Magnetic Anomalies Around The Faeroe Islands

By Niels F. Schrøder)*

Abstract

A reconnaissance magnetic survey has been made around the Faeroes. Differences in the magnetic pattern have made it possible to map the boundary between the lower and middle basaltseries. This boundary shows the existence of two huge dome structures. The gravity anomalies are compared with the structures, and it is suggested that a hidden continental rest may be cause for both.

Introduction

Since 1964 the geophysics of the Faeroe Islands have been one of the main interests of the Laboratory of Applied Geophysics. A review of the geophysical surveyings in the Faeroes has recently been given by *Saxov* (1971). Since 1964 a magnetic survey around the Faeroes has been required, however, it lasted until 1969 before this reconnaissance survey was carried out.

Support from other institutions has been essential. Financial support has been granted by Fróðskaparsetur Føroya (Academia Færoensis), The Danish Geodetical Institute has put the survey boat "Ole Rømer" at disposal, while the magnetometers were borrowed from the Carlsberg Foundation and Deutsches

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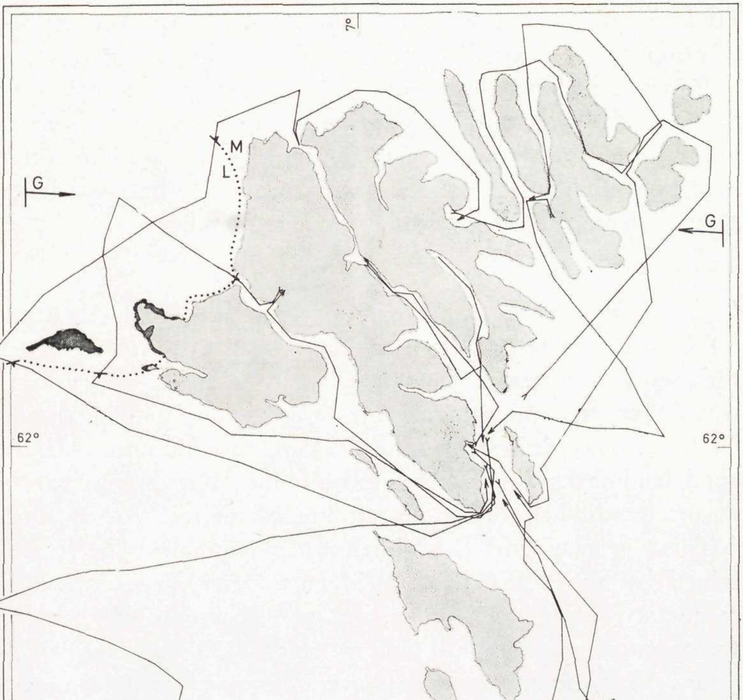

Fig. 1. *The magnetic survey lines, measured June—July 1969. The heavy line segments indicate the profiles used in Fig. 3, while the arrows at G—G locate the gravimetric profile shown in Fig. 4.*

Hydrographisches Institut; I want to thank the institutions mentioned above for their very valuable cooperation.

Presenting the measurements and their interpretation I want to emphasize that it has been a reconnaissance survey, which has given more hints than facts; to give a complete interpretation of the magnetic anomalies around the Faeroe Islands a much denser net of measurements is required.

Survey Operations

Fig. 1 shows the sailing routes where the magnetic total field was measured. The survey ship was "Ole Rømer" a 65 tons wooden cutter. The navigation was done in the classical way, every ten minutes bearings were taken to outstanding landmarks; as survey lines never were far from the islands, good landmarks were always to be found, and the navigation uncertainty is believed to be within 200 metres.

Total geomagnetic field intensity measurements were obtained by an ELSEC Proton Magnetometer Type 592. The magnetic readings were taken on strip chart recorder, where for practical reasons a full scale value of 2000 was used, which means that the measurements were obtained with a uncertainty of 20 gammas.
Due to hard weather the speed of "Ole Rømer" varied (from 5 to 30 km/hour). The lack of digital recording and the mentioned speed variation make it very difficult and laborious to present the measured profiles in a proper way.

No attempts have been done to remove the main geomagnetic field from the total intensity data. This task was not found necessary as I do not want to present a contour map of the magnetic data. A contour map would be quite unrealistic due to the great distance between the profiles.

In the profiles presented corrections for the daily geomagnetic variations have not been applied as the daily variations measured north of Tórshavn in Hoyvík usually had wavelengths of several hours and amplitudes of less than 200 gammas during the survey.

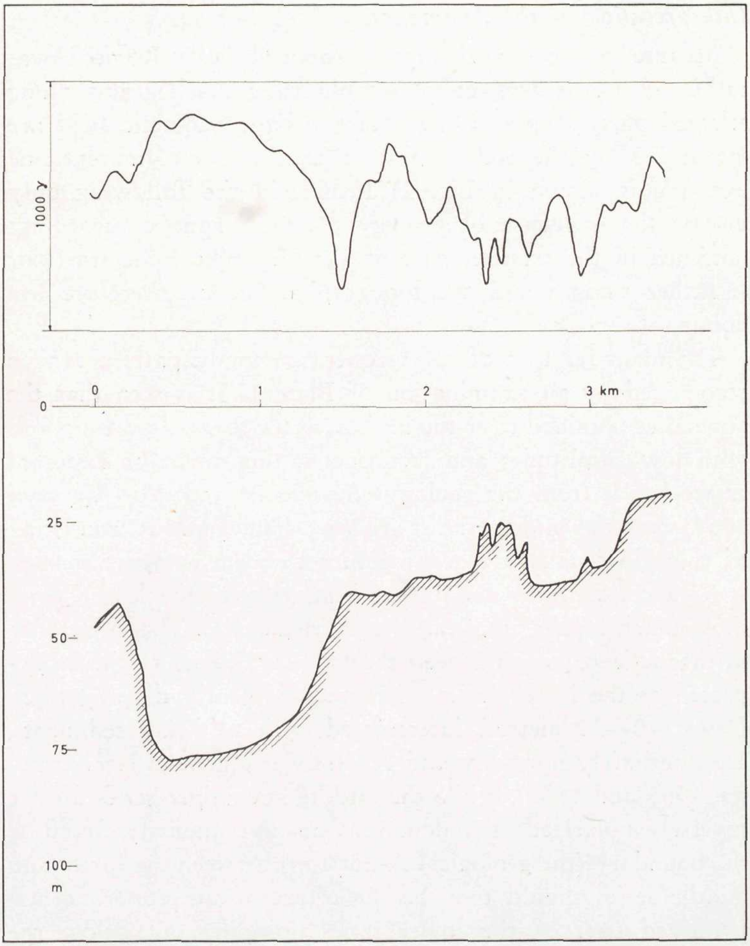

Fig. 2. *Echogram and magnetic profile along the section marked with an A in Plate 1. Obviously there is a certain correlation between bed rock topography and anomalies taking into account that the rocks are reversely magnitized.*

Interpretation of the Anomalies

Because the electrical supply onboard "Ole Rømer" was rather sparse it was only possible to get echograms along selected parts of the sailing routes. As the magnetic field are influenced by the topography of the sea-floor (an extreme example is shown in Fig. 2) I shall in the following only discuss the influence of geology on the magnetic recordings obtained in the western part of the area where the sea-floor is rather smooth and the topographic "noise" therefore less dominant.

The main features of the magnetic anomaly pattern can be recognized by an examination of Plate 1. It is seen that the anomalies obtained over the middle series generally are smooth with low amplitudes and frequencies, this might be expected as we know from the geology (*Rasmussen* and *Noe-Nygaard* 1969) that the middle series are very homogeneous, consisting of thin flow units, welded together to form compact masses.

As a contrast the anomalies obtained over the lower series show much higher amplitudes and frequencies. This difference in magnetic pattern between the two lava series might be expected as the lower series, consisting of gently dipping thick flows (10—30 metres) intercalated with tuff-clay sediments, are alternately normally and reversely magnetized (*Abrahamsen* 1965 and 1967), while the middle and upper series all are reversely polarized. The dominant positive anomaly found at the boundary (the geological A-horizon) between the lower and middle series should then be the effect of the upper normal polarized part of the lower series cropping out below the reversely polarized middle series.

The magnetic anomalies found in areas where older rocks might be present e.g. in the area north of Mykines show that a magnetic basement must be present just below the sea-floor. The pattern of the anomalies here look quite like profiles measured along the gneissic west coast of Sweden (*Schrøder* 1968); however, inhomogeneously magnetized basalts, intersected by dykes, might give a similar pattern.

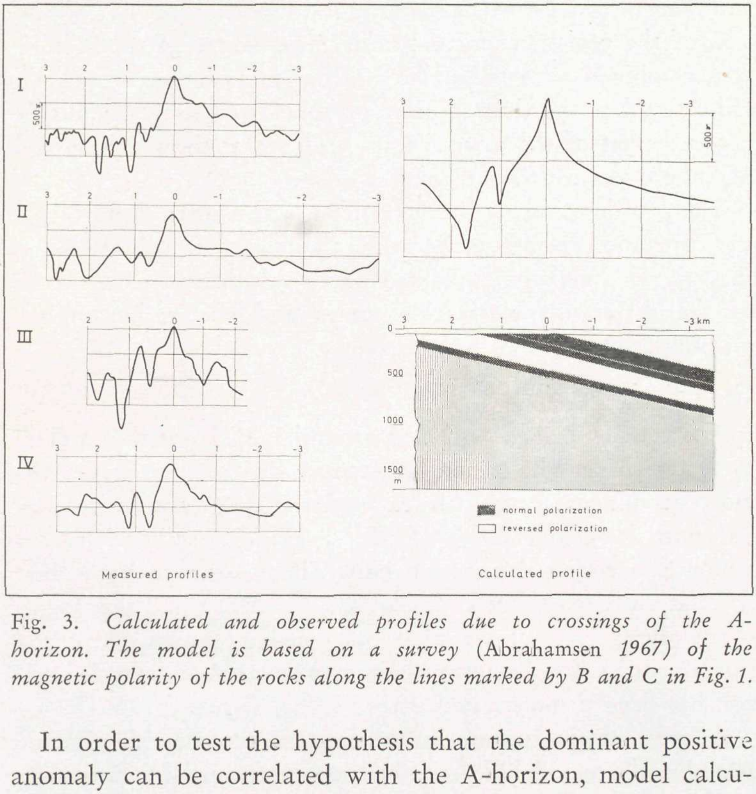

Fig. 3. *Calculated and observed profiles due to crossings of the A-horizon. The model is based on a survey* (Abrahamsen *1967) of the magnetic polarity of the rocks along the lines marked by B and C in Fig. 1.*

In order to test the hypothesis that the dominant positive anomaly can be correlated with the A-horizon, model calculations (Fig. 3) have been carried out. The study of the magnetic properties of the Suðuroy rocks by *Abrahamsen* (1965 and 1967), especially along the profile B in Fig. 1, which crosses the A-horizon, has been used as basis for the model. The values of susceptibility (0.001 e.m.u.) and remanent magnetization (0.006 e.m.u.) assumed in the calculations are also in accordance with an unpublished statistical analysis of magnetic properties of Suðuroy rocks by *Abrahamsen* (personal communication).

The four profiles crossing the A-horizon east of Suðuroy show a rather good resemblance to the calculated profile, taking in account the topographic "noise". It is surprising that the A-horizon is running so close to the island at its southern end, and this fact might give rise to a discussion of the connection of the geological main profile. The course of the A-horizon, combined with the strike and dip measurements on land, indicates that the deepest part of the lower series should be exposed west of the town Vágur, and not at the southern end of Suðuroy as usually assumed.

The profiles crossing the A-horizon in the north do not have the same good resemblance to the calculated curve (Plate 1 and Fig. 3). This may be explained partly by thickness variations of the different polarization zones and partly by oblique crossings.

Geological Theories

The course of the A-horizon around the islands shows (Fig. 1) that besides the general eastward dip of the layers the most prominent tectonical features are two dome-structures, one with its center north of Mykines and a smaller one, of which Suðuroy is the eastern half. There seems to be a good correlation between the course of the A-horizon and the isogals of the Bouguer anomaly map published by *Saxov* (1969); a similar correlation between Bouguer anomalies and the C-horizon has been demonstrated earlier (*Noe-Nygaard* 1966).

A gravimetric survey in the waters between the Faeroe Island and Iceland has recently been performed by Deutsches Hydrographisches Institut and the results are going to be published in the near future (*Fleischer* 1971).

From a preliminary gravity anomaly map, which Dr. Fleischer kindly has put at my disposal, it seems that the general level of Bouguer anomalies around the Faeroe Islands is 40 mGal, and further it is seen that the big minimum over the northern islands (*Saxov* 1969) has its lowest value, — 15 mGal, about 15 km north of Mykines.

While only land measurements were available it was thought that the gravity gradient in the eastern part of the islands was regional and that the local minimum on the north western islands was about — 7 mGal, only. The sea measurements

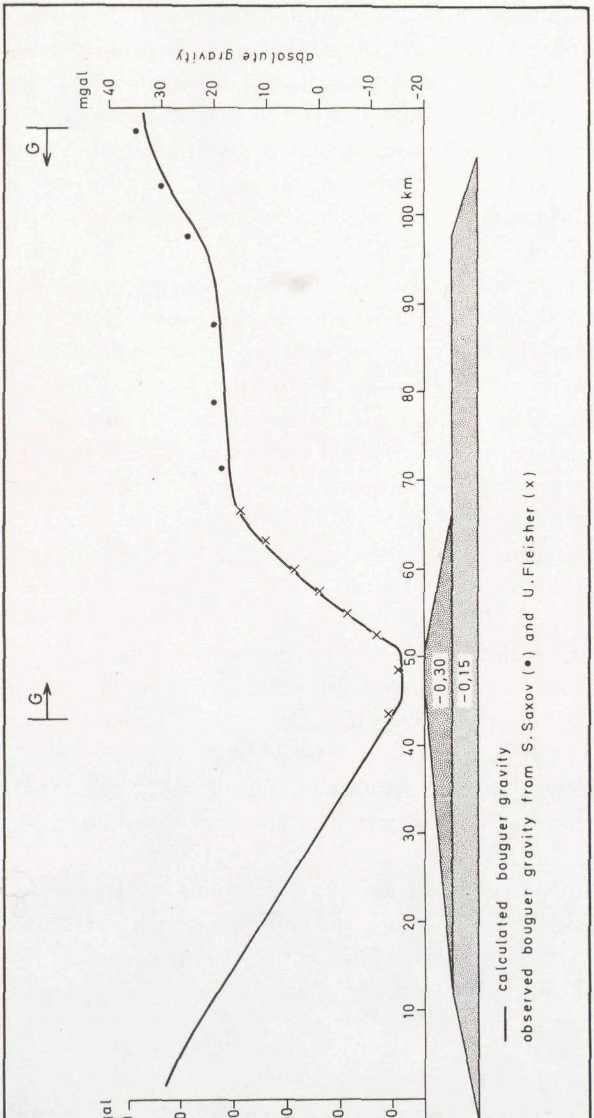

Fig. 4. *Gravimetric profile along the section G—G in Fig. 1. The crosses and dots represent sea measurements and land measurements, respectively.*

now show that the anomaly over the northern islands is local and about — 65 mGal. The geological models on the invisible part of the Faeroes presented by *Saxov* and *Abrahamsen* (1964) and *Noe-Nygaard* (1966) only needed to explain an anomaly of — 7 mGal; neither a hidden mound consisting of submarine palagonite tuffs and pillow breccias, nor a local depression in the crust mantle boundary, however, can explain the anomaly we now see (Fig. 4).

A combination of the above mentioned causes might explain the anomaly (if the tuffs and breccias are allowed to be several times thicker than the 300 m earlier considered). However, it seems more obvious to interpret the — 65 mGal anomaly as caused by a concealed body of salic (continental) rocks; Fig. 4 shows the approximate extension of such a body. Isostatic movements of the salic rock-body might then explain the domestructure.

The recent theories on the sea-floor spreading in the Norwegian Sea presented in *Vogt et al.* (1970) also seems to favour a continental origin of the invisible part of the Faeroe Islands.

Vogt et al. show that the axis of rifting between the Iceland-Faeroe Ridge and the Jan Mayen Fracture Zone has been shifting; they show that the now active Jan Mayen-Iceland Ridge may be as young as 4 m. y. and suggest that the spreading in the Norwegian Sea between about 60—42 m. y. B.P. took place around a now extinct axis (N-S striking along the 4° W median).

This shifting of spreading axis might explain that a continental rest could be left behind; the position of the spreading axis northeast of the Faeroe Islands, at the time when the basalts poured out, may explain that we find the youngest series in the eastern part of the islands.

Acknowledgement

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ÚRTAK

Fyrireikandi sigulmagnskanningar eru gjørdar uttan um oyggjarnar í Føroyum. Munur á sigulmagnsmynstrinum hava gjørt tað møguligt at seta mark millum niðaru basaltfláirnar og miðfláirnar. Hetta markið sýnir at til eru tvær ógvuliga stórar kúpumyndanir. Tyngdarfrávikini eru samanborin við hesar myndanir og hildið verður at ein huld meginlandsleivd er atvoldin til báðar.

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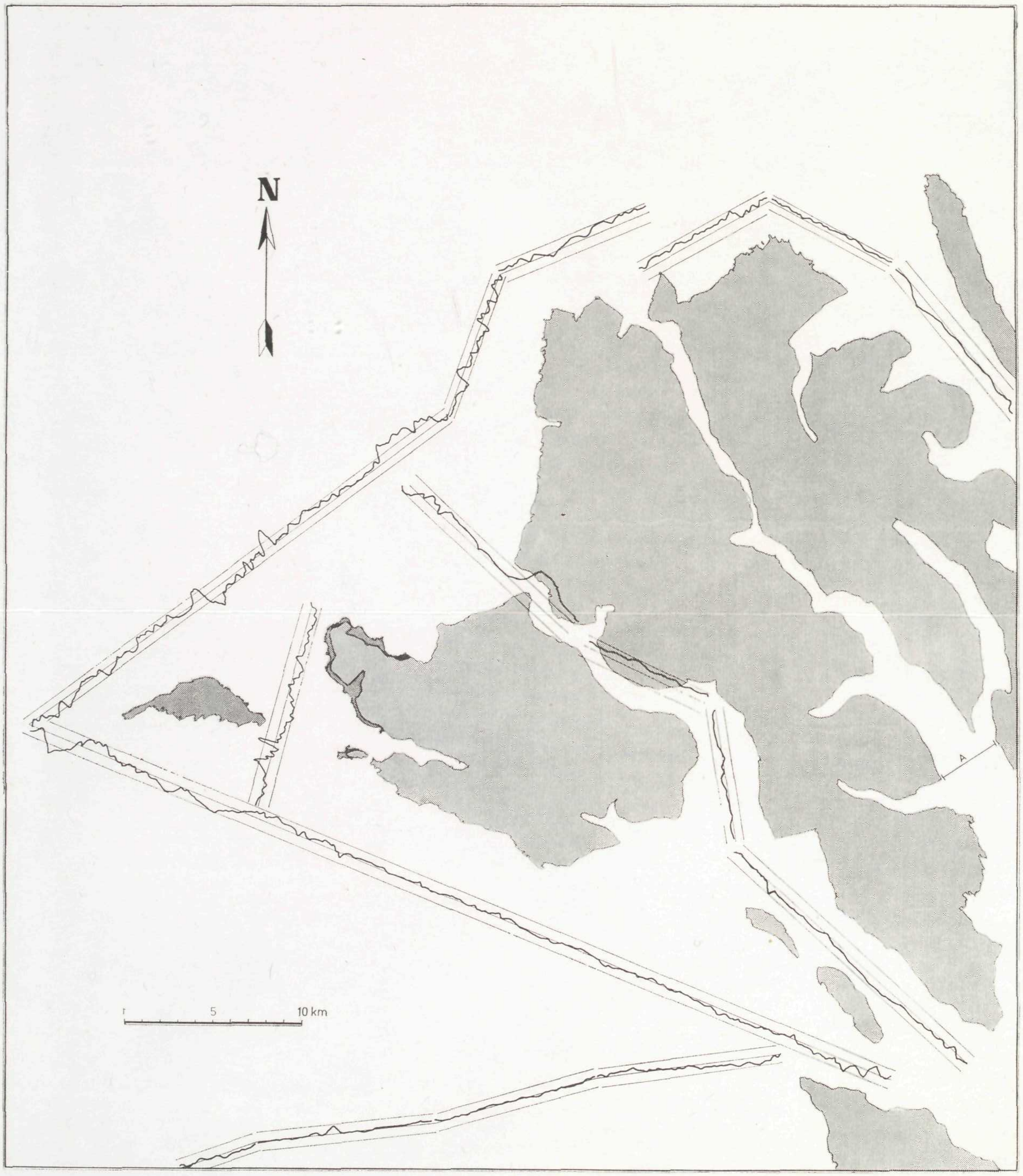

Plate 1. *Some of the magnetic profiles in the northwest. The three thin lines enveloping the anomaly profiles are the levels of 50000, 50500 and 51000 gammas. The contrasting of the anomaly pattern over the lower and middle series show up clearly.*