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Electromagnetic investigations by the VLF method of the ore - bearing veins in the Hornsund Fiord area

ABSTRACT: The present elaboration gives the results of investigations carried out by the VLF method in September, 1980, in Fuglebersletta, in the Hornsund Fiord area, Spitsbergen. The aim of the investigations was to localize precisely the orebearing veins and to trace their course.

Key words: Arctic, Spitsbergen, localization of ore-bearing veins.

1. Introduction

The occurence of ore-bearing veins on the north coast of Hornsund Fiord was found in the course of investigations carried out by Polish scientific expeditions to Spitsbergen in 1957—1969. The results of the investigations were published by K. Birkenmajer and J. Wojciechowski.

The most intense mineralization was found in Fuglebergsletta, about half a kilometer west of the Polish Polar Station. There, occur hydrothermal quartz veins cutting across Hecla-Hoek formations. The major ore materials are pyrite and chalcopyrite, in addition pyrrhotite and sporadically native copper. The secondary minerals are: geothite, limonite, cuprite and malachite H. Kucha, 1982.

In September 1980, electromagnetic investigations were carried out in Fuglebergsletta among the Polish Polar Station Wilczekodden and the outlet of Revvelva River. The north boundary of the research area was constituted by the south slopes of Ariekammen and Skoddefiellet. The measurements were of reconaissance character, covered a relatively small area and were carried out beyond the basic programme of geophysical research performed by the team of the Institute of Geophysics, Technical University of Mining and Metallurgy.

2. Method of investigations

The purpose of investigations was to localize the ore-bearing veins and to trace their course. The VLF method, using infralong radio waves, was employed. The primary field was in this method generated by high-power radio transmitters, used for military comunnication purposes, set up in various parts of the world. These stations emit unmodulated carrier waves continuosly or in the Morse code in the frequency band 15 – 25 MHz.

In the radio technology, these frequencies are called "very low frequencies", because the frequency of waves used to broadcast the usual radio programme is higher by a factor of more than ten. Therefore, the geoelectrical method using the field induced by those radio transmitters is called the VLF method. In the context of geoelectrical methods, where frequencies below even 1 Hz are used, the name VLF is not the really proper one. This method should be included among the induction, so-called "passive" ones, using the "foreign" sources of the primary field.

The mesurements were carried out by using the device EM-16 manufactured by Geonics, Ltd. This device permits the measurement of two parameters: the vertical component of the secondary magnetic field, the so-called real component, i.e. one in phase with respect to the primary phase, and the imaginary vertical component of the secondary magnetic field, i.e. one in antiphase with respect to the primary field. Both in the case of the "in phase" component and in that of the quadrature one, relative values are determined (expressed in %), referred to the magnitude of the primary magnetic field. The measurement scale range is $\pm 150\%$ for the "in phase" component and $\pm 40\%$ for the quadrature one. The readout accuracy is $\pm 1\%$. The ore bodies with strike in agreement with the direction of the local bearing for the radio station cause very large anomalies. Conversely, conductors with strike perpendicular to the bearing for the station are practically undetectable. Therefore the investigations by the VLF method are usually carried out on the basis of two radio transmitters, whose local bearings differ by 45 – 90 . In the Hornsund area the measurements were carried out using as the source of primary field the radio station FUO in Bordeaux, working at a frequency of 15.1 kHz. The signal emitted by the French station was strong and well audible. An attempt was made to use as the "second source" the UMS station off Moscow, which gave in the area of West Spitsbergen a signal as strong as that from the FUO, but irregular dozenodd pauses in the work of the UMS transmitter hampered to a large extent the measurements.

3. Investigation results

Fig. 1. shows schematically the localization of the profiles along which the investigations by the VLF method were carried out. Reconaissance measurements were carried out at two parallel profiles 500 meter distant. One of them was the profile denoted IV in the diagram (Fig. 1). The other, extending from Isbjörnhamna Bay to the outlet of the Revvelva River, was denoted IX. The measurement points in the reconaissance

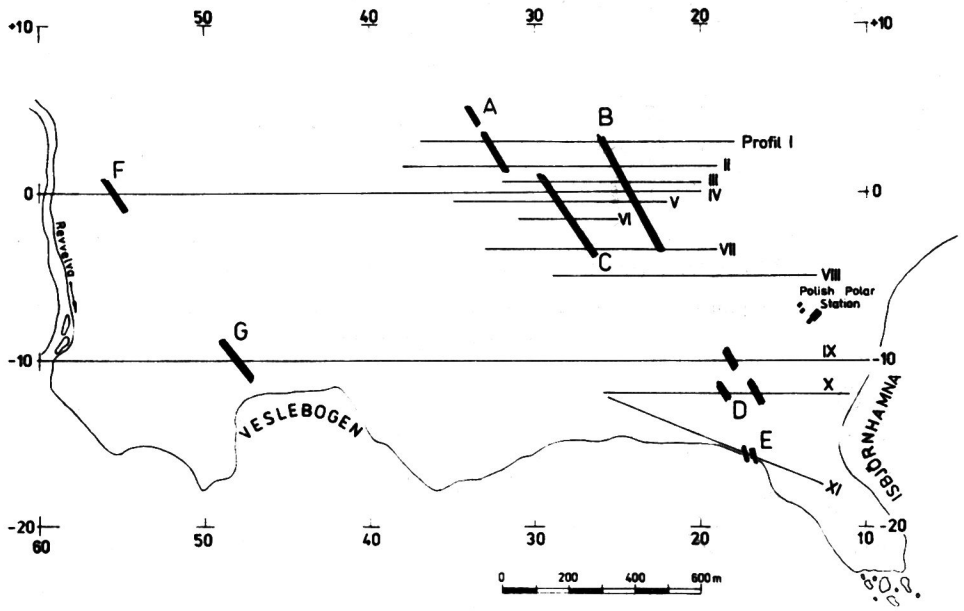


Fig. 1. Schematic diagram of the measurement profiles in Fuglebergsletta

profiles were localized every 25 meters. Fig. 2 shows the curves of change in the relative values of the "in phase" vertical component and those of the quadrature of the anomaly field. It can be seen in these diagrams that a few anomalies were recorded, which should be related to the occurrence of the well conducting bodies – the ore-bearing veins. One of them is the anomaly measured between the 20th and the 30th points of profile IV. The shape of the anomalies, their symmetricity with respect to the "zero" points, indicate the presence of two well conducting veins, dropping vertically (or almost vertically). In the region where this anomaly occured, detailed investigations were carried out by the VLF method, along mutually parallel profiles set at distances of 30–80 meters. The distances between the measurements points were 1–25 meters, most frequently 5–10 meters, depending on the intensity of changes in the vertical magnetic component of the secondary electromagnetic field. In the situation diagram

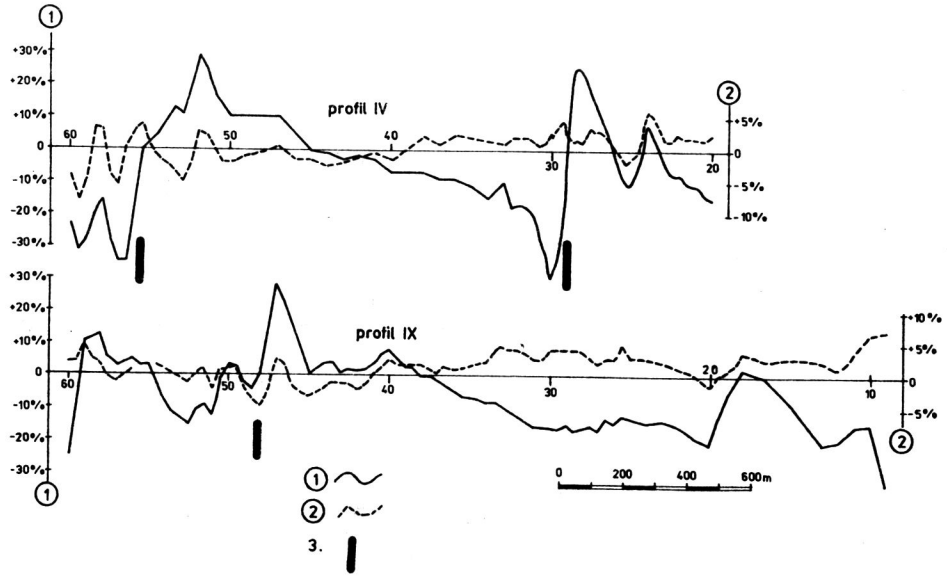


Fig. 2. Curves of changes in the relative value of the vertical magnetic component of the VLF electromagnetic field along the reconaissance profiles

1 — "In phase" component, 2 — quadrature component, 3 — interpreted localization of the outcrops of orebearing veins

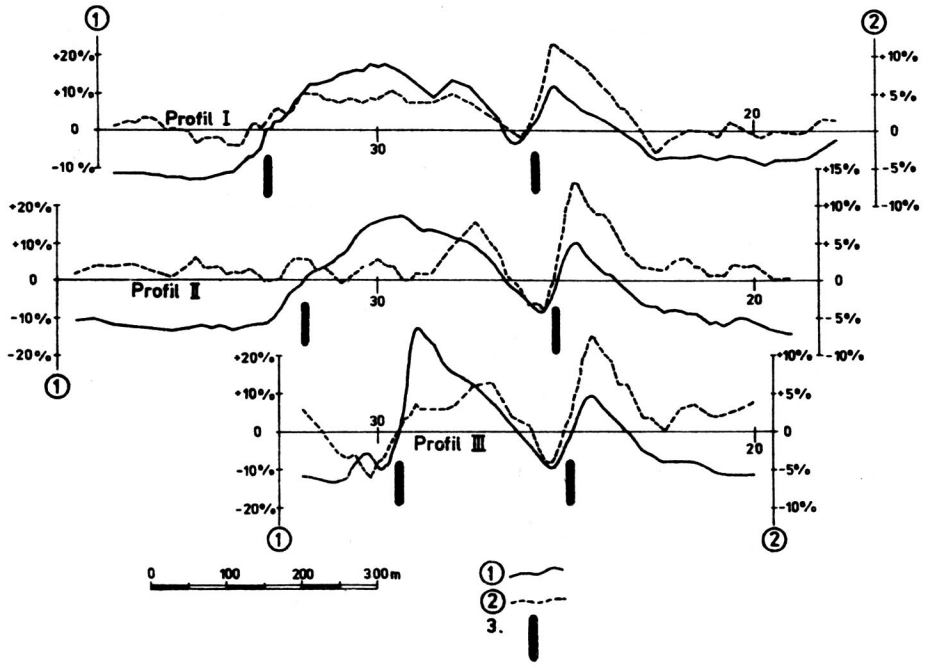


Fig. 3. Curves of changes in the relative value of the vertical magnetic component of the VLF electromagnetic field along the profiles I, II and III

1 — "in phase" component, 2 — quadrature component, 3 — interpreted localizations of the outcrops of orebearing veins

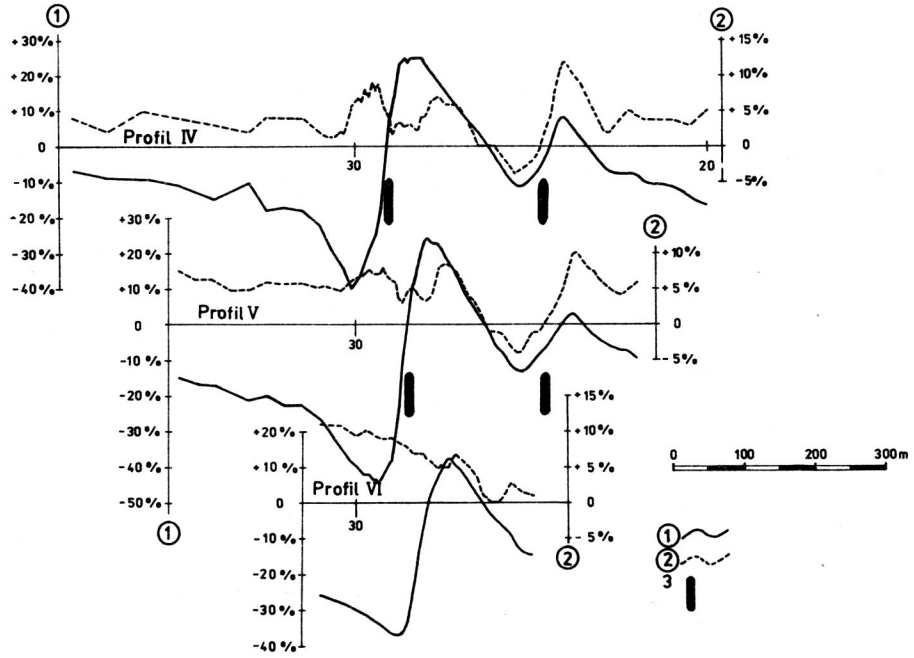
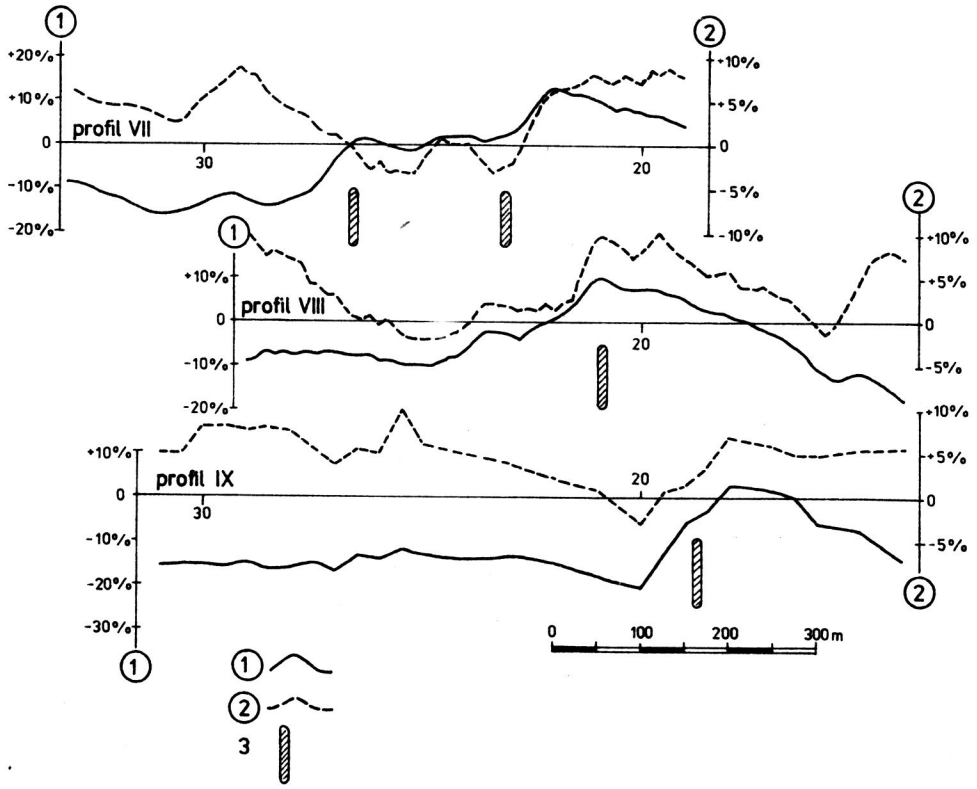


Fig. 4. Curves of changes in the relative value of the vertical magnetic component of the VLF electromagnetic field along the profiles IV, V and VI

1 — "in phase" component, 2 — quadrature component, 3 — interpreted localizations of the outcrops of orebearing veins

(Fig. 1), these profiles are denoted by the numbers: I, II, III, IV, V, VI and VII. Figs. 3—5 show the curves of the "in phase" vertical component and those of the quadrature one, and Fig. 6 represents the map of the distribution of the relative values of the "in phase" vertical component of the anomalous magnetic field. The results of the measurements carried out on the profiles listed above permitted a detailed mapping of the outcrops of three ore-bearing veins (see Figs. 6 and 1). The veins marked as B and C in the diagram have their outcrops just under the surface (in a few outcrop spots), while the outcrop of the vein denoted A, as follows from measurements, is at a depth of dozen-odd meters.

In profiles VIII—XI, anomalies have quite a complex shape. There is no doubt that the ore-content zone, 100 — 200 meters thick, continues. It is traced at all the profiles, form VIII to XI; however, it is difficult to give a detailed localization of the veins. The rather complicated shape of anomalies and the related interpretation difficulties are most probably caused by the occurence of two or three veins, at mutual distances of several score to a hundred meters. The anomalies from the particular ore bodies overlap, giving as the effect a complex behaviour of the curve.


profil VII
profil VIII
profil IX
+20%
+10%
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-20%
-30%
+5%
-5%
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1
2
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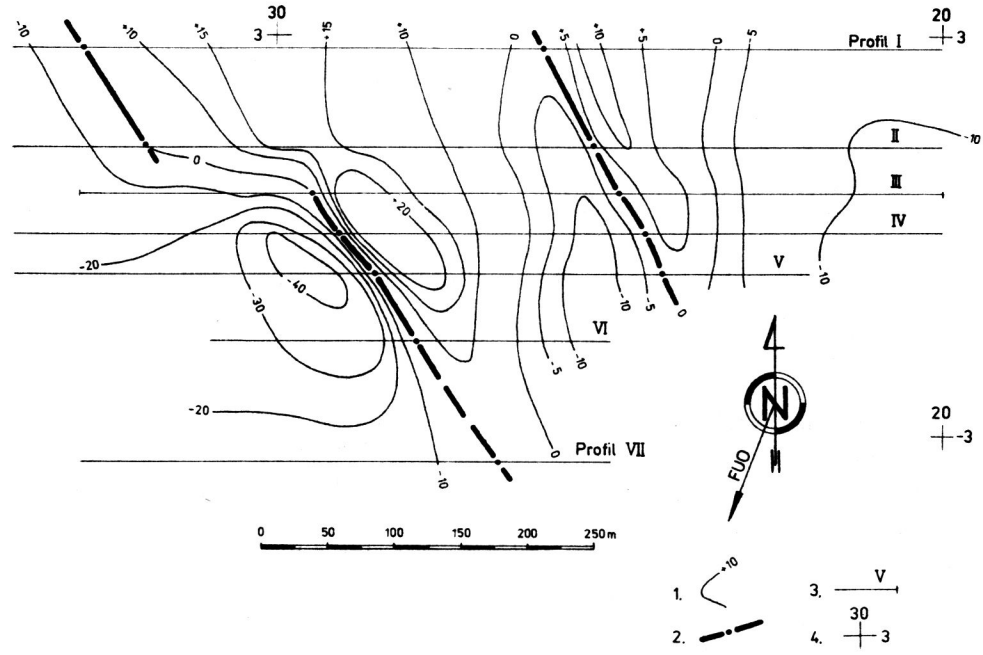
Fig. 5.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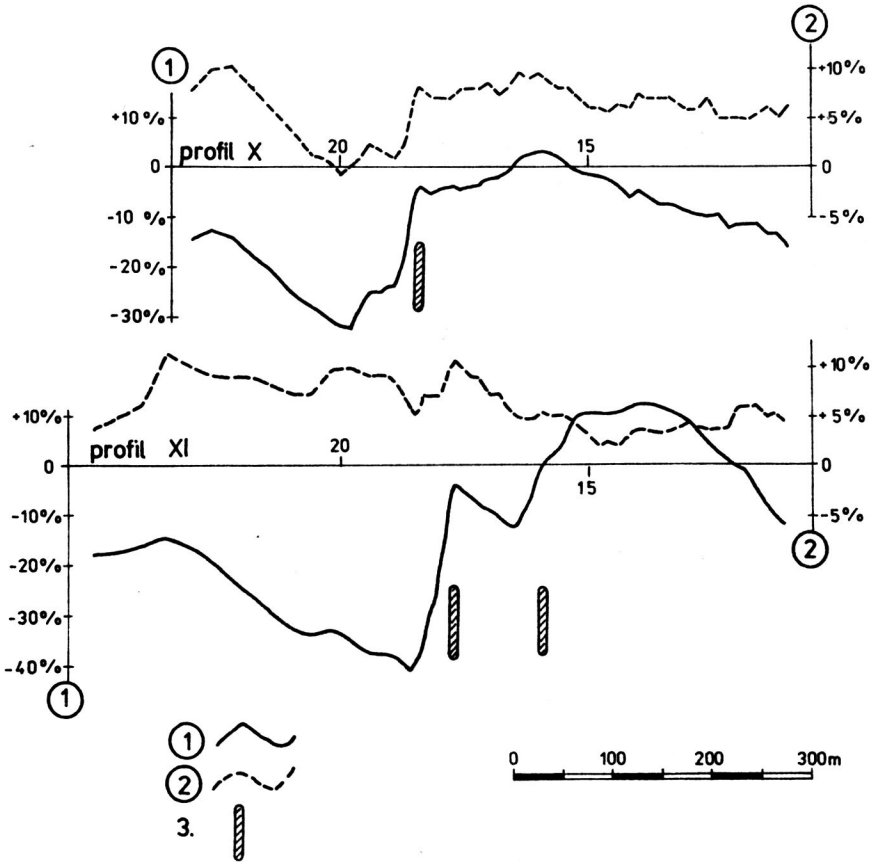

Fig. 7.

Fig. 5. Curves of changes in the relative value of the vertical magnetic component of the VLF electromagnetic field along profiles VII, VIII and IX

1 — "in phase" component, 2 — quadrature component, 3 — interpreted localizations of the outcrops of orebearing veins

Fig. 6. Map of changes in the relative value of the vertical magnetic component "in phase" of the VLF electromagnetic field

1 — isolines of relative values of the vertical magnetic "in phase" component, 2 — interpreted outcrops of ore-bearing veins, 3 — measurement profiles, 4 — coordinates of the regional network of magnetic profiles

Fig. 7. Curves of changes in the relative value of the vertical magnetic component of the VLF electromagnetic field along profiles X and XI

1 — "in phase" component, 2 — quadrature component, 3 — interpreted localizations of the outcrops of orebearing veins

An exact mapping of the outcrops of the veins marked as D, E, F and G in the situation diagram would require that in the mentioned areas of the network short profiles, parallel to the reconaissance ones, should be made.

4. Резюме

Даны результаты исследований, проведенных методом VLF в сеньтябре 1980 года на Фуглебергслетта в районе фиорда Горнзунд на Шпицбергене. Целью исследований было точное определение местонахождения рудоносных жил и установление их распространения.

5. Streszczenie

Autor przedstawił wyniki badań metodą VLF przeprowadzonych we wrześniu 1980 roku na Fuglebergsletta w rejonie fiordu Hornsund na Spitsbergenie. Celem badań było dokładne zlokalizowanie żył kruszconośnych i prześledzenie ich przebiegu.

6. References

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