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ELECTRICAL METHODS ON SHALLOW-WATER AQUATORIAS

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The field geophysical measurements are usually carried out on land and thus aquatorias remain usually out of survey. The inclusion of aquatorias in the investigated area promotes more thorough study of territory, and appreciably increases density of mapping, its productivity and quality. Moreover, there are some problems, which can be decided just on aquatorias. Among these are studies for bridges, pipelines crossings, searches of building materials at the bottom of rivers, and ecological researches.

The studies on aquatorias can be conducted differently, depending on many conditions: by walking on shallow water and on land along a beach, from boat or ship, and from ice cover in winter.

Aquatorial studies at the geophysical department of MSU Geological faculty were begun in 70's under the supervision of professors A.V.Kalinin, V.K.Khmelevskoj and A.A.Ogilvi. Resistivity (profiling and sounding), SP method, water resistivimetry and thermal survey were used. At studies on large rivers from a ship seismoacoustics was also used. In the present report only electrical methods are considered.

For resistivity soundings the floating, bottom and vertical arrays (the last one - for a study of bottom sediments at deep water) can be applied. At soundings from ice cover for electrodes' grounding the holes should be made in ice. Recently another soundings with non-grounded measuring line appeared [4-5]. This technology is faster. Walking sounding on shallow-depth rivers is especially effective in permafrost conditions, where most of rivers are shallow-water. The quality of aquatorial VES is usually higher than on land, because the geological noise's level is lower. The high efficiency of aquatorial sounding claims application of productive systems of VES processing, visualization and interpretation, but also allows to trace the variability and complexity of geophysical fields, connected with river sediments' lithological and structural inhomogeneity. About one third part of soundings finds out features of distortions, caused by horizontal inhomogeneities. For such cases it is necessary to apply 2D models of interpretation instead of 1D. The study of a water resistivity is useful for detection of subterranean waters' discharge and for ecological purposes.

Self potential method finds wide application at aquatorial studies. In walking variants measurements of potential are usually applied. In the case of vessels - the gradient SP measurement is more convenient. The study of SP gradient can be executed for one (X), two (X, Y) or three components (X, Y, Z) of the electrical field. Usually at interpretation of SP data the X-component measurement is recalculated in electrical potential values. Self potential field is the indicator of processes of a leakage, oxidation, diffusion-adsorption phenomena, electrochemical interactions in heterogeneous media and on contacts between rocks of various lithological content. Variety of the reasons, causing occurrence of self-potential anomalies creates problems for SP data interpretation. The attractive side of SP method is relative simplicity of measuring technology and opportunity to conduct measurements continuously.

The SP components' measurements allow to draw vectors and their crossing for tracing sources of SP anomalies not only on measuring line, but also at the side of traverse (fig.1).

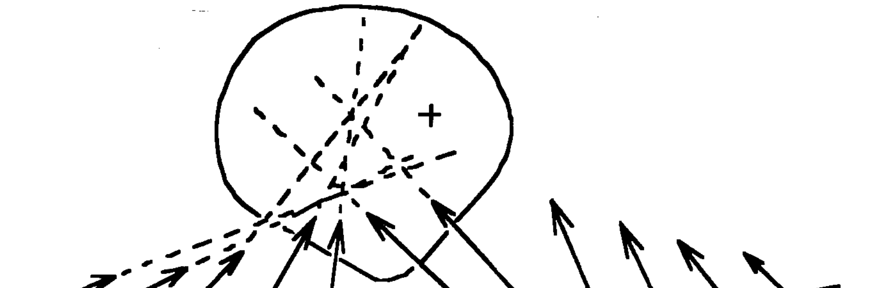

Fig.1. An example of two components SP measurement usage.

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Among many investigated objects it is possible to show the most successful examples.

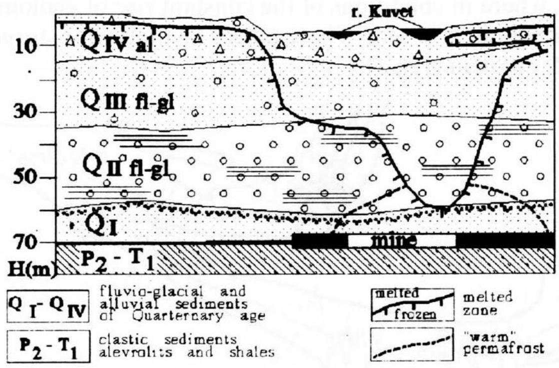

Fig.2. Cross - section with melted zone over gold deposit.

On a gold mineral deposit on Chukotka, placed in the permafrost region beneath the river, were investigated taliks (melted zones), their distribution, shape and depth. The schematic geological cross-section of this place is represented in fig.2. The deep U-formed valley, created by glacial trenching, is filled by loose sediments of about 80 m thickness. On the valley's bottom the layer with gold is situated. The river on the surface has many deep taliks. In the case of mining works' meeting with a melted zone the emergency break of waters in mines is inevitable. To avoid it is necessary to know exactly the depth position, size and shape of taliks. The electrical soundings on shallow-water rivers and streams in conditions of Chukotka were executed with 20 times higher productivity, than on land, and with higher quality. VES data interpretation was made in the framework of 2D models. The example of interpretation is on fig.3. The close correlation of true rock resistivity with their temperature has allowed to construct the forecast map of taliks, used for planning of new mining works.

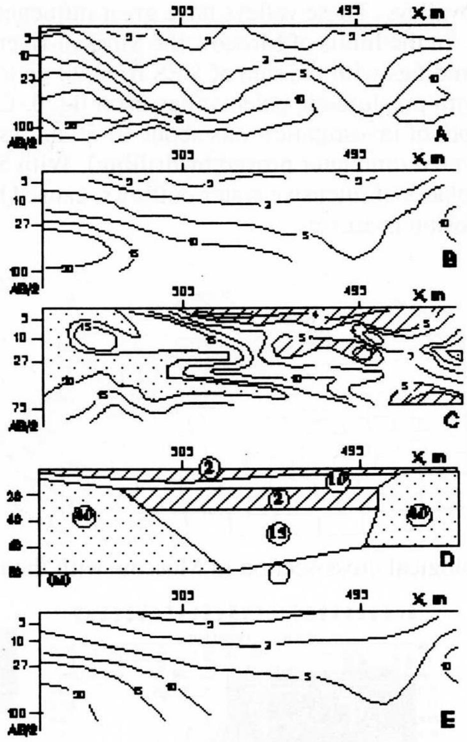

Fig.3. An example of 2D VES interpretation over melted zone. A - measured, B,C -differently transformed, and E - calculated (for model D) fields.

The place of sturgeon spawning on Volga-river in Astrakhan region was investigated. The river Volga has the thick bottom layer of alluvial sandy sediments. For sturgeon spawning is necessary gravel or pebbles, which is possible only in places, where hard rocks outcrop just on the river bottom. Such places can be met in the salt-dome tectonics region, where in conditions of the constant rise of geological structures containing hard rocks, the alluvium at the river bottom is absent. These places favorable for sturgeon spawning are marked by sharply changeable fields of SP gradient (Fig.4).

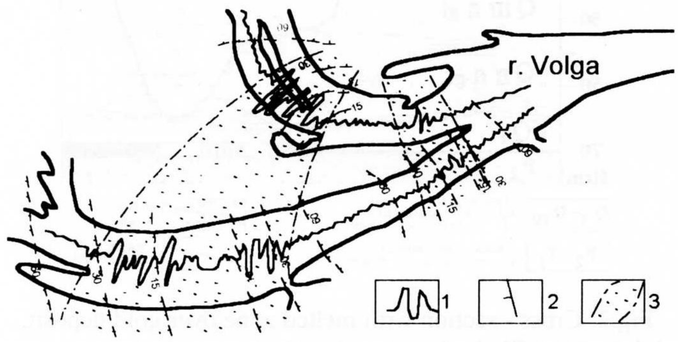

Fig.4. SP field on the place of sturgeon spawning on Volga-river. 1 - SP graphs, 2 - the depth of marker layer, 3 - zones of vertical SP component's anomalies.

In Vologda region in basins of Volga and Suhona a resistivimetry survey was made. Resistivimetry results clear show the sources of pollution and pollution spreading along river system.

Since 1977 during twelve years the work on Moskva-river in the boundaries of Moscow was conducted. In Moscow the large part of the city area is engaged by buildings and streets closed by asphalt. Only aquatoria of Moskva-river is accessible for geophysics.

The typical geoelectrical cross-section on Moskva-river consists of eight layers: 1) water (with resistivity of 30 Ohm.m); 2) sandy alluvium (100); 3) morainic sediments (30-50); 4) Jurassic (Callovian-Oxfordian age) clay (10); 5) Bathonian-Callovian sand (120); 6) Bathonian clay (15); 7) karstic limestone of average Carboniferous age (50-150); 8) unchanged limestone (350 Ohm.m). Usually VES curves reflect not all layers but some groups of layers, in which some layers are united. The base model is usually of 3-4 layered.

The most important geological problem for geophysical survey on Moskva-river is the study of ancient pre-jurassic and pre-glacial paleovalleys. These valleys have great influence on hydrogeological regimee and engineering processes (see fig.5). In the limits of Moscow the Moskva-river bottom on extent more than 50 km was investigated by electrical soundings with the step of VES from 20 up to 50 m (about 2000 soundings). Small fragment of VES results with pre-Jurassic paleo-valley is on fig. 6. Current electrodes' distances change from 2.5 up to 150 m and the depth of investigation was about 40-50 m. As a result the position and structure of many paleovalleys were discovered (and later proved by drilling). With SP method long-term measurements were conducted. These revealed places of intensive water outflows, caused by pumping of underground water, which results to rise of karst-suffosion processes.

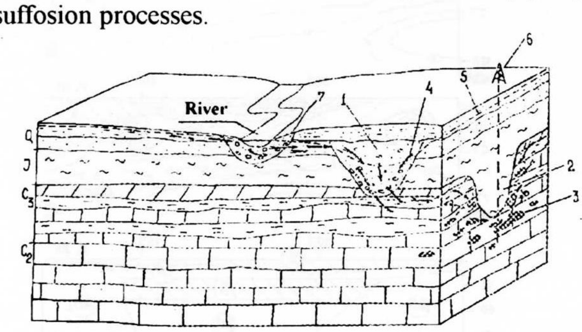

Fig.5. Model of geological cross-section in Moscow with the river and paleo-valleys.

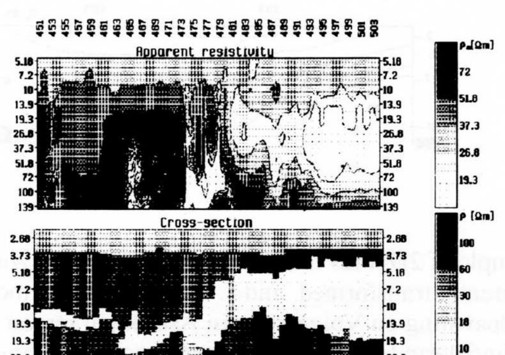

Fig.6. An example of VES results on Moskva-river near Moscow university.

Water resistivity measurements show values from 40 up to 20 Ohm.m, the maximal value is on NW of Moscow and minimal one on SE.

Self potential field on Moskva-river aquatoria has various intensity and complex distribution of SP gradient anomalies. On features of space structure of SP anomalies all territory of Moskva-river is possible to divide into three main zones: northwest, central and southeast.

The joint analysis of geophysical materials has allowed to construct the geological-geophysical scheme of Moscow (see fig.7) and to decide some specific geological problems.

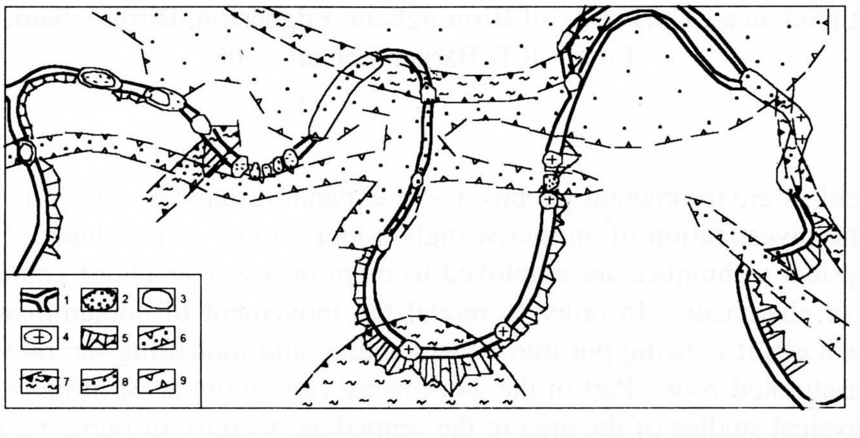

Fig.7. Geological and geophysical scheme for the central part of Moscow on aquatorial geophysical data. The legend: 1 - the river, 2 - hydrogeological „windows", 3 - negative SP anomalies, 4 - positive SP anomalies, 5- the thickness of Jurassic sediments, 6 - pre-glacial and 7 - pre-Jurassic valleys, 8 - regions, favorable for seismoacoustics, 9 - proposed paleo-vallies.

The most simple of these - is mapping of a regional aquiclude of Jurassic clays. The main indicator for their allocation is low and stable values of electrical resistivity (5-10 Ohm.m). Besides the areas of Jurassic clays are marked by the quietest plots of SP field, on which the gradient values do not exceed 0.3-0.5 mV/m.

Mapping of paleovalleys is the key problem at the research of karstic-suffosium processes on the territory of Moscow. In the result of comparison of geophysical and geological data four types of paleo-valleys were allocated, which are divided in geophysical fields due to some specific indicators. The mostly precise allocated are the pre-glacial paleo-valleys, which are characterized by absence of Jurassic clays. A geoelectrical cross-section here is as a rule three-layered of a type A, the first layer is water with resistivity about 30 Ohm.m, the second layer has the thickness about 20 m and resistivity of 40-50 Ohm.m (ancient alluvial sediments and late Carbonic age formation consisted of limestones, marls and clays) and the third layer of a high resistivity (> 200 Ohm.m) is the limestone's basement of middle Carbonic age.

SP field within the limits of pre-glacial paleovalleys is very changeable. Many local negative anomalies and sharp changes on amplitude and direction of transversal SP component (Ey) are observed. For large number of intensive alternated anomalies it is impossible to define a sign of SP potential.

Geophysical methods confidently trace pre-jurassic valleys, which are characterized by a full cross-section of Jurassic sediments. One of the main features, on which pre-jurassic valleys are mapped - their bottom's vertical position on absolute mark 100 m and lower; the second feature is maximal thickness of a conductive layer of clay, reaching 40-50 m. Pre-jurassic paleovalleys are also characterized by SP field without anomalies. There are only separate low-amplitude anomalies of a positive sign of potential.

At separate places pre-jurassic valleys are largely destroyed by pre-glacial ones. However on rudimental remains of clay, filling holes in the upper part of limestones, it is possible to trace a general direction of the valley, and to find approximately its width..

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