CORRESPONDENCE

The Editor,
The Journal of Glaciology

SIR, *Subglacial stoping or block caving*

The description of subglacial stoping or block caving of the Black Rapids Glacier in Alaska in the *Journal of Glaciology*, Vol. 2, No. 20, 1956, p. 727, reminds me of the almost identical conditions of the Kome Glacier on Nugssuaq Peninsula in the Umanaq District of western Greenland observed 27 years ago (*Wissenschaftliche Ergebnisse der Deutschen Grönland-Expedition Alfred Wegener*, 1929, und 1930/31, Bd. 3, 1935, p. 14). Lowering and rapid recession of the central part, caving in with crescent-shaped crevasses, a huge ice tunnel and a vigorous meandering melt water stream cutting through the ice were features of the Kome Glacier too. Such forms are probably created if the front parts of a glacier become stagnant and the destructive forces of melt water are no longer counteracted by the supply of ice from the higher parts of the glacier. These features represent a particularly strong development of a complex of forms which are typical of the ablation zone near the snout of glaciers (see R. v. Klebelsberg, *Handbuch der Glaziologie und Glazialgeologie* 1948, p. 122–139).

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12 November, 1956

SIR, *The Formation of Ogives*

The review by Mr. W. V. Lewis[1] on the status of present-day knowledge on the formation of ogives, and suggestions for the direction that future research should take, is a most stimulating contribution to this important problem.

Mr. Lewis concludes by "posing the greatest puzzle of all—are these ogives the upturned ends of the parcels of annual layers which spill over the lip of the ice fall?" From observations in south-east Iceland[2], conducted by Dr. C. A. M. King and the writer, it appears that the answer to this question is "no"! Ogives on the south-east side of Morsárjökull were seen to form despite the fact that this glacier has been severed from its accumulation area since the 1930's and that the mode of supply is now entirely by avalanching ice. During this process all traces of the original stratification must be completely destroyed. Mr. M. M. Miller has described to the writer a similar glacier in Patagonia where ogives form beneath avalanches. Neither is it likely that such large-scale features as the stratification of the *névé* could descend through a broken ice fall without disruption.

Too much emphasis must not be placed upon the apparent annual formation of ogives, which has admittedly been proven on several glaciers. The spacing of the ogives does not always correspond to the annual movement of the relative section of the glacier. On Svínafellsjökull five ogives were seen to form in the space of one year's movement, albeit every fifth, or annual, ogive was more pronounced than the intervening ones. On Falljökull, however, the spacing, and presumably the time of formation, of the ogives was found to be irregular, and it appears that between six and twelve ogives form during the course of one year.

To explain these characteristics differential movement within the ice fall, or avalanche cones, including possible surges of flow and release of accumulated pressure along zones of thrusting, must be considered, together with the association of pressure ridges at the base of the ice fall with the formation of the ogives. In this connection Professor S. Thorarinsson has aptly commented on the formation of "ogives" in lava streams[3] where the question of an annual rhythm cannot be considered.

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The paper by Dr. J. W. Glen[4] appears to substantiate the relation between the formation of ogives and the mechanism of movement within the ice fall, and surely any theory must take into account the formation of ogives under the different conditions mentioned above.

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17 *December* 1956

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SIR,

Mr. Ives is, of course, correct in pointing out that ogives which form below a severed ice fall cannot be related to the original stratification in the ice field above, but the new stratification—predominantly seasonal—developed in the avalanche fan must surely be present in these ogives. The most helpful studies which Dr. King and Mr. Ives made of ogives in Iceland certainly point to the reality of overthrusting and shearing in rotating the ice layers at the foot of the steep Morsárjökull avalanche fan, and probably at the foot of the ice fall on the same glacier system.

Having at first mistaken sedimentary layering in Norwegian cirque glaciers for tectonic layering, I may now be underestimating the frequency of purely tectonic layering below an ice fall, but I can assure Mr. Ives that I am not underestimating the reality of rotation at the foot of ice falls or other steep slopes on glaciers. This may involve overthrusting along discrete surfaces and also shearing without such discrete fractures. However, I still think that the major problem remains of distinguishing between the contribution of sedimentary layering—primary or secondary—and of tectonic layering to these structures. The complete obliteration of the seasonal layers formed in the *névé* must, I think, be very rare except at a severed ice fall or on a glacier with very complex and active overthrusting and shearing.

I am grateful to Mr. Ives for reminding me that, in thinking too much of Austerdalsbreen in what perhaps should have been a more general discussion, I over-simplified the matter.

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SIR,

The Correct Rammsonde Formula

In his derivation of the theory of the Rammsonde, Haefeli[1] gave two formulae for the ram resistance:

$$W_1 = \frac{Rh}{s} + (R+Q) \text{ for a completely elastic impact,}$$

and

$$W_2 = \frac{Rh}{s} \cdot \frac{R}{R+Q} + (R+Q) \text{ for a completely inelastic impact.}$$

He proceeded to use the first formula, because it is somewhat simpler, and everyone since has followed his example.

However, impacts in snow or firn are almost completely inelastic. When the weight strikes the top of the tube, an elastic wave travels down it. A completely elastic impact would occur only if the

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