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THE BRITISH EAST GREENLAND EXPEDITION 1935–36
LEADER: L. R. WAGER

GEOLOGICAL INVESTIGATIONS IN EAST GREENLAND

PART V
THE PETROGRAPHY OF THE PRINSEN AF WALES BJERGE LAVAS

BY

Y. M. ANWAR

WITH 3 FIGURES IN THE TEXT AND 1 PLATE

KØBENHAVN
C. A. REITZELS FORLAG
BIANCO LUNOS BOGTRYKKERI A/S
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INTRODUCTION

During the British East Greenland Expedition, 1935—36 a series of lavas in the Prinsen af Wales Bjerge northwest of the head of Kangerdlugssuaq, East Greenland, were found by Professors Wager and Deer which were distinct from the usual Plateau Basalts of the area. They state that they "showed up conspicuously from a distance by the lack of parallelism between the flows, there being as much as 30° difference in dip in a short distance. When reached they proved to be handsome porphyritic types not found among the ordinary Plateau Basalts. The series forms the upper part of most of the nunataks in the Prinsen af Wales Bjerge area and the Trekantnunatakker but they were clearly more widespread before erosion as they are found as blocks in the Kangerdlugssuaq syenite intrusion."

The field observation on the Prinsen af Wales Bjerge lavas have been given in a general paper on the "Stratigraphy and Tectonics of Knud Rasmussens and the Kangerdlugssuaq Region" (Wager, 1947, p. 20) and their position in the lava sequence has been discussed. In that paper the term Plateau Basalt Series has been used as a stratigraphic unit for the whole thickness of lavas and tuffs in the area. The series varies much in thickness and to some extent in character at different localities and has been subdivided. Around the mouth of Kangerdlugssuaq there is a Lower Plateau Basalt Series consisting of $2^1/_2$ km of lavas and tuffs laid down in water. The "Main Basalts" overlie these; they are at least 4 km thick and are largely subaerial plateau basalts. The Prinsen af Wales Bjerge lavas form the top of the Plateau Basalt Series in a restricted area inland and are the latest lavas known from this part of East Greenland.

The collections described in this paper were made under difficult conditions during a March—April journey of the British East Greenland Expedition 1935—36 (Wager, 1937, p. 402—03). The specimens available are usually small and collections were made at only three localities in the Prinsen af Wales Bjerge (see map, fig. 1). At a few other localities and particularly on Urbjerget the underlying more ordinary plateau basalts were sampled, and they have received a preliminary examination

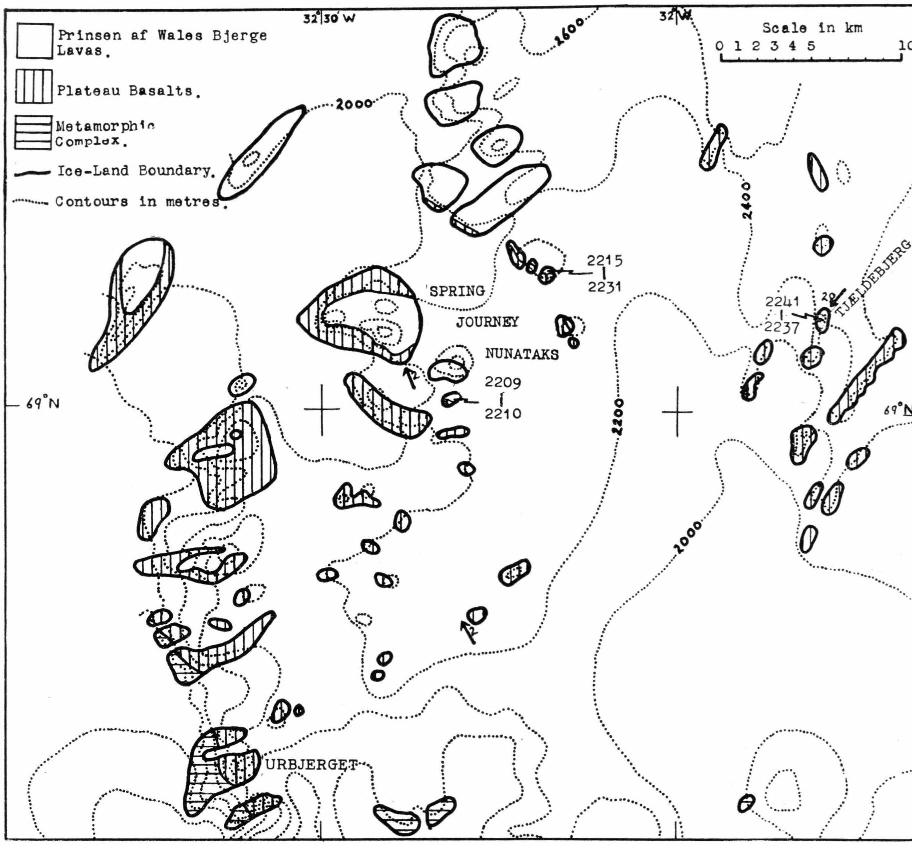

Fig. 1. Map showing the distribution of the outcrops of the Prinsen af Wales lavas.

for comparison with the upper series. A photograph showing the Prinsen af Wales Bjerge lavas resting on the Main Basalts has already been published (WAGER, 1947, pp. 24—26 and fig. 4).

The petrological investigation described in this paper was made by the author under the general supervision of Professor L. R. WAGER as a part of the work for a Doctorate at Durham. The work was completed in 1950 and written up as a thesis which gives the data in more detail than is possible in this paper.

II. CLASSIFICATION AND GENERAL DISTRIBUTION OF THE LAVAS

Many of the Prinsen af Wales Bjerge lavas are dark basaltic rocks having olivine, pyroxene and andesine as conspicuous phenocrysts either singly or in various combinations, and a groundmass which is fine-grained or glassy; others are dark and non-porphyritic and have only been found to differ from more ordinary basalts during the laboratory work. Chemical analyses show that all the Prinsen af Wales lavas have a low silica percentage and they are regarded as varieties of basalts. However, the felspars where determinable, whether in the groundmass or in porphyritic crystals are more sodic than labradorite and the lavas are best described as andesine or oligoclase basalts.

Mineral composition and textural characteristics have in most cases provided a further basis of classification, first, into phyric and aphyric types. The porphyritic group is further divided by the nature of the dominant phenocrysts into olivine-phyric, pyroxene-phyric and plagioclase-phyric types.

The characteristic features of the various types are summarised in table I; the localities of the specimens are shown in fig. 1 and the vertical order of succession, though not the relative thickness, is diagrammatically represented in fig. 2.

Table I. Summary of the features of the chief lava types.

	Phenocrysts	Groundmass	Remarks
A. *Porphyritic Group*			
1. Olivine-phyric oligoclase or andesine basalt	Abundant olivine with subordinate pyroxene and iron ore	The dominant minerals are pyroxene, oligoclase or andesine and iron ore. Analcime and apatite are present in subordinate amounts. Felspar/Ferromagnesian ratio is 1:2	The groundmass is dominantly pyroxene, and felspar is interstitial. In the Tjældebjerg area the plagioclase of the groundmass is more abundant and is andesine in composition.
2. Pyroxene-phyric andesine basalt	Pyroxene with subordinate olivine	The dominant minerals are plagioclase (oligoclase-andesine), pyroxene and iron ore. Apatite and analcime are in subordinate amounts. Felspar/Ferromagnesian ratio is often about 5:1	In some examples the groundmass is glass with microlites of pyroxene and iron ore.
3. Andesine-phyric andesine basalt	Andesine with subordinate pyroxene and olivine	The dominant minerals are acid andesine, pyroxene and iron ore. Apatite, analcime and zeolitic material are present in subordinate amounts. Felspar/Ferromagnesian ratio is 5:1	The proportion of the phenocrysts varies considerably among the group.
B. *Non-porphyritic Group*			
1. Andesine basalt	None	The dominant minerals are oligoclase or andesine, pyroxene, olivine and iron ore. Apatite and analcime occur in subordinate amounts. Felspar/Ferromagnesian ratio is 3:1	Texture is fine-grained and in one rock is trachytic.

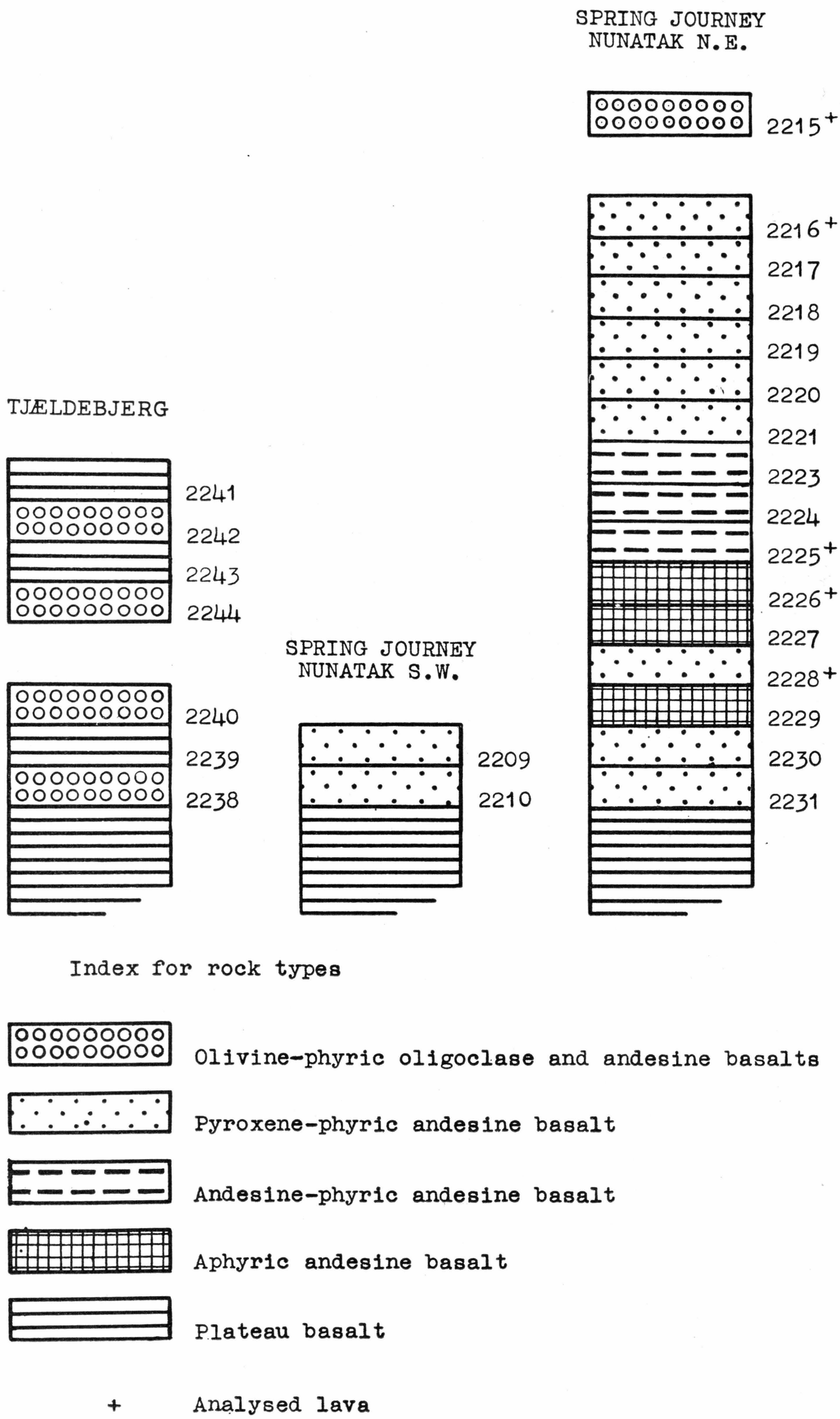

Fig. 2. Diagrammatic representation of the vertical sequence of the Prinsen af Wales lavas.

III. DESCRIPTION OF THE VARIOUS TYPES

A. The Porphyritic Group.

1. Olivine-phyric oligoclase and andesine basalts.

Lavas of this type have been collected from the Spring Journey Nunataks[1]), the Tjældebjerget, where they alternate with apparently more ordinary basalts, and Trekantnunatakker.

The highest flow (2215) in the N.E. Spring Journey Nunataks has been taken as typical. In hand specimen it is dark grey in colour with conspicuous yellow porphyritic crystals of olivine 4 mm in diameter. In thin section, besides the dominant olivine phenocrysts, pyroxene and iron ore are seen to be present in subordinate amount (Pl. I, Fig. 1). The groundmass is largely made up of pyroxene, interstitial felspar and zeolites, including analcime. The mode (see table II) shows that the olivine phenocrysts form nearly one third of the rock by volume while the pyroxene, largely in the groundmass, forms rather more than a third. The olivine phenocrysts have a distinct cleavage parallel to (010), $2\ V_\alpha = 88$, and $\gamma = 1.704$ (± 0.004). These values indicate a fayalite content of about 17 $^0/_0$ (DEER and WAGER, 1939), which is markedly less than the fayalite content of the olivine phenocrysts or the pyroxenes and andesine-phyric lavas.

The pyroxene phenocrysts occur as prismatic crystals up to 4 mm in length; they have a purplish tinge, slight zoning, an optic axial angle of about 57° and $C/\gamma = 44°$. These values indicate that the pyroxene is an augite.

In the groundmass the pyroxene occurs abundantly in small grains, usually rounded with a maximum diameter of .04 mm. It appears to be essentially the same type as the phenocrysts. The felspar, less abundant than the pyroxene, occurs usually in small crystals enclosing pyroxene and rarely twinned. In scattered patches the groundmass is richer in felspar and zeolites and coarser in texture. In these places the felspar shows sufficient twinning to decide from the maximum symmetrical extinction angle that the composition is around An_{30}. Iron ore is abundant, apparently dominantly magnetite; it occurs in fair sized

[1]) In WAGER 1947, p. 20, these are called the Andesite Nunataks but since the lavas are not now described as andesites the name Spring Journey Nunataks has been adopted.

and small grains and octahedra and belongs to both early and late periods of crystallisation.

From the textural relationships of the various components, it seems that olivine, pyroxene and probably iron ore belong to the intratelluric phase. The groundmass, presumably representing the part which was liquid at the time of eruption, contains no appreciable amounts of olivine, but is dominantly of pyroxene, felspar and iron ore.

Rather similar lavas, e. g. 2242 and 2244, were collected from Tjældebjerge except that the olivine phenocrysts are much smaller and the groundmass plagioclase, with more decided lath shape is more calcic being An_{45-50}. Interstitial felspar and zeolitic material are present. The mineral composition of 2244 in volume per cent from micrometric measurment is: olivine (phenocrysts) 19 %; pyroxene (groundmass) 53 %; plagioclase (laths in the groundmass) 18 %; iron ore 8 %; zeolitic material and interstitial felspar 7 %.

The chemical analysis of the first described olivine-rich oligoclase basalt 2251 is given in table II. The rock is characterised by low silica and alumina. Magnesia is high, in accordance with the abundant olivine and pyroxene. The low alumina content corresponds well with the modal-amount of felspar which is dominantly oligoclase.

Table II. Olivine-phyric oligoclase basalt, 2215,
N.E. Spring Journey Nunataks, Prinsen af Wales Bjerge, East Greenland
Anal. Y. Anwar.

	A	Norm		Niggli-values		Mode	
SiO_2	43.26	Or	6.84	si	79	Phenocrysts	
Al_2O_3	5.88	Ab	12.00			Olivine	29
Fe_2O_3	3.66	An	4.81	al	6	Pyroxene	3
FeO	11.66	Np	1.42	fm	72	Iron-ore	2
MgO	17.86	Di	28.26	c	18	Groundmass	
CaO	8.96		14.78	alk	4	Leucocratic	21[1]
Na_2O	1.73		10.43			minerals	
K_2O	1.16		3.05	k	0.30	Fe-Mg-	36[2]
H_2O^+	1.41	Ol	31.35	mg	0.68	minerals	
H_2O^-	0.20		23.70			Iron-ore	9
TiO_2	3.55		7.65	p	0.55		
P_2O_5	0.64	Mt	5.31	ti	4.9		
MnO	0.22	Ilm	6.73				
		Ap	1.51				
Total	100.19						
S.G.	3.20	Plag.	$Ab_{71}An_{29}$				
		Di	$Wo_{52}En_{37}Fs_{11}$				
		Ol	$Fo_{76}Fa_{24}$				

1) Includes felspar, apatite and analcime.
2) Includes pyroxene, and subordinate olivine or its pseudomorphs.

(continued)

Table II (continued).

COMPARISONS

	A	1	2	3	4
SiO_2	43.26	45.20	46.57	48.48	43.27
Al_2O_3	5.88	6.60	7.81	8.47	7.54
Fe_2O_3	3.66	5.36	2.40	2.72	2.22
FeO	11.66	8.01	8.91	8.66	6.18
MgO	17.86	18.14	19.74	11.82	17.65
CaO	8.96	8.02	10.65	10.56	13.72
Na_2O	1.73	1.29	1.70	3.15	1.26
K_2O	1.16	1.71	0.33	0.54	1.14
H_2O^+	1.41	0.65	0.11	1.19	0.38
H_2O^-	0.20	0.56	0.09	0.24	0.22
TiO_2	3.55	4.50	1.67	3.77	1.25
P_2O_5	0.64	0.34	0.34	0.33	0.38
MnO	0.22	0.19	0.13	0.11	n.d.
	100.19	100.57	100.45	100.04	99.21
S. G.	3.20	—	3.164	2.881	—
	Norms				
Or	6.84	10.01	1.67	3.34	
Ab	12.00	11.00	14.15	20.96	
An	4.81	7.23	12.79	7.23	
Np	1.42	—	—	3.12	
Di	28.26	23.98	30.26	41.14	
Hy	—	7.89	0.40	—	
Ol	31.35	21.92	34.14	12.66	
Mt	5.31	7.89	3.48	3.94	
Ilm	6.73	7.30	3.19	7.14	
Ap	1.51	0.67	0.67	0.67	

A. Olivine-phyric oligoclase basalt, E.G. 2215, N.E. Spring Journey Nunataks, East Greenland. Anal. Y. Anwar. (New analysis).

1. Picrite basalt, Leeward Islands, Hawaiian Islands. Anal. Washington. (Washington and Keyes 1926, p. 347).
2. Picrite basalt, Mauna Kea, Hawaii, Anal. Washington. (Washington 1923; p. 500; Macdonald 1949, p. 83).
3. Olivine oligoclase basalt, Mauna Loa, Hawaii, Anal. Washington. (Washington 1923, p. 115).
4. Ankaramite, Ankaramy, Madagascar. (Lacroix 1923, p. 49).

No analysis is found in Washington (1917) under the same subrang that can be said to show close agreement. The nearest approach is found among the basalts of the Hawaiian Islands (col. 1—3). The main difference between the Greenland rock and the picrite basalts (col. 1 & 2) is in the modal plagioclase which is labradorite in the Hawaiian rocks (Washing-

TON 1923, p. 498). The olivine oligoclase basalt from the Hawaiian Islands (col. 3) is more closely comparable; modal and normative plagioclase in both is oligoclase and there is a general similarity in the properties of the minerals and textures. The rock bears some general relationship to the ankaramite of Lacroix (col. 4) but the plagioclase is more albite rich and olivine is the dominant phenocryst.

The names olivine-phyric oligoclase or andesine basalts have been used for this group because of the similarity, both modal and normative, with the olivine oligoclase basalt described by WASHINGTON. In the abundance of olivine and general appearance the rocks resemble oceanite but it seems important to stress the more alkaline felspar in assigning a name to the rock.

2. Pyroxene-phyric andesine basalts.

Lavas of this type were collected from the N.E. Spring Journey Nunataks on a ridge descending to the glacier from a point about 200 yards S.E. of the locality 2215. Two other examples which differ from the above by being glassy come from the S.W. Spring Journey Nunataks (see fig. 2).

In hand specimen, the rocks are generally of dark grey colour with phenocrysts of pyroxene often .5 cm in length. In some cases the pyroxene shows well developed crystal faces and some of them are stumpy crystals while others are rather acicular. Olivine phenocrysts are present in subordinate amounts as glassy looking crystals. The groundmass is generally aphanitic. In some specimens the effect of flow is seen in the parallel arrangement of the pyroxene phenocrysts.

The non-glassy examples will be considered first and of these the analysed specimen 2216 from Spring Journey Nunataks will be described in detail as the type of the group. The phenocrysts in order of abundance are pyroxene, iron ore and olivine. These are embedded in a fine grained groundmass of felspar, pyroxene, iron ore, apatite, analcime, zeolite, chlorite and probably glass (Pl. I, Fig. 2). The mode, table III, shows that the pyroxene phenocrysts form about one fourth of the rock by volume, while the felspars, mainly in the groundmass, form about a third.

The pyroxene phenocrysts occur solitarily or in glomeroporphyritic groups. They have a brownish colour with a purplish tinge. Twinning is not infrequent parallel to (100). In a few cases regular zoning is found as multiple thin layers. Data on the optics of the pyroxene from this rock and of the various specimens belonging to this group are given in table III. From these data the pyroxenes are presumed to be diopsidic.

The olivine phenocrysts are in subordinate amounts and the crystals are in most cases largely altered to brownish green chloritic material. In certain of the rocks more of the olivine is preserved and determinations

Table III. Composition of the minerals and the modes of the pyroxene-phyric andesine basalts.

Specimen	Olivine phenocrysts		Pyroxene phenocrysts						Plagioclase (groundmass)
	2 V	Estimated composition % Fa	2 V	C/γ	γ [1]	Estimated composition [2] % An Wo	En	Fs	Estimated composition % An
2216...... (analysed)	..	..	58 (±2)	45°	1.713	50	34	18	15 (±3)
2217......	86.5	23	53 (±1)	45°	1.713	40	38	22	..
2218......	..	..	56 (±1)	45.5°	1.709	44	38	18	..
2219......	82.5	32	54	42.5°	1.713	41	37	22	..
2221......	..	..	..	..	..	..	..	..	13 (±2)
2230......	84.5	28	55	44°	1.709	44	38	18	30 (±2)
2228...... (analysed glassy)	85	26	54	44°	1.711	43	38	19	..
2209...... (glassy)	85.5	25	58	46°	1.711	50	35	15	..

MODES

Specimen	Phenocrysts			Groundmass	
	Pyroxene	Olivine	Iron ore	Leucocratic-minerals	Melanocratic minerals
2216........... (analysed)	23	5	4	29	39
2217...........	14	8	5	38	35
2218...........	15	6	3	very fine-grained	
2219...........	24	8	8	33	27
2220...........	19	9	5	44	23
2221...........	31	6	3	38	22
2230...........	5	5	2	47	41
2228........... (analysed)	15	5	4	Glassy	
2209...........	10	2	2	Glassy	

[1]) The limits of error of the indices of refraction are 0.003.
[2]) The composition is inferred from 2 V and gama index.

of the optic axial angles were possible from which the estimated compositions lie between Fa_{23} and Fa_{32} (see table III).

In the groundmass the pyroxene occurs as grains and prisms .02 mm in length. Olivine is in subordinate amount and for the greater part is replaced by chloritic material. Felspar predominates over the other constituents. It occurs as irregular interlocking grains and fine laths, .04 mm in length, rarely twinned. The laths in most cases show parallel extinction or an angle of few degrees. Apatite and interstitial analcime are abundant among the felspar. Iron ore is generally abundant.

The other specimens are materially the same, their modal composition in volume percentage being given in table III. The usual texture of the pyroxene-phyric lavas is shown by the analysed rock 2216 (Pl I, Fig. 2). One example, 2230, however, differs in having a rather coarse groundmass consisting dominantly of clear, often untwinned plagioclase about An_{30} (Pl. I, Fig. 4). Three other rocks, 2228, 2210, and 2209, of the pyroxene-phyric group have a glassy, or partly glassy base (Pl. I, Fig. 3).

In the glassy rocks pyroxene, olivine and ore phenocrysts are similar to those in the non-glassy types (table III), but the nature of the glass varies somewhat. In the rock 2228 the glass is of dark brown colour

Table IV. Pyroxene-phyric andesine basalts, 2216 and 2228, N.E. Spring Journey Nunataks, Prinsen af Wales Bjerge, East Greenland. Anal. Y. ANWAR.

	B (2216)	C (2228)	Norms			Niggli-values		
				B	C		A	B
SiO_2	44.16	44.74	Or	10.34	8.12	si	95	97
Al_2O_3	8.34	11.87	Ab	14.88	16.77			
Fe_2O_3	5.74	3.33	An	2.89	13.37	al	15	15
FeO	10.72	11.59	Np	6.87	6.08	fm	54	52
MgO	7.80	7.89	Di	37.99	25.41	c	26	24
CaO	11.20	10.13		19.72	12.93	alk	9	9
Na_2O	3.26	3.31		13.04	6.98			..
K_2O	1.75	1.38		5.23	5.50	k	0.26	0.22
H_2O^+	1.07	2.03	Ol	6.37	16.46	mg	0.46	0.49
H_2O^-	0.40	0.26		4.41	8.81			..
TiO_2	4.47	2.13		1.96	7.65	p	0.78	0.78
P_2O_5	0.83	0.89	Mt	8.33	4.43	ti	7.3	3.5
MnO	0.09	0.20	Ilm	8.48	4.04			
			Ap	1.23	2.14	Modes		
	99.83	99.75						
						Phenocrysts		
S.G.	3.07	3.06	Plag	$Ab_{83}An_{17}$	$Ab_{57}An_{43}$	Olivine	5	5
			Di	$Wo_{52}En_{34}Fs_{14}$	$Wo_{51}En_{27}Fs_{22}$	Pyroxene	23	15
			Ol	$Fo_{69}Fa_{31}$	$Fo_{54}Fa_{46}$	Iron ore	4	2
						Groundmass		Glass with microlites of pyroxene and ore.
						Leucocratic minerals	29	
						Melanocratic minerals	39	

Table V. Comparisons of the pyroxene-phyric andesine basalts (normal and glassy) with other lavas.

	B	C	1	2	3	4	5
SiO_2	44.16	44.74	45.08	48.48	45.10	48.31	45.48
Al_2O_3	8.34	11.87	14.15	8.47	12.86	13.66	11.60
Fe_2O_3	5.74	3.33	2.28	2.72	5.66	2.67	3.12
FeO	10.72	11.59	8.89	8.66	7.10	8.80	7.31
MgO	7.80	7.89	7.01	11.82	8.56	6.34	8.71
CaO	11.20	10.13	10.20	10.56	9.10	8.82	7.98
Na_2O	3.26	3.31	3.99	3.15	3.99	3.27	4.02
K_2O	1.75	1.38	1.79	0.54	1.02	2.24	2.67
H_2O^+	1.07	2.03	0.75	1.19	1.53	0.83	4.39
H_2O^-	0.40	0.26	0.15	0.24	1.10	1.11	—
TiO_3	4.47	2.13	2.93	3.77	3.50	2.20	2.97
P_2O_5	0.83	0.89	0.62	0.33	1.00	0.80	1.98
MnO	0.09	0.20	0.22	0.11	0.08	0.11	0.04
	99.83	99.75	100.15	100.04	100.60	100.16	
S. G.	3.70	3.06	3.01	2.88	2.85	..	2.947
				Norms			
Or	10.34	8.12	10.56	3.34	6.12	15.47	16.12
Ab	14.88	16.77	23.71	20.97	26.72	28.21	22.01
An	2.89	13.37	15.29	7.23	14.46	9.57	5.56
Np	6.87	6.08	5.62	3.12	3.41	4.29	6.53
Di	37.99	25.41	13.74	41.14	19.70	19.28	16.84
Ol	6.37	16.46	14.83	12.66	10.56	11.80	12.28
Mt	8.33	4.83	3.25	3.95	8.12	2.96	4.41
Ilm	8.48	4.04	5.62	7.14	6.69	4.25	5.47
Ap	1.23	2.14	1.24	0.67	2.35	2.22	4.70

B. & C. Pyroxene-phyric andesine basalts (2216 and 2228), East Greenland, Anal. Y. ANWAR. (New analyses).
1. Olivine trachyandesite, Jan Mayen. Anal. HARWOOD. (HOLMES 1916, p. 204).
2. Olivine oligoclase basalt, Mauna Loa, Hawaii. Anal. WASHINGTON. (WASHINGTON 1923, p. 115).
3. Limburgite, Central Victoria. Anal. A. G. HALL. (EDWARDS 1938, p. 291).
4. Andesine basalt (= oligoclase basalt), Central Victoria. A nal. A. B. EDWARDS. (EDWARDS 1938, p. 279).
5. Monchiquite, Japan. Quoted from WASHINGTON tables of chemical analyses. (1917, p. 674—75).

with rare vesicles. Its refractive index showed an average value of 1.543. According to George's determination curve for natural glasses (GEORGE, 1924, p. 365—366) this value corresponds to a composition which lies within the andcsitic field. The glass in the rock 2209 is of two kinds; one is dominant and of dark brown colour, the other is of lighter colour and occurs as patches among the darker type. The refractive index of the dark brown glass is 1.567 and of the light brown 1.547.

The light brown glass in this rock seems to have been derived by a process comparable to that responsible for palagonite formation described by PEACOCK (1926, p. 315). In this process apparently permeating solutions remove ferric iron which causes the bleaching of the original dark brown variety. Alkalies are also removed in this process and may be fixed as zeolites in cavities. Vesicles are abundant in 2209 which has the two types of glass and are rare in 2228.

The rock 2210, another glassy pyroxene-phyric basalt from the S.W. Spring Journey Nunataks shows autobrecciation. In thin section the rock resembles 2228 except that in some parts of the section there occur irregular patches of varying texture. The fine grained patches are seen to be enclosed in a coarser groundmass with a fluidal arrangement of thin pyroxene prisms and parallel streaks of iron ore.

The non-glassy rock 2216 and the glassy rock 2228 which was chosen for analysis prove to be of fairly similar composition (table IV). They show similar low content of silica and rather high content of alkalies; nepheline appears in the norm, although it cannot be seen in the section. The ratio FeO : MgO, considered to be important in indicating the position of a rock on the liquid line of descent, is 1.37 in the normal type and 1.47 in the glassy. There is difference in state of oxidation which may be related to the degree of crystallinity, $FeO/Fe_2O_3 = 4.2$ in the normal type and is 7.7 in the glassy type (cf. TILLEY 1922.)

Comparison of the analysed pyroxene-phyric andesine basalts is given in table V. They show a similarity to an olivine trachyandesite from Jan Mayen (col. 1), but in the latter the dominant phenocrysts are olivine. The same is also true with regard to the olivine oligoclase basalt from Hawaii (col. 2). The limburgite from Central Victoria (col. 3) shows chemical similarity to the present rocks but differs in having more modal olivine as phenocrysts. The andesine basalt from Central Victoria (col. 4) shows a comparable chemical composition, the main difference being the dominance of andesine as phenocrysts in the Central Victoria rock. The present analyses also show some similarity to a monchiquite from Japan (col. 5).

3. Andesine-phyric andesine basalt.

Several different flows of this type were collected from the N.E. Spring Journey Nunataks (see fig. 2). In hand specimen the plagioclase is the conspicuous porphyritic constituent, occuring as large thin plates up to $1.5 \times 1.5 \times .2$ cm in average dimensions and giving the rock a striking appearance. Olivine, pyroxene and ore phenocrysts occur in subordinate and varying amounts. The groundmass is dark grey in colour and fine grained. Vesicles are present and are filled with zeolitic material (thomsonite and chabazite).

The rocks are essentially similar to the analysed specimen 2225 (Pl. I, Fig. 5) which is described in detail. In this rock the plagioclase phenocrysts which occur as tabular crystals, solitary or in glomeroporphyritic groups, show the usual repeated twinning. Zoning is absent except for the outer fringe. The average composition of the plagioclase phenocrysts, determined by immersion methods, is An_{44}. The olivine phenocrysts, 1 mm in diameter, are well shaped and have $2V = 85°$ indicating a fayalite content of 26 % which is similar to that of the olivine in the pyroxene-phyric lavas. The scarce pyroxene phenocrysts have a brownish colour with a purplish tinge and $2V_{\gamma} = 54°$, $C/\gamma = 42°$, $\gamma = 1.714$. These values indicate that the pyroxene is a diopsidic variety similar to that in the pyroxene-phyric lavas.

The groundmass has dominant felspar and also pyroxene, olivine, iron ore, apatite, analcime and chloritic material. The plagioclase, in thin laths was determined as approximately An_{30}, by measurement of maximum symmetrical extinction angles in a large number of grains and also by immersion liquid method.[1]) Interstitial to the laths there occur allotriomorphic felspar, probably alkali felspar. The pyroxene, which is next in abundance to the felspar, occurs as rounded grains or small prisms. Olivine is in subordinate amounts and is usually altered to chloritic material. The iron ore occurs as grains and octahedra. Its percentage varies with the texture of the groundmass; in fine grained rocks the ore content is high. Thus in the lava 2223 — the most fine grained — the groundmass is highly charged with iron ore.

The mineral percentages of the analysed specimen 2225, is compared with the two rather similar overlying flows 2224 and 2223 in the following table:—

Table VI. Mode of andesine-phyric andesine basalts.

Specimens	Phenocrysts				Groundmass	
	Plagioclase	Pyroxene	Olivine	Ore	Leucocratic minerals	Melanocratic minerals
2223..........	6	3	5	4	38	44
2224..........	16	1	5	1	57	20
2225 (analysed)	19	2	5	2	56	16

The plagioclase phenocrysts are much reduced in 2223 and this rock is considered as transitional to the pyroxene-phyric rocks.

[1]) For the refractive index determination, uncovered slide was prepared and the suitable grains were picked out with a needle and washed thoroughly with methylated spirit before the determination was carried out.

The chemical analysis of the andesine-phyric andesine basalt 2225 and comparisons are given in table VII. It shows a similarity to the pyroxene-phyric andesine basalts, but Al_2O_3 is higher and lime and magnesia lower. The rock is fairly similar to andesine basalts described from the Hawaiian Islands by Washington (col. 1 and 2) and the andesine basalt from Central Victoria (col. 3). Comparison can also be made with a basalt from Pantellaria (col. 4).

B. The Non-Porphyritic Group.

Aphyric andesine basalt.

Only three specimens, 2226, 2227 and 2229, belong to this type. They are from the N.E. Spring Journey Nunataks. The higher flow 2226, the thickest of the series being 50′, has been analysed and will be particularly described.

The analysed rock 2226 (Pl. I, Fig. 6) is dark grey aphanitic rock formed of felspar, pyroxene, olivine or its pseudomorphs, iron ore, apa-

Table VII. Andesine-phyric andesine basalt, 2225, N.E. Spring Journey Nunataks, Prinsen af Wales Bjerge, East Greenland. Anal. Y. Anwar.

	D	Norm		Niggli-Values		Mode	
SiO_2	45.81	Or	10.01	si	112	Phenocrysts	
Al_2O_3	12.90	Ab	28.40			Plagioclase	19
Fe_2O_3	4.36	An	15.01	al	19	Pyroxene	2
FeO	10.31	Di	12.25	fm	51	Olivine	5
MgO	5.75	6.28		c	20	Iron ore	2
CaO	7.52	3.65		Alk	10	Groundmass	
Na_2O	3.36	2.32				Leucocratic minerals	43[1]
K_2O	1.70	Hy	7.00	k	0.25		
H_2O^+	1.91	4.28		mg	0.42	Melanocratic minerals	29[2]
H_2O^-	0.88	2.72					
TiO_2	4.03	Ol	7.56	p	1.09		
P_2O_5	1.11	4.44		ti	7.40		
MnO	0.20	3.12					
		Mt	6.33				
	99.84	Ilm	7.65				
		Ap	2.62				
S. G.	2.92	Plag	$Ab_{65}An_{35}$				
		Di	$Wo_{51}En_{30}Fs_{19}$				
		Hy	$En_{61}Fs_{39}$				
		Ol	$Fo_{59}Fa_{41}$				

1) Includes felspar, apatite and analcime.
2) Includes pyroxene, olivine or its pseudomorphs and iron ore.

(continued)

Table VII (continued).

COMPARISONS

	D	1	2	3	4
SiO_2	45.81	48.42	47.98	47.46	45.72
Al_2O_3	12.90	13.97	15.32	15.12	12.45
Fe_2O_3	4.36	4.17	2.49	2.96	1.57
FeO	10.31	9.57	8.86	9.39	10.01
MgO	5.75	4.61	6.16	5.70	5.29
CaO	7.52	8.86	10.28	7.27	9.58
Na_2O	3.36	3.30	3.56	3.51	3.46
K_2O	1.70	1.29	1.08	1.74	1.08
H_2O^+	1.91	0.84	0.62	0.58	0.40
H_2O^-	0.88	0.42	0.25	0.72	0.01
TiO_2	4.03	3.25	3.53	3.10	6.43
P_2O_5	1.11	0.91	0.22	0.78	1.54
MnO	0.20	0.17	0.12	0.25	0.16
	99.84	99.78	100.49	99.57	99.64
S. G.	2.92	2.98	2.99	2.82	—
	Norms				
Qr	—	0.84	—	10.33	—
Or	10.01	7.78	8.90	29.77	6.12
Ab	28.10	27.77	31.96	23.04	28.82
An	15.01	19.46	21.68	—	15.57
Np	—	—	1.99	—	—
Di	12.25	15.49	2.22	7.98	18.67
Hy	7.00	12.88	—	3.57	5.91
Ol	7.56	—	15.35	12.73	6.08
Mt	6.33	6.03	3.71	4.33	2.32
Ilm	7.65	6.23	6.69	2.35	12.16
Ap	2.62	2.02	0.67	1.71	3.36

D. Andesine-phyric andesine basalt, 2225, Spring Journey Nunataks, East Greenland. Anal. Y. Anwar. (New analysis).

1. Aphyric-andesine basalt, Mauna Loa, Hawaii. Anal. Washington. (Washington 1923, p. 493; Macdonald 1949, p. 83).
2. Felspar-phyric basalt (andesine basalt), Kohala, Hawaii. Anal. Washington. (Washington 1923, p. 483; Macdonald 1949, p. 87).
3. Andesine basalt, Central Victoria. (Edwards 1938, p. 278).
4. Basalt dyke in tuff, Pantellaria. (Washington 1907, p. 75).

tite, analcime and chlorite; hornblende is also present in small amounts. The mode is given with the analysis in table VIII.

The plagioclase occurs as interlocking, rarely twinned grains. Refractive index determination indicates that the anorthite content is about 20—25 %. Untwinned low doubly refracting material occurs interstitially and probably includes orthoclase. The pyroxene forms small grains, 1 mm in length, of pale greenish colour. The olivine is in most cases replaced by green chloritic material of high double refraction. The original olivine was microporphyritic in rather elongated crystals. Iron ore is abundant. Apatite is commonly seen enclosed in the felspathic constituents.

The lava 2227, collected immediately below 2226, is similar in hand specimen and in thin section except that it has a trachytic texture. The mineral proportions by volume of the rock are very similar to that of the analysed aphyric andesine basalt and in chemical composition it must also be similar. The analysed rock 2226 (see below) is chemically comparable to the mugearites described in the literature and this name might have been used especially for rock 2227 which shows the trachytic texture.

The chemical analysis of the aphyric andesine basalt is given in table VIII. In composition it is very close to that of the andesine-phyric andesine basalt and it would appear that difference in the condition of

Table VIII. Aphyric-andesine basalt, 2226,
N.E. Spring Journey Nunataks, Prinsen af Wales Bjerge, East Greenland.
Anal. Y. Anwar.

	E	Norm			Niggli-Values		Mode	
SiO_2	47.37	Or		9.23	si	118	Leucocratic-minerals.	58
Al_2O_3	14.51	Ab		29.55				
Fe_2O_3	5.37	An		18.79	al	21	Fe-Mg-minerals	24
FeO	8.68	Di		12.66	fm	47	Iron ore	18
MgO	5.01		6.52		c	21		
CaO	8.12		4.01		alk	11		
Na_2O	3.50		2.13					
K_2O	1.56	Hy		8.97	k	0.23		
H_2O^+	1.44		5.88		mg	0.40		
H_2O^-	0.50		3.09					
TiO_2	3.04	Ol		2.82	p	0.89		
P_2O_5	0.90		1.78		ti	5.7		
MnO	0.03		1.04					
		Mt		7.79				
	100.03	Ilm		5.76				
		Ap		2.12				
S. G.	2.92	Plag		$Ab_{61}An_{39}$				
		Di		$Wo_{51}En_{32}Fs_{17}$				
		Hy		$En_{66}Fs_{34}$				
		Ol		$Fo_{63}Fa_{37}$				

(continued)

Table VIII (continued).

COMPARISONS

	E	1	2	3	4	5
SiO_2	47.37	48.40	49.92	49.72	49.09	48.42
Al_2O_3	14.51	16.66	12.83	14.56	15.15	13.97
Fe_2O_3	5.37	8.54	7.96	3.60	2.95	4.17
FeO	8.68	2.45	6.21	8.55	10.22	9.57
MgO	5.01	4.86	3.78	6.89	4.94	4.61
CaO	8.12	7.44	7.35	9.66	8.47	8.86
Na_2O	3.50	3.42	3.72	2.25	4.03	3.30
K_2O	1.56	1.76	1.73	0.62	1.31	1.29
H_2O^+	1.44	1.19	1.05	1.24	0.17	0.84
H_2O^-	0.50	1.23	—	0.71	0.07	0.42
TiO_2	3.04	3.06	2.04	2.21	2.66	3.25
P_2O_5	0.90	0.49	0.45	0.22	0.80	0.91
MnO	0.03	—	0.52	0.11	0.09	0.17
	100.03	99.89		100.35	99.95	99.78
S. G.	2.92	—	—	—	—	—
	Norms					
Or	9.23	—	—	3.34	7.78	6.67
Ab	29.55	—	—	27.77	34.06	28.82
An	18.79	—	—	23.55	19.46	14.73
Di	12.66	—	—	18.24	14.22	19.54
Hy	8.97	—	—	14.22	0.81	8.06
Ol	2.82	—	—	2.36	12.41	0.28
Mt	7.79	—	—	5.34	4.18	7.19
Ilm	5.76	—	—	4.28	5.02	6.17
Ap	2.12	—	—	0.67	2.20	3.36

E. Aphyric-andesine basalt, 2226, N.E. Spring Journey Nunataks, East Greenland. Anal. Y. ANWAR. (New analysis).

1. Basaltic mugearite, lower member of composite lava flow, Renfrewshire. Anal. B. E. DIXON. (KENNEDY 1931, p. 171).
2. Mugearite, Canna Island, Scotland. (HARKER 1908, p. 130).
3. Andesine basalt, Leeward Islands, Hawaiian Islands. Anal. KEYES. (WASHINGTON and KEYES 1926, p. 339).
4. Olivine oligoclase basalt (= mugearite), Kohala, Hawaii. Anal. WASHINGTON. (WASHINGTON 1923, p. 480; MACDONALD 1949, p. 87).
5. Andesite, Hamakua volcanic series. Anal. WASHINGTON. (WASHINGTON 1923, p. 394).

cooling rather than composition must have given rise to the observed difference in texture.

The analysed rock is comparable with a basaltic mugearite from Renfrewshire (col. 1) and a Tertiary mugearite from Isle of Canna, Scotland (col. 2). The most significant difference is considered to be the state of oxidation of the iron oxides. The andesine basalt (col. 3), the olivine oligoclase andesite (col. 4) and the andesite (col. 5) from the Hawaiian Islands also have a rather similar chemical composition to the Greenland rock but are less oxidised. The aphyric andesine basalt from Greenland is in many ways intermediate between the Scottish mugearites and the andesine basalts of Hawaii.

IV. NOTE ON THE UNDERLYING PLATEAU BASALTS

The character of the Plateau Basalts underlying the Prinsen af Wales Bjerge lavas may be briefly described to allow comparison with the unusual types dealt with in this paper. The plateau basalts of the region, so far as examined, have labradorite as the dominant felspar. They fall into two major groups:

1) Olivine basalts, in which the olivine forms about eight per cent by volume of the rock. The latter is generally altered but when fresh it proves to be about Fa 15 %. In some rocks plagioclase (about $An_{65}/_{70}$) appears as fair-sized porphyritic crystals and olivine and pyroxene as microphenocrysts.

2) Basalts with subordinate or negligible amounts of olivine. In this group two types can be recognised based on textural features, viz. aphyric basalts, composed mainly of pyroxene and plagioclase felspar (55 % An), and plagioclase phyric basalts. In the latter, the plagioclase is the only porphyritic constituent and the percentage of anorthite of several has been found to lie between An_{60} and An_{65}.

V. SUMMARY AND DISCUSSION OF THE RESULTS

The main features of the Prinsen af Wales lavas may be briefly summarised as follows:—

1. The silica percentage is low in the analysed varieties lying between 43 and 48. With this goes relatively high amounts of soda and potash. The normative plagioclase is andesine and sometimes oligoclase (Table IX).
2. Large or relatively large porphyritic crystals are common in the bulk of the specimens. These may be olivine, pyroxene, felspar or iron ore or various combinations of these. The porphyritic olivines are magnesium-rich, 16—27 % Fa; the pyroxenes are apparently diopsidic and the plagioclase phenocrysts are andesine (An 45 %).

Table IX. Chemical analyses of the Prinsen af Wales Bjerge lavas, East Greenland.

	A	B	C	D	E
SiO_2	43.26	44.16	44.74	45.81	47.37
Al_2O_3	5.88	8.34	11.87	12.90	14.51
Fe_2O_3	3.66	5.74	3.33	4.36	5.37
FeO	11.66	10.72	11.59	10.31	8.68
MgO	17.86	7.80	7.89	5.75	5.01
CaO	8.96	11.20	10.13	7.52	8.12
Na_2O	1.73	3.26	3.31	3.36	3.50
K_2O	1.16	1.75	1.36	1.70	1.56
H_2O^+	1.41	1.07	2.03	1.91	1.44
H_2O^-	0.20	0.40	0.26	0.88	0.50
TiO_2	3.55	4.47	2.13	4.03	3.04
P_2O_5	0.64	0.83	0.89	1.11	0.90
MnO	0.22	0.09	0.20	0.20	0.03
	100.19	99.83	99.75	99.84	100.03
S. G.	3.20	3.07	3.06	2.92	2.92

(continued)

Table IX (continued).

	A	B	C	D	E
			C. I. P. W. Norms		
Or	6.84	10.34	8.12	10.01	9.23
Ab	12.00	14.88	16.77	28.40	29.55
An	4.81	2.89	13.37	15.01	18.79
Np	1.42	6.87	6.08	—	—
Di	28.26	37.99	25.41	12.25	12.66
Hy	—	—	—	7.00	8.97
Ol	31.35	6.37	16.46	7.56	2.82
Mt	5.31	8.33	4.83	6.33	7.79
Ilm	6.73	8.48	4.04	7.65	5.76
Ap	1.51	1.23	2.14	2.62	2.12
			Normative Plagioclase		
Ab	71	83	57	65	61
An	29	17	43	35	39
			Normative pyroxene		
Wo	52	52	51	51	51
En	37	34	27	30	32
Fs	11	14	22	19	17
			Normative Olivine		
Fo	76	69	54	59	63
Fa	24	31	46	41	37
			Weight %		
$\frac{FeO + Fe_2O_3\ 100}{MgO + FeO + Fe_2O_3}$	46.3	57.8	65.5	71.8	73.5
			Modes (vol.-%)		
Phenocrysts					
Plagioclase	—	—	—	19	—
Pyroxene	3	23	15	2	—
Olivine	29	5	5	5	—
Iron ore	2	4	2	2	—
Groundmass					
Leucocratic-minerals[1])	21	29	(78% glass)[3])	43	58
Melanocratic minerals[2])	45	39		29	42

[1]) Includes felspar, apatite and analcime.
[2]) Includes pyroxene, subordinate olivine or its pseudomorphs and iron ore.
[3]) The glass contains microlites of pyroxene and iron ore.

A. Olivine-phyric oligoclase basalt, 2215.
B. Pyroxene-phyric andesine basalt, normal development, 2216.
C. Pyroxene-phyric andesine basalt, glassy development, 2228.
D. Andesine-phyric andesine basalt, 2225.
E. Aphyric-andesine basalt, 2226.

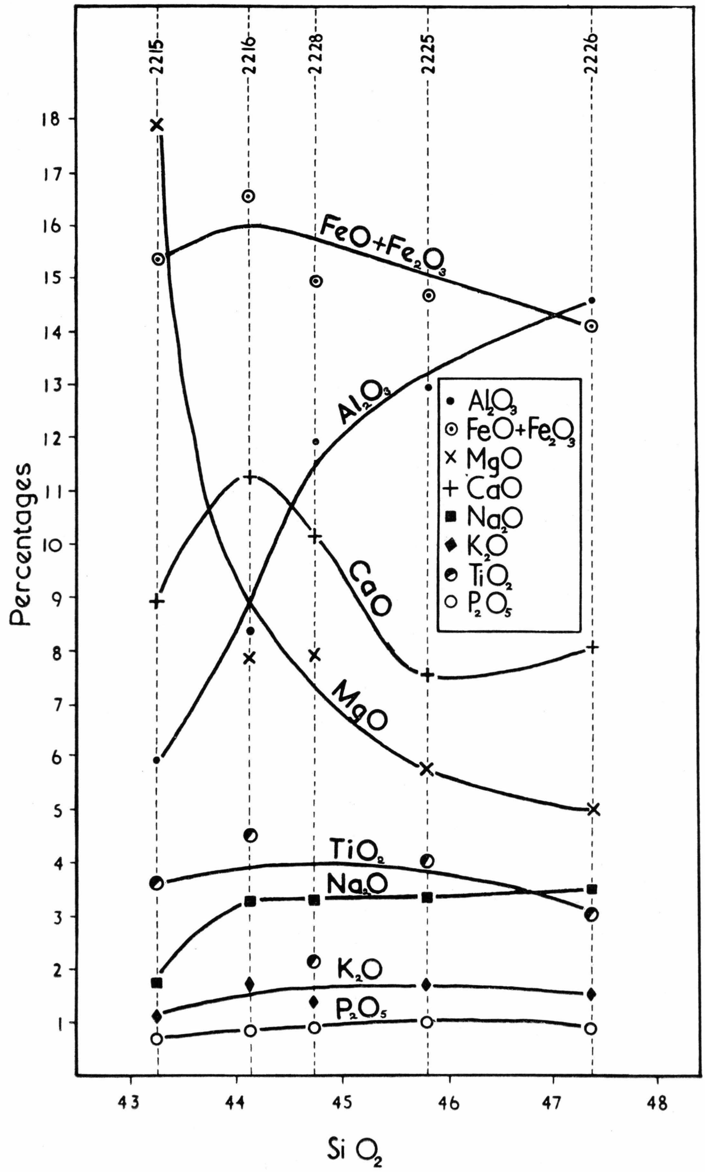

Fig. 3. Variation diagram of the analysed rocks.

3. The groundmass of the porphyritic lavas is variable in texture and may be glassy. The plagioclase of the groundmass is andesine or oligoclase.

4. The aphyric lavas are also andesine or oligoclase basalts approaching mugearites. The analysed specimen has essentially the same composition as the analysed andesine-phyric andesine basalt.

5. Rather high TiO_2 and P_2O_5 seem to be a feature of the series.
6. Considerable viscosity compared with the Plateau Basalts is implied by the variable inclination of the flows.

Although at present there is no real knowledge of the proportion of the various types among the Prinsen af Wales Bjerge lavas because the sampling has been so slight, yet it is worth while averaging the analyses of the four commoner types for comparison with average values from Hawaii and with the world average (table X). From this it would seem that the immediate parent of the Prinsen af Wales lavas was a basalt of mild alkalinity. An ordinary variation diagram showing weight percentages of the various oxides plotted against silica percentage is presented in fig. 3. The order of increasing silica percentage of the analysed rocks is the same as that of increasing iron: magnesium ratio, and it is likely that this order indicates a sequence of types due to crystal fractionation.

The similarity between certain Hawaiian lavas and the Prinsen af Wales lavas has been shown by several examples in the various tables of comparisons. In Greenland there is clearly present a sialic crustal layer but it is suggested that the diversity of the Prinsen af Wales lavas has

Table X. Comparison of the average of the analyses of the Prinsen af Wales lavas with other average values. (Calculated as water free).

	F	1	2	3	4
SiO_2	46.79	47.45	50.8	50.04	49.25
TiO_2	3.52	3.34	1.5	3.12	2.71
Al_2O_3	12.15	12.23	15.3	13.47	14.05
Fe_2O_3	4.47	4.93	4.5	2.65	3.43
FeO	10.62	8.47	6.9	9.79	9.94
MnO	0.13	0.19	0.2	0.12	0.12
MgO	6.79	7.70	7.5	7.79	6.77
CaO	9.51	11.95	8.6	10.49	10.20
Na_2O	3.46	2.34	3.0	2.43	2.48
K_2O	1.63	0.94	1.3	0.55	0.62
P_2O_5	0.93	0.46	0.4	0.29	0.35
	100.00	100.00	100.00	100.00	100.00

F. Average of 4 analyses, 2216, 2228, 2225 and 2226, of the Prinsen af Wales lavas.
1. Average of East Greenland basalts, 7 analyses. (KROKSTRÖM 1944, p. 38).
2. Average of Central Victoria lavas. (WALKER and POLDERVAART 1949, p. 649).
3. Average of Hawaii olivine basalts. (DALY 1944, p. 1392).
4. A grand average after WASHINGTON for plateau basalts from Asia, Africa, North America and various parts of the North Atlantic field. (DALY 1944, p. 1391).

been produced independently of the sial layer since similar lavas are found in Hawaii where all the available evidence shows that no sial is present. Whether the mildly alkaline lava types of the Prinsen af Wales lava series have developed by crystal fractionation from the abundant more ordinary plateau basalt magma of East Greenland, or whether by some other process, has not been decided by the present investigation.

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Færdig fra trykkeriet den 23. november 1955.

Plate I.

Fig. 1. Olivine-phyric oligoclase basalt (2215) showing large idiomorphic olivines, smaller pyroxenes and iron ore, in a groundmass mainly of pyroxene prisms and iron ore with interstitial felspar. Magnification × 12.

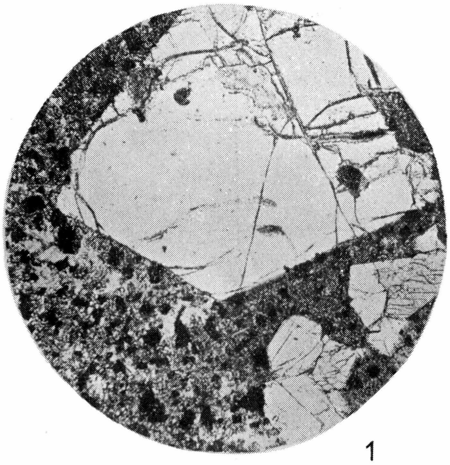
Fig. 2. Pyroxene-phyric andesine basalt (2216) showing phenocrysts of pyroxene, subordinate olivine and iron ore in a groundmass composed of pyroxene, felspar and abundant iron ore. Magnification × 10.

Fig. 3. Glassy pyroxene-phyric andesine basalt (2228). The porphyritic constituents are the same as in the previous rock, but are less abundant.; the groundmass is glass with pyroxene as small prisms and microlites and iron ore. The vesicles contain zeolites. Magnification × 12.

Fig. 4. Pyroxene-phyric andesine basalt (2230), with coarser groundmass showing extensive clear interstitial crystals of felspar enclosing idiomorphic pyroxene crystals and apatite needles. Magnification × 12.

Fig. 5. Andesine-phyric andesine basalt (2225). Large platy plagioclase phenocrysts are abundant with small amounts of olivine and pyroxene, in a groundmass formed of plagioclase and pyroxene in a subdoleritic relationship together with iron ore and analcite. Magnification × 15.

Fig. 6. Aphyric andesine basalt (2226) showing prisms of pyroxene, elongated pseudomorphs of chlorite after olivine and grains of iron ore, in a felspathic base. Magnification × 30.



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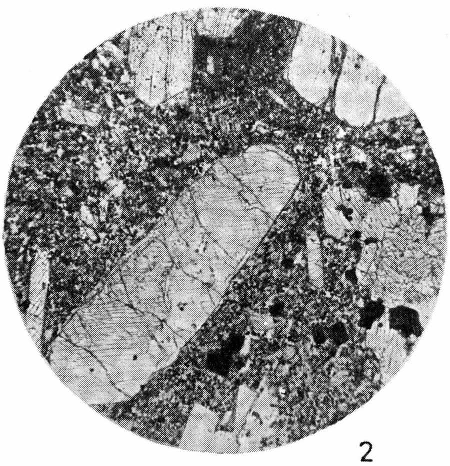

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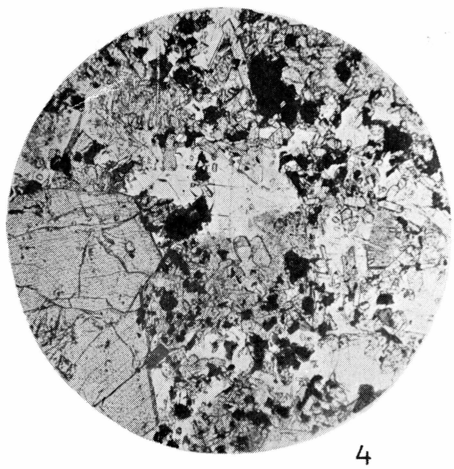

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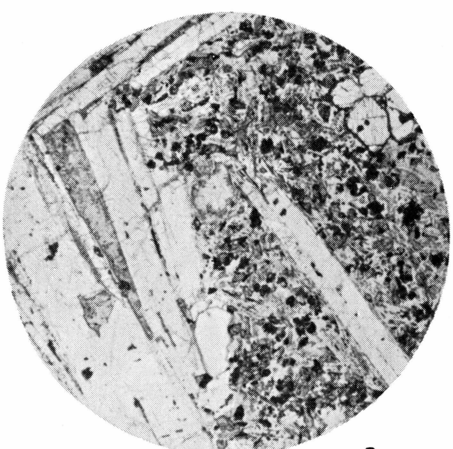

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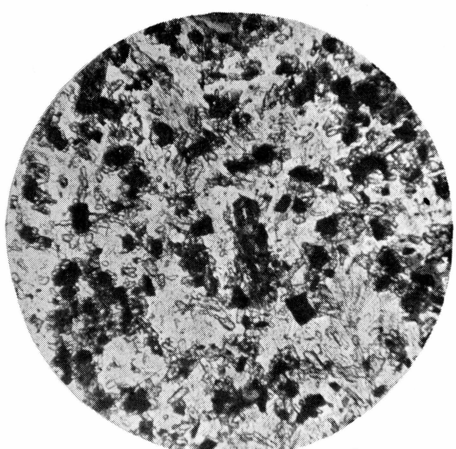

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