NORDIC VOLCANOLOGICAL INSTITUTE 79 01

UNIVERSITY OF ICELAND

GEOLOGY OF THE ÖRÆFI DISTRICT, SOUTHEASTERN ICELAND

by

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ABSTRACT

The central part of the Öræfi district is dominated by various rocks discharged from the still active Öræfajökull central volcano. The peripheral areas, Skaftafellsfjöll in the west and Breidamerkurfjall to the east, are made up of slightly altered rocks of basic as well as silicic composition below an unconformity, indicating that both these areas represent older central volcanoes. The abundance of hyaloclastites and tillites within the piles of these older volcanoes and their relationship to the active Öræfajökull volcano indicate that those volcanoes were active during the Quaternary. The rocks belong to a tholeiitic series, but in contrast to the tholeiites of the rift zones in Iceland many basalts in Öræfi are characterized by clinopyroxene phenocrysts. In Öræfajökull hybrid rocks are found in a few places. Chemically these hybrid rocks are similar to calc-alkaline rocks. Their hybrid nature results from mixing of a basaltic and silicic component.

INTRODUCTION

The Öræfi district comprises the area between Skeidarárjökull and Breidamerkurjökull in south-east Iceland. The dominating topographic and geological feature of the district is Öræfajökull, a central volcano which has erupted twice in historic time (Thorarinsson, 1958).

Öræfajökull is unique in that it is the only active volcano in Iceland lying outside the well defined zones of Quaternary volcanic activity (Jakobsson, 1972; Pálmason & Sæmundsson, 1974). However, the structural relations of the area around Öræfajökull are not well understood. Thorarinsson et al. (1973) discussed the tectonic features of the Vatnajökull area and proposed that a NW-SE trending structural feature immediately SW of Öræfajökull represents a left lateral transcurrent fault. On the other hand Walker (1975) suggested that Öræfajökull represents the southernmost active part of a largely dormant rift zone which can be traced through Snæfell (Fig. 1) and further north. The Öræfajökull might therefore be situated at the intersection of a fracture zone and a spreading axis a structural position to which volcanic activity is often closely connected.

The district of Öræfi forms the lower flanks of the volcano. The central part of the district, between Svínafellsjökull and Hrútárjökull (Fig. 1), is dominated by unaltered volcanic rocks with normal magnetic polarity. The peripheral areas both to the west (Hafrafell - Skaftafellsheidi - Skaftafellsfjöll) and the east (Ærfjall - Breidamerkurfjall) are on the other hand dominated by altered volcanic rocks of both normal and reverse polarity.

Thorarinsson (1958) discussed the history of Öræfajökull and concluded that the activity has been low in postglacial time. The abundant hyaloclastites, however, indicate that most of its activity occurred during glacial periods.

Some idea of the age of Öræfajökull is given in the literature on the fossiliferous lacustrine Svinafell layers. Thorarinsson (1963) concluded that these sediments were deposited in the Mindel-Riss interglacial period. However, from K/Ar determination of subaerial lava flows high up in the volcanic pile of Svinafellsfjall, Albertsson (1976) suggested that the lacustrine Svinafell layers were deposited at any time between post-Jaramillo ($\sim$ 0,89 Ma) and the beginning of the Elster glaciation ($\sim$ 0,6 Ma). The hyaloclastites lying between the sediments and the dated lavas probably formed during the Elster glacial period indicating that Öræfajökull has been active for more than 0.5 Ma. Piper (1971) found that some Icelandic central volcanoes may be active for 0,5 -1,0 Ma. If this is true for Öræfajökull and assuming that it is nearing its end, the base for the presently active center should be found in late Matuyama or early Bruhnes. The time interval in which erosion of the depression and the subsequent deposition of the Svinafell layers occurred, was probably a period of quiescence in the volcanic activity. An obvious working hypothesis then is to suggest that the altered rocks found in some deep sections of the central area (e.g. Slaga) represent either (1) normal volcanic activity inside a rift zone (Walker, 1975), (2) an earlier central volcano of the Öræfajökull type, or (3) a mixture of both these types.

The present contribution tries to supplement the information on the Öræfi district in order to get a better foundation for interpretation of this relatively complex area. The studies on geochemistry and petrology of the Öræfi area based on the geological mapping presented here, will be published later. However, the complexity of the area requires more thorough field work. This should include detailed magnetic polarity studies and radiometric age determinations.

REGIONAL DESCRIPTIONS

Geological mapping

During a one year stay at the Nordic Volcanological Institute, Reykjavik, the author spent six weeks during the summers 1974/75 in mapping parts of the area.

Most of the volcanic activity in Öræfi took place in close proximity with glaciers, resulting in numerous separate units, which in most cases are of limited areal extent. The lack of marker horizons makes the geology complicated and difficult to map. Therefore petrographic divisions are used where possible and depositional types elsewhere. The units mapped (see Fig. 1) are briefly characterized by the following:

(a) Unconsolidated cover, outwash gravel, moraines etc. These material types dominate the plains in the Öræfi district, but they are also found in higher areas (e.g. Hofsfjall - Slettubjörg) from where the glacier recently retreated. In other areas e.g. Svinafellsheidi where the till cover is discontinuous, the map shows only the bedrock.

(b) Rhyolite and dacite. Generally these rocks are easily mapped because of their intrusion or dome-like form. Silicic tuffs (hyaloclastites) are found in a few places. Hybrid dacite and rhyolite with calc-alkaline affinity having restricted extent occur at several places in Öræfajökull, but only the large dome, Hnúta, N of Kvíárjökull is denoted on the map.

(c) Subaerial basic and intermediate volcanic rocks. Most of these are lava flows or remnants of partially eroded flows. Many of these appear to be very young, a few are definitely postglacial (Thorarinsson, 1958). The interglacial tuff cone at Hofsfjall is also included here.

(d) <u>Subglacial (subaquatic) basic and intermediate volcanic rocks.</u> This is the most common rock type, especially in the central area, and comprise different kinds: pillow lavas, pillow breccias, irregularly jointed rocks ("kubbaberg"), and tuffs. Thin lava flows and also some tuffaceous rocks occurring within a mapped unit may represent subaerial eruptions, but are not given special symbols. Aphanatic basalt, basaltic andesite, and icelandite have similar appearance in the field, and are therefore mapped as one unit.

(e) <u>Tillite horizons and beds.</u> Tillites are found in the older and younger sequences (Noe-Nygaard, 1953). The most prominent of these layers are traced on the map.

(f) <u>Granophyre intrusion.</u> The lowermost sections of Breidamerkurfjall (Bæjarsker) are intruded by a grey-coloured, medium-grained silicic rock with graphic texture: granophyre.

(g) <u>Sedimentary rocks of lacustrine and glaciolacustrine origin.</u> Such rocks occur both in Svinafell and Breidamerkurfjall. The fossiliferous layers of Svinafell were described by Thorarinsson (1963).

(h) <u>Rocks of older complexes, unspecified.</u> Rocks with an "old" appearance are included here. They are characterized by (1) slight alteration of groundmass and even some phenocrysts, (2) secondary mineralization in vesicles, (3) comprising units with both reverse and normal magnetic polarity, (4) in most places underlying an unconformity. The different lithologies within these sequences have not been specified on the map except for larger, mapable silicic outcrops and tillite horizons.

In the following description the central area of Öræfi, which is characterized by young, unaltered rocks with normal magnetic polarity, is separated from the stratigraphically lower areas which usually underlie an unconformity and are characterized by older rocks of reversed and normal magnetic polarity and slight alteration. In these altered rocks the following secondary minerals have been identified: Chlorite, quartz, chalcedony, calcite, aragonite, analcime, stilbite, laumontite, chabazite, skolesite and mordenite.

The central area has been mapped in more detail than the rest of the area. Many of the details are therefore easily seen on the map and are not mentioned in the text. On the other hand a more detailed presentation is given of the areas comprising "old" rocks in order to complement the unspecified geology of the map.

In the following description the term hyaloclastite is used quite often. This term is here used in a broad sense and includes the numerous rock types of subglacial or subaquatic eruptions, which typically occur intermingled. (The origin of hyaloclastites as typically developed in Iceland was thoroughly discussed by Sigvaldason (1968)).

Local names used in the text refer to the topographic map: "Sérkort Skaftafell" 1:100.000 and 1:25.000, Landmælingar Islands (1974).

Areas of "old" rocks

A. Breidamerkurfjall/Ærfjall

Gabbro occurs at a few localities along the southern shore of Breidarlon (outside the map to the east). Even though boulders of gabbro are common in the moraines in front of Fjallsjökull, this is the only gabbro exposure (known to the author) in the Öræfi district. The contact relations of the gabbro are nowhere exposed.

From the main road an unconformity is easily seen in a section of Breidamerkurfjall along Fjallsjökull. The oldest rocks are more altered than those overlying the unconformity. These lowermost rocks are at Bæjarsker intruded by a medium-grained, grey-coloured granophyre (Fig. 2). Both the altered section and the intrusion are cut by a number of dikes. Towards the south the density of dikes increases up to about 50%. One of these dikes shows a faint reverse magnetic polarity. The time relation between the unconformity mentioned above and the granophyre intrusion is not quite clear. However, the sequence above the intrusion starts with a tillite. This indicates that the unconformity was formed by glacial erosion and that the granophyre predates this erosion. The stronger alteration of the section beneath the unconformity may be related to a hydrothermal effect from the granophyre.

In the southern part of Hrossadalur the section above the granophyre shows the following stratigraphy:

6. hyaloclastites (occurring from Midaftanstindur and Rakartindur to Eydnatindur)
5. tillite
4. basaltic lava flows and hyaloclastites
3. tillite
2. hyaloclastites (frequently cut by basic dikes)
1. tillite.

In Hrossadalur some hyaloclastite sequences exhibit sedimentary structures such as cross-bedding and stratification. These "hyaloclastites" which are coarse-grained also include silicic material. They probably represent volcanoclastites reworked by glaciofluvial processes. About 1,0 - 1,5 km north or Hrossadalur, close to Breidamerkurjökull, a series of brown coloured, fine-grained, laminated sediments occur. One of the dikes cutting these layers is reversely magnetized, indicating that the sediments are older than 0,7 Ma. In contrast to similar rocks in Svinafell, no fossils have been found in these Breidamerkurfjall sediments.

In Geldingadalur (Fig. 1, Fig. 3) a series of basaltic layers are exposed. Most layers are lava flows, but some have chilled margins and are thus probably sills. These rocks may be correlated with the lava flows occurring between the two uppermost tillites in the Hrossadalur section. The basaltic layers in Geldingadalur are partly eroded and overlain by hyaloclastites. Some of the dikes cutting these hyaloclastites are reversely magnetized. Light coloured screes occurring west of Geldingadalur are erosional products of rhyolitic dikes rather than rhyolite flows or domes.

The lowest rocks of the southeasternmost part of Ærfjall are slightly altered basaltic flows and hyaloclastites. Both normal and reverse magnetic polarities are found. Dikes cutting basalt with normal magnetization are found to have reversed polarity. West of Ofanleiti small outcrops of rhyolite occur close to the ice (glacier) contact. The northernmost parts of Ærfjall are characterized by a sequence of unaltered hyaloclastites capped by a basaltic lava flow. These are interpreted as equilvalents of the young rocks found in the more central parts of Öræfajökull.

Altered rocks are also found along the southern margin of Hrútárjökull. At the base of this section there is a tillite with pebbles of gabbro, granophyre and granite. The tillite is overlain by basic lava flows, sills, and hyaloclastites. In Múli occurs a series of basaltic lava flows dipping slightly WSW (Fig. 4). These are cut by basic dikes. No silicic rocks are observed in the section of "old" rocks south of Hrútárjökull.

B. Slaga/Sandfell/Svinafell

In the central and eastern parts of Öræfi (Hof-Kvísker) altered rocks or rocks with reversed magnetic polarity have not been found. However, the lowermost section in the southwestern part of Slaga (2 km SE Sandfell) consists of slightly altered aphyric basaltic lava with reversed magnetic polarity. This basalt is partly eroded and overlain by a tillite (Fig. 5).

In the deep section at Grænafjallsgljúfur 2,5 km N of Sandfell basaltic flows with abundant secondary minerals are exposed. The magnetic polarity of these rocks is normal.

Around Svinafell altered rocks are found to occur both SE and NW of the fossiliferous sediment layers (Thorarinsson, 1963). The best exposed sections are along Virkisjökull and in Hrútagil close to Svinafellsjökull. Lava flows, hyaloclastites and tillites are found. Most basalts exhibit reversed magnetic polarity. To the south-east this "old" section can be seen to be eroded prior to the glaciolacustrine sediment deposition.

Altered rocks also occur south of Hvannadalur.

C. Hafrafell

The following stratigraphy is found in the southern part of Hafrafell:

6. hyaloclastites, relatively fresh
   -------- unconformity ----------
5. hyaloclastites and basaltic lava flows
4. tillite
3. hyaloclastites and basaltic lava flows
2. tillite
1. basaltic lava flows with fine-grained layers of sediments in between. This unit, where alteration is most conspicuous, is frequently cut by basaltic dikes.

Along Skaftafellsjökull altered basalts and hyaloclastites dominate the lowermost parts. Approximately up to the lower tillite the section is characteristically cut by dikes.

In the higher parts of Hafrafell a dacite massif occurs above altered basaltic rocks (Fig. 6). This massif is cut by slightly altered basaltic dikes, but the contact and the age relations, especially to the youngest hyaloclastites, are unknown. In another silicic massif at Efrimenn large "pillow" structures with columnar jointing are developed (Fig. 7).

Between Fauskagljúfur and Svarthamrar there is a tillite between altered basaltic lava flows and a rather fresh hyaloclastite unit above. Svarthamrar consists exclusively of this hyaloclastite.

Most basalts in the lowermost sections of Hafrafell exhibit reversed magnetic polarity, however, both normal and reverse polarity is found in dikes cutting these rocks. The upper hyaloclastite unit and the slightly altered basalts immediately below the unconformity are of normal magnetic polarity.

D. Skaftafellsheidi

Between Lambhagi and Sjónarnipa basaltic flows predominate. These are frequently cut by dikes. Tillites are also found in a few places. A profile at Sjónarnipa has a lowermost section of basalts with reversed polarity overlain by basalts with normal magnetization. All these basalts, which dip slightly ($\sim 10°$) towards the north, were eroded before they were unconformily overlain by a hyaloclastite unit (Fig. 8) containing fresh breccias and irregularly columnar-jointed basaltic andesite. This relatively young hyaloclastite unit covers most of the Flár area.

Another relatively fresh hyaloclastite unit with pillow breccias at Fremrihnaukur is overlain by a jointed crystalline rhyolite at Kristinartindur. This rhyolite is probably older than the hyaloclastite occurring in the Flár area.

E. Skaftafellsfjöll

The lowermost section of Raudhellar consists of slightly N-dipping basaltic flows which are overlain by hyaloclastites and rhyolite in the highest peaks towards north. Noe-Nygaard (1953) reported two tillite horizons in Raudhellar.

At Háls the oldest flows dip towards west. These basalts are overlain by altered hyaloclastite and lava flows cut by dikes.

In Kjós occur highly altered basic hyaloclastites intermixed with tillite layers. North of Kjós, in Vesturhnúta, basaltic hyaloclastites are overlain by basaltic flows and altered silicic hyaloclastites on the top.

Rhyolitic hyaloclastites have also been observed in Vesturdalur east of Litli Bláhnúkur.

Areas of young rocks

Except for scattered occurrences of young rocks in the areas described above, young rocks are concentrated in the area between Svinafellsjökull and Hrútárjökull. Large silicic massifs occur between Sandfellsheidi and Kvisker. There seems to be no definite time relation between the rhyolitic rocks and the more abundant, mainly basaltic hyaloclastite units; either rock type may be older or younger than the other. However, in Svinafell - Svinafellsheidi where a large succession of various rock types occurs above the sediments, silicic rocks are not represented among the oldest strata. The same feature is found in Sandfellsheidi where the silicic rocks are found highest in the sequence. Thus it appears that silicic rocks became more abundant in the late stage in the evolution of the Öræfajökull volcano.

The abundant occurrence of hyaloclastites shows that most of the activity of Öræfajökull has taken place during glacial periods. Postglacial flows are found in Vatnafjöll and at Svarthamrar south of Kviárjökull (Thorarinsson, 1958). Another basalt flow 2,5 km N of Kvisker is also interpreted as postglacial. However, many of the subaerial flows occurring at high levels on the mountain may be postglacial flows slightly eroded on the upper surface by the glacier which has been oscillating during postglacial time (Thorarinsson, 1958). But these flows may also constitute the late subaerial phase of a mainly subglacial eruption forming hyaloclastites (Sigvaldason, 1968). The relatively thin lava flows occurring within the breccia or tuffaceous hyaloclastite units may be interpreted in the same way.

Extensive flows of basalts occur between Hof and Hnappavellir. These are definitely subaerial and overlain by hyaloclastite. Thorarinsson (1958, p.9) argued that the rather thick basalt flows occurring between Hofsnes and Hnappavellir (including Ingólfshöfdi) are older than the thin basalt layers between Hof and Fátækramannahóll (Fig. 9) which are supposed to have formed during the last interglacial. The relation between the Salthöfdi rocks and the layers between Hofsnes and Hnappavellir is not quite clear, but Salthöfdi is here included in this series even though some features (scoria) at the NW parts of Salthöfdi are reminescent of recent volcanic activity. All these rocks are petrographically very similar, coarse-grained and containing phenocrysts of both plagioclase, olivine and clinopyroxene. Chemical analyses of samples from Bæjargil (Hof), Hof-Fátækramannahóll, and Salthöfdi (Table 1) show close similarity between these rocks. North of Salthöfdi the thick flows are overlain by a series of thinner flows resembling the flows at Hof. There is thus evidence that the flows at Hof are younger (as argued by Thorarinsson, 1958). However, the similar chemical and petrographic features (which <u>are not very typical</u> for Öræfi basalts) indicate that these rocks simply represent different time sequences of the same eruption. The low-angle dip of the flows indicates that they were not viscous and the thin layers at Hof may be flow units within the same lava rather than separate flows (Walker, 1971).

A similar subaerial basalt sequence is found in the Ingólfshöfdi promontory where thick flows, some of which are columnar jointed, rest on a sequence of tuffaceous hyaloclastite (Fig. 10). The same type of basalt is exposed in Borgarklettur (Fig. 11) 1,5 km north of Ingólfs-höfdi.

A sequence of similar porphyritic basaltic flows or flow units ($>$15) occurs close to Falljökullskvisl 2,5 km N of Sandfell. These layers are overlain by tillite or till, but because of the very close proximity to the presently active Falljökull glacier, it is not known whether these rocks are post- or interglacial.

PETROGRAPHY AND CHEMISTRY

The petrography of the basic, intermediate and silicic rock types are summarized in Tables 2 & 3 which shows the modal compositions of 44 representative samples. It should be especially mentioned that clinopyroxene is quite common as a phenocryst phase in basalt from Öræfi. This is in contrast to most basalts from the western and eastern volcanic zones of Iceland (Jakobsson, 1972).

Both the modal analyses and the chemical data (to be published separately) show a bimodal distribution of rock types in Öræfi. Basalt and rhyolite are the predominating types while basaltic andesites, icelandites and dacites are rather scarce. However, basaltic andesite may be underrepresented in the sampled and analysed material because of their resemblance to basalt in the field.

When compared to rocks of other central volcanoes in Iceland (Fig. 12) the Öræfi rocks turn out to be more alkaline than the Thingmúli rocks (Carmichael, 1964) and similar to the rocks of Setberg, Centre 2 (Sigurdsson, 1970). According to the dividing line of Irvine & Baragar (1971) the whole series is nevertheless subalkaline. The AFM diagram (Fig. 13) shows a typical tholeiitic trend for the main series. The basalts of the "old" group tend to be less evolved than those of the younger group. Otherwise no definite trends can be observed separating the two groups.

HYBRID ROCKS

Within the area dominated by young rocks, hybrid intermediate and silicic rocks are found in a few places. The largest occurrence of such rocks is between Vatnafjöll and Kvisker where a large dome of hybrid rhyodacite or rhyolite grading into dacite occurs. Furthermore such rocks have been found close to the contact between rhyolite and basalts in Stadarfjall. The most basic of these hybrid rocks ($SiO_2 \sim 59\%$) are found as small remnants of a subaerial flow at Háasker 1,5 km E of Hof. Another occurrence is a dike crossing Bæjargil at Hof. In Sandfellsheidi rocks of similar appearance have been found, but these have not been analysed enough to prove their hybrid nature.

The hybrid rocks are black with a dense silicic glassy matrix in which megacrysts of olivine (Fo_{82-85}), plagioclase (An_{83-90}) and diopsidic clinopyroxene occur. Furthermore these rocks typically contain xenoliths of basaltic composition. Because these rocks are similar in appearance to both porphyritic basalt and basaltic andesite, they are not easily recognized in the field. Their hybrid nature was first discovered from chemical and petrographical data.

The chemical data (Prestvik, in prep.) show that the hybrid rocks result from mixing of a normal rhyolite and a basalt component. This mixing produces a "rock series" which displays characteristics typical for many calc-alkaline rocks (Fig. 13). The nature of the mixing process is not clear, but it is either a mixing of two magmas or a mixing of a rhyolitic magma and basaltic rocks (xenoliths) which were subsequently mechanically disintegrated and partly assimilated.

Previously, hybrid rocks have been described from the Tertiary of Eastern Iceland (Blake et al., 1965; Walker, 1966; Gunn & Watkins, 1969).

CONCLUDING REMARKS

The description above indicates some of the complexity of the geology of the Öræfi area. The occurrence of silicic rocks both in Skaftafellsfjöll and Breidamerkurfjall shows that central volcano type activity predates the Öræfajökull volcano itself. Judged from the frequency of silicic dikes and hydrothermal alteration the silicic activity in Skaftafellsfjöll was highest in the area around Kjós-Kjósarbotn, in the northeastern part of this area. However, rhyolite also occur farther east in Kristinartindur and probably in Hrútsfjall north of Hafrafell, but no mapping was possible in this latter area. Thorarinsson (1958) mentions that the nunatak Thuridartindur ca. 8 km north of Hvannadalshnúkur (Fig. 1) consists of rhyolite. This opens the possibility that silicic rocks occur more or less continuously between Kjós in Skaftafellsfjöll and Breidamerkurfjall.

As far as Breidamerkurfjall is concerned silicic volcanic activity has been much lower there than in the north-central Skaftafellsfjöll. However, the granophyre intrusion at Bæjarsker and the gabbro along Breidárlón indícate that this area is close to or the site of a former volcanic center as well. This is further substantiated by the high degree of hydrothermal alteration in this area, a feature also found in Kjós.

The limited field data thus indicates that there was one central volcano in Skaftafellsfjöll and another in Breidamerkurfjall. However, the mutual age relationship between these two centers is not clear, but they are both Quaternary since tillite beds are found abundantly in both places. Further investigation including absolute radiometric dating and magnetic stratigraphy studies may solve this problem.

The unconformities found at relatively high levels in both Hafrafell and Skaftafellsheidi probably represent the same erosional event. In both places relatively fresh hyaloclastites similar to those found in the central parts of Öræfi occur above the unconformity. The unconformities are probably younger than the one in Breidamerkurfjall, which is overlain by a thick sequence of various, partly altered rock types.

As was mentioned above some of the analysed "old" basalts from Morsárdalur, Skaftafellsheidi, Hafrafell, Svinafell and Slaga are "more primitive" than other basalts from the Öræfi area. These are chemically similar to many rift basalts from the northern part of the eastern volcanic zone of Iceland (Sigvaldason, 1969; Jakobsson, 1972). These "primitive" rocks are, however, intermixed with more differentiated rocks of "normal Öræfajökull type". In the light of the proposed models for tectonic evolution of the Vatnajökull area (Thorarinsson et al., 1973; Walker, 1975), it seems possible that the "primitive" rocks are related to rift zones (Walker, 1975) rather than representing the central volcanoes.

Walker (1960) related the zones of zeolite minerals in Tertiary basalts of Eastern Iceland to their stratigraphic position within the pile of flood basalts. Some of the zeolite minerals found in altered sequences in Öræfi correspond to intermediate zones in Walker´s model indicating removal of thick covers (~600 m; Walker, 1960) by erosion. However, since the Öræfi basalts are definitely Quaternary (tillites), this seems unlikely. The alteration minerals found in most "old" rocks in Öræfi therefore are most probably related to the local high thermal activity caused by the central volcanic activity of the area.

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Table 1. Major element composition of young, porphyritic (ol - plag - cpx) subaerial basalts.

	Ø 3	Ø 123	Ø 57
SiO_2	48,60	49,46	50,40
TiO_2	1,83	1,77	1,38
Al_2O_3	16,15	16,20	16,75
Fe_2O_3	3,08	4,27	8,17
FeO	7,48	6,31	1,64
MnO	0,16	0,17	0,18
MgO	6,55	6,21	5,50
CaO	12,15	11,90	11,50
Na_2O	2,40	2,60	2,61
K_2O	0,36	0,42	0,42
P_2O_5	0,15	0,23	0,21
H_2O	0,19	0,25	0,44
Total	99,10	99,79	99,20

Localities: Ø 3 Bæjargil, Hof.

Ø 123 Between Hof and Fátækramannahóll (Fig.9).

Ø 57 Salthöfdi.

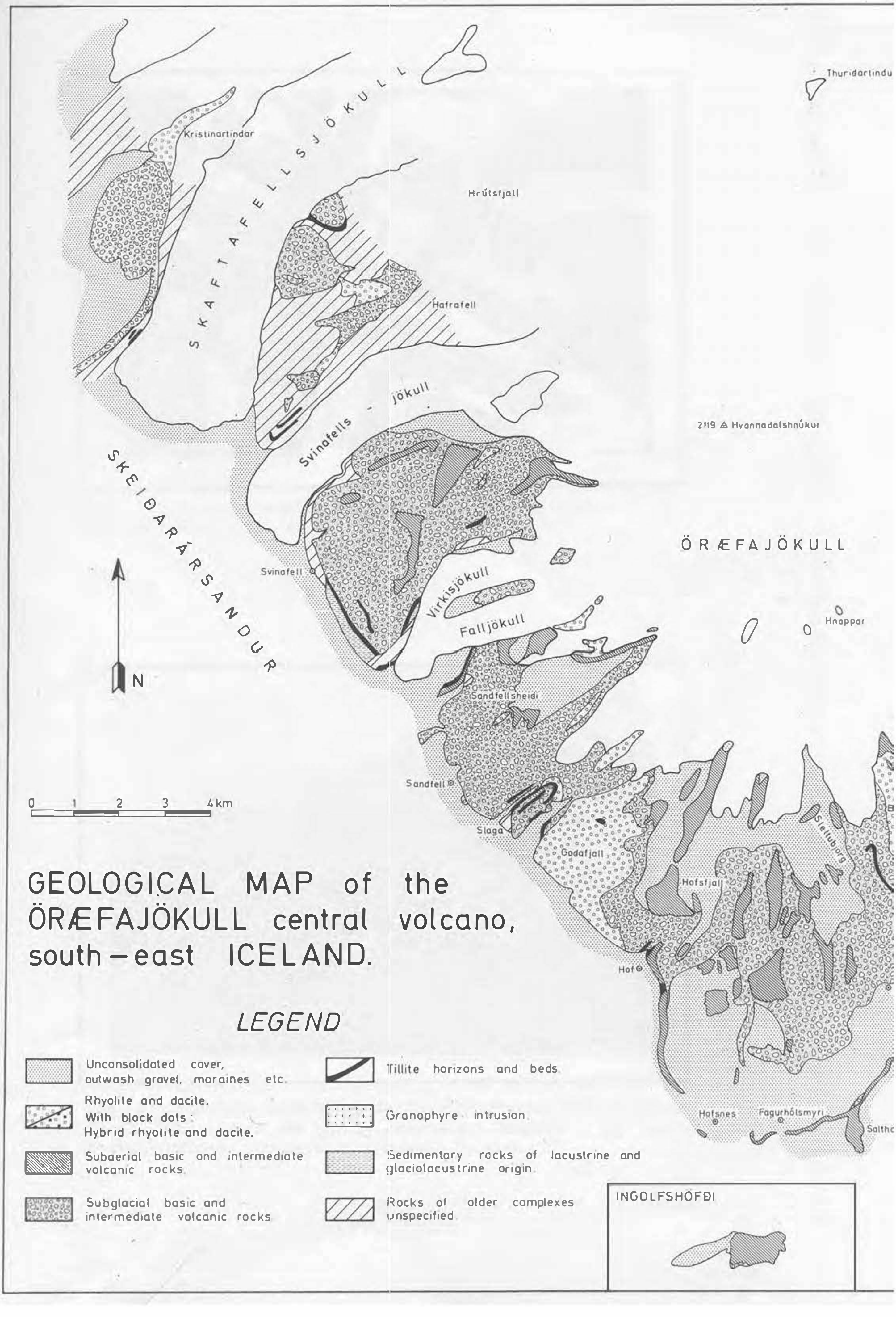
Table 2. Modal analyses of basaltic rocks, Øræfi. Uppermost section: Young rocks. Lowermost section: "Old" rocks.

Sample No.	Phenocryst pl	ol	cpx	mt	Matrix unspecified	Type of occurrence, locality	Special remarks
3	30,9	2,6	5,2		61,3	Lava flow, Bæjargil Hof	Holocrystalline
7	tr				100,0	Hyaloclastite breccia, Bæjargil Hof	Hyalopilitic matrix
8	7,8	0,6	tr		91,6	Dike, Bæjargil Hof	Intersertal matrix
14	36,6	7,0	tr		62,7	Lava flow, Kvisker	Holocrystalline
37	46,9	3,7			48,9	Boulder, Bæjargil Hof	Holocrystalline
54	5,6	2,8	tr		91,6	Lava flow, Hofsfjall (basalt andesite)	Pilotaxitic matrix
63	8,4	0,5	1,0		90,1	Lava flow, Vatnafjøll (postglacial)	Pilotaxitic matrix
73	20,6	1,2		1,4	76,8	Lava flow, Mulagljufur Kvisker	Hyalopilitic matrix
85	11,3	4,6	3,8		80,3	Lava flow, Storhøfdi	Holocrystalline, includes gabbro xenoliths
104	18,9	tr.	3,8		77,3	Lava flow, Ærfjall (young)	Includes gabbro xenoliths
124	30,1	3,6	5,0		61,3	Lava flow, Hnappavallahamrar	Holocrystalline
134	9,9	2,3	0,7	0,3	86,8	Lava flow or sill, Hnuta Svinafell	Hyalopilitic matrix
138	1,5				98,5	Dike, Svinafellsfjall	Pilotaxitic matrix
248	0,8			0,3	98,9	Lava flow, Hvannadalshryggur	Microcrystalline matrix
166					100,0	Lava flow, Slaga	Almost holocrystalline. Interstitial glass altered.
180	18,5	1,4			80,1	Lava flow, Grænafjallsgljufur Sandfell	Intersertal matrix. Glass and olivine partly altered. Vesicls filled.
184	2,6		1,1		96,3	Lava flow, Svinafell/Virkisjøkull	Intersertal matrix. Glass partly altered.
187	3,3				96,7	Lava flow,	Subophitic. Interstial glass altered.
192	tr				100,0	Lava flow, Hrutagil Svinafell	Pilotaxitic. Subordinate glass altered.
194	tr				100,o	Lava flow, Sjonarnipa/Skaftafellsjøkull	Intersertal. Glass completely altered.
201	21,6	0,3	tr.		78,1	Lava flow, Sveltiskard, Hafrafell	Altered intersertal matrix. Calcite in vesicles.
207	42,7	tr.	1,1		56,2	Dike, south of Svarthamrar Hafrafell	Interstial glass altered.
217	0,5				99,5	Dike, front Skaftafellsjøkull Hafrafell	Subophitic. Intersertal glass altered
219	tr				100,0	Dike, Thjohamragil, Skaftafellsheidi	Subophitic. Olivine phenocrysts totally altered.
220	0,7				99,3	Lava flow,	Intersertal matrix. Glass altered.
223	9,8	0,7			89,5	Lava flow	Almost holocrystalline. Matrix slightly altered.
224	10,4				89,6	Dike, Hals Morsarsandur	Subophitic. Intersertal glass altered.
226	1,1		0,7		98,2	Dike, Skorar Morsarsandur/Skaftafellsheidi	Intersertal matrix. Olivine and glass altered.
228	3,6		2,6	0,2	93,6	Lava flow, Eyagil Skaftafellsheidi	Microcrystalline matrix, unaltered.
257					100,0	Lava flow or sill, Geldingdalur Breidamerkurfjall	Highly altered. Matrix includes 5,9% calcite
259	3,5	0,6			95,9	Inhyaloclastite breccia	Pilotaxitic matrix. Olivine and glass partly altered.
267	2,1				97,9	Lava flow, north of Rakartindur Breidamerkurfjall	Slightly altered hyalopilitic matrix.

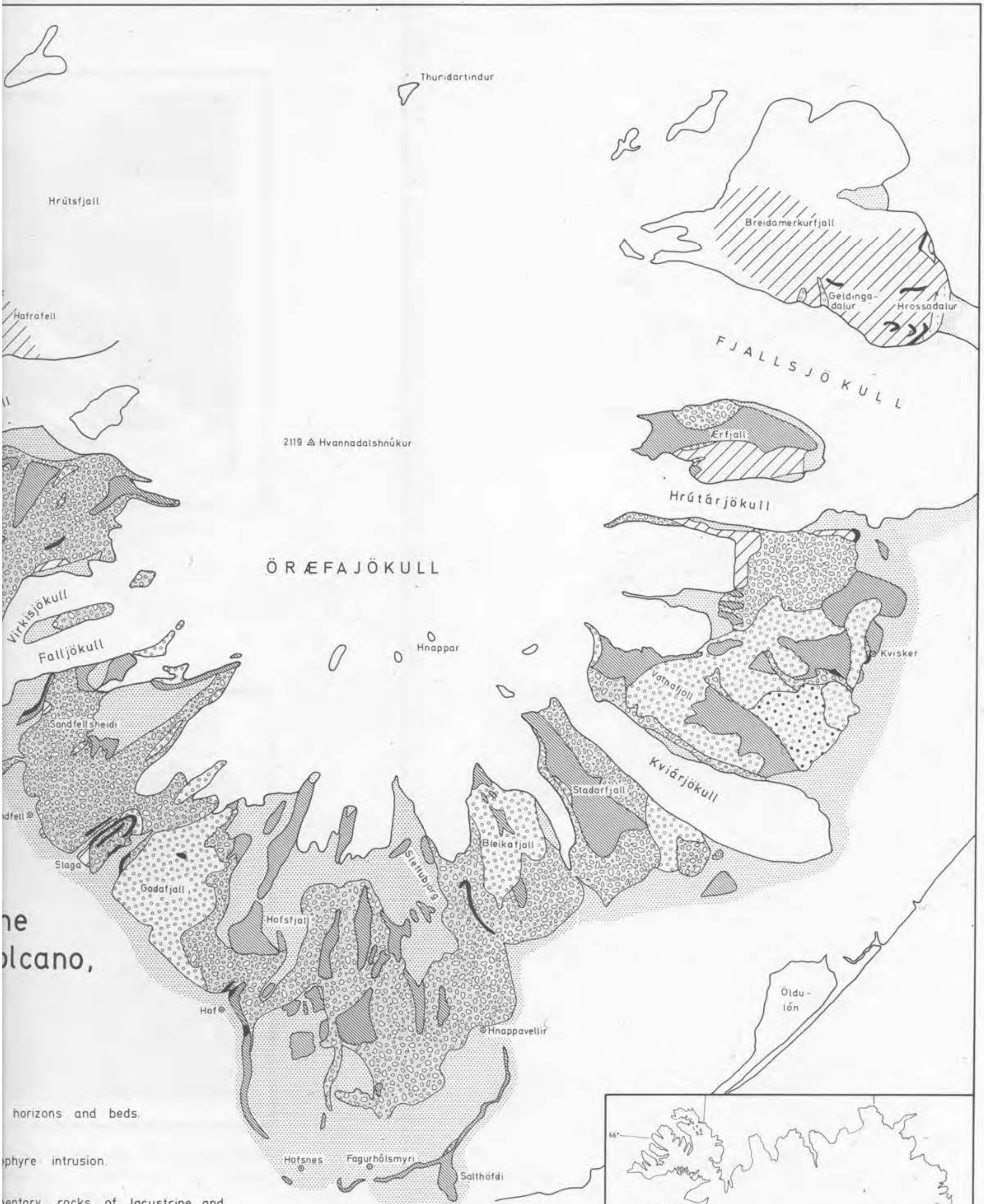
Table 3. Modal analyses of intermediate and silicic rocks, Øræfi.

Sample No	Phenocryst pl	ol	cpx	mt	Matrix unspecified	Rock type, type of occurrence, locality	Special remarks
136					100,0	Basalt andesite, hyaloclastite breccia, Svinafellsfjall	Hyalopilitic and banded
132	0,4		tr.		99,6	Icelandite, scoriaceous hyaloclastite breccia, Hnuta Svinafell	Vesicular and hyalopilitic
143	2,7	0,4			96,9	Dacite, dome, Skardatindur Svinafellsheidi	Glass matrix with flow structure
200*	2,9	0,8	0,9	0,3	95,1	Dacite, lava flow, Hafrafell.	Glassy matrix, partly devitrified.
225*					100,0	Dacite, dike, Hals Morsarsandur	Crystalline. Matrix includes 4,8% calcite.
13	0,8				99,2	Rhyolite, dome. Kvisker	Devitrified. Includes 3,5% quartz.
50	1,3				98,7	Rhyolite (obsidian), dome, Kotargil Godafjall	Flow banded, partly devitrified.
119	0,8		tr		99,2	Rhyolite, dome, Bleikafjall	Crystalline, flow banded.
154					100,0	Rhyolite, dome, Nonhamar, Kvisker	Microcrystalline, faintly banded.
209*	5,5				94,5	Rhyolite, dome, Kristinartindar, Skaftafellsheidi	Devitrified matrix.
261*	5,1				94,9	Rhyolite (obsidian), dike, Geldingadalur,Breidamerkurfj.	Glassy matrix with minute crystallites.
266*	2,7				97,3	Rhyolite, dike, east of Eydnatindur	Devitrified and partly altered (calcite) matrix.

* refers to localities within the areas with "old" rocks.



GEOLOGICAL MAP of the ÖRÆFAJÖKULL central volcano, south-east ICELAND.



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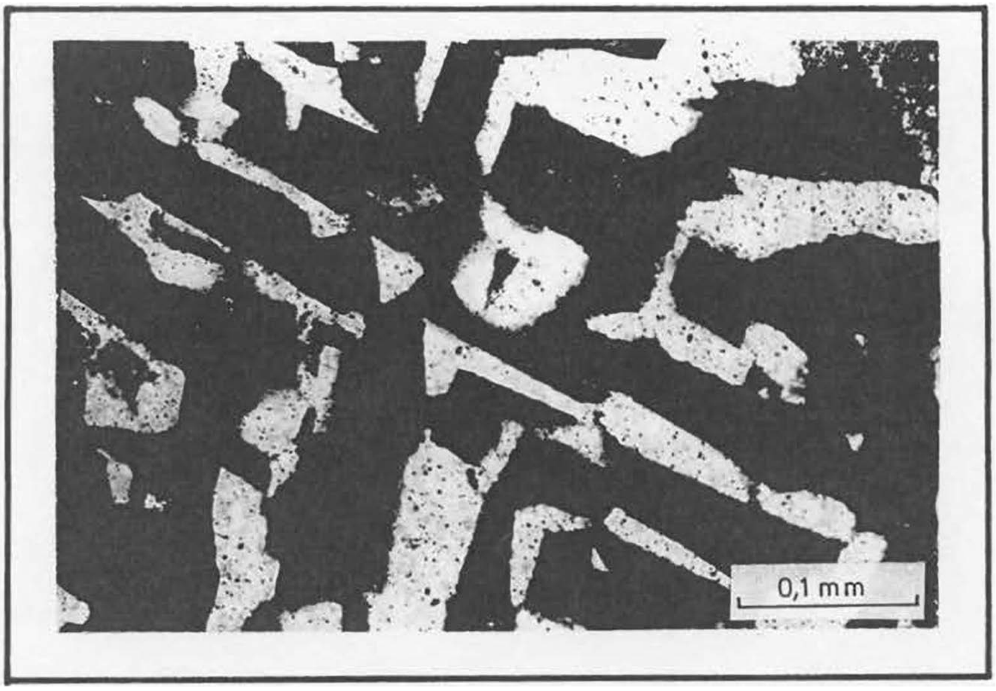

Fig. 2. Graphic texture of granophyre from Bæjarsker, Breidamerkurfjall. (X-nicols).

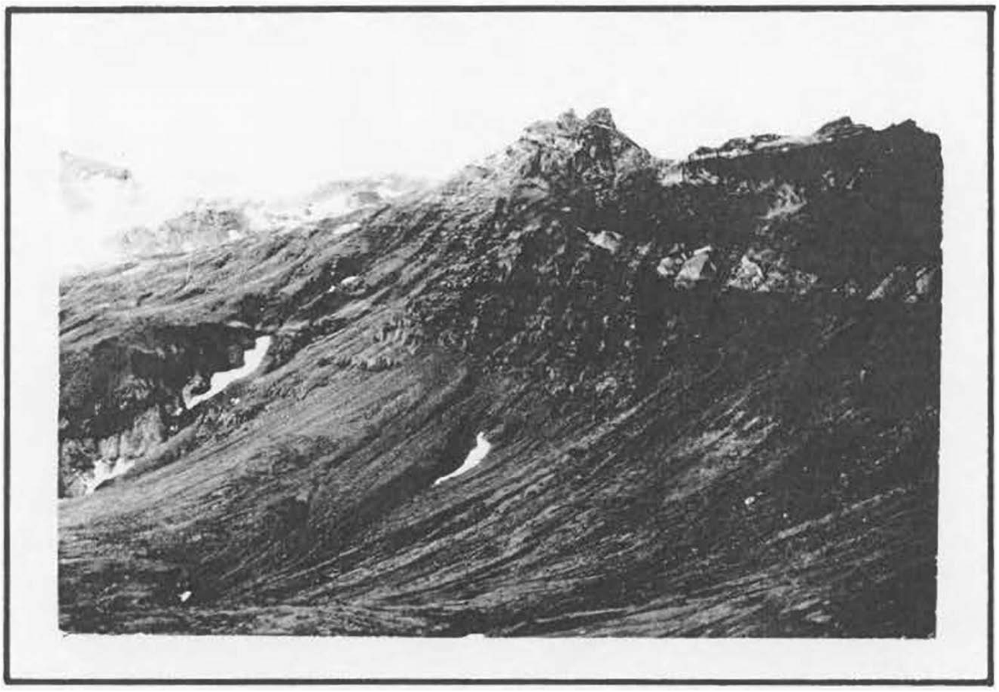

Fig. 3. Basaltic lava flows in Geldingardalur, Breikamerkurfjall. The layers are partly eroded and overlain by basic hyaloclastites. Unconformity marked by arrow.

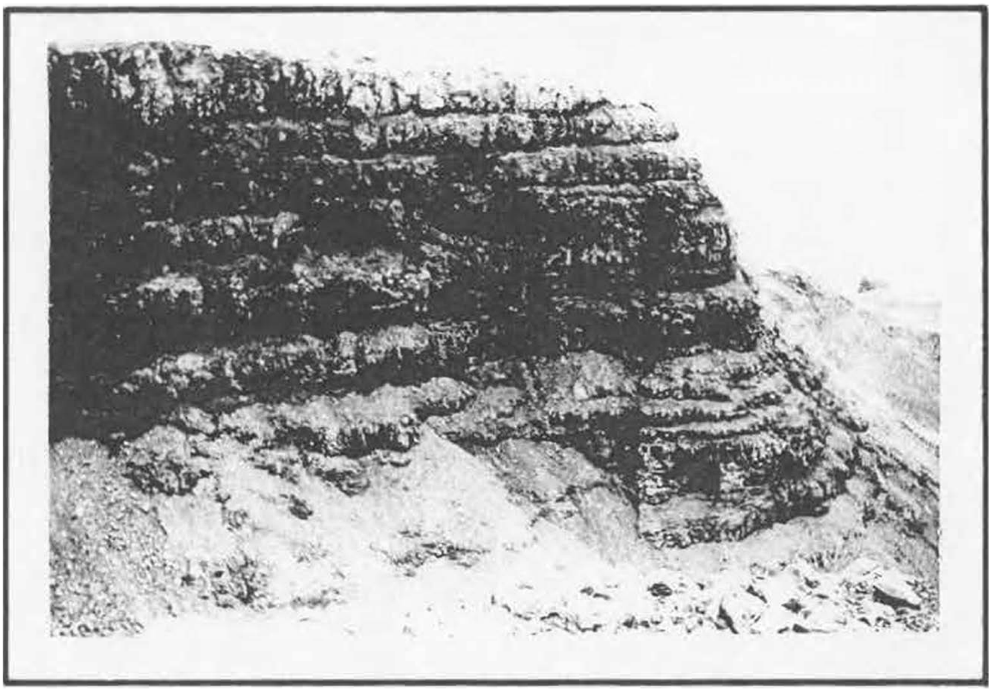

Fig. 4. Basaltic lava flows in Múli, 3 km northwest of Kvisker. Height of section: 130 m.

Fig. 5. Tillite boulders from Slaga. Length of hammer 0,5 m

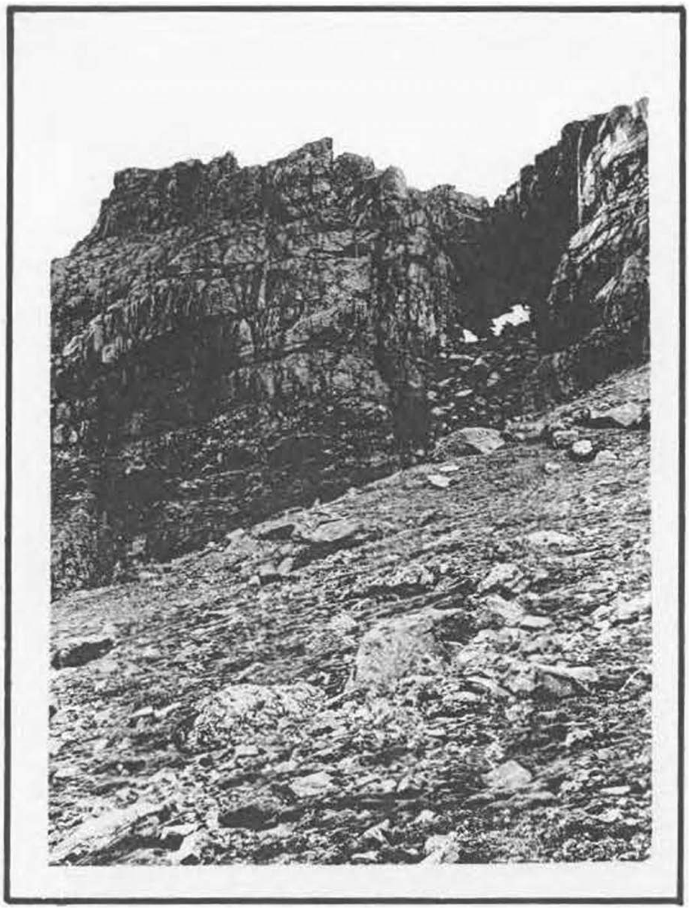

Fig. 6. Massive dacite above altered basaltic rocks, southeast of Svarthamradalur, Hafrafell. Arrow points to base of dacite.

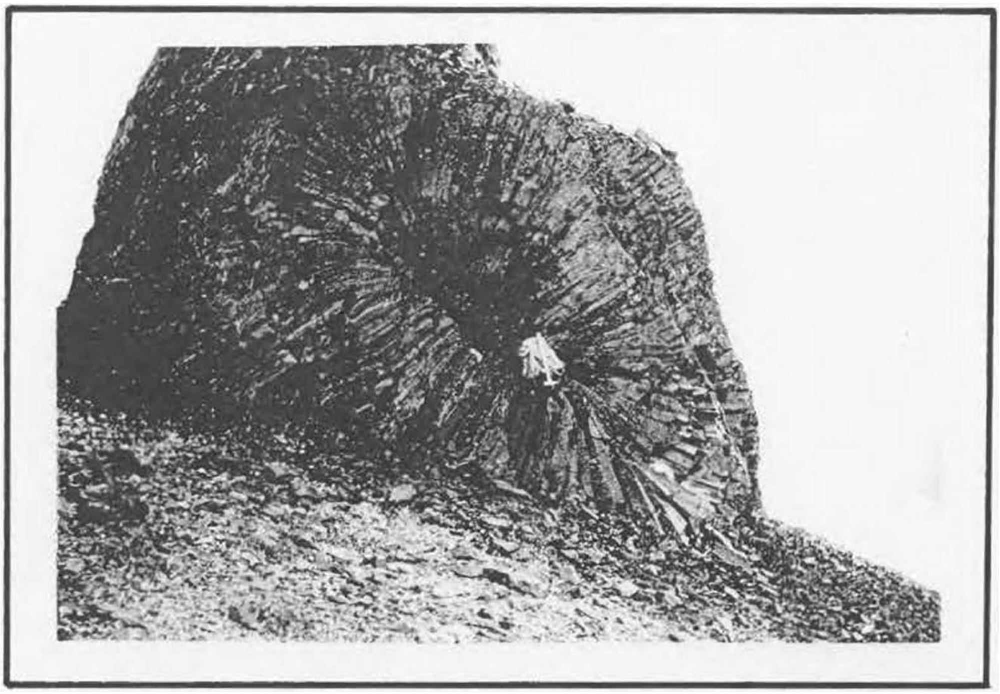

Fig. 7. Radial columnar jointing in a large "pillow" structure in silicic rocks at Efrimenn, Hafrafell.

Fig. 8. Unconformity in the southeastern side of Skaftafellsheidi. A sequence of altered basaltic rocks is eroded and overlain by fresh hyaloclastites of basalt-andesite composition.

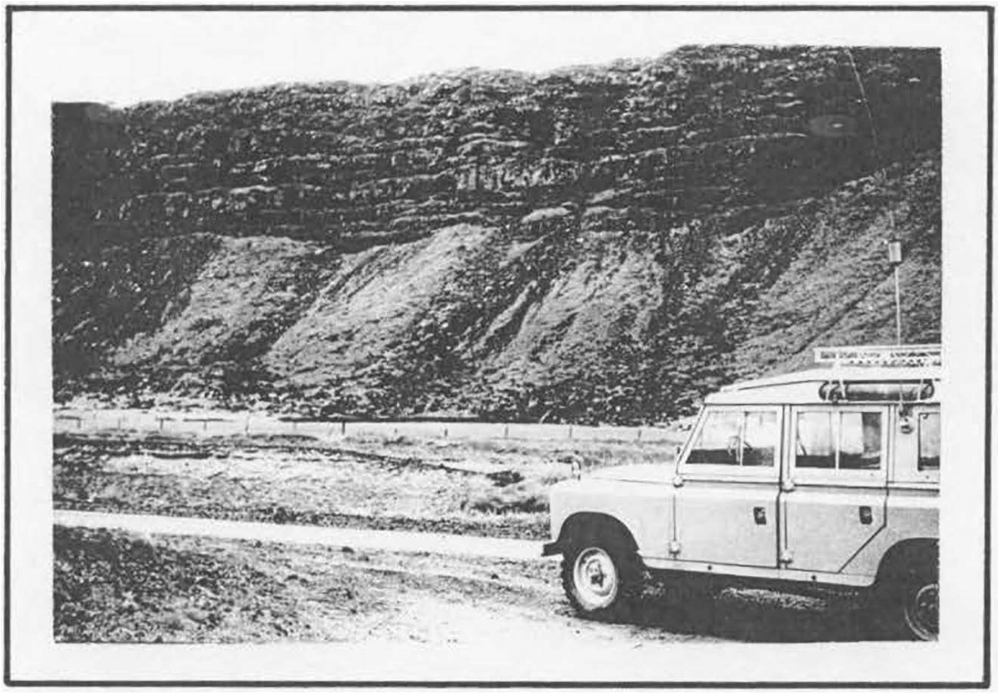

Fig. 9. Flows (or flow units) of porphyritic basalt between Hof and Fátækramannahóll. Height of visible section: 30 m.

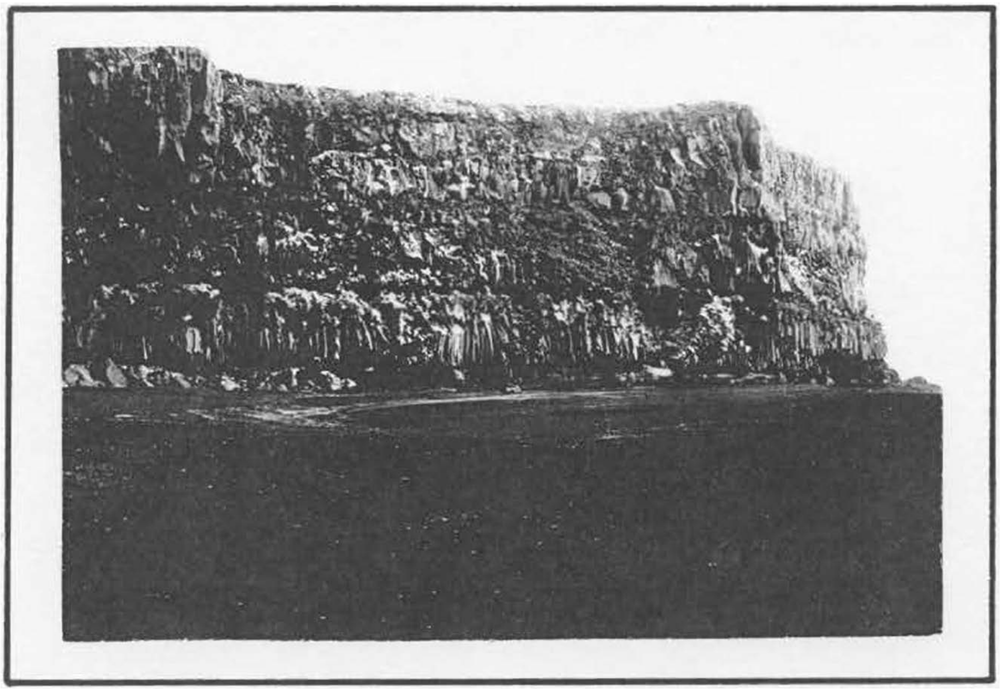

Fig. 10. Columnar jointed flows of basalt from Kóngsvík, Ingólfshöfdi. The flows rest on a sequence of tuffaceous hyaloclastite. Height of section: 50 m.

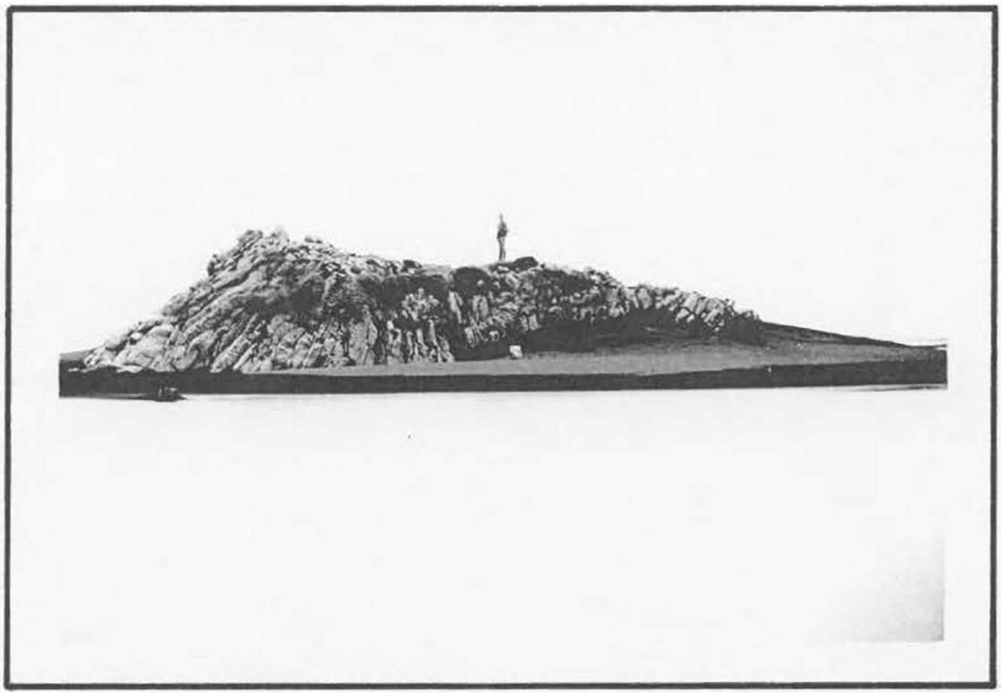

Fig. 11. Irregularly columnar jointing in basalt of Borgarklettur, 1,5 km north of Ingólfshöfdi.

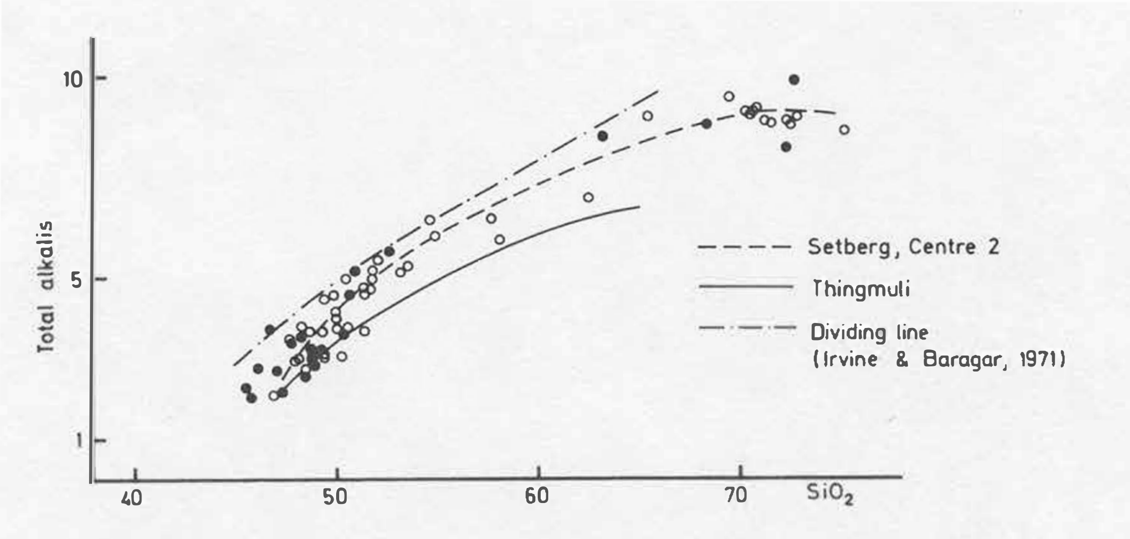

Fig. 12. Total alkali-silica diagram of rocks from the Öræfi district. Open circles: young rocks. Filled circles: "old" rocks. Lines drawn after Sigurdsson(1970) for Setberg, centre 2, Carmichael (1964) for Thingmúli and Irvine & Baragar (1971) for the dividing line.

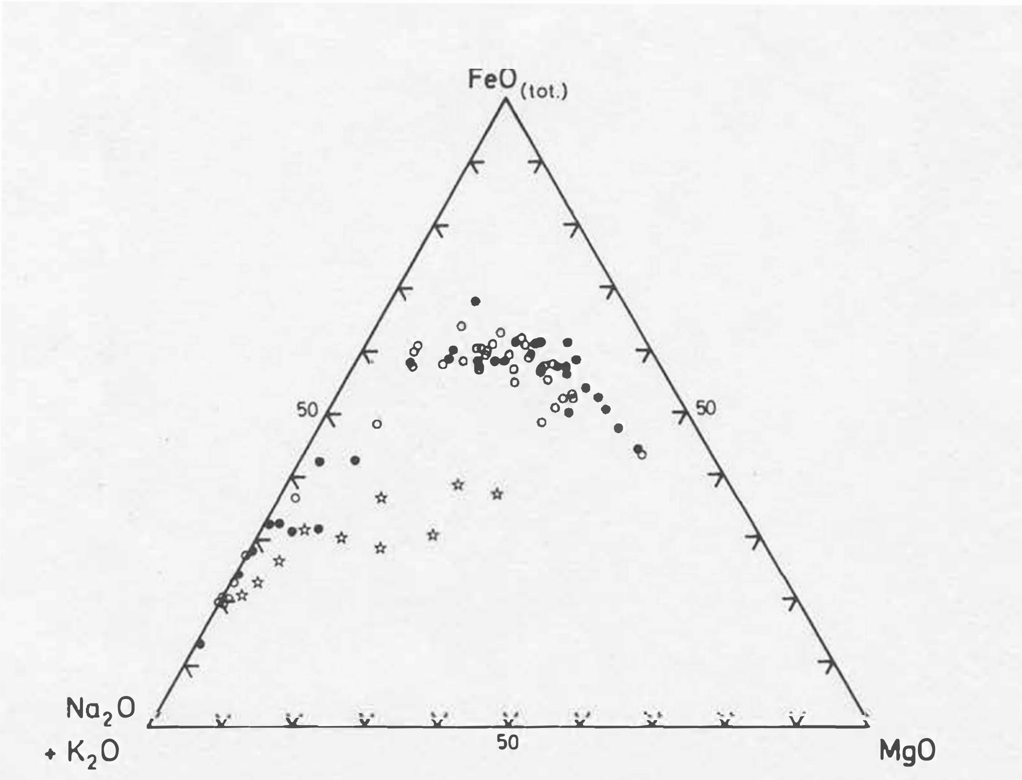

Fig. 13. AFM-diagram of young rocks from the Öræfi district. Open circles: young rocks. Filled circles: "old" rocks. Stars: hybrid rocks.