Natural cairns on rock glaciers as an indication of a solid ice core

Ole Humlum

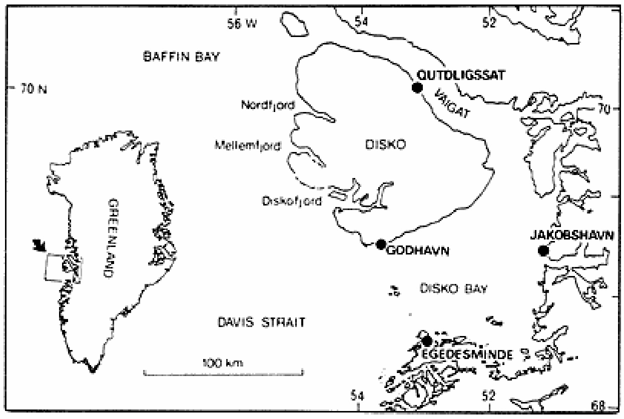

Fig. 1. Location map.

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A special surface feature taking the form of natural cairns is observed on rock glaciers in Disko, central West Greenland, known to possess a core of solid ice. These block accumulations are perceived as developed by the gradually outcropping of large englacial blocks from the ice core due to surface ablation, thereby lifting surface debris lying above. Below a line on the rock glacier where the surface debris layer equals or exceeds the depth of summer thaw, no more cairns are developed. Natural cairns as these on rock glaciers are suggested as a criterion for the existence of a solid ice core within the rock glacier, and the designation rock glacier cairn is proposed for them.

Keywords: *Rock glacier, Glacier-derived rock glacier, West Greenland, Disko.*

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Since the pioneering papers by Spencer (1900), Rohn (1900), Cross and Howe (1905), Howe (1909) and Capps (1910), rock glaciers have been described from many alpine areas throughout the world. The most comprehensive descriptions to date are probably those by Wahrhaftig and Cox (1959), Whalley (1974a), Höllermann (1983) and Haeberli (1985).

Many papers on rock glaciers have dealt with terminology, typology and genesis (see recent review in Martin and Whalley, 1987). There are, however, no complete agreement among investigators on the basic rock glacier classification. Present opinion is that one or more of the following three main types of rock glaciers exist:

A. Glacier-derived rock glaciers (Capps 1910, Pillewizer 1957, Grötzbach 1965, Barsch 1971, Potter 1972, Whalley 1974a, 1983).
B. Talus-derived rock glaciers (Crawford 1913, Outcalt and Benedict 1965, Wahrhaftig and Cox 1959, White 1981, Shakesby et.al. 1987).
C. Landslide-derived rock glaciers (Howe 1909, Shalley 1974b, Johnson 1984a, 1984b).

Glacier-derived rock glaciers are expected to contain a core of massive ice, whereas many talus-derived rock glaciers are envisaged as being ice-cemented by interstitiel ice and some are expected to contain larger bodies of solid ice derived from avalanche snow or refreezing water.

Only relatively little is known about the interior structure and ice content of rock glaciers. The most comprehensive description on this is probably the paper by Haeberli (1985). The general lack of detailed knowledge on this topic is caused by several factors. First of all, intensive rock glacier research has no long tradition, secondly, research on rock glaciers is hampered by the environment in which they occur, and thirdly, the very nature of the rock glacier itself represents a very perceptible difficulty. Most rock glaciers have a surface layer consisting of blocks up to several meters in size. Many rock glacier studies have therefore relied heavily on indirect means, first of all the study of aerial photos, but also implications of the morphology, topographical location and surface texture of the rock glacier. Only in a few cases shallow excavations and geophysical soundings have been carried out (see Barsch 1973 and Haeberli 1985).

Also in the future logistic problems will probably force investigators to apply different indirect means in the study of rock glaciers. It is the purpose of the present paper to draw attention to a small surface feature, which apparently only exists on rock glaciers with a solid ice core. Concurrent with different criteria suggested for use in aerial photo interpretation of rock glaciers (Outcalt and Benedict 1965, Vernon and Hughes 1966, Humlum in press), the field observation of this small-scale surface feature may hopefully assist in discriminating between different types of rock glaciers as to the character of ice content.

ROCK GLACIER CAIRNS

The present author is engaged in a study on glaciers and rock glaciers in Disko Island, central West Greenland (70°N, fig. 1, Humlum 1983, 1984, 1985, 1986, 1987, and in press). About 1700 individual rock glaciers exist in Disko, both glacier-derived and talus-derived features. No landslide- derived rock glaciers have been found. At

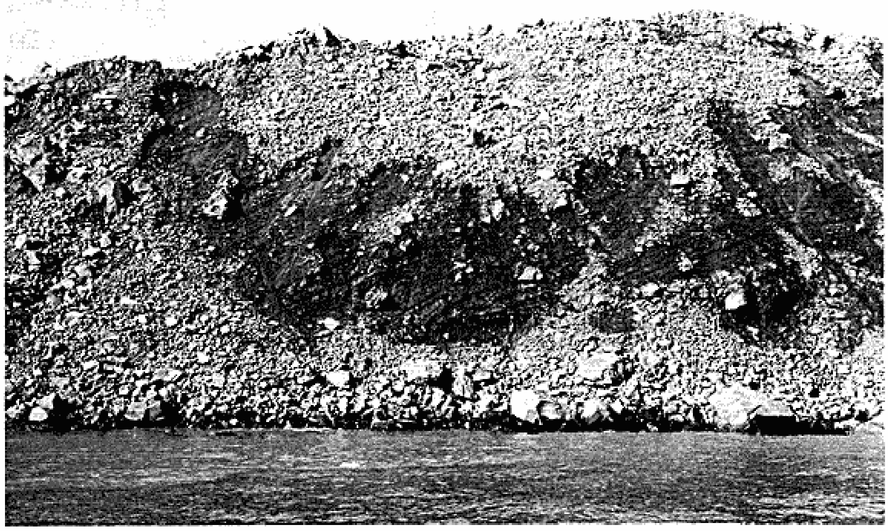

Fig. 2. Exposed core of solid ice in terminus of active, 5 km long glacier-derived rock glacier at Ujaragssuit, northeastern Disko. The rock glacier terminates into the sea, whereby erosion exposes the layered (foliated) ice core. The ice core rests discordantly on a deposit of angular blocks, interpreted as an apron consisting of debris avalanched down the advancing rock glacier front. At present, this rock glacier advances about (10-25 cm/yr. The cliff is about 15 m high. July 1986.

nine rock glaciers natural sections near their terminus have demonstrated the existence of a solid ice core, apparently consisting of glacier ice (fig. 2). In advance to the field investigations, all these rock glaciers were classified as glacier-derived and probably containing a solid ice core on basis of observations from aerial photos. Fig. 3 displays one of above rock glaciers. The individual ice crystals in samples taken from the ice cores were usually 0.5 to 3 cm in size. The solid ice contained both debris and air bubbles, organized in a layered structure, just as normal foliated glacier ice is (see fig. 2).

At all of the above rock glaciers a somewhat peculiar

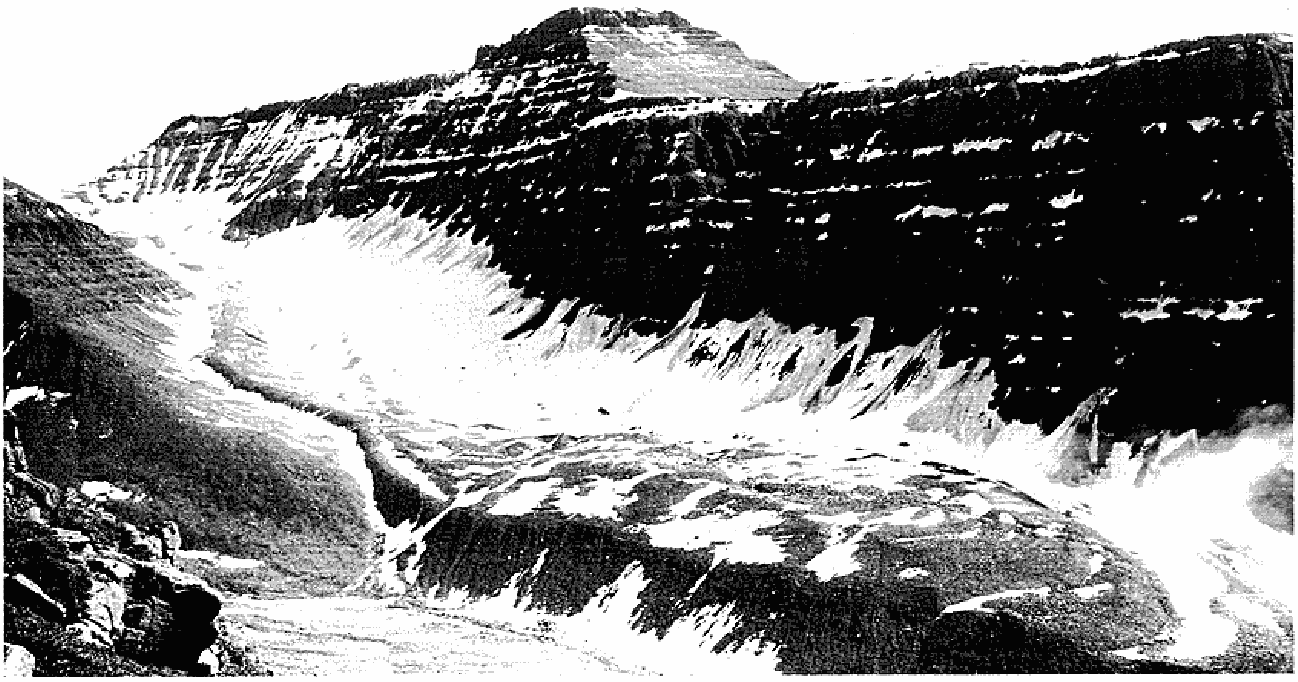

Fig. 3. Active glacier-derived rock glacier north of Mellemfjord, western Disko. The terrain rises to about 1000 m a.s.l. The rock glacier front is about 70 m high. A small normal glacier exists above the rock glacier. Above the head, the rock glacier gives way to a normal lateral moraine with ice core. On the upper half of the rock glacier surface natural cairns are frequent. Seen towards the east. July 1986.

Fig. 4. Rock glacier cairn on glacier-derived rock glacier at Ûnartoq, eastern Disko. The cairn is about 1.3 m high. September 1985.

surface feature was observed (fig. 4, 5, and 6). Natural cairns 1-2 m high occurred several places on the rock glacier surface. In most instances their frequency was rather great near the rock glacier head, where up to several scores could be recognized within visual distance, and declining towards the rock glacier terminus. Some have, however, been observed quite close (150 m) to the terminus. The lower part of these cairns always appears to consist of one large boulder, often 2-4 m in size. In several occasions this basal boulder showed distinct vertical striae (fig. 6).

These natural cairns are perceived as an indication of the presence of a solid ice core beneath the rock glacier surface. The line of reasoning is outlined in fig. 7. Rock fragments derived from the headwall above the glacier falls upon the accumulation area below, where they are buried by snow and incorporated in the glacier. Subsequently the rock fragments are transported towards the ablation area in englacial position as glacial debris. Below the equilibrium line (ELA1 in fig. 7) the fragments crop out on the ice surface concurrent with the loss of ice. During this process, very large boulders, still with their lower part firmly embedded within glacier ice, may slowly lift fragments lying above, relatively to adjoining debris lying on the ablating glacier ice surface. As the large boulders penetrate surface debris, their flanks may become vertically striated due to the contact with adjoining blocks lying on the ice surface. This mechanism would not work in the absence of a solid ice body below the surface debris, and I would, therefore, suggest this phenomenon to represent a useful criterion for the presence of an ice core within rock glaciers where it is observed. This ice core may or may not consist of glacier ice. The emerging boulders lifting surface debris take the appearance of natural cairns, and I would suggest that they should be referred to as *rock glacier cairns.*

Fig. 5. Rock glacier cairn at glacier-derived rock glacier north of Mellemfjord, western Disko (fig. 3). July 1987.

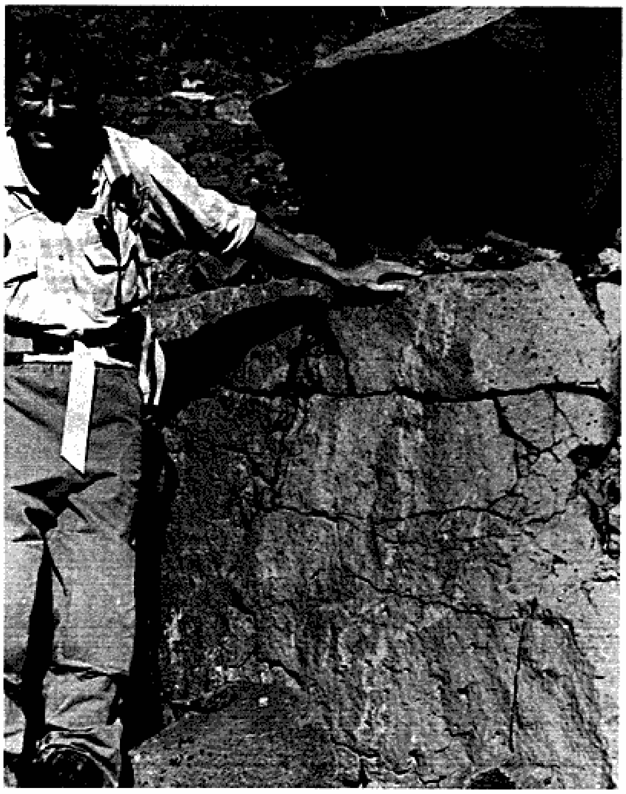

Fig. 6. Vertical striae on flanks of basal boulder in rock glacier cairn. The striaes were presumably produced by contacts with adjoining blocks as the basal boulder emerged through the general rock glacier surface layer. July 1987.

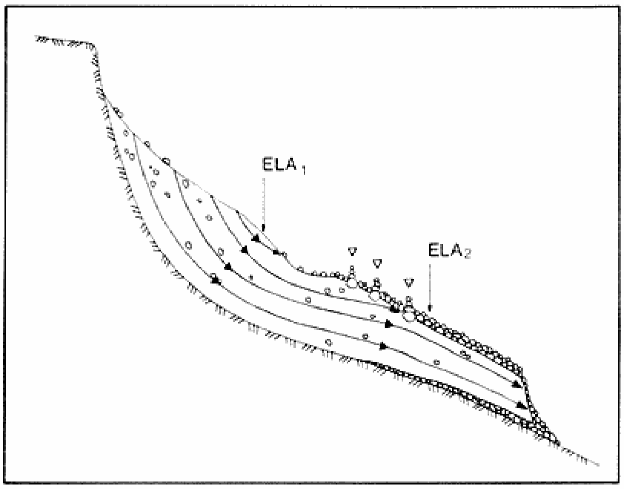

Fig. 7. Model of glacier-derived rock glacier explaining the occurrence of rock glacier cairns. ELA1 is the equilibrium line on the normal glacier above the rock glacier, whereas ELA2 is the equilibrium line on the rock glacier part of the glacier-rock glacier complex. The ELA2 is a hypothetical concept, and may be absent on some rock glaciers. Below the rock glacier equilibrium line the ice mass balance of the rock glacier is positive due to basal refreezing and accretion of superimposed ice on the upper ice surface. Between ELA1 and ELA2 ice flow lines have a component toward the surface, and stacks of smaller blocks may be lifted on the back of large emerging boulders to form rock glacier cairns (triangles).

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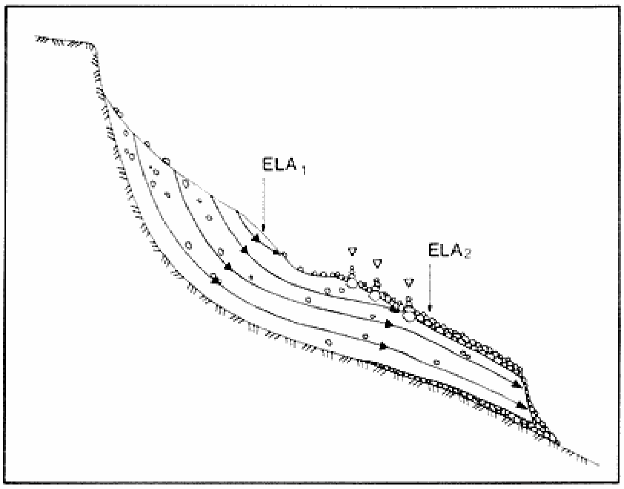

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Massbalance studies of the Mitdluagkat Glacier, Eastern Greenland

Bent Hasholt

Hasholt, Bent: Massbalance studies of the Mitdluagkat Glacier, Eastern Greenland, Geografisk Tidsskrift 88: 82-85. Copenhagen 1988.

Changes in volume of the Mitdluagkat Glacier in Eastern Greenland are studied by comparison of maps based on aerial photos from 1972 and 1981. The results are compared with detailed measurements at the terminus and at ablation stakes.

Keywords: *Glaciology, Hydrology.*

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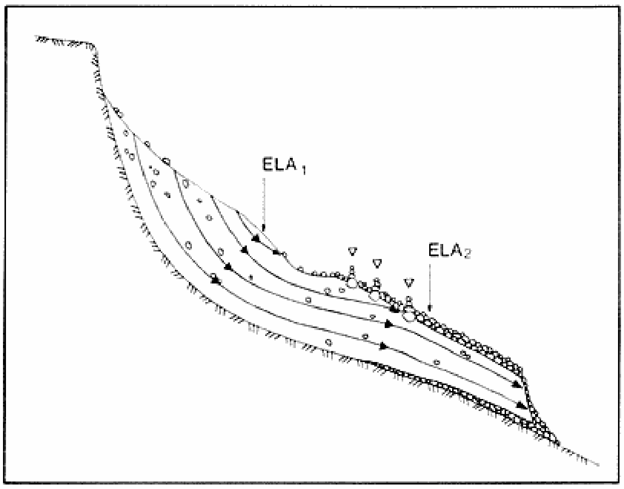
Large variations in the recent behavior of glaciers within and around the North Atlantic area are reported within recent years, Bjørnsson (1979), Knudsen and Theakstone (1981), Gordon (1981), Liestøl (1983), Anda et al. (1985), and Humlum pers.com. (1987). This paper contributes to the knowledge of the overall pattern in delivering new data from an area where very few data exist.

The Mitdluagkat Glacier was described earlier by Fristrup (1960, 1962, and 1970) and Valeur (1959); it was shown that the glacier has retreated since the first observations in 1933. These results are based mainly on observations of the terminus, but a few measurements at stakes in the upper part indicated a negative net-balance for larger parts of the glacier. In 1972 the glacier was photographed from the air, and a triangulation network was made at the same time. In 1976 a map based on the 1972 aerial photos was drawn; the map did not cover the whole glacier, the scale was 1:5000 with 5 m contour intervals. This map was evaluated by Hasholt (1986) on the basis of new triangulations and hydro-glaciological observation. A comparison with older maps showed an accumulation of volume above the 350 m level contradicting the older observations; the conclusion was, however, that it was most likely that the accumulation found was due to errors in the map from 1932-33.

In 1981 the area was photographed again by Geodetic Institute in scale 1:150,000. As an experiment a new map based on these aerial photos covering the whole glacier was drawn in scale 1:20,000 with 10 m contour intervals. An evaluation of this map was published by Hasholt (1987). The evaluation indicated that the new map of the



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