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ROZKŁAD KRÓTKOOKRESOWYCH ZMIAN POLA MAGNETYCZNEGO ZIEMI W EUROPIE ŚRODKOWEJ W POWIĄZANIU Z TEKTONIKĄ

(1 fig.)

Distribution of short—period geomagnetic variations related to tectonics in Central Europe

(1 Fig.)

STRESZCZENIE

Różnice w przebiegach zmian pola magnetycznego obserwowane w różnych punktach na powierzchni Ziemi wiążą się z rozkładem przewodnictwa w podłożu. W oparciu o prace trzech autorów Schmucker U. (1959), Wiese H. (1963), Jankowski J. (1964) zestawiono charakterystyki rozkładu zmian krótkookresowych ziemskiego pola magnetycznego o czasie trwania od kilku do kilkudziesięciu minut dla części Europy środkowej. Dane doświadczalne po ujednoliceniu ostatecznej formy ich opracowania przedstawiono w postaci wektorów c na mapie (fig. 1). Według jakościowej interpretacji geofizycznej, linie przerywane wykreślone na mapie winny odpowiadać strefom dużych dyslokacji tektonicznych. Linie te, jak widać z mapy, dzielą omawianą część Europy na trzy obszary *A*, *B* i *C*. W dalszym ciągu pracy zestawiono dane geofizyczne z geologicznymi.

Na obszarze *A* kierunki wektorów są zgodne z kierunkami struktur waryscyjskich, a niezgodne z postwaryscyjską tektoniką tego obszaru, która musiała słabo przeformować podłoże.

Strefa graniczna obszarów *A* i *B* pokrywa się z północną granicą kaledonidów, a obszar *B* jest masą oporową tych gór. Dla struktur powaryscyjskich obszar *B* odpowiada ściśle centralnej, najsilniej obniżonej części basenu północnoniemieckiego. Obszar *C* leży w obrębie platformy wschodnioeuropejskiej i odznacza się zgodnymi na ogół kierunkami wektorów z tektoniką pokrywy mezozoicznej. Dowodzi to zgodności kształtowania się tektonicznego całej pokrywy osadowej. Pewne niezgodności tłumaczą się istnieniem w podłożu górotworu, prawdopodobnie kaledońskiego wieku, który ciągnie się od Bydgoszczy przez Stargard, Rugię, Man aż do Jutlandii środkowej, znacząc się ciągiem anomalii magnetycznych składowej *Z*. Obszar *B* należy więc zinterpretować jako sztywny masyw śródgórski kaledonidów.

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Research on the natural oscillations of the geomagnetic field has shown the possibility of their utilization for investigation of the deep geological structures. In the following are given some results obtained with one of the relevant methods now under development which consists in utilizing the time-variations of the three magnetic field components observed at the Earth's surface. Short-period variations are called here those whose duration is of the order of several to some tens of minutes.

This method is based on the following concept:

The outer sources of geomagnetic field variations are alternating currents in high layers of the atmosphere producing induced currents in Earth. The experimental data indicate that, in respect to short-period disturbances, those outer sources produce on the Earth's surface in first approximation only variations in the horizontal components. If the conductivity distribution in the Earth depends on depth only (e.g. in a horizontal system of homogeneous horizontal parallel layers), then the induced currents will produce on the Earth's surface only horizontal components too.

If the distribution of electric conductivity in the ground is disturbed in comparison with a horizontal parallel layer system, the induced current lines will concentrate notably along the vertical interfaces of complexes with different values of specific resistivity. Strong differences in concentration of current lines cause distinct variance in magnetic fields, measurable at the Earth's surface. There occurs in this case in particular an anomalous variation in the vertical component Z of the magnetic field, the characteristic surface distribution regularity of those variations yielding the experimental data on this method.

The changes in the vertical component depend on magnitude and direction of the variations in the induced field. This relation may, in first approximation, be considered as linear:

$$\Delta Z(t) = a \cdot \Delta D(t) + b \cdot \Delta H(t)$$

where $\Delta Z(t)$ denotes the time-variation in the vertical component $\Delta H(t)$ and $\Delta D(t)$ the time-variations of the horizontal components in the direction of magnetic North and East.

The coefficients a and b are parameters characterizing the observation point for the selected variation period. To every point can thus be attributed a pair of numbers computed from experimental data. This pair can be conveniently characterized by a vector $\vec{c}$ of appropriate direction and length.

On the map fig. 1 are plotted the vectors $\vec{c}$ for a part of Central Europe, taken from studies by Schmucker K. (1959), Wiese H. (1963), Jankowski J. (1964). This material is not quite homogeneous since somewhat different methods were used by the authors in elaboration of their data. The vectors $\vec{a}$ ($|a| = |c|$) computed for G.D.R. by Wiese (1963) were turned by 90° for the purpose of unification. The vectors $\vec{c}$ for Poland were taken without change from paper Jankowski (1964). The vectors $\vec{c}$ for G.F.R. were plotted from material given by Schmucker (1959). This material had already previously been worked upon and mathematically smoothed by their author to a considerable extent (the directions of the vectors $\vec{c}$ were determined from the course of the isolines z_i and the lengths from the relationship

$c = \frac{z_i}{1 + h_i}$, where z_i and h_i denote the inner part of the disturbances Z and H, which are computed in the quoted paper). The vectors computed in this manner differ markedly from those computed with the other mentioned methods, being e.g. shorter than those obtained with Wiese's method. This fact however can be explained on the grounds of general considerations and the basic experimental facts form in our opinion an adequate basis for certain general conclusions.

When making deductions regarding the nature of conductivity distribution in the substratum we have to bear in mind the following principles:

1. Vector $\vec{c}$ has near-zero length provided that:
   a) the system of ground layers with different electric conductivity is formed by horizontal homogeneous layers. In this case near-by points (up to some tens of kilometers distance) should have too vectors $\vec{c}$ of near-zero length;
   b) the observation point is located approximately above the structure dislocated strongly in respect to the system of horizontal layers with homogeneous electrical conductivity. In this case the near points at both sides of the dislocation will be characterized by inverse direction of vectors $\vec{c}$. In the ideal case of twodimensional conductivity distribution the difference in vector directions should be 180°, the directions $\vec{c}$ running parallel to the dislocation.

The distribution of vector $\vec{c}$ lengths along the profile vertical to the path of conduction anomaly may form an indicator regarding the dislocation geometry (asymmetric distribution e.g. a fault, symmetric distribution e.g. a syncline).

2. The cause of anomalous distribution of short-period magnetic variations on the Earth's surface is to be found in a layer whose thickness is related to the period of the magnetic oscillations. We observe here the skin-effect phenomenon owing to which at very short-periods the current flow is restricted to an extremely thin outer layer of the conductor, while at longer periods it penetrates deeper. Penetration depth depends on the specific resistivity of the substratum and the disturbance period. For the observed periods of several to some tens of minutes the thickness of the layer may attain from about a dozen to over one hundred kilometers.

On map fig. 1 is plotted also the course of the sectors of the line $c = 0$. Their location was determined by interpolation between arrows of distinctly differing directions.

Without prejudice to future, more detailed, interpretations of the problem, we incline to the opinion that those lines correspond to the dislocation axes of complexes with different resistivity. Comparison of the paths of line $c = 0$ with available tectonic data might be of great interest, though unfortunately geologic data cover in most cases only near-surface layers of relatively small depth, exceeding rarely a few kilometers.

To facilitate such comparisons, the discussed European space was divided in three areas A, B, C, (comp. fig. 1), taking as their boundaries long parts of the lines $c = 0$.

Turning now to geological interpretation we are taking as starting point the division in three separate areas.

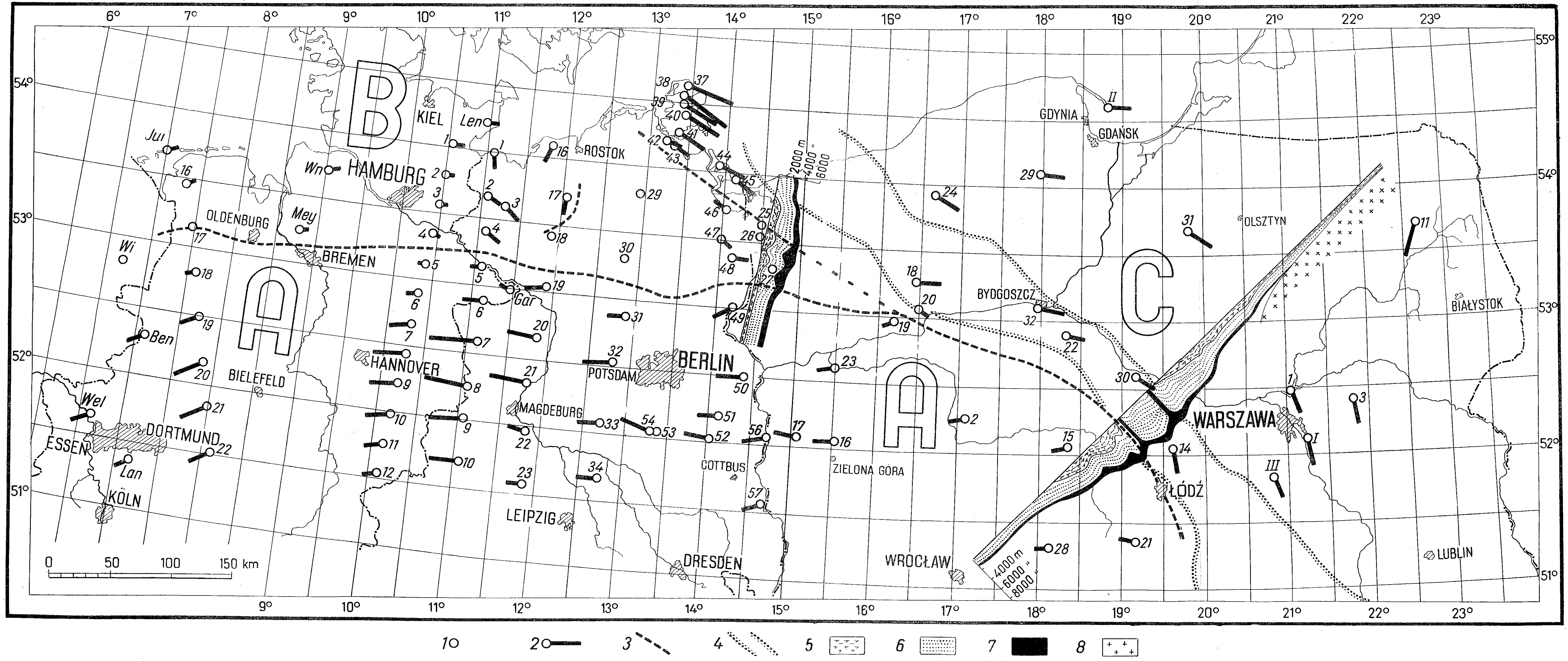
Area *A*. The vector directions on this area are general in accordance with the trends of Variscian folding, as was observed for Germany by U. Schmucker (1959), and H. Wiese (1956), (1962), (1963). West of the Dresden meridian, they are forming an arc curved convexely to the north, while east of the meridian they turn slightly towards the north, forming in the environs of Berlin and Dresden a bulge pointing to the south. In the western part of area *A* the convergence of trends is based on direct observations of the trends of Variscian and Caledonian folds in exposed old massifs (H. Gertner 1950, H. Stille 1951). For the eastern area part no direct observations are however available. We conclude here from indirect data on a parallel course of the Variscian folds on the area between the Harz and Świętokrzyskie Mts. (H. Stille 1951, R. Lauterbach 1953, W. Pożaryski 1957). A new fact would be here the slight deviation of their trend to ENE. It has to be noted that the Post-Variscian tectonic changes on area *A*, whose folding trends differ from Caledonian and Variscian trends, did not find any reflexion in the vector picture, which indicates that their effect on transformation of the deeper layers of the Earth's crust was not sufficiently strong.

Area *B*. The boundary zone of areas *A* and *B* coincides with the northern boundary of the Caledonian Orogen. Its location should therefore be expected in the region of the foredeeps of those mountains, which is in good agreement with geophysical interpretation. Area *B* is a foreland of the Paleozoic Orogen. A similar interpretation of the main tectonic features of this region was given by H. Gertner (1960 fig. 1 non fig. 2) and A. Bogdanov (1962).

As regards Post-Variscian folding, the area *B* corresponds closely to the central part of the North German sedimentary basin (Oldenburg-Schleswig — zone, F. Trusheim 1957) which is separated from the southern basin part by a flat flexure indicated on the base of the German and Polish Permian. This area, not folded from the Cambrian on, should have in its depths horizontal strata, which would correspond to the short, or near-zero, vector lengths of the area. Distinct disturbances of the vector picture appear only to the southwest of Rostock, in the geologically East Elbian Massif (Kölbel 1963), whose tectonics are more complex than those of the adjoining parts of area *B*. The boundary between areas *A* and *B* divides the East Elbian Massif in a northern and a southern part which differ in respect to tectonics of the Permian and younger layers.

Area *C*. It lies in the range of the East European Platform. The whole area differs from the two others in that the vector directions agree in general with the tectonic trends in the mesozoic cover. This proves conformity of the tectonic framework in the whole sedimentary mantle, appearing with special distinctness east of the line Koszalin — Bydgoszcz — Łódź. The boundary between areas *A* and *C* runs on the sector Piła — Bydgoszcz — Łódź near the Middle-Polish Anticlinorium and the Mogilno — Łódź Synclinorium, coinciding probably with it. The boundary line on the sector lies therefore on the Danish-Polish Geosyncline.

An important phenomenon, occurring with special distinctness in the Łódź region, is the oblique approach from the west of Paleozoic folds to the above mentioned boundary line and their disappearance on it,



Rozkład średnich wektorów $\vec{c}$ dla punktów pomiarowych Polski, NRD i NRF. 1 — punkt pomiarowy o wartości c bliskiej zeru; 2 — punkt pomiarowy o wartości $c = 0,5$; 3 — granice obszarów wyznaczone na podstawie rozkładu średnich wektorów $\vec{c}$; 4 — granice antyklinorium środkowo-polskiego; 5 — warstwy kredowe; 6 — warstwy jury i triasu; 7 — warstwy górnego permu (cechsztyn); 8 — podłoże krystaliczne.

Przekroje geologiczne opracował W. Pożaryski przy współpracy M. Jaskowiak opierając się głównie na danych sejsmicznych. Oznaczenia literowe lub liczbowe punktów pomiarowych na mapie są wzięte z podanych w tekście źródeł bibliograficznych

Distribution of mean vector $\vec{c}$ values in Poland, G.D.R. and G. F. R. 1 — measuring point with near-zero value of c; 2 — measuring point with value $c = 0,5$; 3 — area boundaries determined from mean vectors $\vec{c}$ distribution; 4 — boundaries of the Middle-Polish Anticlinorium; 5 — Cretaceous; 6 — Jurassic and Triassic; 7 — Upper Permian (Zechstein); 8 — metamorphic and igneous rocks of basement.

The geological cross-sections were worked out by W. Pożaryski with the assistance of Miss M. Jaskowiak, mainly on basis of seismological data. The numbers or letter symbols of measuring points used above are taken from the quoted bibliographic sources whereas south of Piotrków those folds have passed the Anticlinorium boundary in eastern direction, as we know from geologic and gravimetric data.

Northwest of Bydgoszcz the vector directions do not closely agree with the Anticlinorium axis but coincide with older directions visible in the mesozoic cover and crossing the axis at an angle. For the northern part of area *C* we can take into account the analysis of the map of magnetic anomalies of the vertical component „Z". It appears from the map that in the western prolongation of the Peribaltic Syneclise occur a number of magnetic anomalies with parallel direction. One of them runs from Bydgoszcz through the Piła to Starogard where it turns northwest and goes over into the anomaly of Usedom Island and northern Rügen. Along the southwest border of this set of anomalies runs the boundary separating areas *B* and *C*. It seems probable that this set extends to the anomalies of the Isle of Man, southern Zeeland, Fyn and middle Jutland, forming a trace of a Caledonian Orogen belt surrounding the Baltic Shield (R. Zwerger 1948), which agrees with boring data from North Rügen (H. Kölbel 1963) and Zeeland (G. Larsen, A. Buch 1960).

This hypothesis finds significant confirmation in the vector directions on the isles of Usedom and Rügen.

The area *B* would thus form the foreland of the Caledonian Orogen running through Rügen.

The above comparison of geophysical and geological data points to interesting interrelations, inviting their geological interpretation. The geologic aspects presented above are however still inadequate for elaboration of a geophysical interpretation.

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