DET KONGELIGE DEPARTEMENT
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CRISTOBALITE-TRACHYTES OF JAN MAYEN

BY

HARALD CARSTENS

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DET KONGELIGE DEPARTEMENT FOR INDUSTRI OG HÅNDVERK

NORSK POLARINSTITUTT
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A complete list of publications (including maps and charts) is enclosed in Skrifter Nr. 123.

SKRIFTER

Skrifter nr. 1—89, see numbers of Skrifter previous to Nr. 100.

Nr.

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93. HAGEN, ASBJØRN: *Notes on Arctic fungi. I. Fungi from Jan Mayen. II. Fungi collected by Dr. P. F. Scholandeı on the Swedish-Norwegian Arctic Expedition 1931.* 1950. Kr. 2,00.
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Introduction.

Jan Mayen is a small volcanic island lying NNE of Iceland on a continuation of the Mid-Atlantic ridge. The rocks of the island are entirely volcanic. Most of the trachytes occur on the southern part of Jan Mayen (Sør-Jan) and the domes of these rocks are among the more conspicuous land forms contrasting strongly with the crater-forming basaltic volcanoes.

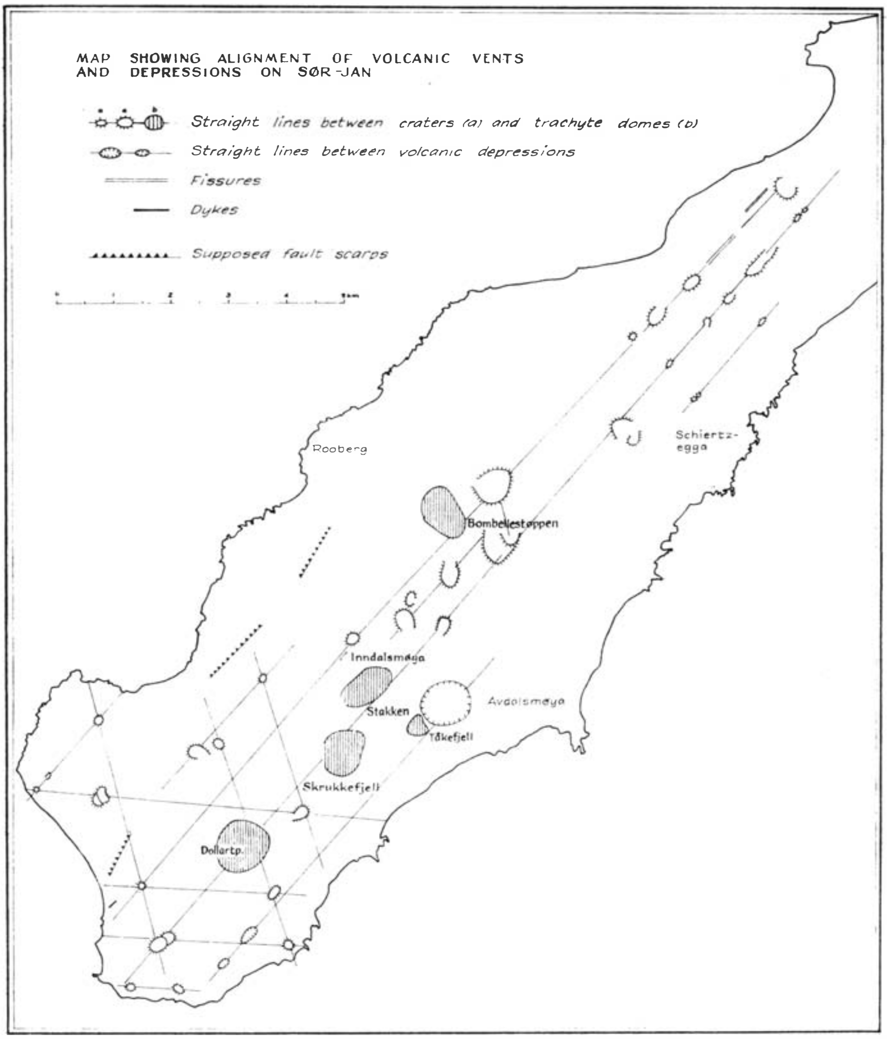

Fig. 1. Tectonic map of Sør-Jan.

Tectonic setting.

Three sets of straight lines connecting volcanic vents may be constructed, fig. 1. The main lines, including as many as ten or more individual vents, trend N 41–42° E and follow the longitudinal direction of the island. The longitudinal lines parallel volcanic fissures and older basaltic dykes which probably represent feeding channels. Three semicircular volcanic depressions (pit craters) on the south-east side are also lined up in this direction.

The other lines between vents are less conspicuous and strike N 14–17° W and E 4–6° S respectively.

This pattern, formed by craters, fissures, dykes, faults, and depressions, undoubtedly represents surface manifestations of an underlying fracture system. The vents commonly lie at the point of intersection of two lines, suggesting that volcanic eruptions were controlled by fracture intersections.

The trachyte domes are found mainly along the longitudinal lines, the slight displacements being due to flow on the sloping terrain. The trachyte of Tåkefjell is located near the rim of a large volcanic depression, 7–800 meters in diameter.

The domes.

The dome-building rocks are *trachytes* containing tridymite or cristobalite, and *trachyandesites* which are devoid of silica minerals, Figs. 2, 3 and 4. In contrast to the dense, felsitic trachytes occasionally exposed by erotion or faulting, the dometrachytes are loose and friable rocks. The trachytes have a light gray to violet colour, the trachyandesites are dark gray or dark violet. Both have a rather massive appearance. The trachyandesites of Dollartoppen, however, may display platy and contorted flowage structures. Polishing of the collected specimens revealed breccia structures in a trachyte taken from the talus below Dollartoppen.

Fig. 2. The trachyte dome of Bombellestoppen.

The trachytes and the trachyandesites of Jan Mayen form flattened domes resembling truncated cones, Figs. 2 and 3. The

Fig. 3. The trachyandesite dome of Dollartoppen.

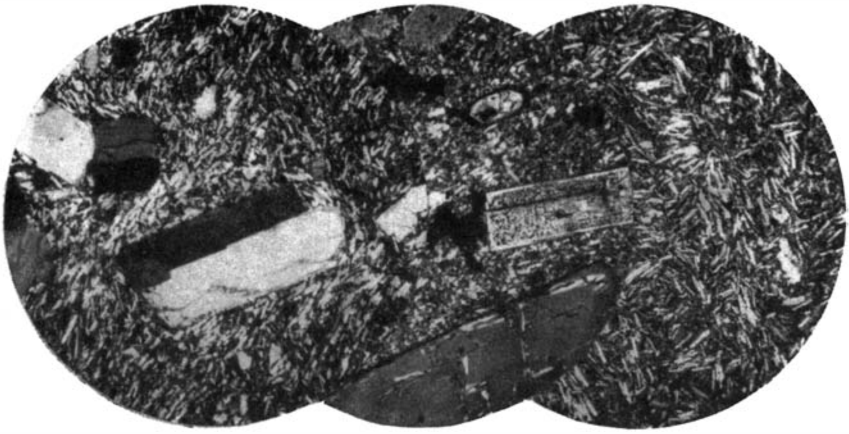

Fig. 4. Photomicrographs of trachyte (left), trachyandesite (center), and felsitic trachyte (right). Crossed nicols, × 15.

domes of Bombellestoppen, Inndalsmøya-Stakken, Skrukkefjell, and Dollartoppen have approximately the same dimensions, being 150–200 meters high and 1000 by 6–800 meters at the base. (H/D 1/5). Talus covers the flanks of some of the domes. A shallow depression occurs on the summit of the Inndalsmøya-Stakken dome and a small lake occupied the basin in July 1959. Similar basin-shaped depressions are not uncommon on the tops of trachyte domes, and they are probably due to withdrawel of the magma (R. von Leyden (1936), R. W. van Bemmelen (1949)). The surface of the dome of Skrukkefjell (meaning puckered mountain) is very rough.

Petrography.

Approximately 9 % of normativ quartz appear in both the analyses of Table I. (1.2). Quartz, however, was only found in a rather silicious and coarse-grained rhyolite (74.50 % SiO_2) at Skrukkefjell. The most abundant silica mineral in the trachytes is cristobalite. It has been found in cavities in the rhyolite together with small platy crystals of hematite, but usually cristobalite occurs in the groundmass as tiny anhedral grains filling the interstices between feldspar laths. Sometimes it has been enriched in small spherical globules consisting of an intergrowth of alkali feldspar and cristobalite. Owing to the small colour con-

Fig. 5. Pebble of orbicular cristobalite-trachyte from a brooklet near Bombellestoppen. $^4/_5$ nat. size.

Table 1.

Chemical analyses of trachytes, trachy-andesites, trachy-basalts, and hornblende trachybasalt inclusion, Jan Mayen.

	1	2	3	4	5	6	7
SiO_2	64.88	65.85	56.71	54.45	46.25	46.04	49.03
TiO_2	0.60	0.25	1.80	1.78	3.75	3.96	2.79
Al_2O_3	16.10	16.10	17.06	17.77	16.07	16.39	16.63
Fe_2O_3	3.35	3.17	3.55	2.05	1.88	4.01	10.37
Fe O	0.70	0.42	3.68	5.46	10.08	7.89	0.53
Mn O	0.18	0.20	0.17	0.44	0.19	0.30	0.21
Mg O	0.32	0.98	2.57	2.57	5.37	5.29	4.20
Ca O	1.23	2.05	4.67	5.35	9.33	9.75	7.94
Na_2 O	5.61	5.58	4.94	4.65	3.45	3.18	4.09
K_2 O	5.33	5.20	3.43	3.25	1.97	1.97	2.11
H_2 O +	1.13	0.27	0.70	0.50	0.18	0.36	0.78
H_2 O —	0.06	0.06	0.04	0.59	0.02	0.17	0.06
P_2 O_5	0.05	0.04	0.43	0.61	1.17	0.83	0.95
S	0.27	n.d.	0.00	0.04	0.03	n.d.	0.05
C O_2		nil.		0.37	0.07	tr.	
	99.81	100.17	99.75	99.88	99.86	100.14	99.74

1. Trachyte, Inndalsmøya, Jan Mayen. Anal., B. I. Borgen, S. R.
2. » Bombellestoppen, Jan Mayen. G. W. Tyrrell 1926 p. 749.
3. Trachyandesite, Dollartoppen, Jan Mayen. Anal., B. I. Borgen, S. R.
4. » » Eggøya, Jan Mayen. G. W. Tyrrell 1926 p. 749.
5. Trachybasalt, Sørbukta, Jan Mayen. Anal., B. I. Borgen, S. R.
6. » » Søylen, Jan Mayen. G. W. Tyrrell 1926 p. 753.
7. Hornblende trachybasalt inclusion in trachyte, Skrukkefjell, Jan Mayen. Anal., B. I. Borgen, S. R.

trast between the globules and the matrix, the globules are only visible on weathered, smooth surfaces and in polished specimens, Figs. 5 and 6. The globules have a milky-white colour and are 0.05–2 mm in diameter. Some large spots have been formed by the coalescing of several individuals. The nuclei of the globules may have a slight red tint and on the moistened surface of the polished rocks, structures like those pictured in Fig. 6b may appear. Phenocrysts of alkali-feldspar, diopside, or biotite sometimes project from the matrix into the globules. A determination of the content of SiO_2 showed 67.0 % in the globules and 62.8 % in the matrix. Spectrographical analyses disclosed that the matrix was considerably richer in Ca, Mg, Fe and Mn than the globules. This is due to the presence of small grains of a pyroxene-like mineral and iron ore in the groundmass.

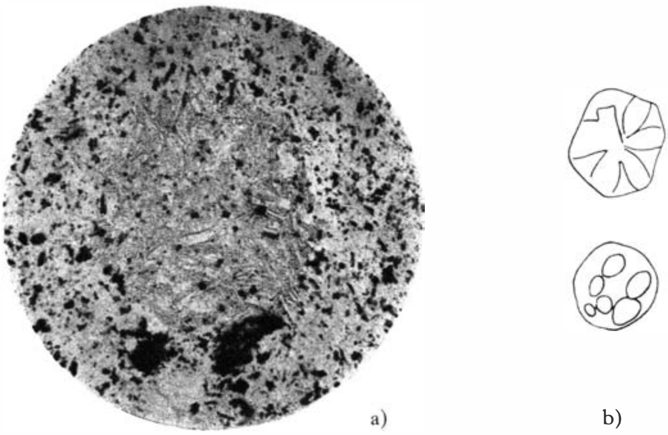

Fig. 6. a) Photomicrograph of a globule in the trachyte of Bombellestoppen. × 29.
b) Drawing of structures found in the globules.

Cristobalite has been found in the trachytes from Bombellestoppen, Inndalsmøya-Stakken, Tåkefjell, and Avdalsmøya. It does also occur in a felsitic intrusive at Rooberg. Cristobalite was also seen in trachyte fragments from the volcanic conglomerates near Skrukkefjell and Schiertzegga.

Cristobalite was recognized by its low refractive index ($\varepsilon,\omega < 1.487$, $\varepsilon,\omega < 1.482$), its low double refraction, and by its characteristic curved fracture system and mottled appearance between crossed nicols (Fig. 7). X-ray powder diagrams were produced to confirm the determinations. The descriptions of cristobalite by H. Kuno (1933) and A. G. MacGregor (1938) greatly facilitated the determinations.

The trachytes have phenocrysts of anorthoclase up to 5–6 mm in size. Plagioclase may also be present. The phenocrysts commonly occur in groups and are allotrimorphically intergrown. Ferromagnesian phenocrysts include diopside, biotite, and iron ore, but they constitute less than 5 % of the rock. The biotite is as a rule heavily stained with iron ore. Accessories are sphene, zircon, and apatite.

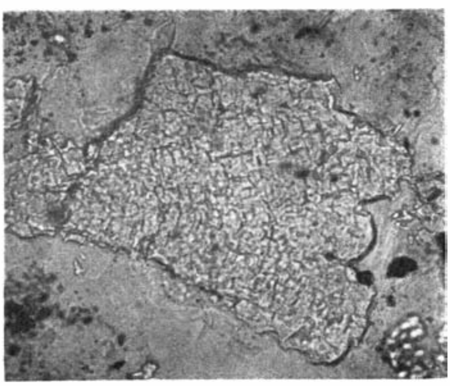

Fig. 7. Photomicrograph of cristobalite with curved cleavage system.
Rhyolite, Skrukkefjell. × 150.

Basic inclusions.

A most characteristic feature of the Jan Mayen trachytes are dark, reddish-brown inclusions of a highly vesicular hornblende trachybasalt. The inclusions stand out in relief on weathered surfaces and they occur in great abundance. The inclusions are generally oblong and well rounded, but are also quite often irregular and show signs of being resorbed. The size varies. The largest one found was 30 cm in length, but as a rule they are much smaller – less than the size of a fist.

Plagioclase (An 45–55), augite, hornblende, olivine, and iron ore occur as phenocrysts. The groundmass consists of approximately equal amounts of plagioclase and hornblende, Fig. 8.

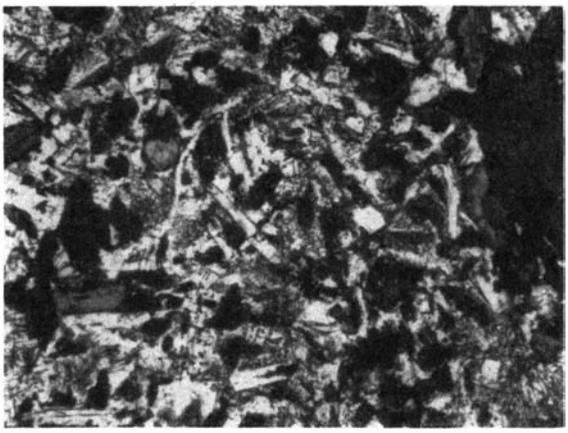

Fig. 8. Photomicrograph of trachybasalt inclusion in trachyte, Bombellestoppen. × 47.

The presence of feldspar in the vesicles of the inclusions is of special interest. Sometimes the vesicles are only partly filled with feldspathic material, sometimes feldspar fills up the entire vesicle. The feldspar is a soda-orthoclase, and an analysis of the material from the vesicles showed 4.19 % Na_2O and 8.31 % K_2O. The feldspar laths may be concentrically arranged but usually they occur in radial groups, Fig. 9. In addition to feldspar, small amounts of radiating prehnite, brown pyroxene, and quartz may occur in the vesicles. These feldspar-filled vesicles are closely similar to the feldspar ocelli so commonly present in lamprophyre dykes (H. Carstens (1959)). The ocelli generally show a considerably enrichment of potash compared to the rocks in which they occur, Table II.

Rather similar basic inclusions in trachyte have been reported from Tristan da Cunha, another volcanic island on the Mid-Atlantic ridge (J. C. Dunne (1946)). According to H. Williams (1932) basic inclusions are typical of volcanic domes in general. It is of interest that the basic inclusions collected by the writer on the trachyte dome Petit Suchet in the Chaine des Puys in Auvergne proved to be identical with those of Jan Mayen.

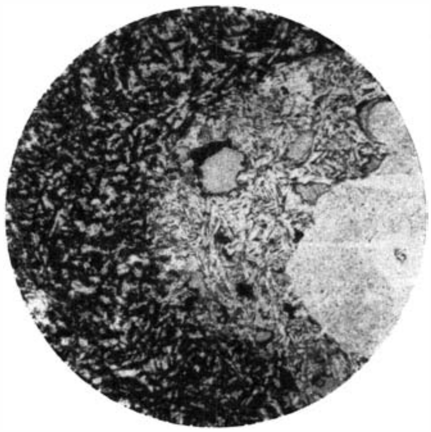

Fig. 9. Photomicrograph of feldspar ocellus in trachybasalt inclusion in trachyte, Skrukkefjell. Empty vesicle in the center. × 19.

Table 2.

Contents of alkalis in feldspar ocelli.

	Na_2O	K_2O
Inclusion of hornblende trachybasalt, Jan Mayen	4.09	2.11
Feldspar ocelli in hornblende trachybasalt, Jan Mayen	4.19	8.31
Oligoclase diabase, Hovedøya, Oslo, Norway	4.19	2.11
Feldspar ocelli in oligoclase diabase, Hovedøya	4.09	7.56
Mesocratic diabase, Ny-Hellesund, Norway	3.90	0.94
Feldspar ocellar pipe in mesocratic diabase, Ny-Hellesund	3.97	2.01
Diabase, Snarøya, Oslo, Norway	4.17	2.92
Leucocratic segregation in diabase, Snarøya, Oslo	3.23	5.94

Anal., B. I. Borgen, S. R.

There can hardly be any doubt that the basic inclusions of the Jan Mayen trachytes are cognate xenoliths. The composition is trachybasaltic (Table I) and, apart from the inverse relations of ferrous and ferric iron, the analysis is similar to the trachybasaltic lavas.

Some conclusions.

Oceanic islands serve as a classic example of the trachyte-basalt association. This association, however, also occurs on the continents, especially in connection with graben faulting. Thus Jan Mayen bears several lithological and structural resemblances to the Chaine des Puys in the Massif Central. This is of considerable interest in view of the recent demonstrations of a close structural relationship between ocean ridges and continental rifts (J. A. Jacobs, R. D. Russel and J. T. Wilson (1959)). Rift structures follow the crest of the ocean ridges and shallow-focus earthquakes associated with the mid-ocean ridges occur along this zone. The join between the great fracture system of Africa and the Indian Ocean in the Gulf of Aden also clearly points to a common origin.

Cristobalite is extremely common in the Jan Mayen trachytes. Although descriptions of similar globular cristobalite-trachytes have not been found, it is considered likely that the globules are remnants of a spherulitic structure. Cristobalite or tridymite in the groundmass of trachytic rocks is easily overlooked. To ascertain whether these silica minerals are more common than usually assumed, the rock specimens sampled by J. C. Dunne on Tristan da Cunha in 1937 were reinvestigated. Abundant tridymite were found in the groundmass and in vesicles of the trachytes from the islands Stoltenhoff and Nightingale of the Tristan da Cunha group, and tridymite and cristobalite pseudomorphoses after tridymite in the groundmass of the trachytes of Inaccessible.

It is believed that the feldspar ocelli – representing small trachytic segregations – in the trachybasalt xenoliths have important bearings upon the problem of trachyte genesis. The writer has earlier (1959) discussed the relations between leucocratic segregations in basaltic rocks and associated alkaline rocks in more detail, and the significance of the volatile phase in the origin of such alkaline rocks was pointed out.

Acknowledgements.

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MAPS

General, geographical, topographical and technical maps:

DRONNING MAUD LAND

				Kr.	
Jutulgryta	H 5	1:250,000	1961	5,55	
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Sør-Rondane		1:250,000	1957	5.55	

GRØNLAND, Austgrønland

Eirik Raudes Land frå Sofiasund til Youngsund		1:200,000	1932	2.20	
Claveringøya		1:100,000	1937	....	From: Karte von Nordostgrönland. Publ. by NSIU 1937. Limited stock, not for sale.
Geographical Society-øya		1:100,000	1937	....	
Jordan Hill		1:100,000	1937	....	

JAN MAYEN*

Jan Mayen		1:100,000	1955	2.20	Preliminary map.
Sør-Jan	Sheet 1	1: 50,000	1959	5.55	
Nord-Jan	» 2	1: 50,000	1959	5.55	

SVALBARD

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Prins Karls Forland	A 8	1:100,000	1959	5.55	
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Van Keulenfjorden	B 11	1:100,000	1952	5.55	
Torellbreen	B 12	1:100,000	1953	5.55	
Adventdalen	C 9	1:100,000	1950	5.55	
Markhambreen	C 12	1:100,000	1957	5.55	
Sørkapp	C 13	1:100,000	1947	5.55	
Adventfjorden—Braganzavågen		1:100,000	1941	2.20	
Hopen		1:100,000	1949	2 20	Preliminary map.
(Claims to land in Svalbard)		1: 50,000	1927	2.20	each. 33 sheets.
Bjørnøya		1: 25,000	1925	5.55	New ed. 1944 and 1955. Also as supplement to Skrifter Nr. 86.
Bjørnøya		1: 10,000	1925	....	6 sheets. Out of print.

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A wall map:

Norden og Norskehavet	1:2,500,000	1959	. . .	Revised edition.

is to be obtained through H. Aschehoug & Co. (W. Nygaard), Oslo.

CHARTS

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501	Bjørnøya	1: 40,000	1932	10.00
502	Bjørnøyfarvatnet	1:350,000	1937	10.00
503	Frå Bellsund til Forlandsrevet med Isfjorden	1:200,000	1932	10.00
504	Frå Sørkapp til Bellsund	1:200,000	1934	10.00
505	Norge—Svalbard, northern sheet	1:750,000	1933	10.00
506	» » southern »	1:750,000	1933	10.00
507	Nordsvalbard	1:600,000	1934	10 00
508	Kongsfjorden og Krossfjorden	1:100,000	1934	10.00
509	Frå Storfjordrenna til Forlandsrevet med Isfjorden	1:350,000	1946	10.00
510	Frå Kapp Linné med Isfjorden til Sorgfjorden	1:350,000	1946	10 00
511	Østgrønland, fra Liverpool Kyst til Store Koldeweys Ø (rev. 1958)	1:600,000	1937	10 00
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