GRØNLANDS GEOLOGISKE UNDERSØGELSE
RAPPORT Nr. 116

*The Geological Survey of Greenland*
*Report No. 116*

# Tertiary volcanic rocks from Bontekoe Ø, East Greenland

*by*

*Arne Noe-Nygaard and Asger Ken Pedersen*

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# Tertiary volcanic rocks from Bontekoe Ø, East Greenland

*by*

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1983

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# Contents

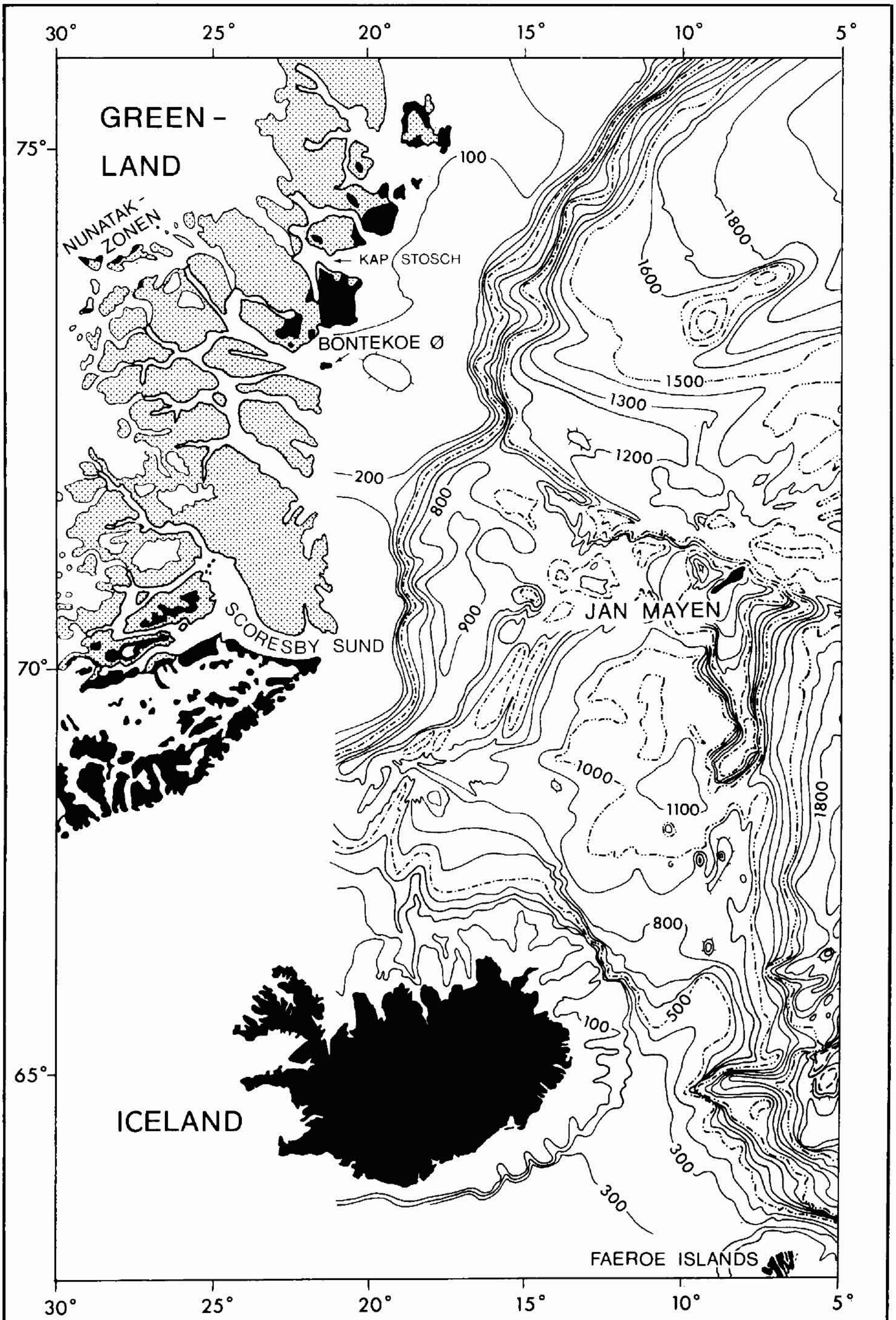


Fig. 1. The location of Bontekoe Ø in central East Greenland. On-shore Tertiary to Recent volcanic rocks are shown in black. Water depth in metres.

# Introduction

In East Greenland Tertiary igneous rocks are found from Kap Gustav Holm (66°30′N) in the south to Shannon (75°30′N) in the north. Within this region three areas are covered by plateau basalts; (a) south of Scoresby Sund (70°N), (b) far inland on the nunataks at 74°N and (c) along the coast between 73° and 75°30′N. Bontekoe Ø belongs to the third region (fig. 1).

The geology of this part of East Greenland is largely known from the activities of Lauge Koch's expeditions during which, curiously enough, the areas dominated by Tertiary volcanism were almost neglected. To remedy this the Geological Survey of Greenland supported some reconnaissance work that was carried out in connection with other geological activity in the region over the last few years. Results of this work were given by Noe-Nygaard & Pedersen (1974), Upton & Emeleus (1977), Hald (1978), Brooks *et al.* (1979) and Upton *et al.* (1980, 1982, in press).

Bontekoe Ø lies off the entrance to the large Kejser Franz Josephs Fjord at about 73°N. It is near to the southernmost preserved part of the northern, coastal lava plateau in East Greenland situated between the strongly alkaline Tertiary volcanics of the nunatak zone (Brooks *et al.*, 1979) and the younger volcanic formations of the Jan Mayen Fracture Zone and Jan Mayen itself (Hawkins & Roberts, 1972 and fig. 1). Hence it is of interest to test whether geochemical anomalies had developed at a pre-Jan Mayen Fracture stage on this island.

Observations made in the early nineteen-thirties by one of us (A.N.-N.) from the sea suggested that basaltic lavas occupied the greater part of the island, although on the geological map completed by Koch & Haller (1971) the island is marked as extrusives, pyroclastic rocks and magmatic breccias of various origins. Samples in the regional collection from Greenland in the Geological Museum of the University of Copenhagen are also basaltic lavas.

The present paper is based on samples, collected by H. G. Backlund and D. Malmqvist from the eastern part of the island in 1932 and on field observations and additional material, collected from the western part of the island, by S. Funder and K. Strand Petersen in 1974.

# Geological setting

Bontekoe Ø (fig. 2) is about 6 by 10 km in area. It is part of a lava plateau almost entirely built up of lavas with very minor tuffs, while hyaloclastites and explosive breccias seem to be lacking. This plateau is extensively faulted and fractured mainly along NE–SW trends. In contrast to the generally westerly dips of the lava plateau to the north in Hold with Hope (Hald, 1978; Upton *et al.*, 1980) the entire succession on Bontekoe Ø dips eastwards.

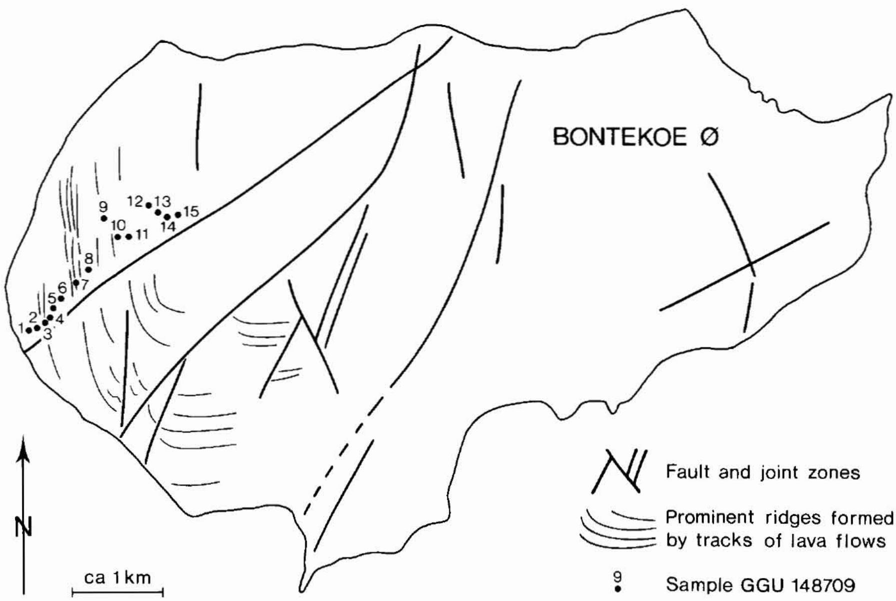


Fig. 2. Sketch map of Bontekoe Ø drawn from vertical aerial photographs. Dots: Locations of tholeiitic basalt samples GGU 148701 to 148715 collected by S. Funder and K. Strand Petersen.

In the western part of the island there is an almost continuous succession of the oldest lavas exposed, representing a cumulative thickness of about 100 m, and consisting of columnar-jointed tholeiitic basaltic lava flows varying in thickness from 2 to 20 m (fig. 2).

On the eastern part of the island an intensely faulted easterly dipping lava sequence occurs; samples collected from low altitudes are tholeiitic, while lavas from the highest tops are hawaiitic. An easterly dipping sequence of tholeiitic lavas covered by younger alkaline flows is therefore inferred as valid for the whole island. Tholeiitic dykes seem to cut the whole pile.

## Petrography

### *Tholeiitic basalts*

The flows from the western profile all consist of medium- to fine-grained basalts, mainly with intergranular texture; cognate microdoleritic inclusions which consist of a few augite crystals and lath-shaped plagioclase in ophitic or subophitic intergrowth are of common occurrence. The basalts are either porphyritic or glomerophyric, only one single flow is aphyric.

The groundmass consists of plagioclase, clinopyroxene, titaniferous magnetite, ilmenite and residual glass. A small number of olivine pseudomorphs are present in several samples, whereas no orthopyroxene was encountered. All Fe-Ti oxides are of late crystallization. In many interstices green sheet silicates, quartz and zeolites are found; carbonate also occurs,

*Table 1. Modal analyses of tholeiitic basalts from Bontekoe Ø*

| | 1† | 2 | 3 | 5 | 6 | 10 | 13 | 14 | 15 | 277‡ |
|---|---|---|---|---|---|---|---|---|---|---|
| Phenocrysts & microphenocrysts | | | | | | | | | | |
| plagioclase | 13.7 | 11.1 | 12.3 | 6.5 | 7.8 | 13.4 | 11.5 | 11.8 | 9.2 | 7.8 |
| clinopyroxene | 2.3 | 3.0 | 1.6 | 0.3 | 0.1 | 0.8 | 0.3 | 2.5 | 2.8 | 4.0 |
| olivine** | 1.6 | 0.6 | 1.1 | 1.2 | 1.7 | - | - | - | 0.7 | 1.6 |
| groundmass | 82.4 | 85.3 | 85.0 | 92.0 | 90.4 | 85.8 | 88.2 | 85.7 | 87.3* | 86.6 |

Modal compositions based on point counter analyses (1700 points or more in one thin section per sample).

*Groundmass includes 2% semiphenocrystic opaque minerals.

†Numbers refer to sample numbers GGU 148701 to 148715.

‡Sample from the collection of the Geological Museum, MM 1980.277.

**Includes pseudomorphs after olivine.

mostly in cracks and irregular patches. Plagioclase phenocrysts may reach a length of 2 mm in porphyritic lavas, while in glomerophyric clusters they rarely exceed 1.2 mm. Colourless clinopyroxene crystals are only half this size, and are often twinned on (100).

Modal analyses of tholeiitic basalts are presented in Table 1. In average the phenocrysts make up 13%.

Mineral analyses from a typical tholeiitic basalt (GGU 148702) were carried out (by A.K.P.) with the TPD-microprobe of the Research School of Earth Sciences, Canberra, applying the procedure described by Reed & Ware (1975). The sample is typical of the least evolved tholeiitic plateau basalts from northern East Greenland.

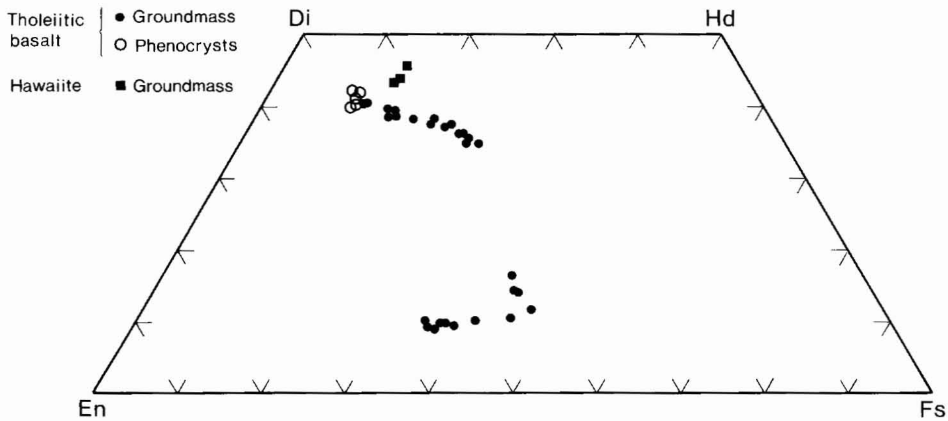


Fig. 3. Ca-Fe$^{(total)}$-Mg diagram (atomic per cent) for pyroxenes from the tholeiitic basalt GGU 148702 and the hawaiite MM 1980.275. The tholeiitic groundmass analyses were made to determine the extent of the pyroxene compositional variation. The dot density is not representative of the modal proportions and overrepresents the amount of pigeonite.

*Table 2. Microprobe analyses of minerals from the basalts of Bontekoe Ø*

| Anal. no. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 52.02 | 51.31 | 51.35 | 50.50 | 36.11 | 50.90 | 38.76 | 43.11 | 41.57 | n.a. | n.a. | n.a. |
| $TiO_2$ | 0.45 | 0.56 | 0.51 | 0.18 | n.d. | 1.37 | 6.40 | 3.95 | 5.25 | 21.86 | 21.21 | 49.85 |
| $Al_2O_3$ | 2.62 | 1.73 | 0.79 | 5.59 | n.d. | 2.28 | 12.67 | 9.10 | 10.41 | 2.85 | 3.01 | 0.68 |
| $Cr_2O_3$ | 0.86 | 0.21 | n.d. | n.d. | n.d. | 0.10 | n.d. | n.d. | n.d. | 0.19 | n.d. | n.d. |
| $FeO^*$ | 6.34 | 14.32 | 26.77 | 13.93 | 32.83 | 8.81 | 8.57 | 9.47 | 9.46 | 68.13 | 68.53 | 42.75 |
| MnO | n.d. | 0.14 | 0.45 | n.d. | 0.96 | 0.13 | n.d. | n.d. | 0.19 | 0.80 | 0.92 | 1.02 |
| MgO | 16.76 | 13.50 | 15.33 | 8.82 | 29.69 | 14.34 | 18.48 | 15.37 | 14.68 | 4.02 | 3.35 | 4.19 |
| CaO | 20.51 | 17.79 | 5.01 | 1.68 | 0.36 | 20.78 | 0.11 | 11.15 | 11.54 | 0.09 | 0.30 | 0.30 |
| $Na_2O$ | 0.21 | 0.29 | 0.25 | 0.31 | n.d. | 0.66 | 0.81 | 3.04 | 3.03 | n.a. | n.a. | n.a. |
| $K_2O$ | n.d. | n.d. | n.d. | 0.66 | n.d. | n.d. | 9.01 | 1.25 | 1.23 | n.a. | n.a. | n.a. |
| Total | 99.75 | 99.86 | 100.46 | 81.67 | 99.95 | 99.37 | 94.82 | 96.45 | 97.36 | 97.94 | 97.32 | 98.79 |
| $Fe_2O_3$ } as calculated from stoichiometry | | | | | | | | | | 25.79 | 26.34 | 7.56 |
| FeO } as calculated from stoichiometry | | | | | | | | | | 44.93 | 44.83 | 35.94 |
| | | | | | | | | | Total | 100.53 | 99.96 | 99.54 |
| Atomic Mg/Mg+ $Fe^{2+}$ | 0.825 | 0.627 | 0.505 | 0.530 | 0.617 | 0.744 | 0.793 | 0.743 | 0.734 | | | |
| Cations based on no. of oxygens | 6 ox. | 6 ox. | 6 ox. | 22 ox. | 4 ox. | 6 ox. | 22 ox. | 23 ox. | 23 ox. | 24 cat. 32 ox. | 24 cat. 32 ox. | 4 cat. 6 ox. |
| Si | 1.917 | 1.944 | 1.974 | 8.023 | 0.995 | 1.912 | 5.651 | 6.407 | 6.149 | | | |
| Ti | 0.013 | 0.016 | 0.015 | 0.022 | | 0.039 | 0.702 | 0.442 | 0.584 | 4.715 | 4.618 | 1.841 |
| Al | 0.114 | 0.077 | 0.036 | 1.047 | | 0.101 | 2.176 | 1.593 | 1.815 | 0.963 | 1.027 | 0.039 |
| Cr | 0.025 | 0.006 | | | | 0.003 | | | | 0.043 | | |
| $Fe^{3+}$ | | | | | | | | | | 5.565 | 5.738 | 0.279 |
| $Fe^{2+}$ | 0.195 | 0.454 | 0.861 | 1.851 | 0.757 | 0.277 | 1.045 | 1.177 | 1.170 | 10.774 | 10.853 | 1.476 |
| Mn | | 0.005 | 0.015 | | 0.022 | 0.004 | | | 0.024 | 0.194 | 0.226 | 0.042 |
| Mg | 0.921 | 0.763 | 0.878 | 2.088 | 1.220 | 0.803 | 4.015 | 3.404 | 3.236 | 1.718 | 1.445 | 0.307 |
| Ca | 0.810 | 0.722 | 0.206 | 0.286 | 0.010 | 0.836 | 0.017 | 1.776 | 1.829 | 0.028 | 0.093 | 0.016 |
| Na | 0.015 | 0.021 | 0.019 | 0.096 | | 0.048 | 0.230 | 0.875 | 0.869 | | | |
| K | | | | 0.134 | | | 1.676 | 0.238 | 0.232 | | | |
| Total cations | 4.009 | 4.009 | 4.003 | 13.546 | 3.004 | 4.023 | 15.512 | 15.911 | 15.909 | 24.000 | 24.000 | 4.000 |

1. Augite phenocryst in tholeiitic basalt, GGU 148702.
2. Augite groundmass grain in tholeiitic basalt, GGU 148702.
3. Pigeonite groundmass grain in tholeiitic basalt, GGU 148702.
4. Cavity filling brown sheet silicate, GGU 148702.
5. Olivine phenocryst core in hawaiite, MM 1980.275.
6. Groundmass pyroxene in hawaiite, MM 1980.275.
7. Titanian phlogopite in groundmass in hawaiite, MM 1980.275.
8. Brown groundmass amphibole in hawaiite, MM 1980.275.
9. Kaersutite in kaersutite-pseudomorph, MM 1980.275.
10. Titanomagnetite microphenocryst in hawaiite, MM 1980.275.
11. Titanomagnetite in groundmass in hawaiite, MM 1980.275.
12. Ilmenite in groundmass in hawaiite, MM 1980.275.

*Total iron as FeO.
n.d. = not detected.
n.a. = not analysed.

*Olivine* phenocrysts are pseudomorphosed by *carbonate* and a green *iron-magnesium hydrosilicate* with Mg/Mg + $Fe^{total}$ = 0.5. The olivine pseudomorphs do not contain chromite inclusions.

*Clinopyroxene* forms colourless phenocrysts with a composition around $Ca_{41}Mg_{48}Fe_{11}$ Table 2, no. 1). They are rich in $Cr_2O_3$ (0.75%) and poor in $TiO_2$ (0.45%). The groundmass pyroxene (fig. 3) shows substantial variations in composition with both *augite* (dominant) and *pigeonite* (subordinate) present, and emphasizes the tholeiitic character of the basalt. Typical compositions of groundmass augite and pigeonite are shown in Table 2, no. 2 and 3.

*Plagioclase* from zoned phenocrysts and glomerophyric clusters varies in composition from $Ca_{83.3}Na_{15.8}K_{0.9}$ to $Ca_{71.7}Na_{27.8}K_{0.5}$. The groundmass plagioclase varies from the least calcic phenocryst level to about $Ca_{46.5}Na_{51.3}K_{2.2}$.

*Fe-Ti oxides* are titanomagnetite and ilmenite. These oxides crystallized late and have been modified by several stages of subsolidus oxidation.

*Residual glass* is not preserved; it has been completely altered to *green* and *brown sheet-silicate* masses, which also fill most vesicles together with *silica* and *carbonates*. *Zeolites* are not present. A representative analysis of a late brown sheet silicate is given in Table 2, no. 4.

The carbonates often fill cavities and form characteristic concentric bodies, which vary compositionally from $Ca_{1.9}Mg_{49.4}Fe_{46.0}Mn_{0.7}$ at the margins to $Ca_{10.2}Mg_{23.3}Fe_{65.2}Mn_{1.3}$ in the cores. In another investigated tholeiitic basalt the carbonate was nearly pure calcite.

## *Hawaiites*

These vary in appearance from black microporphyritic, fresh rocks to reddish, vesicular, highly oxidized rocks – apparently lavas – with carbonate-filled cavities. The fresh rocks carry olivine, plagioclase and titanomagnetite in a pilotaxitic groundmass which is composed of plagioclase, clinopyroxene, biotite, amphibole, apatite, titanomagnetite and ilmenite.

Microprobe work was carried out on a fresh sample (no. MM 1980.275).

*Olivine* forms well-preserved microphenocrysts with $Mg/Mg + Fe^{total} = 0.63–0.61$. A representative analysis is given in Table 2, no. 5.

*Pyroxene* is a very subordinate constituent and forms small, light red-brown to grey-green, euhedral prisms in the groundmass. Crystals sufficiently large to be analysed show a very restricted compositional range around $Ca_{43.5}Mg_{42.0}Fe_{14.5}$ (fig. 3). A representative analysis is given in Table 2, no. 6.

*Plagioclase* occurs as numerous tabular microphenocrysts, normally zoned from $Ca_{58.5}Na_{39.2}K_{2.3}$ to $Ca_{52}Na_{45.5}K_{2.5}$. Plagioclase is the dominant mineral in the groundmass and shows compositional variation from the least calcic phenocryst composition to $Ca_{17.5}Na_{71.5}K_{11.0}$.

*Biotite* forms late groundmass crystals of irregular size. It is a titanian biotite (Table 2, no. 7) with a $Mg/Mg + Fe^{total}$ ratio of 0.63.

*Amphibole* is found as dark brown groundmass crystals. It is a titaniferous calcic amphibole with $Mg/Mg + Fe^{total}$ around 0.75. A representative analysis is given in Table 2, no. 8. Using Leake's classification (1978) it is titanian pargasitic hornblende.

*Titanomagnetite* forms both microphenocrysts and groundmass grains and varies only slightly in composition; it is characterized by a Usp/(Usp + Mt) ratio of about 0.57. Two analyses are given in Table 2, no. 10 and 11. The amount of groundmass titanomagnetite greatly exceeds ilmenite, which is found as homogeneous laths with an Ilm/(Ilm + Hm) ratio of 0.91 to 0.92 (Table 2, no. 12).

The coexisting groundmass Fe-Ti oxides indicate a late stage cooling of the hawaiite around 940°C with $f_{O_2} \sim 10^{-12}$ according to the geothermometer of Spencer & Lindsley (1981).

A single millimetre-sized pseudomorph of rounded shape proved to be composed of titanomagnetite (Usp/(Usp + Mt) = 0.53), kaersutite with $Mg/Mg + Fe^{total} = 0.68$ (Table 2, no. 9) and a greenish brown sheet silicate. The composition and structure strongly suggest that it is a partly dehydrated amphibole megacryst, which broke down prior to or during the eruption.

## *Dyke rocks*

One sample (MM 1980.270) is a magnesian transitional basalt with phenocrystic olivine (partly altered to sheet silicates and with minute brown chromite inclusions) and sector-zoned calcic clinopyroxene. Plagioclase is a scarce microphenocryst phase. The groundmass texture is intergranular to pilotaxitic. It consists of flow-aligned plagioclase, clinopyroxene and Fe-Ti oxides in a residual mass largely altered to green sheet silicates. Both brown phlogopite and brown amphibole occur as late-stage phases.

The other analysed dyke (MM 1980.276) is a silicic basalt with microphenocrystic plagioclase in a well-crystallized groundmass of plagioclase, predominantly prismatic

*Table 3. Chemical compositions and CIPW norms of tholeiitic basalts from the western part of Bontekoe Ø*

| | Flow group 1 | | | Flow group 2 | | | | | | Flow group 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GGU no. | 148701 | 148702 | 148703 | 148705 | 148706 | 148707 | 148708 | 148709 | 148710 | 148711 | 148712 | 148713 | 148715 |
| $SiO_2$ | 49.31 | 48.70 | 49.28 | 48.95 | 49.01 | 49.05 | 49.15 | 48.82 | 49.17 | 49.00 | 49.01 | 49.03 | 49.03 |
| $TiO_2$ | 1.77 | 1.78 | 1.80 | 2.06 | 2.02 | 1.98 | 2.03 | 2.11 | 1.90 | 1.68 | 1.65 | 1.86 | 2.09 |
| $Al_2O_3$ | 15.11 | 14.70 | 14.90 | 14.20 | 14.65 | 13.88 | 14.79 | 14.51 | 14.94 | 13.97 | 14.06 | 14.51 | 14.48 |
| $Fe_2O_3$ | 3.79 | 3.51 | 4.16 | 4.68 | 4.95 | 6.05 | 3.70 | 4.89 | 4.45 | 4.08 | 5.35 | 4.12 | 4.09 |
| FeO | 7.24 | 7.90 | 6.96 | 8.25 | 7.61 | 6.55 | 8.33 | 7.67 | 7.45 | 8.04 | 6.76 | 8.13 | 8.58 |
| MnO | 0.16 | 0.17 | 0.17 | 0.20 | 0.17 | 0.16 | 0.17 | 0.17 | 0.20 | 0.19 | 0.19 | 0.19 | 0.21 |
| MgO | 6.54 | 6.35 | 6.59 | 5.86 | 6.39 | 6.69 | 6.32 | 6.07 | 6.22 | 7.58 | 7.12 | 6.72 | 5.92 |
| CaO | 12.05 | 11.78 | 12.06 | 11.33 | 11.10 | 11.32 | 11.25 | 11.56 | 11.73 | 11.95 | 12.19 | 11.45 | 11.46 |
| $Na_2O$ | 2.01 | 2.03 | 2.07 | 2.28 | 2.08 | 1.96 | 2.15 | 2.08 | 2.10 | 2.26 | 2.11 | 2.27 | 2.43 |
| $K_2O$ | 0.15 | 0.14 | 0.13 | 0.13 | 0.23 | 0.19 | 0.24 | 0.15 | 0.13 | 0.15 | 0.12 | 0.20 | 0.16 |
| $P_2O_5$ | 0.14 | 0.12 | 0.14 | 0.16 | 0.17 | 0.15 | 0.17 | 0.17 | 0.16 | 0.13 | 0.11 | 0.16 | 0.18 |
| $H_2O^+$ | 1.53 | 2.60† | 1.69 | 1.81 | 1.57 | 2.05 | 1.50 | 1.69 | 1.51 | 1.31 | 1.59 | 1.24 | 1.29 |
| Total | 99.80 | 99.78 | 99.95 | 99.91 | 99.95 | 100.03 | 99.80 | 99.89 | 99.96 | 100.34 | 100.26 | 99.88 | 99.92 |
| FeO* | 10.65 | 11.06 | 10.70 | 12.46 | 12.07 | 12.00 | 11.66 | 12.07 | 11.46 | 11.77 | 11.58 | 11.84 | 12.26 |
| CIPW norm** | | | | | | | | | | | | | |
| q | 3.0 | 1.5 | 1.3 | 1.3 | 1.5 | 2.0 | 1.4 | 1.7 | 1.6 | | | | 0.3 |
| or | 0.9 | 0.09 | 0.8 | 0.8 | 1.4 | 1.1 | 1.4 | 0.9 | 0.8 | 0.9 | 0.7 | 1.2 | 1.0 |
| ab | 17.6 | 17.7 | 17.9 | 19.7 | 17.9 | 17.0 | 18.5 | 18.0 | 18.1 | 20.1 | 18.2 | 19.5 | 20.9 |
| an | 32.8 | 31.6 | 31.6 | 28.8 | 30.6 | 29.2 | 30.6 | 30.5 | 31.5 | 28.9 | 29.0 | 29.3 | 28.6 |
| di | 23.0 | 23.0 | 23.4 | 22.9 | 20.2 | 22.5 | 20.8 | 22.3 | 22.0 | 26.6 | 26.1 | 22.6 | 23.2 |
| hy | 16.8 | 19.5 | 19.0 | 19.7 | 21.7 | 21.5 | 20.7 | 19.7 | 19.7 | 13.0 | 19.5 | 20.8 | 19.2 |
| ol | | | | | | | | | | 4.4 | 0.8 | 0.3 | |
| mt | 2.1 | 2.2 | 2.1 | 2.5 | 2.4 | 2.4 | 2.3 | 2.4 | 2.2 | 2.4 | 2.2 | 2.3 | 2.4 |
| il | 3.5 | 3.5 | 3.5 | 4.0 | 3.9 | 3.9 | 3.9 | 4.1 | 3.7 | 3.3 | 3.2 | 3.6 | 4.0 |
| ap | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.3 | 0.3 | 0.4 | 0.4 |
| Atomic Mg/Mg+Fe$^{total}$ | 0.523 | 0.506 | 0.523 | 0.456 | 0.485 | 0.498 | 0.491 | 0.473 | 0.492 | 0.536 | 0.523 | 0.503 | 0.463 |

†Includes 1.50% $Co_2$.

*Total iron as FeO.

**$Fe_2O_3$/FeO = 0.15 in norm calculation.

Analyses by GGUs chemical laboratories (Sørensen, 1975).

GGU 148701: 9 m thick lava flow, alt. 58 m.
GGU 148702: 19 m thick lava flow, alt. 74 m.
GGU 148703: 2 m thick lava flow, alt. 96 m.
GGU 148705: 3 m thick lava flow, alt. 103 m.
GGU 148706: 4 m thick lava flow, alt. 105 m.
GGU 148707: 3 m thick lava flow, alt. 111 m.
GGU 148708: 10 m thick lava flow, alt. 120 m.
GGU 148709: 3 m thick lava flow, alt. 101 m.
GGU 148710: 18 m thick lava flow, alt. 140 m.
GGU 148711: 2 m thick lava flow, alt. 147 m.
GGU 148712: 1 m thick lava flow, alt. 154 m.
GGU 148713: 3 m thick lava flow, alt. 158 m.
GGU 148715: 3 m thick lava flow, alt. 166 m.

clinopyroxene, Fe-Ti oxides and acid residuum. A single core of orthopyroxene mantled by clinopyroxene has been observed. A xenocrystic aggregate of twinned cordierite points to contamination of this dyke.

## Chemistry

### *Tholeiitic basalts*

The tholeiitic lavas from the profile show a very restricted variation in chemistry, e.g. $K_2O$ from 0.13% to 0.24%, $TiO_2$ from 1.65% to 2.09% and $P_2O_5$ from 0.14% to 0.18% (Table 3). In the lava succession in the profile small sequences can be distinguished as chemically homogenous 'flow groups' indicating that several thinner flows are flow units from the same eruption. Such flow groups are indicated in Table 3.

When adjusted to a $Fe_2O_3/FeO$ ratio of 0.15 the analyses are of approximately saturated tholeiitic composition; most have small amounts of normative quartz while a small number contain a few per cent of normative olivine.

The single sample (MM 1980.277) from east Bontekoe Ø (Table 4) is a tholeiitic basalt very similar to the lavas in flow group 2, except for slightly higher Ti and P values.

### *Hawaiites*

The two fresh hawaiite samples (Table 4) have a typical hawaiitic composition (Irvine & Baragar, 1971) with a much higher content of alkalies than the tholeiites. The $TiO_2$ value is comparable with the high-$TiO_2$ tholeiites of the province and the rock is characterized by a considerably higher $P_2O_5$ content than the normal tholeiites. When adjusted for deuteric oxidation the rocks are slightly nepheline normative. Three samples (Table 4) represent increasingly altered and strongly oxidized hawaiites, which may originally have been almost identical with the fresh samples.

The hawaiites are very similar to alkaline lavas from the upper series lavas at Giesecke Bjerge (e.g. Hald, 1978, table 2, no. 4).

### *Dykes*

Two samples of dykes have been analysed. One of these (sample MM 1980.270) is a magnesian transitional basalt with high normative olivine and resembles some late basaltic dykes from Giesecke Bjerge (Hald, 1978). The other dyke (MM 1980.276) is a silicic basalt which may have been enriched in several elements such as $SiO_2$ and $K_2O$ through reaction with crustal rocks.

## Conclusions

Bontekoe Ø consists of a lava sequence with an easterly dip. Two lava series have been recognized a) tholeiites and b) evolved alkaline rocks (hawaiites). The oldest lavas are

*Table 4. Chemical compositions and CIPW norms of lavas and dykes from the eastern part of Bontekoe Ø*

| | Hawaiite, fresh | | Hawaiites, oxidized and altered | | | Tholeiitic lava | Basaltic dykes | |
|---|---|---|---|---|---|---|---|---|
| MM no. | 1980.274 | 1980.275 | 1980.272 | 1980.273 | 1980.271 | 1980.277 | 1980.270 | 1980.276 |
| $SiO_2$ | 48.11 | 48.37 | 48.35 | 46.92 | 45.97 | 48.35 | 46.61 | 52.63 |
| $TiO_2$ | 3.10 | 3.02 | 3.01 | 2.60 | 2.43 | 2.21 | 2.20 | 2.62 |
| $Al_2O_3$ | 16.77 | 16.76 | 16.86 | 15.80 | 16.15 | 13.73 | 13.51 | 13.50 |
| $Fe_2O_3$ | 3.77 | 4.59 | 11.68 | 11.14 | 9.62 | 5.39 | 4.07 | 4.33 |
| FeO | 7.56 | 6.87 | 0.60 | 0.08 | 0.64 | 7.68 | 6.79 | 7.87 |
| MnO | 0.21 | 0.21 | 0.18 | 0.18 | 0.20 | 0.23 | 0.18 | 0.19 |
| MgO | 5.01 | 4.54 | 3.47 | 2.31 | 2.37 | 6.05 | 10.09 | 4.65 |
| CaO | 7.59 | 7.50 | 7.40 | 7.20 | 8.02 | 11.46 | 10.46 | 8.15 |
| $Na_2O$ | 4.45 | 4.48 | 4.45 | 2.29 | 2.04 | 2.53 | 2.19 | 2.68 |
| $K_2O$ | 1.24 | 1.22 | 1.39 | 1.98 | 1.47 | 0.21 | 0.60 | 1.31 |
| $P_2O_5$ | 0.73 | 0.81 | 0.86 | 0.96 | 0.89 | 0.20 | 0.29 | 0.34 |
| $H_2O^+$ | 1.42 | 1.56 | 1.63 | | | 1.75 | 3.00 | 1.59 |
| Volat. | | | | 7.01 | 10.00 | | | |
| Total | 99.96 | 99.93 | 99.88 | 98.47 | 99.80 | 99.79 | 99.99 | 99.86 |
| $FeO^*$ | 10.95 | 11.00 | 11.11 | 10.11 | 9.30 | 12.53 | 10.45 | 11.77 |
| CIPW norm$^+$ | | | | | | | | |
| q | | | | 5.8 | 7.0 | | | 6.2 |
| or | 7.5 | 7.4 | 8.5 | 12.9 | 9.8 | 1.3 | 3.7 | 7.9 |
| ab | 34.0 | 36.0 | 37.3 | 21.4 | 19.4 | 21.9 | 19.2 | 23.1 |
| an | 22.5 | 22.5 | 22.6 | 29.8 | 34.4 | 26.1 | 26.1 | 21.4 |
| ne | 2.3 | 1.4 | 0.8 | | | | | |
| di | 8.9 | 8.4 | 7.9 | 2.3 | 3.2 | 25.5 | 20.7 | 14.7 |
| hy | | | | 17.7 | 16.7 | 15.6 | 8.6 | 18.6 |
| ol | 14.9 | 14.5 | 12.9 | | | 2.4 | 14.7 | |
| mt | 2.1 | 2.1 | 2.2 | 2.1 | 2.0 | 2.5 | 2.1 | 2.3 |
| il | 6.0 | 5.9 | 5.9 | 5.4 | 5.2 | 4.3 | 4.3 | 5.1 |
| ap | 1.8 | 1.9 | 2.0 | 2.5 | 2.3 | 0.5 | 0.7 | 0.8 |
| Mg/Mg+Fe | 0.449 | 0.424 | 0.358 | 0.289 | 0.312 | 0.463 | 0.632 | 0.413 |

Analyses by GGUs chemical laboratories (Sørensen, 1965).

Volat.: total volatiles determined from the loss on ignition.

*Total iron as FeO.

$^+Fe_2O_3/FeO = 0.15$ in norm calculation.

All samples are from the Geological Museum, Copenhagen, and were collected by H.G. Backlund and D. Malmquist 15/7-1932.

tholeiitic basalts poor in $P_2O_5$ and $TiO_2$. These are similar to the lowermost plateau basalts at Kap Stosch (Noe-Nygaard & Pedersen, 1974) and more generally to the least evolved basalts in a fissure erupted plateau basalt series called informally Lower Plateau Lava Series (LPSL) which has been recognized from the Hold with Hope to the Wollaston Forland area (Upton *et al.*, 1980, 1982, in press).

The youngest lavas are represented by nepheline normative hawaiites, which resemble some lavas from the Upper Plateau Lava Series (UPLS) of Upton *et al.*, (1980, 1982) in the Gauss Halvø – Hold with Hope area north of Bontekoe Ø.

The igneous rocks described do not reveal any volcanological, petrological or chemical anomalies, which could suggest an unusual magmatic evolution on or just around Bontekoe Ø in the Kejser Franz Joseph Fjord area. There is thus no trace of a specific pre-Jan Mayen Fracture Zone activity on Bontekoe Ø, which at the time of volcanic activity formed part of a large coherent lava plateau.

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