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Determination of the absolute values (D,H,T) of the geomagnetic field at secular points in the Hornsund area, Spitsbergen, 1979

ABSTRACT: The results and method of measurements of D, H and T carried out at Hornsund in the summer of 1979 are presented. The relative and absolute values of these elements are given in reduction to the Polish magnetic station at Hornsund. An initial evaluation of changes in the magnetic field from 1957 to 1979 is carried out.

Key words: Arctic Spitsbergen magnetic measurements

1. Introduction

The history of magnetic investigations in the Hornsund area dates from the early 17th century when first J. Poole (1610) and then W. Baffin (1613) determined the declination (D). The subsequent known magnetic observations in this area came only in 1899. They were made by a Swedish-Russian expedition in the vicinity of Goose Bay (Gashamna). In addition to declination also the inclination (I) and the horizontal componend (H) were determined then.

The investigations mentioned are discussed in Lundquist's (1957) synthetic work devoted to analysis of secular changes in the geomagnetic field in the Svalbard archipelago between 1596 and 1953.

Polish magnetic investigations in the Hornsund area were initiated during the 3rd International Geophysical Year (IGY). At the initiative of the author mentioned, in 1957, at the edge of the fiord, five observation points were set up, where the participants of the Polish IGY expedition carried out the first series of measurements of declination, inclination and the horizontal component. The repeated localization of one of the stations P_3 — Gashamna

in the place of the measurements from 1899 allowed the researchers (J. Kowalczuk, K. Karaczun, 1963) to evaluate changes in the elements of the terrestrial magnetism for about 60 years.

By taking advantage of the existing, well-preserved network of measurement points and their azimuth marks, in the summer of 1979 another series of investigations was carried out in the fiord region. This time, in addition to D and H, a third element of the field being measured was the modulus of the total intensity T. The measurements were carried out at all points of the network, i.e., in using the notations assumed previously, at P_1 — Wilczekodden, P_2 — Hyttevika, P_3 — Gashamna (Konstantinovka), P_4 — Treskelodden and P_5 — Suffolkpynten. The base point to which they were reduced, was the magnetic station at Hornsund.

The present elaboration gives a brief outline of the most important results and the method of these measurements.

2. Method of the measurements

2.1. Declination

Determination of magnetic declination at a given point requires, as it is known, knowledge of the magnetic and astronimical azimuths of the azimuth mark. Since the astronomical azimuths of all magnetic points are known (op. cit., 1963), our measurements were only limited to the determination of their magnetic azimuths. The No. 192 Mating and Wiesenberg magnetic theodolite was used for this purpose.

Before measurements at secular points the theodolite was tested in the absolute measurement pavilion at the Polish magnetic station at Hornsund. The coefficient of residual torsion of the thread and some values of D were determined here for comparison with the results of permanent registration at the magnetograms of the station.

The magnetic azimuths were found at measurement posts in keeping with the generally known principles, on the basis of observations of the direction of the azimuth mark and direction of the magnetic North on the horizontal circle of the theodolite. The direction of the magnetic North was determined from observations of the equilibrium position of two magnets, M_1 and M_2, with different magnetic moments, suspended on phosphor-bronze threads. By applying the procedure of suspension and readout of the indications of the magnets according to the sequence: AS, BS, BN and AN, in one full measurement series, successively 4 indications of the weak magnet M_1, 8 indications of the strong magnet M_2 and another 4 indications of the magnet M_1 were observed. The series of observations

of the positions of the magnets was preceded and concluded by double readouts from the horizontal circle of the theodolite oriented at azimuth mark.

2.2 Horizontal component H

The measurements of the horizontal component were carried out by the No. 412 QHM magnetometer. The indications of this device were compared with values of H calculated on the basis of measurements by the control magnetometer of the station, No. 244 QHM. A systematic difference of 49 nT was found among the control measurements. It was taken into account, in the form of a constant correction, in calculating the value of H with respect to the station.

At all the posts, the so-called double measurement procedure was applied, permitting the determination of two values of H from measurements carried out in one series. The observations were made for torsion of the thread of the measurement system by an angle of $\pm 1\pi$ with respect to the neutral position.

2.3. Total intensity T

The measurements of the total intensity T were carried out by the PMP-4 type proton magnetometer with a sensitivity of ± 1 nT. The control measurements by the magnetometer at the station were compared with slow recordings of H and Z, since the station cannot carry out permanent registration of T. A dozen-odd measurement series made on different days showed that differences between T and $(H^2+Z^2)^{1/2}$ varied only within ± 3 nT.

In the network of secular points, observations of T were carried out with automatic release of the measurement signal of the magnetometer at 3-second intervals. Thus, before and after observations of H and D, about 100—150 measurements were carried out to estimate correctly the mean interval value of T for an interval of 3 min. Subsequently, these mean values were reduced due to the diurnal variations in the external magnetic field.

In this case, the selection of ways of measurement and reduction depended on the properties of the station records of H and Z, where 1 mm on the horizontal scale corresponds to an interval of 3 min.

3. Result of the measurements

The reduction of the external magnetic field was carried out in keeping with changes recorded by magnetograms at the Hornsund station. Time

corrections for the geographic longitude of the points of observation were neglected since these corrections were within the accuracy of the magnetograms.

The relative values of D, H and T were calculated with reference to the station. Because of the limited space, the present elaboration does not provide a full documentation of the measurements, but only their final results in the form of the mean values, ΔD, ΔH and ΔT, and their root mean square (RMS) errors. They are given in Tables II, III and IV. In turn Table I presents the results of comparison of declination measurements carried out at the magnetic station by the No. 192 M-W theodolite with permanent registration, whose the base D_0 is defined by means of the No. 244 QHM magnetometer.

Table I

Comparison of the results of measurements of declination at the magnetic station. D_1 — value determined by No. 192 M–W theodolite. D_2 — result of permanent registration

Date	T GMT	D_1	D_2	ΔD	$\Delta\bar{D}$	RMS
1	2	3	4	5	6	7
19.07	22^h56^m	−0°44.0′	−0°45.0′	1.0′		
20.07	14^h51^m	−1°03.8′	−1°03.2′	−0.6′		
21.07	7^h36^m	−0°28.1′	−0°28.6′	0.5′	−0.3′	2,5′
21.07	20^h58^m	−1°22.9′	−1°19.9′	−3.0′		
22.07	11^h44^m	−0°49.8′	−0°46.7′	−3.1′		
22.07	13^h40^m	−0°47.2′	−0°50.6′	3.4′		

Table II

The relative values ΔD of the declination

Post	Measuring period	Number of measurements	ΔD	RMS
P_1	22.07—25.08	64	0°00.0′	1.1′
P_2	14.08—18.08	136	−0°07.0′	2.0′
P_3	3.08—5.08	88	0°10.4′	1.7′
P_4	1.08	24	0°52.6′	2.0′
P_5	8.08—10.08	72	0°16.6′	1.7′

It can be seen from the tables that the RMS for all elements usually falls within the limits of recording sensitivity on the magnetograms. During the measurements it was on average: $\varepsilon_D = 3.28'/\text{mm}$ for declination, $\varepsilon_H = 7{,}88$ nT/mm for the horizontal component and $\varepsilon_Z = 7{,}68$ nT/mm for the vertical component.

Table III

The relative values ΔH of the horizontal component

Post	Measuring period	Number of measurements	ΔH [nT]	RMS [nT]
P_1	23.07—25.08	30	−1	5
P_2	16.08—18.08	35	0	4
P_3	3.08—4.08	22	33	6
P_4	1.08	11	−46	11
P_5	8.08—11.08	33	81	10

Table IV

The relative values ΔT of the total intensity

Post	Measuring period	Number of measurements	ΔT [nT]	RMS [nT]
P_1	22.07—4.09	27	−21	3
P_2	13.08—18.08	42	−44	5
P_3	2.08—5.08	48	−36	6
P_4	1.08	48	−16	8
P_5	7.08—11.08	33	−47	8

Table V shows the absolute values of D, H and T reduced to the 1979,5 epoch. They were determined by adding to the relative values of ΔD, ΔH and ΔT the yearly means of these elements for the Hornsund station. The mean values of D, H and T for the year 1979, according to Szymański (1984), are: D = −0°32′, H = 8394 nT, T = 54101 nT. The latter value was calculated from H and Z = 53447 nT.

Table V.

The absolute values of D, H and T for the 1979,5 epoch

Post	D	H [nT]	T [nT]
P_1	−0°32,0′	8383	54080
P_2	−0°39,0′	8384	54057
P_3	−0°21,6′	8417	54065
P_4	0°20,6′	8338	54085
P_5	−0°15,4′	8303	54054

The surface distributions of the relative values of D, H and T are shown in Figs. 1, 2 and 3. They illustrate approximately the regional properties of the magnetic field in the Hornsund region.

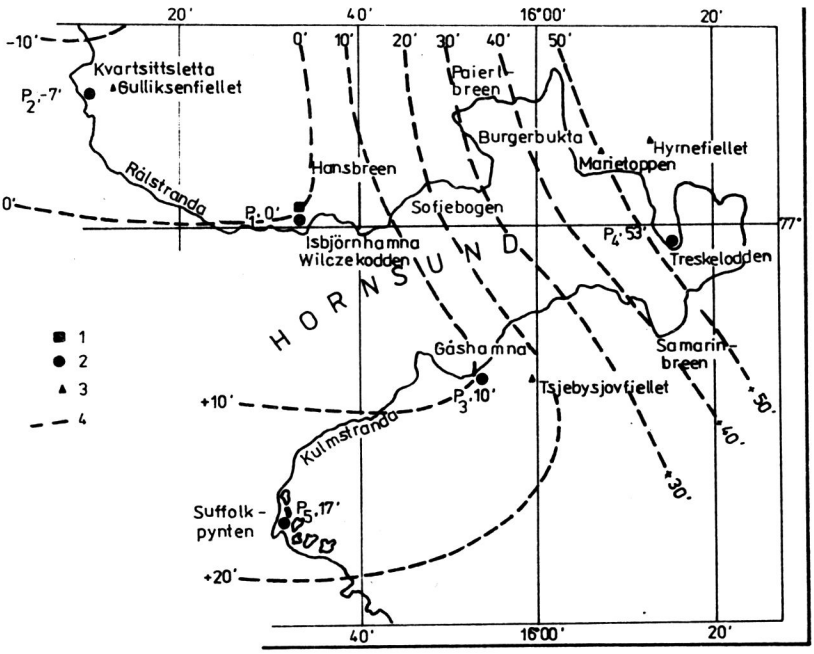

Fig. 1. Map of the ΔD anomalies, Hornsund, 1979. 1 — Polish Polar Station, 2 — secular points, 3 — peaks, 4 — isogonic lines in minutes

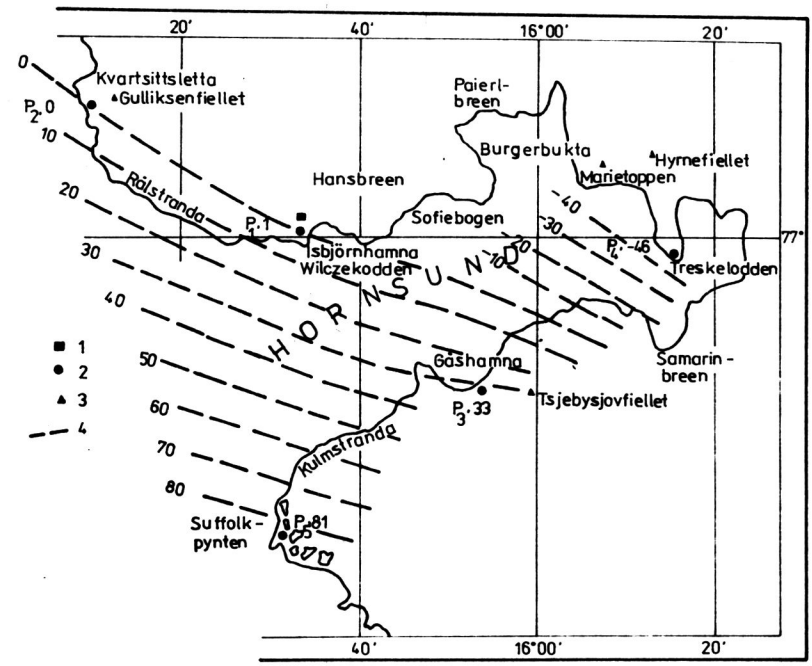

Fig. 2. Map of the ΔH anomalies, Hornsund, 1979. 1, 2 and 3 as in Fig. 1; 4 — isolines in nT

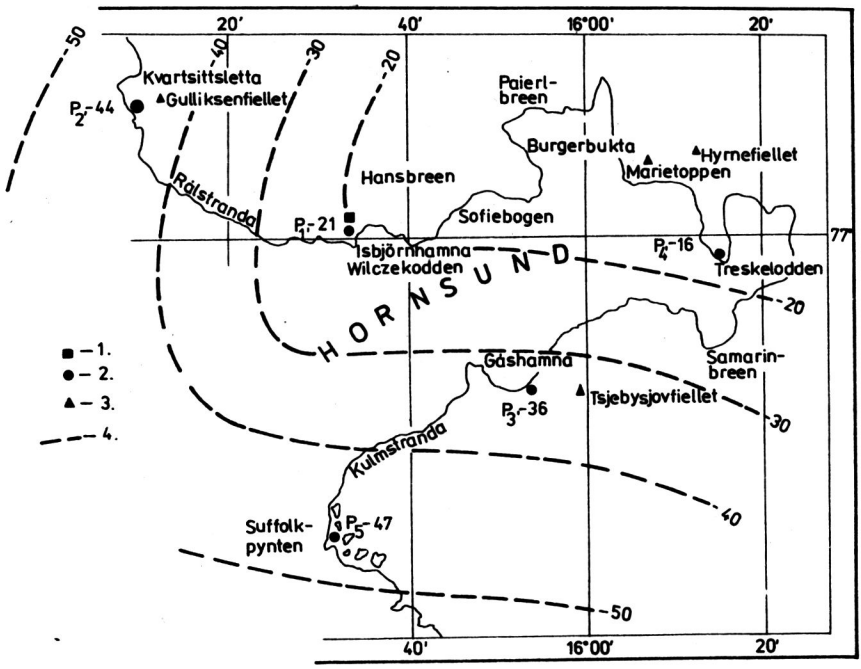

Fig. 3. Map of the ΔT anomalies, Hornsund, 1979. 1, 2, 3, and 4 as in Fig. 2

4. Preliminary analysis of secular changes

To estimate the amplitude, velocity and the direction of changes in the geomagnetic field from the absolute values for the 1957,5 and 1979,5 epochs, it is indispensable to know the difference between the yearly mean values for the stations in relation to which the values were determined. The complete characteristics of the changes ought to include the estimation of errors resulting from the non-stationary state condition of the external field during the reduction of measurements. In 1957 they were reduced to the magnetic station on the Bear Island that is about 250 km from Hornsund.

The approximate evaluation of changes during last 22 years can be obtained while basing on the analysis of the total horizontal gradient of the anomalous field or — in a more simple way — on the analysis of differences between the values of the same element for selected pairs of points, calculated for 1957,5 and 1979,5 epochs. Taking for example the horizontal component at the points P_5 and P_1 for the 1957,5, we have: $\Delta H_{1957,5} = H_{(5)} - H_{(1)} = 38$ nT (Table XXXIII, op. cit., 1963), whereas for the 1979,5 epoch: $\Delta H_{1979,5} = H_{(5)} - H_{(1)} = 82$ nT. Analogous calculations for the

pair of points P_4 and P_1 give -52 and -45 nT. In both cases the intensity of the field increased but the increase is not identical. For the point P_5 it is 44 nT and only 7 nT for P_4. Nonlinear changes within the network confirm the presumed presence of the local sources of the secular changes in the Hornsund region. However, there are no reasons for more detailed conclusions related to the character of the changes.

5. Резюме

В 1977 г. определяли абсолятные величины элементов магнитного поля земного шара D, H T в пяти вековых пунктах на площади фиорда Горнсунд, а также разницы ΔD, ΔH и ΔT по отношению к польской базе на Шпицбергене. Составлены карты изолиний ΔD, ΔH и ΔT (рис. 1, 2, 3).

6. Streszczenie

W pracy przedstawiono wyniki i metodykę pomiarów D, H i T, wykonanych latem 1979 roku w Hornsundzie. Podano wartości absolutne i względne tych elementów w redukcji do polskiej stacji magnetycznej w Hornsundzie. Dokonano wstępnej oceny zmian pola magnetycznego w okresie od 1957 do 1979 roku.

7. References

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