PIPELINES' STUDIES -- NEW PROBLEM FOR GEOPHYSICS.

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The modern technical civilization creates the advanced network of subterranean communications. From the century's beginning many thousand kilometers of various pipes and cables were stacked in ground on depth up to 5-6 meters. Their large part concentrates in cities. Among these there are communication's lines, electrical power cables, water, oil and gas tubes, heat-conducting, water drain and waste water pipes. Especially large density of the communications achieves at territory of industrial plants. This network of pipes and cables creates artificial (technogenic) medium, which requires the constant control. At installation of pipes and cables their position is reflected in documents, however in time some engineering specification becomes outdated or even lost.

Gradually as a result of long influence of both ground waters and other electrochemical and mechanical processes the communications decay. At long interaction of pipes with ground, their corrosion arises, deformations of ground cause mechanical stress and strains in pipes, result to formation of fractures. There are many reasons of fractures' formation: damages at digging works, displacement of ground, wrong assembly or stacking of pipes, untight connection of different sensors. For pipes' protection against corrosion cathodic protection of pipes is applied. At cathodic protection negative DC potential contacts to a pipe, while positive pole contacts to additional grounding place out of pipe. In places of pipe isolation's infringement the current flows away and protects the pipe surface from corrosion. Corrosion danger depends on resistivity of environment, the low resistivity is, the higher its danger is. Pipes in ground have the limited term of operation of the order 25 years. Many pipes are under the high pressure, contain dangerous, combustible or toxic substance.

Separate problem is water outflow from water supply system. Clean drinking water is a valuable product, and its outflow result in

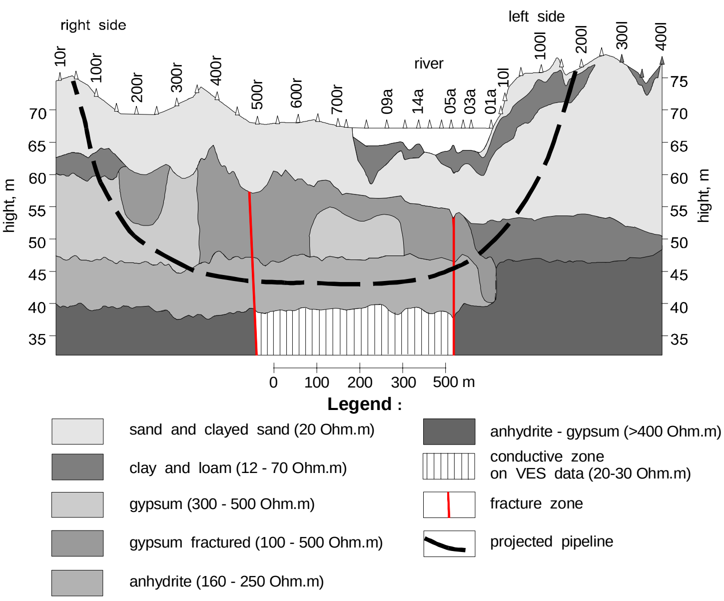

Fig.1. Geological cross-section for the projected pipeline crossing river.

heavy losses, both directly from loss of water, and indirectly, from additional watering of ground near its outflow. Estimations of water's losses in different countries make from 5 up to 40%.

In this area there are many problems, which require correct decisions. This area actually turns to independent branch of ecological geophysics. We call it technical geophysics.

The geophysical methods can help at the decision of many problems of pipes' control. The first task is a study of trace before pipeline's construction, especially in the most responsible places, for example on rivers' crossings. Recently the project of pipe stacking under the river in horizontal borehole, placed in the most safe layer has become considered as more reliable. At studies of places, where pipeline crosses the river, a number of aquatorial and land geophysical methods can be used. Among them there are aquatorial seismoacoustics and VES, land studies with a georadar, resistivity sounding (TES technology), land and aquatorial boreholes drilling. Seismoacoustics gives detailed stratification of the top layers in aquatoria limits. Together with electrical methods it allows to estimate each layer lithology, and to determine a degree of their safety. Land and aquatorial electrical survey allow to connect in a uniform cross-section land and aquatorial studies. On fig.1 a final cross-section drawn on geophysical and drilling data in a place of projected pipeline crossing river in central Russia is shown.

When pipe's stacking is completed a number of other tasks have appeared. One of them is correct estimation of pipe's site and depths. The actual site can differ from planned one. The depth can be changed in process of stacking or in time. Among methods of pipelines' inspection georadar survey and trace-searchers prevail. On our opinion to these methods resistivity sounding (fig.2) and profiling, potential of cathodic protection study and pipe tracing with magnetic antenna should be added. Magnetic antenna measures electromagnetic field exited in pipe with industrial noise, or AC component of cathodic protection's current or EM field induced in pipe with special artificial source. The instrument ERA, producing in St.-Petersburg, allows to carry out all these studies with the same tool. For an estimation of pipe position in plan and on depth studies with magnetic antenna are very convenient. For this purpose it is possible to apply several techniques:

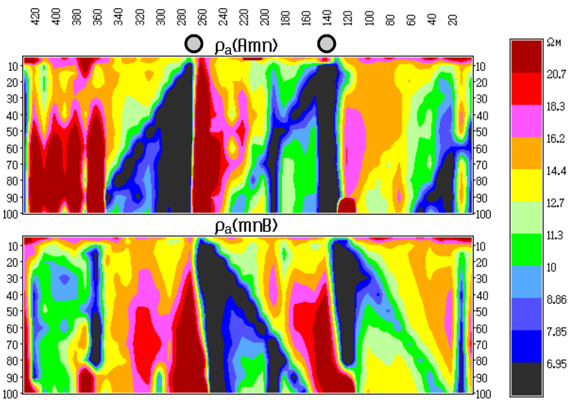

Fig.2. ρ_a pseudo-sections, distorted by pipelines influence

1. Tracing a pipe position on frequency 50 Hz (passive detection). In an environment there is the significant level of noise on frequency 50 Hz from near and distant industrial sources. This EM noise causes occurrence in a pipe induced currents, and anomalous of a magnetic field of frequency 50 Hz occurs above a pipe. At studies of horizontal magnetic field's component with the help of magnetic antenna, directed normally to a pipe axis, maximum of Hy will be observed.

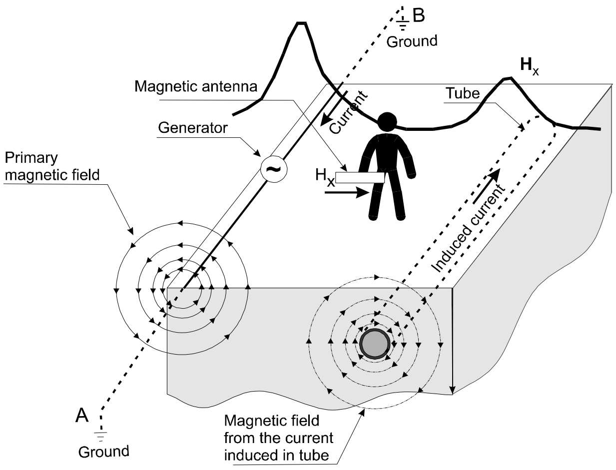

Fig.3. Study of pipe position with magnetic antenna

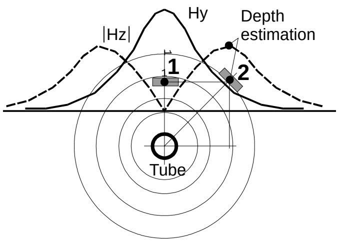

Fig.4. Position (1) and depth estimation (2) with magnetic antenna

2. If the pipe is under cathodic protection, its detection and tracing can be carried out with magnetic antenna on frequency 100 Hz. This technology is used AC component of cathodic protection. It is more noise-resistant technology.

3. If it is possible to connect of one or two poles of a current line from 625 Hz generator to the pipe, its tracing is possible with magnetic antenna on frequency 625 Hz.

4. If in parallel the pipe to put wire, with electric current 625 Hz, the pipe exited by this current can be out with the help of a magnetic antenna (fig.3).

For estimation of pipe depth it is necessary to know a pipe projection on ground surface and its direction. Departing from a pipe normally to it with magnetic antenna inclined under 45°, it is possible to receive maximal signal on a distance from the pipe projection equal to the depth of its center. Hz component maximums are at the same distance (fig.4). It is necessary to note, that the estimations of depths for a pipe and electric power cable are different, because the pipe is a single pole line, and the cable is a dipole line. These can be distinguished on character of EM field changes at removal from the source.

The definition of cathodic protection currents in a pipe is carried out on amplitude Hy in the maximum of anomaly, which is proportional to current value in the pipe. In places of significant damages of isolation the current leaves into ground and the magnetic field Hy decreases. By comparison of magnetic field Hy with CPP anomalies it is visible, that the zones of CPP minima coincide with zones of magnetic field Hy reduction (fig.5).

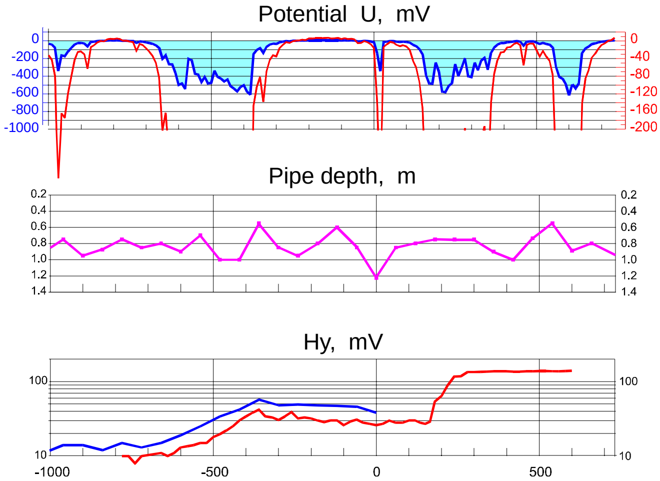

Fig.5. Example of CPP, depth estimation and Hy amplitude measurements above pipeline.

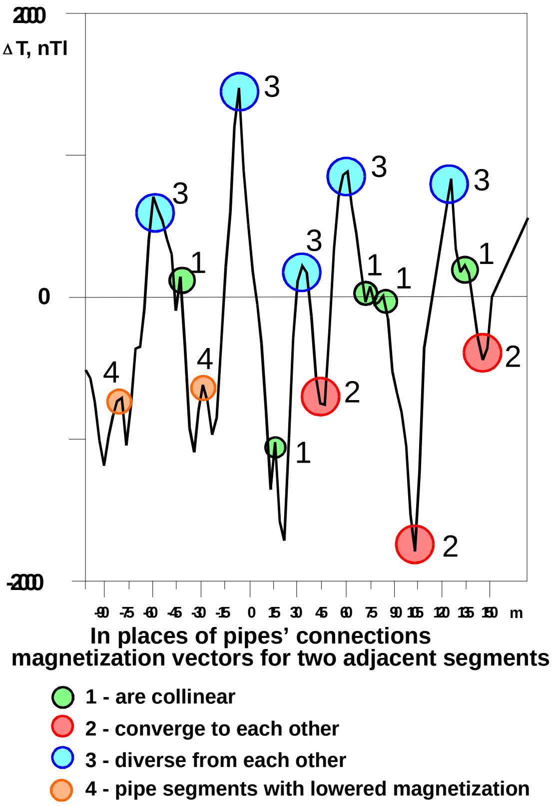

Fig.6. Example of anomalous magnetic field above pipeline fragment.

The measurements of natural magnetic field were carried out to investigate opportunities of the method for pipelines study. The profile studies across and along pipeline and mapping measurement are applied. On series of transversal profiles the difference of anomalous fields' amplitudes was noticed, which was then investigated with longitudinal profile in details. On the diagram of magnetic field along longitudinal profile the periodicity of anomalies is appreciable. The account of spectra has allowed to establish presence of the periods, equal to pipe length 11.6 m.

The joint consideration of longitudinal and transversal profiles has shown, that not only amplitude, but also direction of a magnetization varies. The pipeline consists of separate segments, and each being magnetic dipole with termo - remanent magnetization. These dipoles incorporate either with two "plus", or with two "minus", or "plus" of the first pipe segment is neighboring with "minus" of the other one (fig.7). At consecutive connection the length of uniform magnetic segment can grow. Therefore on periodogram there are periods equal to length of several pipe's segments. However and this model is unsufficiently complete. Among additional elements of the model there are places of welding, where during connection of segments there was a strong heating and magnetization with a natural magnetic field already in a place of pipe stacking. Besides separate sections of pipeline probably have appreciably lowered magnetization. Pipes on their origin can be of three different types: pipe with one longitudinal seam, with two longitudinal seams and made from stripe. When two half-cylinders of the second type pipe are connected with two longitudinal seams so, that the magnetization vectors are directed towards each other, the total magnetization becomes reduced. The stripe pipes, appearing the cheapest in manufacture, are least reliable in operation. The detection in the pipeline such least reliable sections will allow to control them.

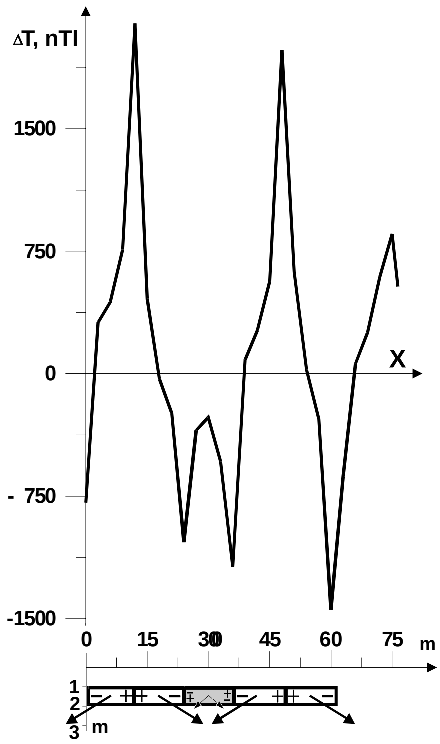

Fig.7. Results of 2D modeling magnetic field T over pipeline fragment.

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