

SNAEFELL, EAST ICELAND

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ABSTRACT. The morphology of Snaefell, East Iceland, and the state of its glaciers in 1937 are described. There are four small glaciers. Two of these exist in well-developed cirques incised into the lavas, tuffs and breccias of this Pleistocene volcano. The third receives ice from a summit ice cap, while the fourth also receives ice from the same source as well as lying in a cirque. The firn line in 1937 is put between 1350 and 1500 m. so that the mass balance of the glaciers is unlikely to have been favourable, although only one showed any abandoned moraines. An explanation of the varying glacial modification of the different slopes of Snaefell is suggested in terms of structural trends, shading from the sun and snow-drifting.

ZUSAMMENFASSUNG. Die Morphologie des Snaefell, Ost Island, und die Verfassung seiner Gletscher im Jahre 1937 sind beschrieben. Es gibt da vier Gletscher, von denen zwei gut entwickelte Kare einnehmen, die in die Lava, die Tuffe und Breccien dieses Pleistozän-Vulkanes eingeschnitten sind. Der dritte Gletscher empfängt sein Eis von einer Gipfel-Eiskappe, während der vierte sowohl Eis von derselben Quelle empfängt als auch in einem Kar liegt. Die Firn-Linie wird für das Jahr 1937 als auf zwischen 1350 und 1500 m. angegeben, so dass es unwahrscheinlich ist, dass die Massenbilanz der Gletscher eine günstige war, obwohl nur ein Gletscher eine aufgegebene Moräne aufwies. Die variierende Eis-Modifikation der verschiedenen Abhänge des Snaefell wird dadurch erklärt, dass sie von struktureller Entwicklung, Sonnen-Schattierung und Schneetreiben abhängig ist.

THE purpose of this note is to describe briefly the morphology and glaciers of Snaefell, east Iceland, so as to furnish a basis for reviewing, in the future, changes in an interesting assemblage of small glaciers radiating from an isolated summit.*

Snaefell and its smaller neighbours rise sharply from the Tertiary basalt plateau, here 600-700 m. above sea-level, near the north-easternmost extension of Vatnajökull. It is but 8 km. from Snaefell summit (1833 m.) to the snout of the outlet glacier, Eyjabakkajökull, the outwash plain from which extends along the mountain's eastern flank. The mountain throws off ridges to the north and south; independent conical hills and ridges, chiefly of tuff, also occur on these sides and to the west. All these features trend between S.W.-N.E. and S.S.W.-N.N.E. Within the young volcanic zone of central Iceland (the "zone of submergence" of Thorarinsson,¹), the tectonic lines are S.W.-N.E. in the southern part and S.-N. in the northern; thus around Snaefell are found trends appropriately intermediate.

Snaefell is compact in form. The lower slopes steepen upwards to a marked structural platform at 1550-1650 m.; above, the mountain rises more gradually to the summit. In contrast with the fairly symmetrical main mass of the mountain, this upper part takes the form of a S.-N. ridge with a steep face to the east and a gentle slope to the west. However, the mountain has been also much diversified by the glaciers, some of which have incised deep cirques into it. The summit is nearly covered by a small ice cap, not everywhere in active motion. West of the summit escarpment, crevasses reach nearly to the crest, however, and the ice may be thicker there than to the east where small rock outcrops break the surface.

On the mountain there are four true glaciers (A, B, C, D in Fig. 1, p. 135). The north-east glacier (A) heads in a deep cirque, whose walls rise nearly 200 m. above the *névé* field. The walls of volcanic tuffs and breccias are very steep and intricately sculptured; no ice appeared to reach this glacier from the summit in 1937, even by avalanche. The glacier drops with two unpronounced steps to end just above the surrounding plateau at 800 m.; the last half kilometre is an area of irregular piles of moraine, very slightly vegetated but with slip faces, indicative of melting ice cores. Although the pattern of moraine suggests the lines of former transverse crevasses, there were no indications of present movement.

On the north-west is a composite cirque (Fig. 2, p. 132), divided by a pinnacled buttress ridge, of tuff, which also composes the broken northern wall. The eastern headwalls are steeper, increasing

* On the Cambridge expedition of 1937 to east Iceland, led by W. V. Lewis, the writer surveyed the Snaefell mountain group on a scale of 1/25,000 by plane table, employing and extending a graphic triangulation of F. George in 1936. Fig. 1, p. 135, is reduced from a part of this survey. Heights are derived from the Danish Geodetic Institute's triangulated height of 1833 m. for the summit of Snaefell.

in height to the southern sidewall, which culminates in an impressive vertical cliff some 250 m. high. Resistant basaltic lavas cap tuffs and thick breccias in these cliffs. The shallower northern cirque carries a glacier (B) of fairly uniform gradient, which is not fed from the summit ice cap, whereas the glacier (C) in the deeper cirque to the south (Fig. 3, p. 132) is fed by the summit ice to a much greater extent than any other; this ice cascades down a steep ice fall to the main glacier tongue. Below the ice fall, there are two lesser, but still pronounced steps on the glacier profile within the cirque, one of them being associated with a lava bed in the valley floor.² The two adjacent glaciers meet as they extend beyond the intervening buttress, yet remain independent ice streams for they diverge again towards their snouts (Fig. 4, p. 132). The two moraine-covered tongues stand high above the lower mountain slopes with steep, well-defined margins 20–60 m. high (Fig. 2). Small ice outcrops and slip surfaces indicate ice cores close to the ends of the moraines, though there is little sign now of movement over the final three-quarter kilometre of these two tongues. Almost in the middle of the southern glacier (C) and about 400 m. from its snout, a vertical spike of rock, surrounded by a heap of its own debris, stands some 30 m. above the general moraine level. Apparently *in situ*, it was nevertheless difficult to accept it as the plug of a subsidiary volcanic cone, for the general arrangement of moraine around showed no disturbance such as would suggest that the ice had had to flow round such an obstacle. Moreover the spike continues southwards in an arcuate line of moraine hillocks, suggestive of a transverse crevasse system. The alternative suggestion that the origin is to be sought in a large splint of rock from the high cliff behind also bristles with difficulties, *e.g.* its great original size and the unlikelihood of such a pillar remaining upright in a moving glacier. Whatever the origin, it is a useful point of reference for future observers of the state of the glacier.

Ice from the summit plateau also flows down to the south-west to form a fourth true glacier (D). It is thin and the poorly developed crevasse system suggested but slight movement in 1937. Nevertheless this south-west glacier is of interest in that it possesses the only abandoned terminal moraine seen on Snaefell in that year. This showed most clearly on the southern side; in the west it is being dissected by the outwash river, which drops into a gorge beyond the moraine. The terminal has only recently been abandoned as it is still ice-cored and the outer slope is still steep and well preserved. A second notable and puzzling characteristic is that there has been practically no cirque development by this glacier, only a very shallow embayment occurring where its ice falls down from the summit.

There remain to be considered the slopes of Snaefell not occupied by true glaciers. Between the two ridges running north from the mountain lies an extensive *névé* field (E) linked with the summit ice. No crevassing or other signs of movement were to be seen in its upper reaches. Its lower margin was unfortunately not examined at close quarters, though the streams issuing from it were seen lower down to lack glacier silt. Accordingly this area would seem to fall into Ahlmann's category of "firn mantle" or "firn cake." On this northern flank also there is no cirque-like incision.

Of similar glaciological character to this *névé* field are the two extensions of firn (F, G), which occupy high-lying but shallow valleys running east from the summit ridge. Their lower margins reach somewhat below the platform level, ending on steps of resistant lava. Below are longitudinal snow patches in funnel-shaped nivation hollows.³

On the southern side of Snaefell there is a wide basin between the two ridges, Thjófahnjúkar. Nevertheless the summit ice does not overflow the high lava terrace overlooking it, although the scarp is well scalloped by rounded nivation hollows due to the longitudinal snow patches.

In his discussion of Iceland's glaciers, Ahlmann⁴ utilizes the "top" method of Partsch-Brückner to determine glaciation limits. Namely, to what height do unglacierized mountains rise? This method might be expected to be unsatisfactory in the Snaefell region, since these hills apart from Snaefell itself are steep-sided and have narrow ridges or pointed peaks. In such cases, snow-drifting and avalanches may prevent glaciers forming on them although the climate may otherwise be favourable. From the absence of glaciers or *névé* fields on these hills, Ahlmann offers a tentative glaciation limit here of >1350 m. In August 1937, extensive areas of bare ice were observed up to

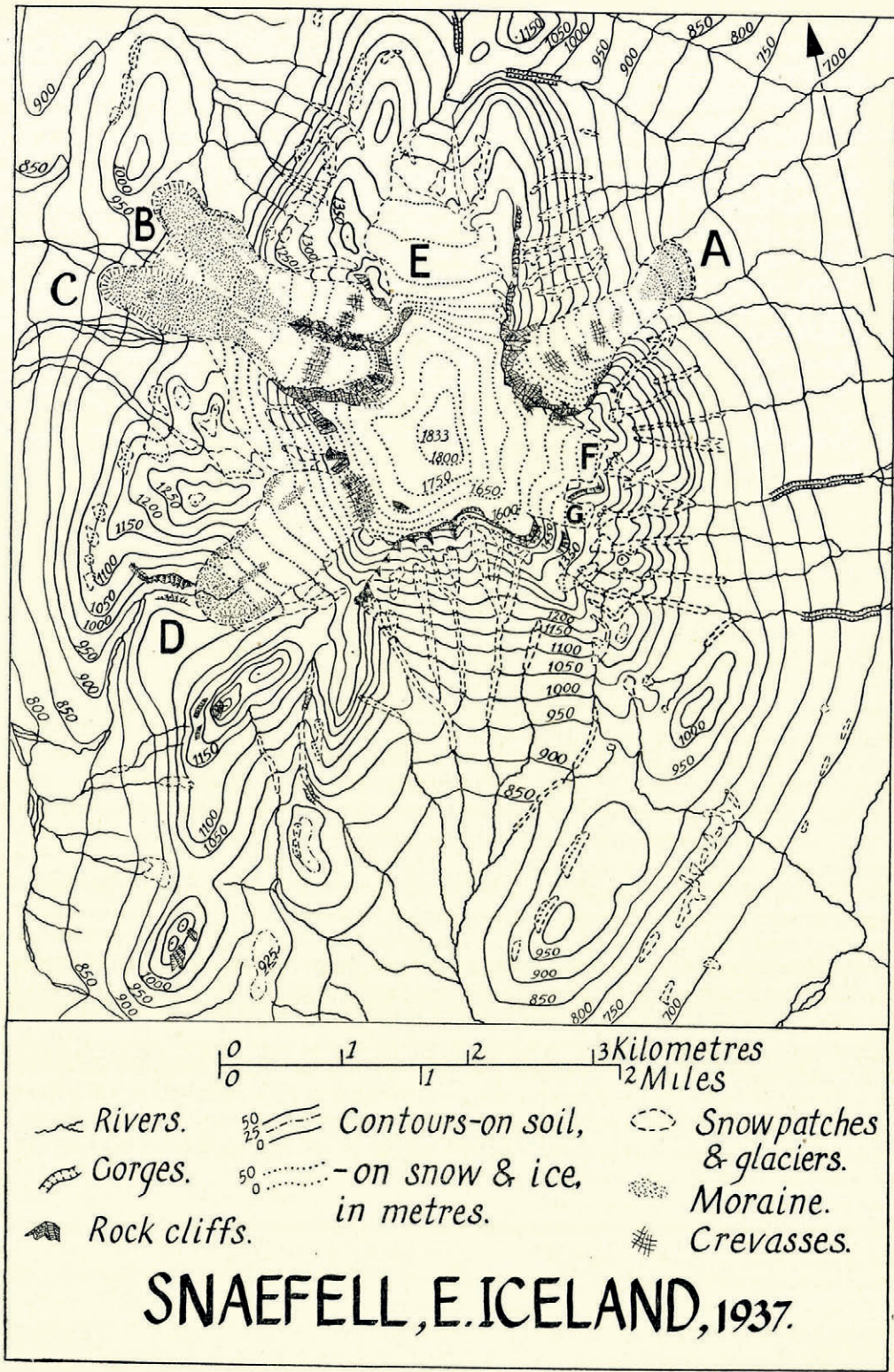


Fig. 1

approximately 1500 m. on the north-west and south-west glaciers and to 1350 m. on the north-east glacier. The northern firn mantle reaches down to 1300 m. and the eastern *névé* fields to 1380 and 1340 m. One concludes that, despite the unfavourable terrain, the "top" method was not misleading in this instance and Ahlmann is justified in postulating a very rapid fall in the glaciation limit from Snaefell to northern Vatnajökull. The figures given above have significance also for the state of the glaciers of Snaefell in 1937. In that year very little of their areas lay above the firn line, the two which are fed by the summit ice being slightly less badly off in this respect; the balance of accumulation and ablation can hardly have been other than a negative and unfavourable one. As the 1937 summer was not unduly warm or rainy for the decade, this condition would lead us to expect the glaciers to be recessive. This is the case clearly with the south-west glacier, and the lowest parts of the other three show little sign of disturbance of the moraine cover by present-day ice movement. On the other hand, the margins of all the moraines are steep, well-preserved and fresh-looking; the glaciers cannot have been at a standstill for many decades. Further there are no signs beyond these moraines of former greater extension on to the plateau, other than the evidence of regional glaciation from the last major ice period. Thus there is nothing in the field evidence here, which conflicts with Ahlmann's and Thorarinsson's general conclusion for Vatnajökull, "Those Vatnajökull districts that are mainly conditioned by climate, have for the last 4-7 decades been receding from what was probably their maximum extension in historical time, for some of them, possibly even in the whole post-glacial period,"⁵

The precipitousness of the walls of the cirques of the north-west and the north-east, in rocks of but moderate resistance to weathering, implies active glacial sapping to the present day. Lewis^{6a, b} has discussed the nature of the processes involved. Nevertheless it is worth while to consider whether the present cirque glaciers have been responsible for their full excavation. It must be remembered that these present glaciers may possibly have formed since the post-glacial warmth maximum in the most recent phase of climatic deterioration or reversion, perhaps since the Bronze Age.⁷ The Snaefell volcano is generally regarded as earlier than Holocene in age^{1, 8}; therefore the cirques of Snaefell may have been partly formed in the last major ice period in the Pleistocene. Thorarinsson (*op. cit.*, p. 171), applies the test of the amount of material in the moraines of the present cirque glaciers or in the glacier-free cirques; for north-west, middle north and east Iceland he reaches the conclusion that these amounts are not commensurate with the size of the cirques, which in his view owe their existence to the larger glaciers of the last ice period. To the writer this would also seem true of those of Snaefell, despite the younger structure of this area compared with those reviewed by Thorarinsson. Perhaps then these cirques must be considered as beginning to form in the last ice period, though the products of this erosive phase must have been swept away in the regional glaciation. The present small cirque glaciers may have persisted throughout post-glacial time to build the present moraines but there is also the possibility that they have re-occupied and refashioned the cirques since the post-glacial warmth maximum.

The chief point of general interest arising from this discussion of Snaefell's geomorphology, lies in the diversity of glacial modification of its different slopes, which must surely have been rather uniform originally. The north-east and north-west slopes have been deeply etched into cirques which are still occupied by glaciers; the south-west has a glacier, somewhat moribund perhaps, but no cirque; north and east are "firn cakes" only, while on the south are found simply semi-permanent snow-patches and nivation hollows. Unfortunately data are lacking whereby these significant contrasts might be explained with certainty. Although Snaefell appears to be a simple strato-volcano of basaltic lavas, tuffs and breccias, structural factors cannot be ruled out because the mountain is virtually uninvestigated geologically. Thoroddsen,⁹ * however, describes a liparitic dyke, possibly of post-glacial age, traversing the mountain from south to north. Structural influence may, therefore, account for the summit ridge and this feature must have tended to direct most of the high level ice to the west and to the east and so helps to explain on the north and south slopes

* The reference is to p. 274 of this work, but on p. 221 the direction is given as S.W.-N.E.

the poor expression of glacierization to-day and of glacial erosion in the past. That this factor is not the only one, is shown by the existence of two good cirques not fed from the summit ice, one on the north-east and one on the north-west (B). Other factors must be sought and they would seem to be climatological. Thus shading from the sun of the north-east, north and north-west slopes favours the preservation and activity of glaciers there. Wind-drifting of snow might be expected to be another significant factor. No local wind and precipitation data are available and consequently it can only be inferred on general climatological grounds that the most frequent winds bringing snow will reach Snaefell between east and south, *i.e.* from the nearest coasts and warm sea water. If this is so, wind-drifting of snow to lee sides would favour glaciers on western and northern slopes.* Thus in interaction, three factors—relief trendlines dependent on structure, shading and snow-drifting—may combine to account for the varied aspects Snaefell presents to the different points of the compass.

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* The mapping of snow-patches in Fig. 1 does not help very much in this matter, since the eastern and southern slopes on the whole were mapped first and the western and northern slopes mapped later in the melting season. The map is therefore unfavourable to the amount of snow lying on western and northern slopes. Movement round the mountain group soon after our arrival gave a clear impression of there being more snow on the western slopes.

GLACIER RECESSION AND PERIGLACIAL PHENOMENA IN THE RUWENZORI RANGE (BELGIAN CONGO)

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INTRODUCTION

The Ruwenzori Range is composed of Precambrian (granitic and metamorphic) rocks, whereas the other glaciated central African mountains are the result of volcanic processes. Their morphologies are also different, Ruwenzori being decidedly more alpine. Mount Stanley is the most western ridge and, with the highest peaks of the range, forms the boundary of the Belgian Congo.



Fig. 2 (top). N.W. face of Snæfell with composite cirque divided by tuff buttness. Moraines of Glacier B. in foreground

Fig. 3 (centre). Summit ice cap of Snæfell feeding Glacier C. In foreground the top of the rock spike in the moraine of this glacier is seen (see text, p. 134)

Fig. 4 (bottom). Moraine-covered snout of Glacier C. The rock spike mentioned in the text (p. 134) can be seen in the centre

Photographs by W. V. Lewis