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Determining the Presence and Structure of a Subsurface Radioactive Burial when Interpreting the Results of the GPR Method by Analyzing a Three-Dimensional Rotating Radio Image

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ABSTRACT

The state of burial sites for radioactive and other toxic substances poses an environmental hazard, when there are no schemes for their placement and the technical arrangement of their structures is unknown. Thus, it is necessary to determine the condition and structure of underground structures by non-invasive methods. One of the most non-invasive methods in terms of information content and minimization of threats in research is the GPR method [1, 2]. Based on the foregoing, we present two-dimensional and three-dimensional radio images of the underground repository. Rotating radio images at different angles, it is possible to determine the structure of an object located under the daylight surface.
Field georadar work was carried out using the Zond 12e georadar and the interpretation of the results was carried out using the Prism-2.5 and Voxler-4 programs [3, 4].

Key words: *Georadiolocation, 2D and 3D radio images, radioactive burial.*

Introduction

The Scientific Research Institute of Radiation Agronomy of Plants was located and functioned on the Georgia territory of Anaseuli, Chokhatauri region since the 60s of the last century. At present, the remains of the institute building, the remains of the perimeter of the foundation, the remains of a number of demolished objects have been preserved. In the collapsed building of the institute and around it, there were signs of radiation contamination, the sources of which could be located under the daytime surface of the soil, in more or less protected places.

Instrumental part and environment

The purpose of the georadar study was to determine the position, shape and location of radio images of possible underground objects in pre-designated areas (five areas). Georadar work was carried out by the Zond 12 georadar with standard antennas at frequencies of 150 MHz and 75 MHz, data collection and processing was carried out using its Prism-2.5 software. The work was carried out in the area, the soil of which consists of red soil, is common in the southwestern part of the humid subtropics zone (Adzharia, Guria) at an altitude of about 100-300 m above sea level and occupies a hilly-mountainous area. Red soil is characterized by heavy clay, clay and heavy clay with a mechanical composition. The red color is due to the content of ferric iron.

On the territory of the former Soviet Union, including former Soviet Georgia, near-surface radiation repositories were created. Their structure is more or less diverse in shape and partitions made of materials with different ability to reflect electromagnetic waves that create different cavities. The fig. 1 shows exemplary types of radioactive burial sites for underground structures consisting of various protective layers. Numbers on the fig.1 indicate the radioactive storage burial grounds that are isolated from the external environment with layers of various types of material composition (concrete, clay, sand, inert materials, etc.).

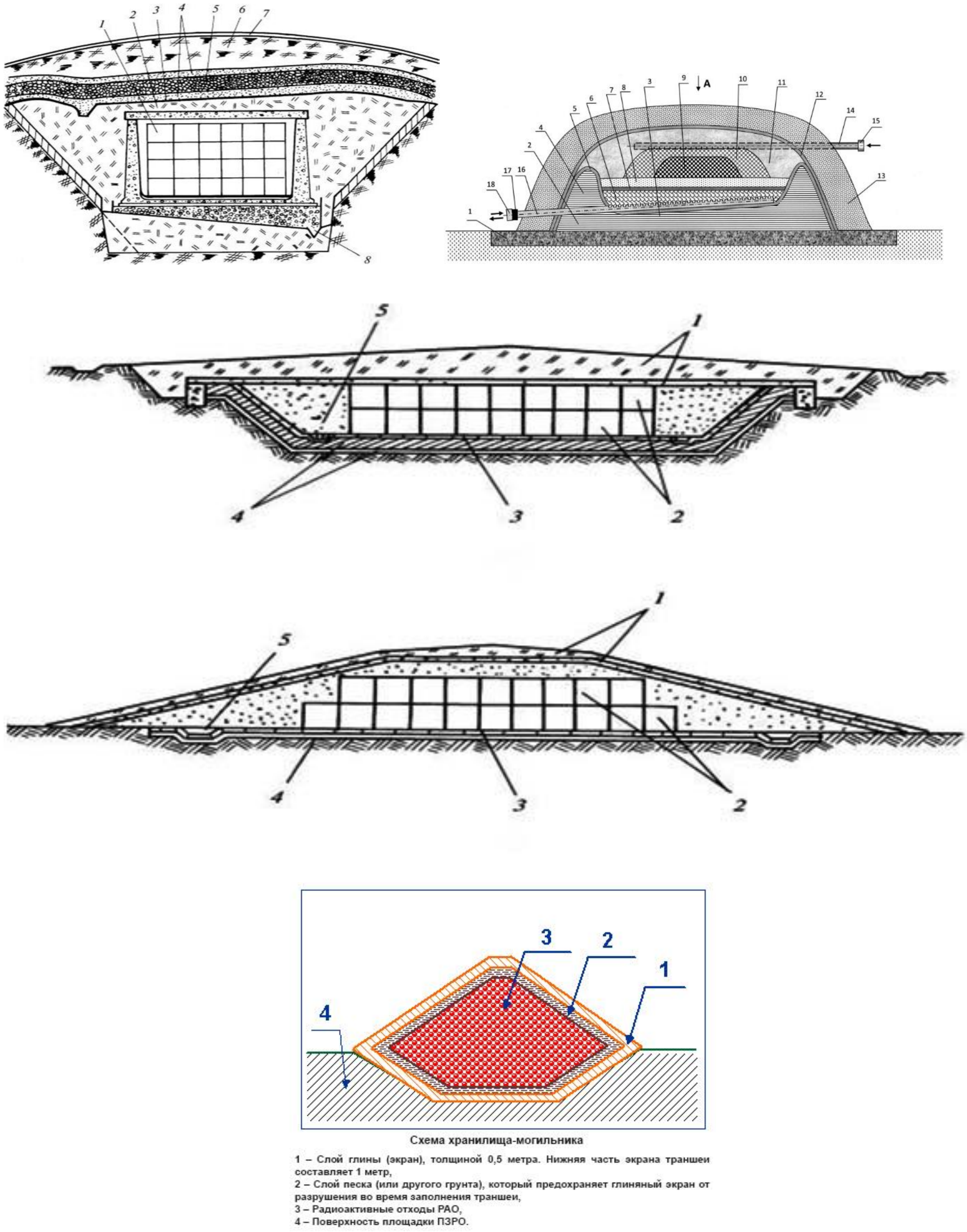

Fig.1. Simple and complex type of some radiation burials.

Results and discussion

Results in fig. 2-8 are presented.

Fig.2. Photo shows the region of the study area-5. The directions of GPR profiles (5a and 5b) are marked with white lines, marking their completion by the arrows.

We present GPR data of the fifth survey site and their two- and three-dimensional radio images.

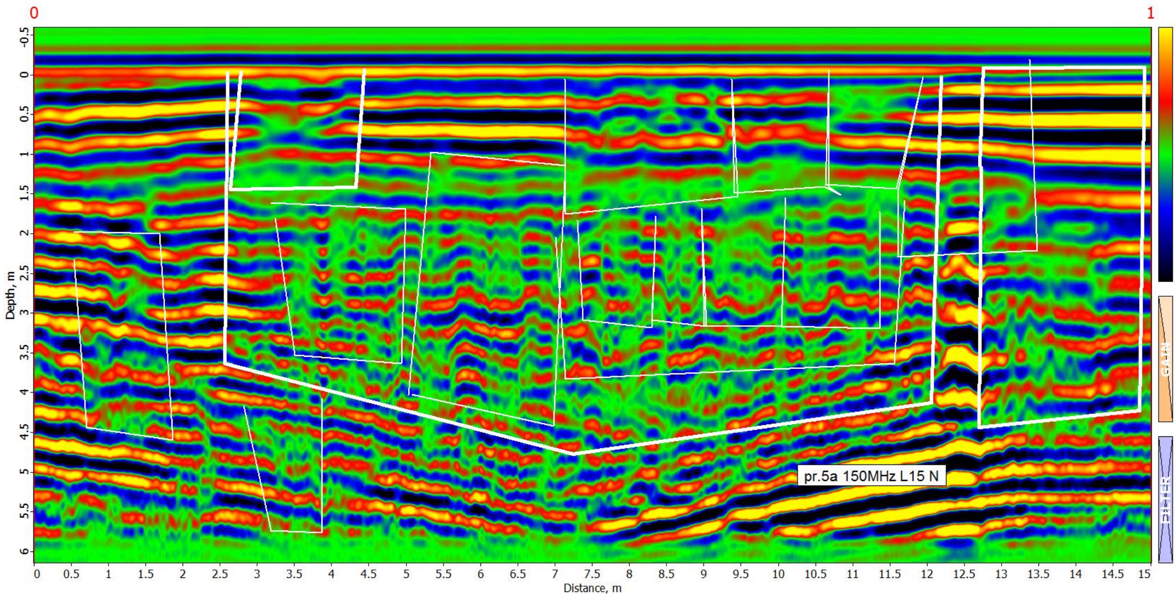

Fig.3. GPR- section with a depth of 6 m and a length of 15 m, presented on the radargram (profile 5a-3647), was made by the Zond 12e georadar with a standard 150 MHz dipole antenna.

The fig. 3 and fig. 4 show the corresponding radargrams of two-dimensional intersecting GPR profiles.

In the center of profile-5a is noted an approximate cavity about 4.5-5 m from the surface. Individual approximate cavities are outlined with white lines at distances of 2.5-12 m and 13-14 m. The radio image of the object at distances of 5.5-7.5 m with a thickness of 2.5-4 m is defined as a "box-shaped" [5, 6]. At distances of 7-12 m is noted a complex, folded radio image of a three-chamber object. Under the large cavity is clearly distinguished a conical base with a tip at a distance of 7.5 m.

From the surface of the tile in depth there are cavities 1.5 m thick [7, 8] (possibly filled with demolished material), under the tile there are cavities at a distance of 2.5-4.5 m, 7.5-9.5 and 10.5-12 m, these are possible traces of destruction.

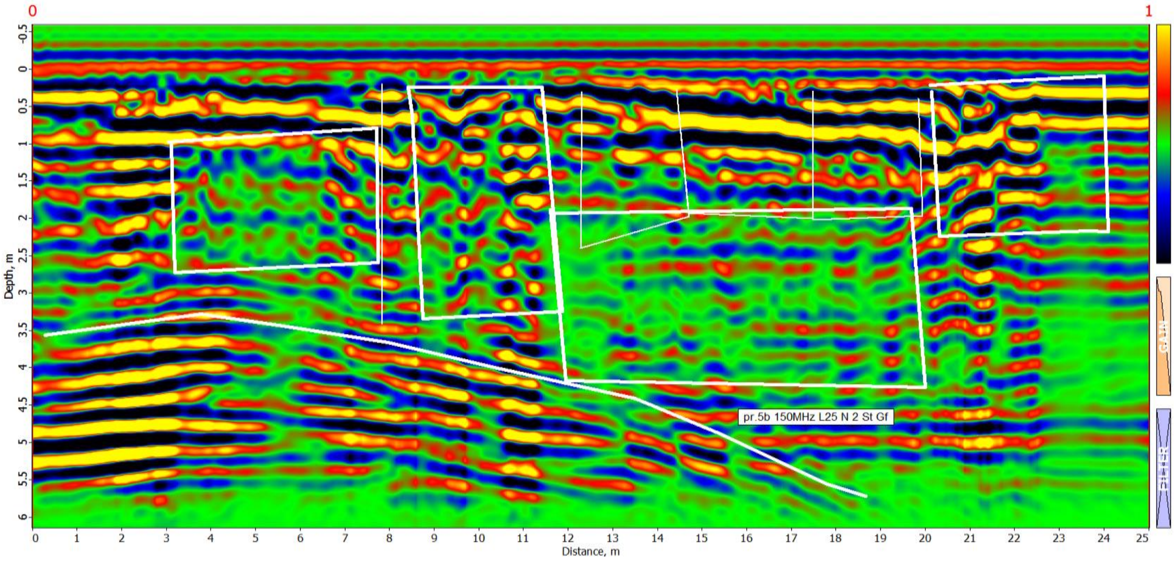

Fig. 4. GPR-section (profile 5b-3648) with a depth of 6 m and a length of 25 m, made by the Zond-12e georadar with a standard 150 MHz dipole antenna.

Profile 5b clearly shows cavities marked with white lines at distances of 3-7 and 12-20. A radio image of the "bow-tie" type is determined at a distance of 8-11 m from a depth of 0.5 m to 3.5-4 m. A cavity was also noted at 20-24 distances. The inverted cone-shaped part of the base was clearly distinguished at distances of 0–18, which is in good agreement with the results of profile 5a. Generally, profile-5a and profile-5b are in good agreement with each other and complement each other.

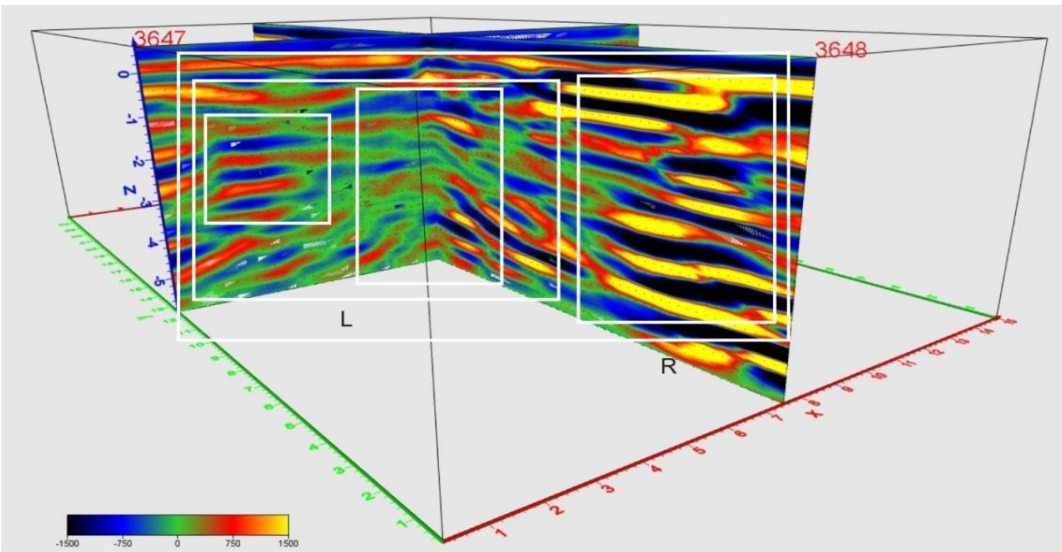

Fig.5. 3D radio image, created from profile-5a and profile-5b radargrams GPR-section. The lengths of the profiles are measured along the axes: Prof-5a length -15 m and Prof-5b length -25 m, which are built with GPR files-3647 "front" and file-3648 "rear". The selected segment of the electromagnetic wave amplitude is set according to the legend.

To represent the radio image in a 3D image, the software Prism-2.5 and Voxler-4 were used, they made it possible to see the radio image of the object in three dimensions [3, 4], by selecting the amplitude segment of the electromagnetic wave and using the appropriate rotation option.

Figures 5, 6, 7, 8 show views of the radio image of the object at different angles of rotation from the vertical axis of the intersection of the profiles.

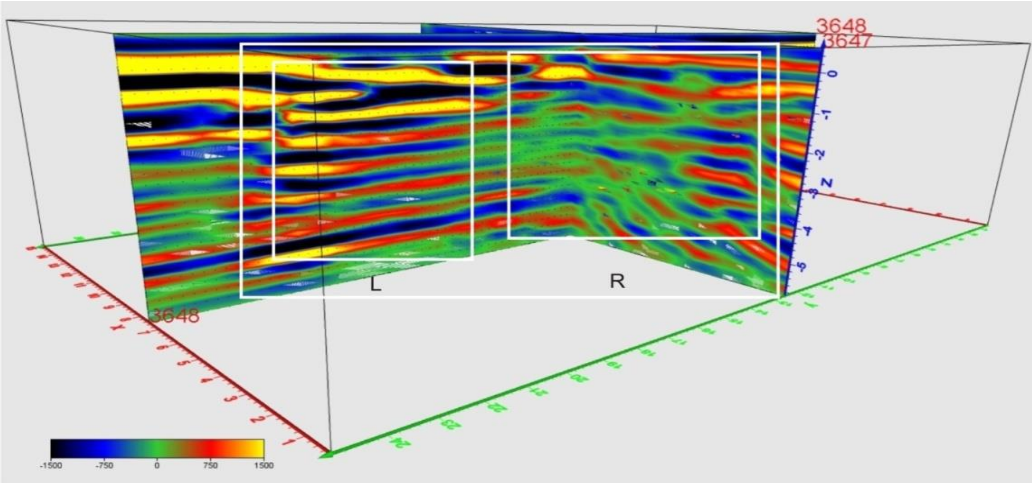

Fig. 6. 3D radio image created with profile 5a and profile 5b radargrams. The lengths of the profiles were measured along the axes: Prof-5a length 15 m, Prof-5b length 25 m. The radio image was rotated at an angle of 90 degrees from the axis of the intersection of the profiles.

Three-dimensional coordinates of the radio image are marked in meters. The left side is marked (L) and the right side is marked (R), special areas of the radio image are marked with white rectangles. The left side of the radio image consists of two main shapes with partial overlaps. In the center of the radio image is the so-called "bow-tie" with its characteristic arrangement of the in-phase axes, complicated by the horizontal axes of the in-phase of the left, rectangular overlapped object. The left large rectangular area of the radio image common-mode is read as a complexity of a "pit" type complex with vertical walls. The right rectangle is distinguished by a more reflexively located uneven-walled wall, it is horizontally covered by a possible reinforced concrete slab and has a pronounced base. As a wall material, it was possible to use brick or concrete-block masonry, separated from the environment by a clay-like material.

Thus, the interior of the burial ground consists of a distinctly isolated three-dimensional cavity, complicated by horizontal rectangular non-uniform partition inserts.

On the fig. 6 the angle of the radio image, twisted at an angle of about 90 degrees. Clearly distinguishes the left wall with a bounding vertical partition, turning into the radio image of the "pit" type object, file-3647 "rear part".

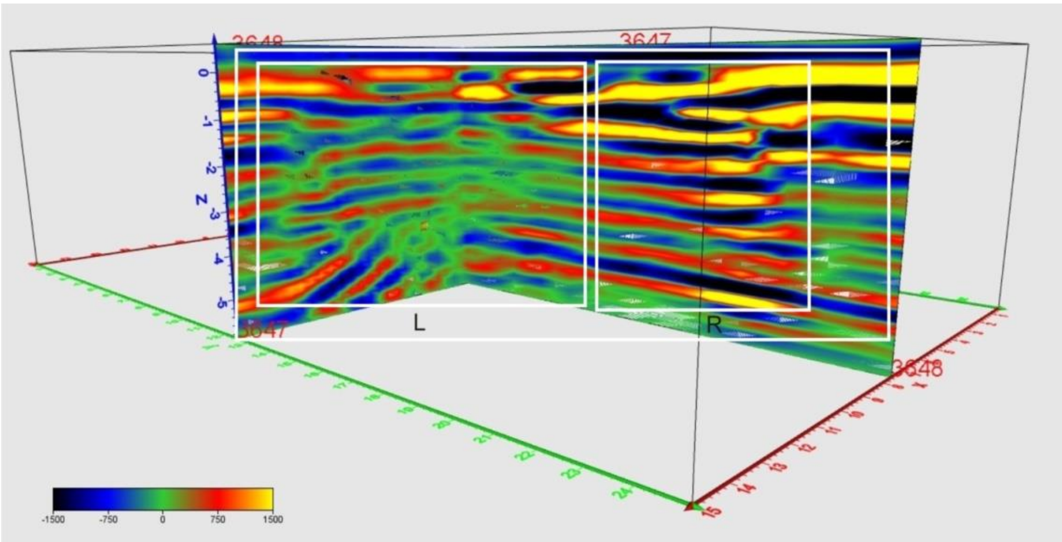

Fig.7. 3D radio image created with profile 5a and profile 5b radargrams. Profile lengths are measured along the Prof-5a axes at -15m, and Prof-5b at -25m. It consists of a "rear" file 3647 and a "rear" file 3648.

Have been identified the "Bow-tie", complicated by horizontal surfaces and space created by a wall of highly reflective material.

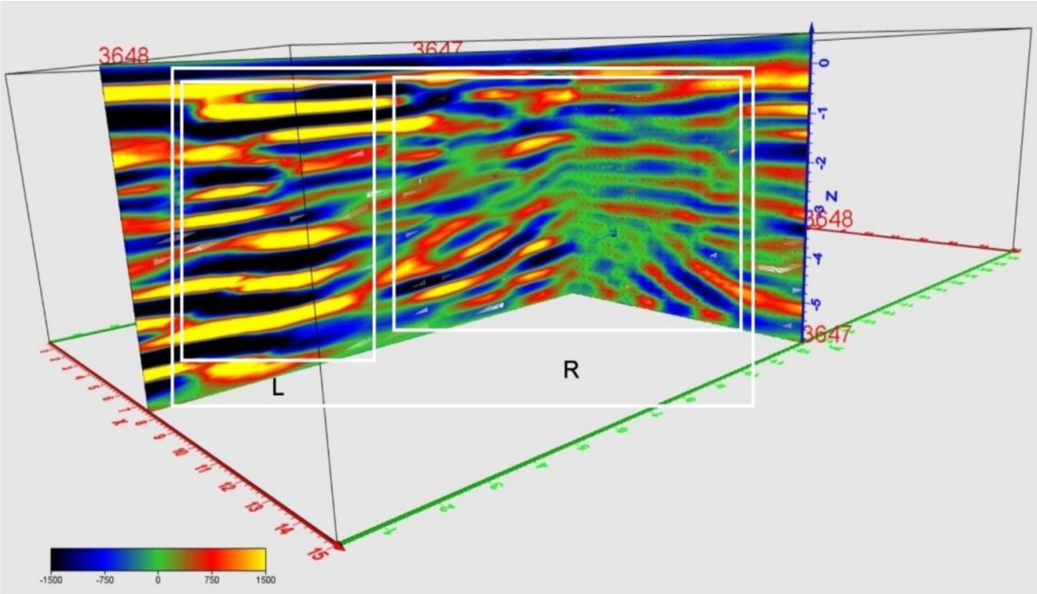

Fig. 8. 3D radio image created using profiles 5a and 5b radargrams. The lengths of the profiles are measured along the axes: Prof-5a length 15 m and Prof-5b - 25 m.

The space was clearly represented by a radio image, “bow-tie” complicated by radio images superimposed by horizontal inclusions at depths of 2-4 m.

Conclusion

Fragmentary GPR studies conducted in Ozurgeti, at the previously designated sites of the Research Institute of Radiation Agronomy of Plants, revealed a variety of 2D-dimensional radio images [7, 8, 9], indicating the existence of different types of radioactive insects [10, 11, 12].

Rotation shapes of 3D radio images of underground objects were analyzed to determine the location and shape of the object. In particular, the angles of rotation of the three-dimensional radio face of the "Plot-5" object were used to clarify the internal spatial cavity of the burial ground, to delineate the space marked with "bow-tie" and complicated by horizontally located inclusions.

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გეორადიოლოკაციური მეთოდის შედეგების ინტერპრეტაციისას სამგანზომილებიანი მობრუნებითი რადიოსახის ანალიზი, ახლოქვეზედაპირული განთავსების რადიოაქტიური სამარხ-საცავის არსებობისა და მისი აგებულების დადგენა

დ. ოდილავაძე, თ. ჭელიძე, ნ. ღლონტი, ო. იავოლოვსკაია

რეზუმე

ჯვარედინად გატარებული გეორადიოლოკაციური კვეთების (Prism 2.5) მიხედვით აგებული პროფილების შედეგად მიღებული შედეგების მიხედვით გაკეთებული ინტერპრეტაციის დასაზუსტებლად საჭირო ხდება დამატებით ,,Voxler 4" პროგრამის გამოყენება, რათა დაზუსტდეს რადიოსახის გვარობა, მაშინ როდესაც ის მკაფიოდ არ იკვეთება. ჩვენს შემთხვევაში კვეთებზე (Prism 2.5) მიღებული შედეგების მიხედვით არ გამოიკვეთა მკაფიოდ სიღრუის დამაფიქსირებელი ,,ბოუ-თაის" ტიპის რადიოსახე. ,,Voxler4 ,, პროგრამული უზრუნველყოფის გამოყენების შედეგად , მკაფიოდ დაფიქსირდა ,,ბოუ-თაის " ტიპის 3D რადიოსახე, ხოლო პროფილთა გადაკვეთის ღერძის გარშემო ბრუნვითი რაკურსების შედეგად დადასტურდა რადიოსახის არსებობა. ამრიგად, შეიძლება ჩვენს მიერ მოყვანილი მაგალითი გამოდგეს პარადიგმად გეორადიოლოკაციური ინტერპრეტაციისას პრობლემურ პირობებში შედეგების მეტი ინფორმატულობით წარმოდგენისთვის.

Определение наличия и структуры подповерхностного радиоактивного захоронения при интерпретации результатов георадарного метода по анализу трехмерного вращающегося радиоизображения

Д.Т. Одилавадзе, Т.Л. Челидзе, Н.Я. Глонти, О.В. Яволовская

Резюме

Для уточнения интерпретации результатов, полученных по профилям, построенным по поперечным георадиолокационным разрезам (Prism 2.5), желательно использовать дополнительную программу " Voxler 4" для уточнения наименования радиообраза, когда его не видно. В нашем случае результаты, полученные на пересечениях (Prism 2.5), не выявили радиоизображения типа «боу-тай», четко определяющего глубину. В результате использования программного обеспечения Voxler было четко идентифицирован 3D радиообраз типа боу-тай, а наличие радиообраза было подтверждено углами поворота вокруг оси пересечения профиля.

Приведенный нами пример можно использовать как парадигму интерпретации георадиолокации для более информативного представления результата в проблемных условиях.