Geophysical Research Abstracts
Vol. 21, EGU2019-3144, 2019
EGU General Assembly 2019
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History and state of the art of magnetotelluric studies of the lithosphere in Russia

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The geophysical method of magnetotelluric sounding is based on the use of the low-frequency electromagnetic field of the Earth to study its electrical conductivity at various depths. The history of this method began in the 1950s with the pioneering works of A.N. Tikhonov (USSR), L. Cagniard (France) and T. Rikitake (Japan). Since then, the method has been developed and applied throughout the world, but in the USSR, it happened, due to political and economic reasons, somewhat isolated and with its own specifics. Substantial advances have been made in deep magnetotelluric studies of electrical conductivity anomalies in the consolidated crust. The efforts of specialists from various regions of the country were united in the framework the project, headed by M.N. Berdichevsky, on compilation of the map of such anomalies in the USSR. Also, magnetotelluric soundings were actively used in regional geophysical studies of hydrocarbon prospective sedimentary basins.

The collapse of the USSR was accompanied by significant economic difficulties of the 1990s, which led to a sharp reduction in scientific research. A gradual exit from this crisis, as well as the rapid development of computer technology, led to the introduction of new measurement technologies and methods for data processing and interpretation. On the territory of Russia with state support, magnetotelluric soundings began to be performed with frequent steps (1 km or less) along profiles ranging in length from a few hundred to more than a thousand km. By order of state and private companies, detailed magnetotelluric studies of oil and gas, geothermal and ore deposits began to be conducted. In the last decade, regional areal studies have been applied, combining deep and exploration magnetotelluric sensing, a vivid example is the Kirovograd project, implemented on the initiative of Iv.M. Varentsov.

In this way, which has taken more than half a century, the magnetotelluric method has gone from a time-consuming, rough method of identifying bright anomalies of deep electrical conductivity to modern technology for constructing detailed volumetric geoelectric models. In the most general form, the results of applying the method in deep and exploration research can be formulated as follows.

1. Most of the extended electrical conductivity anomalies in the consolidated crust mark ancient or modern boundaries of crustal blocks, these zones are favorable for increased heat and mass transfer and participate in the formation of geodynamic activity. The ratio of the contribution of electron-conducting minerals to the contribution of fluids to the electrical conductivity of anomalies for tectonically stable regions is higher than for active ones. In the latter there are also anomalies that are caused by the melting of rocks and may not be associated with tectonic boundaries.

2. A lot of practical geological problems were solved, characterized by different types of objects under study, scales and depths of investigation: identifying oil and gas perspective structures, delineating areas of various types of mineralization, prospecting geothermal zones, surveying for civil engineering, assessing groundwater resources.