1979

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Journal of Glaciology, Vol. 22, No. 86, 1979

PATTERN OF ICE SURFACE LOWERING FOR RENNICK GLACIER, NORTHERN VICTORIA LAND, ANTARCTICA

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ABSTRACT. Rennick Glacier is one of the major ice drainages in northern Victoria Land. Unlike glaciers farther south along the Transantarctic Mountains, Rennick Glacier does not drain into the Ross Ice Shelf but flows directly into a seasonally ice-covered ocean. Therefore, current fluctuations of this glacier are unhampered by the dampening effects of the Ross Ice Shelf. The primary controls on the activity of this glacier and others in this region are mass balance and sea-level.

Two major glacial events are recorded in the upper Rennick Glacier region. The location of erratics and glacially scoured features suggest that during the oldest or Evans glaciation ice covered all but the highest peaks in the region. Following this glaciation a re-advance produced the Rennick glaciation. Drift produced during this glaciation has a surface cover of unweathered clasts and is commonly found in the form of recessional moraines with associated ice-marginal lakes. Rennick Glacier is currently in a recessional phase of the Rennick glaciation. The phase is characterized by physical re-adjustments of local ice masses including progressive inland migration of the Rennick Glacier grounding line. To date the grounding line has migrated up to the mid-point of the glacier. This trend may be expected to continue.

RÉSUMÉ. *Mode de l'abaissement de surface du Rennick Glacier, en Victoria Land du Nord, Antarctique.* Le Rennick Glacier forme un des écoulements glaciaires les plus importants dans le Nord de la Victoria Land. Contrairement aux glaciers situés plus au Sud le long des Montagnes Transantarctiques, le Rennick Glacier ne s'écoule pas dans le Ross Ice Shelf, mais directement dans un océan périodiquement couvert de glace. De cette façon, les régimes glaciaires actuels dans cette région témoignent directement de l'action de la glace du Nord de la Victoria Land qui se trouve dans le réseau de drainage du Rennick Glacier, sans être influencés par les effets du Ross Ice Shelf.

Deux développements glaciaires importants se manifestent dans la région supérieure du Rennick Glacier. La position des blocs erratiques et les stries glaciaires nous font penser que durant le développement le plus ancien (le développement Evans) tous les sommets de la région, en déhors des cimes les plus hautes, furent couverts de glace. La distribution des moraines de retraite (couvertes d'une couche de sédiments clastiques intacts) et les lacs au bord du glacier témoignent du développement plus récent (le développement Rennick), comprenant une avance renouvelée, et — à présent — un retrait. La phase de retrait du développement Rennick est caractérisée par les rajustements physiques des masses de glace locales, y compris la migration progressive vers l'intérieur de la ligne de fond du glacier Rennick. Jusqu'à présent, cette ligne a migré jusqu'au milieu du glacier. On peut s'attendre à ce que cette tendance continue.

ZUSAMMENFASSUNG. *Der Ablauf des Absinkens der Eisoberfläche am Rennick Glacier, Nord-Victoria-Land, Antarktis.* Der Rennick Glacier bildet einen der bedeutendsten glazialen Abflüsse im nördlichen Victoria-Land. Im Gegensatz zu weiter südlich, entlang dem Transantarktischen Gebirge gelegenen Gletschern fliesst der Rennick Glacier nicht in das Ross Ice Shelf, sondern unmittelbar in einen periodisch eisüberdeckten Ozean. Auf diese Weise bilden die heutigen Gletscherregime in dieser Gegend einen direkten Beleg für die Eistätigkeit der im Nord-Victoria-Land innerhalb des Entwässerungssystems des Rennick Glacier gelegenen Eismassen, unbeeinflusst von Dämpfungseffekten des Ross Ice Shelf.

Zwei bedeutende glaziale Vorgänge lassen sich im oberen Rennick Glacier-gebiet erkennen. Die Lage der erratischen Blöcke und die Gletscherschrammen lassen vermuten, dass während des ältesten oder Evans-Vorgangs alle Gipfel, mit Ausnahme der höchsten, eisüberdeckt waren. Die Verteilung der mit einer Schicht unverwitterter Sedimente überdeckten Rückzugsmoränen und die am Gletscherrand gelegenen Seen dokumentieren den jüngeren oder Rennick-Vorgang, der einen erneuerten Vorschub und gegenwärtig einen Rückzug mit sich brachte. Die Rückzugsphase des Rennick-Vorgangs zeichnet sich durch physische Umlagerung der örtlichen Eismassen an, einschliesslich einer fortschreitenden Landeinwärtswanderung der Grundkontaktgrenze des Rennick-Glaciers. Bis jetzt hat diese Grenze die Mitte des Gletschers erreicht. ist zu erwarten, dass sich dieser Trend weiterhin erhalten wird.

A NON-ICE-SHELF BOUNDED OUTLET GLACIER

Previous studies of the outlet glaciers in the Transantarctic Mountains (Denton and others, 1971; Hughes, 1972; Mayewski, 1975; Mayewski and Goldthwait, in press) have all dealt with the examination of outlet glaciers that drain directly into the Ross Ice Shelf. Changes in the ice-surface profiles of these outlet glaciers have been used to monitor changes in volume of the East Antarctic ice sheet and/or Ross Ice Shelf.

Rennick Glacier (Fig. 1) is the most northerly situated outlet glacier in the Transantarctic Mountains. Compared to previously studied outlet glaciers in this range it is different because it does not drain into an ice shelf but rather into a seasonally ice-covered embayment, Rennick Bay. It is the largest outlet glacier in northern Victoria Land and contains the largest inland exposure of ice-free terrain in the region. Flowing in a northerly direction it roughly parallels the 162° 30′ E. meridian of longitude, for a length of approximately 400 km. The glacier has a maximum width of 80 km north of the Morozumi Range and narrows to a 25 km width just south of this range. Several tributary glaciers feed the Rennick, the largest of which is Gressitt Glacier.

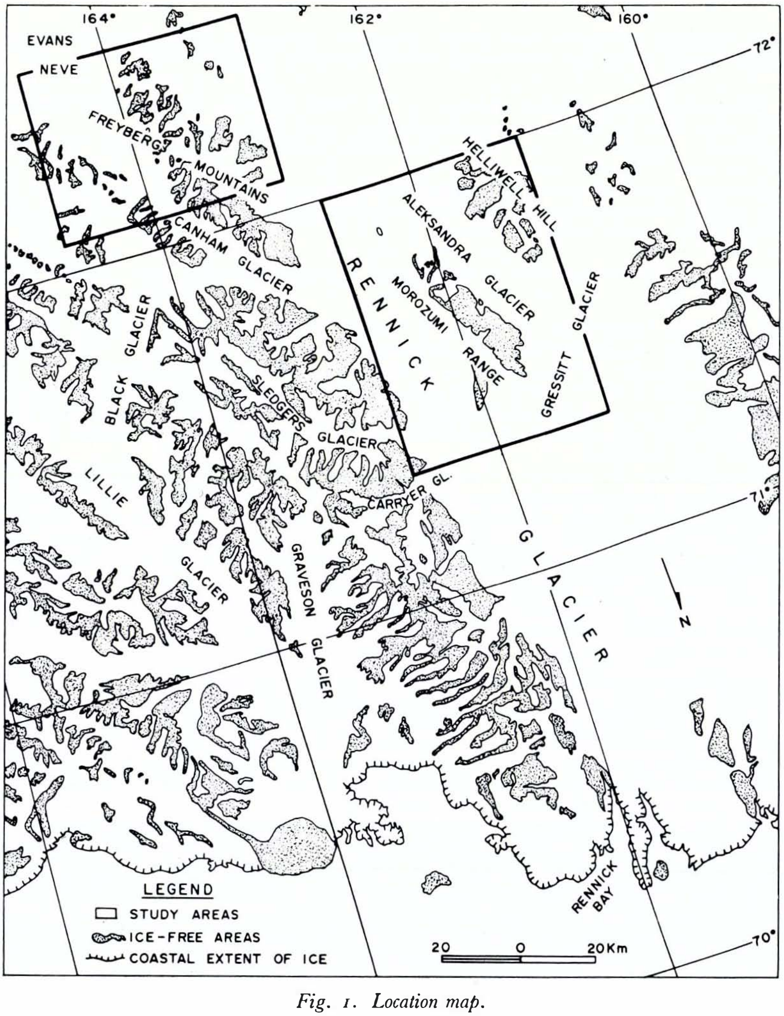

Fig. 1. Location map.

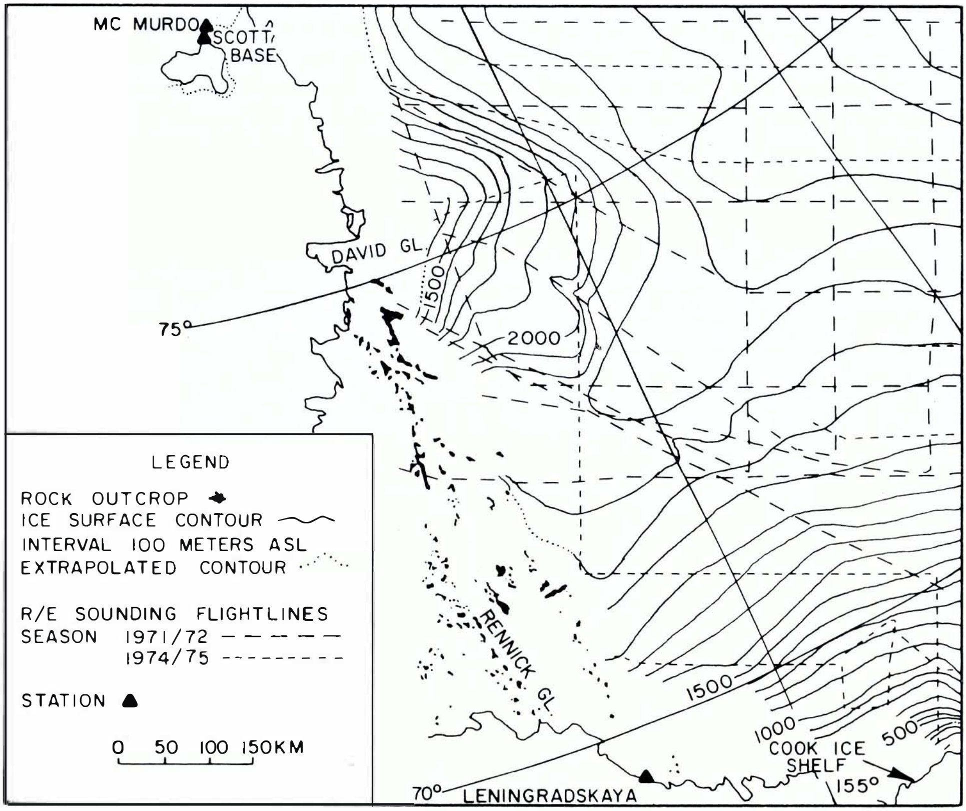

Fig. 2. Ice-sheet surface in the vicinity of Rennick Glacier (portion of a figure from Steed and Drewry (in press)).

Recent mapping of the ice-sheet surface in the vicinity of northern Victoria Land (Fig. 2) by Steed and Drewry (in press) suggests that Rennick Glacier has a small drainage basin and receives little, if any, of its ice from interior sectors of the East Antarctic ice sheet. East Antarctic ice flowing in an east-north-east direction toward Rennick Glacier becomes diverted, possibly by a bedrock ridge, and flows off laterally to the David Glacier drainage basin to the south-south-east and the Cook Ice Shelf to the north-north-west. Steep ice-sheet surface gradients flank the proposed ridge. Precipitation reaching Rennick Glacier and the surrounding ice masses comes primarily from either the Ross Sea or the open ocean to the north. Therefore, seasonal ice cover, degree of open water, and cyclogenesis appear to be the major regional controls on the mass balance of this northern Victoria Land glacier. Only a major expansion of the East Antarctic ice sheet would direct enough ice into the Rennick Glacier drainage to allow it to respond to ice-sheet fluctuations.

Glacial history

Discovered in 1960 (Stuart and Heine, 1961), the Rennick Glacier region has since been visited almost exclusively by bedrock-geology parties. The bedrock-geology accounts of Gunn and Warren (1962), Sturm and Carryer (1970), and Dow and Neall (1974) contain some reference to the glacial history of the region and all agree that the region was once more extensively glaciated/glacierized. Evidence presented in this paper suggests that a larger Rennick Glacier once covered all but the highest peaks of the upper Rennick Glacier region.

A general lowering of the ice surface punctuated by one recorded re-advance has characterized the glacial history of the area since the period of high, extensive ice cover. The increasing exposure of ice-free massifs resulting from this ice thinning has led to the current channelling of ice in the form of outlet and tributary glaciers. The older, more extensive ice surface existed during what is named here the Evans glaciation, and the re-advance marks the onset of the Rennick glaciation which continues to the present.

Evans glaciation

The name Evans glaciation has been assigned to the period of maximum recorded ice coverage in the upper Rennick Glacier region. It was at this time that an ice surface similar in character to that currently only covering inland regions of the study area, such as Evans Névé, covered most of the now ice-free *massifs* of the study area. Evidence used to define the extent of the Evans ice surface comes from the Morozumi Range and the Helliwell Hills (Fig. 3, Table I) and Evans Névé (Fig. 4, Table II). The maximum elevation of erratics and

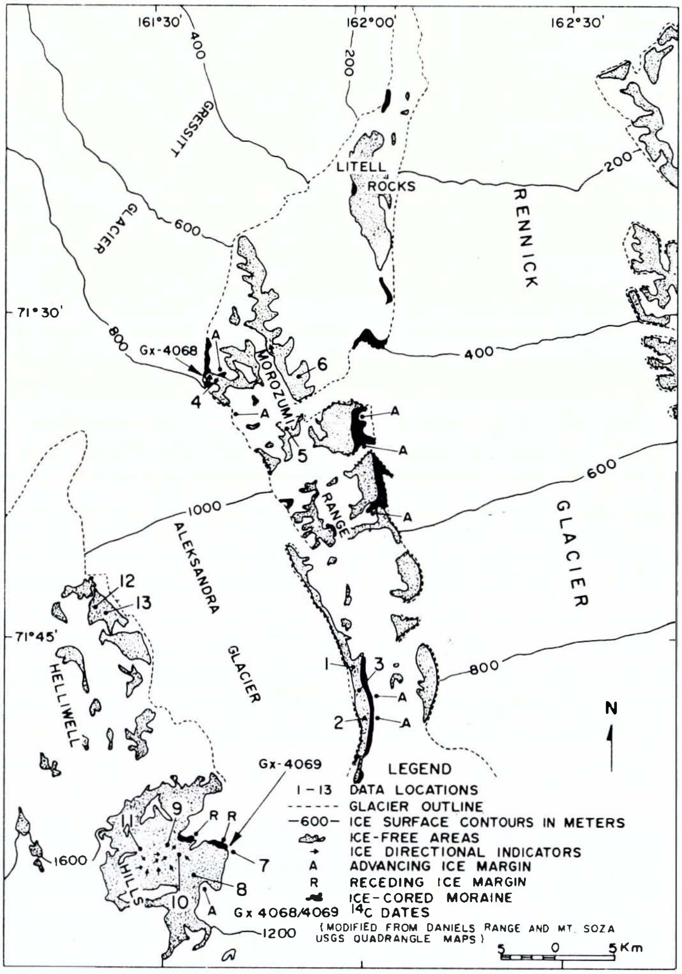

Fig. 3. Morozumi Range and Helliwell Hills.

glacially scoured ice-directional indicators and the transition between the most weathered surface clasts in the region and markedly less-weathered surface clasts were all combined to reconstruct the extent of ice during the Evans glaciation.

TABLE I. DESCRIPTION OF GLACIAL EVIDENCE FROM THE MOROZUMI RANGE AND HELLIWELL HILLS

Map location (see Fig. 3)	*Elevation* m	*Glaciation*	*Evidence*
1, 2, 4, 5, 6, 8, 11, 12, 13	1 800, 1 430, 1 300, 1 510, 1 300, 1 480, 1 650, 1 450, 1 400	Evans	Highest recorded level of weathered erratics with striated and faceted clasts at lower levels
12	1 400	Evans	Top of glacially-eroded valley
3	1 170	Rennick (maximum)	Highest recorded level of fresh surface clasts with local area containing fresh, steep moraines, soils with poor profile development, boulder belts, and ice-marginal lakes
7	1 210	Rennick (maximum)	Contact between fresh and weathered surface clasts
9	1 100	Rennick	Highest recorded level of fresh surface clasts and fresh, steep moraines
10	980	Rennick	Ice-marginal lake and cryoturbated bedrock

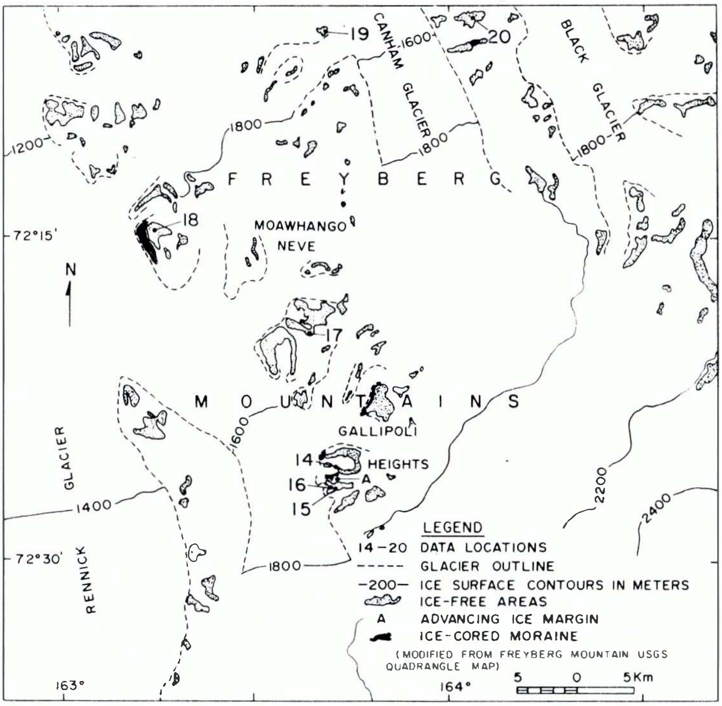

Fig. 4. Evans Névé.

Table II. Description of glacial evidence from Evans Névé

Map location (see Fig. 4)	*Elevation* m	*Glaciation*	*Evidence*
16	1 960	Evans	Highest recorded level of weathered erratics
20	1 990	Evans	Highly weathered bedrock
14, 15	1 850, 1 800	Rennick (maximum)	Highest recorded level of fresh erratics and soils with poor profile development
17, 19	2 100, 1 820	Rennick (maximum)	Contact between fresh and weathered bedrock
18	2 130	Rennick (maximum)	Contact between fresh and weathered bedrocks and sharp demarcation in surface salt concentrations

Further north along the Transantarctic Mountains, in the Queen Maud Mountains, Mayewski (1975) and Mayewski and Goldthwait (in press) have collected evidence documenting four glacial maxima. Ice-surface reconstructions have been produced for each glaciation. During the oldest and most extensive of these, the Queen Maud glaciation, the Rennick Glacier region would have been almost entirely ice-covered. Comparison of this ice surface with the Evans ice surface indirectly suggests the equivalence of these two glaciations. The suggested age of the Queen Maud glaciation is more than 4.2 million years B.P.

Rennick glaciation

During the latter stages of the Evans glaciation general reduction of the regional ice surface was interrupted by a re-advance. This re-advance marks the onset of the Rennick glaciation. Documentation of the Rennick glaciation comes from an examination of: ice-directional indicators, the distribution of unweathered soils and clasts on drift surfaces, sharply defined morainic ridges, and ice-marginal lakes throughout the Morozumi Range and Helliwell Hills (Fig. 3, Table I) and Evans Névé (Fig. 4, Table II.)

The initial re-advance leading to the onset of the Rennick glaciation is defined on the basis of: a buried soil, the presence of sharp breaks between unweathered Rennick drift and weathered Evans drift, and the distribution of fresh, angular morainic ridges.

Along the south-east flank of the Morozumi Range (Fig. 3) a buried soil (26 cm thick) was found underlying fresh, unweathered Rennick drift ($<$20 cm thick). The buried soil displays weak soil-profile development defined vaguely by the vertical distribution of a poorly-sorted fine fraction. Although the weak profile development differs little from the almost non-existent profile development of soils developed in Rennick drift, the presence of a weathered clast cap on the former is markedly different from the fresh surface cover on the Rennick drift. The presence of the older buried surface beneath the unweathered Rennick drift suggests that Rennick ice re-advanced at least once over areas previously uncovered during Evans glaciation ice retreat.

Ice retreat since the Rennick maximum has been recorded by the deposition of a veneer of fresh drift and erratics and a series of sharp morainic ridges, the exposure of fresh striae and gouges, and the development of ice-marginal lakes. The relatively recent nature of the ice recession is typified by the freshness of both the drift and the recently uncovered erosion features. In Boggs Valley (Fig. 3) fresh striae and gouges are commonly found on bedrock surfaces. Their sharpness and lack of weathering is comparable only to erosion features on clasts currently falling out of active ice margins. An indication of the pattern of this ice retreat is displayed along the south-east flank of the Morozumi Range. At this site a criss-cross pattern of moraines rest on topographic highs. Their distribution seems best fitted to a crevasse pattern into which the till from a thin, decaying ice mass has been deposited. Series of ice-cored moraines flank present ice margins throughout the study area further typifying the recent ice retreat.

Ice-marginal lakes are common on the flanks of retreating ice in the upper Rennick Glacier area. Their previous extent appears to have been controlled by the location of ice margins, bedrock topography, and/or former climate in the region. Stranded above and surrounding the modern ice-marginal lakes is the evidence of their former extent in the form of: lacustrine strandlines (Fig. 5), relict patches of dated algal peat, and evaporite concentrations.

Fig. 5. Lacustrine strandlines at the south-eastern end of the Morozumi Range.

At the south-east margin of the Morozumi Range ice-marginal lakes (Fig. 3) at one time all but filled this currently ice-free area and former water levels were as high as 10 m above present lake level. This former lake system was dammed by an ice-margin that has since retreated up to 1.5 km. Other ice-marginal lakes and water-eroded slopes farther north along the range attest to the once greater volumes of melt water in the area. Algal peats provide the only available datable material related to the glacial events in this area. Samples were collected from a small ice-cored moraine (Fig. 3) that dams a modern ice-marginal lake. The peat was found draped onto the ice-cored moraine, 2 m above present lake level. It yielded a ^{14}C date of 1085 ± 105 years B.P. (GX-4068).

Former lake levels in the Helliwell Hills (Fig. 3) also suggest a recent period of lake desiccation and/or ice-marginal recession. In Boggs Valley the intersection of several ice tongues and the entrapment of melt water between these tongues led to the development of lakes since desiccated and today recorded by concentrations of evaporite salts. Highly cryoturbated sediments presumably produced during the more extensive lake period line the former lake basin. Similar relict lakes are scattered throughout the valley. A small lake dammed by an ice-cored moraine at the southern end of the Helliwell Hills (Fig. 3) contained algal peat samples for ^{14}C dating in the same relative location as those found in the Morozumi Range. Here samples of desiccated algal peat provided an age of 1265 ± 130 years B.P. (GX-4069). Farther north in the Helliwell Hills, traces of algal peat and strand lines indicate that ice-marginal lakes in this area were a minimum of 50–100 m wider and as much as 0.5 m higher than modern lake levels.

Ice-marginal lakes are also present throughout the nunatak areas of Evans Névé. For example, along the southern side of Gallipoli Heights there is evidence for the existence and subsequent shrinkage of ice-marginal lakes. In addition, Skinner and Ricker (1968) working to the south of Evans Névé, between Reeves Glacier and Backstairs Passage, investigated numerous small lakes describes by them as having been formerly as much as 0.3 m above present lake level.

Since either ice-marginal recession and/or lake desiccation is postulated as the stranding mechanism for both algal deposits, the dates are minima for the time of transition to lower moisture availability for the local area.

Ice-surface reconstructions

Field studies provided twenty sites containing evidence of the former levels of Evans and maximum Rennick ice surfaces in the upper Rennick Glacier region (Tables I and II). Fifteen of these sites record the former ice surfaces for the upper Rennick Glacier, Canham Glacier, and "Aleksandra"* glacier (Fig. 1). Current and former ice-surface profiles for these three glaciers appear in Figure 6. All ice-surface profiles
of the glaciers. Reconstructed ice-surface profiles in this figure

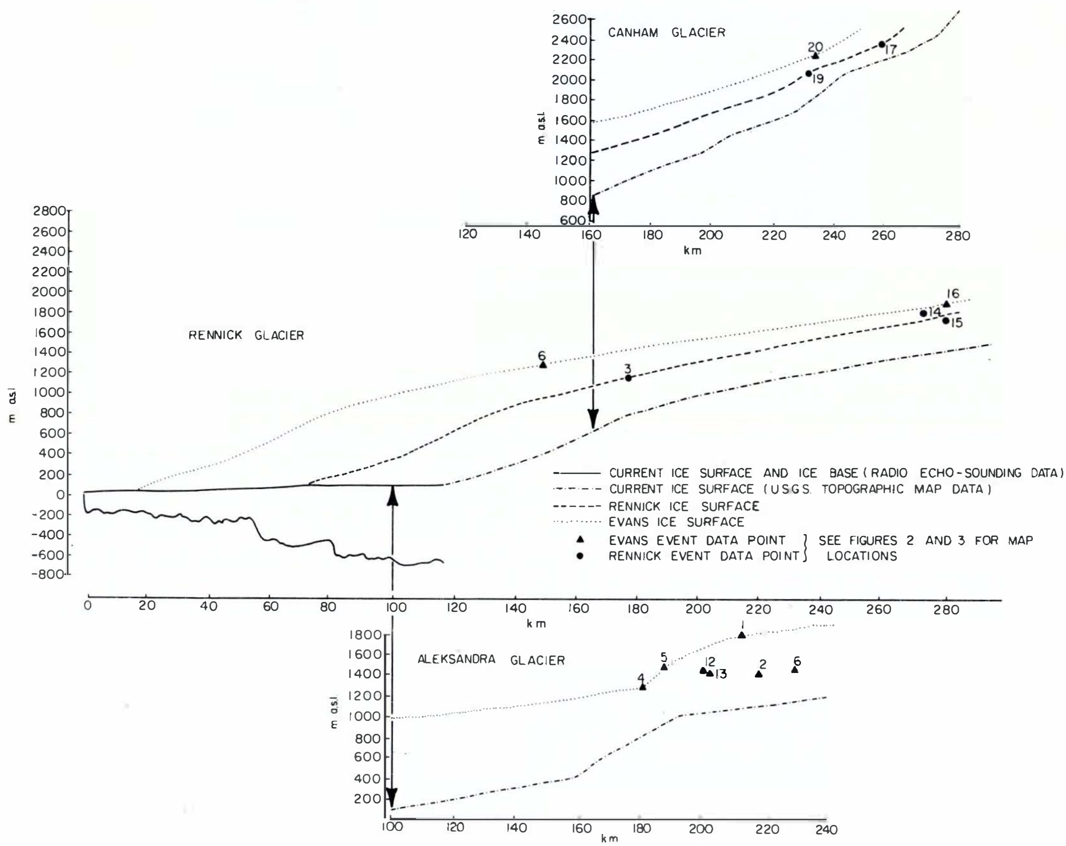

Fig. 6. Comparison of current ice-surface profiles with ice-surface profiles of the Evans and maximum Rennick glaciation. Ice-surface profiles are drawn down the center line of the glaciers.

* Unofficial name.

(1) Evans and maximum Rennick ice-surface profiles were generally similar in shape to current ice-surface profiles and (2) Canham Glacier and "Aleksandra" glacier were tributaries of Rennick Glacier during both Evans and maximum Rennick glaciations. Current ice-surface profiles were taken from U.S.G.S. (1 : 250 000) topographic maps and a radio echo-sounding traverse covering the Rennick Glacier region.

Ice-surface and ice-thickness profiles (Fig. 6) of the coastal portion of Rennick Glacier are available from data collected during a 1969–70 radio echo-sounding survey flown between Litell Rocks (Fig. 1) and the coast. Due to the lack of availability of inertial navigation at the time this traverse was flown, the position of radio echo-sounding profiles by an SFIM flight recorder coupled with sight reckoning between aerial photographs and visible surface features of known position. Estimated navigational accuracy using this technique is 1 km. Unfortunately the flight line does not follow a single flow line of Rennick Glacier.

The ice-surface elevation resolved from the radio echo-sounding data is estimated accurate to no better than 30–50 m. Examination of the echo-strengths from Rennick Glacier over the whole section demonstrates a strong reflection at the glacier bed indicative of an ice/water interface. We infer that the whole portion of the glacier that was scanned is currently floating. In accordance with this inference, improved surface elevations were derived from the ice thickness data assuming simple hydrostatic equilibrium. Thickening and surface changes induced by marginal shear were ignored since the profile predominantly followed the glacier center line. Surface altitude H is thus:

$$H = h\left(1-\frac{\rho_i}{\rho_w}\right) - S\left(\frac{\rho_s-\rho_i}{\rho_w}\right), \qquad (1)$$

where h is the ice thickness, ρ_i the density of ice below surface layers, ρ_w the density of sea-water, ρ_s the density of ice in surface layers, and S the depth of low-density surface layers.

If we take values similar to those employed by Crary (1966) for Skelton Glacier: $\rho_i = 0.92$ Mg m^{-3}, $\rho_s = 0.82$ Mg m^{-3}, $\rho_w = 1.027$ Mg m^{-3}, and $S = 80$ m, (1) becomes: $H = 0.104\ 2h + 7.79$ and was used in constructing Figure 6.

Radio echo-sounding ice-thickness data were digitized at a mean frequency of 1.1 km and are accurate to about 10 m. The radio-echo data demonstrate that the glacier is freely floating along the flight track, except possibly next to Litell Rocks were it begins to ground. An accurate placement of the grounding line cannot be made from this radio echo-sounding profile
Rocks. Thickness of the floating ice increases from 200 m at the ice front to almost 800 m inland (Fig. 6). Two major changes in ice thickness occur along the profile and relate to the entrance of tributaries into Rennick Glacier.

Hyperbolic returns from the glacier bottom were noted on the original photographic records and are presumed due to bottom crevasses. Between the ice front and the first ice-thickness change the bottom is very irregular and exhibits a complicated pattern of echoes indicating an extensive rough area which may be caused by vigorous bottom melting.

Comparison of the reconstructed former ice-surface profiles of Rennick Glacier, Canham Glacier, and "Aleksandra" glacier with their current ice-surface profiles suggests the following:

(a) Evans and maximum Rennick ice surfaces were higher than current ice-surfaces rising to as much as 1 000 m and 600 m higher than present, respectively, in the coastal, currently floating, portion of Rennick Glacier.

(b) The Rennick Glacier grounding line extended 98 km and 43 km farther north than its current position during the Evans and maximum Rennick glaciations, respectively.

(c) Increased ice-surface elevations during the Evans and maximum Rennick glaciations dampened the effects of local subglacial topography. However, the steep ice-surface profile gradient near the junction of "Aleksandra" glacier and Rennick Glacier was present even during the Evans glaciation suggesting that the subglacial topography in this area has a very steep coastally inclined gradient.

Recent ice-surface lowering

Both ice-surface lowering and grounding-line retreat appear to characterize near-recent and current Rennick glaciation ice regime. Several types of evidence were used in the study area to interpret this condition including the examination of current degree of ice margin activity, crevasse distribution, and alpine outlet-glacier interaction.

Ice-marginal regimes were investigated by differentiating advance margins from retreat margins morphologically (Figs 3 and 4). Advancing fronts were characterized by the presence of cliffs and/or overridden ice-cored moraines. Retreat margins were characterized by gently sloping to concave margins and/or recessional features in their immediate vicinity.

The best-developed examples of margins in advance or in retreat come from the south-east flank of the Morozumi Range (Fig. 7). Here advancing ice margins form near-vertical cliffs, override their ice-cored moraines and are actively depositing lodgement till. The till is compact, gray to cream in color comprising poorly-sorted and angular local and erratic lithologies intermixed with stratified
ice abrasion and debris transport has been fairly continually maintained at the margin of an advancing or steady-state glacier. Englacial and superglacial flow and dump tills composed of material both coarser and less compact than the lodgement till form a surface cover in some places along these same margins. Sectors of the ice margin in this area which demonstrate retreat display either concave or gentle slopes with ice-cored moraines and/or ice-marginal lakes strung out away from the ice margin. Non-compact, coarse, angular material comparable to an ablation till derived englacially and/or super-glacially, litters this immediate margin area.

The distribution of advance and retreat margins is believed to be indicative of the general down-wasting of the ice surface in the region. Ice margins in retreat are consistently found down-flow-line from advance sections (Fig. 3). This may be explained by: (1) general up-glacier migration of the effects of lowering ice-surface level generated from the coast inland with controls set by local subglacial topography, or (2) lower subglacial barriers in areas with

Fig. 7. Advance (A) and retreat (R) style ice margins at the south-eastern end of the Morozumi

ice margins in advance yielding passage of greater volumes of ice to these sectors. The former suggestion allows for a more uniform trend to be developed throughout the region.

The recency of the presumed ice-surface lowering is exemplified by the occurrence of "stranded crevasses" and reversals of ice drainage. "Stranded crevasses" occur on mountain platforms and ridges throughout northern Victoria Land. They appear to be fracturing remnants of recently higher ice surfaces. Currently ice flow is being topographically diverted around these crevassed ice bodies. Similarly, examples of ice drainage reversals suggest recent changes in ice-surface levels. As an example, in the area of the southern Gallipoli Heights, ice-cored medial moraines record former ice flow in a direction opposite to that at present, controlled possibly by ice-surface level changes.

Physical re-adjustments of tributary ice masses in the region of the upper Rennick Glacier were examined by observing the contact relationships between alpine and outlet glaciers. Under equilibrium conditions, it is assumed that if an alpine glacier acts as a tributary to an outlet glacier the former should be graded to the surface level of the latter. On the eastern side of the Morozumi Range lowering of the ice surface of Rennick Glacier may be responsible for the recent advance of several tributary alpine glaciers. Furthermore, the patterns of the ice-cored moraine of several unnamed alpine glaciers on the east-central side of this range appear to be flowing in a direction opposite to that of Rennick Glacier. This apparent disparity in flow direction between Rennick Glacier and these alpine glaciers may be accounted for by a lowering of the level of Rennick Glacier in the connection area of the tributary glaciers.

Along the north-western side of the Morozumi Range the cliffed terminii of several alpine glaciers suggest either recent advance of these alpine glaciers or a recent break in contact between the alpine glaciers and their base level, "Aleksandra" glacier. Alternatively, alpine glaciers along the south-western margin of the Morozumi Range consistently maintain contact with their outlet glacier base level. From this relationship it is assumed that the up-glacier migration of the descending "Aleksandra" glacier ice-surface may be tripping the breaks in contact between the alpine glaciers and this outlet glacier. It should, however, be noted that because of the lack of mass balance data from these alpine glaciers, interpretation of their location and activity, as suggested here, relies only upon the limited evidence for base-level lowering previously discussed.

Recent grounding line locations are not known with any certainty for any of the glaciers in northern Victoria Land except possibly for Rennick Glacier. The 1969–70 radio echo-sounding data for Rennick Glacier indicates that the grounding-line at this time extended inland, at least, as far as the northern tip of Litell Rocks, thus allowing marine waters to enter approximately 120 km inland. At this time there is no reason to believe that the inland grounding-line migration suggested by this study will not continue into the future causing successive inland-directed waves of ice-surface lowering. Therefore, this study concludes that the most northerly outlet glaciers of the Transantarctic Mountains are retreating.

Summary

The upper Rennick Glacier region has experienced at least two major glaciations. The oldest, Evans glaciation, has its upper limit marked by erratics and glacial erosional features and represents a period during which the region of the upper Rennick Glacier was almost entirely covered by ice. Although absolute dates are lacking, comparison of the Evans glaciation ice-surface with ice surfaces marking the maximum recorded ice inundation farther south along the Transantarctic Mountains reveals a general similarity. Therefore, the Evans glaciation may be loosely correlated with a maximum ice stand in the Transantarctic Mountains.

Re-advance of Rennick ice followed the retreat of Evans ice in the region of the upper Rennick Glacier. A buried soil at one of the field localities indicates that there was a period of subaerial erosion which interrupted the two glacial events. Steep slopes in the study area prevent exact determination of the maximum ice-surface level attained during the Rennick glaciation. However, a detailed pattern of Rennick ice retreat is apparent from the distribution of the fresh, unweathered surface clasts, sharp moraine ridges, and ice-marginal lakes. Most recent retreat during the Rennick glaciation is based upon ^{14}C dated algal peat deposits and recent physical re-adjustments of outlet and alpine glaciers. Algal peat deposits from ice-marginal lakes formed during the retreatal phase of the Rennick glaciation yield ages of 1085 and 1265 years B.P. The dates can be interpreted as either minimum deglaciation dates and/or dates for the initiation of a moist, dry climatic regime.

Physical re-adjustments of ice masses during the retreat phase of the Rennick glaciation all indicate a general inland migration of the Rennick Glacier grounding line. Migration of the grounding line has proceeded as far up Rennick Glacier as Littel Rocks. Continued inland migration of the grounding line is postulated.

ACKNOWLEDGEMENTS

The Rennick Glacier field party (P. A. Mayewski, J. W. Attig, R. Slocum, and S. A. Abakumov) wish to express thanks to: Squadron VXE-6 (U.S. Navy Support Force, Antarctica) for their invaluable air support, Holmes and Narver Co. for their logistic support, and the Supply and the Photographic Lab (U.S. Navy Support Force, Antarctica) for providing detailed aerial photographic coverage. In addition we wish to thank the New Zealand Antarctic Research Program based at Scott Base, Antarctica for loan of a light-weight field radio and for transmitting our radio communications. Radio-echo-sounding data were gathered during 1969–70 under a joint NSF–SPRI project. Data reduction at the Scott Polar Research Institute was funded under (United Kingdom) Natural Environment Research Council grant GR/3/2291. The authors wish to thank P. E. Calkin (State University of New York at Buffalo) for critically reviewing the manuscript. Research was supported by NSF Grant OPP 74-15210 while the senior author was a member of the Department of Geological Sciences and the Institute for Quaternary Studies at the University of Maine at Orono.

MS. received 20 January 1978 and in revised form 3 May 1978

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