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THREE-DIMENSIONAL REPRESENTATION OF THE INITIAL SURVEY OF THE NARIKALA CITADEL

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Abstract. *Due to the construction and rehabilitation works in the territory of "Old Tbilisi", one of the historically ancient and archaeologically very important places in the capital of Georgia, Tbilisi, there was a need to carry out a preliminary reconnaissance archaeogeoradiolocation survey. The pre-marked area for the archaeogeoradiolocation survey was intended as a place for the operation of construction equipment. During the construction process, it was possible to damage multi-ton construction equipment and cause accidents as a result of underground voids, as well as destroy possible archaeological monuments.*

It turned out that the study area is loaded with objects containing cavities of various shapes and contents. The continentality of the soil is disturbed by numerous cavities. Their depth ranges from 0.5 m to 5 m and their length is 1-5 m. A boundary between geological layers has been identified, on which a radio image of a man-made object could be located, such as a foundation, tunnel, culvert, or other cylindrical object located above the foundation and with a width of 1–1.5 m. A radio 3D image of a possible partially collapsed underground passage or partially disintegrated foundation remains is presented.

***Keywords*:** *archaeogeoradiolocation survey, georadar works, radio image.*

Introduction

The paper presents radar images of geo-radiolocation profiles of one of the historically ancient and archaeologically very important sites in the capital of Georgia, Tbilisi. Due to the construction and rehabilitation works in the territory of "Old Tbilisi", there was a need to carry out a preliminary reconnaissance archaeogeoradiolocation survey. The pre-marked area of the archaeogeoradiolocation [1, 2, 3] survey was intended as a place for the operation of construction equipment, where it was possible to destroy archaeological monuments.

The survey revealed a number of voids, signs of the existence of possible archaeological monuments and mapped their locations. The archaeo-geo-radiolocation works were carried out [4, 5, 6, 7, 8] using the Zond 12e ground penetrating radar, the data were collected, processed, and interpreted using the software Prizm 2.6.

Since a significant two-dimensional band structure was revealed [8], it was decided to investigate it using a specific three-dimensional methodology, which yielded positive results.

Task/Objective

The purpose of the task was to conduct a geo-radiolocation survey to detect voids in the underground near-subsurface arrangement [4, 5, 6, 7, 8] and their three-dimensional representation in order to clarify the nature of the revealed object.

Environment and Instrumentation

On the territory, adjacent to the "Old Tbilisi" citadel, "Narikala", in conditions of geographically difficult terrain, in a pre-marked area, the geo-radiolocation survey was conducted using Georadar Zond 12e, with its standard 150MHz dipole antenna and Prizm-2.6 software, to detect voids in the underground near-subsurface arrangement.

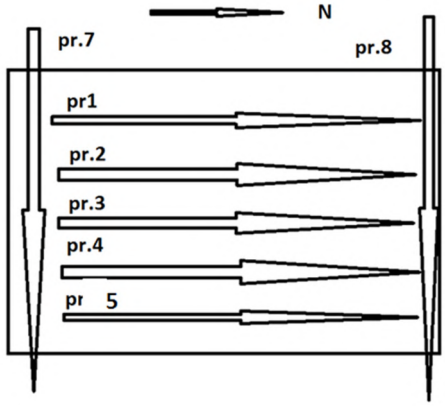
To obtain a three-dimensional representation, Prizm-2.6 and its compatible software, Voxler 4 were additionally used.

For clarity, old engravings of the study area from the book “European Engravings of Old Tbilisi” are included (Engraving 1, 2).

We present a schematic drawing of the placement of a number of profiles (Scheme 1). The schematic drawing (Scheme 1) shows the conditional placement of geo-radiolocation profiles and their directions.

Engraving 1. Narikala Fortress, from the first panoramic sketch of Tbilisi. Jean Chardin's Travels, 1673. Artist Guillaume Joseph Grelot. Published by Moses Pitt, London, 1686 [9].

Engraving 2. Tbilisi, unknown German edition. 19th century.[9]



Scheme 1.

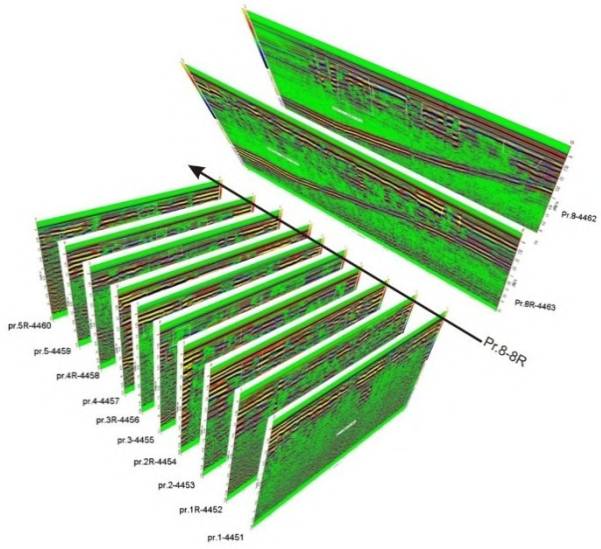


Fig. 1

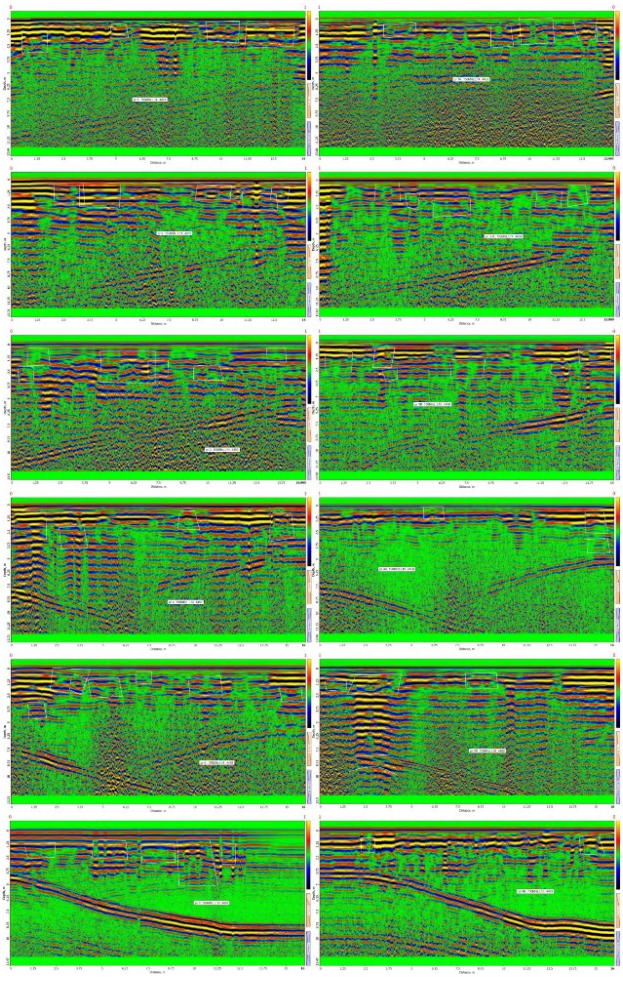


Fig. 2 Sequence of radar profiles

From the profiles presented in Fig. 1, the R-indexed profiles are separated from the corresponding parallel profiles by a distance of approximately 1-1.5 m. Layout of radarograms from profile 1 to profile 8 is presented in Scheme 1. In Fig.1 are shown 2 longitudinal (Pr-8-4462 and Pr 8R-4463) as well as 10 crossing sections of the territory. On profiles Pr.. 8-8R, the sequential subsidence of the banded object is visible, which was reflected both in Fig. 1 in the direction of Pr-5R, and in most radarograms in Fig. 2 (some of them are incompletely visible in profile 8-8R (due to the difficult terrain).

The intersections are indicated by the inhomogeneities observed at the edges of the profile-1-5R. On the radar profiles, the strip passing through the foundation of the tower, Pr.5R, while on the radar profile, the radio image of the tower is no longer visible, since the profiles are 1-1.5m apart and the radio image of the tower obtained by diffracted waves did not appear. However, the dip of the strip is clearly visible (Fig. 2).

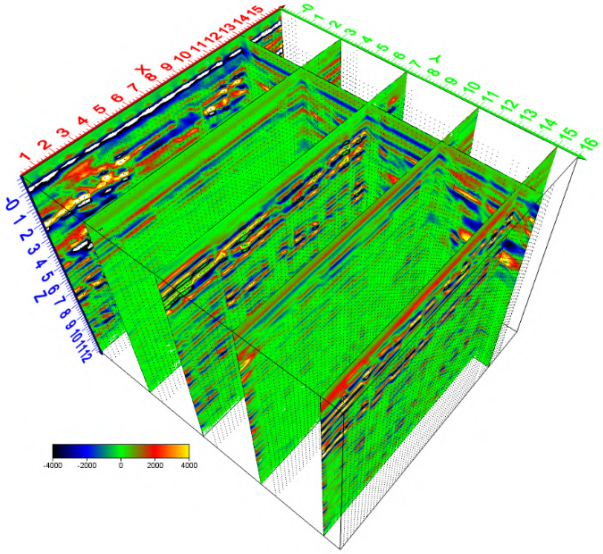


Fig. 3. The intersections of the profiles 1R-5R and 8R

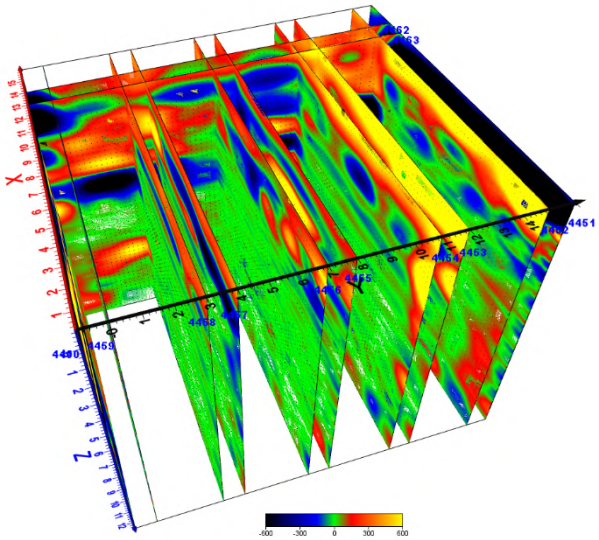


Fig. 4. Gaussian variant. The continuity of the radio image representation at the intersection of the profiles are determined

Reversal profiles 1R-5R and 8R. Clear spots appear at the intersections of the profiles, which indicates the detection of common continuous radio image (Fig. 3).

Voxler-4 uses a Gaussian variant (Fig. 4), which minimizes weak signals. The location of strong signals and the continuity of the synphasic axes of their radio image representation at the intersection of the profiles are determined/

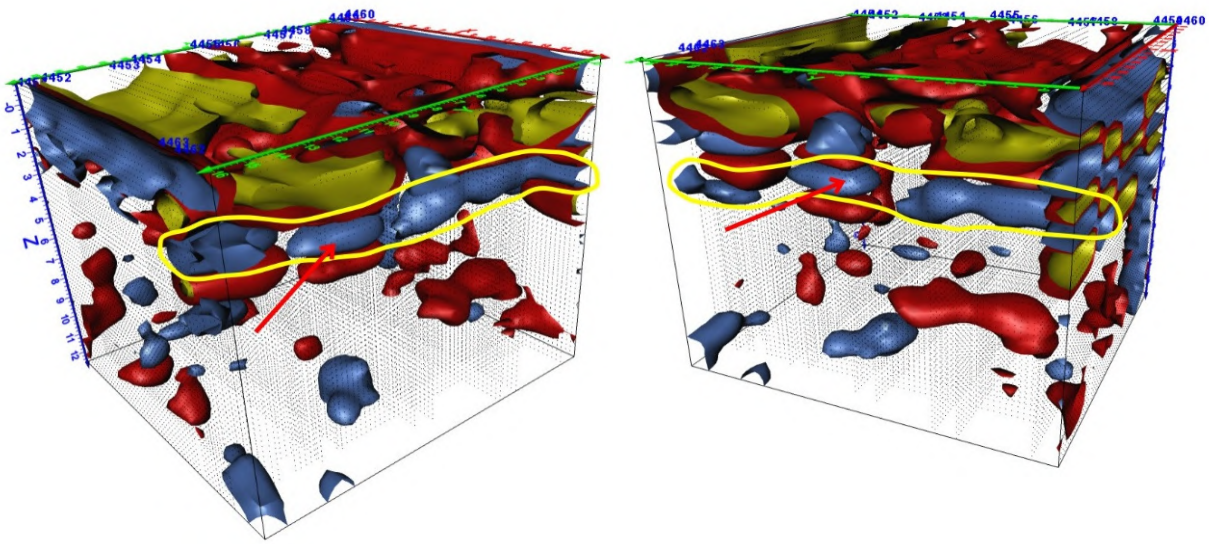


Fig. 5 The three-dimensional representation from two different angles clearly shows the location of the longitudinal body, which is marked with red lines at the location indicated by the arrow.w

Fig. 5 presents a radio image of a possible partially collapsed underground passage or partially disintegrated foundation remnant. It coincides in length with profile 8. With a height of 1-5m. The coordinates of the cut-off points are read from the 3D spatial location of the profiles.

Conclusion

The study area is loaded with objects containing cavities of many shapes and contents, [8] the continentality of the soil is violated by multiple cavities. Their depth ranges from 0.5 m to 5m and their length is 1-5m.

Using the 3D method, 2D georadiolocation profiles were investigated and, according to the interpretation of the obtained results, a corresponding radio image of a banded continuous object was observed, from which it follows that the object is a body containing hollow spaces of anthropogenic origin at an average depth of 5 m, with a length of 16 m. A radio 3D image of a possible partially collapsed underground passage or partially disintegrated foundation remains is presented

References

1. Odilavadze D., Kiria J., Ghlonti N., Yavolovskaya O., The Results of Archaeogeoradiolocation Investigations of the Territory Inside the Rampart of St. Sophia Church of Khobi. // „Moambe" Bulletin of the Georgian National Academy of Sciences, V.14, n.4, 2020, pp. 51-56.
2. Chelidze T., Odilavadze D., Pitskhelauri K., Archaeogeophysics in Georgia-New Results, New Prospects. Journal of Georgian Geophysical Society. // Proceedings OF THE GEORGIAN NATIONAL ACADEMY OF SCIENCES. Series of History, Archeology, Ethnology and Art History, №.15, 2013, pp. 24-34.
3. Odilavadze D. T., Chelidze T.L., A Preliminary GPR investigation of Metekhi Cathedral and the surrounding area. // Journal of Georgian Geophysical Society, № 14, 2011.
4. Kofman L., Ronen A., Frydman S., Detection of model voids by identifying reverberation phenomena in GPR records. // Journal of Applied Geophysics. (59), 2006, pp. 284-299.
5. Odilavadze D., Chelidze T., Yavolovskaya O., Some georadiolocation images of cylindrical bodies built with different dielectric fillers, placed in a dielectric environment. Mikheil Nodia Institute of Geophysics of Ivane Javakhishvili Tbilisi State University, Tbilisi, Georgia, International Scientific Conference "Geophysical Processes in the Earth and its Envelopes". // Proceedings, ISBN 978-9941-36-147-0, Tbilisi, Georgia, November 16-17, 2023, pp.217-220.
6. Odilavadze D. T., Chelidze T. L., Ghlonti N. Y., Yavolovskaya O.V., 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. // Journal of the Georgian Geophysical Society, e-ISSN: 2667-9973, p-ISSN: 1512-1127. Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v. 25(1), 2022, pp.21-28.
7. Odilavadze D. T., Chelidze T. L., Yavolovskaya O. Y., THE RADIO IMAGE OF AN OBJECT WITH AN ELONGATED, FACE-FRAGMENTED, DIELECTRICALLY COMPLEX STRUCTURE WAS STUDIED USING THE METHOD OF GEORADAR PHYSICAL MODELING. // Journal of the Georgian Geophysical Society, e-ISSN: 2667-9973, p-ISSN: 1512-1127, Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v. 27(2), 2024, pp.15 – 28.
8. Odilavadze D. T., Chelidze T. L., Yavolovskaya O. Y., Preliminary archaeogeophysical survey of the construction site in the vicinity of the Narikala Citadel. // Journal of the Georgian Geophysical Society, e-ISSN: 2667-9973, p-ISSN: 1512-1127, Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v. 28(1), 2025, pp.27-35
9. European gravures of old Tbilisi ISBN 978-9941-487-96-5 /Artanuji Publishing www.artanuji.ge, Author-compiler Sulkhan Saladze, 2020, pp.197.