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## Magnetic mapping in the occurrence range of metamorphosed rocks and magma intrusions in the area of the Hornsund Fiord in Spitsbergen

**ABSTRACT:** This paper discussed the results of pilot magnetic investigations carried out at the foot of the Fugleberget mountain and in the Skå valley in the area of the northwestern shores of the Hornsund Fiord.

The investigations showed the large usefulness of the magnetic method in stratification of different rock types which occur within the metamorphic complex, and, in the case of magma intrusions, they found that dolerite dykes are characterized by high, uniform magnetization and very simple geometrical form.

Key words: Arctic magnetic mapping, Spitsbergen.

### 1. Introduction

This paper reports on the pilot investigations carried out during the summer polar expedition to Spitsbergen in 1979. They were located at the foot of the Fugleberget mountain and in the Skål valley, in the area of the northwestern shores of the Hornsund Fiord. In the metamorphic zone, at the foot of the Fugleberget, the measurement profiles, A-A and B-B (Fig. 1, part A), were made over a rock complex including slates, marbles, quartzites and amphibolites. In this section measurements were taken by the method of synchronized observations with proton magnetometers. In these profiles the measurement step is 5 m, while the number of observations in a series at individual points is 8. After reduction the measurement accuracy is 1 nT.

A similar method was used in the investigations in the Skål valley where a dolerite dyke occurs.

The course of the dyke was considered in two profiles, C-C and D-D, whose location is shown in Fig. 1, part B. These profiles are about 400 m long distant by 70 m from each other. In this case the measurement step was also 5 m, while the number of observations in a synchronic series was limited to 3.

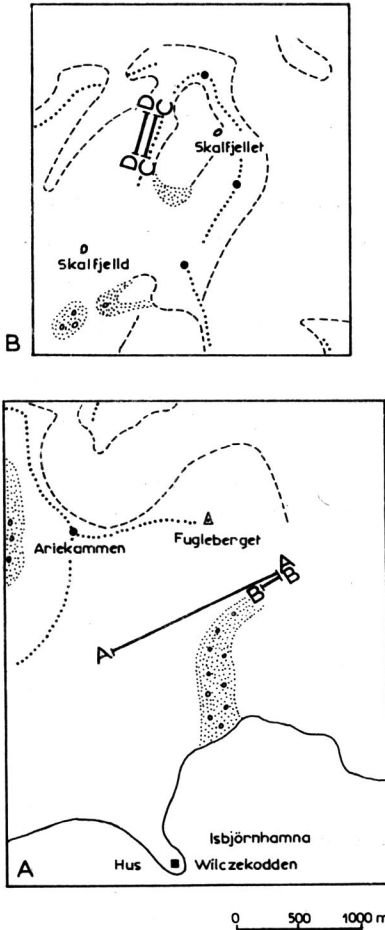


Fig. 1. A Schematic location diagram of the measurement profiles. A. the location of the profiles in the zone of the metamorphic complex, the Fugleberget; B. the location of the profiles in the area of the dolerite dyke, the Skål Valley... quartzites, .oo. rock detritus.

## 2. Qualitative interpretation of the magnetic investigations in the area of the metamorphic complex

The measurement profiles A-A and B-B are located in a zone where the metamorphic complex consists of amphibolites, quartzites, micaschists and marbles. According to the division made by Birkenmajer (K. Birkenmajer,

W. Narębski 1960), these rocks belong to different stratigraphic series of the Precambrian Eimfjellet and Isbjørnhamna Formations. The slates and marbles are assigned to the Ariekammen series; quartzites and amphibolites, to the Skålfjellet series. The boundary between the two series runs at about 3/4 length of the profile A-A.

This change in the character of geological structure along the profile is fully reflected in the results of magnetic measurements (Fig. 2). Within the Ariekammen series, where the metamorphic complex has the nature of flysch made of alternating slates and marbles, the differentiation of the anomaly is very low. In the transitory zone, despite its slightly less intensity, the anomaly behaves in a similar way. A change in the properties of their distribution does not occur before the final part of the profile. Within the Skålfjellet series two distinct anomalies with an amplitude of about 70 nT can be observed.

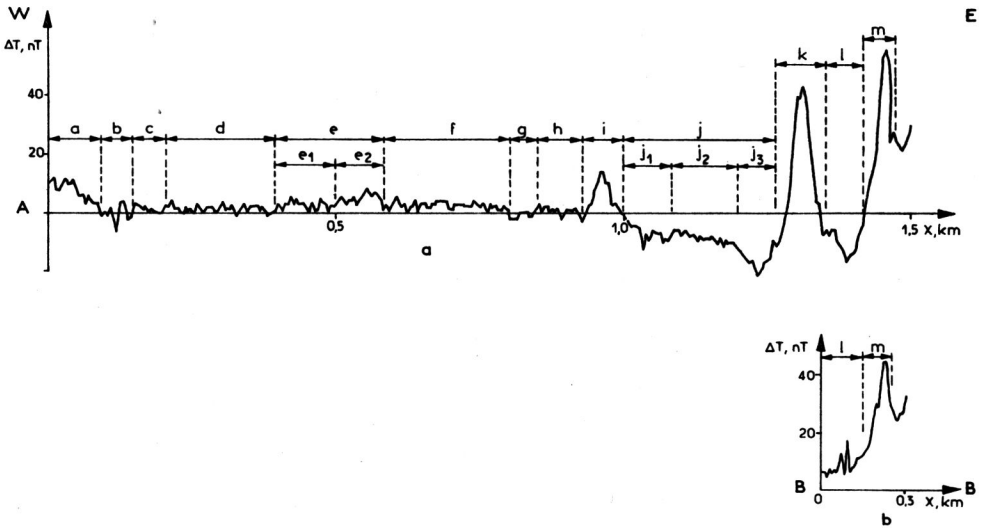


Fig. 2. The magnetic anomalies  $\Delta T$  in the zone of the metamorphic series.

In order to analyze in greater detail the results of the mapping of the profile A-A, based on the correlation properties of the measurements, a number of anomalous zones about 50 to 200 m long were distinguished. They are marked in Fig. 2 with letter indices. Under the principle of this division the final part of the profile was correlated to the geological diagram of the southern slope of Fugleberget.

Fig. 3 shows, over the section drawn from the 1965 paper of W. Smulikowski, sections corresponding to the anomalous zones distinguished. Comparison indicates that section m (positive anomaly) lies in the zone of

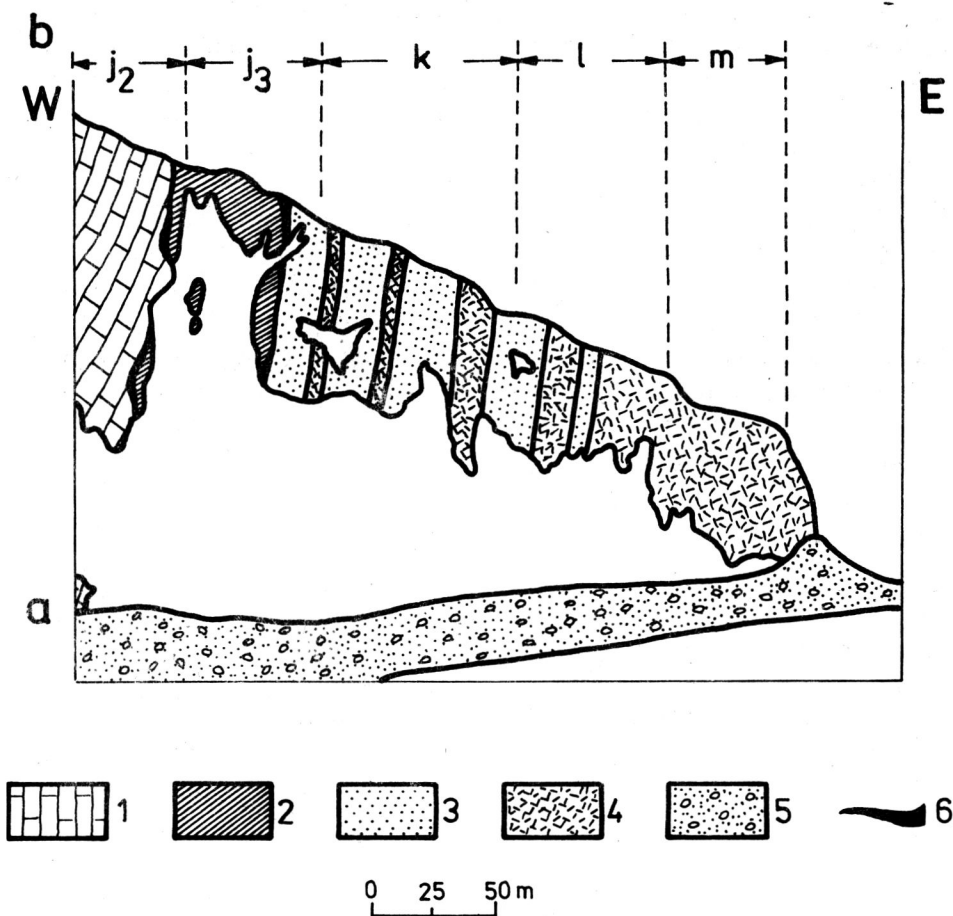


Fig. 3. A schematic geological diagram of the southern slopes of the Fugleberget (acc. to W. Smulikowski, 1965) 1. marbles; 2. mica-schists; 3. quartzites; 4. amphibolites; 5. rock detritus; 6. mylonites.

amphibolites (Torbjornsenfjellet amphibolites) but that this zone also includes section 1 which corresponds to the relatively negative part of the anomaly. There is therefore no direct relation between the magnitude of the anomaly and its position and the presence of amphibolites in the individuated complex. The differences to be observed, irrespective of errors in the localization of profiles and section and schematic treatment of elements of geological structure, can be explained by petrological variation of the formations (rocks) of the amphibolite facies, which is related to the different stages of their transformation.

Another positive anomaly (section k), with properties similar to the previous one, lies in the zone of the so-called Steinviks kardet beds. Also in this

case it is related to the presence of amphibolites. Beyond this anomaly, in a section where the Skålfjellet series turns into the Ariekammen series, in the zone of slates ( $j_3$ ) the intensity decreases and takes the lowest value for the whole profile. It is possible that this characteristic change, with an appropriate network of profiles, could serve to define the boundary between the Eimfjellet and Isbjornhamna Formations throughout the area of their presence.

Within the Ariekammen series the differentiation in anomaly amplitude is very low. Here local intensity changes are related to the transition from slates to marbles and to increased concentration of femic compounds in their contact zones.

### 3. Magnetic investigations in the Skål Valley

The dolerite intrusions in the Hornsund area are known to occur frequently. They often appear on the surface in the form of vertical dykes cutting across different-age older formations (K. Birkenmajer, T. Morawski, 1960). In the area where magnetic measurements were taken there is a dyke 2 km long which cuts across garnet slates of the Ariekammen and Skoddefjellet series. In the Skål Valley this dyke is covered by an overlay of rock detritus several m thick.

The measurements carried out here have confirmed the large magnetic properties of dolerite veins and a regular form in which they occur. The anomalies in Fig. 4 are characteristic of homogeneously magnetized bodies with regular shape and finite propagation in a vertical direction. Such a model was assumed in quantitative interpretation of the anomalies observed.

This interpretation was performed under the assumption that over the short section between the profiles (70 m) the magnetization of a body remains constant. It was further assumed that dolerites are only magnetized by the present magnetic field (with the influence of the remnant component being neglected) and that, in view of the parallel extension of the body, the inclination of the magnetization vector in cross-section agrees with the inclination angle. From other data on the Hornsund area, this angle is  $81^\circ$ .

Under these assumption the geometrical parameters of the dyke were determined. This dyke has a very regular form and is inclined at an angle of about  $100^\circ$  southwards. Its horizontal thickness is 30 m and is slightly less than from geological data.

In the profiles C-C and D-D, apart from the anomaly over the dyke, much smaller but correlating anomalies can also be observed. In one case the amplitude of such an anomaly reaches about 150 nT. This may be related

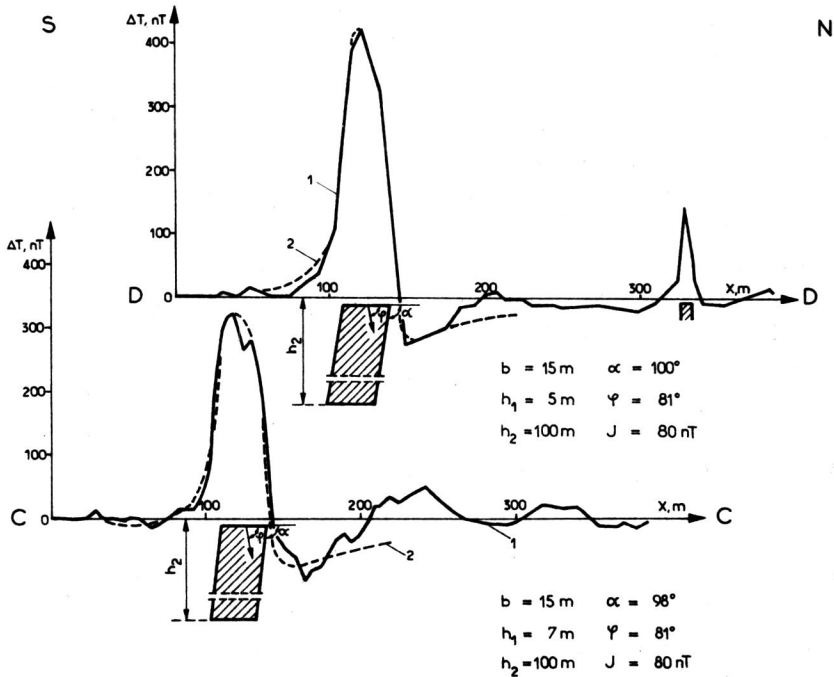


Fig. 4. The magnetic anomalies  $\Delta T$  over the dolerite dyke 1. the measurement curve; 2. theoretical distribution over the dyke model.

to the presence of a thinner dolerite vein, which is marked in the profile; no closer interpretation of these anomalies, however, is given here. Their presence only confirms that also in this Hornsund area the magnetic method can effectively be used in the case of stratification of different links of the metamorphic complex.

#### 4. Conclusions

The magnetic investigations in the Hornsund area were the first pilot research in this part of Spitsbergen. It was found in the course of these investigations that when an appropriate observation technique (synchronized measurements) is used, it is possible to achieve accurate mapping even in those areas where the differentiation of magnetic properties is very weak. This is confirmed by the example of the Fugleberget area. If, however, as in all cases, interpretation of weak anomalies requires a greater number of geological reference point, it is very easy to identify dolerites

from magnetic measurements. They are characterized by a simple distribution of the field, which corresponds to classical interpretation models.

## 5. Резюме

Обсуждаются результаты разведочных магнетических исследований, проведенных у подножья горы Фуглебергет и в долине Скаль в районе северо-западного побережья фиорда Горнзунд. Исследования выявили пригодность магнетического метода для изучения пород разного типа, входящих в состав метаморфического комплекса. Кроме того, в случае магматических интрузий, исследования дали возможность обнаружить, что дайки долеритов отличаются большой, однородной намагниченностью и очень простой геометрической формой.

## 6. Streszczenie

W pracy omówiono wyniki rekonesansowych badań magnetycznych, które wykonano u podnóża góry Fugleberget i w dolinie Skål w rejonie północno-zachodnich wybrzeży fiordu Hornsund. Badania wykazały dużą przydatność metody magnetycznej do rozwarstwienia różnych typów skał występujących w obrębie kompleksu metamorficznego, a ponad to w przypadku intruzji magmowych, pozwoliły stwierdzić, że дайки долеритów charakteryzują się dużym i jednorodnym namagnesowaniem oraz bardzo prostą formą geometryczną.

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