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Fig. 1

Figure 1: Fig. 1

Abstract

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STUDY OF THE INTERNAL STRUCTURE OF THE CRYSTALLINE BASEMENT BY ELECTROMAGNETIC SOUNDINGS

The problem of subdividing the crystalline basement is of great scientific interest. An important step in solving this problem is the determination of geophysical methods suitable for distinguishing, within the basement, regions differing in physical structure. The article is devoted to the results of a study on the application of electromagnetic methods to solving this problem.

Figure 1 shows a characteristic curve I, obtained as a result of these studies at one of the sites in the Priozersk district of the Leningrad

Fig. 1

region. The curve covers the frequency range 14 kHz–0.004 Hz. Soundings in the frequency range 14 kHz–0.5 Hz were carried out by us at several sites separated from one another by distances of up to 30 km. However, measurements in the range 0.025–0.004 Hz were carried out at only one site, to which the curve in Fig. 1 corresponds. The curve shown indicates a substantial heterogeneity with depth in the structure of the crystalline basement in terms of electrical properties, and the possibility of its subdivision by means of electromagnetic methods.

1. Let us consider in more detail the apparatus and methodology by which curve I in Fig. 1 was obtained.

The entire curve is composed of three parts obtained as a result of measurements carried out with three different sets of apparatus.

Measurements in the frequency range 14 kHz–250 Hz were carried out using the apparatus and methodology ([1]) for frequency soundings of small and medium depths with an equatorial arrangement of the transmitting and receiving dipoles and with the distance between their centers $r = 4$ km. The curve obtained in this case is represented in Fig. 1 by the dotted line between points 1 and 1′.

Measurements in the frequency range 520–0.5 Hz were carried out using the apparatus and methodology ([2]) for deep frequency soundings with an equatorial arrangement of the transmitting and receiving dipoles and the distance between their centers $r = 16$ km. The curve obtained in this way is shown in Fig. 1 by the dashed line between points 2 and 2′.

Measurements in the frequency range 0.025 Hz–0.004 Hz were carried out by the MTZ method using MTL-62 apparatus. We used measurements of the components E_x and H_y, with E_x perpendicular to the axis of frequency sounding. In accordance with (3), the results of measurements by the MTZ method were recalculated as applied to the ChZ method for a separation $r = \infty$. The resulting curve is shown in Fig. 1 by the solid line between points 3 and 3′.

To join the measurements in the frequency ranges 14 kHz–250 Hz and 520 Hz –0.5 Hz, carried out at different values of r, the curve 1—1′ was transformed, with the aid of a two-layer palette, from a separation of 4 km to a separation of 16 km (curve 4—4′).

Next, to join the curves 4—2—2′ and 3—3′, corresponding to different values of r, we transformed the first of them from $r = 16$ km to $r = \infty$. As a result of the transformation, instead of the curve 4—4′—2′, the curve 4—4′—5 was obtained; moreover, only its right-hand part underwent a slight change, whereas the left-hand part remained unchanged. The latter is explained by the fact that in this frequency range the shape of the curve practically does not depend on the magnitude of r.

Measurements in the frequency range 0.3—0.025 Hz were not carried out, and this segment is shown in Fig. 1 by the dashed line 5—3.

Thus, curve *I* in Fig. 1 (between points 4, 4′, 5 and 3′), obtained as a result of combining three initial curves, corresponds to a frequency-sounding curve with separation $r = \infty$.

2. To obtain qualitative results, curve *I* was interpreted by the usual methods, using the model of a horizontally layered medium. In this case, even the roughest visual examination of the curve shows that the section studied, to a depth on the order of several tens of kilometers, is subdivided into 6 layers forming a geoelectric complex of the type $\rho_1 < \rho_2 > \rho_3 < \rho_4 > \rho_5 < \rho_6$, of which the upper layer is due to low-thickness loose deposits, while the 5 underlying layers are associated with the internal structure of the basement. The limited materials available do not provide sufficient grounds for judging the layering of the basement in the area studied. Nevertheless, because the curves obtained at various points in the frequency range 520

Fig. 2

Figure 2: Fig. 2

–0.5 Hz are similar to the corresponding part of curve I in Fig. 1, we considered it expedient to interpret the curve, the results of which, naturally, should be assigned only a qualitative character.

As a result of the interpretation, the following thicknesses and resistivities of all 5 layers of the section were determined: $H_1 \approx 90$ m, $\rho_1 \approx 300\ \Omega \cdot$ m, $H_2 \approx 870$ m, $\rho_2 = 4000$—$6000\ \Omega \cdot$ m, $H_3 \approx 660$ m, $\rho_3 \approx 450\ \Omega \cdot$ m, $H_4 \approx 3000$ m, $\rho_4 \approx 5600\ \Omega \cdot$ m, $H_5 \approx 30$ km and $\rho_5 \approx 100\ \Omega \cdot$ m ($H = H_1 + ... + H_5 \approx 35$ km).

The limitation of the lower part of the frequency range to 0.004 Hz did not make it possible to obtain, in the right-hand part of the curve, the maximum and descending branch associated, as is known, with the presence of a well-conducting horizon, usually detected by electromagnetic soundings at depths of several hundred kilometers.

Figure 2 gives the ChZ curve compiled from measurements of the vertical component of the magnetic field at this same point in the frequency range 14 kHz–0.5 Hz. Interpretation of this curve gives results similar to those obtained from the curve in Fig. 1 in the frequency range 14 kHz–0.5 Hz.

To check the interpretation results, a theoretical curve II in Fig. 1 (dash-dot line) was calculated from the obtained values of the layer thicknesses and their resistivities.

3. In conclusion, we note that A. P. Kraev, A. S. Semenov, and A. G. Tarkhov carried out dipole sounding in 1946 at the po-

direct current with spacings of up to 70 km, with the aim of investigating the internal structure of the basement ([4]). However, taking into account the difficulties of surveying high-resistivity strata by the direct-current method and its imperfections in measurements with large spacings, one should hardly count on the possibility

Fig. 2

of using it to study inhomogeneities in the crystalline basement.

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Note: Figure translations are in progress. See original paper for figures.