# SOME GEORADIOLOCATION IMAGES OF CYLINDRICAL BODIES BUILT WITH DIFFERENT DIELECTRIC FILLERS, PLACED IN A DIELECTRIC ENVIRONMENT

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***Abstract.*** *For mining-geological, speleological, archaeological, specific and other interests, it is important to study underground voids with partial water-air filling when they are in a homogeneous environment. In the sector of applied and experimental geophysics of the Institute of Geophysics of TSU, a study of GPR physical modeling for horizontally located cylindrical models was carried out. Models contain spaces bounded by a cylindrical surface filled with water, air and partly water-air. Georadar (GPR Zond 12-e, soft Prizm 2.6) profile studies were carried out in the plane of the horizontal placement of the model relative to the day surface and in planes directed perpendicular to the day surface. Based on the results obtained, the corresponding radio images and their frequency-geometric correspondences in natural conditions were identified and recorded.*

***Key words:*** *georadar, radio image, GPR profiles, physical modeling*

## Introduction

Determination of the air-water component of the environment in a mine-rescue underground confined space; study of the state of laying geotechnical underground cables and condition of cable-conducting constructions; fullness of drainage channels, for invasive studies of archaeological deep voids; the need for deep protection of protected areas; speleological research from the day surface - for all this, it is important to study the complex dielectric composition of underground objects. In the study of the karst environment, an important place is occupied by the possibility of detecting spaces containing air and water, suffusions, siphons - their fixation by geographic, speleological and geophysical methods [1]. Despite the development of such methods as geolocation, electrometry, seismometry, the possible identification, localization and interpretation of a partially water-containing space presents a significant difficulty. With the help of the method of physical modeling of electromagnetic fields of GPR, it turned out to be possible to successfully solve a number of direct problems of electrodynamics [2].

## Instrumental and methodological part

At the Department of Applied and Experimental Geophysics of TSU, in the laboratory of GPR and electrometry of the Institute of Geophysics, physical modeling of electromagnetic fields in a homogeneous medium with dimensions of 1.5x1.5x2.4m was carried out on a modeling device. Three modeling options were considered: a fully water-containing, half-water-containing and fully air-containing model of a horizontal polyethylenecylinder (thickness of wall - 0.2-0.4mm, 0.17 m in diameter, with an axis of 0.3 m) placed horizontally in a homogeneous sand medium and with an axis directed perpendicular to the GPR profiles. Georadar profiles (Profiles 1-7) were carried out both on the day surface relative to the cylinder and three profiles in the vertical plane relative to the cylinder, the central one on the cylinder placement strip.

The task is to divide - fix and identify the radio image created by electromagnetic waves of the georadar for a cylindrical object, partially containing water and located in a homogeneous medium.

## Results and discussion

The studies were carried out on the modeling facility of the Georadar Laboratory of the Applied and Experimental Geophysics Sector of the Institute of Geophysics of TSU [3]. Three models of a cylindrical body: completely filled with water, completely filled with air and half filled with water with non-galvanic coupling [4] in a homogeneous sand medium. Seven georadar profiles were drawn on the day surface of the model (GPR Zond 12-e, soft-Prizm 2.6), of which we present only the central ones.

On fig.1 from the interpretation of radargrams from diffracted waves of radio images of the surface of the cylinder, it can be seen that in all three cases, the location coordinates correspond to the length of the diameter of the cylinder outlined by white lines.

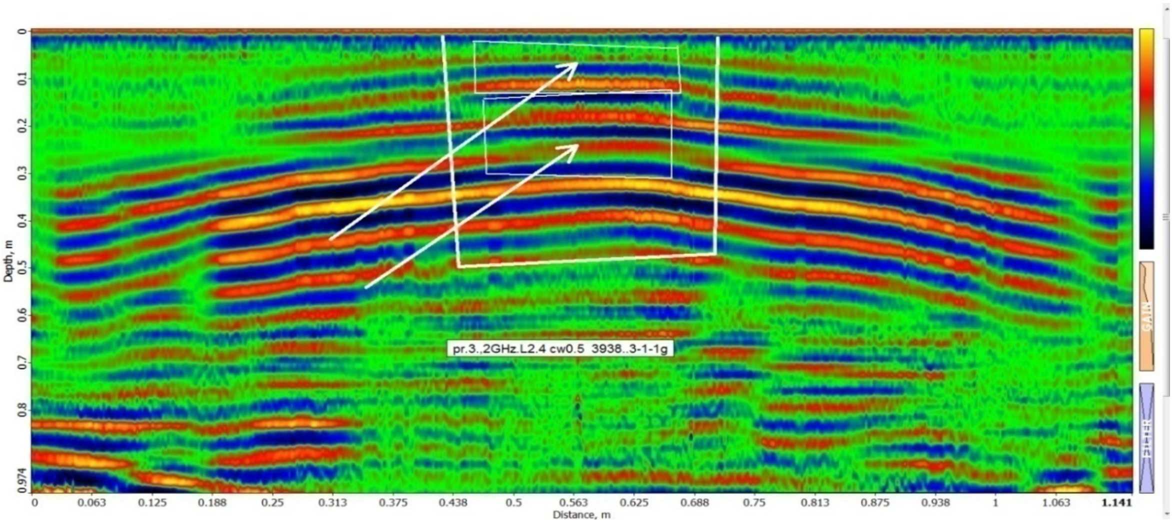


*Fig.1. The radargram of the central profile 2.4m is presented, for a cylinder 0.3m long, half filled with water, when crossing the Zond 12-e georadar with a 2GHz antenna.*

In this case, it turns out that the characteristics of the radio image are also visible from the lower side of the location of the cylinder. In particular, in fig. 1, a feature of the in-phase axes is noticeable - a sharp decrease in intensity at distances of 1-1.18m and at depths of 0.3-0.5m, which has a screening/shield character.

On fig. 1 axes of in-phase radio image are sharply divided into two parts. For depths of 0.1-0.25m, the watershed surface is clearly characterized in the cylinder space. Along with this, the lower extended part with a thickness of 0.3-0.5m also has a screening character.

On radargram of an air-containing cylinder contains a feature of in-phase axes for depths of 0.15-0.25m, which in width corresponds to the diameter of the cylinder, and at a depth of 0.3-0.5m it has an interference character of in-phase axes.

A strong interference image, which characterizes all three cylindrical models at distances of about 0.05-1m and depths of about 0.7m, arises as a result of the superposition of diffraction-reverberation phenomena from the vertical walls of the model block and requires additional studies for the vertical plane of GPR exposure.

GPR survey of horizontally located cylinder models was carried out from a vertical plane, GPR profiles were carried out along the side slopes of the research space in the direction perpendicular to the axes of the cylinders.Using the tracing and selection options, the rectangle marked with white circles corresponds to the location of the cylinder completely filled with water. The radio image represents the profile radargram 1V2., 2GHz., L2.4m., Rim. It should be noted that the size of the radio image is about 10 times larger than the size of the object itself. It is also important to note that the walls of the cylinder itself form a small "butterfly" in relation to the walls of the model space, which is quite understandable and provides an additional clue to confirm the presence of parallel walls.

Using the tracing and selection options, the box marked with white lines (Fig. 2) corresponds to the location of the cylinder half filled with water and half filled with air. The radio image represents the profile radargram 2V2, 2GHz, L2.4m, Rim. It should be noted that the size of the radio image is about 10 times larger than the size of the object itself. It is also important to note that the walls of the cylinder themselves form a small "bow tie" with the walls of the model space, creating an additional tell-tale sign of parallel walls.

The main envelopes are the so-called in-phase axes corresponding to the diffraction and forming a "plateau" at the near base of the cylinder under study at a distance of 1.05-1.25m and „mustache” a thickness of 0.3m, which fully corresponds to the dimensions of the cylinder.

Using the tracing and selection parameters (radargram is not shown here) - the rectangle marked with white circles corresponds to the location of the cylinder completely filled with air. The radio image represents the profile radargram 3V2, 2GHz, L2.4m, Rim. It should be noted that the size of the radio image is about 10 times larger than the size of the object itself. It is also important to note that the walls of the cylinder itself form a "butterfly" with respect to the walls of the model space, which is quite understandable and provides an additional clue to confirm the presence of parallel walls.

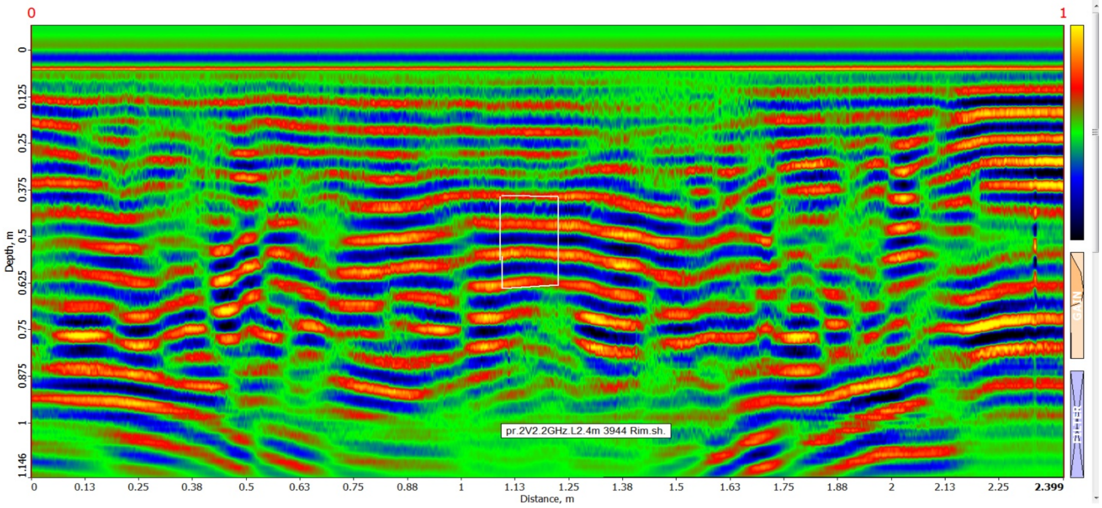


*Fig. 2. The presented radargram corresponds to a central profile 2.4 m long, for a cylinder half filled with water and half filled with air, made by the Zond 12th georadar with a 2 GHz antenna in the vertical plane.*

The main envelopes are the so-called in-phase axes corresponding to the diffraction "whisker". They form a set of horizontal in-phase axes in the marked rectangle with the base of the cylinder closest to the surface, at distances of 1.1-1.27m and a thickness of 0.3m, which fully corresponds to the dimensions of the cylinder.

From a comparative analysis of GPR profiles carried out in a vertical plane, it follows that the radio profile of a cylinder containing water corresponds to a clearly defined hyperbole. The radio profile of a cylinder containing half water and half air is formed as a degenerate hyperbola at the upper base with a plateau located between two humps. A cylinder completely containing air forms only a flat "plateau" containing a hyperbola.

Based on the theory of similarity of electromagnetic fields [2] using similarity coefficients [2], for laboratory geometric and frequency parameters, it can be concluded that in field conditions for a similar model, an object can be four times larger than the corresponding form of a radio form for a medium with a constant relative dielectric permeability with a central frequency of 500MHz.

Table 1.

| $l_m$=1 $f_m$=2GHz | $f_n$ | 2GHz | 500MHz | 300MHz | 150MHz | 100MHz | 75MHz | 40MHz |
|---|---|---|---|---|---|---|---|---|
| | $l_n$ | $l_n$1м.($f$ = 2 GHz) | 4m | 6.67m | 13.3m | 20m | 26.7m | 50m |
| $l_m$=1m $f_m$=500MHz | $l_n$ | | 1m | 1.67m | 3.33m | 5m | 6.67m | 12.5m |
| $l_m$=1m $f_m$=300MHz | $l_n$ | | | 1m | 2m | 3m | 4m | 7.5m |
| $l_m$=1m $f_m$=150MHz | $l_n$ | | | | 1m | 1.5m | 2m | 3.75m |
| $l_m$=1m $f_m$100MHz | $l_n$ | | | | | 1m | 1.33m | 2.5m |
| $l_m$=1m $f_m$=75MHz | $l_n$ | | | | | | 1m | 1.88m |

Table 1 shows the correspondences of the characteristic lengths of the geometric scale for different central frequencies of geolocation waves for identical radio images observed in model and field studies. The recalculation was based on the application of the basic relation of the theory of similarity [2]. Index-**m** corresponds to model parameters, and index-**n** corresponds to field, natural parameters under conditions of constant relative permittivity. In the case of different relative permittivity, one should take into account the numerical values of the corresponding similarity coefficient [4].

## References


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