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Hágöngur
A Partially Sub-Glacial Volcano in SW-Vatnajökull.

(Paper of the IV. Danish-Icelandic Expedition)

By

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In a pocket in the ice edge immediately to the east of Skaptárjökull in the south-west border of Vatnajökull the border mountain Hágöngur is situated (Fig. 1). Hágöngur has been considered a partially sub-glacial volcano (NOE-NYGAARD, 1940, p. 57), which might well be worth a more thorough investigation. The mountain is 1120 metres high and is divided into two parts by a valley. At the foot of the east wall both in the northern and the southern half there is an outcrop of a yellow, tuffaceous sediment on which the lava rests.

North of the valley the mountain chiefly consists of globular basalt. Between the individual pillows a plainly stratified, probably water-laid sedimentary series is found, which in its material resembles the subjacent series. Conditions in this place are shown in plates 17–20 (NOE-NYGAARD, 1940). By a continuous transition in a westerly direction the globular basalts are replaced by columnar basalt with rather irregular columns. The globular basalt may be followed into the southern mountain, where it occurs in one or two places resting on the afore-mentioned pre-volcanic sediment. Upwards, the globular structure is obliterated and ordinary compact basalt is seen. This in its turn is replaced upwards by a more porous material, and the whole south slope of the southern mountain consists of porous eruption materials: scoriæ, bombs and ash between which are found numerous liparite fragments the size of a nut. From the field geology it has not been possible to decide whether the liparite comes from the substratum of the volcano or was lying on the pre-volcanic land surface.

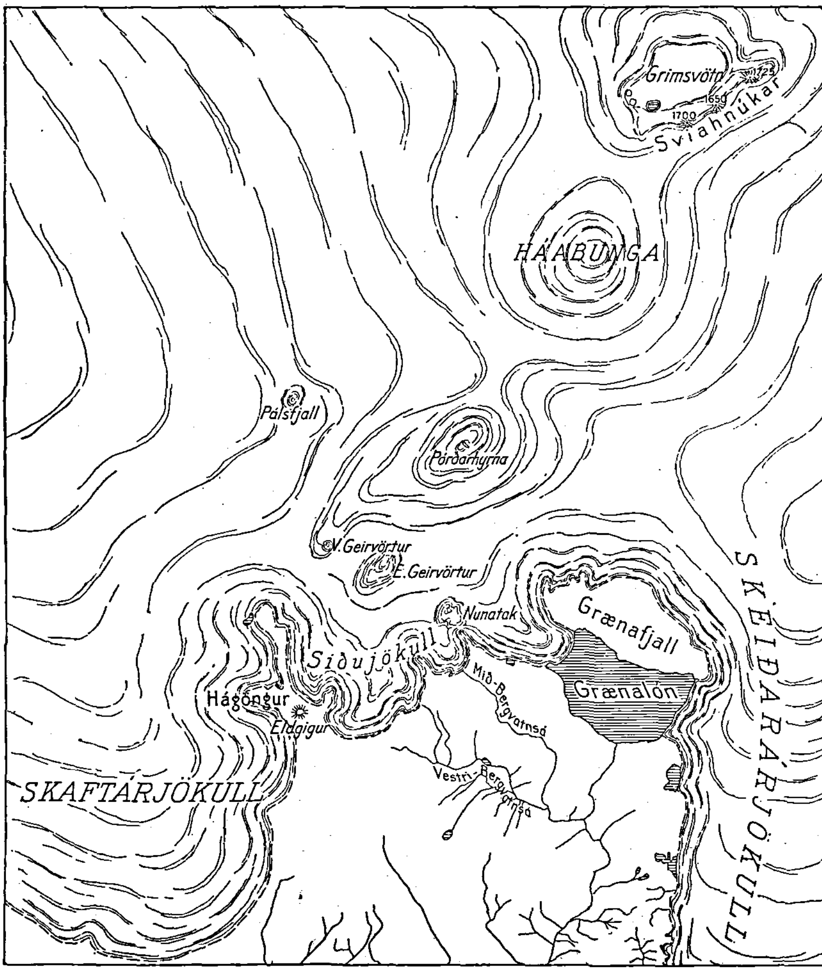

Fig. 1.

All the southern part of the Hágöngur mountain is intersected with dykes from 1 to 3 metres thick. They are vertical or almost so. Their resistance against weathering is considerably greater than that of the surrounding porous, volcanic deposits so that they stand out like walls in the area.

Most of the dykes run a rather winding course, strike dominantly SW–NE and have a mantle of sideromelane 2–3 centimetres thick.

On the south slope of the southern mountain is a small crater presumably indicating a minor flank eruption. It has given off a small, subaeric lava flow, which has flowed down the slope, which is built up of loose volcanic material. It is evident that the slope must then have had the same dip as it has to-day. In ravines in the small lava flow it can be seen that the subjacent loose material contains blocks of porous lava, either formed as throw slags or by decomposition of a slightly older lava flow presumably from the same flank crater.

From the above description the following conclusion can most likely be drawn:

The Hágöngur volcano must be the remains of an eruption through the ice where the melt water released by the eruption is responsible for the pillow structure at the bottom and in the northern mountain. Near the edge of Vatnajökull the ice has presumably been rather thin, for which reason the eruption has ended up with a subaerial stage; to-day preserved in the southern mountain of Hágöngur. (Cfr. sketch fig. 2).

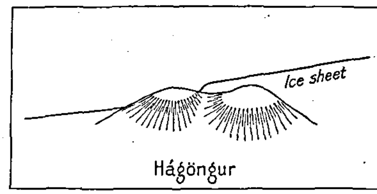

Fig. 2. Sketch showing a probable reconstruction of ice conditions during the last period of eruption in Hágöngur.

Both the globular basalt and the compact and the porous rock types consist of the same porphyritic plagioclase basalt.

The microscopical examination gave the following result:

The rocks are in all cases only partially crystallized. The groundmass consists either of glass (sideromelane) on the outside of the pillows, or of a black non-translucent interstitial mass. The generation of phenocrystals is dominated by plagioclase, but both olivine and monoclinic pyroxene also occur. Microscopic examination was made of:

1. Three different pillows, (I, II and III),
2. Compact columnar basalt, and
3. A porous basalt dyke from the south side of the southern mountain.

1. Four thin sections of pillow I were examined under the microscope, one from the central part, one from the intermediate zone and the outer part, respectively, and, finally, one from the outermost crust of sideromelane which surrounds the individual pillows like a mantle and may be 1–3 centimetres thick according

to the size of the pillows (NOE-NYGAARD 1940, Pl. 20). As might be expected the degree of crystallinity increases inwards from the outer part. The average composition of the *plagioclase* both as phenocrysts and as groundmass is labradoritic. With the value of 88° for $2\ V_\alpha$ the phenocrystic *olivine*, which is quite colourless in section, is Mg-rich. The *pyroxene* has $2\ V_\gamma = 47°$. In addition to the ordinary phenocrysts of (bytownite-) *labradorite* the rock, strangely enough, also contains plagioclase with an *andesinic* composition in the form of phenocrysts of the size of about 1 millimeter. In general, the latter individuals may be developed in three ways. Either most of the individual consists of andesine with a narrow or somewhat wider outer reaction border, spotted all over with an opaque material (cf. fig. 2, plate X), in which case inverse zonation may be seen, or the central part and the outer zone have almost the same composition, or finally the individual may have a small core of andesine in the centre, which is surrounded by a wide reaction zone of an opaque substance and may have a narrow outer new border of labradorite (cf. fig. 1, plate X). The latter type represents the most advanced stage of the transformation. It is difficult to say from where these andesine crystals came, but they are clearly not in equilibrium with the basalt, in which they now occur. They may be surviving phenocrysts from a liparitic (or andesitic) rock which has been absorbed by the basalt on its upward course, in which connection the liparitic material in the loose material on the south mountain of Hágöngur should be remembered (p. 513). Quite another origin has been suggested elsewhere (NOE-NYGAARD, 1951).

Two sections of pillow no. II were examined. They show the same characteristics as pillow no. I. Measured in two individuals the monoclinic *pyroxene* has an optic angle over γ of 47° and 49°, respectively; the composition of the *plagioclase* is labradoritic. In some cases inverse zonation is seen in the *andesines* with a reaction zone.

Pillow no. III. Only one thin section of the central part was examined and was found to be in complete agreement with both the preceding ones. The Mg-rich *olivine* has $2\ V = 90°$.

2. Columnar basalt. Although this rock appears rather compact, it contains quite a number of pores. The degree of crystallization closely corresponds to the inner part of the pillows. The angle of the optical axes of the *olivine* is positive but quite near 90°. The rock contains besides normal phenocrysts the afore-mentioned *andesines* with a reaction zone.

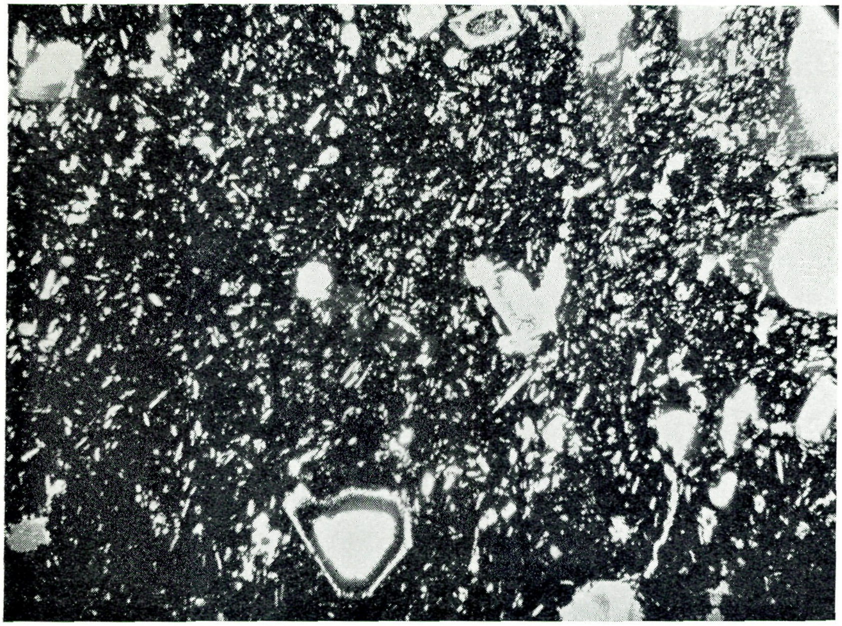

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Fig. 1. Pa. I, no. 25. 1. Nic. 20 × magn. Lower edge: plagioclase phenocryst with reaction rim and new-formed outer brim. Upper edge: plagioclase phenocryst in the central part thoroughly altered, with new-formed marginal zone.

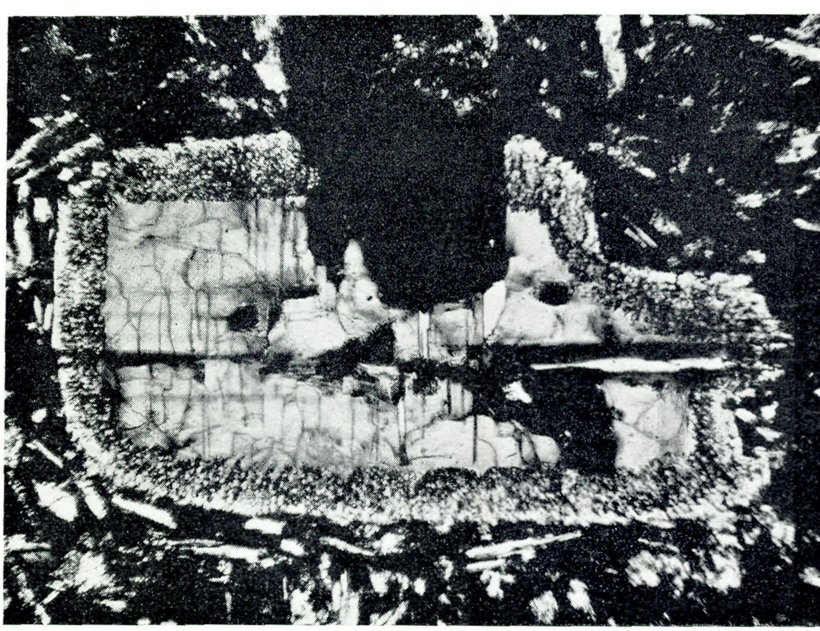

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Fig. 2. Pa. I, no. 32. + Nic. 88 × magn. Large phenocrystic plagioclase with reaction rim.

Table 1.

	Pillow No. I (sideromelane mantle)	Pillow No. I (outer zone)	Pillow No. I (intermediate zone)	Pillow No. I (central part)	Pillow No. II (outer part)	Pillow No. II (central part)	Pillow No. III (central part)	Columnar basalt	Porous basalt dyke
Very large phenocrysts; core	—	—	—	—	—	—	—	85 %	—
Very large phenocrysts; outer zone	—	—	—	—	—	—	—	70 %	—
Large phenocrysts; core	65 %	—	64 %	65 %	65 %	58 %	71, 70, 64 %	72 %	—
Large phenocrysts; outer zone	—	—	—	60 %	—	—	—	63 %	—
Small phenocrysts; core	—	62 %	58 %	—	55 %	58 %	—	—	52 %
Small phenocrysts; outer zone	—	—	—	—	—	40 %	—	—	—
Groundmass plagioclase	—	—	—	—	—	—	—	58 %, 50 %	—
Andesine phenocrysts; core	40 %	39 %	—	41 %	32 % 35 % 40 %	—	—	35 %	—
Andesine phenocrysts; outer zone	40 %	—	—	—	40 %, 48 %	—	—	—	—
Andesine phenocrysts; new-formed outer brim	—	—	—	—	—	—	—	61 %	—

3. Porous basalt dyke. The material of the rock is chiefly opaque, and only very slight crystallization of the groundmass is found. The phenocryst generation is identical with that found in pillow lava and columnar basalt.

The results of the determinations of plagioclase in the various thin sections have been compiled in Table 1.

A compact pillow lava from Hágöngur was chemically analysed by W. H. and F. Herdsman. The result may be seen from Table 2.

For the purpose of determining whether the quickly cooled sideromelane mantle of the pillows had a higher content of water than the more crystallized inner part, a separate determination of water was made on a sample of a sideromelane crust from the same pillow as the main analysis. The content of water proved to be the same:

Table 2.

	Weight %	v. Wolff values	Niggli values	Normative minerals		εq. Mol-%	εq. Norm
SiO_2	54.47	Q = 4.50	al = 25.2	Q = 4.20	Si	51.3	Q 2.7
TiO_2	1.46	L = 56.36	fm = 40.2	or = 6.12	Ti	1.0	Or 6.5
P_2O_5	trace	M = 39.14	c = 25.0	ab = 25.68	Al	7.8	Ab 28.0
Al_2O_3	16.12		alk = 9.6	an = 27.24	$Fe^{\cdot\cdot\cdot}$	0.3	An 27.4
Fe_2O_3	0.53	A = 3.88	Si = 145	Σ_{sal} 63.24	$Fe^{\cdot\cdot}$	7.2	Σ_{sal} 64.6
FeO	8.97	C = 6.33	(qz = +6.60)	en = 11.70	Mg	6.7	En 13.4
MnO	0.18	K_2O = 0.71	ti = 2.88	fs = 14.12	Ca	8.8	Fs 13.8
MgO	4.71	MgO = 7.56	k = 0.18	wo = 6.73	Na	5.6	wo 6.6
CaO	8.76	C′ = 3.75	mg = 0.47	il = 2.74	K	1.3	Il 2.0
Na_2O	3.05	Fe″ = 8.07	c/fm = 0.62	mt = 0.70	P	—	Mt 0.6
K_2O	1.03	Mt = 0.38		Σ_{fem} 35.99	(H_2O)	(2.7)	Σ_{fem} 36.4
CO_2	nil		Sect. IV.				
H_2O^+	0.54			H_2O 0.84			
$H_2O^{\div}$	0.30						
Sum	100.12	Anal: W. H. & F. Herdsman		100.07		100.0	100.0

	Inner part of pillow	Sideromelane mantle
$H_2O^{+105^\circ C}$	0.54	0.53
$H_2O^{\div 105^\circ C}$	0.30	0.26

A comparison between lava from Hágöngur and the Grimsvötn lava shows that in addition to higher SiO_2 and Al_2O_3 values, the rock from Hágöngur mainly differs from the Grimsvötn rock by having considerably lower values of Fe, such as 9 per cent against 14 per cent. The Fe-value of Grimsvötn is quite consistent with that of Kverkfjöll on one side and Laki and Katla on the other, all having 14–15 per cent total Fe.

It is not known when the Hágöngur volcano has had an eruption, but the circumstance that there is a considerable difference between its chemical composition and that of the latest active volcanic zone suggests that it took place rather a long time ago. On the other hand, a slope of loose volcanic material as it stands to-day and as it was before the small lava flow in the southern mountain was formed (cf. p. 515) hardly stay for a very long space of time.

It is, however, probable that the volcanic activity is younger than the liparite formation in south-west Vatnajökull, (NOE-NYGAARD, 1951). There can further be little doubt that it is prehistoric since no information on volcanic eruptions in this area since Iceland was first populated is at hand (THORODDSEN, 1925).

LITERATURE:

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Dansk resumé.

Der gives en beskrivelse af forholdene i randfjeldet Hágøngur i Vatnajøkulls sydrand; dette opfattes som resterne af en delvis subglacial vulkan. Den petrografiske behandling opholder sig i særlig grad ved et indhold af store andesinstrøkorn, der udviser ejendommelige reaktionsforhold (sml. tavle X). En ny kemisk analyse af bjergarten fra Hágøngur publiceres her for første gang. Vulkanen må anses for at være præhistorisk.

Færdig fra trykkeriet den 15. januar 1951.