University of Oulou Press, Oulou, Finland (in press).

Crary, A.P. 1960. Arctic ice island and ice shelf studies, Part II. Arctic Vol. 13, No. 1, p. 32-50.

Hattersley-Smith, G. 1963. The Ward Hunt Ice Shelf; recent changes of the ice front. J. Glaciol. Vol. 4, No. 34, p. 415-24.

__________ 1967. Note on ice shelves off the north coast of Ellesmere Island. Arctic Circular Vol. 17 (1965-66), No. 1, p. 13-14.

Hattersley-Smith, G., Crary, A.P. and Christie, R.L. 1955. Northern Ellesmere Island, 1953 and 1954. Arctic Vol. 8, No. 1, p. 3-36.

Keys, J.E., Johannessen, O.M. and Long, A. 1969. The oceanography of Disraeli Fiord, northern Ellesmere Island. Defence Research Board Report Geophysics Hazen 34, 7p.

Lyons, J.B. and Mielke, J.E. 1972. Holocene history of a part of northernmost Ellesmere Island. Arctic (in press).

Lyons, J.B., Savin, S.M. and Tamburi, A.J. 1971. Basement ice, Ward Hunt Ice Shelf, Ellesmere Island, Canada. J. Glaciol. Vol. 10, No. 58, p. 93-100.

Mielke, J.E. and Long, A. 1969. Smithsonian Institution radiocarbon measurements V. Radiocarbon Vol. 11, No. 1, p. 163-82.

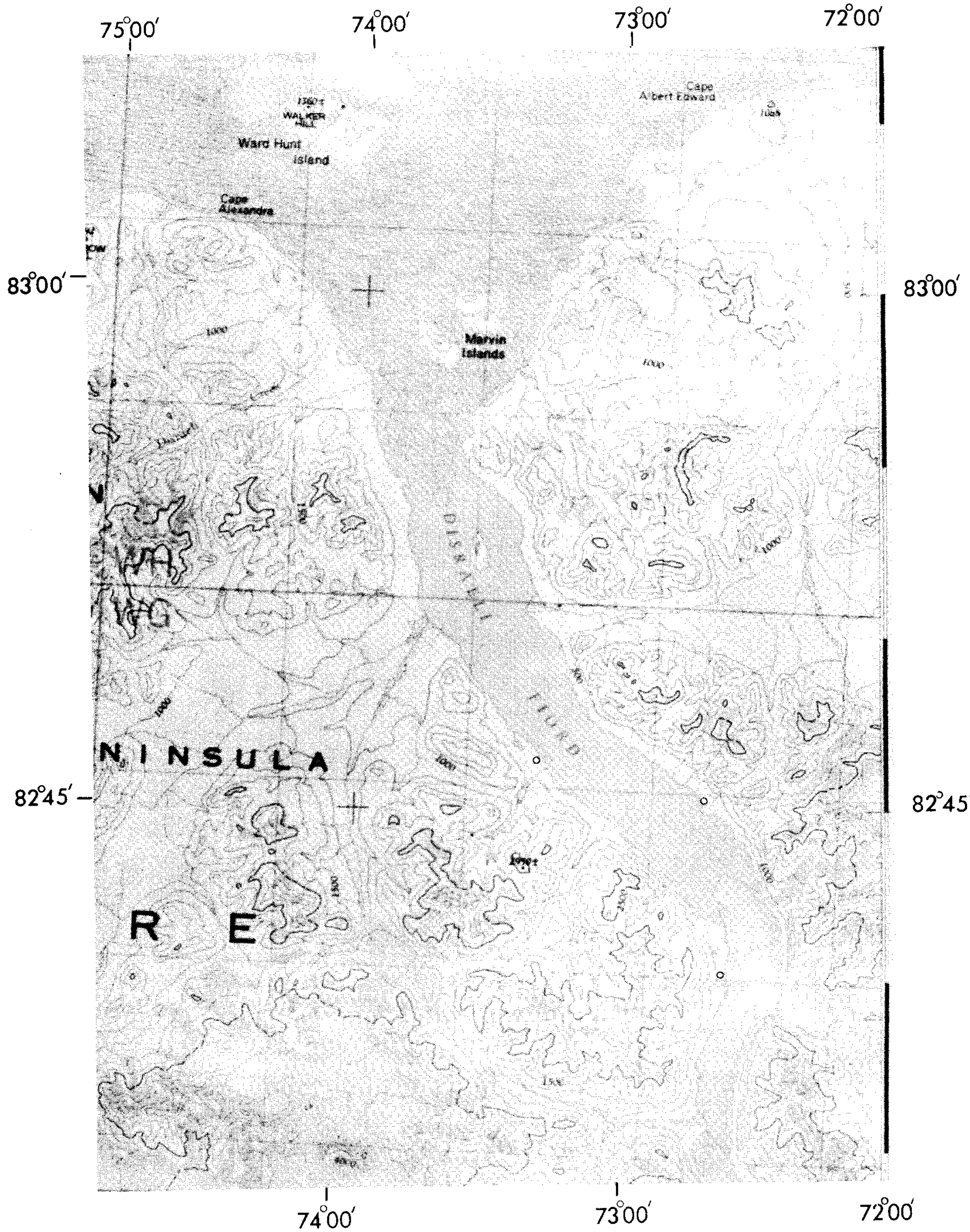

Fig. 1. *Disraeli Fiord, northern Ellesmere Island. Driftwood was collected at the prominent deltas southeast and southwest of the unnamed island and at the three points circled. (Department of Energy, Mines and Resources: part of NTS 340E and 340H).*

Fig. 2. *Disraeli Fiord from an altitude of 5180 m looking northwest. (K.R. Greenaway, RCAF, 24 April 1947).*

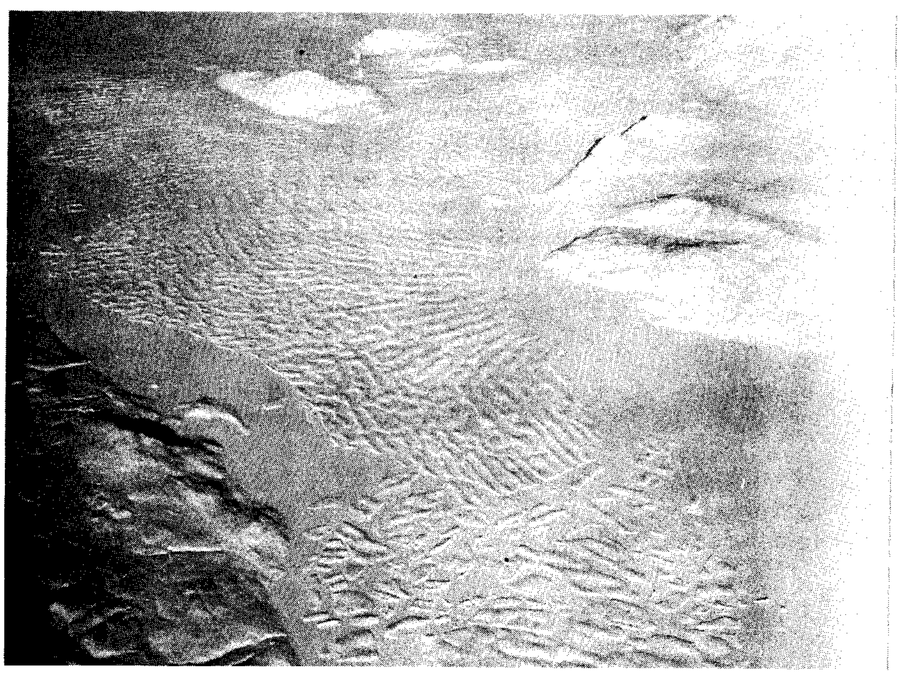

Fig. 3 *Ice shelf in Disraeli Fiord from an altitude of 4875 m looking north. (K.R. Greenaway, RCAF, 24 April 1947).*

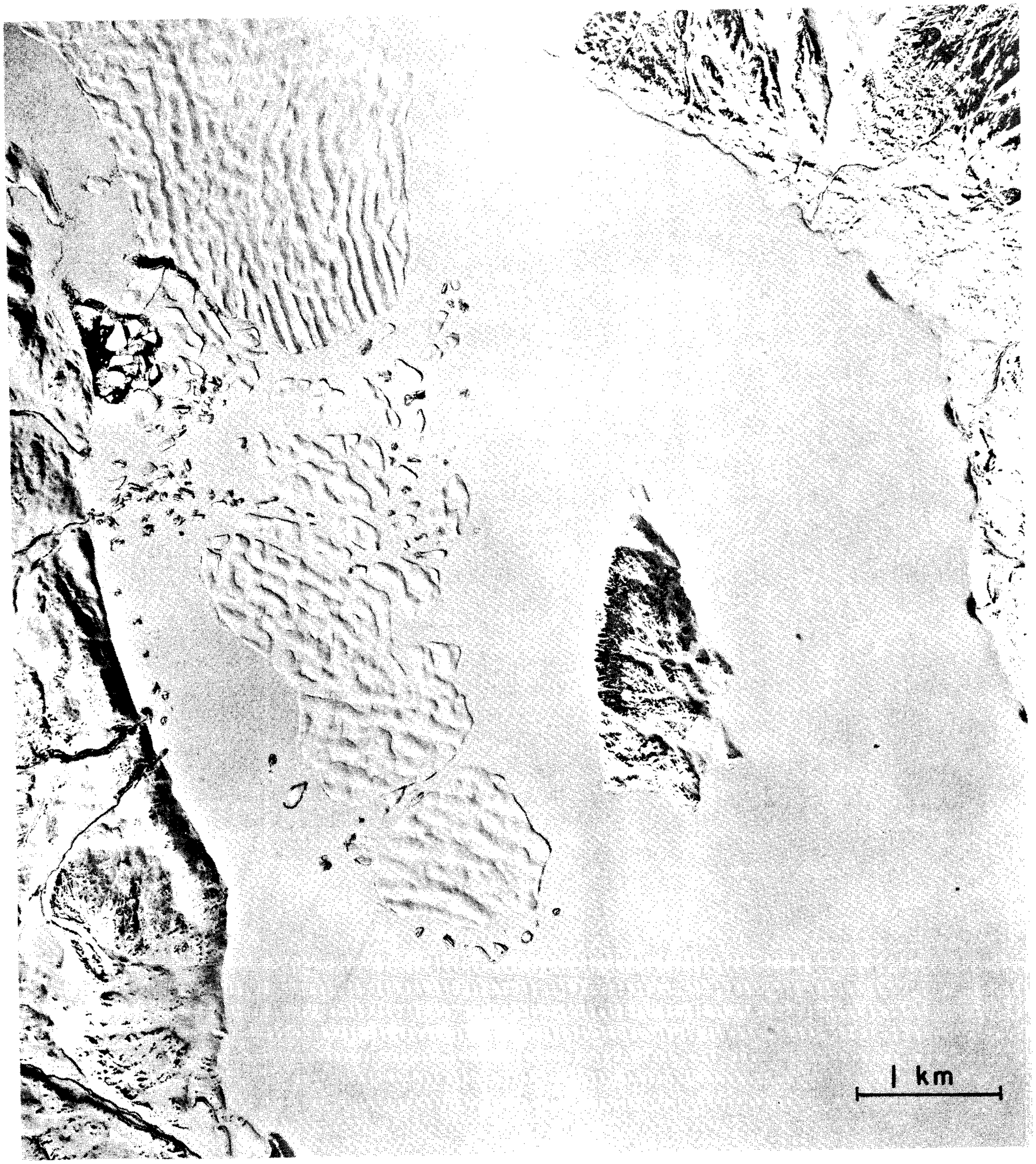

Fig. 4. *Disraeli Fiord from an altitude of 6095 m showing unnamed island and southern front of ice shelf. (Department of Energy, Mines and Resources: T. 400C-88, 24 June 1950).*

Fig. 5 *Disraeli Fiord from an altitude of 9140 m showing unnamed island and southern front of ice shelf. (Department of Energy, Mines and Resources: A. 16725-131, 11 August 1959).*

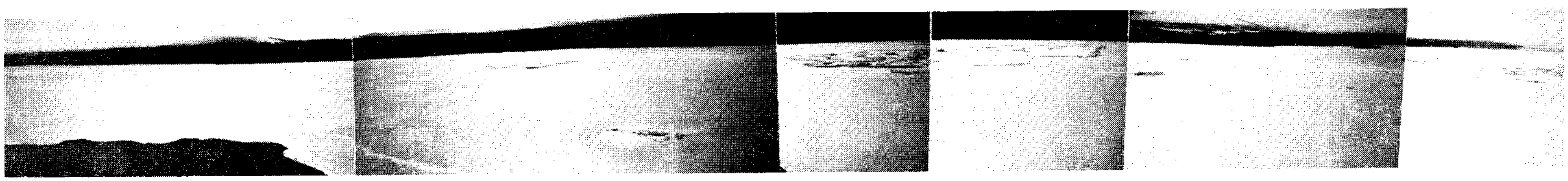

Fig. 6 *Panorama of west side of Disraeli Fiord to show southern front of ice shelf and bergs of various sizes. Note gravel-covered berg in middle foreground (also shown in Fig. 7) and very small berg at extreme left. (J.E. Keys, DREO, 12 August 1972).*

Fig. 7 *Gravel-covered fiord ice and berg to west of unnamed island. (J.E. Keys, DREO, 12 August 1972).*

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