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A Contribution to the Geology of the Kerlingarfjöll

A PRELIMINARY REPORT

BY

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WITH 8 FIGURES IN THE TEXT

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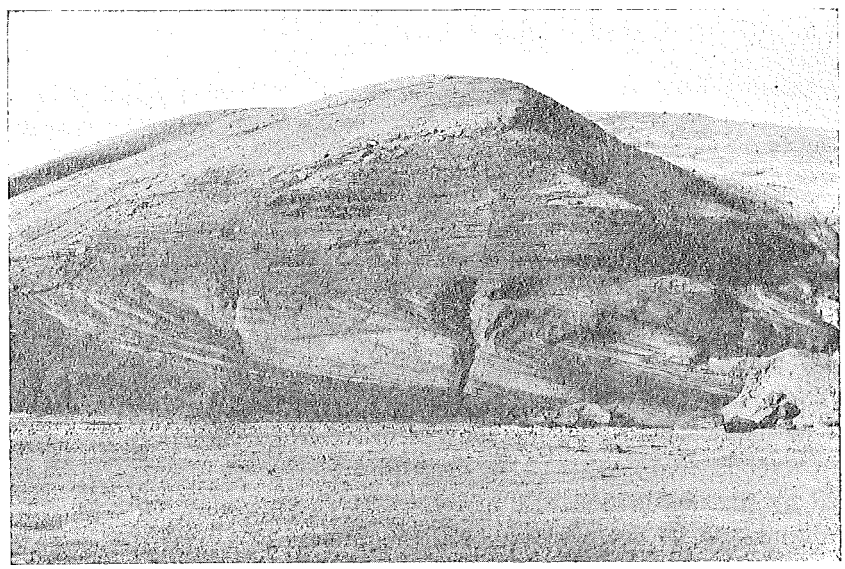
Abstract: A brief survey of the stratigraphy of the plateau south of *Hofsjökull* between the rivers *Þjórsá* and *Hvítá*. The *Kerlingarfjöll* rising from the plateau in the north must be considered as a region of volcanic protrusions.

THE PLATEAU

Excluding the *Kerlingarfjöll* and the marginal mountains the plateau south of the *Hofsjökull* between the rivers *Þjórsá* and *Hvítá* is of comparatively small relief. The Kerlingarfjöll are in sharp contrast with the surrounding country both as regards shape and colour. In most places the surface of this barren plateau is covered with unconsolidated gravel and sand. The fragments of which the gravel is composed are the results of weathering, mainly produced by the action of freezing water. Here and on *Kjölur* we have an abundance of interesting examples illustrative of the disintegrating influence of this agency on basaltic rocks. In many places where a rock has been split by the expansive power of frozen water accumulated in pores and cracks and other openings, it is easy to see how the broken fragments fit together. Weathering brought about by this agency produces different results according to structural differences in the basalt. Rocks of the flow-structure type tend to split into thin plates. The ordinary medium-grained dolerite and the porphyritic feldspar-basalt seem to crumble by the action of water into sand and gravel. Water and frost pulverize tuffs little by little, reducing them to dust.

The whole of the plateau was formerly covered by glaciers. In the troughs between the dolerite ridges clay moraines due to these glaciers are found. In some places, especially in the northern part of the plateau, there are thick fresh-water deposits, often beautifully stratified. The gravelly flats to the south of the river *Árskarðsá* are of this kind — ancient deposits of an ice-dammed lake. During the

time of the ice-retreat the mountains of the plateau gradually emerged. In the gaps left between them and the ice-margin, ice-dammed lakes were formed, and judging from the thickness of the strata deposited in them, some of them seem to have been pent up for a considerable time. A well-defined cross-section of a delta (of an ancient Árskarðsá-river) is to be seen south of the river opposite the



Photograph by J. Áskelsson.

Fig. 1. — Stratified fresh-water deposits of late-glacial and post-glacial age. A section south of the Árskarðsá-river opposite the rest-house in Kerlingarfjöll.

rest-house in the Kerlingarfjöll (Fig. 1.) The unmistakable shorelines of such ice-dammed lakes appear on the eastern slopes of *Hrútafell* and *Þverbrekkur* of southern Kjölur.

Where solid rock comes to the surface of the plateau it is always dolerite and tuff. The dolerite assumes the forms of convex ridges and domed elevations, some of which were moulded into roches moutonnêes with striated and grooved surface. Nielsen (2) has described the only post-glacial lava-sheet to be found in these parts, namely, *Illahraun* at the southern margin of Hofsjökull.

The vertical sections of the plateau are most clearly exposed in the gorges dug by the rivers. At *Gljúfurleit* by Þjórsá the topmost layer

of the plateau consists of glaciated dolerite, resting on tillite, which again is succeeded downwards by layers of conglomerate, sandstone and mudstone. These formations are all clearly stratified and their thickness is a matter of many meters. They must have been deposited in water of considerable depth. The search for fossils in these sediments has so far met with failure. Still farther down in the Gljúfurleit-section there appears a stratum of tillite, which is older than that mentioned above. The footwall of this older tillite is basalt.

To the west the river Hvítá is in progress of cutting a gorge into the southern margin of the plateau. A short distance south of the waterfall *Gullfoss* the stratification of the eastern rock-wall of the river-gorge is as follows (See also section by Martin Peacock in (4)):

I. At the top of the section, dolerite with glaciated surface.
II. Breccia intercalated with thin basaltic sheets. The breccia contains black glass particles and small fragments of scoria, 8—10 m.
III. Dolerite, 5—6 m (The edge of the upper cascade).
IV. Sandy gravel-layer, 0.75 m.
V. Conglomerate, 3 m.
VI. Sandy gravel bed, 0.75 m.
VII. Stratified mudstone of a bluish-grey colour (wet), in places crosslaminated, 2 m.
VIII. Sandstone, 0.75 m, passing downwards into
IX. badly stratified mudstone, 2—3 m.
X. Basalt-sheets interbedded with thin tuff strata of reddish colour.

Our knowledge of the stratification of the northernmost part of the plateau is based on evidence furnished by the rock-walls of the river-gorge of Árskarðsá. On the edge of the waterfall *Sælufoss,* a short distance to the west of the rest-house, basalt is revealed in the floor and sides of the river bed. Towards the east the basalt disappears under the delta-layers, which form the clayey flats of *Árskarð* as already stated. But farther east, north of the mouth of the valley of *Hveradalir,* the walls of the gorge consist of scoriaceous tuff from top to bottom.

In the foregoing sections an account has been given of the stratification of the plateau which is most clearly exposed in the deepest

gorges and gullies. This investigation warrants the following conclusions as to the age and formation of the plateau:

a. The lava-sheet at the southern edge of Hofsjökull (Illahraun) is youngest. It has all been poured out since the close of the last glaciation. Of geologically recent origin is also most of the debris covering the surface of the plateau. It is chiefly the results of weathering. Some of these loose materials, however, are unconsolidated moraines deriving from the latter part of the Ice Age or from the final stages of the ice-retreat.

b. Next in age is the tuff. It has been formed after the dolerite-lavas were poured out, probably during the last phase of the glacial epoch.

c. Then comes the dolerite, striated and polished by glaciers. As a matter of fact the dolerite was originally poured out in the form of lava-sheets.

d. Older than the dolerite lavas are the moraines and mudstone layers, which are found at Gljúfurleit. The dolerite lavas have swept over these sedimentary deposits. There are two belts of moraines at Gljúfurleit. In Helgi Pjeturss' opinion the freshwater deposits that separate them should correspond to an interglacial period, because such thick layers of regularly stratified mudstone can hardly have been deposited in the vicinity of the glaciers (5). It seems justifiable to draw the same inferences from the mudstone-layers underlying the striated dolerite in the river-gorge of Hvítá.

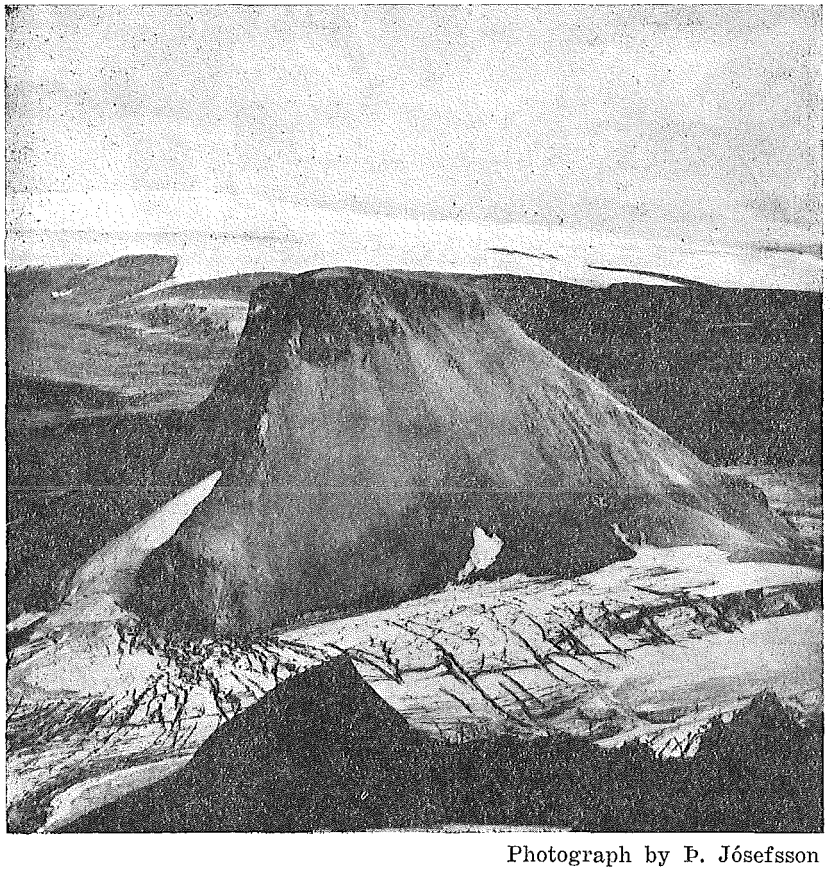
e. Oldest among the exposed strata of the plateau are the basaltic layers, which appear under the sedimentary deposits mentioned above.

THE MOUNTAINS

The Kerlingarfjöll are frequently referred to in the geological literature of Iceland. Þorvaldur Thoroddsen (7) quotes the most important references. With the exception of a chapter on the hot springs of Kerlingarfjöll in Th. Thorkelsson's paper (6) everything else that has been written on these mountains is more in the field of geography than geology.

External Forms and Dimensions: Where the Kerlingarfjöll rise above the plateau the floor is about 700 m above sea-level. As already stated the mountains contrast sharply with their surroundings both in shape and colour. The whole of this mountain region is about 150

square kilometers comprising an area bounded on the south by the mountain *Klakkur,* on the north by the *Árskarðsfjall,* on the west by the *Fell,* and on the east by the *Tröllabarmur.* Most of the highest mountains have the forms of truncated pyramids: *Loðmundur* (1432



Photograph by Þ. Jósefsson

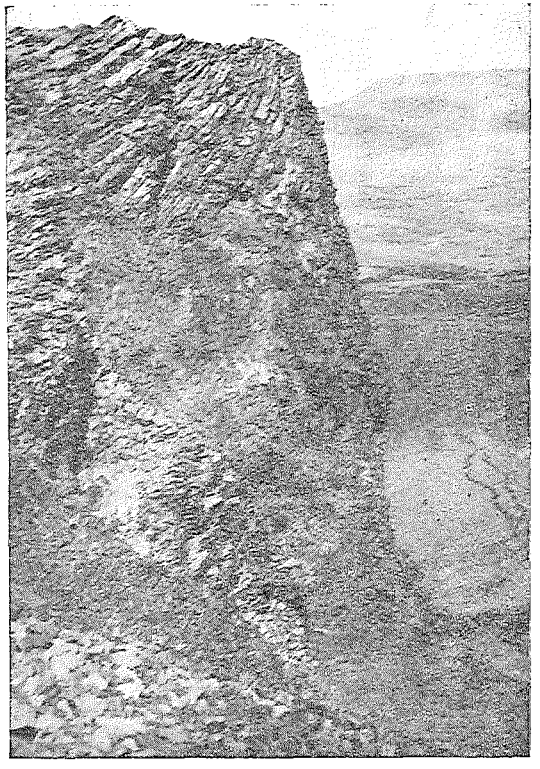
Fig. 2. — The mountain Loðmundur. A truncate-shaped protrusion.

m, Fig. 2) *Ögmundur* (1352 m), *Snækollur* (1478 m). *Mænir* on the other hand (1335 m, Fig. 3) has the form of ridge. The slopes are concealed by great banks of talus, the stones of which are very equally sized and angular. The angle of inclination may be as much as 42°. The tops are flat or slightly domed, covered with heaps of boulders. The lower mountains on the other hand approach more the dome shape.

Photograph by P. Jónsson.

Fig. 3. — The mountain Mænir. A ridge-shaped protrusion.

Photograph by J. Áskelsson.
Fig. 4. — Vertical flow structure in the rhyolite. Mountain Loðmundur.

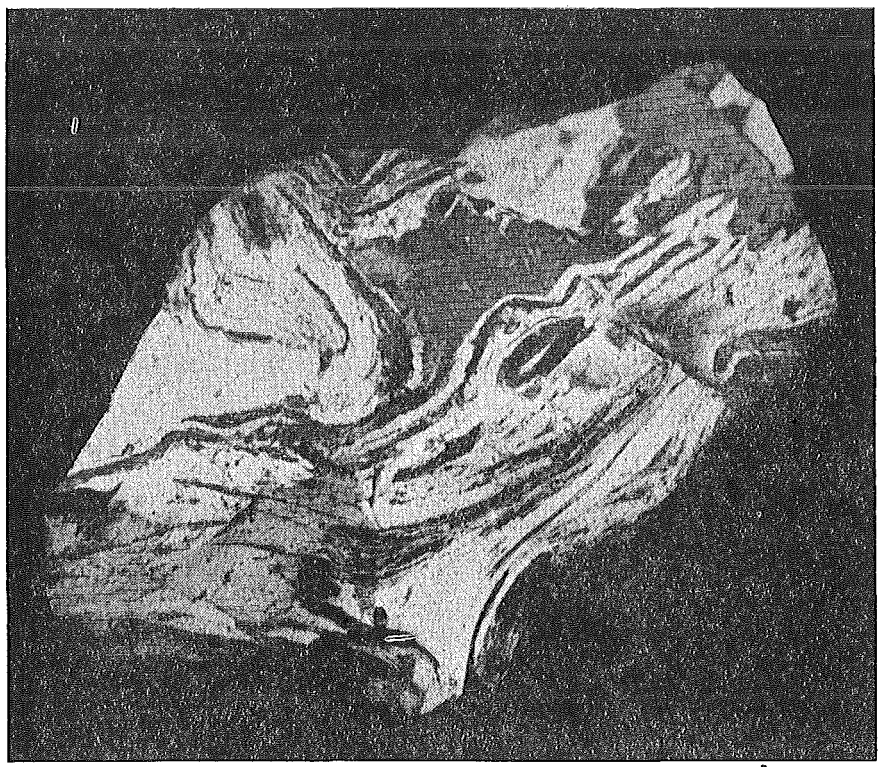


Photograph by J. Áskelsson.
Fig. 5. — Columnar jointing occurring in the rhyolite. Mountain Loðmundur.

Petrography: The dominant lava of Kerlingarfjöll is rhyolite with, however, a considerable admixture of tuff, especially in the lower parts of the mountains. Basalt outcrops at the summit of the *Hveradalahnúkur,* and elsewhere at the foot of the main mountains.

All the highest mountains consist of rhyolite. The rock is of a light-brown colour and decidedly massive and monolithic. It is of a fine-grained texture. On the northern solid exposures of Loðmundur a faint vertical banding was observed. Columnar jointing rarely occurs, but where it was found the columns dip inwards as the figure shows. (Fig. 4 and 5).

The rhyolitic screes are frequently sprinkled with fragments of obsidian and pumice. Fluidal banding in the obsidian is not infrequent and spherulitic varieties are quite common. Obsidian is not found in



Photograph by Ó. Gíslason.

Fig. 6. — A parallel arrangement of obsidian and opal. From the surface of the upper part of the mountain Ögmundur.

massive rock until a considerable height is reached, or the zone above the tuff-limit. Here it sometimes completely covers the rock, for instance, on the north-eastern side of Loðmundur and in the upper parts of Ögmundur (Fig. 6).

Three analyses of the rhyolitic material are given here. A is the average type of the light-brown coloured rhyolite, B is of the darker variety, and C is pumice:[1])

	A	B	C
SiO_2	73,95	72,25	71,32
Al_2O_3	15,00	12,80	14,35
Fe_2O_3	1,05	5,10	3,30
MgO	0,15	0,25	0,10
CaO	0,72	2,55	1,22
Na_2O	5,30	4,33	4,22
K_2O	2,37	1,68	1,55
H_2O	0,51	1,27	3,08

The tuff lies like a fringe at the base of the rhyolitic mountains, extended in jagged and dissected tongues up the slopes, but getting thinner with distance from the base, having in most places completely disappeared when we approach the edges of the mountains. Yet a glassy basaltic scoria is found at the summit of the *Austurnípa* and on the northern side of Loðmundur lumps of tuff occur in the upper part of the slope. These tuff tongues show most clearly on both sides of Mænir. Here the tuff extends up the rhyolitic slopes like a slanting roof. It is covered by a rather fine-grained volcanic agglomerate, in which there is embedded a large contingent of fragments of obsidian and pumice. This volcanic agglomerate is younger than the underlying tuff formation, as will be more fully dealt with later (Fig. 7).

All the lower mountains of Kerlingarfjöll, such as *Kerlingarskyggnir, Hveradalahnúkur* and *Árskarðsfjall* are dome-shaped. On the face of it these mountains seem to be composed of tuff. But the tuff-layer og Kerlingarskyggnir is so thin that in many places rhyolitic rock can be seen to crop out through the tuff. The bulk of the moun-

1. Analysed by B. Jósefsson, University Institute for Applied Natural Sciences, Reykjavík.

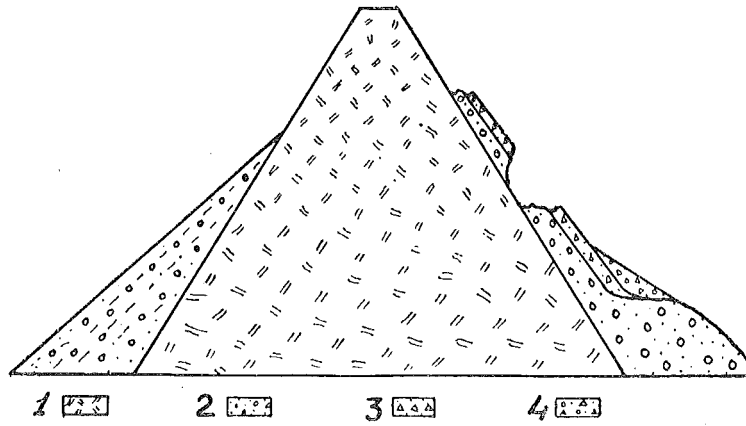


Fig. 7. — A cross-section of the mountain Mænir. 1 Rhyolite, 2 Tuff, 3 Volcanic agglomerate, 4 Talus.

tain is therefore made of this type of rock, and most probably this also applies to the rest of the lower mountains. At the very summit of Hveradalahnúkur, it is true, basalt becomes visible under the tuff, the latter having been weathered away from the top. But on the floors of ravines excavated in the tuff deposits at the western base of the mountain, rhyolite crops out indicating that the core is made of such rock.

Besides the basalt found at the summit of Hveradalahnúkur, as already stated, this rock occurs occasionally elsewhere, especially at the foot of the mountains. Where the strata are exposed, the basalt is usually found under the tuff. In the banks of the river *Fremri-Árskarðsá,* some distance south-west of the rest-house, an outcrop of pillow-lava is seen.

Solfataric Activity: Solfataric emanations are more violent in Kerlingarfjöll than elsewhere in Iceland. The main foci of emission are situated in the central region of the mountains, but on the outskirts of the mountain area there is still some thermal activity although it is quite evident that it used to be much more vigorous. No fissures have so far been located but possibly a closer investigation might lead to their detection. Rather thick accumulations of sulphureous clay cover the area of exhalations. No friction breccias were observed, but with regard to these phenomena as well as the formation of slickensides further investigations might prove profitable.

Origin and Age: From the foregoing review it seems possible to draw some conclusions as to the age and origin of the Kerlingarfjöll. The vertical flow structure observed, for instance, in the core of Loðmundur dipping a little inward along the marginal zones, must be considered as an indication of an upheaval of rhyolitic magma. The tilting tuff-layers stretching in disrupted patches up along the rhyolitic core of the highest mountains, while completely covering the lower ones, show that the rhyolitic magma, while surging upwards, must have lifted the overlying tuff. The rhyolite, therefore, is a younger formation than the tuff.

It has been mentioned above that a volcanic agglomerate is found on the eastern side of Mænir on top of the dipping tuff-strata. This volcanic agglomerate runs parallel with the underlying tuff-strata.

In the *Hattarkluftir* and the *Hraukar* thick formations of fine-textured pumice occur, now cemented into solid strata. These formations with their unmistakable resemblance to the heaps of pumice piled up around the eruptive centre of *Grímsvötn* in 1934 (1) must owe their origin to a subaerial eruption, the focus of which must have lain within this mountain region. It is most natural to suppose the material which constitutes the volcanic agglomerate overlying the tuff on the eastern side of Mænir to have been derived from this eruptive focus. But from the conformity of these two formations it follows that the subaerial eruption must have taken place before the rhyolitic magma was thrust up.

As stated above obsidian does not occur in solid rock until a good way up the slopes of the highest mountains, or, to put it more precisely, above the level reached by the tuff. From this it may be inferred that the rhyolitic magma of the highest mountains has forced its way up through the tuff-formation and solidified subaerially. This circumstance justifies the following conclusion to be drawn about the origin of the Kerlingarfjöll: That they are partly endogenous (all the lower mountains) and partly exogenous (all the higher ones).

Some evidence as to the age of the Kerlingarfjöll is provided by the stratigraphy of the plateau around them. An examination of the arrangement and sequence of the strata reveals the fact, as already pointed out, that the tuff is everywhere superimposed on the ice-worn dolerite. Consequently the tuff was formed after the doleritic lavas had flowed out, congealed and been polished by the glaciers.

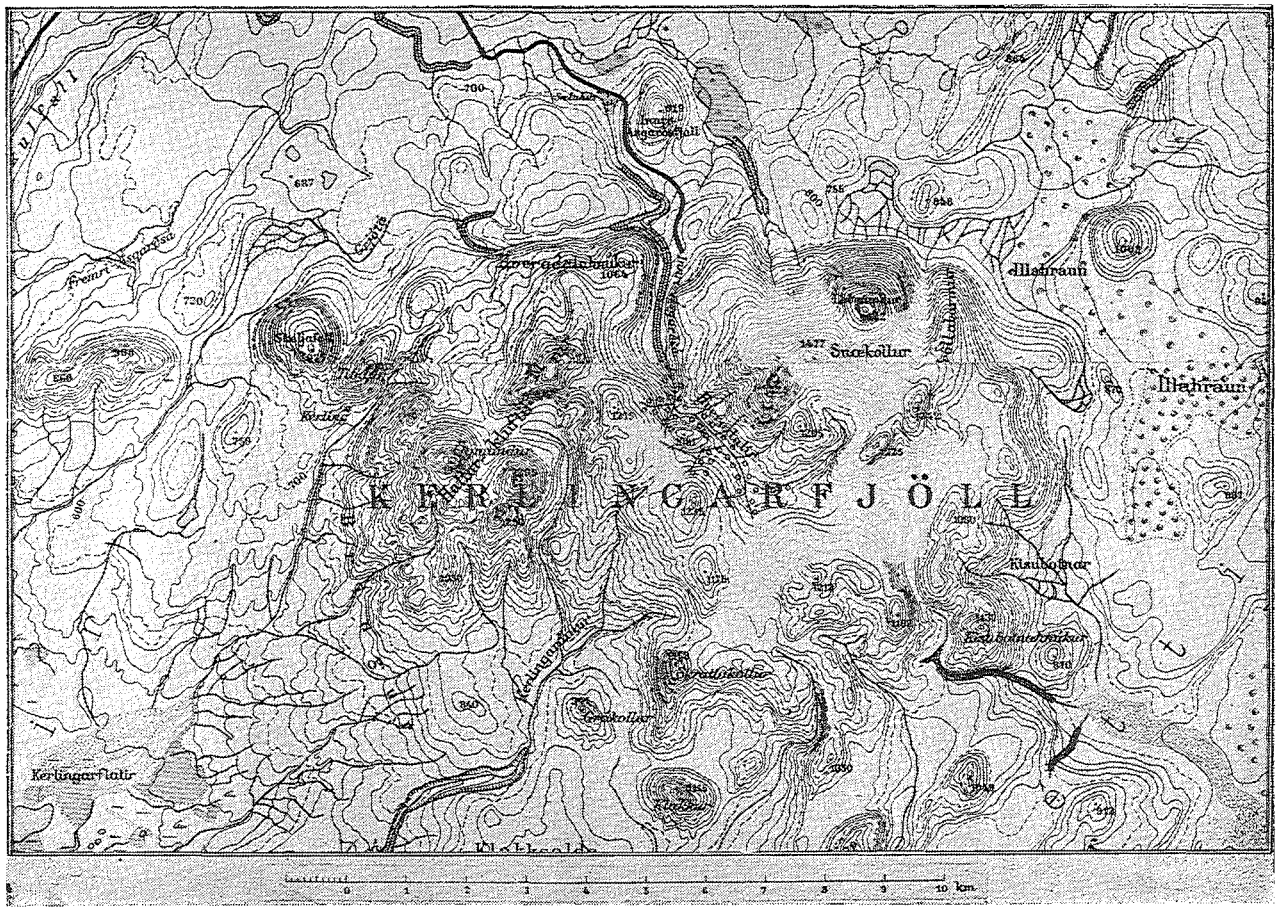


Fig. 8. — A map of Kerlingarfjöll and their surroundings. Reprinted from no.s 55 Hveravellir and 56 Kerlingarfjöll, Geodetic Institute, Copenhagen 1945.

Thus it becomes evident that the formation of tuff in these parts must be referred to the last glaciation in Iceland. Now the rhyolitic formations of Kerlingarfjöll are younger than the tuff as is clearly evidenced by the relative position of their strata, consequently the upheaval of the rhyolitic magma cannot have taken place until the closing phase of the Pleistocene period and probably not until Recent time.

The Kerlingarfjöll are not the only example to be found in Iceland of rhyolitic protrusions. At *Snæfellsnes* this phenomenon seems to be quite common (e.g. *Mælifell* and *Drápuhlíðarfjall).* Nielsen (3) thinks it probable that the mountains *Hágöngur* in *Landmannaafréttur* may correspond in the form to the "Staukuppe" known in other volcanic regions, and still more examples will most probably be discovered by further investigation of the country.

Causes of Upheaval: Howell Williams in his work entitled "The History and Character of Volcanic Domes" (8) considers the propelling force in domical protrusions to be the pressure of volatiles. In addition to this another factor may seemingly be conceived as playing a part in the upheaval of rhyolitic magma in Iceland, viz. the difference between the specific gravity of the acid rhyolitic magma and that of the basaltic eruptives in which the acid protrusions always occur in this country.

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