THREE-DIMENSIONAL MODEL OF THE KOCHERIV SECTION OF THE WESTERN PART OF THE UKRAINIAN SHIELD

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The electrical conductivity studies of the Kocherivska section where different geological and tectonic structures of the western part of the Ukrainian Shield intersect are conducted in the work. A spatial temporal picture of the distribution of geomagnetic variations and the tellurium field on the Earth's surface is obtained, which allows us to estimate the magnitude of the electrical conductivity and the geoelectric structure of the section vertically and literally. The modeling and construction of a three-dimensional model of the electrical conductivity of the site.

Key words: the Kocherivska section, a three-dimensional model, the Ukrainian Shield.

Introduction. The electrical conductivity studies of the Kocherivska section where different geological and tectonic structures of the western part of the Ukrainian Shield (USh) intersect are conducted in the work. A spatial-temporal picture of the distribution of geomagnetic variations and the tellurium field on the Earth's surface is obtained, which allows us to estimate the magnitude of the electrical conductivity and the geoelectric structure of the section vertically and literally. The modeling and construction of a three-dimensional model of the electrical conductivity of the site.

Previous studies of magnetoteluric sounding (MTS) and magnetovariational profiling (MVP) of the Kocheriv section have been characterized. In recent decades, small local areas and the regional Chernivtsi - Korosten anomaly of electrical conductivity have been identified. According to the MVP, the Ruzhyn anomaly was discovered, which has a complex three-dimensional structure in the surface of the consolidated crust, which manifested itself along the Eurobridge profile - crossing the southern part of the Pripyat Strait, Ovruch Avlakogen and Korosten Pluto of Volyn Megoblock USh. According to two-dimensional model constructions, anomalous structures were found in the area at a depth of 15 to 30 km, with a length of 70 and 120 km.

The next step in the study was the construction of a quasi-three-dimensional film model of the western part of the USh [Kulik, Burakhovich, 2007]. This approach made it possible to characterize with precision the spatial boundaries of the Chernivtsi - Korostenskaya conductivity anomaly with an upper edge at a depth of 15 km and a total longitudinal conductivity of 500 to 1000 S. total longitudinal conductivity - 10 S, while in the northern boundary between the cities of Korostyshiv and Irpin, a sub-latitudinal zone of high electrical conductivity is traced, which is revealed by the differently oriented directions of the Vise vectors of up to 0.1. As a result of the construction of the three-dimensional model in the west of the USh, the volumetric parameters of the anomaly were estimated. Within the southeastern part of Volyn and in the north of the Podilskyi megablock there are anomalies with a specific resistance (ρ) of 5 Ohm•m and contain a high-ohmic object with $\rho \approx 1000$ Ohm•m in the area of Zhytomyr. The western part of this structure is characterized by an average value of ρ - 20 Ohm•m and goes beyond the USh.

Examples (Optional). Modern experimental MT/MV studies of the Kocherivsk section of the western part of the UCH, which were outlined in this paper, were conducted from 2015 to 2019. Long-period digital stations LEMI-417 with ferro-probe magnetometers were used. A study was conducted to study the deep geoelectric structure of the complex fault system of the Volyn, Rosyn, and eastern outskirts of the Podolsk megablock.

Electromagnetic fields were registered at 49 points along seven profiles: Radomyshl - Fastiv, Kornynskyi, Ruzhyn - Skvira, Belylivka - Antonov, Shirmivka - Logvin, Ordyntsi - Lobachev and Zozov – Strizhavka [Ilienko et al., 2019, 2020]. The duration of synchronous observations ranged from 1.5 to 2 days. At the base point for the profile Kornynskyi - the village Rudka (item RDK) one week, at the base point for the other profiles - the village Rogizna (item RGZ) one month. The distance between field points averaged 10 km; between Radomyshl - Fastiv and Kornynsky profiles - 30 km, between the latter and Ruzhyn - Skvira - 30 km, for the remaining 10 km on average.

The experimental works satisfy the requirements for the observed data when using the procedure of synchronous estimation of the transmitting operators MT/MV fields by the software complex PRCMTMV. Typer estimates were obtained for periods (T) of geomagnetic variations from 50 to 3400 seconds (s), for curves of apparent resistance (ρa) and impedance phases (φ) - from 20 to 10000 s.

The article [Burakhovich et al., 2015] describes the results of geoelectric studies by audio-MTS, MTS and MVP methods with three sub-width profiles - Makarivsky, Fastovsky and Skvirivsky. Experimental studies have shown very high values of ρa - from 1000 to 5000 Ohm•m in Volyn and Podolsk, ~ 1000 Ohm•m in the Rosinsky megablock of the USh. The Zvezdal-Zaleska and Brusyliv fault zones are manifested as contacts of different ρa - 5000 and 1000, 1000 and 300 Ohm•m, respectively. Ogiivskyi, Pogrebyshchensky, Kocheryvskyi, Central, Starosilskyi, Velikieurchykivskyi, Vilensky and partially Vilshansky faults form low-ohm anomalies (up to 300, sometimes up to 500 Ohm•m) in the whole frequency range.

Within the western part of USh the orientation of the Vise vector (W) from the southwestern, in the Volyn and Rosinski megablock, to the northwest - in Podolsk is clearly observed. Just south of the latitude of the city of Vinnytsia, the vector W turns south. The vector module W averages 0.3. The orientation of the induction parameters is influenced by tellurium current systems arising in electrically conducting sedimentary deposits of the Dnieper-Donets Basin, Chernivtsi-Korosten, Vinnitsa and Ruzhyn anomalous zones. The total longitudinal conductivity of sedimentary formations varies on average from 0.25 in Volyn and Rosinski megablocks, in Podilsky - up to 10 S.

Obtained modern observations of complex induction parameters do not contradict and complement the picture of the spatial distribution of Vise vectors. The orientation of the true west-southwest tip component is observed at almost all frequencies for all points. For short periods the magnitudes of the imaginary and the true components are proportional. The maximum frequency response with an average value of 0.3 - 0.6 is between 150 and 400 s.

MTS curves for different polarization in most points diverge at all periods. The divergence of the curves for different polarizations increases with increasing period.

The discrepancy between the visual resistances obtained from the analysis of different polarizations of the MT field ($\rho a\ xy \neq \rho a\ yx$) is evidence of the presence of surface or depth in homogeneities in the horizontal-layer section.

As a result of qualitative interpretation of complex types and curves of MTS, anomalies of high electrical conductivity (several surfaces and one depth) in the crust of a complex system of faults in the area of articulation of the Podilsky and Rosinsky megablocks were revealed. The analysis of MTS curves shows a heterogeneous three-dimensional situation throughout the study area, anomalies are characterized by different electrical conductivity, depth of occurrence and configuration. Estimates obtained from different approaches to the formal interpretation of MTS are consistent with the regional three-dimensional geoelectric model of the western part of the USh and complement the idea of a depth debate.

Surface conductivity anomalies were detected: on the Kornynsky profile within the KRN point; profiles Belylivka - Antonov is located between OGV and BHN; Shirmivka - Logvin profiles at KRG and RGZ points; profile of Ordintsy - Lobachiv at SKB; profile of Zozov - Strizhavka at AND and NND points; in the center of the Radomyshl - Fastov profile, a highly conductive zone is assumed both at the surface and at depth. A deep local electrical conductivity anomaly is highlighted on the Ruzhyn - Skvira profile, which extends eastwards along the profile. The high electrical conductivity anomalies tend to gravitate to the tectonic fault zones and zones of metasomatic changes, their nature is explained by the increased content of graphite and shrinkage.

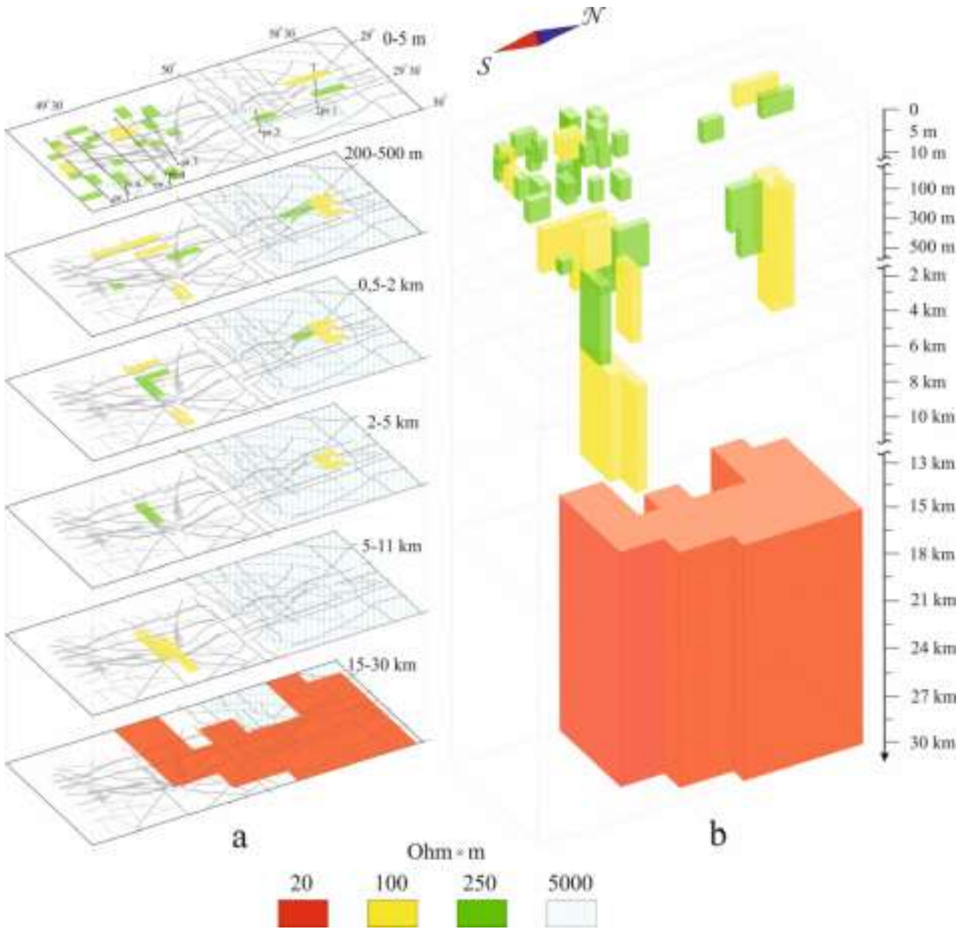

Fig. 1. Electrical conductivity anomalies of the Kocheriv section of the western part of the USh, according to the results of three-dimensional simulation of the electromagnetic field: a - on the geological and structural map of the surface of the crystalline foundation; b - 3D geoelectric model.

A three-dimensional simulation of the Kocheriv section was conducted. The standard normal geological section of the earth's crust and upper mantle is laid in the model, in which the resistance drops from 160 km with increasing depth, and in the lower layer is 1 Ohm•m. The size of the cells in the main part of the model is 5×5 km, in the modeling area the number of cells is x - 32, y - 41, and 18 horizons. The model contained a priori information about the regional Korostensk anomaly of electrical conductivity, and its northern branch and the leading asthenosphere [Burahovich, Shirkov, 2015] in the southern part of the model. Six models were calculated, two of which were theoretical, in which the depth of the Zvezdal-Zalesky fault zone and the metasomatic zone were modeled based on information obtained in literature.

In the final model (Fig. 1), a number of conductors were calculated and allocated. Largest: it coincides in space with the Kocheriv synclinorium, sinks to a depth of 5 km with ρa - 100 Ohm•m; a conductor that coincides spatially with the sub-latitudinal Samgorod fault at a depth of 2 to 11 km, with a width of 45 km with ρa - 100 - 250 Ohm•m; meridional conductors that coincide spatially with the Ogiivsky and Pogrebyshchensky faults at depths from 200 m to 2 km ρa - 100 - 250 Ohm•m.

Conclusions. Dedicated conductors tend to reach areas of distribution of metasomatites and metasomatically altered rocks that are promising for endogenous shrinkage (see Fig. 1). Namely Skarn in the Volyn megablock; grazies and areas of epidotization; quartzing in the Kocherov syncline; zones of quartzing and microclinization of the Zvezdal-Zalesky fault zone; areas of muscovization, epidotization and quartzing of the Rosinski megablock. Their territorial location corresponds to the metallogenic ore zones. Therefore, these anomalies can serve as geoelectric criteria in the search for minerals.

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