DE DANSKE EKSPEDITIONER TIL ØSTGRØNLAND 1947—58

UNDER LEDELSE AF LAUGE KOCH

ON THE ALKALI MASSIF
OF THE WERNER BJERGE IN
EAST GREENLAND

BY

P. BEARTH

WITH 9 FIGURES IN THE TEXT
AND 25 PLATES

CONTENTS

PREFACE

The small mountain massif of the Werner Bjerge lies in Scoresby Land, near the East coast of Greenland, almost at the point of intersection of latitude 72° N. and longitude 24° W., and rises from a rather monotonous table landscape as a large mountain chain, fractured and glaciated (see pl. 1). The highest elevations, Monte Somma and Breithorn, reach an altitude of 1885 m and accordingly are much lower than the neighbouring Staunings Alper (cf. "Berge der Welt" 1953). The greater part of the surface investigated is covered by ice and the glaciers flowing towards the west and north can be compared with the major glaciers of the Alps, the Greenland glaciers, however, having a much flatter profile.

As early as 1950 and 1951 the Werner Bjerge were visited by prospectors who followed the large glaciers with sledges, crossing both Skelpas and Mellempas. The leader of the first party was HASSE BERGLUND, while SVEN LJUNGREN conducted the second party. Both parties searched the moraines for ore, but the sporadic samples of galena and molybdenite found by them did not seem to promise much. In 1948 a party led by Dr. H. STAUBER visited the massif from the bay of Mesters Vig. They were the first to climb Pyramiden, the only peak climbed before our arrival. We do not know anything about the scientific activity of this party.

The systematic geological mapping of the area was not commenced until 1953 when Dr. LAUGE KOCH took the initiative. Two parties started work there, one led by Professor Dr. E. WENK, and the other by the present author.

In 1953 we stayed in Greenland from July 20th to September 3rd. The actual geological work, however, was limited to five weeks, and these were further much reduced by bad weather. The sites of the camps and the routes followed can be seen from plates 24 and 25. The base camp of the expedition was first set up in the bay at Mesters Vig, and later moved to Antarctics Havn, whither provisions were carried by aircraft or boat from Ella Ø. The transport of provisions to the "high camp" as well as the downward transport of rock samples was undertaken by our carriers, H. P. BUESS, M. D. (Basel), ing. geol. Dr. H. ZWEIFEL

(Glarus), E. BINER, E. GRAVEN, and H. PERREN (all three from Zermatt), Dr. A. SCHNEIDER (Basel), and TH. BEARTH (Somvix, Co. Grisons).

In 1954 the expedition party under the leadership of the author started from Mesters Vig on July 29th, and after three days of very tiring walk across the snow-bound Mellempas (see pl. 2) it reached the site of the future Katederet camp at the confluence of Sirius Gletscher and Schuchert Gl. This time the leader was accompanied by F. MÜLLER, E. BINER, and R. GANZONI. An attempt was made to parachute supplies from aircraft but all the fuel and some of the provisions were lost and this entailed a delay of the geological work. Work was resumed on 4th August, but on the 29th we had to start the return journey. The summer of 1954 was cool, but in our working area it rained less than in 1953. The exceptionally heavy snowfall in the spring of 1954 proved advantageous to us, for the glaciers which in the previous year had been full of crevasses, could be conveniently and safely crossed in cold weather.

On some trips we had to overcome considerable differences in height and the marches were often very long. However, in arctic regions long walks are favoured by the light nights. Most of the routes naturally went across mountain ridges and along their foot. Unfortunately our work was much impeded by the dissected rock, much of it disintegrated and very loose. The poor condition of the cliffs not only rendered the approach difficult but in particular hindered the observation of geological details, as many contacts were obscured, due partly to frost cracks but mainly to widespread impregnation with ore combined with strong limonitic disintegration. These processes are responsible for the intense orange-yellow to brick-red or even black colours of many parts of the Werner Bjerge.

In a detailed paper our companion F. MÜLLER has reported about occasional observations of soil structures, crested ice formations, and, chiefly, about measurements taken of several "pingoes" at the southern end of the massif (Pingo Dal).

A sketch map prepared by the Geodetic Institute, Copenhagen, on the scale of 1:50,000 and indicating the outlines between the solid rock and the ice or debris served as a basis for our observations. We also had the use of high altitude air photographs; but our greatest help were the aerial photographs taken by M. BRENNEISEN and placed at our disposal by the leader of the expedition. On these pictures we marked occasional geological observations and the localities; and they have been used, in part, as the basis of the geological map accompanying the present paper.

The whole area was covered by as dense as possible a net of field observations; nevertheless, some districts are very incompletely known. This is especially the case in regard to the southernmost point with its basic volcanics and intrusions.

As already mentioned, we are indebted to Dr. LAUGE KOCH, the leader of the Danish East Greenland Expeditions, for suggesting the investigation of this area. He also rendered possible the chemical and spectrographic examinations and has supported us liberally in every respect.

Professor E. WENK, Ph. D., head of the Institute of Mineralogy and Petrography of the University of Basel, participated in the petrographical investigation of the material collected. We are greatly indebted to him, for he not only placed at our disposal all the facilities of his institute but even handed over to us for further examination the samples which he had collected in 1953.

The chemical analyses were carried out by Dr. H. SCHWANDER, Basel, while Dr. STURE LANDERGREN, Stockholm, carried out spectrographic determinations on more than a hundred mineral and rock samples.

The ore determinations required were carried out by Dr. O. GRÜTTER, Basel, Drs. A. GÜNTHERT and H. ZWEIFEL helped in the optical examinations, in particular in the determinations of the plagioclases by FEDOROW's method; and H. P. HERES made Rosiwal estimations of the mineral composition whenever feasible.

To Dr. J. HALLER we are indebted for drawing the originals of the attached maps and to Miss. E. GLEERUP (Copenhagen), Dr. W. B. HARLAND (Cambridge), and Miss L. AEGERTER (Basel) for translating the paper and reading the proofs.

We wish to thank all these colleagues and cooperators most cordially for their help, also Mr. E. GLAUSER who prepared nearly 500 sections.
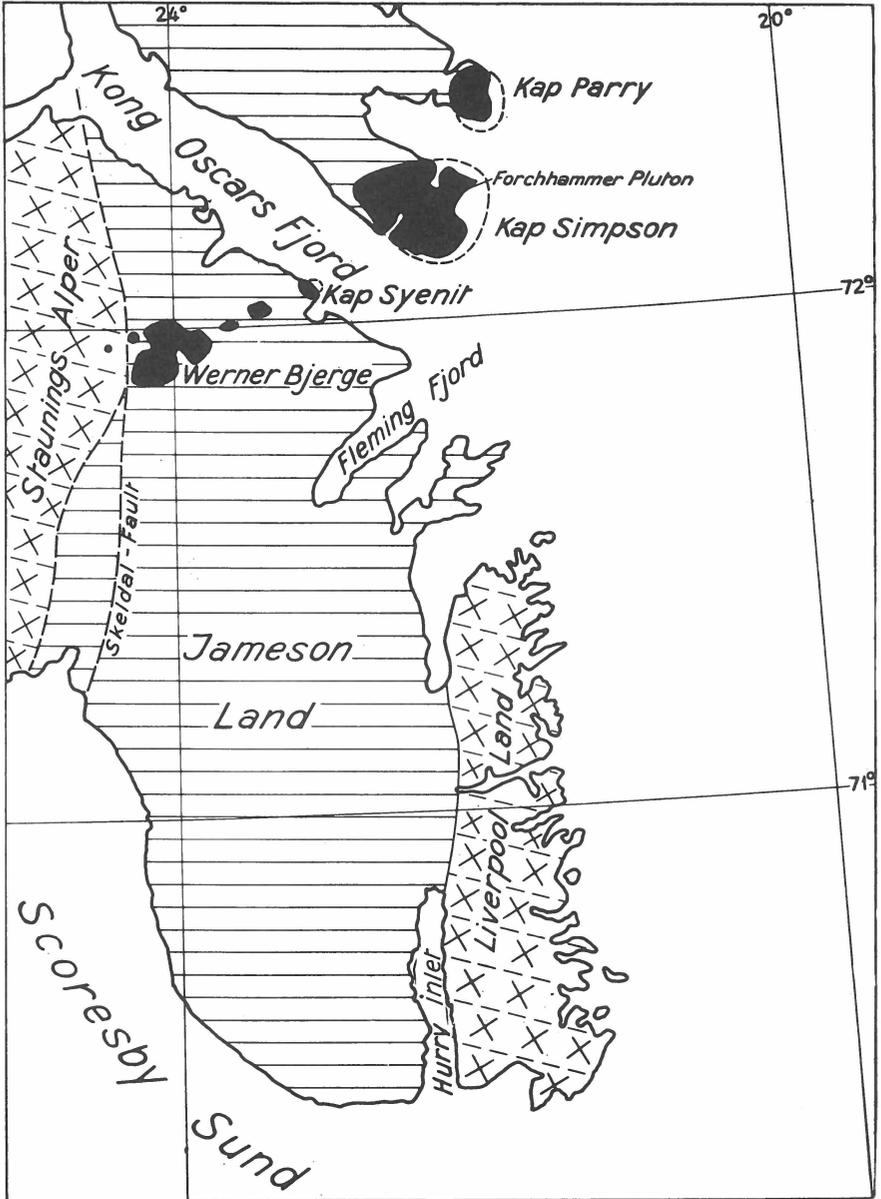
Fig. 1. Map showing position of the Werner Bjerge.

black   = Upper Cretaceous to Tertiary igneous rocks
ruled   = Palaeozoic and Mesozoic sediments
crossed = Caledonian crystalline complex

ON THE ALKALINE MASSIF OF
THE WERNER BJERGE IN EAST GREENLAND

The present paper is a report of field work done in the summers of 1953 and 1954 and of the results of chemical, spectrochemical, and microscopical examination of the material collected during these periods. The amount of material is so large that the complete description will not be ready for some time yet, so this paper is of a preliminary nature. An intensive petrographic study will probably furnish new data of greater accuracy.

Geology.

Between Angmagssalik and Kejser Franz Josephs Fjord, on the coast of East Greenland, a great many acid intrusions are known, probably all belonging to the same Upper Cretaceous-Tertiary cycle. The Werner Bjerge are but a link in this chain of granite-syenite intrusions. The occurrences south of Scoresby Sund were discovered and have been studied by L. R. WAGER but their petrographical study has not yet been terminated. (1934 and 1935. WAGER and DEER 1939), whereas we have very little information about the syenite intrusions north of this fjord. It is true that H. P. SCHAUB collected abundant material on Traill Ø in 1936 and 1937, but only a small selection of these rock samples (Forchhammer Pluton) have been studied. This intrusion is at present being studied by H. P. HERES.

A brief petrographic note with chemical analyses on the neighbouring small syenite block of Kap Syenit (Antarctics Havn) on the south shore of Kong Oscars Fjord, has been published by A. NOE-NYGAARD (1940).

In 1953 we had the opportunity to collect material at Kap Syenit and at Drømmebugten on the opposite side (Traill Ø). In Kolledalen we found two additional minor intrusions, which were partially studied; like the Werner Bjerge they consist of volcanic breccias, alkali-syenites and basic rocks, and they connect the Werner Bjerge in the west to the intrusions at the southern end of Traill Ø in the east (Fig. 1). These intrusions have been surveyed by Dr. H. Kapp.

According to H. P. SCHAUB, the syenites and granites of Traill Ø are Upper Cretaceous to Tertiary. Later on Donovan (1953) stated: "Some

or all of the igneous rocks are post-Campanian but there is no more exact evidence as to their age."

We have no doubt that the other intrusions located along the line Kap Parry-Schuchert Gl. are of the same age. In the Werner Bjerge exact dating is impossible. To the West the massif borders on the Skeldal fault, which here follows the depression of the Schucherts Flod Valley. Isolated occurrences of acid intrusions (veins, minor stocks) are still found in the Staunings Alper, that is, west of the fault. Unfortunately we do not yet know the exact age of the Skeldal fault in this area. The whole massif is surrounded by Upper Palaeozoic sediments (Carboniferous and Permian) and only along Vestre Gletscher and in the southern slopes are Triassic beds cut. Thus we can state only that the Werner Bjerge Intrusion must be of post-Triassic age.

The Contact between Massif and Sediment.

The late-Palaeozoic formations surrounding the massif consist almost exclusively of terrestrial deposits (arkoses, sandstones, conglomerates, and shales). The Permian is also represented by gypsum and dolomite, and the lower marine Trias chiefly by sandstones and shales. These sediments form a huge sheet, dipping slightly towards the south and cut up by numerous faults. Basalts (sills and dykes) are frequently found, especially in the upper parts of the series.

The various intrusions of the massif cut steeply through these flat-lying sediments. On approaching the border of the massif, the vol-cano-tectonic faults become more crowded though they are still of minor importance. It is true that the central roof, where these faults may have reached their culmination, has been entirely removed by erosion but on the periphery the massif has been broken up into small dome-shaped stocks intruding the flat-lying sediments without greatly disturbing them (fig. 2).

Displaced and detached lumps of sedimentary rock can often be observed and in several places acid dykes have literally cut the country rock to pieces. Large sedimentary fragments floating in syenite are found at Retrætegletscher, Sirius Gletscher, and Studer Gletscher (see pl. 4). Unfortunately we could not study systematically these volcano-tectonic phenomena, however interesting such an investigation would have been with a view to the mechanism of the intrusion.

Likewise the thermal and metasomatic influence of the intrusion upon the surrounding rocks was remarkably small. Clayey sediments are transformed into biotite-hornfels, limestones into diopside-bearing lime silicate-rock. Fragments of sediments (or basalts) frequently show marginal resorption, but such resorption is also frequently absent. These phenomena are mainly limited to the outermost rim of the intrusions,

where the adjoining rocks are often full of veins and where inclusions of migmatites, showing various stages of resorption, occur locally. In the interior of the massif, however, brecciated zones may also be found, containing dioritic to essexitic xenoliths of varying degrees of resorption in an alkali- or nepheline-syenite cement.

At the present stage of our investigations the extent and genetic importance of these assimilation phenomena can not yet be estimated; but neither seems to have been considerable.
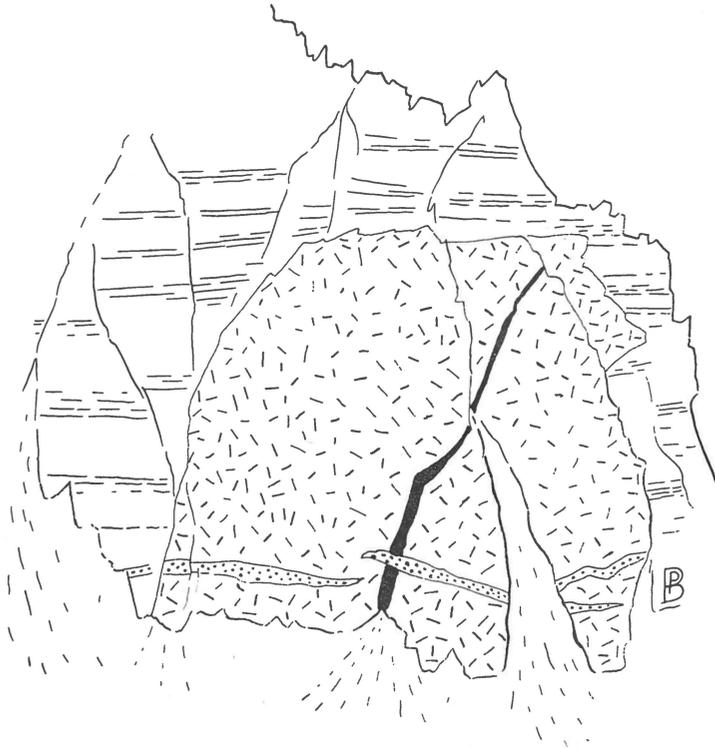
Fig. 2. Basic stock in Palaeozoic sediments on the upper Studer Gletscher.
Stippled = acid dyke, black = basalt.

Eruptive Rocks.

We have provisionally put four separate main rock groups on the geological map. A detailed map will be published later.

In the northern part of the massif, chiefly acid (alkali-syenitic to alkali-granitic) rocks occur, partly as porphyries, but only the granites have been distinguished by a special sign. In the field the feldspathoid-bearing (pulaskitic) alkali-syenites could not be separated from the feldspathoid-free rocks, with the exception of the fairly large sodalite- and nepheline-bearing alkali-syenite of the Titanitspids.

Foyaitic intrusions dominate the area on either side of Sirius Gletscher and its tributaries, Aldebaran Gletscher and Randgletscher, while the upper basin of Østre Gletscher is surrounded by mountains built chiefly of basic rocks (pyroxenites, essexite-gabbros, monzonites) but partly, also, of basic breccias and volcanic agglomerates (see pl. 5). This part includes the largest uplifts and the most striking mountain forms of the Werner Bjerge.

This fairly clear division of the eruptive mass into three parts corresponds to three centres of intrusion more or less independent of each other. Their time relationships will be dealt with below (p. 47).

A fourth group of rocks consists principally of acid volcanics, chiefly breccias and porphyries. In the main, these rocks are preserved in coherent masses in the centre and along the southern border. They were formerly, no doubt, more extensively distributed, and it seems that they once formed the roof, most of which has since been eroded.

Most of the acid dykes, too, are associated with the volcanics; these have not been distinguished on the map. The *tinguaites* are found only in the area of the nepheline-syenites, while the basalts and the lamprophyres from which they cannot be distinguished in the field are widely distributed. Only a few basalt dykes are indicated on the map.

A strong pneumatolytic to hydrothermal decomposition can be observed throughout the plutonic rocks, giving rise to the frequently observed, intensely red colour which also characterizes the intrusions in Antartic Dal and at Kap Simpson. In the Werner Bjerge this decomposition is sporadically accompanied by intensive ore formation and impregnation. The most important areas of mineralization are indicated on the map. As will be seen, they are mainly concentrated along the northern margin, while the impregnation with ore appears to be much slighter in the nepheline-syenitic and even more so in the basic sector.

The individual rock groups will be dealt with in the sections which follow.

The Basic Complex.

Plutonic rocks.

Basic plutonic and volcanic rocks form a fairly large continuous complex in the south-eastern corner of the pluton. Some minor intrusions are embedded in the sediments of the eastern slope as well. All these rock bodies are of a very heterogeneous composition; the first separated ultrabasic and basic predominate, but they are penetrated by contemporaneous schlieren-shaped bands of acid residual units of differentiation, or they float in them as more or less reabsorbed blocks. The banded inter-mixture is especially remarkable in the small stocks at Antarctic Gletscher and Studer Gletscher (see fig. 2), while the large mass of rock between Maageborg and Monte Somma generally shows a clearer separation into units of basic or ultra-basic, and into meso- to leucocratic intermediary types (diorites, monzonites). Here gabbroid (or syeno-gabbroid) and pyroxenitic masses predominate, followed at a fair distance by syeno-dioritic to monzonitic intrusions, while granitic and alkali-syenitic residual products occur only in the form of narrow dykes or veins (fig. 3). However, here too all transitional forms may be found without difficulty, residual basic rocks always being surrounded by the lighter-coloured products of differentiation. Thus for instance peridotite- or pyroxenite-xenoliths in gabbro and residual gabbro in diorite can be found.

Heterogeneity is therefore a remarkable characteristic of the basic rock bodies. But the close mixing of melanocratic with leucocratic and of basic with intermediary types of rock implies that an important part of this heterogeneity came into existence at the time of their consolidation and *after* the intrusion—in other words, that at least part of the differentiation took place in situ.

In two places we found distinct traces of gravity (in part rhythmic) segregation. Along the ridge of the Ruinerne (see pl. 6), between the western and the eastern peak, we crossed an isolated basic rock mass shaped like a shallow dish, the bottom of which consists of pyroxenite (mainly titanaugite and ore), while inside is a highly decomposed light-coloured autohydro-thermal saussurite-gabbro. The two rocks continuously pass into one another.

Similar conditions were observed in the western wall of Peters-ryggen—here in repeated rhythmical recurrence, but not nearly as distinctly developed as recorded from Kangerdlugssuaq by WAGER and DEER.

10 cm
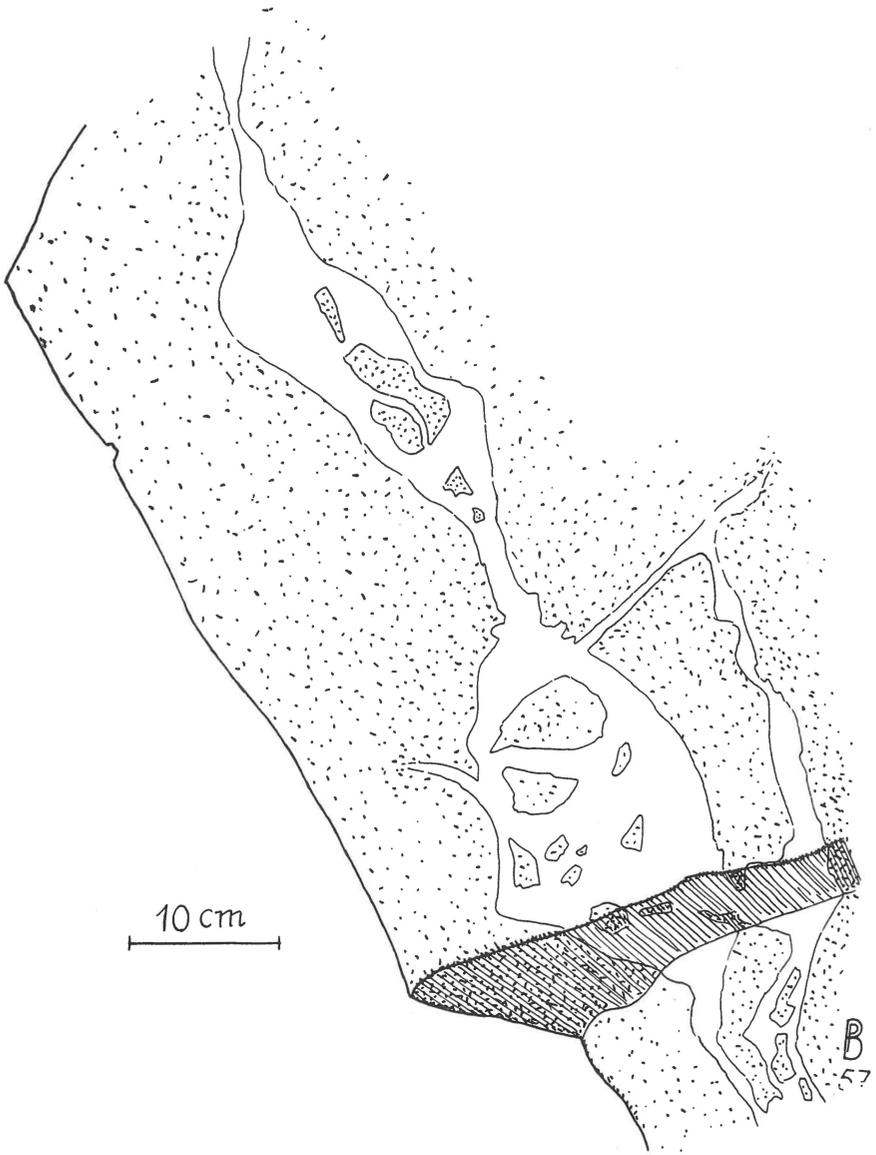
Fig. 3. Peters Bjerg. Granite vein (white) in gabbro (stippled).
(Hatching = shadowed joint planes).

The mineralogical composition of the most important rock types of the basic series, together with their acid products of differentiation, is shown on Table 1. The chemical variation can be seen from analyses WB 140, 141, 142, 150, and from WW 48 (and perhaps WW 97). (Table 2)[1].

The microscopic examination has already shown that we are here partly concerned with rocks more closely related to the essexites than to the ordinary gabbros and diorites. In more than fifty carefully examined samples from this rock group not one feldspathoid was found: but apart from this, the mineral content with titanaugite, alkali-hornblende, biotite, and frequent alkali-feldspar is typical of essexite, and the chemical composition unmistakably shows that the rocks should be referred to that group, not to the family of gabbros and diorites. We are here confronted with the same heteromorphic phenomena as those recently described by A. STRECKEISEN for Ditro-essexites, which present a chemical composition very much like that of our monzonites, syenodiorites or syeno-gabbros.

The autohydrothermal transformation of the primary minerals described for the saussurite gabbro of the Ruinerne is a peculiarity existing for all meso- to leucocratic rock types of the basic complex.

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[1] For each analysis the Niggli molecular norm was calculated. A norm variant was added which was adapted as far as possible to the modal mineral composition. As a rule the calculation was done with the help of ideal formulas with the exception of analyses WB 150 and WW 48 where I made use of E. Tröger's data for the composition of titanaugite i. e. of basaltic hornblende.

Where the minerals were in a good enough state of preservation, they were determined volumetrically on the Leitz integration stage by cand. geol. H. P. Heres.

For such further chemical parameters as Niggli values, BARTH-ESKOLA norms of cations etc. see pp. 48—50/51, Tables 10—12.

Table 1. Mineral content of the most important rock types of the basic complex.

	Pyroxenites	Gabbros	Syeno-gabbro "Essexites"	Syeno-diorites and Monzonites	Alkali-syenites	Granites to Alkali-granites
Quartz						Quartz
Feldspar [1])		Andesine-Bytownite	Potash-feldspar Andesine-Labradorite	Potash-feldspar Andesine-Labradorite	Micro-perthite (Oligoclase)	Micro-perthite Oligoclase
Olivine	Olivine	Olivine				
Pyroxene [2])	Titanaugite	Titanaugite ± Diopsidic Augite	Titanaugite ± Diopsidic Augite	(Diopside)	Diopsidic Augite	
Amphibole [3])	Amphibole reddish-brown	Amphibole reddish-brown	Amphibole greenish-brown	Amphibole green	Amphibole brown and green	Amphibole green
Biotite	Biotite brownish-red	Biotite brownish-red	Biotite brown and green	Biotite brown	Biotite brown and green	Biotite brown
Accessories	Pyrite, Magnetite, Ilmenite, Sphene, Apatite, Rutile, Zircon (?)					
Secondary hydrothermal	Albite, Tremolite, Zoisite, Epidote, Sericite, Serpentine, Bowlingite, Chlorite, Talc, Carbonate, Ore					

1. As a rule the plagioclase is normally zoned, but it also occurs un-
zoned, chiefly so in mesocratic, gabbroid, and dioritic types. In
gabbroid rocks its composition varies between 26 and 89 An, medium
value 80 An. Cores containing about 80 $\%$ An are nearly always
sharply set off against the acid rim while those of labradoritic
composition are not. In the first case the rim generally consists
of an andesine, while in the second it is formed by basic oligoclase.
All rocks may show secondary albite or acid oligoclase.

The following twinning laws were determined:

Albite, Carlsbad, Albite-Carlsbad-Complex,
Albite-Ala, Albite-Ala-B-Complex, Manebach,
Complex + Akline, Pericline.

The most frequent is the Albite law.

2. The titanaugite often shows zonal structure and the well-known
hour-glass structure. A colourless core surrounded by a dark purple
rim is common. In such a crystal we measured —

	core	rim	other measurements yielded
$n\gamma/c$	43°	40°	for $n\gamma/c$ 46—48°
$+2V$	49°	48°	$+2V$ 40—54°
			$n\gamma - n\alpha \sim 0,027 - 0,029$

3. The red-brown oxy-hornblende shows the following optical data:

$n\gamma/c$ 7—12°
$-2V$ 74—84° $n\gamma - n\alpha$ 0,019—0,020

Brown hornblende is successively replaced by green hornblende
and biotite by chlorite, while plagioclase disintegrates into saus-
surite. In the alkali-feldspar-bearing rocks metasomatic transforma-
tion plays a significant part, above all the replacement of plagio-
clase by potash feldspar.

Mesocratic xenoliths of monzonitic composition are also met with
in the alkali-syenites, for example at the eastern bank of the lower
Østre Gletscher, whence the analysed rock sample WW 48 is derived.
These monzonites there gradually change into alkali-syenites (E. WENK).
The porphyrite of the Kolossen (cf. geol. map) may be a member of the
basic series as well. Floating as a gigantic block in the alkali-syenite, this
rock forms the summit and the northern slope of the Kolossen (see pl. 3).
It exhibits white phenocrysts of oligoclase (rarely orthoclase) in a black,
highly pigmented and extremely micro-crystalline ground mass. The
phenocrysts as well as the occasional bodies of diopside and green horn-
blende are surrounded by a light-coloured quartzitic edge. This rock
may be a hypabyssal equivalent of the basic series. The chemical analysis

Table 2. Basic Complex.

	No: WB 142		No: WB 141		No: WW 48
SiO_2	65.53	SiO_2	56.67	SiO_2	50.57
TiO_2	0.68	TiO_2	1.81	TiO_2	3.21
Al_2O_3	16.08	Al_2O_3	17.58	Al_2O_3	17.49
Fe_2O_3	0.22	Fe_2O_3	0.35	Fe_2O_3	2.48
FeO	2.63	FeO	5.47	FeO	5.04
MnO	tr.	MnO	0.07	MnO	0.11
MgO	0.87	MgO	2.52	MgO	2.96
CaO	2.48	CaO	6.17	CaO	7.09
Na_2O	4.52	Na_2O	5.12	Na_2O	5.31
K_2O	5.38	K_2O	3.43	K_2O	4.04
H_2O^+	0.60	H_2O^+	0.36	H_2O^+	0.76
H_2O^-	0.13	H_2O^-	0.07	H_2O^-	0.13
P_2O_5	0.24	P_2O_5	0.50	P_2O_5	1.03
CO_2	0.71	CO_2	..	CO_2	..
S	0.00	S	..	S	0.00
F	..	F	..	F	0.15
$-O(F)$	..	$-O(F)$	..	$-O(F)$	0.06
	100.07		100.12		100.31

Mol. Norm

	WB 142			WB 141			WW 48	
Q	10.9	10.9	Q	−2.2	−2.2	Q	−9.9	−9.9
Or	32.1		Or	20.0		Or	23.9	
Ab	40.4	80.4	Ab	45.5	80.3	Ab	47.1	83.0
An	7.9		An	14.8		An	12.0	
En	2.4	6.3	Wo	1.9		Wo	0.7	
Hy	3.9		En	6.8	17.1	En	8.1	15.1
			Hy	8.4		Hy	6.3	
Mt	0.2					Mt	2.6	
Ru	0.5	2.4	Mt	0.3		Tip	6.6	11.8
Cp	0.4		Tit	3.6	4.8	Cp	1.9	
Cc	1.3		Cp	0.9		Fr	0.7	
	100.0			100.0			100.0	

Variant of Mol. Norm:

Zoisite, Chlorite			Diopside, Biotite			Hornblende, Biotite		
Q	12.8	12.8	Q	2.1	2.1	Q	−4.0	−4.0
Or	32.0	72.4	Or	11.5		Or	18.3	
Ab	40.4		Ab	45.5	71.8	Ab	45.0	69.8
An	..		An	14.8		An	6.5	
Zo	6.4	6.4	Di	10.2	23.7	Ho*)	17.0	24.6
Am } Chl {....	2.0	6.0	Bi	13.5		Bi	7.6	
Ant } Chl {....	4.0					Mt	1.4	
Mt	0.2		Mt	0.1	2.4	Tit	5.1	9.6
Ru	0.5	2.4	Ru	1.2		Ru	0.5	
Cp	0.4		Cp	0.9		Cp	1.9	
Cc	1.3			100.0		Fr	0.7	
	100.0						100.0	

*) basaltic Hornblende after E. Tröger.

Mode (measured)

WB 142

	Vol. %
Quartz	15.2
Alkali-feldspar, Oligoclase (both decomposed)	75.1
Chlorite	7.6
Ore	2.0

Analyst: Dr. H. Schwander

WB 141 — Mode (measured)

	Vol. %
Quartz	6.6
Feldspar (Kalifeldspar) (decomposed) + Plagioclase	73.9
Colourless Pyroxene + colourless and green Hornblende	15.2
Biotite (replaced by Chlorite)	2.1
Ore, Sphene, Apatite	2.3

WW 48 — Mode (measured)

	Vol. %
Alkali-feldspar + Plagioclase	70.1
Basaltic Hornblendee (with rim of arfvedsonite)	17.1
Biotite (with Sagenite)	7.9
Ore, Sphene	3.7
Apatite	1.2

Table 2 cont.

No: WB 150		No: WB 140		No: WW 97	
SiO_2	45.19	SiO_2	40.02	SiO_2	54.30
TiO_2	6.65	TiO_2	3.01	TiO_2	1.29
Al_2O_3	14.13	Al_2O_3	6.31	Al_2O_3	18.75
Fe_2O_3	3.18	Fe_2O_3	4.05	Fe_2O_3	1.97
FeO	8.75	FeO	8.80	FeO	4.30
MnO	0.13	MnO	0.13	MnO	0.06
MgO	4.23	MgO	18.56	MgO	4.27
CaO	9.28	CaO	15.85	CaO	5.54
Na_2O	3.30	Na_2O	0.64	Na_2O	4.03
K_2O	2.49	K_2O	0.58	K_2O	4.54
H_2O^+	1.35	H_2O^+	1.79	H_2O^+	0.17
H_2O^-	0.12	H_2O^-	0.07	H_2O^-	0.04
P_2O_5	1.08	P_2O_5	0.04	P_2O_5	0.75
CO_2	..	CO_2	tr.	CO_2	..
S	0.41	S	0.32	S	..
F	tr.	F	tr.	F	..
—O(S)	—0.10	—O(S)	—0.08	—O(S)	..
	100.19		100.09		100.01

Mol. Norm			Mol. Norm			Mol. Norm		
Q.............	—7.2	—7.2	Q.............	—2.5	—2.5	Q.............	—4.3	—4.3
Or.........	15.4		Or.........	3.7		Or.........	26.5	
Ab.........	30.5	62.8	Ab.........	6.0	22.2	Ab.........	35.9	81.9
An.........	16.9		An.........	12.5		An.........	19.5	
Wo.........	9.7		Wo.........	26.8		En.........	11.7	17.0
En.........	12.1	32.5	Fo.........	38.9	74.0	Hy.........	5.3	
Hy.........	10.7		Fa.........	8.3		Mt.........	2.1	
Mt.........	3.5		Mt.........	4.2	6.3	Tit.........	1.4	5.4
FeS.........	1.4	11.9	Ru.........	2.1		Ru.........	0.4	
Ru.........	4.8			100.0		Cp.........	1.5	
Cp.........	2.2						100.0	
	100,0							

Variant of Mol. Norm: Augite, Biotite			Variant of Mol. Norm: Tit. Augite, Hornblende			Variant of Mol. Norm: Diopside, Ho, Amesite		
Or.........	14.4		Q.............	—0.7		Q.............	4.3	4.3
Ab.........	30.5	51.3	Ol.............	19.8		Or.........	26.5	
An.........	6.4		Tit. Aug.......	59.0		Ab.........	25.9	57.9
Ol.........	4.1		Di.........	3.2		An.........	5.5	
Tit. Aug.*).....	32.6	38.3	Ho (basaltic)...	16.0		Di.........	7.2	
Bi.........	1.6		Mt.........	2.7		Ho.........	16.0	32.4
Mt.........	3.5			100.0		Am.........	9.2	
FeS.........	1.4	10.3				Mt.........	2.1	
Ru.........	3.2					Tit.........	1.4	5.4
Cp.........	2.2					Ru.........	0.4	
	99.9					Cp.........	1.5	
							100.0	

*) after Tröger.

Mode (measured) Vol. %		Mode (measured) Vol. %		Mineralogical composition
Plagioclase (zoned 53—35 % An strongly decomposed)	54.8	Olivine	19.8	Oligoclase, Diopside, Augite, Hornblende.
Olivine (replaced partly by Biotite)	4.0	Titanaugite	60.8	Ground mass indeterminable.
Titanaugite (zoned)...	27.9	Basaltic Hornblende ..	16.0	Accessories Ore + Quartz.
Biotite (Lepidomelane)	1.2	Ore	3.4	
Ore, Apatite, Chlorite.	11.9			

(WW 97) also suggests this, but so far we have found no other rock corresponding to it. We therefore refer the porphyrites of the Kolossen to the basic complex but with reservations.

The Maageborg-Monte Somma complex is repeatedly pierced by acid dykes of alkali-syenitic composition. Larger alkali-syenitic masses enclosed therein are indicated separately on the map.

These observations show that the basic intrusions are older than a number of the alkali-syenitic ones.

Numerous sills and dykes seem to extend from the basic complex towards the east and south. The vein systems between Søndergletscher and the Blomsterdal show a radial arrangement (E. WENK, cf. map). For the petrographic composition of these dykes and their relationship to the basalts, see p. 36.

Basic Marginal Facies and Breccias.

The peaks of Uglespids and Petersryggen and also the ridge of the latter extending towards Antarctic Dal consist of a fine- to close-grained, partly porphyritic, marginal facies of the basic intrusion which has the character of a breccia (Pl. VII). The mineral content of these rocks of diabasic appearance agrees with that one of the coarsely crystalline gabbroid rocks, but the ground mass—and in this mainly the plagioclase—is almost completely decomposed. Thus, rocks from the Petersryggen contain idiomorphic phenocrysts of titanaugite or plagioclase (normally zoned with 40 to 41 An) in their dark-green ground mass. The lath-shaped plagioclase of this ground mass is decomposed and pyroxene as well as hornblende is always residual. In addition to ore, the products of disintegration are chlorite, green hornblende, epidote, and calcite and occasional quartz. At the Petersryggen as well as at the Uglespids this marginal facies is interspersed with light-coloured alkali-granitic to alkali-syenitic veins, precisely like the gabbros elsewhere.

A somewhat different composition is shown by the upper part of the Maageborg. Both in the south slope and in the northern ridge of this mountain we observed a polygenic breccia, at least 400 m thick. In a basic, highly decomposed cement light-reddish, angular or roundish constituents of alkali-granitic and alkali-syenitic composition occur, partly micro-trachitic in texture. Towards the summit these components grow less dominant and finally they almost entirely disappear, so that a rock of diabasic character results which is very similar to the marginal facies of the Uglespids mentioned above.

These breccias with their typical reddish components must also be distributed in the mountains between Petersryggen and Uglespids (see pl. 8), for they are frequently met with in the moraines of the upper Blomsterdal (E. WENK). Unfortunately this part is imperfectly known and we are

therefore unaware of the exact extension of the breccia. The transition into a border facies of diabasic character in the southern slope of the Maageborg makes us think that the basic magma carried with it numerous fragments of older alkali-syenites (and alkali-granites) accumulating in the upper portions of that magma, which was ready for eruption. These reddish alkali-syenites have not been found in situ in the Werner Bjerge region.

The Volcanic Agglomerate.

The material collected by E. Wenk (1953) during the ascent of Monte Somma is of quite a different character. This series ranges from tuff-breccias to volcanic agglomerates and seems to be confined to the southern border of the gabbro-pyroxenite mass. These agglomerates are cut by basic dykes (i. e. pyroxenite veins) which are connected with the basic or ultrabasic intrusions (photo A, pl. 14).

The composition of the rocks confronts us with some new questions which, owing to our unsatisfactory knowledge of this section, we are unable to answer. In a dark-brown, glassy or tuffaceous ground mass, angular or rounded hypo- or micro-crystalline, and often amygdaloid constituents of basaltic nature occur, and among them we see a few plutonic components (monzonites and pyroxenites). The latter would indicate that some of the basic intrusives had already crystallized before the loose masses were ejected. These tuff-breccias and agglomerates may be vent formations.

The Shape of the Basic Intrusion.

The basement of the intrusion is well exposed in two places. South of Antarctic Gletscher it consists of flat-lying sediments. A close-grained, in part brecciated, marginal facies of diabasic appearance here forms the contact and is united with the analogously developed upper marginal facies which slopes roof-like from the Petersryggen towards Antarctic Dal. The profile thus shows that the intrusion wedges out rather rapidly towards the east. The different stages of transition from a coarsely grained plutonic facies into a marginal facies of diabasic appearance and into breccias make the subvolcanic character of the intrusion clearly visible.

The northernmost offshoot of the basic complex occurs in situ near the Ruinerne (see p. 14), its basement dipping 20° to 30° towards the south and made up of alkali-syenite breccias and intrusions penetrating the basic rock as numerous apophyses.

Along the southern margin (Monte Somma) basic agglomerates abut on the intrusive bodies, the contact planes being steep. This is probably the case with the entire southern margin, which is completely covered by the ice of the Nord Gletscher. In the basin of this glacier we

assume the presence of a fault line, separating the flat-lying sediments of the western bank from the basic series and possibly furnishing the zone of eruption for the basic magma.

From these fragmentary observations it appears that the intrusive body had an asymmetrical form with steep west and south sides and a central portion of the same character. Northwards the intrusion ran out into a flat tongue and in the east, too, the sediments dip flatly beneath the basic eruptive rocks.

These remarks refer to the outline of the main intrusion. As already mentioned, basic masses still occur marginally as minor stocks or broad veins in the upper part of Antarctic Dal (see fig. 2). To the north too the basic intrusions must—at any rate at depth—originally have reached farther, because monzonite (or essexite) boulders occur in the alkali-syenites at the western edge of Østre Gletscher. There is in fact no proof that these belong to the basic complex, but basic to intermediary rocks, some of which are rich in alkali, seem to have preceded the acid series of alkali-syenite and granitic eruptive rocks over the whole region.

The Group of Dark Porphyries, Tuff-breccias, and Porphyritic Breccias.

The main representatives of this group are dark-brown, chocolate-coloured, or grey porphyries with tabular phenocrysts of alkali-feldspar (micro-perthite, antiperthite) up to one centimetre in size, set in a microcrystalline ground mass of microperthite, albite, and biotite. These aplite-syenite rocks form dykes and are intermingled with acid volcanic breccias. The contacts are usually concealed by mineralization which in this group of rocks is particularly frequent; but transition of porphyries into breccias as well as a sharp contact between them were observed. Breccias and porphyries are in part contemporary, but some of the porphyries are younger, for they often surround blocks from the breccias; porous tuffs are intercalated with these breccias. The huge accumulation of breccias building up the central and eastern roofs obscures any recognizable structure. Only at the eastern ridge of Antarctic Spids could we see clearly defined beds, but unfortunately we could not examine them. The breccias here overlap flat-lying Palaeozoic sediments. In other places, as for instance on the northern bank of Sirius Gletscher, they are seen to dip below the sediments.

The microscopic examination showed that two groups of *breccias* occur and that they are distinguishable by their cement. The constituents, which rarely attain the size of a head, in both cases consist of aplite- or alkali-syenite rocks; trachytic and porphyritic textures are widely distributed, spherulitic and aplitic or granophyric textures are rarer,

and only exceptionally does hyalopilitic texture occur. In these constituents we come across the same kinds of rock as in the numerous acid dykes, which break up this hypabyssal breccia- and porphyry-complex. (See p. 34).

For the most part angular—seldom rounded—fragments are as a rule cemented together by a pyroclastic, partially microbrecciated matrix, consisting of the same material as the components. This first group of breccias may consist of conduit material or of accumulations of loose material as if from the roof.

In the second group of breccias, the cement is formed by an aplite-syenite crystallization product of a melt (holo- or hypo-crystalline, often porphyritic), with extensive flow structures.

During the formation of this whole complex of breccias explosive processes must have alternated with relatively quiet phases. The material already consolidated was broken up by subsequent intrusions of the highly viscous melts which fill the interstices.

Of a somewhat different character is a monogene vent breccia we found on the ridge connecting the Antarctic Spids and the Lejrryggen. Its transverse section is approximately circular, and it consists of remarkably coarse, partly angular, partly rounded, cubic meter sized components of an almost white porphyritic microtrachyte. The components were here cemented together by a cement of the same kind and partly by hydrothermal deposits with limonite, quartz, and calcite.

The uniform petrographic composition of the breccias is noteworthy. The complete absence of sedimentary components is especially remarkable. The porphyrites, which are very rarely found enclosed, are of a composition very similar to the porphyrite of the Kolossen mentioned above.

Although the whole group of porphyries and breccias shows an aplite- to alkali-syenitic composition, these rocks are usually of a dark colour due to a fine manganiferous limonitic pigment resulting from a late- or post-magmatic impregnation with volatiles.

Alkali-Granites and Alkali-Syenites.

Rocks of alkali-(aplite-)granitic or alkali-syenitic composition are widely distributed in the northern part of the massif on either side of the Mellemgletscher and Østre Gletscher. The quartz-bearing acid intrusions are even limited exclusively to the northern edge of the pluton. They pass imperceptibly through nordmarkites into the alkali- and aplite-syenite intrusions. A thick marginal facies at the contact between alkali-granites and alkali-syenites was observed only sporadically; in general, quartz-bearing and quartz-free facies alternate imperceptibly.

Table 3. Alkali-granites.

No: WB 6			No: WB 14		
SiO_2	74.37		SiO_2	71.38	
TiO_2	tr.		TiO_2	0.25	
Al_2O_3	13.22		Al_2O_3	14.65	
Fe_2O_3	0.12		Fe_2O_3	0.17	
FeO	1.05		FeO	1.54	
MnO	0.07		MnO	0.04	
MgO	0.61		MgO	0.31	
CaO	1.44		CaO	1.60	
Na_2O	4.87		Na_2O	4.51	
K_2O	3.97		K_2O	4.64	
H_2O^+	0.19		H_2O^+	0.21	
H_2O^-	0.05		H_2O^-	0.07	
P_2O_5	tr.		P_2O_5	0.64	
S	0.04		S	0.00	
F	0.07		F	0.14	
—OF	0.03		—OF	0.06	
—OS	0.01		—OS	..	
	100.03			100.09	

Mol. Norm			Mol. Norm		
Q	25.4	25.4	Q	21.8	21.8
Or	23.6		Or	27.5	
Ab	43.5	69.1	Ab	40.3	71.4
An	2.0		An	3.6	
Wo	1.9		Cord	2.2	
En	1.6		Fe-Cord	0.5	4.7
Hy	1.7	5.5	Hy	2.0	
Fr	0.3		Mt	0.2	
	100.0		Ru	0.2	2.1
			Cp	1.1	
			Fr	0.6	
				100.0	

Variant of Mol. Norm. Diopside, Biotite			Variant of Mol. Norm: Biotite-Amesite		
Q	26.1		Q	23.5	23.5
Or	22.5		Or	26.7	
Ab	43.5	68.0	Ab	40.3	70.6
An	2.0		An	3.6	
Di	3.8		Bi	1.3	
Bi	1.8	5.6	Am	2.5	3.8
Fr	0.3	0.3	Mt	0.2	
	100.0		Ru	0.2	2.1
			Cp	1.1	
			Fr	0.6	
				100.0	

Mode (measured)	Vol. %	Mode (measured)	Vol. %
Quartz	34.2	Quartz	33.1
Perthite and Albite	62.4	Microperthite	57.1
Biotite	1.9	Plagioclase	5.9
Ore	0.8	Biotite (+ Chlorite)	3.2
Fluorite	0.6	Ore, Apatite, Fluorite	0.6

Analyst: Dr. H. SCHWANDER.

Table 4. Alkali-syenites and syenite-porphyries.

No: WW 9		No: WW 54		No: WB 39	
SiO_2	63.12	SiO_2	62.74	SiO_2	61.44
TiO_2	0.82	TiO_2	0.98	TiO_2	1.19
Al_2O_3	17.69	Al_2O_3	17.65	Al_2O_3	17.99
Fe_2O_3	1.12	Fe_2O_3	1.67	Fe_2O_3	1.72
FeO	2.01	FeO	0.98	FeO	1.05
MnO	0.02	MnO	tr.	MnO	0.12
MgO	0.29	MgO	0.93	MgO	0.63
CaO	1.10	CaO	1.03	CaO	1.48
Na_2O	7.91	Na_2O	7.22	Na_2O	6.90
K_2O	3.61	K_2O	6.11	K_2O	6.02
H_2O^+	1.22	H_2O^+	0.59	H_2O^+	1.17
H_2O^-	0.12	H_2O^-	0.08	H_2O^-	0.10
P_2O_5	0.02	P_2O_5	0.09	P_2O_5	0.14
CO_2	..	CO_2	0.0	CO_2	0.37
$^1/_2 SO_3$	0.84	$^1/_2 SO_3$	..	$^1/_2 SO_3$	..
S	..	S	0.0	S	..
F	..	F	..	F	..
$-OF$	..	$-OF$	..	$-OF$	..
	99.89		100.07		100.32

Mol. Norm			Mol. Norm			Mol. Norm		
Q	0.6	0.6	Q	−3.6	−3.6	Q	−2.6	−2.6
Or	21.0		Or	35.0		Or	34.8	
Ab	70.6	93.7	Ab	58.8	93.8	Ab	60.3	95.4
An	2.1		Ac	3.5		An	0.3	$Or_{37}Ab_{63}$
En	0.8		En	2.5	7.2	En	1.7	
Hy	2.3	3.1	Hy	1.2		Hy	0.7	2.4
Mt	1.2		Mt	0.4		Mt	1.7	
Tit	1.4	2.6	Tit	2.0	2.6	Tit	1.7	
			Cp	0.2		Ru	0.2	4.8
						Cp	0.3	
						Cc	0.9	
	100.0			100.0			100.0	

Variant of Mol. Norm: Arfvedsonite, Biotite			Variant of Mol. Norm: Nepheline, Acmite, Biotite			Variant of Mol. Norm: Biotite Variant		
Q	1.7	1.7	Q	..	..	Q	−1.4	−1.4
Or	20.5		Or	32.0		Or	32.8	
Ab	64.4	89.0	Ab	54.3	86.3	Ab	60.3	93.4
An	4.1		Ne	2.7	2.7	An	0.3	
Arfv	6.6		Ac	3.5		Bi	3.2	3.2
Bi	0.8	7.4	Bi	4.8	8.3	Mt	1.7	
Mt	1.2		Mt	0.4		Tit	1.7	
Tit + Ru	0.6	1.8	Tit	2.0	2.6	Ru	0.2	4.8
			Cp	0.2		Cp	0.3	
						Cc	0.9	
	99.9			99.9			100.0	

Mode (measured)	Vol. %	Mineralogical composition:	Mode (measured)	Vol. %
Alkali-feldspar	90.1	Microperthite, Albite, Biotite, Aegirine-augite. Sphene, Apatite, Ore.	Quartz	1.2
Arfvedsonite, Diopside, Biotite	7.8		Microperthite	91.7
Ore, Sphene, Apatite etc.	2.1		Ore, Sphene	4.9
			Calcite	2.1

Analyst: Dr. H. Schwander.

Table 4 cont.

No: WB 59		No: WW 95		No: WB 76	
SiO_2	62.20	SiO_2	61.43	SiO_2	60.76
TiO_2	0.82	TiO_2	0.83	TiO_2	1.07
Al_2O_3	17.39	Al_2O_3	19.90	Al_2O_3	19.39
Fe_2O_3	1.76	Fe_2O_3	0.80	Fe_2O_3	1.30
FeO	2.10	FeO	0.63	FeO	1.61
MnO	tr.	MnO	0.11	MnO	0.10
MgO	1.03	MgO	0.41	MgO	0.74
CaO	1.20	CaO	1.63	CaO	0.77
Na_2O	7.02	Na_2O	7.67	Na_2O	6.52
K_2O	5.51	K_2O	5.80	K_2O	6.68
H_2O^+	0.72	H_2O^+	0.49	H_2O^+	0.25
H_2O^-	0.11	H_2O^-	0.18	H_2O^-	0.07
P_2O_5	0.15	P_2O_5	0.18	P_2O_5	0.08
CO_2	0.0	CO_2	..	CO_2	0.62
$^1/_2 SO_3$	..	$^1/_2 SO_3$	..	$^1/_2 SO_3$	..
S	0.0	S	0.00	S	tr.
F	..	F	0.13	F	..
—OF	..	—OF	0.05	—OF	..
	100.01		100.14		99.96

Mol. Norm			Mol. Norm			Mol. Norm		
Q	−3.0	−3.0	Q	−6.8	−6.8	Q	−5.4	−5.4
Or	32.0	93.4	Or	33.1	101.6	Or	38.6	95.6
Ab	61.4		Ab	65.5		Ab	57.0	
Wo	0.7		An	3.0		An	..	
En	2.8	6.3	En	1.1	1.8	Cord	4.2	
Hy	2.3		Hy	0.7		En	0.4	6.3
Ac	0.5		Mt	0.8		Hy	1.7	
Mt	1.5		Tit	1.4	3.4	Mt	1.3	
Tit	1.5	3.3	Cp	0.4		Ru	0.7	3.5
Cp	0.3		Nat	0.8		Cc	1.5	
	100.0			100.0			100.0	

Variant of Mol. Norm: Acmite, Biotite			Variant of Mol. Norm: Sodalite, Analcime			Variant of Mol. Norm: Biotite, Sericite		
Q	−0.4	−0.4	Q	..	..	Q	−2.9	−2.9
Or	27.7	89.1	Or	31.6		Or	30.9	
Ab	61.4		Ab	47.5	82.4	Ab	57.0	93.4
Wo	0.7		An	3.3		Sc	5.5	
Ac	0.5	8.0	Sod	8.0	12.0	Bi	6.0	6.0
Bi	6.8		Anc	4.0		Mt	1.3	
Mt	1.5		Arfv	1.1	3.5	Ru	0.7	3.5
Tit	1.5	3.3	Bi	2.4		Cc	1.5	
Cp	0.3		Tit, Ru, Hm, Cp	2.2	2.2		100.0	
	100.0			100.1				

Mode (measured)	Vol. %	Mode (measured)	Vol. %	Mode (measured)	Vol. %
Alkali-feldspar	90.1	Perthite, Antiperthite,		Alkali-feldspar	
Phenocrysts (25.0)		Albite	91.7	(decomposed)	92.8
+ ground mass (65.1)		Sodalite, Analcime	4.2	Pyroxene, Biotite	4.5
Brown Hornblende,		Arfvedsonite, Biotite	3.2	Ore, Carbonate	2.7
Riebeckite, Biotite	7.9	Ore, Sphene	0.9		
Ore, Sphene, Apatite	2.0				

Table 4 cont.

No: WB 123		No: WW 30		No: WW 104	
SiO$_2$	60.43	SiO$_2$	59.23	SiO$_2$	58.05
TiO$_2$	0.58	TiO$_2$	1.35	TiO$_2$	1.99
Al$_2$O$_3$	20.17	Al$_2$O$_3$	18.41	Al$_2$O$_3$	19.86
Fe$_2$O$_3$	1.98	Fe$_2$O$_3$	2.05	Fe$_2$O$_3$	1.07
FeO	0.70	FeO	1.47	FeO	1.18
MnO	0.24	MnO	0.07	MnO	0.08
MgO	1.09	MgO	0.47	MgO	1.29
CaO	1.86	CaO	3.44	CaO	1.92
Na$_2$O	8.08	Na$_2$O	5.78	Na$_2$O	7.54
K$_2$O	4.67	K$_2$O	6.85	K$_2$O	5.89
H$_2$O$^+$	0.06	H$_2$O$^+$	0.77	H$_2$O$^+$	0.86
H$_2$O$^-$	0.11	H$_2$O$^-$	0.13	H$_2$O$^-$	0.09
P$_2$O$_5$	tr.	P$_2$O$_5$	0.15	P$_2$O$_5$	0.05
CO$_2$	0.22	CO$_2$	tr.	CO$_2$	0.12
$^1/_2$ SO$_3$	..	$^1/_2$ SO$_3$	..	$^1/_2$ SO$_3$	..
S	tr.	S	..	S	..
F	0.11	F	tr.	F	..
—OF	0.05	—OF	..	—OF	..
	100.25		100.17		99.99

Mol. Norm			Mol. Norm			Mol. Norm		
Q	—8.1	—8.1	Q	—4.9	—4.9	Q	—11.7	—11.7
Or	27.0		Or	40.0		Or	33.9	
Ab	69.9	101.5	Ab	51.2	95.4	Ab	65.5	102.4
An	4.6		An	4.2		An	3.0	
En	2.9	2.9	Wo	2.3		En	3.5	4.8
Mt	2.0		En	1.2	4.4	Hy	1.3	
Tit	1.3	3.7	Hy	0.9		Mt	1.1	
Cc	0.4		Mt	2.1		Tit	2.7	4.5
	100.0		Tit	2.7	5.1	Ru	0.5	
			Cp	0.3		Cc	0.2	
				100.0			100.0	

Variant of Mol. Norm: Cancrinite, Acmite, Biotite			Variant of Mol. Norm: Prehnite, Biotite			Variant of Mol. Norm: Analcime, Cancrinite, Biotite		
Q	—3.5	—3.5	Q	—3.3	—3.3	Q	—6.1	—6.1
Or	23.8		Or	38.3		Or	29.9	
Ab	56.8	87.3	Ab	51.2	89.5	Ab	52.5	85.4
An	6.7		Prh	5.9	5.9	An	3.0	
Canc	4.0		Bi	2.8	2.8	Anc	8.0	10.0
Ac	5.5	15.1	Mt	2.1		Canc	2.0	
Bi	5.6		Tit	2.7	5.1	Bi	6.4	6.4
Ru	0.4	1.2	Cp	0.3		Mt + Tit etc.	4.3	4.3
Sill	0.8			100.0			100.0	
	100.1							

Mode (measured)			Mineralogical composition:		Mode (measured)	
	Vol. $^0/_0$					Vol. $^0/_0$
Perthite, Antiperthite, Albite	92.2		Phenocrysts (25 Vol. $^0/_0$) in ground mass of Alkali-feldspar, Augite and Biotite. Accessories: Sphene, Prehnite, Carbonate.		Perthite and Antiperthite (partly decomposed)	92.3
Cancrinite (?), Carbonate	4.3				Analcime	2.5
Ore	3.3				Amphibole	0.9
					Biotite	3.3
					Ore, Sphene, Apatite	1.2

All these rocks are medium- to coarse-grained. They often, and not only at the margin, turn into porphyries with a fine- to close-grained ground mass and occasionally they also change into felsitic or (rarely) granophyric and trachytic varieties free from phenocrysts. Transition into brecciated portions can be seen as well. Banded alternation of grain-size and texture and development of pegmatoid patches are typical. All these facts are signs of a shallow intrusion level.

Alkali-feldspar (microcline-micro-perthite and antiperthite, anortho-clase, orthoclase) is the dominant constituent everywhere. The crystals have a fringe of *albite* and this mineral also fills the interstices. *Plagio-clase* (An 4—17) was seen sporadically only once as a relict of an inversely zoned feldspar 0—21 An. There are two generations of *quartz*; it appears as phenocrysts and also is seen filling interstices as a late exudation. It is remarkable that the phenocrysts show nowhere the typical form of quartz-porphyries. Even macroscopically their rounded shapes are conspicuous and resemble grains of sand; the outlines are of an irregu-larly fringy appearance and the crystals are broken. This suggests that here foreign material has been derived from the surrounding sediments and only partially—if at all—absorbed. (See also p. 55).

Of the sparse mafic minerals, only occasional residual biotite can be recognized, all else having been replaced by limonite. This decom-position probably takes place parallel with deuteric processes and the formation of *fluorite*, which especially in quartz-bearing rocks can be observed regularly. In addition to fluorite, chlorite, and ore, accessory apatite, zircon, epidote, and—most frequently—calcite, occur.

In druses in these rocks we have also found purple fluorite, molyb-denite, and wolframite, as well as quartz, feldspar, and chlorite. Molyb-denite and wolframite also occur as phenocrysts in pegmatoid schlieren. Sparse amounts of chalco-pyrite(?), pyrite, and zinc blende complete this paragenesis. Tables 3 and 4 give the chemical analyses of alkali-granite, alkali-syenite-aplites, and alkali-porphyries and are discussed on page 47.

Smaller quantities of feldspathoid-bearing alkali-syenites (pulaskites) also occur in this area, for example at the northern foot of the Karhöjen, at Savkammen, and at Titanitspids. In addition to alkali-feldspar (perthite, antiperthite, and albite), they contain sodalite, analcite, and colourless finely laminated mica, natrolite(?), and fluorite. For the most part these feldspathoid-bearing rocks contain rather more mafic minerals than the quartz-bearing ones, and—in contrast to the group mentioned above—they are, as a rule, well preserved (diopsidic augite, aegirine, aegirine-augite, riebeckite, arfvedsonite, and barkevikite (rare) beside brown or olive-green biotites). Accessories are chlorite, zircon, sphene,

ore, calcite, and quartz. The pegmatoid alkali-syenite of Titanitspids contains some percentage of sphene. In addition to Fe, Mn, Zr, and Nb, the spectrographic examination of the sphene showed a notably high content of rare earths (cf. plate 21).

The main area of distribution of the feldspathoid-bearing alkali-syenites is found on either side of the line Antarctic Pas-Sirius Gletscher, where pulaskites are closely associated with nepheline-syenites and appear as a special facies of these rocks; they will therefore be described in more detail with those in the next section. Some of the feldspathoid-bearing rocks occurring north of the abovementioned line may be connected with this major nepheline-syenite intrusion. Table 6 contains the analyses of some rocks belonging to this intermediary group.

The Nepheline-Syenites.

According to A. Noe-Nygaard, Nordenskiöld brought home from Nordostbugten in Scoresby Sund a sample of an erratic nepheline-syenite, which has hitherto been the only evidence of a possible occurrence in situ of this kind of rock in the entrance area of Schuchert Gl. In fact the nepheline-syenites have their main distribution in the upper part of the Schucherts Flod Valley, on either side of Sirius Gletscher and Aldebaran Gletscher, so that abundant nepheline-syenite erratics can be expected to occur towards Scoresby Sund.

In fresh sections the nepheline-syenites generally show a dark colour; in grain-size and texture, however, they constantly vary. Pegmatoids and sometimes pegmatoid-trachytoid schlieren and masses can be observed especially in the light-weathering rocks of the Hvide Ryg and at the Randgletscher; of a more homogeneous and bulkier appearance, however, are the darker-coloured nepheline-syenites on the western slope of the Hvide Ryg and on either side of the lower portion of Aldebaran Gletscher (pls. 9, 10, 16). We are possibly concerned here with two different foyaitic intrusions; in the upper part of the southern wall of Hvide Ryg apophyses of the light-weathering rock seem to penetrate into the darker rock extending in front of it, and dissolving it into blocks. Unfortunately I was unable to examine that ridge in 1954. In the rock wall itself the transition from one kind of rock to the other takes place imperceptibly and so far no difference of composition has been ascertained even under the microscope. The problem remains unsettled for the present, so in the following pages only *one* nepheline-syenite intrusion will be dealt with.

At various points of the Hvide Ryg the nepheline-syenites have disintegrated hydrothermally along fissures and have become reddish in colour on weathering. The cracks contain quartz, calcite, siderite,

fibrous strontianite and baryte (?), often in beautiful crystals. Only occasionally a connection between these vents and minor zones of disturbance exists; for the most part they end blindly upwards in the fresh rock. Another disintegration of the primary mineral content is conspicuous in many places, especially between the Aldebaran Gletscher and the Randgletscher. Here the rock often turns dark-grey and is hard to distinguish from the breccias and porphyries it cuts. The alkalifeldspar of the nepheline-syenite then becomes dully reddish, while the nepheline crumbles into a grey to light-green aggregate of microcrystalline scales (kaolinite?).

In various places the nepheline-syenite contains inclusions from the adjacent rocks, partly as small fragments of a brecciated character, partly as blocks many metres thick (pl. 11). They are derived either from the sedimentary covering beds, from the group of porphyries and breccias, or from basalts, and show some resorption phenomena. In the basalts this causes a complete disappearance of the feldspathic part, while the augite is preserved as an "armoured relict" enclosed in a reaction rim of phlogopite and aegirine-augite.

Constituents of the Nepheline-Syenites.

The minerals of the nepheline-syenites are listed below:

Feldspar: Microcline-microperthite and antiperthite, albite.

Feldspathoids: Nepheline, sodalite, analcime, cancrinite.

Mafics: Aegirine (some colourless), aegirine-augite (partly with diopside cores), barkevikite, arfvedsonite, biotite (brown).

Accessories: Apatite, sphene, ore, zoisite, rutile (?), muscovite, fluorite, calcite.

Secondary: Muscovite, zoisite, kaolinite (?).

Rare minerals: Låvenite, zircon, lamprophyllite, mosandrite, and narsarsukite (and some doubtful minerals).

Some additional remarks:

Main constituents are the alkali-feldspars and the feldspathoids which, however, vary greatly in quantity, so that all transitions from alkalisyenitic through pulaskitic and nepheline-syenitic to juvaitic types can be found.

Disregarding occasional schlieren, the content of mafics remains below 10 vol. per cent.

As a rule, the light-coloured components are of a similar grey colour and it is difficult to distinguish them from one another macroscopically. The *nepheline* is frequently transformed into brick-red spreustein

Table 5. Nepheline-Syenite.

No: WB 250

SiO_2	55.19
TiO_2	0.84
Al_2O_3	21.90
Fe_2O_3	1.29
FeO	1.19
MnO	0.09
MgO	0.49
CaO	2.28
Na_2O	8.11
K_2O	6.80
H_2O^+	0.77
H_2O^-	0.15
P_2O_5	0.12
CO_2	0.71
F	tr.
	99.93

Mol. Norm

Or	38.6	
Ab	22.0	64.0
An	3.4	
Ne	28.9	28.9
En	1.3	2.5
Hy	1.2	
Mt	1.3	
Tit	1.3	4.6
Cp	0.3	
Cc	1.7	
	100.0	

Variant of Mol. Norm:
Cancrinite, Biotite

Or	36,6	
Ab	25.2	65.2
An	3.4	
Ne	11.7	28.7
Canc	17.0	
Bi	3.2	3.2
Mt + Tit + Cp	2.9	2.9
	100.0	

Mode (measured)
Vol. %

Orthoclase and Microperthite (decomposed)	66.2
Nepheline (partly changed into Cancrinite or Sodalite)	19.5
Sodalite	4.8
Cancrinite	5.2
Aegirine, Biotite (< 1.0 %)	3.2
Ore, Sphene	1.0

Analyst: Dr. H. Schwander.

Table 6. Alkali-Syenites.

No: WB 51		No: WB 51 A	
SiO_2	59.51	SiO_2	58.34
TiO_2	0.93	TiO_2	0.97
Al_2O_3	20.04	Al_2O_3	20.44
Fe_2O_3	0.65	Fe_2O_3	0.68
FeO	1.40	FeO	1.40
MnO	0.12	MnO	0.12
MgO	1.24	MgO	0.76
CaO	2.20	CaO	2.28
Na_2O	6.98	Na_2O	6.49
K_2O	5.96	K_2O	7.70
H_2O^+	0.72	H_2O^+	0.38
H_2O^-	0.14	H_2O^-	0.13
P_2O_5	0.17	P_2O_5	0.11
CO_2	0.20	CO_2	0.12
S	tr.	S	0.00
F	0.16	F	0.09
—OF	0.07	—OF	0.04
	100.35		99.97

Mol. Norm			Mol. Norm		
Q	−7.5	−7.5	Q	−11.6	−11.6
Or	33.3		Or	44.0	
Ab	61.1	99.9	Ab	56.0	103.9
An	5.5		An	3.9	
En	3.3		Wo	0.8	
Hy	1.7	5.0	En	2.0	4.5
Mt	0.6		Hy	1.7	
Ru	0.6		Mt	0.7	
Cp	0.4	2.6	Tit	1.8	3.2
Fr	0.6		Cp + Fr + Cc ..	0.7	
Cc	0.4				
	100.0			100.0	

Variant of Mol. Norm: Acmite, Analcime, Biotite			Variant of Mol. Norm: Cancrinite, Sodalite, Analcime-Natrolite		
Q	−0.8	−0.8	Q	..	..
Or	28.8		Or	41.6	
Ab	39.1	89.4	Ab	21.0	66.5
An	5.5		An	3.9	
Anc	16.0		Anc	8.8	
Ac	1.6	8.8	Natr	10.5	25.3
Bi	7.2		Sod	4.0	
Mt	0.6		Canc	2.0	
Ru	0.6		Di	1.6	5.6
Cp	0.4	2.6	Bi	4.0	
Fr	0.6		Mt + Tit + Cp .	2.6	2.6
Cc	0.4				
	100.0			100.0	

Mode (measured)	Vol. %	Mode (measured)	Vol. %
Alkali-feldspar (partly replaced by Analcime)	88.4	Alkali-feldspar (strongly decomposed in parts & turned into Natrolite + Analcime + Cancrinite (?))	92.3
Aegirine, Aegirine-Augite	4.4		
Biotite	3.1	Pyroxene, Amphibole, Biotite	5.0
Analcime (in interstices)	2.9	Ore, Sphene, Carbonate	2.6
Ore, Sphene, Carbonate, Apatite	1.1		

Analyst: Dr. H. SCHWANDER.

[aggregate of fine-scaled mica; — 2 V:0 — 30°, n_α 1,5—1,6 $n\gamma$ — $n\alpha$ ~ 0,025 radially fibrous; with a fine pigment, colourless or red (haematite) and opaque] or into greenish kaolinite (?). *Sodalite* is primary, occurring as drop-shaped inclusions in feldspar and in aegirine. It is only blue in the pegmatitic schlieren. The analcime too is probably in part primary, but for the other part it is certainly derived from transformation of nepheline or sodalite, while cancrinite always develops at the expense of nepheline.

Alkali-feldspar (sometimes with sodalite?) is the first of the light-coloured components to crystallize out, then follows nepheline. Analcime and sodalite fill the interstices (secondary?) but aegirine and calcite also occur as the last products of separation. The interval of formation seems to be broader for aegirine than it is for feldspar. Since mafics are rare, and inclined to aggregate, their relation to the crystallization of the light-coloured components often cannot be ascertained clearly. Within the mafics apatite develops first, followed by ore and sphene, the crystallization of which may last longer than the crystallization of aegirine. Part of the biotite crystallizes out before aegirine and part after.

The most widely distributed type of rock of the Hvide Ryg is represented by analysis WB 250. (Table 5).

An interesting paragenesis is shown by the druses occurring in the pegmatitic schlieren, nests, and tubes (see plate 16). The minerals identified so far are: *alkali-feldspar* (often with skeleton-like hollows), wax-coloured *calcite* rhombohedra (no cordylite), *quartz*, *aegirine* (-columns and -rosettes, growing in or on feldspar), "leucitohedra" of white *analcime*, and dark purple octahedra of *fluorite* (very rare). An accessory rarely absent is *narsarsukite*, which is developed in water-clear honey-coloured slabs with a maximum edge-length of 10 mm (see plate 17).

The Trachytic Alkali-Syenite of the Hvidefjeld.

On the map the rocks of the Hvidefjeld, which are conspicuous for their light colour and trachytic-miarolitic texture, are also referred to the nepheline-syenite complex. Trachytic types also occur at the Hvide Ryg and at the Skaarkammen—here as veins or apophyses of the nepheline-syenite intrusion and as its structural variety. At the western crag of the roof and at the northern foot of the Maageborg, similar rocks occur in situ; this fact points likewise towards a connection of Hvidefjeld with the intrusion at the Sirius Gletscher.

At the Petersryggen the trachytic alkali-syenite of the Hvidefjeld is bounded in the south by a porphyritic marginal facies; syenite (WB 51) and porphyry (WB 51 A) have the same normal foyaitic composition (cf. Table 6).

Apophyses of coarse-grained syenite penetrate the marginal facies and the contact adjoining southwards, which consists mainly of breccias and porphyries, and upon which follow the pyroxenites of the Peters-ryggen. The alkali-syenite of the Hvidefjeld may be one of the youngest
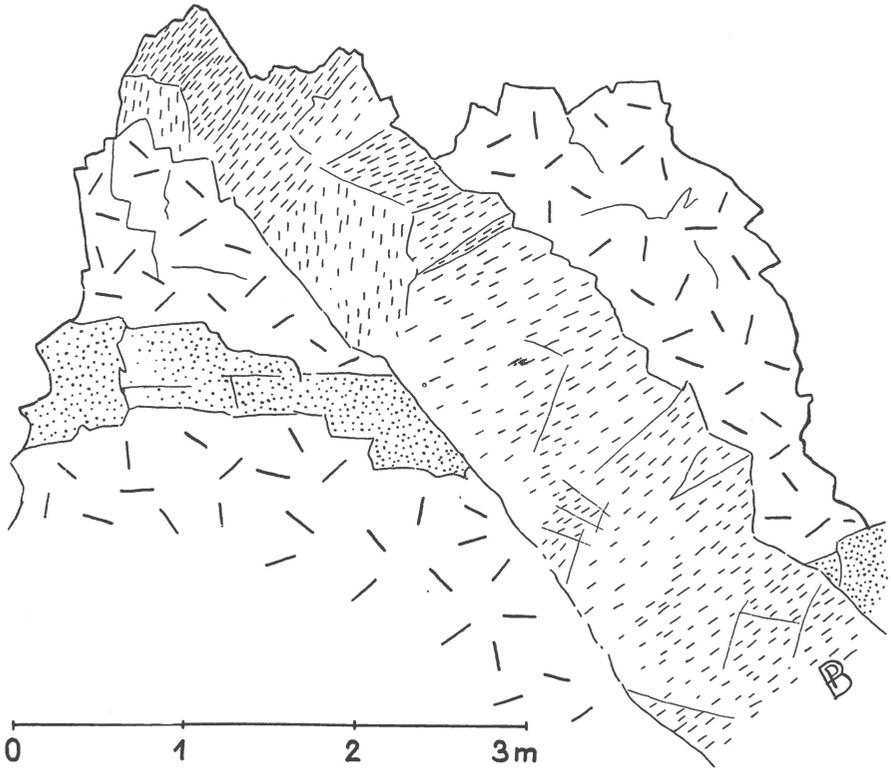
Fig. 4. Top of Ruinerne. Coarse-grained alkali-syenite, cut by felsite (stippled) and basalt (parallel, dotted lines).

—perhaps even *the* youngest—intrusion of the Werner Bjerge. What applies to it, may also apply to the nepheline-syenites of Sirius Gletscher and Aldebaran Gletscher.

The Leucocratic Dyke Rocks.

All the rock groups hitherto dealt with, including the sediments, are penetrated by numerous acid (and basic) dykes (fig. 4). The mostly holo-leucocratic dyke rocks belong to the suite of the alkali-syenites and alkali-aplite-syenites. The dykes are from a few centimetres to several metres wide and light-grey to white in colour, or, if influenced by miner-alization, dark-grey or brown. The larger dykes usually exhibit a trachy-tic or porphyritic texture; the smaller ones are fine- to close-grained

and vary greatly in texture (in most cases micro-trachytic or porphyritic and fluidal, more rarely pilotaxitic, spherulitic, or even granophyric). The most widely distributed are bostonite and bostonite-porphyries; less frequent are alkali-syenite-porphyries, and only rarely were granophyres found. The mineral content is as follows: Microperthite, microcline, albite; quartz; biotite (generally replaced by chlorite); ore, sphene, apatite; fluorite, sericite (from nepheline?) analcime (very rare); epidote and calcite, limonite.

These dykes appear concentrated in swarms in some places inside and along the margin of the pluton. In a few places they are so close to one another that the rock pierced by them seems to be dissolved into a

Table 7. Tinguaite.

No: WB 277a	
SiO_2	53.44
TiO_2	tr.
Al_2O_3	22.78
Fe_2O_3	1.88
FeO	0.92
MnO	tr.
MgO	0.14
CaO	1.12
Na_2O	9.16
K_2O	8.89
H_2O^+	1.98
H_2O^-	0.02
P_2O_5	0.01
$^1/_2 SO_3$	0.04
	100.38

Mol. Norm		
Q.............	−1.3	−1.3
Or	50.3	50.3
Ne...........	41.2	42.3
Ns	1.1	
Ac	5.1	
Wo	2.0	8.7
En...........	0.3	
Hy	1.3	
	100.0	

Mineralogical
composition:
Vol. %

Alkali-feldspar. 11.1 } Phe-
Nepheline ..... 14.4 } no-
Aegirine-augite 1.2 } crysts
Ground mass .. 73.2
(Microliths of Aegirine
in interstices of Feld-
spar and Nepheline (?))

Analyst: Dr. H. Schwander.

kind of breccia. Most of these dykes occur in combination with the acid breccias, while they are very rare in the whole area of the nepheline-syenites.

Mutual intersection shows that we are here concerned with intrusions of different ages. Some of them are undoubtedly post-syenitic, but the remarkable crowding within the dark porphyries and breccias suggests that a still older generation is represented. Their almost complete absence from the nepheline-syenite part of the massif, however, points to a dying out of these intrusions before the nepheline-syenite intrusion set in.

Dyke Rocks of the Nepheline-Syenites.

The tinguaites are not particularly frequent and are located within the area of the nepheline-syenite intrusion. They differ from the diabases and lamprophyres by their lighter colour. Their texture is porphyritic; the strictly idiomorphic phenocrysts of alkali-feldspar, nepheline, and sodalite (rarely aegirine-augite and biotite), however, are not always visible to the naked eye. Analcime was occasionally observed as an inclusion.

As a rule the ground mass is micro-crypto-crystalline. It is composed of alkali-feldspar, aegirine, amphibole, and brown biotite, but a determination was not always possible; in one case the ground mass contained abundant apatite and zircon (cf. analysis WB 277 a, table 7, p. 35).

Leucocratic *nepheline-syenite-porphyries* are rarely found among our samples; probably these close-grained light-coloured rocks were mistaken for alkali-aplite intrusions and overlooked here and there. In contrast to the tinguaites, they, at any rate are not restricted to the area of the nepheline-syenites.

Their composition resembles that of the tinguaites but the mafic minerals are less conspicuous in the ground mass as well. The nepheline has become micaceous. Sodalite and analcime were not observed.

The Basic Dyke Rocks.

Basic dykes and sills are widely distributed within the whole massif and in the surrounding sediments (see pl. 14, 15). During the observations in the field they were generally denoted as dolerites, basalts, porphyritic basalts, and diabases; the examination showed, however, that lamprophyres occur as well.

In the massif several generations of basic dyke rocks are easily distinguished; one of these is decidedly pre-syenitic, another postsyenitic (fig. 5). Even tinguaites are still penetrated by "basalts". The intrusion by these dykes accordingly took place during a considerable space of time, presumably throughout the whole magmatic cycle of the Werner Bjerge.

Within and in the environment of the Werner Bjerge several centres can be ascertained from which basaltic dykes radiate. One of these coincides with the basic complex. The dykes (and sills) traced by WENK in the Blomsterdal (see photo B, pl. 14) are centred around this massif (see the geological map).

Another centre is located at the Oksehorn, east of the Werner Bjerge, on the left-hand side of Antarctic Dal. Here a huge, elongated dolerite body (WB 178) is interspersed among a complex volcanic-intrusive syenite stock. The dolerite extends across the Lille Oksedal in a WNW direction but disappears before reaching the watershed to Delta-dal (Mesters Vig). The numerous basic dykes at the Aggersborg are probably connected with it and, no doubt, this applies to the many sills and dykes occurring in the sediments of the Oksehorn (WB 180, 181).

Dolerites and Basalts etc.
Petrographic Remarks.

As mentioned above, we must distinguish among the basic dykes between a group of purely basaltic and a group of lamprophyric composition. Many of these rocks, however, are so strongly disintegrated that grouping is impossible.

Among the basaltic dykes and sills the following rock types can be distinguished:

Dolerite, basalt, porphyritic basalt, gabbro-porphyrite, diabase, and diabase-porphyrite.

Their mineral content is as follows:

Plagioclase: Andesine to labradorite; (rarely bytownite), albite-oligo-clase (in diabases).

Mafics: Olivine (rare), diopsidic augite, titanaugite ($n\gamma/c$ 34—45° + 2 V 35—39°), in one case (WW 120) pigeonite, brown and green hornblende, uralite, brown biotite (→ chlorite).

Accessories: Epidote, ore, apatite, zircon, carbonate.
(For analyses see Table 8.)

As regards the alkali-basaltic composition, titanaugite and brown hornblende (± biotite) occur as mafics. These rocks recall very vividly the essexite-gabbroid types of the basic intrusive complex.

The sills are generally coarser-grained than the dykes, and as a rule, are also better preserved. By hydrothermal alteration are formed: albite, actinolite, chlorite, serpentine, sericite, clinozoisite-epidote, prehnite (rare), quartz, carbonate, natrolite, and analcime.

In the sills, especially in the upper margin, minor amygdaloid vesicles accumulate, filled with the substances which also appear as the

Table 8. Basic dykes and sills.

No: WW 8		No: WW 165		No: WW 159	
SiO_2	55.70	SiO_2	48.52	SiO_2	45.11
TiO_2	1.33	TiO_2	0.71	TiO_2	2.89
Al_2O_3	18.28	Al_2O_3	22.99	Al2O3	12.63
Fe_2O_3	2.31	Fe_2O_3	2.32	Fe_2O_3	6.39
FeO	3.69	FeO	6.93	FeO	5.04
MnO	0.08	MnO	0.12	MnO	0.10
MgO	2.20	MgO	3.19	MgO	7.67
CaO	5.65	CaO	11.08	CaO	11.32
Na_2O	6.73	Na_2O	0.64	Na_2O	2.80
K_2O	3.27	K_2O	1.12	K_2O	2.41
H_2O^+	0.60	H_2O^+	2.01	H_2O^+	2.59
H_2O^-	0.10	H_2O^-	0.07	H_2O^-	0.21
P_2O_5	0.04	P_2O_5	0.41	P_2O_5	0.73
CO_2	tr.	CO_2	tr.	CO_2	0.43
S	..	S	..	S	..
SO_3	0.32	SO_3	0.31	SO_3	..
	100.29		100.42		100.32

Mol. Norm			Mol. Norm			Mol. Norm		
Q	−8.2	−8.2	Q	7.5	7.5	Q	−9.8	−9.8
Or	19.2		Or	6.6		Or	14.9	
Ab	59.1	88.3	Ab	5.9	67.5	Ab	25.9	56.2
An	10.0		An	55.0		An	15.4	
Wo	4.7		En	7.3		Wo	14.3	
En	5.9	14.9	Hy	9.6	21.3	En	21.9	44.5
Hy	4.3		Cord	4.4		Hy	8.3	
Mt	2.4		Mt	2.5		Ru	2.0	
Tit	2.7	5.1	Ru	0.5	3.7	Hm	4.6	9.1
			Cp	0.7		Cp	1.4	
	100.1			100.0		Cc	1.1	
							100.0	

Variant of Mol. Norm: Diopside, Ho, Biotit			Variant of Mol. Norm: Chlorite Variant			Variant of Mol. Norm: Olivine, Pyroxene		
Q	−3.8	−3.8	Q	12.0	12.0	Q	−4.1	−4.1
Or	16.0		Or	6.6		Or	14.9	
Ab	51.0	77.0	Ab	5.9	67.5	Ab	18.4	47.3
An	10.0		An	55.0		An	14.0	
Di	6.2		Ant	12.8		Ol	11.1	
Ho	12.7	24.1	Am	4.0	16.8	Di	8.6	49.4
Bi	5.2		Mt	2.5		Tit. Aug*)	29.7	
Tit	2.7	2.7	Ru	0.5	3.7	Hm	3.0	
	100.0		Cp	0.7		Ru	2.0	7.5
				100.0		Cp	1.4	
						Cc	1.1	
							100.1	

*) Titanaugite after E. TRÖGER.

Mineralogical composition: Vol. $^0/_0$	Mode (measured)	Mode (measured) Vol. $^0/_0$
Feldspar (Albite-Oligoclase) 62.0	Phenocrysts:	Plagioclase (An 50— 70 $^0/_0$) Phenocrysts & ground mass 48.6
Mafics (green Hornblende), Diopside, Biotite 38.0	Augite (partly chloritized) Plagioclase Ore	Olivine 13.4
+ Ore, Apatite, Sphene	Ground mass: Plagioclase, Quartz Chlorite Ore	Titanaugite .... 16.1 Ore
Analyst: Dr. H. SCHWANDER.		crypto-crystalline Aggregates (Carbonate + Chlorite (?)) 21.9

(continued)

Table 8 cont.

No: WW 155			No: WW 145			No: WW 120		
SiO_2		43.45	SiO_2		40.40	SiO_2		47.70
TiO_2		3.51	TiO_2		5.39	TiO_2		3.28
Al_2O_3		7.91	Al_2O_3		14.12	Al_2O_3		16.09
Fe_2O_3		3.50	Fe_2O_3		5.32	Fe_2O_3		1.85
FeO		6.41	FeO		7.04	FeO		10.22
MnO		0.18	MnO		0.17	MnO		0.13
MgO		10.42	MgO		7.16	MgO		6.07
CaO		15.91	CaO		11.81	CaO		10.76
Na_2O		3.31	Na_2O		2.96	Na_2O		2.47
K_2O		1.22	K_2O		2.69	K_2O		0.47
H_2O^+		1.40	H_2O^+		2.30	H_2O^+		0.97
H_2O^-		0.17	H_2O^-		0.13	H_2O^-		0.06
P_2O_5		0.42	P_2O_5		0.75	P_2O_5		0.29
CO_2		2.44	CO_2		0.21	CO_2		0.0
S		..	S		..	S		0.0
SO_3		..	SO_3		..	SO_3		..
		100.25			100.45			100.36

Mol. Norm			Mol. Norm			Mol. Norm		
Q	−14.2	−14.2	Q	−17.8	−17.8	Q	..	..
Or	7.1		Or	16.3		Or	2.9	
Ab	29.7	39.9	Ab	27.1	61.3	Ab	22.9	58.2
An	3.1		An	17.9		An	32.4	
Wo	23.2		Wo	14.7		Wo	8.4	
En	28.8	62.3	En	20.3	46.5	En	9.2	
Hy	10.3		Hy	11.5		Hy	8.4	38.0
Hm	2.3		Hm	4.2		Fo	6.0	
Ru	2.7		Ru	3.8		Fa	6.0	
Cp	0.8	12.0	Cp	1.5	10.0	Hm	1.3	
Cc	6.2		Cc	0.5		Ru	2.3	3.8
						Cp	0.2	
	100.0			100.0			100.0	

Variant of Mol. Norm: Titanaugite, Biotite			Variant of Mol. Norm: Diopside, Amesite			Variant of Mol. Norm: Diopside, Antigorite		
Q	−3.1	−3.1	Q	−11.8	−11.8	Q	0.2	0.2
Or	1.3		Or	16.3		Or	2.9	
Ab	11.2	12.5	Ab	27.1	46.3	Ab	22.9	58.2
An			An	2.9		An	32.4	
Tit. Aug*)	71.8		Di	39.6		Di	16.8	
Bi	9.3	81.1	Wo	0.9	55.5	Ant	21.0	37.8
Ru + Cc + Cp	9.5	9.5	Am	15.0		Hm	1.3	
	100.0		Hm	4.2		Ru	2.3	3.8
			Ru	3.8	10.0	Cp	0.2	
			Cp	1.5			100.0	
			Cc	0.5				
				100.0				

*) after E. Tröger.

Mode (measured)		Mineralogical composition:	Mode (measured)	
	Vol. %	Oligoclase, Titanaugite, Chlorite		Vol. %
Plagioclase	12.0	In amygdules:	Plagioclase (Andesine-Labrador)	44.8
Titanaugite + brown Hornblende + Biotite	76.0	Carbonate, Natrolite, Analcime.	Pyroxene (Pigeonite)	12.2
Ore, Limonite	8.0		Chlorite, Hornblende	38.5
Carbonate, Apatite	4.0		Ore	4.5

Table 8 cont.

No: WB 178		No: WW 180		No: WB 181	
SiO_2	48.72	SiO_2	45.40	SiO_2	43.52
TiO_2	1.18	TiO_2	0.84	TiO_2	2.61
Al_2O_3	14.61	Al_2O_3	15.46	Al_2O_3	17.48
Fe_2O_3	4.09	Fe_2O_3	3.16	Fe_2O_3	2.62
FeO	13.00	FeO	8.24	FeO	8.34
MnO	0.23	MnO	0.08	Mn	0.13
MgO	2.90	MgO	6.56	MgO	3.94
CaO	8.06	CaO	12.88	CaO	12.94
Na_2O	3.42	Na_2O	1.66	Na_2O	4.17
K_2O	0.75	K_2O	1.83	K_2O	2.01
H_2O^+	2.61	H_2O^+	3.68	$H_2{}^+$	2.14
H_2O^-	0.08	H_2O^-	0.04	H_2O^-	0.02
P_2O_5	0.11	P_2O_5	0.18	P_2O_5	0.20
CO_2	tr.	CO_2	tr.	CO_2	tr.
S	..	S	..	S	..
SO_3	0.11	SO_3	0.08	SO_3	0.07
	99.87		100.09		100.19

Mol. Norm			Mol. Norm			Mol. Norm		
Q	−0.8	−0.8	Q	−6.2	−6.2	Q	−12.5	−12.5
Or	4.6		Or	11.1		Or	11.4	
Ab	32.5	60.7	Ab	15.5	57.6	Ab	36.4	70.4
An	23.6		An	31.0		An	22.6	
Wo	5.3		Wo	13.7		Wo	15.3	
En	8.5	32.6	En	19.1	44.0	En	10.5	38.3
Hy	18.8		Hy	11.2		Hy	12.5	
Mt	4.5		Mt	3.5		Hm	1.7	
Tit	2.8	7.5	Ru	0.6	4.5	Ru	1.7	3.8
Cp	0.2		Cp	0.4		Cp	0.4	
	100.0			99.9			100.0	

Variant of Mol. Norm: Diopside, Antigorite			Variant of Mol. Norm: Augite, Biotite, Antigorite			Variant of Mol. Norm: Diopside, Antigorite, Epidote		
Q	2.9	2.9	Q	0.3	0.3	Q	−8.7	−8.7
Or	4.6		Or	6.1		Or	11.4	
Ab	32.5	60.7	Ab	5.3	40.3	Ab	36.4	50.4
An	23.6		An	28.9		An	2.6	
Di	10.6		Tit.Aug*)	40.7		Di	15.8	
Ant	18.3	28.9	Bi	8.0	58.2	Ant	12.0	51.8
Mt	4.5		Ant	9.5		Ep	24.0	
Tit	2.8	7.5	Hm	0.2		Mt	1.0	
Cp	0.2		Ru	0.6	1.2	Tit	5.1	6.5
			Cp	0.4		Cp	0.4	
	100.0			100.0			100.0	

*) after E. Tröger.

Mode (measured)	Vol. %
Feldspar	26.8
Natrolite	8.6
Pyroxene, Chlorite	49.2
Ore, Leucoxene	5.9
Quartz, Calcite, Apatite	9.3

Mode (measured) Vol. %

Phenocrysts:
Titanaugite + few
  Pseudomorphs after
  Olivine (changed into
  Calcite + Chlorite +
  Talc + Ore) 44.4
Ground mass:
  Plagioclase (partly
    changed into Chlorite) 24.1
  Pyroxene, Amphibole,
    Biotite, Chlorite 23.0
  Ore, Apatite, Limo-
    nite 8.5

Mineralogical composition:

Plagioclase + Orthoclase
(both decomposed),
Pyroxene (partly decom-
posed and changed into
Chlorite), brown Horn-
blende, Ore, Leucoxene, Apa-
tite, Calcite, Epidote.

Table 9. Lamprophyre.

No: WB 27

SiO_2	40.72
TiO_2	2.12
Al_2O_3	18.46
Fe_2O_3	4.67
FeO	6.79
MnO	0.10
MgO	4.73
CaO	12.88
Na_2O	3.64
K_2O	2.13
H_2O^+	3.41
H_2O^-	0.03
P_2O_5	0.24
CO_2	tr.
SO_3	0.21
	100.13

Mol. Norm

Q	−14.0	−14.0
Or	13.4	
Ab	35.9	80.2
An	30.9	
Wo	2.9	
En	14.3	28.9
Hy	11.7	
Hm	2.7	
Ru	1.6	4.8
Cp	0.5	
	99.9	

Variant of Mol. Norm

Q	−2.4	−2.4
Or	13.4	
Ab	35.9	54.6
An	5.3	
Di	12.8	38.4
Am	25.6	
Mt	4.0	
Tit	4.8	9.3
Cp	0.5	
	99.9	

Mineralogical
composition:

Plagioclase (decomposed),
  brown Hornblende, Augite
Ore, Biotite (?), Apatite
Secondary:
  Chlorite, Epidote, Calcite

Analyst: Dr. H. SCHWANDER.

disintegration products of the primary minerals. So far the following
minerals have been identified:

Potash-feldspar, albite, thomsonite, antigorite, chlorite, actinolite,
    epidote, garnet, calcite, ore and rutile.

Although scarce, the occurrence of potash-feldspar deserves special
attention.

Lamprophyres.

The samples further include some well-preserved rocks which are
undoubtedly of lamprophyric composition and texture. *Spessartite* seems
to be the most frequent, while *kersantites* and *camptonites* are met with
less often. In the field we could not separate the lamprophyres from
the other basic dykes and our collection is therefore a random assort-
ment which may not include all the types occurring in the area. For
chemical analysis see Table 9.

Comments on the Chemistry (see Table 8).

Of the ten analysed basic dykes WW 145, 155, and 159 are derived
from the upper Blomsterdal and probably belong to the dyke rocks of
the basic complex of the Werner Bjerge. Their composition (basic plagio-
clase, titanaugite, brown hornblende) likewise points in that direction,
as much as their alkali-basaltic chemical qualities. The sill WW 155
shows an ankaramitic chemical character. However, the rock carries
no olivine but has, in addition to titanaugite, diopsidic augite and brown
hornblende. The three rock samples WB 178, 180 and 181 occur in situ
in the Lille Oksedal, as mentioned above. WB 180 and 181 correspond
to sills issuing from the huge dolerite dyke WB 178. A comparison of
the analyses with the mineral composition shows them to be markedly
different and implies that a differentiation took place at the time of the
intrusion. WW 120 was collected by E. WENK in the lower part of Antarc-
tic Dal and therefore, strictly speaking, does not belong to the Werner
Bjerge intrusion. This rock exhibits the kind of variable, more normal-
gabbroid chemical composition fairly often present in the arctic basalts.

For further remarks about the chemistry of the basic dykes
see p. 56.

The Late- to Post-Magmatic Pneumatolytic-Hydrothermal Formations.

An extensive pneumatolytic-hydrothermal decomposition of all
groups of rock is a striking feature of the Werner Bjerge and of the
syenite intrusions on both sides of Kong Oscars Fjord in general. Sporadi-
cally it also affects the sediments and there—as in the interior of the
massif—it is accompanied by a strong mineralization. Such zones are

conspicuous from great distances owing to their multicoloured, vermilion, ochre, and black tints.

According to their appearance we may distinguish between a diffuse *pneumatolytic-hydrothermal decomposition*, uniformly affecting whole rock masses and often accompanied by an introduction of ore and an impregnation by ore-bearing solutions, always limited to fissures and cracks,

Fig 5. Mountain top northeast of Antarcticspids. Alkali-syenite cut by basalt dykes (black) and zones of hydrothermal disintegration (stippled).

penetrating for short distances into the adjacent rocks. Genetically, however, these phenomena belong together.

The first "victims" of the *diffuse decomposition* are the mafics, while the light-coloured constituents are rarely completely destroyed. The effect of the diffuse decomposition on the nepheline-syenites was mentioned in the description of that rock group. It is remarkable that the alkali-feldspars in all the affected rocks show a relatively high degree of resistance. The replacement of the mafics by a zirconbearing limonitic substance and the concentration of the residues in wedges and miarolitic cavities (e. g. in the alkali-syenites of Hvidefjeld) seem, however, to be merely the first results of volatiles penetrating late- or post-magmatically. In the majority of the rocks concerned ore doubtlessly exerted its influence. An impregnation with pyrite can often be seen with the naked eye. It is, however, true that some dykes which did not undergo disintegration are also pyrite-bearing, but there it is of a purely magmatic origin. The red and orange colours are due to finely distributed haematite and to limonite partly developed from pyrite by oxidation.

The impregnation by ore along fissures and cracks is likewise due to haematite and manganiferous limonite. These red- or yellow-coloured

zones often terminate blindly in the middle of the fresh rock. Along these zones the rock is disintegrated and crumbled into gravel; thus narrow lanes will arise, bounded by smooth walls. At first it was thought that these phenomena must be ascribed to weathering and this may have played a certain role locally (sulphate solutions from pyrite)—but the quite fresh adjacent rocks are evidence against such a supposition.

Frequently the composition follows the acid, or also the basic, dykes without, however, being limited to them.

The fissures or cracks from which the disintegration starts are lined with calcite and quartz, frequently also with siderite, haematite, strontianite, baryte (?), and fluorite, often all beautifully crystallized. The whole is coated with limonite, often also with a crust of black manganese-ore, which makes its way dendritically into the adjacent rock.

These impregnations correspond to the last manifestation of magmatic activity in the Werner Bjerge. Blocks of dark porphyry or sediment, surrounded on all sides by syenite, were spared with the exception of cases where both rocks are affected. The ore impregnation generally avoids the basic intrusions and is here almost exclusively limited to the leucocratic veins which cut them; but it also pierces post-syenite basalts, so that a considerable interval of time may have elapsed between the later alkali-syenite or nepheline-syenite intrusions and this pneumatolytic-hydrothermal mineralization.

The map shows the distribution of the most important zones of ore impregnation. It coincides remarkably with the distribution of the quartz-bearing alkali-syenite and alkali-granite intrusives which in general contain much fluorite.

The results of the observations in the field and of the microscopic examination are described above. In order to learn more about the ore content, numerous ore-bearing rock samples have been examined spectrographically. This examination was also extended to some limonitic fillings of miarolitic cavities, to hydrothermal vein formations, and to a few minerals (pyrite). The results are compiled in plate 21. Here the results will be considered as far as this seems necessary for a better understanding of the whole phenomenon.

All samples were examined for the content of 33 elements and, compared with the non-impregnated zones, the contents of Fe, Mn, Ti, Zr, and Nb showed an increase in the zones of mineralization. As to the remaining elements (e. g. Ag, Sn, and Pb), the enrichment is either entirely doubtful, or only sporadic and found in small quantities only. In extremely mineralized samples (WW 111 and WW 117) rare earths were also traced and there seems to be an enrichment of Mo (10 to 100 ppm).

In the repeatedly mentioned zircon-rich limonitic remains of the alkali-syenites of Hvidefjeld we find a quite similar association of elements with an abundance of rare earths (also thorium). These substances, however, were leached out from the disintegrated mafics of the alkali-syenite and deposited in the miarolitic druses. The dark constituents which are decomposed in all the diffusely decomposed zones probably supply a considerable number of the elements to be traced in the mineralization. In particular, we suppose that Zr and Nb, the rare earths, and Ti originate from the decomposition of the mafics. In addition to these, however, the gases (or solutions) responsible for the mineralization must have supplied Fe and especially Mn, depositing the former partly as pyrite, partly as haematite. The limonitization spreading in this way may be traced back to a subsequent hydrolysis.

Thus only a few (Fe, Mn) of the elements concentrated in the ore-impregnated zones would be primarily enriched in magmatic residues; the others would have made their way into the ore-depositing solutions or vapours owing to a leaching of the dark constituents.

Four different samples of hydrothermal contents of fissure were examined spectroscopically (WB 54 a, b, c, and WB 119, see pl. 21). They all proved to contain Sr and Li. Both these elements were also ascertained sporadically in the mineralized samples, though only in traces.

The Molybdenite Occurrences at the Malmbjerg.

As early as in 1953 molybdenite was found in several places along the northwestern border of the massif, though nowhere in situ. Thus WENK and BEARTH found crystals of molybdenite and wolframite in druses of alkali-granites and alkali-syenites in the southern moraine of Mellemgletscher. From the same moraine WENK later collected several molybdenite-bearing samples, among which was also a rock consisting of microcrystalline quartz and mica, matching certain rocks found later at the Malmbjerg. A similar sample containing pyrite and fluorite was obtained from the moraine of Sukces Gletscher; spectroscopically a content of 0.01—0.1 per cent of Mo was ascertained here. Another find of molybdenite, this time in the western frontal marginal moraine of the Mellemgletscher, was made in 1954. Unfortunately we failed to observe the ore in situ in the uppermost part of the glacier. However, these discoveries point to the presence of a molybdenum-bearing zone of mineralization, which must be looked for in the region of the Mellempas and between the upper Mellemgletscher and the Vestre Gletscher. It may represent an apophysis of the deposits of the Malm-bjerg discovered by BEARTH in 1954 and coincide with the periphery of alkali-granites.

The Malmbjerg is situated at the confluence of the Arcturus Glet-
scher with the Schuchert Gl. (see pl. 12). Here a dome-shaped intrusion
of alkali-granitic (partly also alkali-syenitic (?)) composition penetrated
the carboniferous sediments (sandstones, arkoses, and clay slates). Af-
terwards both the dome and the sediments were mineralized and this
process completely obliterated the outline of the intrusion.

The Malmbjerg shows a multi-coloured outward zone, conspicuous
for its rust-red, black, and yellow. In a semi-circle it forms a frame
round the light-coloured ore stock proper. This dome is clearly visible
on plate 13. In the roof of the dome sub-horizontal streaks show, which
can be recognized much more clearly on the photograph than in the
field and which represent the original bedding of the sediments.

We at first thought that the layers showing in the ore stock itself
corresponded to the original bedding which had partly been obscured
by metasomatic changes. But it was found to be a matter of a younger
"Pseudo-stratification" consisting of sub-parallel layers impregnated
with quartz and manganese ore, and wolframite. Some of the layers in
the roof may perhaps result from mineralization as well.

The light-coloured stock as well as the multi-coloured marginal
portion are now intersected by a net of fine fissures impregnated with
ore; in the stock itself these are impregnated exclusively with *molybdenite*
(superficially transformed into molybdenite-ochre, (photo 1, pl. 18) but
in the periphery they show an impregnation with manganese-, iron-, and
wolfram-ore. In the multi-coloured marginal zone the rock between the
fissures is highly impregnated with ore as well, while the light-coloured
core is free from it to a great extent. Moreover, as has been mentioned
already, the original mineral content of the sandstones and arkoses and
perhaps also of the alkali-granites (?) was largely replaced by a micro-
crystalline quartz-mica-topaz-structure, peripherally even more so than
in the core. Kaolinization of feldspars, too, is very common here. Several
phases of mineralization issuing from *quartz*- and *fluorite*-bearing veins
can be clearly distinguished. Pale-green fluorite is visible to the naked
eye at the rims of the cracks; it is regularly accompanied by iron-bearing
carbonates, while *cassiterite* and apatite occur only sporadically and
albite-bearing veins with pyrite, galena, and sphalerite are also rare.

On the periphery, columnar *wolframite* (hübnerite) and yellowish
topaz crystals of a tetrahedral habitus were observed in sub-horizontally
extending quartz-filled fissures (see photo A, B, pl. 19). Wolframite may
also be fairly distributed otherwise and may even have played an essential
part in the microscopically fine ore impregnation of the periphery. Scheelite
was observed, but a few crystals of millimetre size only.

On the molybdenite-overlain hybrids of the central portion scales
2 millimetres long of a biotite-like, dull-brown mica (zinnwaldite), con-

taining about 0.4 per cent of Li, are frequently found. In places these nests of mica are filled with tiny inclusions of zircon (or thorite?) (pleochroic haloes).

Various rocks and minerals of the ore stock were examined spectroscopically by Dr. LANDERGREN. The results are given in plate 21. They show that in addition to the enrichment of Fe and Mn, Ti, Zr, Nb, and especially Zn, Ga, W, and Be (?) observed in other ore-impregnation zones, in the quartz-rich impregnations Li is certainly concentrated as well. On the other hand there appears to be only a slight enrichment of Molybdenum (and partly W) but a small percentage of this element is contained (except in molybdenite) in some wolframite crystals of the quartz fissures. Sb was indicated in molybdenite, while in other samples it always lies below the limit of detection. Re was found as well.

The mineral content of the ore stock bears a great resemblance to the well-known zinnstone- and molybdenite-bearing pneumatolytic mineralizations of the Erzgebirge. Rather striking also is the analogy with the molybdenum deposits of Climax (Colorado). The mineral association is the same in both places, and in Greenland as well as in Climax several phases of the metasomatic processes can be distinguished.

At present prospecting is being done at the Malmbjerg. It will probably bring many new observations.

Relationship to the Galena-Zincblende-Bearing Ore Veins in the Sedimentary Cover.

The sporadic occurrence of pyrite-, galena-, and zincblende-bearing veins in the Malmbjerg points to a possible connection of this ore impregnation with the apomagmatic ore veins (galena, zincblende, chalcopyrite) of Mesters Vig, the working of which was commenced in 1956. The ore (PbS) of Mesters Vig, as well as that of the ore stock at the Schuchert Gl. contains silver. In both places quartz is the dominant dyke rock.

In 1955 a deposit of galena was found south of the Werner Bjerge, near Lomsöen. Smaller occurrences have been observed also in the Staunings Alper.

All these ore deposits are genetically related and belong to the alkali-rock province of the Werner Bjerge.

Remarks on the Chemistry of the Magmatic Rocks.

In the Werner Bjerge three series of magmatic rocks have been established.

The series of the *pyroxenite-granites* of the basic complex is the oldest, while the *alkali-granites*, the *alkali-syenites*, and the nepheline-sye-

nites with their subsequent dyke swarms, are the youngest intrusions. The third series includes the *basic dyke rocks* of different age, some of which must be grouped with the basic complex and some with the regionally distributed basalts.

Tables 10 to 12 contain those Niggli and Barth-Eskola parameters which can be calculated from the chemical analyses.

Table 10. Niggli values.

			si	al	fm	c	alk	k	mg	ti	p	Magma types
WB	6	Alkali-granite..........	403	42	10	9	39	0.35	0.48	..	..	normal alkali-granitic
WB	14	Alkali-granite..........	367	44	9	9	38	0.41	0.23	0.9	2.5	aplite-granitic
WW	9	Syenite-aplite..........	257	42	12	5	41	0.23	0.14	2.5	..	nordmarkitic
WB	54	Alkali-syenite..........	243	40	14	4	42	0.35	0.40	2.8	0.2	nordmarkitic
WB	39	Perthosite.............	237	41	12	6	41	0.37	0.31	3.5	0.5	nordmarkitic
WB	59	Alkali-syenite-porphyry .	236	39	17	5	39	0.34	0.34	2.3	0.5	nordmarkite-umptekitic
WW	95	Alkali-syenite..........	233	44	7	7	42	0.33	0.32	2.3	0.7	alkali-syenite-aplitic
WB	76	Alkali-syenite-porphyry .	231	44	13	3	40	0.41	0.32	3.0	0.2	bostonitic
WB	123	Alkali-syenite..........	223	41	14	7	38	0.27	0.41	1.5	..	bostonite-pulaskitic
WW	30	Augite-syenite-porphyry	213	39	12	13	36	0.44	0.19	3.4	0.4	kalifoyaitic
WB	51	Alkali-syenite..........	211	42	13	8	37	0.36	0.50	2.3	0.6	bostonite-pulaskitic
WB	51A	Alkali-syenite..........	204	42	10	9	39	0.44	0.40	2.5	0.2	normal foyaitic
WW	104	Alkali-syenite containing Analcime	203	41	13	7	39	0.34	0.50	5.2	0.2	normal foyaitic
WB	250	Cancrinite-Nepheline-syenite	183	44	10	5	41	0.36	0.26	2.0	0.4	normal foyaitic
WB	277a	Tinguaite	170	43	7	4	46	0.40	0.10	..	..	
WB	142	Granite	279	41	15	11	33	0.45	0.34	2.3	0.8	granosyenitic
WB	141	Syenodiorite..........	174	32	26	20	22	0.31	0.43	4.1	1.3	essexite-akeritic
WW	48	Monzonite.............	140	29	29	21	21	0.34	0.42	6.7	2.3	normal essexitic
WB	150	Syeno-gabbro containing Olivine	115	21	41	26	12	0.33	0.39	12.7	2.3	essexite-gabbrodioritic
WB	140	Pyroxenite	67	6	64	28.5	1.5	0.38	0.72	3.7	..	pyroxenitic
WW	97	Porphyrite	154	31	33	17	19	0.43	0.55	2.7	1.9	normal monzonitic normal essexitic
WW	165	Augite-porphyrite	124	35	32	30	3	0.54	0.38	1.4	0.38	ossipitic
WW	8	Diabase-porphyrite	166	32	24	18	26	0.24	0.40	2.9	..	kassaitic
WW	159	Gabbro-porphyrite	120	17	46	27	6	0.36	0.56	4.9	1.4	hawaiitic
WW	120	Dolerite...............	112	22	45	27	6	0.11	0.47	5.8	0.6	normal gabbroid
WB	178	Dolerite...............	123	22	47	22	9	0.12	0.23	2.3	..	normal gabbro-dioritic
WB	180	Porphyritic Basalt	101	20	43	31	6	0.42	0.51	1.3	0.2	gabbroid
WB	181	Dolerite...............	98	23	34	31	12	0.24	0.40	4.35	0.2	turjaite-gabbroid
WW	155	Basalt	88	9	48	35	8	0.20	0.66	5.4	0.7	alkali-jacupirangitic
WW	145	Gabbro-porphyrite	88	18	45	27	10	0.37	0.51	8.7	1.4	essexite-gabbro-theralitic
WB	27	Spessartite	89	24	35	30	11	0.37	0.43	3.4	..	turjaite-gabbroid

Table 11. Base values after Niggli.

	Q	Kp	Ne	Ns	Cal	Cc	Sp	Cs	Fs	Fa	Fo	Ru	Cp	Q	L	M	Kp	Ne	Col
WB 6	54.2	14.2	26.2	..	1.4	..	..	1.5	..	1.3	1.2	..	..	54.2	41.8	4.0	34.0	62.6	3.4
WB 14	52.1	16.6	24.3	..	2.7	..	0.9	..	0.2	1.7	0.2	0.2	1.1	52.1	43.6	4.3	38.0	55.8	6.2
WW 9	38.2	12.6	42.4	..	1.3	..	..	0.9	1.2	2.3	0.6	0.5	..	38.2	56.3	5.5	22.4	75.3	2.3
WB 54	35.5	21.0	35.3	1.3	..	..	..	1.3	1.7	1.1	1.9	0.7	0.2	35.5	56.3	8.2	37.3	62.7	..
WB 59	35.3	20.8	36.1	..	0.2	0.9	..	1.1	1.7	1.3	1.3	0.8	0.3	35.3	58.2	6.5	36.4	63.3	0.3
WB 39	35.3	19.2	36.8	0.2	..	..	..	1.5	1.7	2.4	2.1	0.5	0.3	35.3	56.0	8.7	34.3	65.7	..
WW 95	34.0	20.0	39.9	..	1.6	..	..	1.2	0.8	0.9	0.8	0.5	0.4	34.0	61.4	4.6	32.4	65.0	2.6
WB 76	34.6	23.2	34.2	..	..	1.5	2.3	..	1.3	1.9	0.3	0.7	..	34.6	58.9	6.5	40.4	59.6	..
WB 123	32.8	16.0	41.9	..	2.8	0.4	..	0.9	2.0	1.0	2.2	0.4	..	32.4	61.1	6.5	26.3	69.1	4.6
WW 30	33.4	24.0	30.7	..	2.5	..	..	3.5	2.1	1.7	0.9	0.9	0.3	33.4	57.2	9.4	42.0	53.6	4.4
WB 51	32.8	20.4	36.6	..	3.3	0.4	..	0.8	0.6	1.6	2.5	0.6	0.4	32.8	60.7	6.5	33.9	60.6	5.5
WB 51 A	30.4	26.5	34.1	..	2.3	0.2	..	2.0	0.7	1.6	1.5	0.6	0.1	30.4	63.1	6.5	42.0	54.3	3.7
WW 104	30.0	20.3	39.3	..	1.8	0.2	..	1.8	1.1	1.5	2.6	1.4	..	30.0	61.6	8.4	33.0	64.1	2.9
WB 250	25.6	23.2	42.1	..	2.0	1.7	..	0.8	1.3	1.5	1.0	0.5	0.3	25.6	69.0	5.4	34.5	62.6	2.9
WB 277a	20.0	30.2	41.2	3.0	..	..	..	1.5	1.9	1.0	0.2	..	..	21.0	71.4	6.1	42.3	57.7	..
WB 142	44.6	19.3	24.2	..	4.7	1.3	..	..	0.2	3.0	1.8	0.5	0.4	44.6	49.5	5.9	40.1	50.1	9.8
WB 141	34.1	12.0	27.3	..	8.9	..	..	3.8	0.3	6.4	5.1	1.2	0.9	34.6	49.5	15.8	25.0	56.6	18.4
WW 48	25.9	14.4	28.5	..	7.2	..	..	5.2	2.6	6.0	6.1	2.2	1.9	25.9	50.1	24.0	28.7	56.9	14.4
WB 150	24.3	9.3	18.5	..	10.2	..	..	7.4	3.5	10.7	9.1	4.8	2.2	24.3	38.0	37.7	24.5	48.7	26.8
WB 140	11.0	2.2	3.6	..	7.5	..	..	20.1	4.2	10.4	38.9	2.1	..	11.0	13.3	75.7	16.6	27.1	56.3
WW 97	31.7	15.9	21.5	..	11.7	..	..	0.9	2.1	5.0	8.8	0.9	1.5	31.7	49.1	19.2	32.4	43.8	23.8
WW 165	39.5	4.0	3.5	..	33.0	..	2.4	..	2.5	8.4	5.6	0.5	0.7	40.0	41.0	19.0	10.0	8.6	81.4
WW 8	29.7	11.5	35.5	..	6.0	..	..	5.3	2.4	4.3	4.4	0.9	..	29.7	53.0	17.3	21.7	67.0	11.3
WW 159	21.7	8.9	15.5	..	9.2	1.1	..	10.7	6.9	6.2	16.4	2.0	1.4	21.7	34.7	43.6	26.4	46.1	27.5
WW 120	29.2	1.7	13.7	..	19.4	..	..	6.3	2.0	12.3	12.9	2.3	0.2	29.2	34.8	36.0	4.9	39.4	55.7
WB 178	29.7	2.8	19.5	..	14.2	..	..	5.5	4.5	16.3	6.4	0.9	0.2	29.7	36.5	33.8	7.7	53.4	38.9
WB 180	26.1	6.7	9.3	..	18.7	..	..	10.3	3.5	10.1	14.3	0.6	0.4	26.1	34.1	39.2	19.2	26.8	54.0
WB 181	24.3	6.8	21.8	..	13.6	..	..	11.5	2.6	9.4	7.9	1.7	0.4	24.3	42.2	33.5	16.2	51.5	32.3
WW 155	16.2	4.3	17.8	..	1.9	6.1	..	17.4	3.7	7.7	21.7	2.4	0.8	16.2	30.1	53.7	18.0	74.1	7.9
WW 145	16.3	9.8	16.3	..	10.7	0.5	..	11.0	6.3	8.6	15.2	3.8	1.5	16.3	37.3	46.4	26.6	44.3	29.1
WB 27	22.6	8.1	21.5	..	18.5	..	..	2.2	5.5	8.8	10.7	1.6	0.5	22.6	48.1	29.3	16.8	44.7	38.5

Table 12.   Norms of Cations after Barth-

	Alkali-granites		Alkali-syenites											Ne-syenite	Tinguaite
	WB 6	WB 14	WW 9	WW 54	WB 39	WB 59	WW 95	WB 76	WB 123	WW 30	WB 51	WB 51A	WW 104	WB 250	WB 277a
Si.....	69.1	66.5	58.0	56.8	56.7	56.6	55.3	55.1	53.7	54.2	53.7	52.6	52.2	49.5	47.3
Ti	..	0.2	0.6	0.7	0.8	0.5	0.5	0.7	0.4	0.9	0.6	0.6	1.4	0.5	..
Al	14.4	16.1	19.2	18.8	19.1	18.8	20.9	20.8	21.2	20.0	21.2	21.8	21.1	23.2	23.8
Fe^{3+}..	0.1	0.1	0.8	1.1	1.1	1.1	0.5	0.9	1.3	1.4	0.4	0.5	0.8	0.9	1.3
Fe^{2+} +Mn^{2+}	0.8	1.1	1.5	0.8	0.9	1.6	0.6	1.3	0.7	1.2	1.1	1.1	1.0	1.0	0.6
Mg....	0.8	0.4	0.4	1.2	0.9	1.4	0.5	1.0	1.4	0.6	1.7	1.0	1.7	0.6	0.2
Ca	1.4	1.5	1.1	1.0	1.5	1.1	1.6	0.8	1.8	3.4	2.1	2.2	1.8	2.2	1.0
Na....	8.8	8.1	14.1	12.6	12.0	12.4	13.3	11.4	14.0	10.2	12.2	11.4	13.2	14.2	15.8
K.....	4.7	5.5	4.2	7.0	6.9	6.4	6.6	7.8	5.4	8.0	6.8	8.8	6.8	7.8	10.0
P	..	0.4	..	..	0.1	0.1	0.2	0.1	..	0.1	0.2	..	..	0.1	..
	100.0	99.9	99.9	100.0	100.0	100.0	100.0	99.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0

The diagrams which follow show the variation of the Niggli values for the first and second of these three groups. The Q L M-diagram gives a survey of all three rock series and of the relations possible between them (fig. 6).

First we will look at the diagram of fig. 7 representing the variation in the series pyroxenite-granite (Wb 140, 150, 141, 142). The four points linked in the Q L M-diagram by a line doubtlessly correspond to a genetic series. The typically uniform slope of the curve must, however, not deceive us: there are very complicated processes going on behind. Apart from gravity differentiation combined with an enrichment of alkalies in the residual melts, hybridization also plays an important part. Thus the late syeno-dioritic to granitic (and alkali-syenitic) rocks of this series are products of the reaction of acid melts (or solutions) rich in alkali with an earlier crystallization of more basic material. These residual melts must have been richer in alkali, and partly also in silicic acid, than the hybrid granite WB 142. Their composition may have varied between alkali-syenite and alkali-granite.

A genetic relationship between the "basic complex" and the series of the alkali-syenites and their descent from a common (alkali-basalt) magma is not out of the question. A somewhat irregular position in the diagram is held by the essexitic monzonite (WW 48); this rock is not directly connected with the "basic complex" of Monte Somma-Uglespids, but intermediary rock types of that complex very much resemble monzonite in their mineralogical composition. In the Q L M-diagram this rock occupies a position between the syeno-gabbro (WB 150) and

Eskola. (H, C, S, F not considered).

Basic Complex						Basic Sills and Dikes									Lam-pro-phyre
WB 140	WB 150	WB 141	WB 142	WW 48	WW 97	WW 8	WW 165	WW 159	WW 120	WW 155	WW 145	WB 178	WB 180	WB 181	WB 27
37.5	43.8	52.2	61.1	46.9	49.7	50.9	47.0	43.4	45.3	41.7	38.8	48.0	44.2	41.1	39.1
2.1	4.8	1.2	0.5	2.2	0.9	0.9	0.5	2.1	2.3	2.5	3.9	0.9	0.6	1.8	1.5
6.9	16.1	19.1	17.8	19.1	20.3	19.6	26.3	14.3	18.0	8.9	16.0	17.0	17.8	19.5	21.0
2.8	2.3	0.2	0.1	1.7	1.4	1.6	1.7	4.6	1.3	2.5	3.9	3.0	2.3	1.8	3.4
7.0	7.2	4.3	2.0	4.0	3.4	2.9	5.6	4.1	8.2	5.3	5.7	10.9	6.7	6.7	5.5
25.9	6.0	3.4	1.2	4.0	5.8	3.0	4.6	11.0	8.5	14.9	10.2	4.3	9.5	5.6	6.7
15.9	9.6	6.1	2.5	7.0	5.4	5.5	11.5	11.6	11.0	16.3	12.1	8.5	13.4	13.2	13.2
1.2	6.2	9.1	8.1	9.5	7.2	11.8	1.2	5.4	4.6	6.1	5.5	6.5	3.1	7.7	6.8
0.7	3.1	4.0	6.5	4.8	5.3	3.8	1.3	2.9	0.6	1.5	3.3	0.9	2.2	2.4	2.6
..	0.9	0.4	0.2	0.8	0.6	...	0.3	0.6	0.2	0.3	0.6	..	0.2	0.2	0.2
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

▽ Basic Dykes and Sills
▼ „Basic Complex"
▼ Monzonite WW 48
● Alkali-Granites
○ Alkali-Syenites
◎ Nepheline-Syenite
⊘ Tinguaite
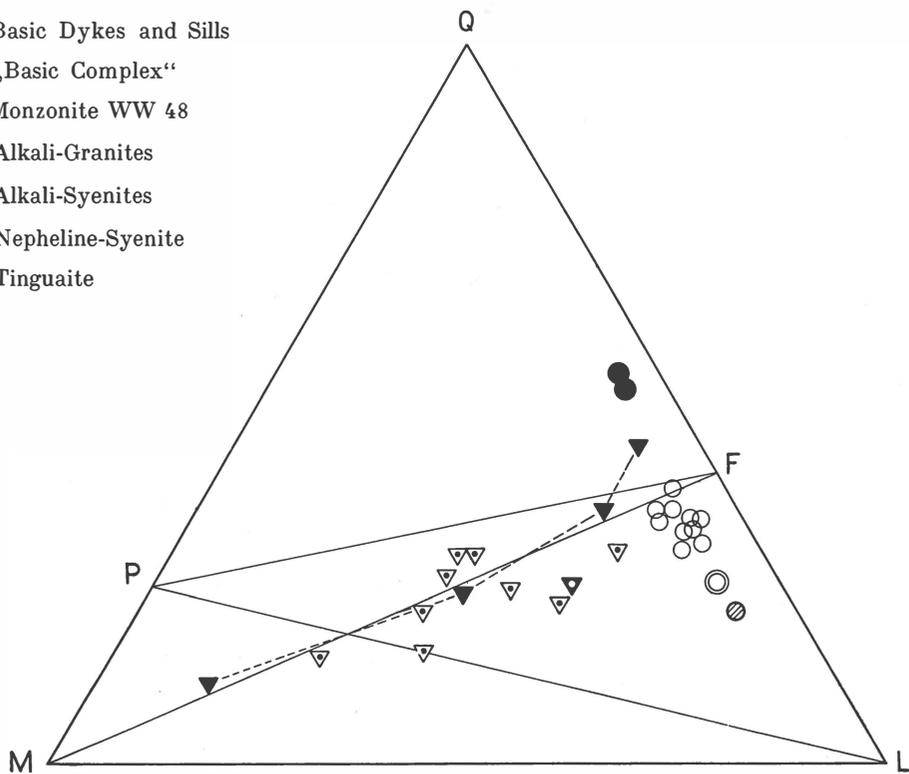
Fig. 6. QLM-diagram of the Werner Bjerge rocks.

4*
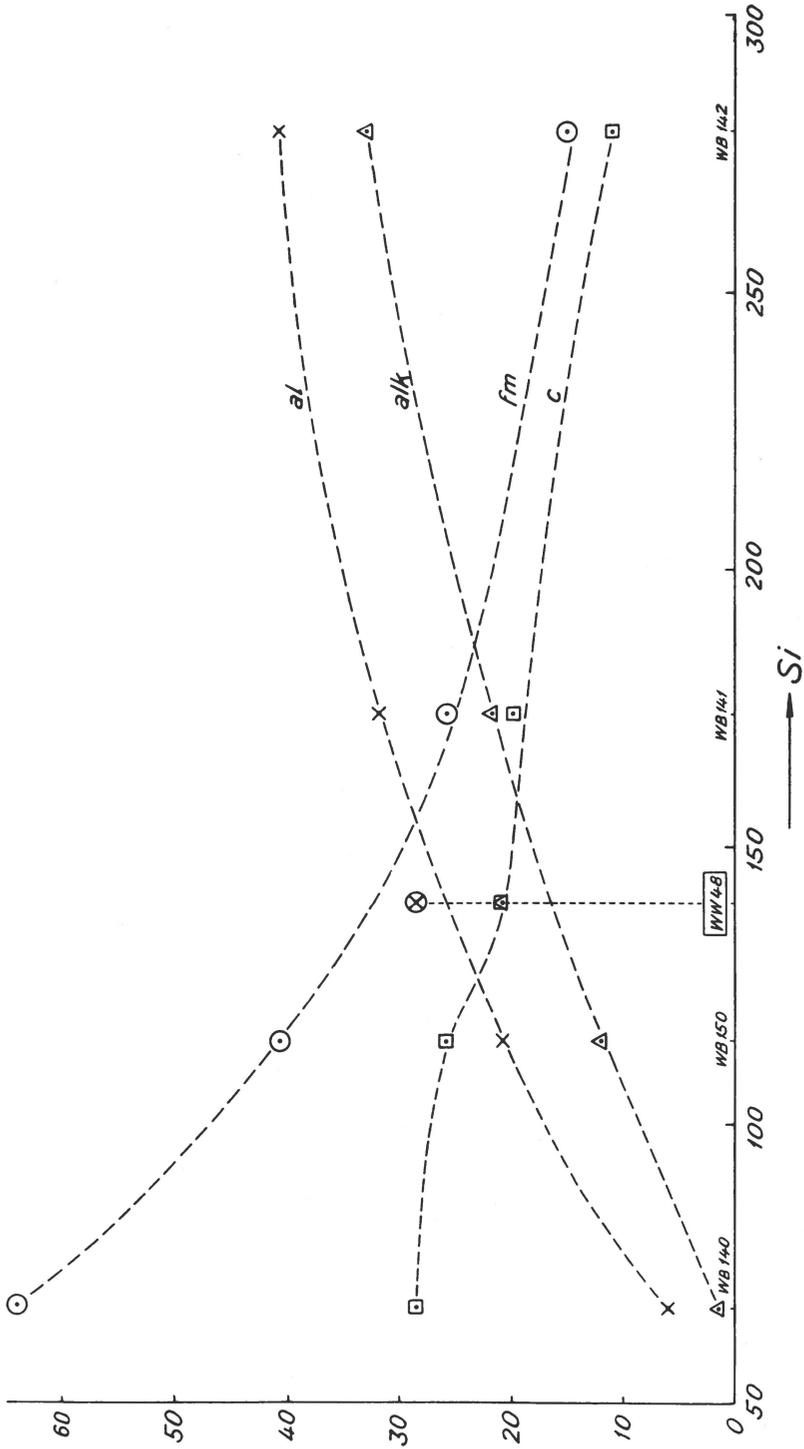
Fig. 7. Niggli diagram of the Werner Bjerge basic series.
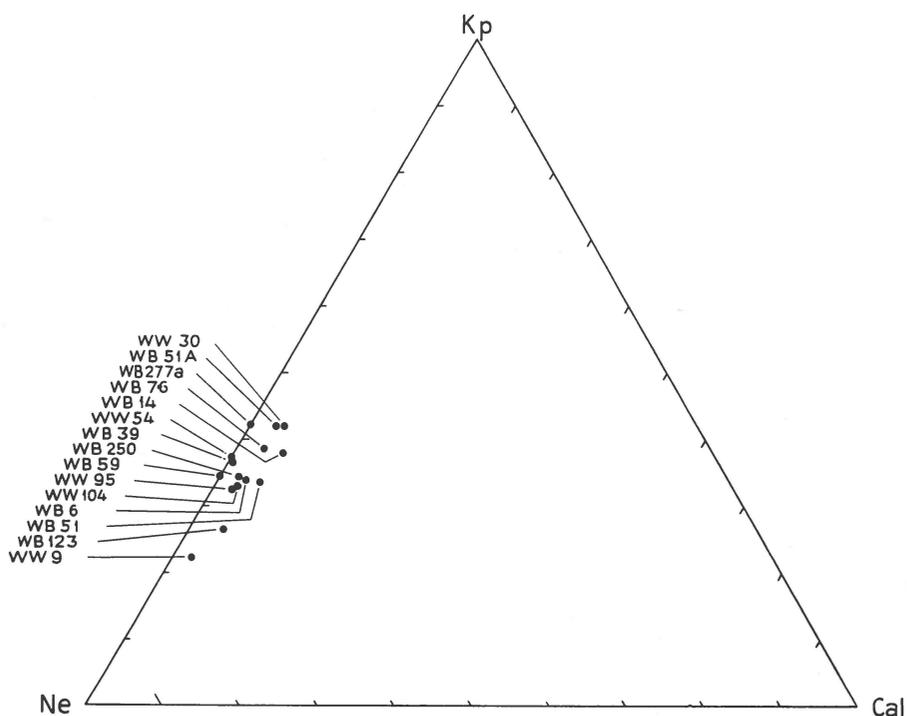
Fig. 8. Normative feldspar of alkali-syenites, granites, and nepheline-syenites.

the alkali-syenites. The monzonite could therefore be the connecting link of a second series of differentiation, starting from an alkali-basalt magma and leading to an alkali- or nepheline-syenite residual magma.

With regard to the variation diagram of the alkali- to nepheline-syenites (fig. 9) it must be observed next that the gap between the alkali-syenites and the alkali-granites is only an apparent one. In fact all transition phases between the rocks rich in quartz and those free from quartz are present.

If we ignore the granites, of which there are too few to be important, the small variation of the fm, al, c, and alk values attracts our attention. This fact we attribute to the almost hololeucocratic character of those rocks, which consist mainly of alkali-feldspar (or alkali-feldspar and nepheline). This feldspar contains very little anorthite. See fig. 8, which shows also the variability of the feldspars in their alkali content, the number of Al-atoms of the analysis as a rule exceeding that of the alkalis only slightly. In the alkali-syenite WB 54 and especially in the tinguaite WB 277a, $Na + K > Al$, the cause of which we see in the aegirine (+ biotite) which it contains. The slight variation of the c and fm values is caused by the changing content and the varying composition of the mafics.
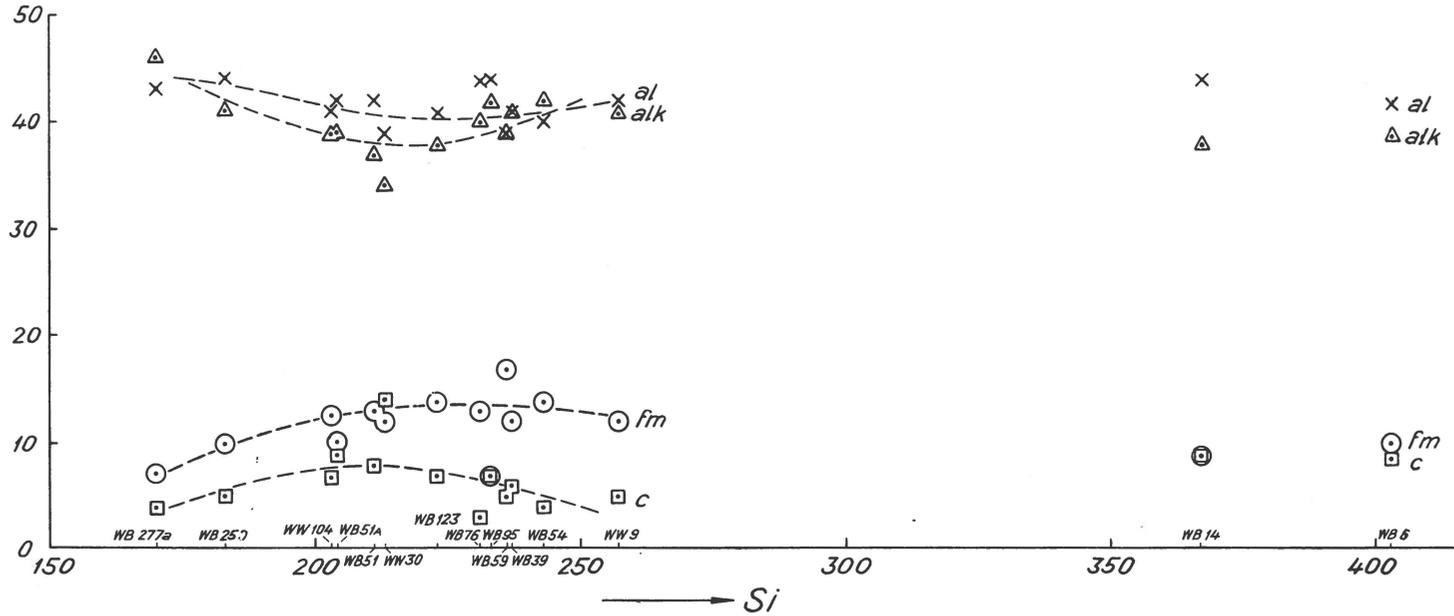
Fig. 9. Niggli diagram of the nepheline-syenites, alkali-syenites, and granites.

The average composition of the alkali- and nepheline-syenites corresponds to the Niggli values: si 218 al 42 fm 12 c 6 alk 40, i. e., to a bostonite-pulaskite composition. These values undergo only an insignificant change if the granites are included.

If we look upon this average composition as characteristic of an alkali-syenite origin we could explain the variation observed within the series nepheline-syenite to granite as due to a shifting of the equilibrium of the reaction:

$$\text{nepheline} + \text{quartz} = \text{albite.}$$
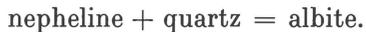
An increased removal of quartz with progressive crystallization would push the point of equilibrium towards the left and cause nepheline to crystallize out. The first products of crystallization would have to be of an alkali-syenite composition while the later ones would contain more and more nepheline. There are in fact signs of such a migration of silicic acid. As such we may consider the presence of quartz in miarolitic cavities of the nepheline-syenite and also the introduction of silicic acid owing to pneumatolytic or hydrothermal causes connected with the formation of the molybdenite deposit of the Malmbjerg. Consequently this hypothesis would agree very well with the sequence of development of the rocks and minerals.

The granites, too, as formations of a later period could be ranged in such a scheme, but it is doubtful whether here all the quartz present would be of magmatic origin. If we take the granites to be purely the products of magmatic differentiation then we must expect a more pronounced change of the alkali content of the feldspars. Now the ratio of the number of sodium atoms to the potassium atoms is almost equal in the alkali-granite BW 6 and in the nepheline-syenite (BW 250) and approaches the values characteristic of most alkali-syenites. It is only the porphyritic marginal facies of the alkali-syenite of the Hvidefjeld (BW 51 A) and the natron-syenite-aplite WW 9 that deviate from the mean value, the former showing a high content of potash-feldspar, and the aplite containing an extreme quantity of albite. But these very examples prove that during differentiation changes in the Or:Ab ratio are to be expected. The fact that no variation is present in the granites could be another sign that these must not be regarded as pure products of differentiation, but rather that they have taken some of the quartz from the sediments.

A more exact study of form, intergrowth, and distribution of the quartz will be needed to furnish a full explanation of this.

The Chemistry of Dolerites and Basalts etc.

The chemical variation of the analysed basic dyke rocks can be seen from the Q L M-diagram. This group comprises alkali- and normal-basaltic as well as sub-basaltic rocks. The three analyses WB 178, 180, and 181 are of importance because the two sills WB 180 and 181 issue from the dolerite WB 178 of the Lille Oksedal. While the dolerite still belongs to the field of the normal basalts, the points of projection of WB 180 and WB 181 lie in the sub-basaltic or alkali-basaltic range. Important changes in the mineralogical and chemical composition may result from a differentiation parallel to the intrusion, but this can hardly be responsible for the whole variation.

As mentioned above, there are basic dykes probably connected with the intrusion of the Werner Bjerge among the analysed samples, but there are also representatives of the regionally distributed basaltic family. Can we separate those two groups petrochemically?

So far such an attempt must fail owing to our sketchy knowledge of the variation within both the groups and, chiefly, for lack of certain criteria for the determination of their origin in the field.

Such an investigation is badly needed to clear up the problem as to whether the alkali-gabbroid intrusions of the Werner Bjerge are derived from the magma of the regional basalts (for instance the basalt cover south of Scoresby Sund). The centre of gravity of the basic intrusions lies on the line of demarcation between alkali-basalt and sub-basalt. A connection of this kind may be considered, but at the same time it would show the alkali-syenite intrusions in a new light and thereby elucidate the problem of this still puzzling group of rocks. We are still far from this aim and in this connection it is chiefly the basalt cover of East Greenland that requires a more detailed chemical study.

We are not yet able to say which dyke rocks must be attributed to small basic centres of intrusion and which belong to the regional basaltic magmatism and we do not yet know either, whether both of these are but different manifestations of the same initial phenomena.

Spectral Analytic Data.

The spectrographical examination of part of the material collected was occasioned by the intensive mineralization observed in the Werner Bjerge. As the leader of the expedition, Dr. LAUGE KOCH, was primarily interested in the mineralization, this had to be taken into consideration in the selection of the samples. However, some minerals and rocks not impregnated by ore have been examined as well.

The spectral-analytical examination was carried out by Dr. STURE LANDERGREN, Stockholm. At first a number of samples were examined

for Ti, V, Cr, Mn, Fe, Co, Ni, Mo, Ag, Cd, Sn, Sb, Pb, and Bi, then the determinations were extended to As, Ga, Zr, Nb, Li, Be, Sr, and Ba. In all the samples LANDERGREN—though with a negative result— looked for Ge and Re. In addition he determined by X-ray spectroscope the presence of Sc, Y, La, Ce, Nd, and Sm in 24 samples. After a previous chemical enrichment the elements Rb, Re, and Hf were ascertained in the following minerals: aegirine (WB 260c), biotite (WW 110), a mixture of biotite and titanite (WW 104), molybdenite (WW 69), and wolframite (WB 315). Au was determined quantitatively only in the highly ore-impregnated sample WW 111 by a special method at the Statens Prov-ningsanstalt, Stockholm.

The results of the examination are represented graphically in the tables. This representation is based on the subdivision into rock groups resulting from the geological investigations. To save space not all the determinations have been given; in particular those for the basic rocks have been omitted as they are of little interest.

In order to arrive at a clear representation, the values given by Dr. LANDERGREN were divided into four classes of magnitude, viz.

Class 1 Contents between 0.0001—0.001 per cent = 1—10 ppm
Class 2 Contents between 0.001—0.01 per cent = 10—100 ppm
Class 3 Contents between 0.01—0.1 per cent = 100—1000 ppm
Class 4 Contents between 0.1—1.0 per cent or more > 1000 ppm

The necessity of assuming a large interval for the 4th class was found by comparing the spectral-analytical records with the chemical determinations, for it turned out that the records in LANDERGREN's table of 0.1—1.0 per cent and > 1 per cent for some elements (e. g. Fe and Mn) express precisely the same. Suspecting that this might apply to other elements, all these values were gathered into one class of magni-tude. In this way the characteristic features of the distribution of the trace elements were even more distinctly displayed. It is true that by this method the difference in the content of Fe and Mn is obliterated, but apart from that, this difference can only be ascertained by chemical determination. Where necessary, the drawbacks involved by our pro-cedure have been corrected by detailed data in the discussion of the principles governing the distribution of the individual elements.

As to the majority of the elements, the limit of detection is at or above 10 ppm (—0.001 per cent). For the correct assessment of the results it is therefore necessary to know this limiting value. Hence, in the subjoined table we give under the symbol of the particular element the corresponding value according to LANDERGREN's records in ppm, adding the mean value of the lithosphere underneath.

Li	Be	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Zn	Ga	As	Sr	Y	Zr
10	10	?	30	10	10	1000	30	30	10	?	5—10	100	10	?	300
65	6	?	4400	150	200	1000	50000	23	80	?	15	5	300	?	220

Nb	Mo	Ag	Cd	Sn	Sb	Ba	La	Ce	Nd	Sm	W	Pb	Bi	U
100	10	3	100	10	100	10	300	500	100—300		?	30	10	?
24	15	0.1	?	40	1	250	18	50	24	6.5	?	15	?	?

The results have already been discussed in the geological part (see p. 44). Here we shall merely add a few remarks about the distribution of a few elements in the minerals and rocks of the Werner Bjerge.

Li, Be, and B.

Li was found to be present in many samples; most of the values, however, range below 100 ppm. As expected, the strongest enrichment was found in biotite. The biotite of the alkali-syenites contains between 0.01 and 0.1 per cent of Li. Much higher (ca. 0.4 per cent) is the Li-content of the mica of the pneumatogenic molybdenum veins—the highest value found by us.

In several samples, quantities of Be ranging between 10 and 100 ppm were found; an enrichment nearly ten times as high was noted in the molybdenite of the Malmbjerg; of about the same magnitude was the Be-content of the sphene of an alkali-syenite (WW 104).

So far we lack particulars about the boron content of the minerals of the Werner Bjerge; it is noteworthy though, that boron minerals (e. g. tourmaline) were not found anywhere, not even in the pneumatogenic mineralization.

Rb was determined (after chemical enrichment) only in a mixture of titanite in the alkali-syenite WW 104 as 50—500 ppm.

Sr and Ba.

From the paper of NOLL we know that Sr is primarily enriched in nepheline-syenites, and here chiefly in the nepheline. In fact, the Sr-content in the nepheline is nearly 1 per cent while it is only about 0.1 per cent in the alkali-feldspar of the same rock. The ratio Sr:Ba varies between 10 and 2 in these minerals and rocks.

Both these elements are strongly enriched in hydrothermal fissure-fillings carrying strontianite and barite.

Rare Earths.

The rare earths exhibit a distinct enrichment in the biotite of the alkali syenites (WW 104). The content of Y- and Ce-earths is especially high in the sphene of the same rock. LANDERGREN's values for Y, La,

Ce, and Nd range between 0.1 and 1 per cent and the Th-value of the mineral is just as high. The same order of magnitude is shown by the data for the limonitic residues of the hydrothermally decomposed trachytic syenites of Hvidefjeld; the rare earths here are probably contained in the zirconium.

In extremely mineralized rocks a noticeable enrichment of rare earths must likewise have taken place; the contents given here range about 0.1 per cent.

Zr, Hf, Th, and Nb.

Of zirconium silicates låvenite, mosandrite, and, much more frequently, zircon are known; the latter is especially abundant in the miarolitic alkali-syenites of Hvidefjeld and probably came into existence through the decomposition of the dark components of the alkali-syenite rocks. Actually both aegirine and biotite contain about 1 per cent of Zr.

A Zr-content of 1 per cent was also ascertained in many highly mineralized breccias and acid dyke rocks; in almost all such instances tiny zircon crystals could be seen in the microscope, some of them as inclusions in limonite pseudomorphs after aegirine. Pneumatogenic analcime-rich decomposition products of the nepheline-syenite-pegmatites are often crammed with zircon crystals (WB 261).

Th attains its highest values in the sphene and in the zircon-bearing decomposition products of the alkali-syenites. Problematical thorite occurs in the dark mica of the molybdenite veins of the Malmbjerg. *Hf* has been determined in aegirine, in the above mentioned zircon-bearing decomposition products, and in wolframite. (Content: 0.5 to 5 ppm, for all three determinations).

Nb is a regular accessory of zircon. The ratio Zr:Nb ranges about 10:1 and seems to be fairly constant.

Ti, V, Cr, Mn, Co, Ni.

Of titanium minerals, ilmenite, titanomagnetite, rutile, lamprophyllite, narsarsukite, and sphene were found. The first two are enriched in schlieren of the pyroxenites and of the "essexite"-gabbros. The high content of titanium in these rocks (cf. the analyses), however, is not only to be ascribed to the ore; the dark constituents (titanaugite, brown hornblende, and lepidomelane) are likewise rich in Ti. In lepidomelane Ti is often segregated in the form of rutile needles (sagenite).

Granular rutile also occurs sporadically in alkali- and nepheline-syenites. Here, however, sphene is the Ti-mineral most commonly met with, lamprophyllite being much rarer. The high content of rare earths and Th in the sphene has been pointed out above. It is not impossible

that this mineral was concentrated in the fluvioglacial deposits of the Østre Gletscher and the Kongespejlet.

In the aegirine of the nepheline-syenites a Ti-content of 100 to 1000 ppm has been determined, in the biotite about ten times as much.

A few tenths to more than 1 per cent of Ti were found in mineralized breccias, etc.; the quantity concentrated there was leached out during the decomposition of the dark constituents and migrated with the gases or solutions to its present location.

The V, Cr, Co, and Ni content of the majority of rocks and minerals of the Werner Bjerge is inconsiderable. These elements are enriched in the basic, and chiefly in the ultra-basic rocks. There the Cr content can reach several tenths per cent. In the mafics (titanaugite, brown hornblende, and biotite) it is from 100 to 1000 ppm, most of which may be contained in the magnetite.

In the pneumatolytic-hydrothermal decomposition products the content of these elements varies, but in most cases it remains below 0.1 per cent. The pyrite (Wb 36 a) contains about 30 ppm of Co.

Manganese.—The spectroscopic records for Mn as a rule turned out to be too high. As chemical data are only available for the analysed rocks, we know for the present only very little about its quantitative distribution. It is a fact, however, that Mn is always present in the haematitic and limonitic ore impregnations, in some places it is perhaps even dominant. At any rate, the proportion Fe:Mn seems to vary considerably.

Cu, Ag, Au.

Cu was not detected in any of the analysed samples. Chalcopyrite was found sporadically in druses of alkali-syenites; otherwise the massif (Malmbjerg included) is amazingly poor in Cu. The same applies to Au, which in an extremely mineralized sample was determined to be 0.01 ppm. On the other hand, Ag (limit of detection 3 ppm)—as also Pb and Sn —was found to be present in all the minerals, although in quantities which only exceptionally exceed 100 ppm. Ag is an accessory of Pb and has been observed in a concentration of 100 and 1000 ppm in the galena- and zincblende-bearing fissures of the Malmbjerg.

Similarly, Zn, Sb and Pb are known to form minerals only in the Malmbjerg, where small quantities of cassiterite, galena, and zincblende occur. Galena was also observed in boulders of Vestre Gletscher, derived from ore veins which here pierce the sedimentary cover.

As, Sb, Bi.

Of these elements Sb has been detected only in the galena of the Malmbjerg (10 to 100 ppm of Sb), and As only in the pyrite of the Lejrryggen (WB 36 a 100 to 1000 ppm), while Bi was found in the biotite

of an alkali-syenite (WW 104) and in a galena- and limonite-bearing
ore sample from the moraine of the Vestre Gletscher (10 to 100 ppm).

Mo, W, U.

In ore-impregnated material Mo occurs only sporadically in spec-
troscopically ascertainable quantities (10 to 100 ppm of Mo). A pneu-
matogenic molybdenite deposit occurs in the Malmbjerg. Molybdenite
has also been observed in druses of alkali-syenites and alkali-granites,
sometimes with wolframite. The manganese-bearing wolframite of the
Malmbjerg contains about 3000 ppm of Mo.

The W-content of the rocks and the wolframite content of younger
quartz-topaz veins have been mentioned already (see p. 46).

No noteworthy concentrations of uranium were found anywhere.

Re.

In two samples of molybdenite a content of Re of 10 to 100 ppm
was ascertained. This corresponds to the content of 20 ppm of Re re-
ported for the same mineral by J. and W. NODDACK.

C, S, P, F.

Some remarks about information gained from rock analyses or
microscopical observations of the elements C, S, P, and F follow.

Of C-bearing compounds in addition to cancrinite exclusively
carbonates—calcite and siderite—were found. Both these minerals
occur as hydrothermal fissure fillings, calcite only also as a secondary
decomposition product in diabases and as amygdaloid fillings in basalts.
As the last magmatic constituent, calcite often also fills the interstices
of alkali- and nepheline-syenites.

S occurs as pyrite in basic rocks and in pneumatolytic-hydrother-
mally ore-impregnated zones. It was also found in the hydrothermal
fissures as sulphate (baryte?, strontianite).

Fluorite is, without doubt, the most frequent F-compound in the
Werner Bjerge. This mineral is not only a frequent constituent of the
alkali-granites and -syenites, but it is especially concentrated in large
quantities in the *fluorite*- and *topaz*-greisen of the Malmbjerg. A few
isolated fluorite crystals were also found in nepheline-syenite-pegmatites.
Låvenite and narsarsukite also contain fluorine. Nothing is known about
the F-content of the other zones of mineralization; no fluorite has been
found in them or in the hydrothermal dykes.

The only important P mineral is apatite which is at its richest in
alkali-gabbroid rocks, in certain basalts, and in some exceptional alkali-
syenites. Xenotime is of very rare occurrence.

List of the Minerals found to date.

Quartz

Oligoclase, andesine, labradorite, bytownite

microcline-microperthite and antiperthite, anorthoclase, orthoclase(?), albite

Nepheline, sodalite, analcime, cancrinite

Olivine

Diopside, titanaugite, pigeonite, aegirine, aegirine-augite

Brown and green amphibole, barkevikite, arfvedsonite riebeckite

Brown and green biotite

Magnetite, ilmenite, haematite, cassiterite, rutile, spinel

Pyrite, galena, zincblende, molybdenite

Sphene, zirconium, topaz

Lâvenite, lamprophyllite, mosandrite, narsarsukite

Wolframite, scheelite, baryte (?), strontianite

Apatite, xenotime

Fluorite

Natrolite, thomsonite, chabazite(?), zoisite, epidote, prehnite, garnet, tremolite, sericite, serpentine (antigorite), bowlingite, chlorite, talc, kaolin(?), calcite, siderite.

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PLATES

Plate 1.

The plutonic massif of the Werner Bjerge seen from northwest. In the centre the Kolossen surrounded by the Østre Gletscher (top) and Mellemgletscher (bottom).

Plate 2.

The Mellempas. Contact of the alkali-granitic intrusion with paleozoic sediments.
Gr = alkali-granite, Qp = quartz-porphyry, S = sediments.

Plate 3.

The Kolossen. Porphyrite Xenolith (Pt) floating in alkalisyenite (Sy).
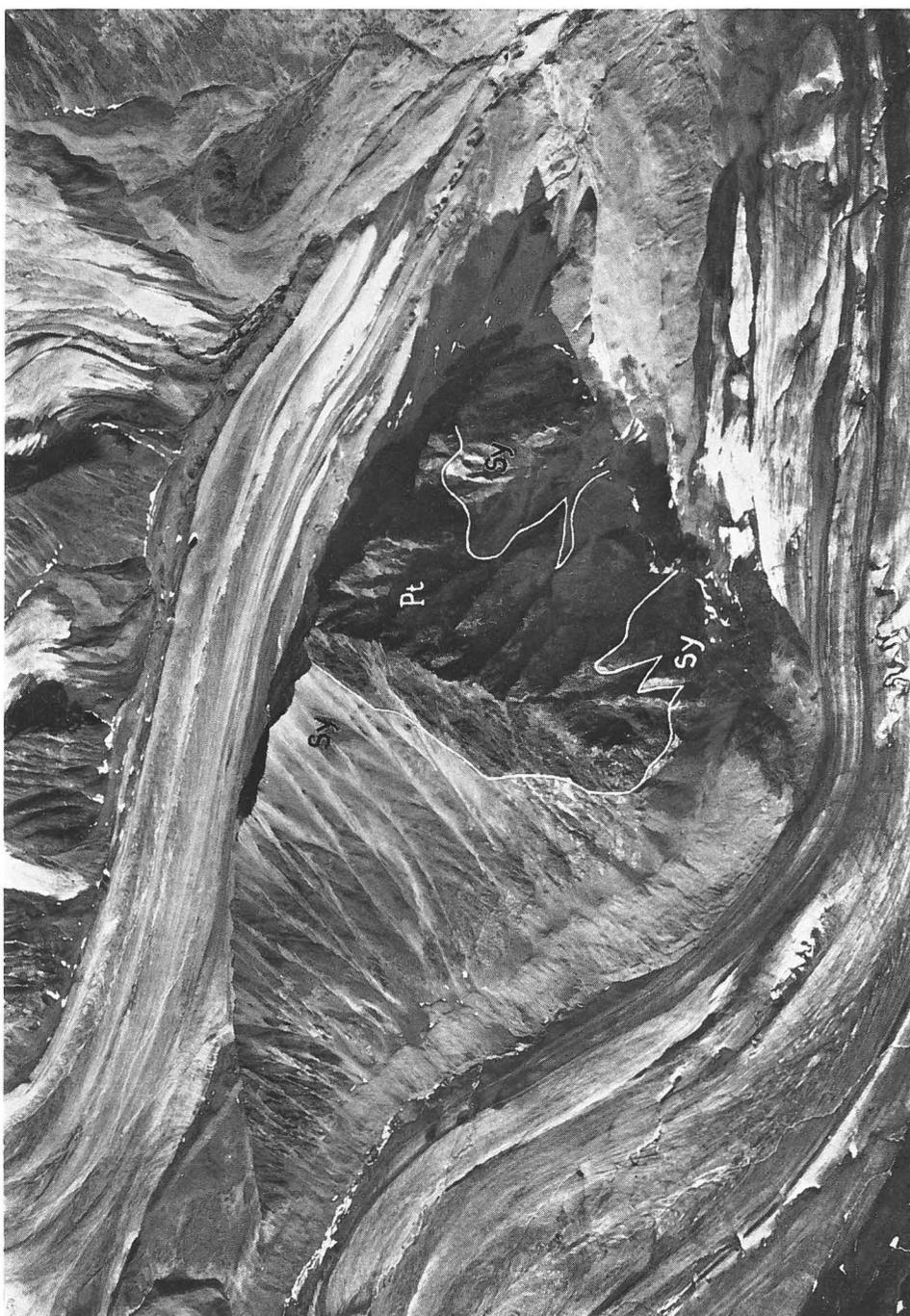
Plate 4.

Aerial view of the summits South of Retrætegletscher: Titanitspids and Dreiesel-
berg. Østre Gletscher on the right, bottom. Sedimentary xenoliths in alkali-syenite.
Br + P = breccias and porphyrites, Mo = Monzonite, S = sediment, Sy = Syenite.

Plate 5.

Upper Østre Gletscher. The uppermost basin is surrounded by gabbros (G), pyro-xenites (P), and basic breccias (D. Br.). The trachytic alkali-syenite (Tr) of "Hvide-fjeld" forms the southern rim of the two lateral glaciers, flowing together in the centre.

O = site of camp 1953, Br = acid breccias, Sy = alkalisyenite, V = mineraliza-tion at the Lejrryggen.

Plate 6.

View across the Ruinerne (foreground) and the Antarctic Pas towards Antarctic Havn.
Sy = alkali-syenite, Tr = trachitic alkali-syenite of Hvidefjeld, Br = breccias
and porphyries, G + P = gabbros, pyroxenites.

Plate 7.
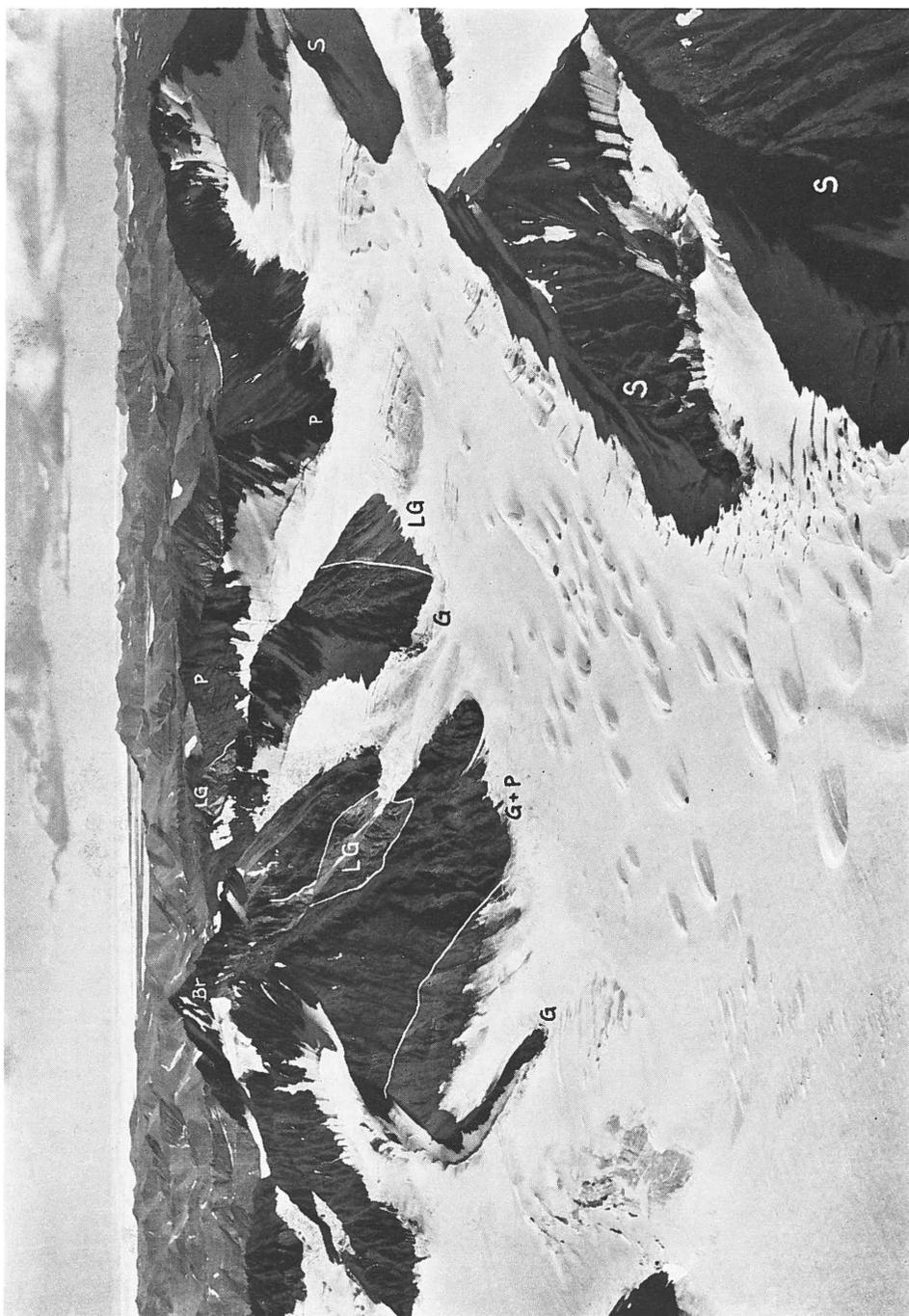
Plate 8.

Central part of the basic complex.
For legend see Phot. 7. Gm = fine-grained gabbro at the Uglespids.

Plate 9.

View upon the nepheline-syenite of Hvide Ryg and upon the southern margin of the plutonic complex. Notice in the foreground the shifted sedimentary lumps in the intrusion of the Katederet.

Plate 10.

Leftward western end of the Hvide Ryg. In the centre Aldebaran Gletscher; to the right the southern margin of the plutonic complex overlaid with Upper Paleozoic (Sp), to Triassic (STr) sediments. Syn = nepheline-syenite, Br + P = breccias and porphyries.

Plate 11.

The nepheline-syenite of the Hvide Ryg seen from the south. On the farther side of Sirius Gletscher two dome-shaped alkali- and nepheline-syenitic Stocks. Notice the big xenoliths of subvolcanic breccias (dark) in the intrusion on the right.

Plate 12.

The confluence of the Schuchert Gl. (left) and of Sirius Gletscher (right) seen from the south. In the background Skelpas with Skeldal fault.

O = camp of 1954, on its righthand side the intrusion of the Katederet, E = Malmbjerg.

Plate 13.

The Malmbjerg. Steep rock wall above the Schuchert Gl. Arcturus Gletscher in the background.

dark = sedimentary layers, multi-coloured in part, light = dome-shaped ore stock.

Plate 14.

Photo A.

Eastern slope of Kravebjerg as seen from Vindueskarmen (Sill-Ryggen), showing sills (samples WW. 155, 156, 159, 161) and dykes (samples WW. 157, 158, 160) in mesozoic sediments. Monte Somma in the background (right).

Basalt dykes.

Photo B.

Dyke in the mesozoic sediments of Vindueskarmen (Sill-Ryggen), with Blomsterdal in the background.

Basalt dykes.

Photo A.

Photo B.

Plate 15.

Basic dykes in the syenite of Titanitspids (Southern crest) and Sukces Gletscher.
Note the shattered nature of the rock wall.
Basalt dykes.
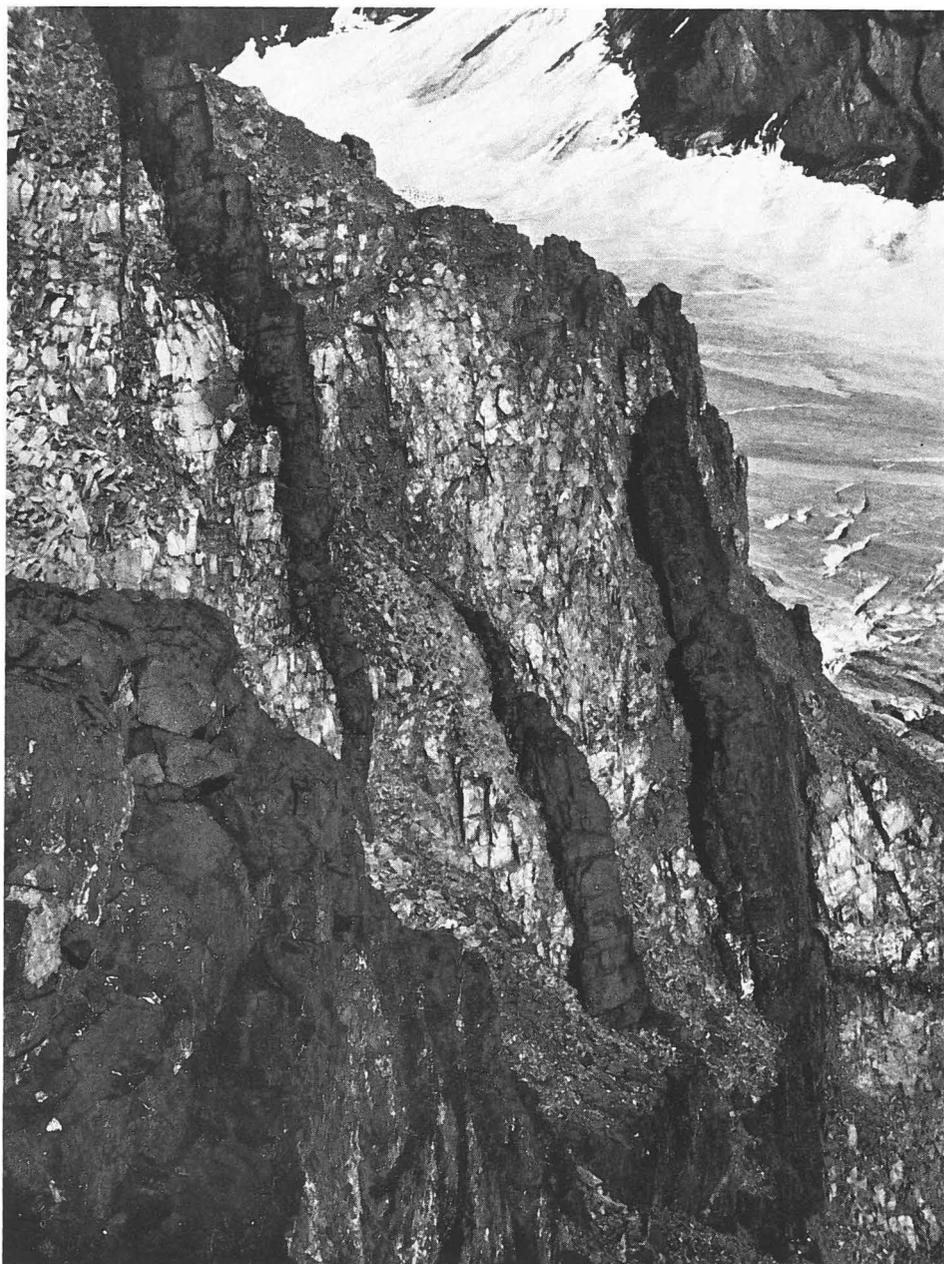
Plate 16.

Photo A.

Pegmatite tubes in the nepheline-syenite of the Hvide Ryg.

Photo B.

Nests of pegmatites in nepheline-syenite. Roches moutonnées at the Randgletscher.

Photo C.

"Nest" of pegmatites in the nepheline-syenite of the Hvide Ryg.
white = alkali-feldspar
grey = nepheline
black = aegirine.

Photo A.
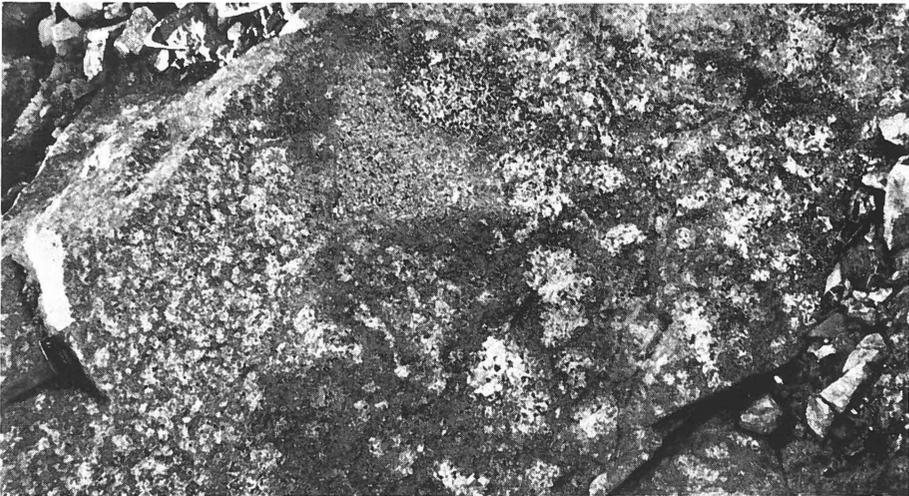
Photo B.

Photo C.

Plate 17.

Table-shaped crystals of narsarsukite in a druse of pegmatite.

Plate 18.

Molybdenite (righthand side) on planes of joint in intrusive rock of the Malm-
bjerg (Schuchert Gl.).

1 cm
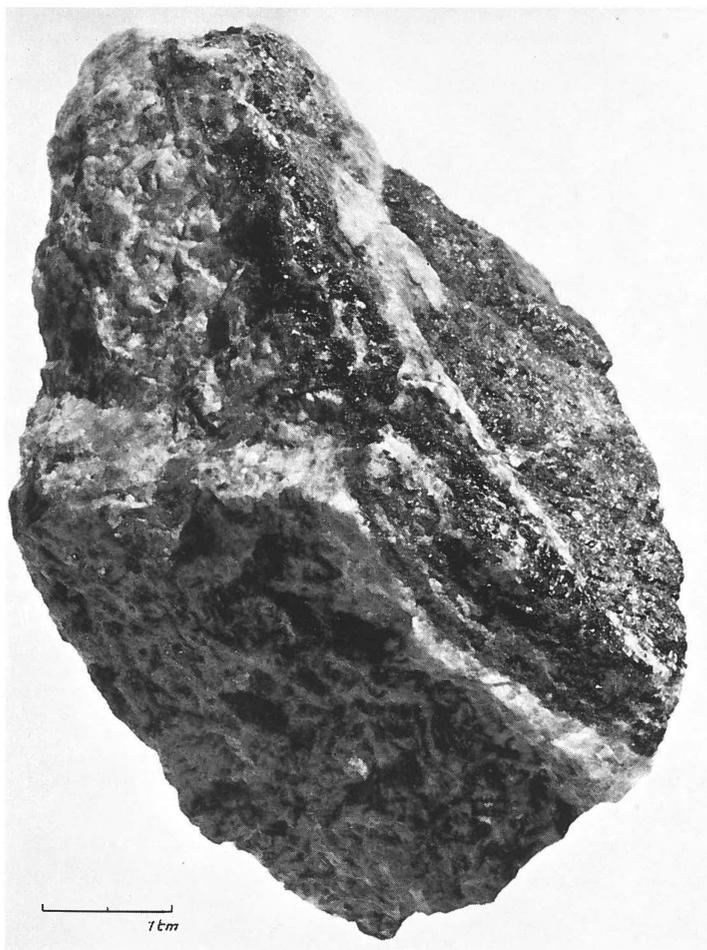
Plate 19.

Photo A.

Wolframite (prisms of Hubnerite, black) intergrown with quartz (white). Malmbjerg
(Schuchert Gl.).

Photo B.

Topaz crystals on quartz-wolframite joint. Malmbjerg.
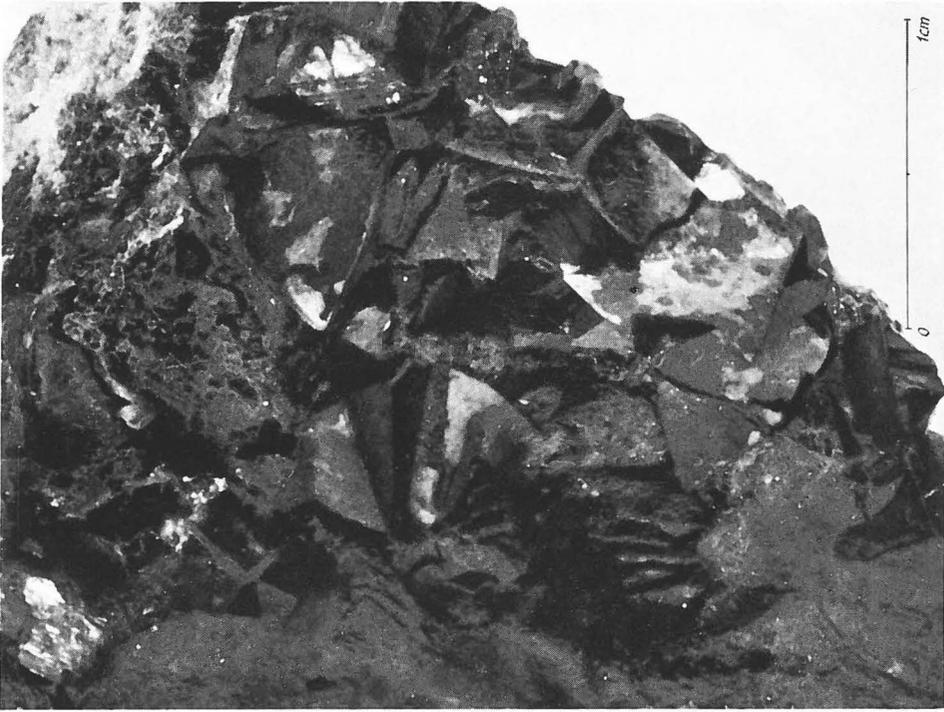
Photo B.

Photo A.

Plate 20.

Map showing localities of analysed samples. Contour of the plutonic body marked by a black line.
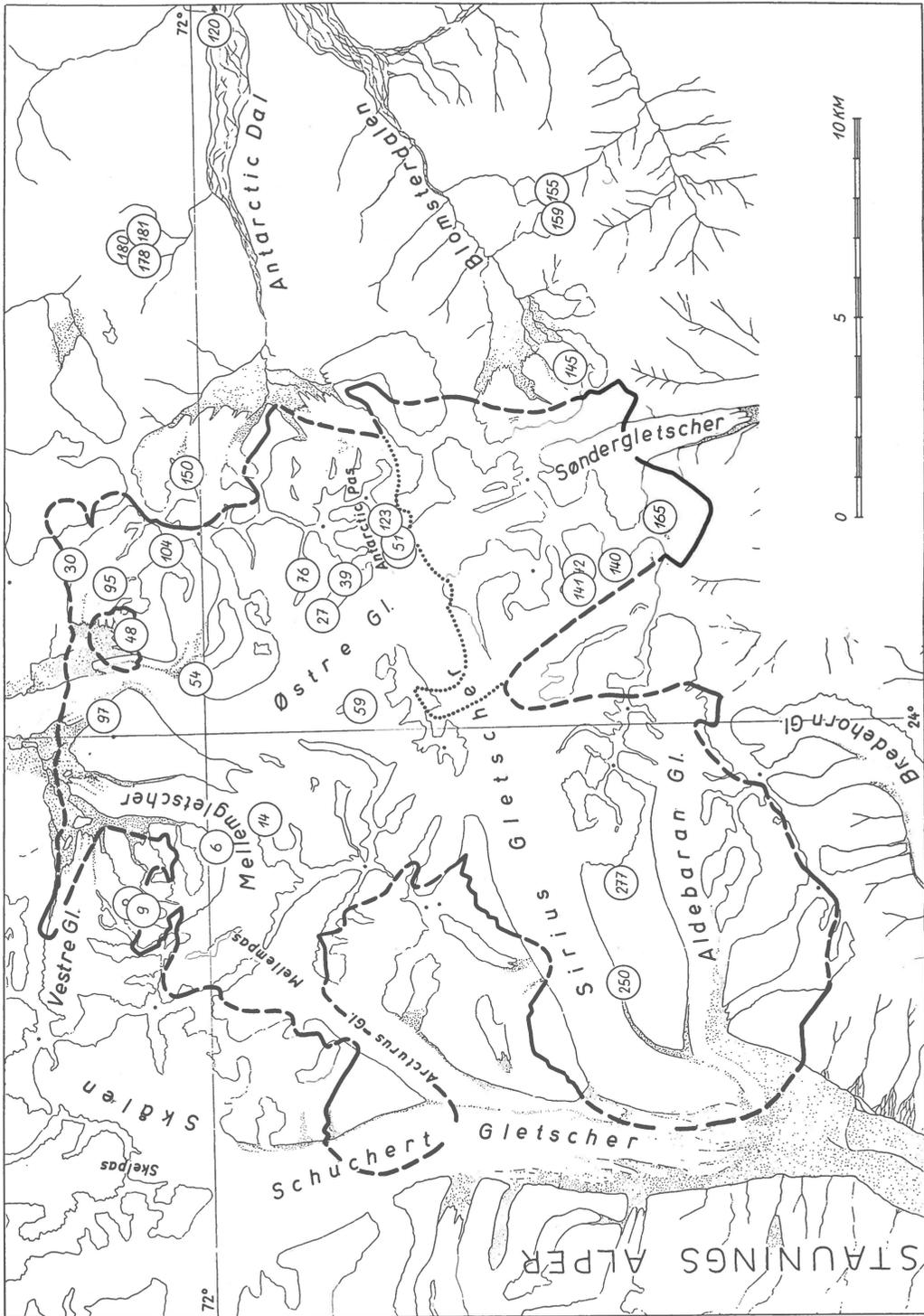
PLATE 20.

Plate 21.

Graphic representation of results of the spectral-analytical examination based on the subdivision into rock groups resulting from the geological investigations.

| = 1 — 10 ppm.   ‖ = 10 — 100 ppm.

| = 100 — 1000 ppm.   ‖ > 1000 ppm.

Column headers: Li Be Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga As Sr Y Zr Nb Mo Ag Cd Sn Sb Ba La Ce Nd Sm W Au Pb Bi Th U

	Rock No	Li Be Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga As Sr Y Zr Nb Mo Ag Cd Sn Sb Ba La Ce Nd Sm W Au Pb Bi Th U
MINERALS		
Microperthite	WB 260 a	
"	" 133	
Nepheline	" 260 b	
Sodalite	" 323	
Analcime	" 267	
Aegyrine	" 134	
"	" 260 c	
Biotite	" 51	
"	WW 104	
Sphene	" 104	
Limonitic interstitial matter	" 110	
ROCKS		
Alkali-Granites	WB 6	
	" 14	
Alkali-Syenites	" 39	
	" 51	
	" 51A	
	" 123	
	" 30	
	" 95	
	" 104	+50-500 ppm Rb
Nepheline-Syenite	" 250	
MINERALIZED DYKES, BRECCIES AND TUFFS	WB 26	
	" 28	
	" 29	
	" 44	
	WW 17	
	WB 33	
Iron ore coats	" 332	
	" 126	
	" 67	
	WW 67	
	WB 21	
	" 25	
	WW 95	
	" 117	
	WB 119	
Hydrothermale joint-fillings	" 54a	
	" 54b	
	" 54c	
Limonitic interstitial matter	WW 110	
Iron ore coat	" 111A	
Molybdenite	WB 295	
"	WW 69	
Wolframite	WB 315	
Quartz-Fluorite-Mica-impregnations	" 319	
	" 320	
	WW 99	

Rock No | Li Be Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga As Sr Y Zr Nb Mo Ag Cd Sn Sb Ba La Ce Nd Sm W Au Pb Bi Th U

Medd. om Grønl. Bd. 153, Nr. 4. 1959. [P. Bearth].

Pl. 22.

Werner Bjerge

Geological Map

by

P. Bearth and E. Wenk

0   5 km

1 : 100 000

MESTERS VIG

Ekspeditionshus

Deltadal

Oksedal

Vestre Gl.

Skelpas

Skaalen

Mellemgletscher

Mellenpas

Antarctic Dal

72°

72°

Arcturus Gl.

Östre Gl.

Antarctic Pas

Blomsterdal

T

T

Schuchert Gletscher

Sirius Gletscher

Aldebaran Gl.

Söndergletscher

STAUNINGS ALPER

Breithorn Gl.

Schuchert Flod

Lomsöen

Pingo Dal
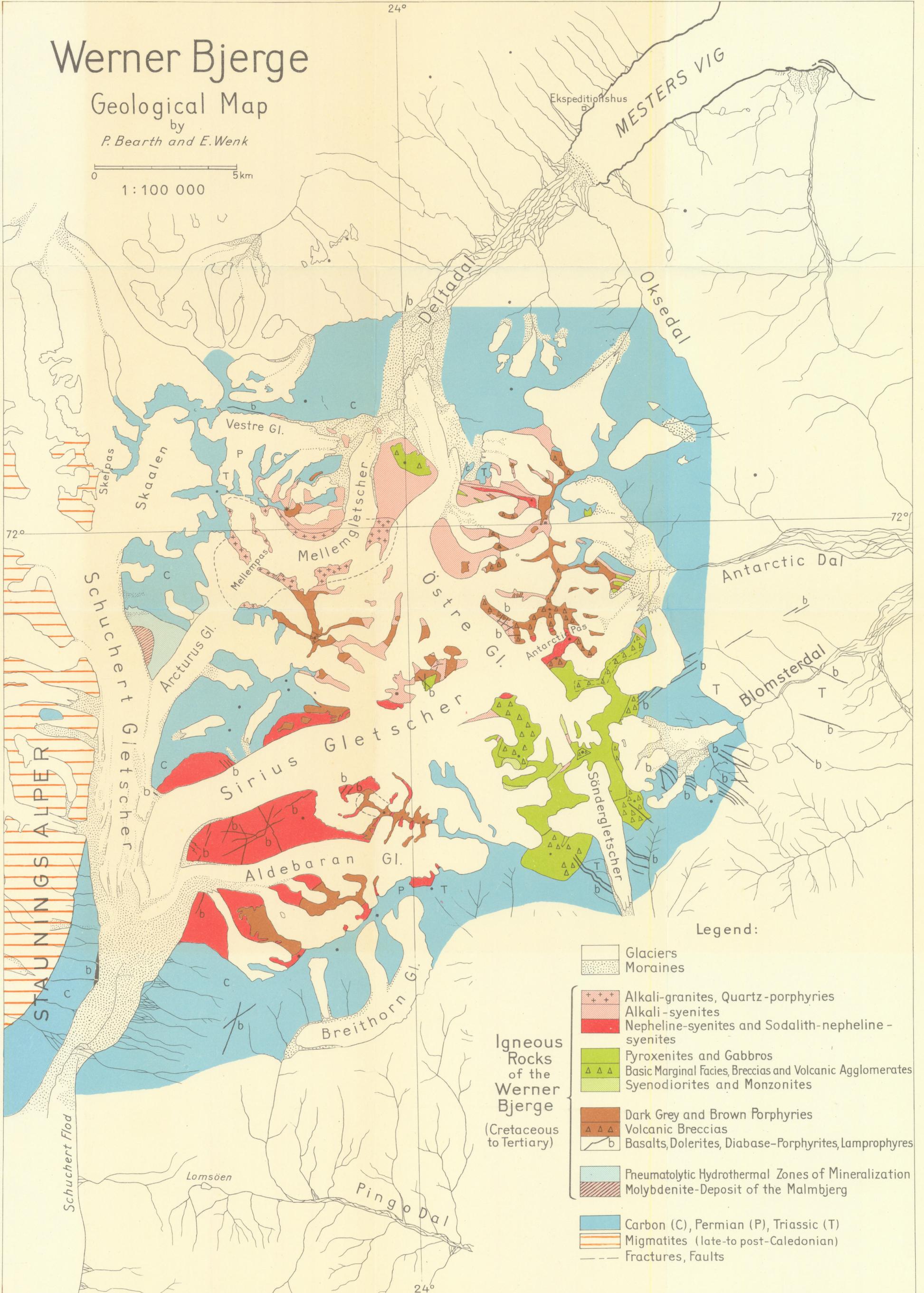
Legend:

Glaciers

Moraines

Igneous Rocks of the Werner Bjerge

(Cretaceous to Tertiary)

Alkali-granites, Quartz-porphyries

Alkali-syenites

Nepheline-syenites and Sodalith-nepheline-syenites

Pyroxenites and Gabbros

Basic Marginal Facies, Breccias and Volcanic Agglomerates

Syenodiorites and Monzonites

Dark Grey and Brown Porphyries

Volcanic Breccias

Basalts, Dolerites, Diabase-Porphyrites, Lamprophyres

Pneumatolytic Hydrothermal Zones of Mineralization

Molybdenite-Deposit of the Malmbjerg

Carbon (C), Permian (P), Triassic (T)

Migmatites (late- to post-Caledonian)

Fractures, Faults

Pl. 23.

Werner Bjerge
Mineralization
by
P. Bearth and E. Wenk

0 _____ 5 km

1 : 100 000

MESTERS VIG

Ekspeditionshus

Deltadal

Oksedal

Vestre Gl.

Skalpas

Skaalen

72°

Fe Mn

Fe Mn

Fe Mn

Mellemgletscher

Fe Mn

Fe Mn

72°

Antarctic Dal

Fe Mn

Fe Mn

Mellempas

Mo

Östre Gl.

Fe Mn

Fe Mn

Fe Mn

Antarctic Pas

W

Mo

Arcturus Gl.

Fe Mn

W

Mo

Blomsterdal

Söndergletscher

STAUNINGS ALPER

Schuchert Gletscher

Sirius Gletscher

Aldebaran Gl.

Fe Mn

Breithorn Gl.
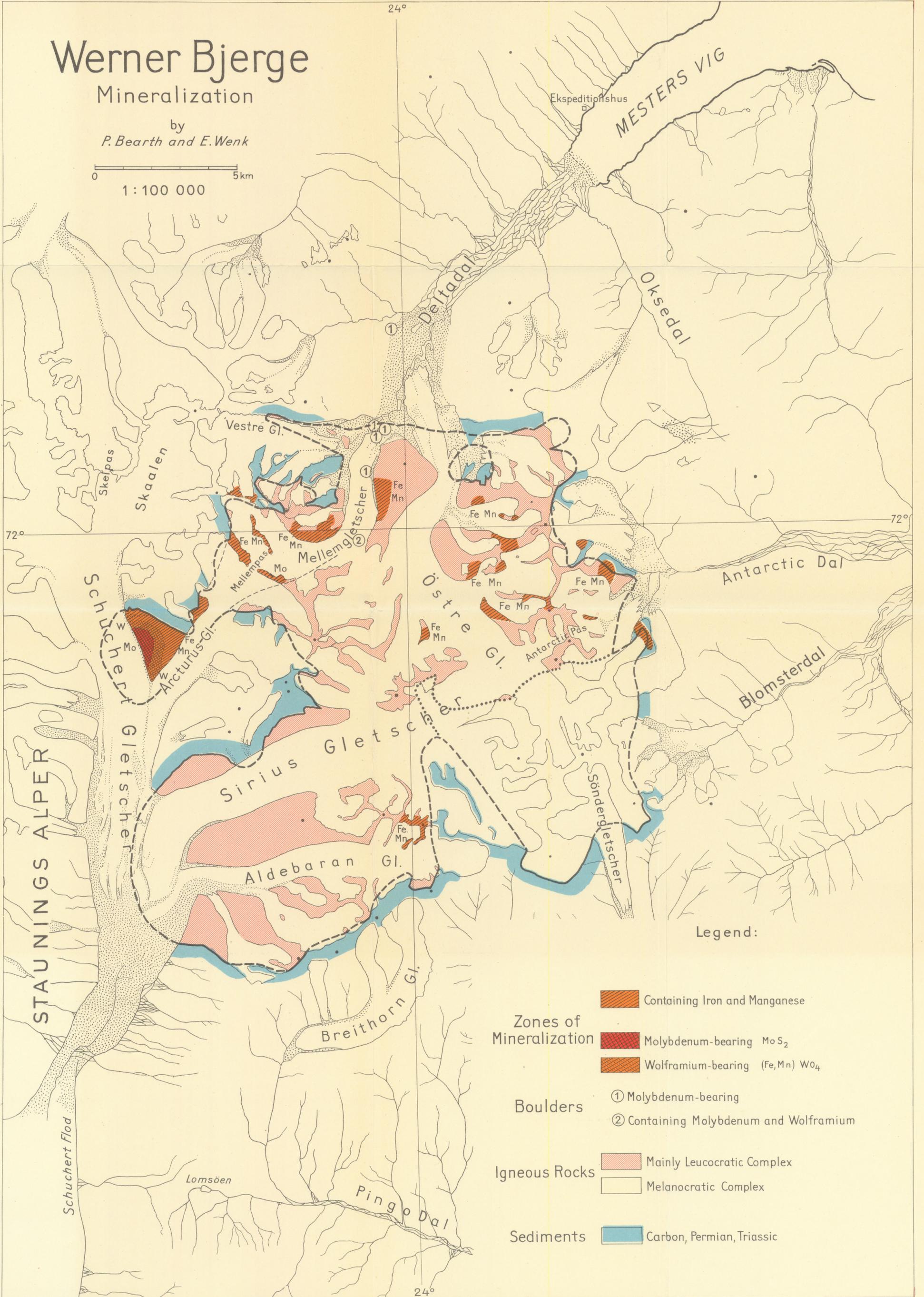
Legend:

Containing Iron and Manganese

Zones of Mineralization

Molybdenum-bearing MoS₂

Wolframium-bearing (Fe,Mn)WO₄

Schuchert Flod

Lomsöen

Pingo Dal

Boulders

① Molybdenum-bearing

② Containing Molybdenum and Wolframium

Igneous Rocks

Mainly Leucocratic Complex

Melanocratic Complex

Sediments

Carbon, Permian, Triassic

24°

24°

Werner Bjerge
Route - Map
No. 1

ca 1:53'000

MESTERS VIG

Ekspeditionshus

Oksedal

Delhdal

Skålen

Vestre Gr.

Kolonien

Titanitspide

Mellem-Gletscher

72°   72°

Antarctic Dal

Schuchert-Gletscher

Arcturus Gl.

Pyramiden

Blomstardalen

Sirius Gletscher

Mooseborg   Uglefjeld

Kravebjerg

Søndergletscher

Aldebaran Gl.

STAUNINGS ALPER

1050
Monte Somma

Bredehorn Gl.

Schuchert River

Lummen Sø

Pingo Dal

24°

Legend:

————— Route Bearth 1953

- - - - - Routes Wenk 1953

◎ Base Camp

△ Camp Bivouac

Werner Bjerge
Route - Map
No. 2

ca 1:53'000

——— Route Bearth 1954

◎ Base Camp

△ Camp

☂ Victualling Parachute