THE GEOLOGY, VOLCANIC ACTIVITY, AND AGE OF BOUVETØYA, SOUTH ATLANTIC *

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ABSTRACT

The volcanic cone of Bouvetøya is built up of two formations. The older formation, of predominantly pyroclastic rocks which are typically hydrothermally altered, is overlain by a formation of mainly lava flows. The rocks present on the island constitute a transitional volcanic series. K/Ar dating indicates that surface rocks were formed as early as 1.4 Ma B.P. The rocks of Nyrøysa are 0.4-0.5 Ma, showing that this platform, which formed between 1955 and 1958, represents a landslide type deposit rather than a recent eruption as has previously been suggested by several workers. Various kinds of evidence suggest that the volcanic activity, or a cycle of activity, of Bouvetøya is now in a declining phase.

* Publication No. 58 of the Norwegian Antarctic Research Expeditions (1978/79).

INTRODUCTION

Bouvetøya is an oceanic island located close to the Bouvet triple junction in the South Atlantic Ocean (Fig. 1). On the basis of distance from the central part of the Bouvet ridge and half spreading rates for this region given by SCLATER *et al.* (1976), the age of the oceanic crust beneath the islands is estimated to 4.5-5.0 Ma. This is thus a maximum age of the volcanic activity responsible for the Bouvetøya cone.

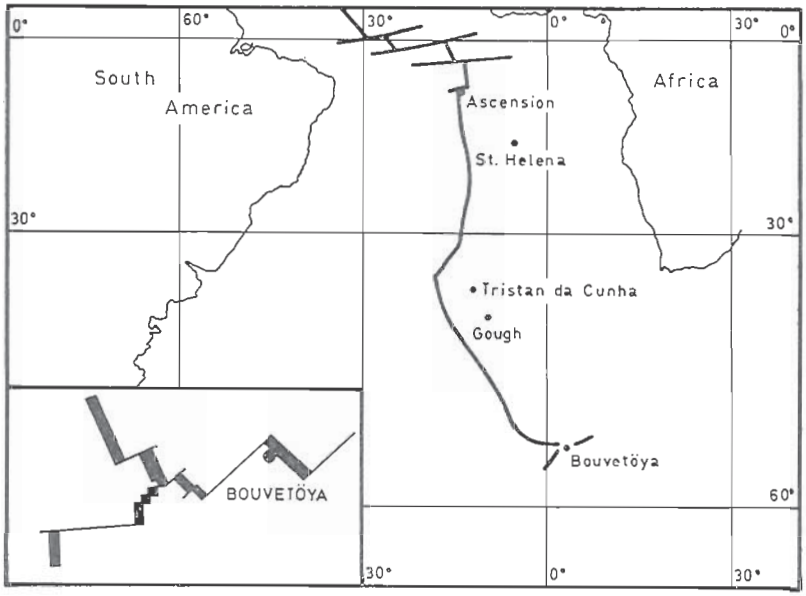

Fig. 1 — Location of Bouvetøya. The tectonic relations of the Bouvet triple junction as interpreted by SCLATER *et al.* (1976) are inserted.

The island covers an area of only 55 km² of which about 95 % is capped by permanent ice. The assymetrical shape of Bouvetøya, with the crater/caldera area in the northwest (Fig. 2), is influenced by the wave action caused by almost permanent westerly winds in the area. Rocks are, however, well exposed in outcrops along the coast (Fig. 2).

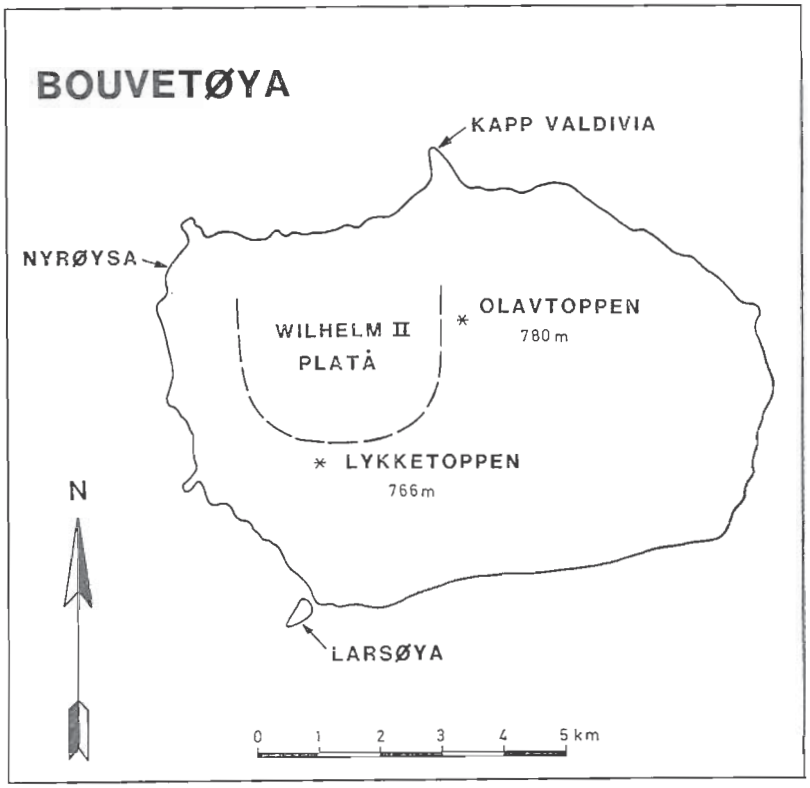

Fig. 2 — Sketch map of Bouvetøya.

The Norvegia expeditions in 1927-28 and 1928-29, a joint British/South African expedition in 1964, a South African expedition in 1966, and a Norwegian expedition in 1977, resulted in several papers concerning the geology and petrology of Bou-

vetøya. It was established that the volcanic rocks of the island belong to a transitional volcanic series (BROCH, 1946; VERWOERD *et al.*, 1976; IMSLAND *et al.*, 1977). The origin of the platform, now called Nyrøysa, that appeared on the northwestern coast between 1955 and 1958 has, however, been a matter of discussion. This platform was interpreted as the result of a recent eruption by some workers, whereas others thought it represented an avalanche type deposit. To resolve this question was therefore one of the goals set by the members of the Norwegian Antarctic Expedition 1978-79 that visited Bouvetøya for about two weeks. Evan though the weather conditions were bad during this expedition, much new information was obtained. Detailed descriptions of these findings and a discussion of the geology of Bouvetøya have been given by PRESTVIK and WINSENS (1981).

In the present paper the new information is summarized and briefly discussed together with what is known about petrology from previous work.

GEOLOGY AND PETROLOGY

The volcanic cone of Bouvetøya is built up of two major formations. The older formation consists of various kinds of volcaniclastic rocks as seen in the steep cliffs of the southern, western, and northern coasts (Fig. 2) where deep sections are well exposed. This formation is frequently cut by dikes and hydrothermal alteration is conspicuous, especially in areas close to the crater/caldera area. Fumarolic activity, which has been observed by all recent expeditions, is also concentrated in this area. The volcaniclastic rocks of this formation were probably formed as hyaloclastites (Surtsey type eruption).

The pyroclastic rocks are overlain by a formation of mainly lava flows which are characteristically less altered than the

underlying rocks. In some places the lava flows are mixed with minor occurrences of palagonitized hyaloclastites. These features indicate that the island had only a thin icecap that gave rise to small amounts of hyaloclastites before it melted locally so that subaerial lava flows could be formed.

The transition between the two formations is interpreted to represent the tome when the volcanic structure of the island became rigid and compact enough to prevent seawater from entering conduits or vents.

Transitional basalt (hawaiite) is the predominant rock type of Bouvetøya. Intermediate rocks (trachytic icelandite or benmoreite) occur on the Nyrøysa platform, and peralkaline rhyolite (comendite) is found in a lava flow on the islet of Larsøya, in a dome at Kapp Valdivia (Fig. 2), and in a few dikes cutting the lowermost pyroclastic formation.

The petrology of these rocks has recently been discussed by VERWOERD *et al.* (1976), IMSLAND *el al.* (1977), and PRESTVIK (in press). The different members of the transitional suite are thought to be interrelated by fractional crystalization (VERWOERD *et al.*, 1976). However, IMSLAND *et al.*, (1977) proposed a model for the evolution of the series involving fractional crystallization under varying conditions of P, T, and P_{H_2O} either from slightly different magma types *or* from one parental magma type in an open system. The whole series displays a chondrite-normalized pattern characterized by light REE enrichment (Fig. 3). A strong negative Eu anomaly of the comendites suggests strong feldspar fractionation under low P_{O_2} at a late stage in the evolution of the series (PRESTVIK, in press).

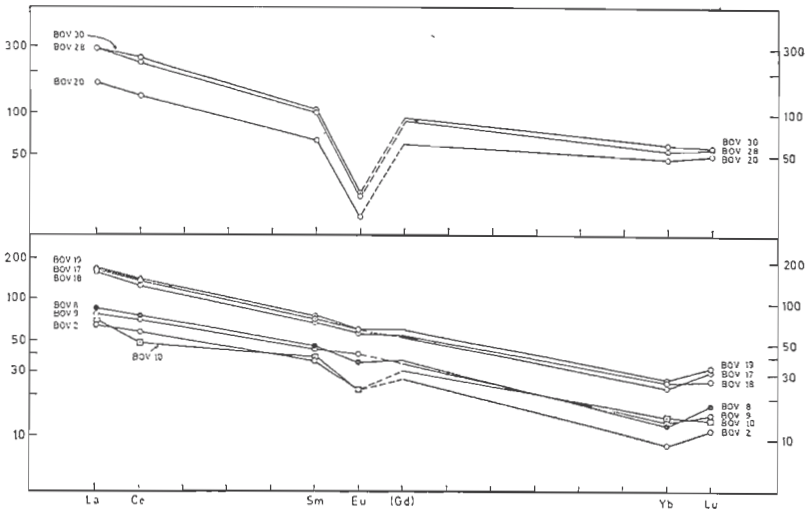

Fig. 3 — Chondrite normalized REE patterns of volcanic rocks from Bouvetøya. From PRESTVIK (in press). Vertical scale : Sample/ chondrite ratios.

THE VOLCANIC ACTIVITY AND AGE OF BOUVETØYA AND THE FORMATION OF NYRØYSA

It was mentioned above that the maximum age of the Bouvetøya volcanic cone is estimated to some 4.0-5.0 Ma. The real age of the initiation of this volcanism is unknown because no dating of rocks from the submarine structure has been performed. VERWOERD *et al.* (1976) discussed the age of Bouvetøya (super-surface part) and concluded that an age in excess of 1 Ma was unlikely.

K-Ar datings on new material from Bouvetøya (PRESTVIK and WINSNES, 1981) show that two subaerial lava flows from a low stratigraphic position in the upper formation have apparent ages of 1.39 Ma and 1.06 Ma. The lowermost formation

of pyroclastic rocks is probably only slightly older than the overlying lava flows, because it is unlikely that the predominantly pyroclastic cone could survive the intense marine abrasion of the area for any long time. However, K-Ar dating of the lowermost formation gave lower apparent K-Ar ages than what were found in the overlying lava flows. This is interpreted as due to loss of radiogenic argon, probably as a result of the extensive hydrothermal alteration of these rocks.

Furthermore, field and petrographic evidences (PRESTVIK and WINSNES, 1981) indicate that the silicic rocks of Larsøya and Kapp Valdivia are relatively young. This impression is further substantiated by the K-Ar apparent ages (< 0.2 Ma) obtained for these rocks.

The Nyrøysa platform on the northeastern coast (Fig. 2) has been interpreted as the result of a recent eruption (BAKER and TOMBLIN, 1964; LUNDE, 1965; BAKER, 1967; FURNES and LØVLIE, 1978) whereas WINSNES (1966) and VERWOERD *et al.* (1976) interpreted this platform as an avalanche type deposit.

Recent K-Ar analyses of rocks from the Nyrøysa platform (PRESTVIK and WINSNES, 1981) gave ages of 0.4-0.5 Ma showing that the platform does not represent a recent eruption. Several features, such as consistent magnetic polarity directions (FURNES and LØVLIE, 1978) and stratigraphy, indicate that the platform represents a landslide rather than an avalanche.

The real stratigraphic position of the intermediate rocks of Nyrøysa in the Bouvetøya cone is as yet not known in detail. They must however, represent a position above the basic lavas occurring immediately above pyroclastic rocks of the lower formation. The relatively big age difference between these basic lavas and the rocks now present at Nyrøysa indicates that the volcanic activity was low at this stage of construction of the Bouvetøya cone. The size and shape of the plateau surrounded by a few peaks in the summit area (Fig. 2) indicates that the island has evolved beyond the stafe of caldera collapse (IMSLAND *et al.*, 1977). Even though very little is

known about the continuity of the magmatic activity of Bouvetøya, several features such as a general trend from basic to intermediate and silicic rocks with time and the scarcity of apparently very young rocks, indicate that the volcanic activity or a cycle of activity is now in a declining phase.

ACKNOWLEDGEMENTS

Thanks are due to Prof. Chr. Oftedahl and Prof. F. M. Vokes who made comments on the paper.

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