AN ESKER-LIKE RIDGE IN PROCESS OF FORMATION, FLATISEN, NORWAY

By J. C. Stokes
(Cambridge Expedition to Svartisen, 1957)

Abstract. A ridge of drift emerging from the snout of Flatisen resembles a small esker. It originates in a subglacial tunnel. The source of the material forming the ridge was a number of thrust planes exposed in the sides and roof of the tunnel. The main features of the tunnel and the ridge are described and the mode of formation of the ridge suggested.

Zusammenfassung. Ein aus Schotter bestehender Rücken, der sich aus der Spitze des Flatisen erhebt, gleicht einem kleinen Os. Er entspringt aus einem subglaziären Tunnel. Der Ursprung des den Rücken bildenden Grundstoffes lag in einer Anzahl von Überschiebungsflächen, die an den Seiten und der Decke des Tunnels blossgelegt waren. Die Hauptmerkmale des Tunnels und des Rückens werden beschrieben, und die Formationsweise des Rückens wird erwogen.

Flatisen is one of the larger outlet glaciers of the Svartisen Ice Cap in northern Norway. It has retreated in the present century, ponding back a large lake along almost the whole length of its snout. The snout is approximately 1000 m. wide and the ice cliffs reach a maximum height of 18 m. above the lake. Retreat has been rapid in the present century. In 1935 the glacier still extended almost right across the basin of the present lake. The lake is thus of very recent creation. Photographs of Flatisen before the lake existed include those by Rekstad (1891), Marstrander (1910) and Lundqvist (1935).*

An esker-like ridge emerges from a subglacial tunnel on dry land close to the northern margin of the lake (extreme right of first photograph on p. 289). Although the ridge closely follows the lake shore, there is nothing to indicate that the presence of the lake has played any direct part in its formation. It was possible to penetrate several hundred metres under the ice along the tunnel and see the ridge being formed. The process seemed different from any previously described.

I have called the feature "an esker-like ridge" rather than an esker because it differs somewhat from the accepted definition of the term.[1] The ridge consists mainly of fine rock flour, sand and gravel with some large boulders and extends in almost a straight line for over 300 m. at right angles to the ice front, that is, in approximately a west-east direction. It is bounded by a small beach sloping down to the lake on the south and by a small, braided stream flowing on morainic debris to the north. The stream breaks through the ridge in several places; otherwise it is continuous except for a small gap close to the snout. The ridge attains its maximum height (16 m.) near the snout where it is ice-cored, but becomes gradually smaller in cross section away from the glacier where the ice core has melted and erosion has proceeded longer. At its far end it is only 1-2 m. high and for much of its length it does not exceed 5 m. in height. The sides are everywhere steep, partly because of undercutting by the stream on one side and probably by the lake in the high-water season on the other. The undulating crest line is quite narrow for most of its length, though it is broad and curved in the ice-cored section near the snout, and in places has a wider, irregular surface resembling that of kettle moraine. Unfortunately no large section was cut, but half an hour's work with an ice axe on one of the slopes failed to reveal any stratification of the drift. This is the main point of contrast between this feature and the normal esker.

The north-east corner of the snout of Flatisen from which this esker-like ridge issues is composed of thin, dirty ice which has spread out northwards down-glacier from a large protruding rock spur and become almost stagnant (Fig. 1). A great thickness of lateral,

* Granlund, E., *and* Lundqvist, G., Några iakttagelser från en resa i Helgeland sommaren 1935. *Norsk Geografisk Tidskrift*, Vol. 6, No. 1, 1936.

https://doi.org/10.3189/S0022143000023935 Published online by Cambridge University Press

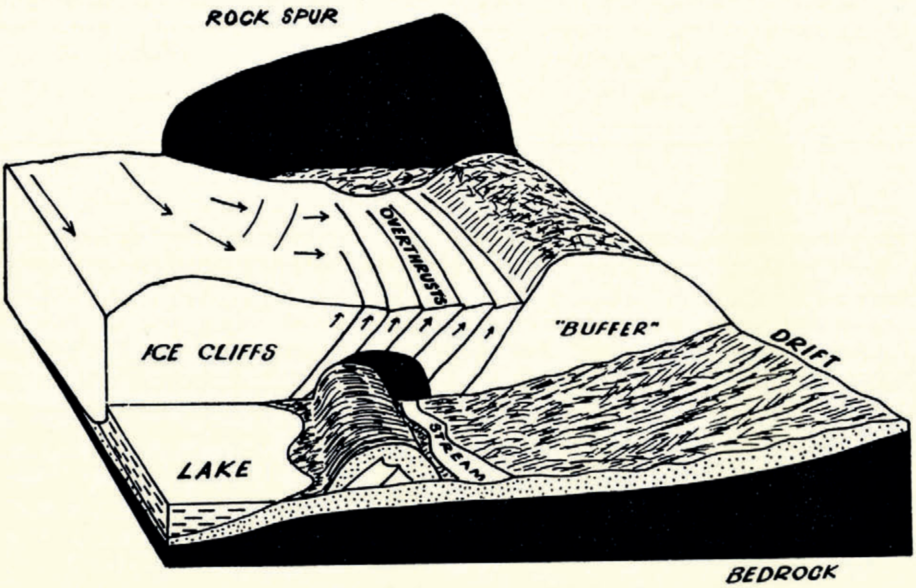

Fig. 1. Illustrating lateral overthrusting near the snout of Flatisen and its relationship with the cave and its esker-like ridge. The ice-cored ridge is seen emerging from the cave

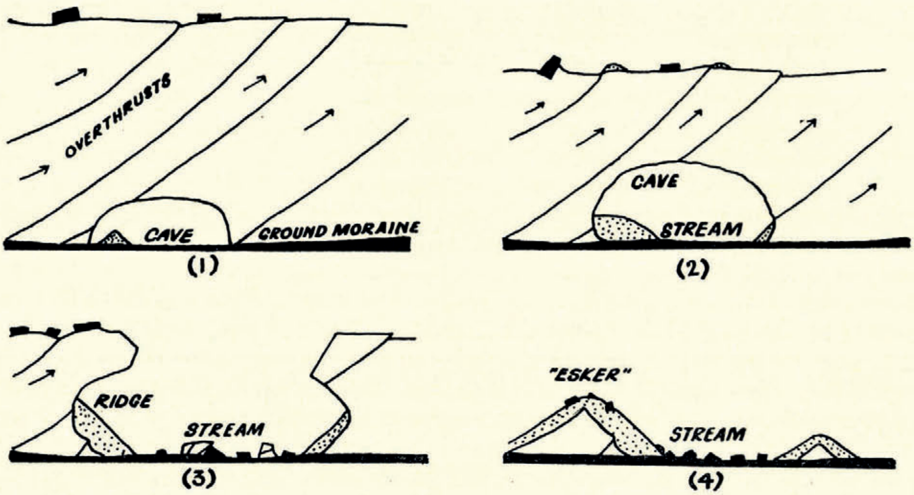

Fig. 2. Successive stages in the formation of an esker-like ridge within an ice cave

moraine-covered ice acts as an effective buffer to further movement in this direction. A large number of roughly parallel inclined cracks break the surface of the ice close to this buffer. They are confined to the thin, cleaner, more active ice, are parallel to its lateral margin and dip towards the centre of the glacier. They all contain dirt which in places forms lines of dirt cones on the surface of the glacier. Occasionally they separate dirty, black ice from cleaner, blue or white ice. No measurements of differential motion were attempted, but the position and form of the cracks led me to interpret them as overthrusts. Chamberlin [2] ascribed lateral thrusting of this type to frictional retardation of the ice at the edge of the glacier. This may well be important here. The presence of the buffer of thick, moraine-laden ice, which would oppose a component of thrust outwards from the middle of the glacier, is probably another important factor.

An extensive system of subglacial tunnels riddles this part of the glacier. They carry both glacial melt water and streams which plunge down the valley wall and disappear under the ice. The floor of the tunnels almost invariably consists of boulders from which the finer material has been removed by running water. Occasionally the bedrock is exposed. The passages are roughly semi-circular in cross section with large polygonal scallops on roof and sides. They curve gently, are tributary one to the other and frequently divide and rejoin to form "ox-bow" loops. The union of several passages has resulted in the formation of one or two large chambers which are 15-20 m. wide and have roofs 4-5 m. high. Only in a few places, however, does the height of the roof exceed 3 m. and the width of the floor 10 m., while the smaller tributary passages and "ox-bows" are frequently about 2 m. wide and 1 m. high. The numerous thrust planes of this part of the glacier were very much in evidence on the walls and roof of the main tunnel.

The most conspicuous features of the tunnel system, however, were several long ridges of debris piled against the ice walls. If the surrounding ice were to melt away these ridges would form an elongation of the esker-like feature already described. Here was that rarely seen phenomenon [3]—an "esker" in process of formation. The piles of debris formed an almost continuous line of steep-sided ice-contact ridges in the main tunnel. The drift was frequently piled as high as the ice roof on one side of the cave and was occasionally present on both sides. It consisted of the same fine material as that of the ridge outside the cave.

The large size of the caves appears to be due to ablation of the roof and sides, rather than to melting by the subglacial stream. This small stream is an obvious misfit in its large tunnel. If its volume were increased tenfold, the water level would still be well below the roof of the tunnel. It is therefore unlikely that debris piled as high as the roof could have been deposited by the stream although the stream doubtless kept the ridges steep by undercutting them.

The ridges were present only in those passages which cut through thrust planes on the roof and sides. These thrust planes appeared to be the source of the material. The diagrams (Fig. 2) demonstrate the mechanism of the process. The drift is brought up from the sole of the glacier by movement of the ice along thrust planes. It is deposited when they are melted out.

It is perhaps surprising that the thrust planes carry material in sufficient quantity to leave a prominent ridge once the surrounding ice has melted. Yet Salisbury [4] and others have shown that large ridges may be built on the surface of the ice by much the same process. An additional source of material for the ridge is ablation moraine which is let down on the top of the other debris when the ice finally melts away. This was a conspicuous deposit because of the generally larger size of its individual particles, but it nowhere contributed more than a small fraction of the total debris of the ridge and tended to roll and slide off as the ice core melted.

Clearly this process is rather a special one which can only construct small, unstratified features resembling eskers. Yet they may not be rare. An opportunity of witnessing their mode of formation under the ice may not have previously been offered.

MS. received 7 February 1958

REFERENCES

1. Flint, R. F. *Glacial and Pleistocene geology*. New York, John Wiley & Sons, Inc., 1957.
2. Chamberlin, R. T. Instrumental work on the nature of glacier motion. *Journal of Geology*, Vol. 36, No. 1, 1928.
3. Lewis, W. V. An esker in process of formation, Böverbreen, Jotunheimen, 1947. *Journal of Glaciology*, Vol. 1, No. 6, 1949, p. 314-19.
4. Salisbury, R. D. Salient points concerning the glacial geology of northern Greenland. *Journal of Geology*, Vol. 4, No. 7, 1896.

Top left. Flatisen; *the ridge is just visible on the right shore of the lake*

Top right. The esker-like ridge

Centre left and right. Extrusion of the ridge from the glacier. Minor shearing of the ice is visible in the snout

Bottom left and right. The ridge inside the cave

https://doi.org/10.3189/S0022143000023935 Published online by Cambridge University Press