

Mitteilungen

Genesis of the Push Moraine at Kötlujökull, Iceland: A Commentary

By Ole Humlum*

INTRODUCTION

In a recent paper in this journal, HEIM (1984) describes the formation of a push moraine, which at present is being formed along the margin of the glacier Kötlujökull (also called Höfdabrekkujökull), Iceland. In this paper HEIM introduces the concept of a "glacier-foot" (Gletscherfuß), derived from the lowermost part of the steep glacier terminus by small-scale extrusion-flow, and supposed to be of considerable importance for the formation of the push moraine described.

As a member of the Danish geomorphological Myrdalsjökull research group (lead by J. Krüger, Univ. Copenhagen), I have myself studied the formation of the above moraine during the summers of 1977, 1979 and 1982 (KRÜGER & HUMLUM, 1981; HUMLUM, 1983, 1985). Our investigations were done along the northern half of the almost 12 km glacier terminus of Höfdabrekkujökull, i. e. just north of the area studied by HEIM. On this basis, I enjoyed reading the paper by HEIM (1984), but I disagree as to the supposed origin of the so-called "glacier-foot". This will shortly be outlined below. In his paper, HEIM (1984) mentions my 1983-paper, and points out correctly that my interpretation differs from that proposed by him. However, he did not mention the nature of the disagreement.

OBSERVATIONS ON THE "GLACIER-FOOT"

As described by HUMLUM (1983, 1985) and HEIM (1984), Höfdabrekkujökull/Kötlujökull is at present advancing at a rate of 10—25 m/yr. Because of this, a 2—10 m high push moraine is being formed along the glacier front which is especially pronounced where the glacier overrides glaciofluvial sediments. The moraine, which may have an imbricated inner structure, contains bodies of solid glacier ice at some locations (HEIM, 1985), whilst at other locations no ice is found within it (HUMLUM, 1983, 1985).

In the summer of 1977, when I had the opportunity to study the glacier margin of Höfdabrekkujökull for the first time, the advance noted above had just been initiated following several years of backwasting (since about 1955; see KRÜGER & HUMLUM, 1981). At this time the glacier front was generally not as steep as is observed today (10—40 deg. versus 50—90 deg.). The lower part of the glacier front was then covered by a considerable amount of debris.

In 1979 the overall appearance of the glacier terminus had changed considerably. At several locations the glacier was now clearly advancing, and the general surface gradient at the terminus had increased to 30—70 deg. Along sections of the margin, the debris covered remnants of the old glacier terminus were being pushed over ice-free terrain by reactivated ice further upglacier (Fig. 1). The visual appearance of the glacier terminus were thus identical to the "glacier-foot situation" described by HEIM (1984).

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Fig. 1: The terminus of Höfdabrekkujökull in July 1979. A frontal apron consisting of glacier ice covered by supraglacial debris is prominent. To the right the active, exposed part of the glacier terminus is seen.

Abb. 1: Die Gletscherstirn des Höfdabrekkujökull im Juli 1979. Davor ein Schurz von Gletschereis, welches mit supraglazialen Schutt bedeckt ist. Rechts ist der aktive, exponierte Teil des Gletscherabfalles sichtbar.

GENESIS OF THE "GLACIER-FOOT"

Three years later, during the summer of 1982, a situation as shown in Fig. 1 was still apparent at several localities along the northeastern margin of Höfdabrekkujökull. In all cases, my clear impression — partly justified by comparison with photographs obtained in 1977 and 1979 — was that the bodies of glacier ice found along the lower part of the steep, active front were remnants of the distal part of an older ice surface. In no cases did they appear to be derived by extrusion from the lowermost part of the glacier front. Along the distal rim of these remnants, a push moraine was being formed as these ice bodies were being pushed by the active ice upglacier, just as a push moraine was being formed along the active ice margin at places where no ice remnants were present.

The extreme northeastern part of the glacier was not included in the general advance until much later, and along this part of the glacier terminus it was still possible in 1982 to find examples of almost detached remnants of the older glacier front, which laterally gave way to other remnants in contact with the active ice. Those remnants were being pushed over the foreland beyond, thereby producing a push moraine along their distal rim (Fig. 2) — much the same as the situation described by HEIM (1984).

I would therefore suggest, that also the "glacier-foot"-features described by HEIM (1984), at least the majority, are also reactivated remnants of an earlier glacier surface. These remnants have survived either because of a substantial cover of supraglacial debris, or because of burial by glaciofluvial sediments. Very high positive net sedimentation rates (up to 3 cm/day) are common in many fluvial sedimentation basins close to the present ice margin. I am therefore sceptical about the concept of a "glacier-foot"



Fig. 2: Folding of glaciofluvial sediments along debris-covered remnant ice bodies, which are being pushed over ice-free terrain by active ice farther to the right. July 1982

Abb. 2: Faltung von glazifluviatilen Sedimenten an schuttbedeckten Toteiskörpern, welche von aktivem Eis (weiter rechts) über eisfreien Untergrund geschoben werden. July 1982.

produced by extrusion flow from the lowermost part of a steep glacier front. Furthermore, I do not find it quite appropriate to involve the theoretical developments by GLEN (1955) and NYE (1957) on ice deformation in the present context (see HEIM 1984: 34), as these theoretical descriptions may be invalidated by large surface gradients such as those experienced close to a glacier margin.

Having presented this alternative point of view, I want to emphasize that professor HEIM has presented a very valuable and thorough description of a recent push moraine. This is clearly a field of glacial geomorphology where the general glaciological situation characterizing many glaciated areas in our century before 1960—1970 (backwasting glaciers) has made investigations on this subject at recent glaciers difficult, if not to say impossible. More work on the formation of moraines at recent glaciers is therefore much needed. Finally, I would like to draw attention to a coming paper by KRÜGER (in press), in which important supplementary results from the continuing work by the research group on the push moraine at Höfdabrekkujökull will be presented.

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Genesis of the Push Moraine at Kötlujökull, Iceland: A Reply

By Dieter Heim*

When my co-workers first talked about ice-slabs extruding from the base of Kötlujökull, I became angry and told them, that those slabs could correspond only with old remnant ice previously buried by fluvio-glacial debris and then pushed upwards by the progressing glacier. However now — surely to learn a lesson — again and again I have to defend my glacier-foot against old ice-relicts.

In fact, the Fig. 2 of Dr. Humlums "Commentary" appears to represent a similar situation at the north-eastern margin of Kötlujökull 1982 as I found at the southeastern and eastern margin in July and August 1983, if the debris ridge in Dr. Humlums figure ends to the right at a steep glacier slope. And perhaps this ridge hides old reactivated ice remnants (though I suppose, that one has to excavate that ridge to make sure). But at the southeastern and eastern margin of Kötlujökull excavations of 9 ice-cores distributed over 5 km glacier margin as well as some less extensive diggings clearly showed, that here ice grew out of the glacier slope without joints in 1983. When the glacier ice showed foliation, the closest part of the extruding ice-slab showed the same foliation. Often one could observe the top of a ridge shaped ice-core bending out of a small meltwater generated ridge of the glacier slope (e. g. the left ridge in Fig. 1) and ending in the third push moraine ridge in front of the glacier-foot.

Dr. Humlum's comments with regard to the evolution of the margin of Kötlujökull since 1977 are generally in good agreement with my own results (HEIM, 1983: 27; 1984: 23—26). However, according to air-photo surveys the progression of the glacier already began before August 1975. It was clearly recognizable at the southern margin in July 1978 to me, and during the following years it successively seized the southeastern and eastern margin. By 1983 this part of the glacier was certainly in a more advanced stage of evolution than the northeastern part in 1982, and I suppose that this caused some different observations in our research areas.

In the first stage of evolution the progressing glacier conflicted with an apron of old ice remnants, in our

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