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Research Article

APPLICATIONS OF GPR RESEARCHES ON HYDRAULIC ENGINEERING STRUCTURES

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ABSTRACT
Possibilities of a GPR (Ground Penetrating Radar) method for condition monitoring of dams and embankments are presented in this article. Using this method we can obtain data about layers which are characterized by different dielectric indicators. At rather homogeneous soils which, as a rule, fill out dams, dielectric indicators can change only due to moistening or due to existence of zones of development of emptiness and cavities in an array.

Keywords: *GPR, Geophysical Methods, Electro-Magnetic Wave Fields, Dielectric Permeability, High-Frequency Conductivity, Seismic Exploration, Dams*

INTRODUCTION
The GPR and seismic exploration are the wave methods of geophysics (Vladov *et al.,* 2004). In a GPR distribution of electromagnetic waves of meter and decimeter range in the geological environment, dielectric is described by Maxwell's equations. Distribution of elastic (seismic) waves within the geologic environment, which is an imperfect elastic body is described by the equations of the theory of elasticity (the equations of the movement). At the same time, both of these methods differ from other geophysical methods in structure of the obtained data (Izyumov *et al.,* 2008).
Using of the GPR allows to solve the following problems: identification of underground cavities and emptiness, cracks, demultiplexing zones; inspection of a body of earth dams for assessment of their state; establishment of a depth of ground waters and top water; raying of ground deposits (from a surface of fresh reservoirs) with an arrangement of wells, necessary for interpretation, on coast of a reservoir; identification of zones of the increased filtering; studying of an engineering-geological situation of the territories adjacent to meliorative systems and constructions.
We carried out by the “Oko-2” device a radarogram of 310 m length on the Tupolang dam.

MATERIALS AND METHODS
Method of GPR researches
The GPR is the geophysical device for carrying out quick profiling of soil. At the moment one of the most demanded and often applied devises of a radar-location at a geophysical survey is the “Oko-2” GPR (Russia). The principle of operation of the equipment of subsurface radar sounding (in the standard terminology - the GPR) is based on the radiation of ultra broad band (nanosecond) impulses of meter and decimeter range of electromagnetic waves and reception of the signals reflected from limits of the section of the layers of the probed environment having different electrophysical properties. Such limits of the section in the studied environments are the contacts between dry and moist saturated soils - ground water level, contacts between layers of different lithologic structure, between sequences and material of an artificial structure, between bed and sedimentary rocks, etc (Davidov, 2012; Shuvalov, 2011).
In depth parameter methods are blocked in the field of about 3-15 meters, and on resolution the GPR costs much above.
Before working on the site, measurement parameters such as, average dielectric permeability, development on depth, the sounding mode, a signal delay are set. After input of parameters of measurement the ABDL antenna block - "Triton" is stretched along a profile with smooth movement, at this moment there is a data recording on the control unit and processings. The available wells and holes are noted by a tag on a radarogram for a further binding of data at interpretation of a radarogram. After a

distance of 300m, data recording stops. The antenna block is switched-off directly by the operator, the file with radarogram is saved automatically in the control unit and processings.

Processing field researches and interpretation of the results received by the GPR.

Use of a uniform mathematical apparatus for the description of these two types of physical fields defines uniform approach and to processing of field data in wave methods. A set of procedures for transformation of records for the purpose of allocation of a useful signal - the reflected and diffracted waves against the background of hindrances is uniform for both methods. Generally it is strip filtering, a deconvolution and Gilbert's transformations for processing of single routes, both two-dimensional and three-dimensional transformations of a temporary sections - filtering, migration and summing by a common-depth-point method. Set and the sequence of procedures in a processing flow for a GPR and seismic exploration will differ according to types of regular hindrances and accidental noise, specific to each of fields.

The unity of approaches to the solution of direct and inverse problems, identity of forms of displays of the reflecting borders and the diffracting objects on time sections caused that the seismic stratigraphy approach to interpretation of the results of processing of field data which is well developed in seismic exploration successfully is applied also in a GPR.

Thus, in spite of the fact that the method of subsurface GPR sounding is technologically new, at the design of a technique of works, processing and interpretation of results approaches, receptions and software of modern seismic exploration are used (Ogilvi, 1990).

For interpretation of data of a GPR the "GeoScan 32" software is used. This software is intended for filtering of introduction of corrections, and layer-by-layer interpretation of data of a GPR. Interpretation included horizontal and strip filtering for the purpose of allocation of borders and layer-by-layer interpretation (Finkilshtein *et al.*, 2000-2005; Staravoytov, 2008).

First of all, radarogram of the existing wells and holes for a binding to wells and the correct interpretation of data of a GPR were interpreted. Before interpretation the window with property of a profile in which the value of lengths of a radarogram "the step of X" is established opens, the base of the antenna is established, the window of a boning board in which the value 0 scale is established opens.

Further is established optimum values of contrast and strengthening of a profile. On a radarogram there are borders on which layers were allocated. After allocation of border in layer-by-layer interpretation on each layer dielectric permeability on which the power of a layer and speed of distribution of electromagnetic waves in this layer is calculated is set (Vahromeev *et al.*, 1989).

RESULTS AND DISCUSSION

The Tupolang dam belongs to the heterogeneous type and consists of rock mass with an antifiltrational core from average loam and layers of filters from both borders of a core. According to the received radarogram, in the Tupolang three layers are allocated, there is also a huge number of the diffracted waves which origin is connected with hindrances on an object as their speed is equal to 40 cm/nanosecond (fig. 1.).

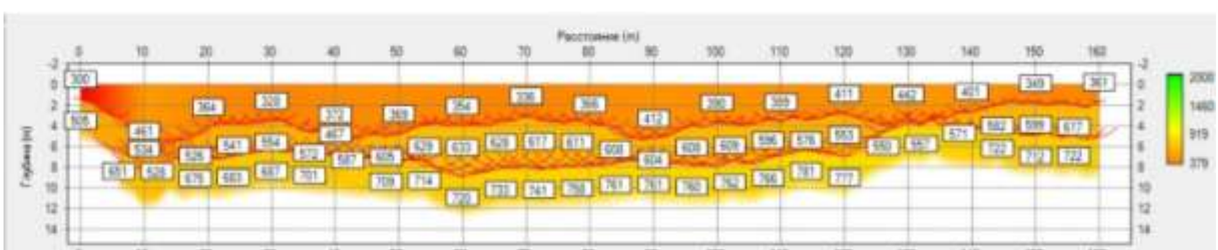

Figure. 1 Seismogeological section on a profile IV (NUP, mountain weight, 8 m from a filtrational layer) PK2+17 - PK3+66. Dam of the Tupolang water reservoir

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Speed of the first layer is equal to V=10.5 cm/nanosecond, ε=6 that corresponds to soft and sedimentary magmatic rocks. The second layer has lower speed at the expense of bigger density V=8.7 ε=6. The third layer is presented by SWL, has high dielectric permeability ε=81 and very low speed of V=3.2 cm/nanosecond.

Earlier we carried out seismic surveys in a dam of Tupolang. The seismic section of a part of the dam presented by the mountain stuff is presented by three seismic layers differing from each other in speeds of distribution of elastic waves (fig. 2).

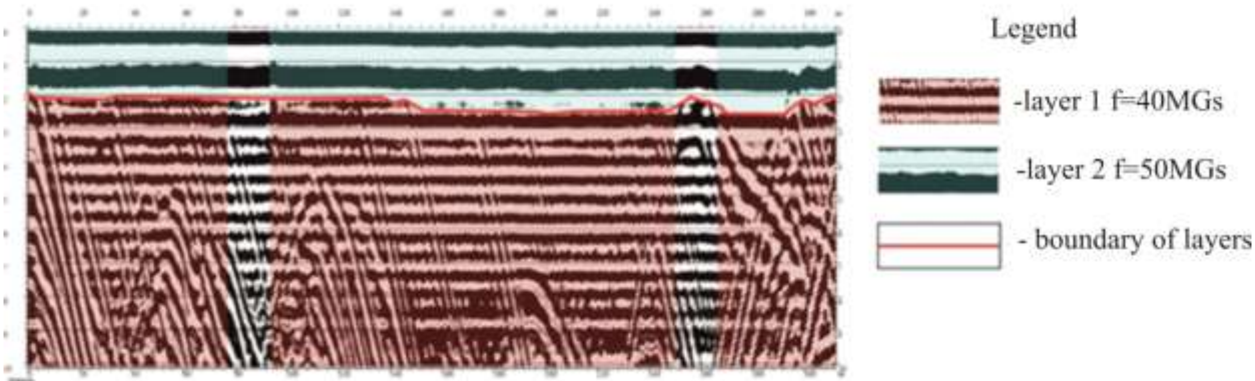

Figure 2: Radarogram on the site (A dam of the Tupolang water reservoir)

The most upper layer is characterized by velocities of Vp from 300 to 442 m/s, the layer which is characterized by velocities of Vp from 505 to 633 m/s is located below. It spread by the soil which is characterized by velocities of Vp from 651 to 758 m/s. Apparently from a section, with the depth, seismic speeds increase. It is connected with the fact that with a depth pressure of overlying layers on underlying increases that promotes increase in elastic waves (Eskin, 2010; Goryainov *et al.*, 1970).

The seismic section of the core of a dam put from average loam consists of two seismic layers (fig. 3).

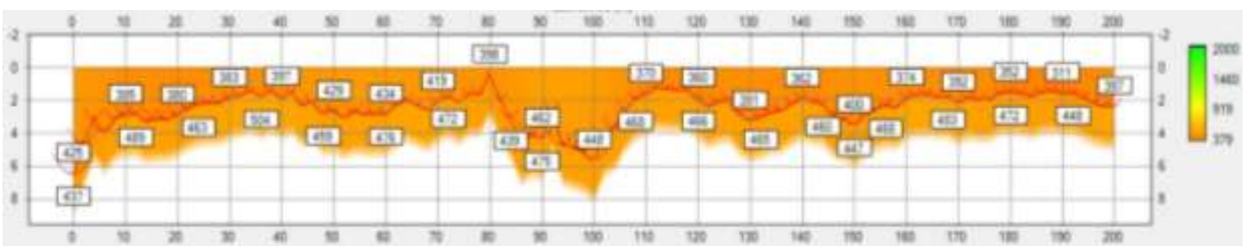

Figure 3: The seismogeological section on a profile III (A core of a dam of the Tupalang water reservoir).

The upper seismic layer is characterized by velocities of Vp from 311 to 434 m/s. In the lower seismic layer, velocity of Vp increases a little and reaches 437 - 475 m/s. This increase in velocity of Vp in the second layer is connected with increase in pressure of an overlying layer on underlying (Torgoev *et al.*, 2011).

As a result of the carried works, places of filtering of water in a dam body, a dam structure are revealed, the lithologic structure of the basis is specified, elastic characteristics of soil are defined, zones of the weakened rocks of the increased filtering are revealed. Contrast seismic borders match data of a radarogram. For small depths the method of the reflected waves is almost non informative (see Fig. 3) therefore technogenic soil was divided according to a GPR (see fig. 1).

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