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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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Fig. 1: Two debris covered ice-ridges, connected at the base and extruding out of the glacier slope (the left ending behind the spade) with an excavated push- and pile-moraine (see Fig. 10 in HEIM, 1984).

Abb. 1: Zwei schuttbedeckte, an ihrer Basis miteinander verbundene und aus der Gletscherwand heraustretende Eis-Zungen (die linke endet hinter dem Spaten) mit einer ausgegrabenen Stauch- und Stapelmoräne (vgl. auch Abb. 10 in HEIM 1984).

research area mostly with ice-cored debris ridges. Usually, the glacier succeeded here in surmounting these ridges (Fig. 2), perhaps because of the relative high base of the glacier. In a second stage, when the glacier had crossed that apron, one could observe first a belt of push moraines with 1—3 ridges directly in front of the steep glacier slope, not similar to the moraines described in HEIM (1984). After this stage of evolution and partly at the same time the development of a "glacier-foot" and crescent-shaped push moraines 5—60 m in front of the glacier slope began. Whereas the remnant ice usually caused debris ridges parallel to the glacier margin, meltwater-shaped ridges vertical to the margin and small protruding ice-slabs are characteristic of the glacier-foot.

With regard to remnant ice below the surface of the glacier foreland, I found until 1981 indications for the presence of buried ice by new formations of holes in fluvioglacial plains in front of the eastern glacier margin. Therefore we tried a thorough investigation for buried ice relics in this area with hammer shock seismics and excavations in July 1983. We found some ice cores in end-moraines 30—40 years old, but no relics near the glacier margin (with the exception of one just molten ice-plate, which probably never belonged to the glacier).

If there can be no doubt about the primary connection of the glacier-foot with the present glacier slope in

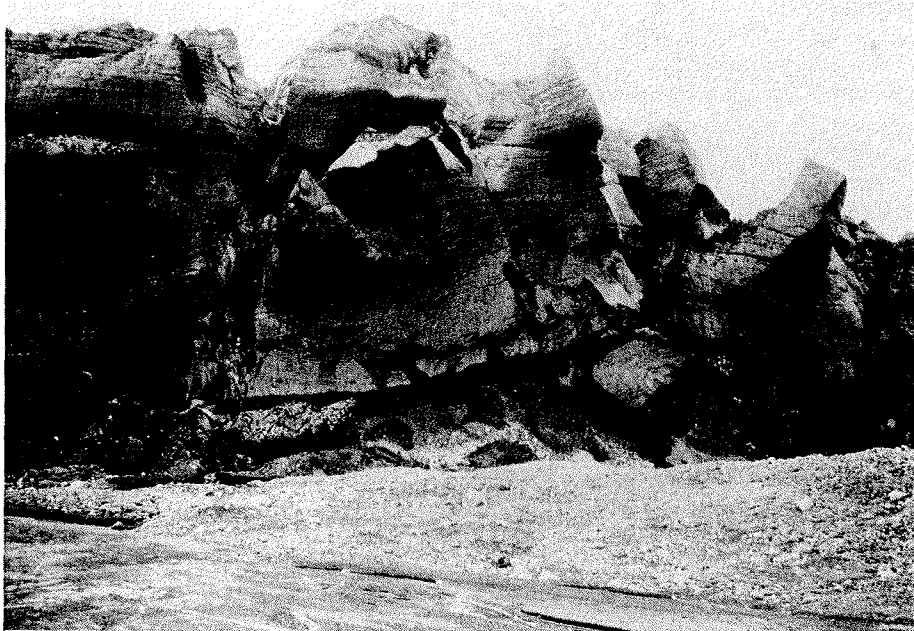


Fig. 2: The Kötlujökull surmountin old ice-cored moraines.

Abb. 2: Der Kötlujökull überfährt alte Eiskern-Moränen.

our research area, there are of course many questions open concerning the reason of this appearance. All observations mentioned in my article are in good accordance with extrusion-flows near the melting-point. Another assumption could be a different melting of the glacier slope, especially a delayed melting of the debris covered base. But certain observations yield strong arguments against assumptions of this kind.

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