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Some results of magnetic mapping in the Fuglebergsletta area at the northwest edge of Hornsund Fiord, Spitsbergen

ABSTRACT: This paper presents the results of magnetic mapping carried out in the area of the metamorphic series of Ariekammen and Skoddefjellet. On the basis of qualitative interpretation of measurements a number of anomalous zones were distinguished, whose position can be correlated with local changes in mineralitation and polymetallic ore content in the Fuglebergsletta area. The SE-NW orientation, skew to the almost meridional run of the layers of slates and marbles making up the metamorphic complex, dominates in the course of the anomalous zones.

KEY WORDS: Arctic, interpretation of magnetic measurements.

1. Introduction

The measurements described were carried out in the course of geophysical research on Spitsbergen in 1980. Together with the author, Dr. J. Antoniuk, J. Grabowski, Eng., and J. Radomiński, Eng., took part in the measurement work.

The magnetically mapped area extends between the lateral moraine of Hans Glacier in the east and the Rev river in the west. The south and north borders of the measurements area were the shore line of the fiord and the south slopes of Ariekammen and Fugleberget. The area investigated is about 4.5 km^2.

Its geological structure includes metamorphic formations of the Ariekammen and Skoddefjellet series. These are blue micaschists and marbles, among which polymetallic ores of hydrothermal origin can be met. The origin of the ores, distribution and mineral content of the ore-bearing

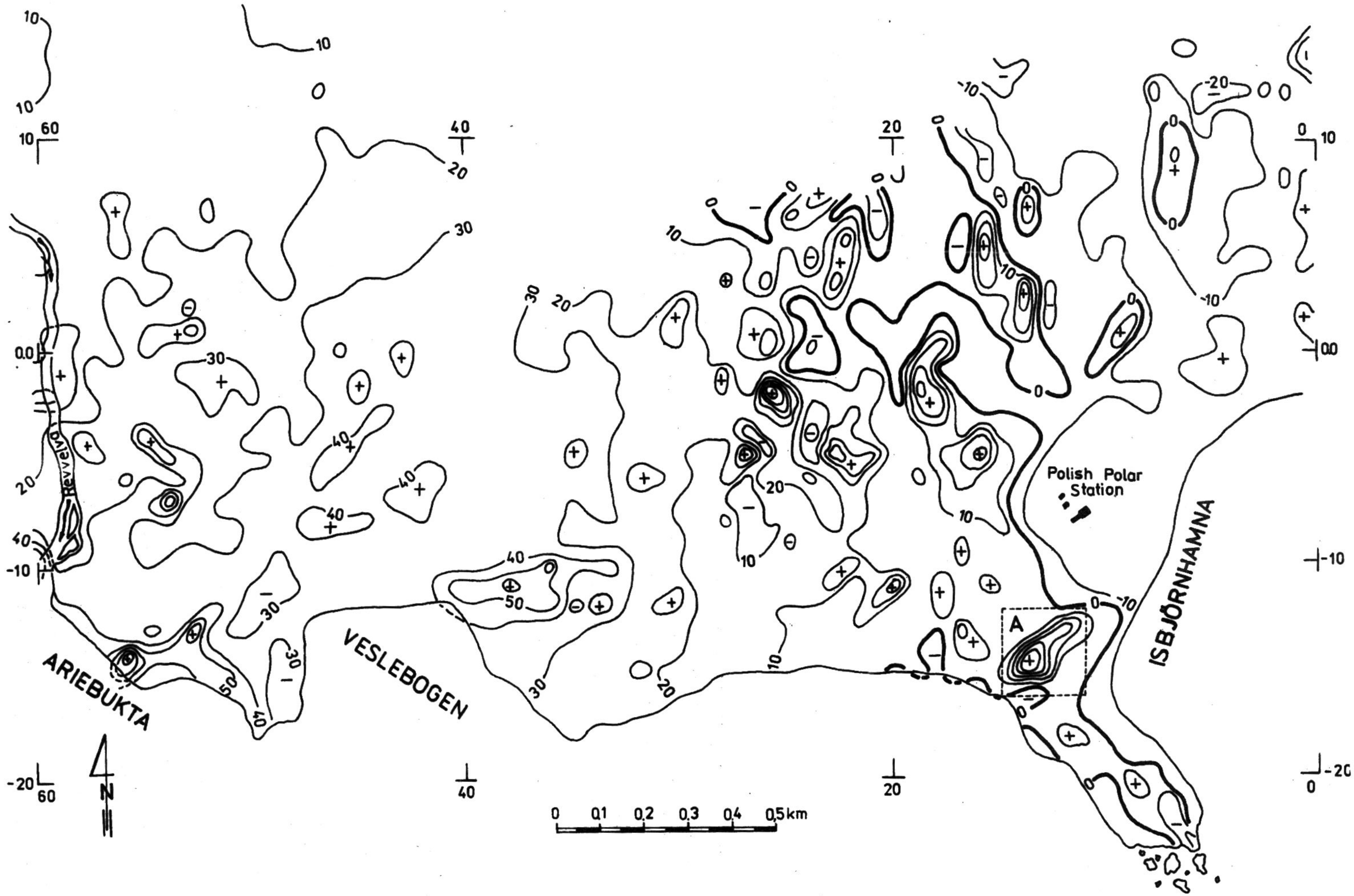

Fig. 1. Map of magnetic anomalies of ΔT

veins in the Hornsund area have already been the object of geological investigations (K. Birkenmajer, J. Wojciechowski, 1964; J. Wojciechowski, 1964). Referring to these investigations, in the course of geophysical research carried out in the summer of 1980, an attempt was made to map magnetically the elements of the tectonics and distribution of ore-bearing zones in the area where they are known to be most frequent.

The magnetic measurement of the Fuglebergsletta area was the first detailed mapping of this type in the Hornsund area and probably so throughout Spitsbergen. It was carried out in a regular network with 50 × 50 m dimensions, composed of about 1500 measurement posts. The measurements were carried by the method of synchronized observations by means of two PMP-4 type proton magnetometers. The occuracy of the mapping was not less than 2 nT.

Fig. 1 shows the distribution of ΔT anomalies in the Fuglebergsletta area.

2. Structure of the anomalous image

In a geophysical sense, the map analysed has a typical two-component structure, partly perturbed by random fluctuations. Local anomalies, whose sources lie just below the surface or directly on the measurement surface, impose themselves on the regional background related to the deeper structure of the metamorphic complex. Random fluctuations are understood here to be not so much the error involved in the measurements themselves as single deviations, related to an accidental distribution of small sources (boulders), as a result of material transport by glaciers.

A characteristic feature of the map is a zonal distribution of local anomalies. Most of them are grouped in the east part of the map, in a band about 1 km wide. In the west part the character of the image is less mosaic-like, while it is least so close to the +40 cut-off line. The intensity of anomalies varies according to a similar principle. Only sporadically their amplitudes do exceed 50 nT. Irregular forms dominate, which need not be related to the character of the source, but rather to the sampling depth. Realistically speaking, in a large number of cases, the sizes of bodies are so small that with this density of the network they cannot have been sufficiently outlined. This was investigated in detail on profiles undescribed here and in region A, in the south part of the map.

It is rather difficult, even in the case of the zones, with highest intensity, to determine directly on the basis of ΔT the favoured directions of anomalies. For not only SE–NW and SW–NE, but also meridional and parallel orientations occur. This results from a complex origin of the

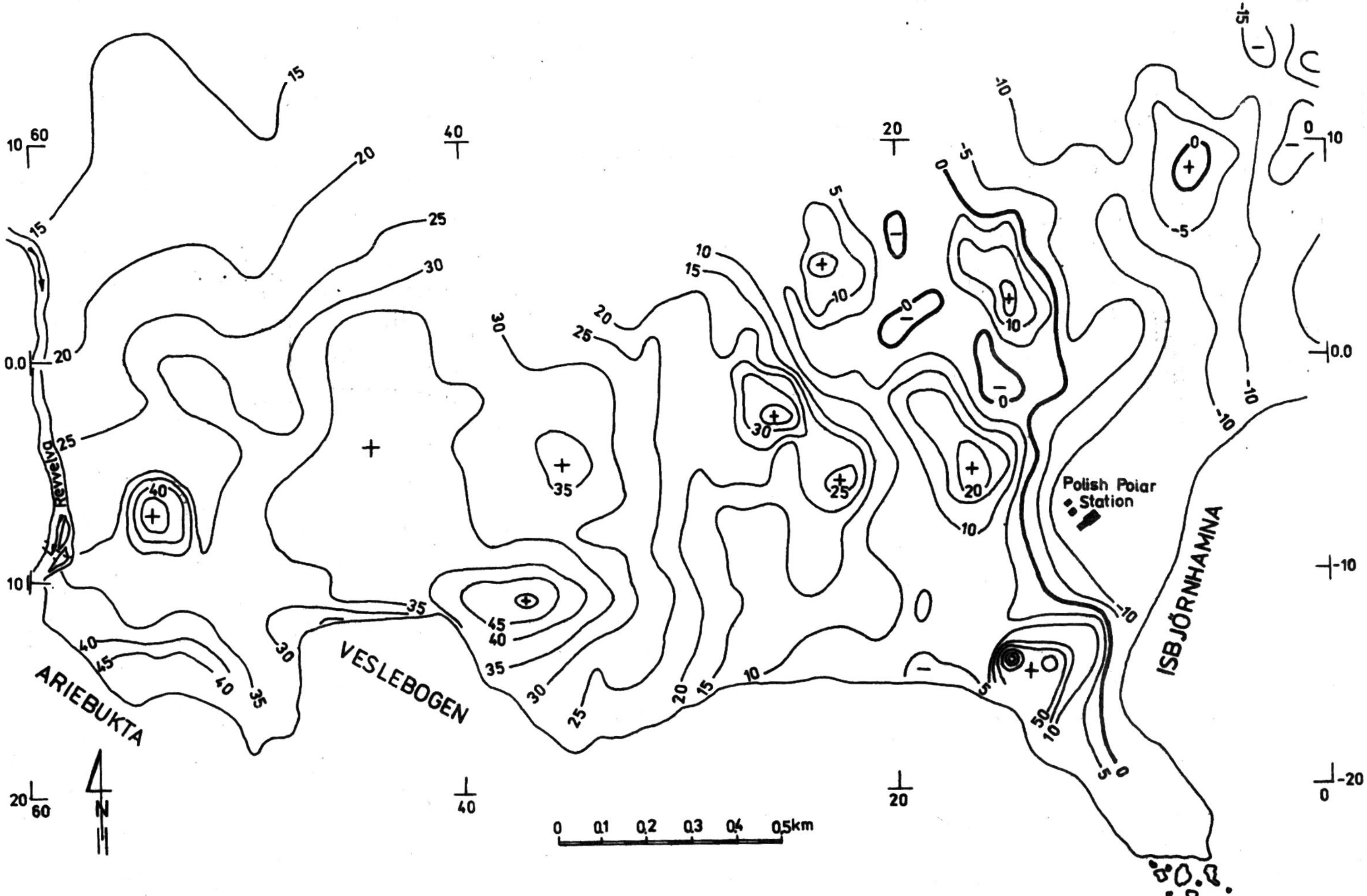

Fig. 2. Approximate distribution of the measurement field of ΔT

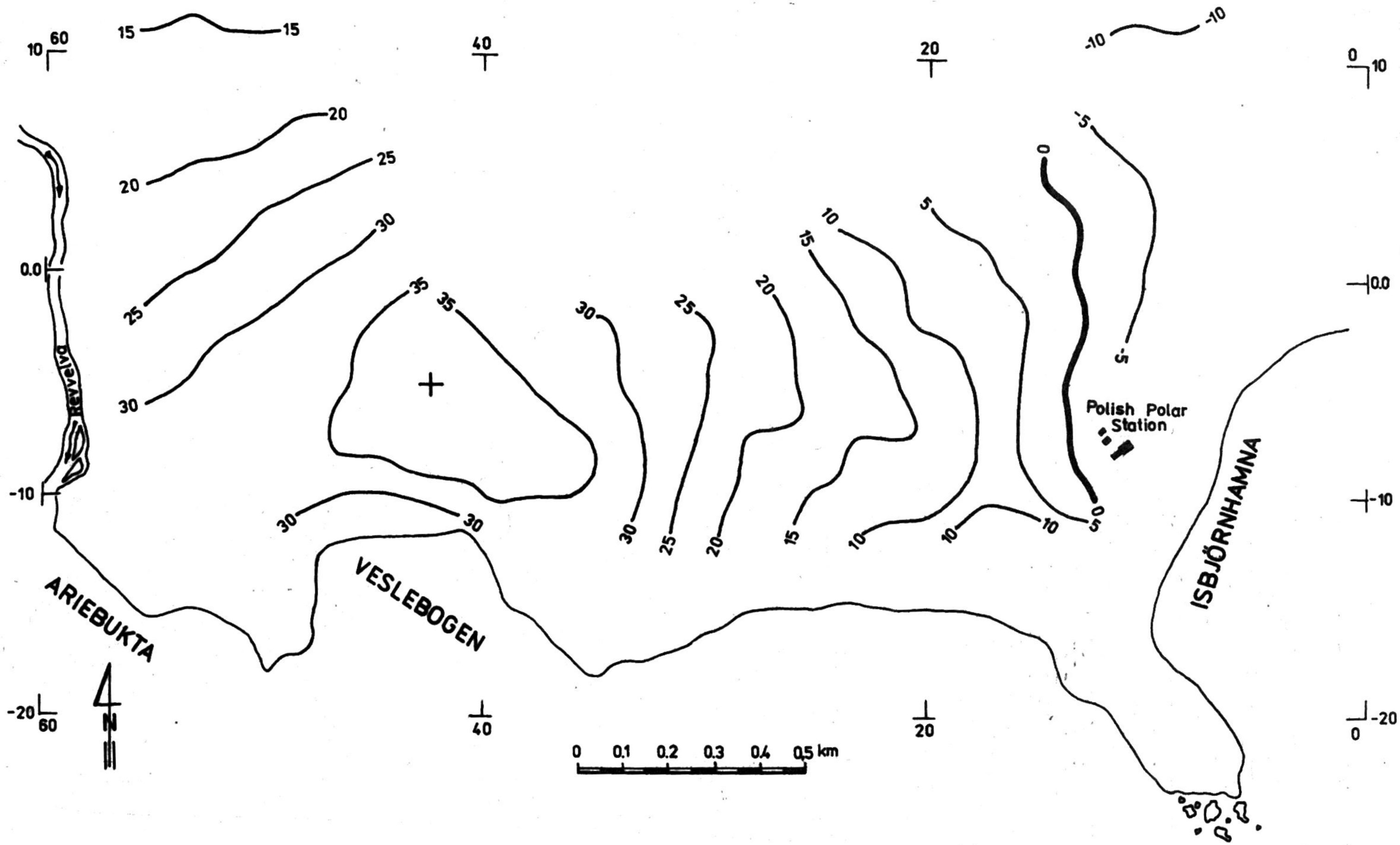

Fig. 3. Regional trend in ΔT in the Fuglebergsletta area

anomalies. Apart from the ore content or only greater mineralization in the primary regions, of tectonic character, secondary concentration may have occurred as a result of rock mass transport by glaciers.

A more exhaustive characteristic of the field observed was provided by analysis of the trend. It was carried out by the method of local approximation with polynomials, by means of a power polynomial of the 1st degree.

The essence of this method, elaborated for data from a regular square network (A. Koblański, 1975) is the approximation of the measurement field in the middle of a locally chosen square with a side of (2N+1) s; where s is the sampling step and N characterizes the number of data. Application of the moving window procedure to the square gives a set of free terms a_{00} of the polynomial, which, for a given degree, depend functionally on the coordinates x, y and on the parameter N. In the case of a polynomial of the 1st degree the method works similarly to the known Griffin's method, since the parameter N plays here the role of the radius r.

Fig. 2 shows the approximation of measurement data for ΔT with $N = 1$. It can be seen that this field does not contain this part of measurements which, showing the properties of a sign-alternating series with its mean tending to zero, disturbed so intensely the legibility of the initial image. Most of local anomalies are grouped in the central and east parts of the map, and SE–NW is the dominating orientation direction. They occur in the regional background, whose approximate form with $N = 4$ is shown in Fig. 3.

3. Interpretation of the relationship between the major anomalous zones and tectonics

Despite grasping some structural properties of the field, it is rather difficult to interpret the spatial relations among anomalies, mainly because effects of superposition between the regional and local components and in addition, within this group of anomalies, strong interference can be observed. This is evidenced distinctly by the example of detailed mapping in the area designated by the index A, where measurements were taken in a 10 × 10 m network (Fig. 4).

In a less detailed form, as Fig. 1 shows, in this region the field is homogeneous, while the anomaly runs SW–NE. This is, however, as Fig. 4 shows, a result of composition, for there is mutual superposition of the perpendicular directions, SW–NE and SE–NW. Much less intensive anomalies, running in an arc from SW to NE, are adjacent to the most intensive one with an amplitude of about 800 nT (the highest found in the whole mapped area). The axes of the anomalies are displaced with respect to each other as though the final orientatuin of their sources had shaped

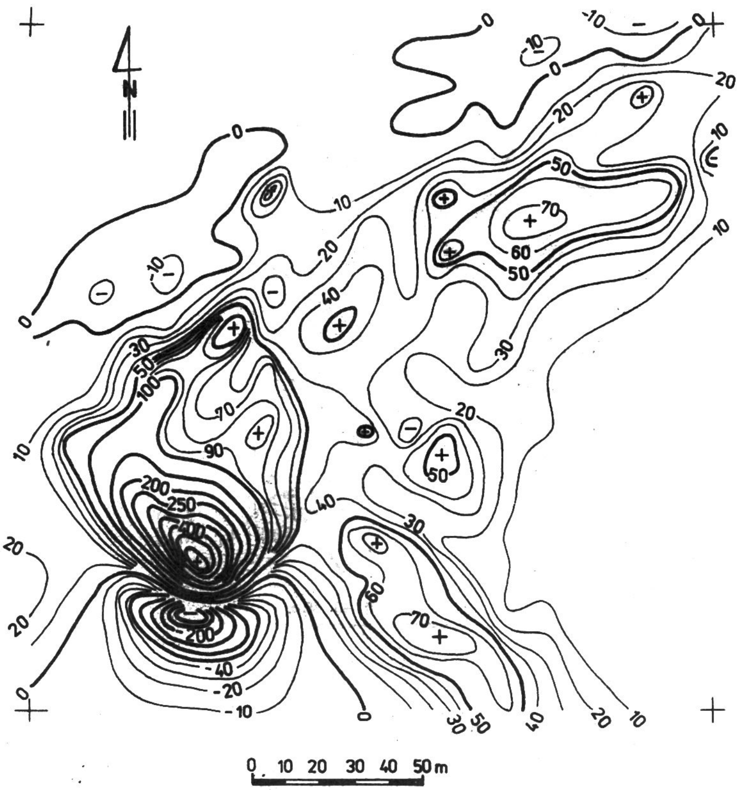

Fig. 4. Micromagnetic mapping of ΔT in region A

as a result of thrust movements. It cannot be excluded that there has been here an imposition of two different stratigraphic metamorphic stages along a limit oriented SE–NW, whose continuity was perturbed by transverse dislocations with the SW–NE orientation.

Fig. 5 shows the relations discussed above in the form of a tectonic outline. In the east part, in relation to the possible rotation, a system of throw and shift dislocations with small amplitudes can be observed, with varying direction and approximately perpendicular to the arc defined by the course of the axes of the anomalies.

It is impossible to achieve a similarly detailed qualitative interpretation for the whole Fuglebergsletta area. In view of lack of data to permit correlation, Fig. 6 shows only the more important anomalous zones related to the elements of tectonics, whose interpretation can still raise the least objections.

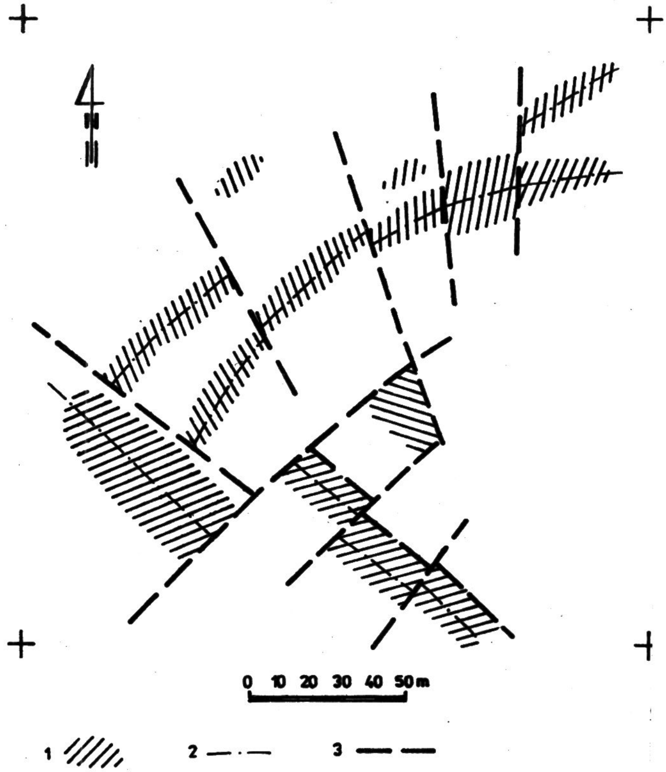

Fig. 5. Qualitative interpretation of the micromagnetic mapping.
1 — approximate outline of the anomaly source, 2 — axes of positive anomalies, 3 — probable dislocations

On the basis of analysis of the mapping of ΔT and its transformation in the area in the vicinity of the Polar Station, a few zones with axes orientated SE–NW were distinguished. Only slight displacements of the axes of anomalies can be discerned here, which may have occurred as a result of later shift movements.

In such a case, the course of the primary dislocations or cracks along which ore-bearing veins would have formed would be defined by the position and direction of the anomalous extention. When these directions are referred to the line of the maximum gradient of the regional field (Fig. 3), it can be seen that they intersect. Hence, it follows that, as is known from geological research (K. Birkenmajer, op. cit.), the system of dislocations related to ore deposition is yonger than the tectonics which shaped the principal features of the metamorphic complex.

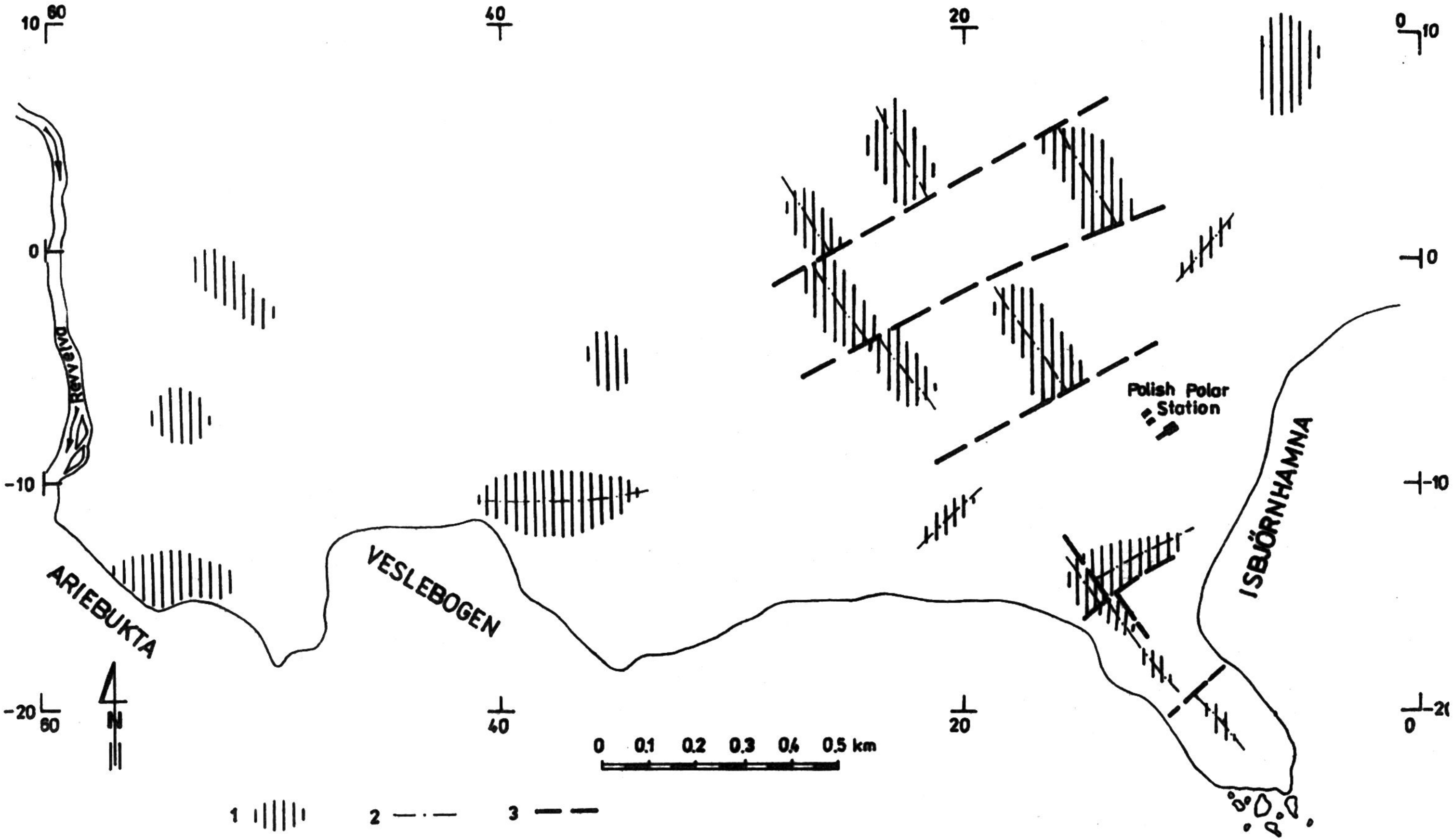

Fig. 6. Schematic diagram of the distribution of the major anomalous zones in the Fuglebergsletta area. 1 — approximate outline of the anomaly source, 2 — axes of positive anomalies, 3 — probable dislocations

4. Conclusion

Despite the very high density of the network, the magnetic mapping of the Fuglebergsletta area does not permit a detailed correlation of ore-bearing zones and the related tectonics. It provides in turn the possibility of less accurate inventory, which can become the basis for planning a micromagnetic research. If such a research were started, the magnetic mapping should be carried out it a network such as that in region A or even smaller, with 5 × 5 m dimensions. An example of the measurements carried out in part of the area confirms that the rather good general geological investigation of the metamorphic complex could be complemented with geophysical research by the magnetic method.

5. Резюме

Магнитное поле на территории фуглебергслетта имеет типичную двухчленную структуру. На региональный фон, связанный с глубинным строением метаморфического комплекса, накладываются локальные аномалии нерегулярных форм.

На основании качественного анлиза измеряемого поля можно здесь выделить несколько важнейших аномальных зон, которых расположение коррелируется с выступающими на этой территории прявлениями рудной минерализации.

Направление аномалии в этих зонах дифференцируется, но в масштабе целово района преобладает ориентация SE-NW.

Более детальные исследования в южной части территории (зона „A") показывают, что кроме изменений в концентрации ферро- или ферримагнитных минералов источником анизотропии поля является сильно, развитая микротектоника.

6. Streszczenie

Pole magnetyczne na obszarze Fuglebergslletta posiada typową strukturę dwuskładnikową. Na tło regionalne, związane z głębszą budową kompleksu metamorficznego, nałożone są anomalie lokalne o zmiennej intensywności i morfologii.

Metodą analizy jakościowej wydzielono z pola pomiarowego na tym obszarze kilka większych stref anomalnych, których położenie może być korelowane z występującymi tu objawami mineralizacji kruszcowej. Jakkolwiek rozciągłość poszczególnych stref jest zróżnicowana, w skali całego obszaru dominuje kierunek SE-NW.

Szczegółowsze badania w południowej części zdjęcia (strefa „A") wykazały że oprócz zmian w koncentracji minerałów ferro- lub ferrimagnetycznych źródłem anizotropii pola jest silnie rozwinięta mikrotektonika.

7. References

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