CORRESPONDENCE

The Editor,

Journal of Glaciology

Sɪʀ, *Depth hoar on Arctic glaciers*

A coarse-grained, low-density layer of snow forms in late summer or early winter in both the accumulation and the ablation zones of Arctic glaciers and on glaciers elsewhere; it usually contains depth-hoar crystals, and forms a convenient stratigraphic annual marker (Benson, 1959, p. 51–52). Benson attributes the formation of the layer to a combination of strong wind and steep temperature gradient in the autumn, causing loss of mass by sublimation and evaporation. He uses the discontinuity between this layer and a finer-grained, denser and harder layer above as his annual boundary in pit profiles in the accumulation zone; in other words, the depth-hoar layer is the *top* component of his annual accumulation.

The purpose of this letter is to point out that in the ablation zone of a glacier the depth-hoar layer which forms immediately above the ice surface in, say, the 1962 spring is naturally regarded as the *bottom* component of the 1961–62 accumulation; no one would regard it as the accumulation of the 1960–61 budget year deposited after the end of the ablation season. In the accumulation zone, therefore, consistency and convenience in making computations of mass balance require that the bottom, not the top, of the depth-hoar layer be regarded as the annual boundary. Although the same processes operate, the depth-hoar layer does not of course form simultaneously on all parts of the glacier; it forms earliest in the highest accumulation areas and latest near the glacier terminus. It follows that the budget year should be considered as ending on different dates at different altitudes, which is not the same as saying that the budget year ends at the time when the snow-line on the glacier has reached its maximum recession.

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Defence Research Board,

Ottawa, Canada.

11 December 1961

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Benson, C. S. 1959. Physical investigations on the snow and firn of northwest Greenland during 1952, 1953, and 1954: interim report. *U.S. Snow, Ice and Permafrost Research Establishment. Research Report* 26.

Sɪʀ, *Patterned ground under ice fields**

The description which Dr. Stephenson gives of the occurrence of patterned ground adjacent to small ice fields in Antarctica (Stephenson, 1961) is in some ways similar to a situation which I recently noted while comparing air photographs of small ice fields in northern Baffin Island, District of Franklin, N.W.T., Canada.

Air photographs of a small ice field were made in 1949 and 1958 and comparison reveals that an average marginal recession of 180 m. took place in the nine-year interval. In the area thus exposed large high-centred tundra polygons with diameters of about 50 m. can be seen (Fig. 1). Similar polygons are visible on both sets of photographs extending over much of the surrounding country. No marked variation in size with distance from the ice field can be seen although some tundra polygons are elsewhere reported to form initially as large features and to divide up into progressively smaller polygons with age (Black, 1952). A close examination of the 1949 and 1958 ice margin using a high magnification stereoscope indicates that the large polygons are actually melting out from under the glacier ice giving a slightly "scalloped" appearance to the ice margin. Goldthwait (1951) described patterned ground including fissure polygons (tundra polygons) immediately adjacent to the Barnes Ice Cap in central Baffin Island and considered them as partial evidence of the expansion of the Barnes Ice Cap in the recent past, asserting that the patterned ground could not have been disturbed by glacier movement for many decades. Patterned ground has been reported emerging from beneath receding glacier ice in northern Ellesmere Island (Smith, 1961), in addition to the examples in Antarctica described by Stephenson (1961).

As Dr. Stephenson points out some of these features may pre-date the formation of the ice fields and

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this I believe may be the case in the example from northern Baffin Island. That tundra polygons can grow comparatively rapidly, probably in 50 to 100 years, has been shown by Mackay (1958), but it seems unlikely that the large polygons in northern Baffin Island could have developed in nine years, apart from the fact that half-emerged polygons are visible at the ice edge. It is also difficult to imagine their formation under the ice because of their very great size and raised centres. If the north Baffin Island polygons are "fossil" forms, then the ineffectiveness of the small ice fields as agents of direct erosion, or possibly their recent origin, is suggested. (Small ice fields on the Brodeur Peninsula of Baffin Island reveal incised V-shaped valleys on receding, similarly indicating their inability to alter the pre-existing landscape.)

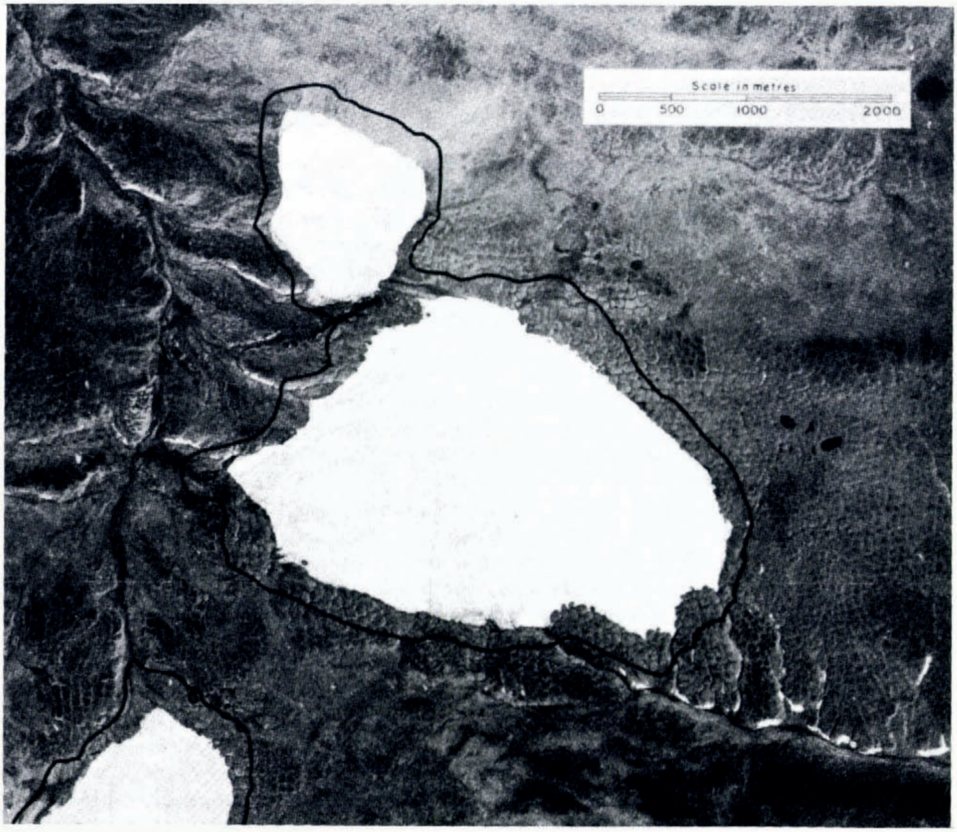

Fig. 1. Patterned ground emerging from beneath small receding ice fields in northern Baffin Island, Northwest Territories, Canada, 1 September 1958. The black line indicates the position of the ice field margin on 8 August 1949

(R.C.A.F. photograph)

An extension of glaciological and geomorphological studies in north-central Baffin Island by the Geographical Branch is planned for the summer of 1962 and further light may be thrown on these problems.

Geographical Branch,
Department of Mines and Technical Surveys,
Ottawa, Canada.
23 November 1961

G. FALCONER

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Stephenson, P. J. 1961. Patterned ground in Antarctica. *Journal of Glaciology*, Vol. 3, No. 30, p. 1163–64. [Letter.]

Sir, *Quaternary glaciations in southern Victoria Land, Antarctica*

Following the glaciological work of the Victoria University of Wellington Antarctic Expeditions (1958-59 and 1959-60) in the Wright and Victoria Valleys area of southern Victoria Land, Antarctica (Bull and others, 1962), more detailed observations on the late glacial history of the eastern half of the Wright Valley were made in 1959-60 and 1960-61 by Dr. R. L. Nichols of Tufts University (Nichols, 1961).

In general these later observations confirm the earlier ones. In the lower levels of the eastern part of the Wright Valley, Nichols has distinguished three stages in the extent of the glacier flowing westward from the area at present occupied by the Wilson Piedmont Glacier. The oldest of these stages (Nichols's *Pecten Glaciation*) is represented by the outwash gravels and sediments which occur south-east of Bull Pass, about 18 km. west of the present terminus of the Lower Wright Glacier (see Bull and others, 1962, fig. 8). The next youngest stage, Nichols's *Loop Glaciation* is represented by the prominent terminal moraine 11 km. west of the Lower Wright Glacier and by associated lateral moraines extending eastwards from this point. His most recent stage, the *Trilogy Glaciation*, is represented by terminal, lateral and ground moraines in the area near the Clark and Lower Wright Glaciers. The most recent of these moraines, extending 2 or 3 km. from the present snouts of these glaciers, are still ice-cored.

Nichols's *Loop Glaciation* corresponds to our *Third Glaciation* in the eastern part of the valley. We did not map the recent moraines near the Clark and Lower Wright Glaciers and have not marked them as being a separate glaciation on our map because the moraine ridges which establish this *Trilogy Glaciation* are much less pronounced than the features used to distinguish other glaciations in the valley. However, in the text we mention that moraines of our *Fourth* (Nichols's *Trilogy*) *Glaciation* and more recent moraines occur near the Lower Wright Glacier.

The only significant difference in interpretation occurs with the stratified gravels near Bull Pass. Nichols associates them with a separate (*Pecten*) glaciation; we regarded them as outwash from the *Loop* or *Third Glaciation*. The difference arises from the age attributed to the moraines which in places overlie the gravels. These were deposited by glaciers flowing from Bull Pass on the north and by the unnamed hanging glaciers on the south side of Wright Valley. Although these are marked as *Third Glaciation* on our generalized map we have regarded them (on the basis of degree of weathering) as being somewhat younger than the main deposits of Nichols's *Loop Glaciation*. Nichols regards these overlying moraines as contemporaneous with the main *Loop Glaciation* deposits, so that the gravels must be associated with an older glaciation. Nichols's interpretation may be strengthened by the presence of the formless deposits occurring on the sides of the valley between the *Loop Glaciation* terminal moraine and Bull Pass. Nichols has regarded these as lateral moraines associated with the *Pecten Glaciation*, while we considered them as being an earlier part of the *Third Glaciation*, considerably modified by the action of the lakes which later occupied the part of the valley west of the main terminal moraine of the *Loop* or *Third Glaciation*.

Further information on this problem may result from the work in the valley carried out in this last austral summer.

A more significant problem is the presence of the pectens which Nichols found in the stratified gravels in the centre of the Wright Valley, nearly 40 km. from the present coastline.

All of the glaciations referred to above post-date the last continuous glacier which flowed from the inland ice plateau through the valley to the McMurdo Sound area. After the disruption of the continuous glacier, small increases in the flow of plateau ice over the rock threshold at the head of the valley have caused local advances of the Upper Wright Glacier, as reported earlier. The relationship between these stages in the western end of the valley and those in the eastern end is not yet firmly established, but it is apparent that at the time the pectens were deposited the flow of ice eastwards from the plateau was not much greater than at present, while the glacier flowing westwards in the eastern part of the valley was relatively much more extensive than now.

It must be emphasized that the differences in the regime of the glaciers at the two ends of the valley are extreme. The supply of ice to the Clark Glacier and to the Wilson Piedmont Glacier and its extension,