საქართველოს მეცნიერებათა ეროვნული აკადემიის მოამბე, ტ. 14, №4, 2020
BULLETIN OF THE GEORGIAN NATIONAL ACADEMY OF SCIENCES, vol. 14, no. 4, 2020

Geophysics

The Results of Archaeogeoradiolocation Investigations of the Territory Inside the Rampart of St. Sophia Church of Khobi

Davit Odilavadze*, Jemal Kiria*, Nugzar Ghlonti*, Olga Yavolovskaya*

*M. Nodia Institute of Geophysics, Ivane Javakhishvili Tbilisi State University, Tbilisi, Georgia

(Presented by Academy Member Tamaz Chelidze)

St. Sophia Church was built at the beginning of the 17th century on the flattened surface of a hill 3-4 m above the church yard. The building occupies quite significant part of the hill. The goal of our studies was to determine the possible buried objects near the surface and reveal archaeological areas on the territory inside the rampart of the church. We conducted preliminary archaeogeoradiolocation research using georadar ZOND 12e, in the vicinity of the church of St. Sophia. We selected four areas for primary georadiolocation investigations. We may say that the studied, with its four parallel, similar georadiolocation sections, gives a radio image of an underground archaeological architectural complex structure. Two-dimensional and three-dimensional interpretation of the results using the software PRISM 2.5 and VOXLER 3D showed the possibility of the existence of near-surface remains of a complex underground structure of anthropogenic origin. A radio image of a structured object was revealed with a periodic arrangement of arched-type roofing in two- and three-dimensional spaces, which can be associated with an architectural object. This result is an important achievement of such science as archaeogeoradiolocation that can be used to find and determine the location of buried objects in historical territories like Georgia. © *2020 Bull. Georg. Natl. Acad. Sci.*

St Sophia Church of Khobi, archaeogeoradiolocation, radio image, georadar ZOND 12e, softwares PRISM 2.5 and VOXLER 3D.

Materials and Methods

In November, 2020 the Sector of Applied and Experimental Geophysics of Institute of Geophysics organized an expedition on the territory of St. Sophia Church of Khobi. The investigations were carried out with Georadar ZOND 12e equipped with 500 GHz screened transmissive/ receiving antenna. The obtained results were processed using the software PRISM 2.5. The 3D graphics were received by data interpretation with software PRISM 2.5 and VOXLER 3D (RADAR Systems, Inc. Prizm2, Software Package, Version 2.5 Users Manual Riga, 2010 pp.38-44). We used the similarity theory and physical modeling method [1-5] for solution of the direct and inverse problems of electrodynamics for verification of the radio images at interpreting the georadiolocation profiles.

We selected four areas for primary georadiolocation investigations. A relatively plane area of the church yard: A – four 14 m long parallel profiles; B – two 30 m long parallel profiles; C – two concentric 80 m and 86 m long profiles around the church; D – three profiles on the hill (one of them is 16 m long and runs alongside the church wall) (Fig. 1).

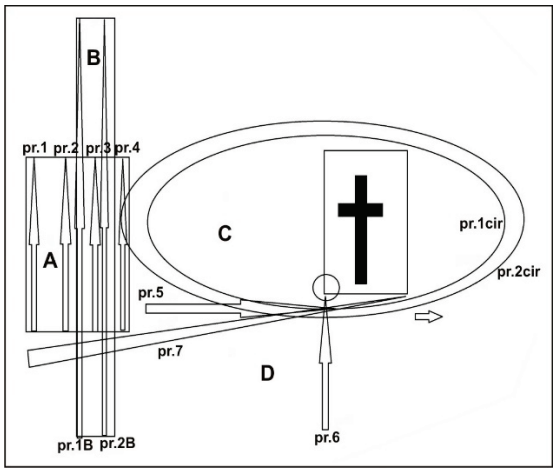


Fig. 1. The profiles grouped by the areas.

Results and Discussions

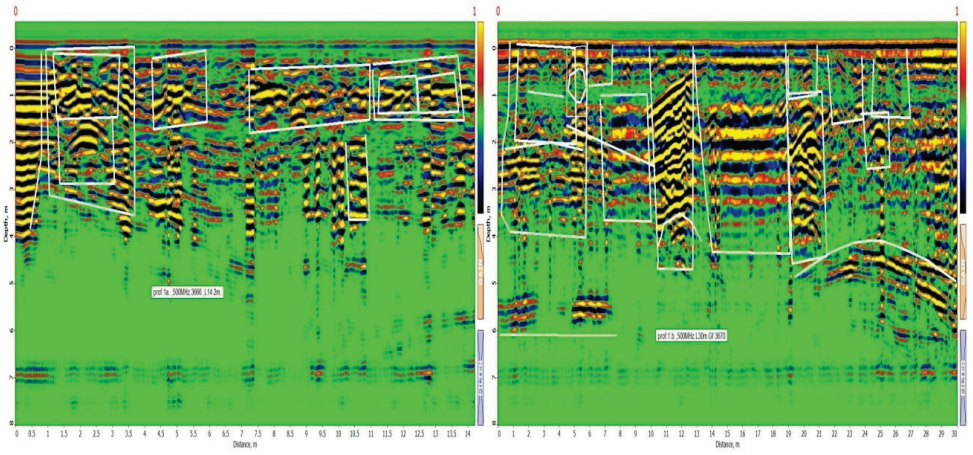
At 1-3 m distance of Profile 1A (Fig. 2a) we obtained a radio image characteristic of a holewith a depth up to 1.5 m, below which we can see a tube-like void. At 4-5 m distance there is a radio image of a hole-shape void (so called "bow-tie"). A radio image of a complex shape body located at 7.5-10 distance belongs to probable fragments of an architectural construction. At the following distances we can also see the radio images of hole-like contours.

Below 20 m depth we can see radio images corresponding to foundation remains.

We may say that the studied ***Area-A***, with its four parallel, similar georadiolocation sections, gives a radio image of an underground archaeo-logical architectural complex structure.

In the ***Area-B*** we made two parallel 30 m cross sections south to the rampart gate. The profile directions and titles are shown with transparent arrows (Fig. 1). We will consider one of profiles from ***Area-B*** (Profile 1B) as an illustration.

The radar survey (Fig. 2b) shows the radio images of several near-surface bodies. At the 4 m depth and 0-6 m distance of this symmetric and probably anthropogenic origin area we can see two fragmented constructions, each having 2 m length and arranged one above the other. One has partially



a **b**

Fig. 2. a) The georadiolocation section of the profile 1A was obtained by 500 MHz antenna on a 14 m long and 7 m penetration depth profile. Radio images of linear tube-like objects were obtained from parallel profiles 2A, 3A, 4A.

b) The radar survey of Profile 1B, length – 30 m, penetration depth – 7 m.

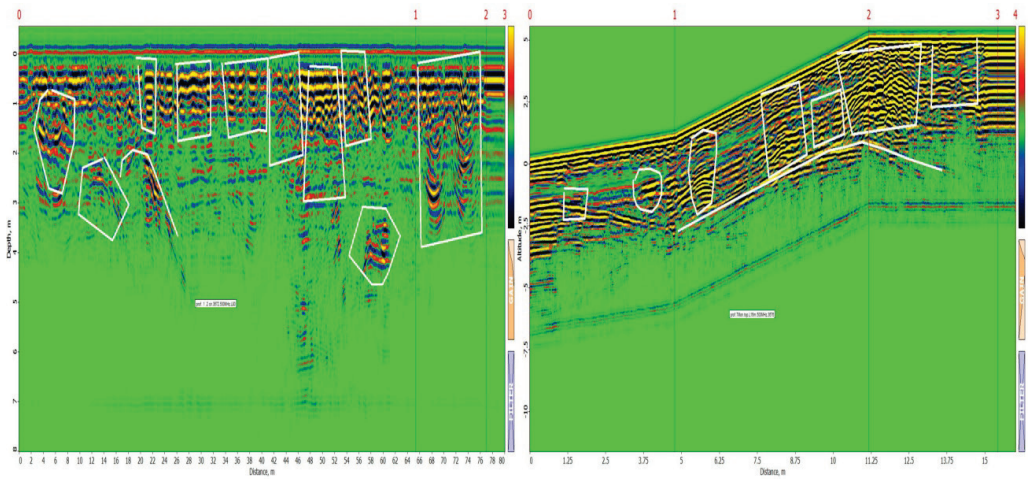
collapsed and the other has survived relatively safe. At 11-13 m distance we distinguished the remains of a probable foundation, the upper part of which is declined towards the horizon. Under it, at 3-4 m depth there can be seen a void. At 8-10 m distance and 14-19 m depth we can see a clear geometrical space with a homogenous lineup texture down to 3.5 m depth. It might be a man-made object with wavy-arch roof. The construction leans against the foundation remains located at 19-21 m distance and 4 m depth. We also revealed the radio images of large construction bodies at 6m depth and 0-3 m, 5-8 m at 20-30 m distances (arch-shape boundary) with 1m thickness. Some voids were distinguished at 5-6 m and 25-26 m distances near the surface.

A number of objects were revealed on both the first and second parallel profiles, which indicates their longitudinal location.

Area-C. On the territory around the church we constructed more or less concentric ellipse-shape 80 m and 86 m long profiles (see Fig. 1). Fig. 3a shows a concentric profile ellipse-shaped Profile 1cir.

correspond to the radio images of architectural objects. At 4-8 m distance and 1-3 m depth we revealed a covered void. Its radio image is quite symmetric and therefore, may correspond to a man-made object. At 12-14 m and 18-22 m distances we can see voids with partially damaged oval-shape coverings at 2-2.5 m depths. At 24 m distance there are the remains of a probable foundation at 0.5-1.5 m depth. At distances 26-32 m and 36-40 m and depth 0-2 m there must be foundation remains as well. There is a hole-like void at 42-46 m distance. At 48-54 m distance, up to 3 m depth there is also a void of 0.6-0.8 m thickness with a firm covering. We distinguished a probable void at 58-62 m distance and 3.5-5 m depth. At 66-76 m distance we revealed a void with firm covering, which is based on two parallel multi-fragment "foundations".

On ellipse-shaped Profile 2cir we revealed a radio image of a clearly expressed linear object with the image corresponding to a hole-like void at 42-46 m distance. There is also a void at 48-54 m distance up to 3 m depth. The void has a firm covering and 0.6-0.8 m thickness. At 58-62 m



a **b**

Fig. 3. a) The first ellipse-shaped profile (Profile 1cir, the length – 80 m).

b) Profile 7 – images of the anomaly locations interpreted in accordance with relief.

On the GPR-section (Fig. 3a), according to the electromagnetic wave lineup configuration, we may distinguish some inhomogeneities, which may

distance and 3.5-5 m depth we distinguished a probable void. At 76-82 m distance, like an ellipse-shaped Profile 1, we distinguished a void, which

had a firm covering placed on the two parallel multi-fragmental foundations.

Area-D. The GPS-coordinates of the building's corners, shown by arrows are: 0736017; 4693635 (Fig. 1). We illustrate a georadar section made on Profile 7 along the path leading to the church hill up to the second angle of the church.The length of the profile is 16 m. The relief image of the profile is shown in Fig. 3b.

construction under the ground. For illustration, we also present work [5], which shows the photo of explored territory after the archaeological excavations Fig. 6 (left), as well as 3D images – results of the georadiolocation investigations carried out by the VOXLER 3D method before excavations Fig. 6 (right) on the territory inside the rampart of the Church of Dormition of the Virgin of Khobi. In Fig. 6 (right) the traces of profiles Pr1,

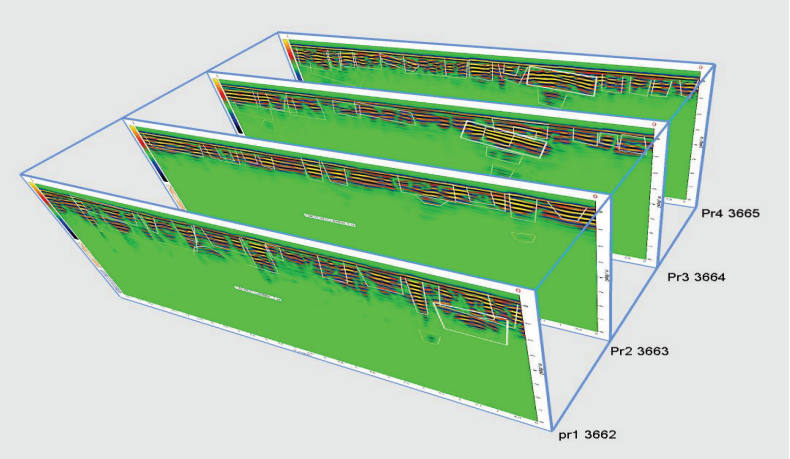


Fig. 4. A spatial image of parallel profiles Pr.1, Pr.2, Pr.3, Pr.4 in the ***Area-A*** (see Fig.1) processed by the similar amplification option. Linear radio images are revealed at 2-3 m depths on all four parallel profiles.

At 2-3 m distance and 0-1 m depth we revealed a radio image of a hole with a firm covering. At 5.5-6.5 m distance and 1 m and 2.5 m depths we discovered two tubular bodies arranged one above the other. Alongside them, at 7.5-9.5 m distance we revealed the radio images of holes also arranged one above the other. A symmetric underground object is clearly distinguished at 10-14 m distance up to 3 m depth.

Spatial interpretation of profiles. Fig. 4 shows the 3D image of the results obtained from ***Area-A***, processed by VOXLER 3D software. The image clearly shows a structured periodicity of nearly equal arch-like spaces. This indicates to their anthropogenic genesis.

The radio images of the arch-like covering of buildings, which are characteristic of all four parallel georadar sections, clearly indicate the existence of the remains of an architectural

Pr2, Pr3, Pr4, performed before excavation, are shown. Note remarkable accordance of excavated archaeological objects with locations of georadar anomalies.

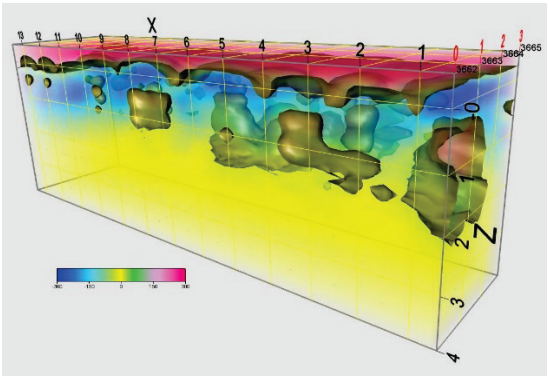


Fig. 5. A symmetric arrangement of near-surface probable voids on the parallel profiles Pr.1, Pr.2, Pr.3, Pr.4 in the ***Area-A*** (see Fig. 1). The profile images were produced using software VOXLER 3D compatible to PRISM 2.5.

Fig. 5 shows the results of interpretation of georadar data with locations of near-surface voids, walls, foundation and staircases. The images of the profiles are processed by the use of VOXLER 3D software compatible to PRISM 2.5. Note remarkable accordance of excavated archaeological objects with locations of georadar anomalies.

we have a detail radio image of a whole complex architectural construction to 1-6 m depth. We performed the 3D interpretation of images of the buried objects using PRISM 2.5 and VOXLER 3D software.

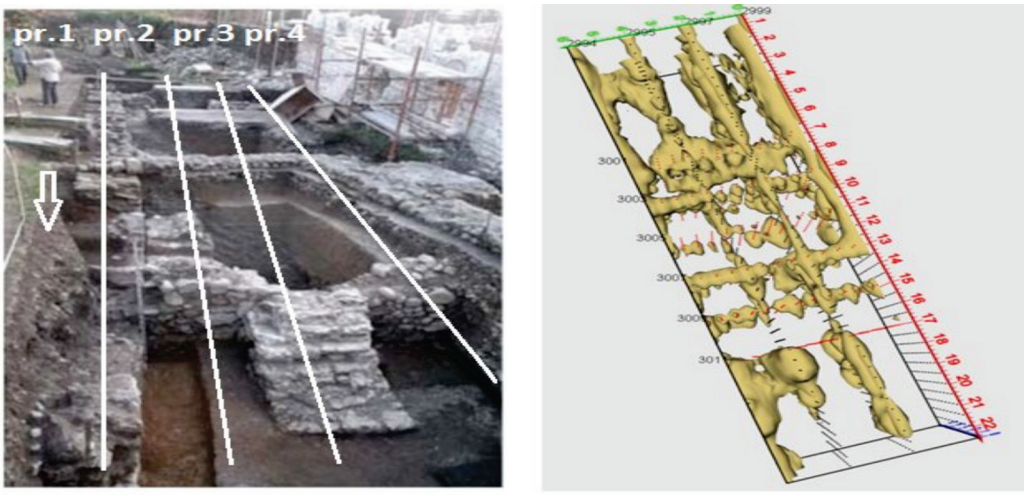


Fig. 6. A photo depicting the studied territory alongside the rampart of the Church of Dormition of the Virgin of Khobi after the excavations (left). It shows locations of the parallel profiles Pr1, Pr2, Pr3, Pr4 performed before excavation.

Conclusion

According to the results of georadiolocation data interpretation of the the selected areas by PRISM 2.5 software (two parallel 30 m long profiles, two 80-86 m long concentric ellipse-shape profiles, two perpendicular profiles intersecting each other at the church corners, a 16 m long relief profile and four parallel 14 m long profiles) we may conclude that

The authors are thankful to Poti and Khobi Episcopate of the Patriarchate of Georgia, without the invitation and support of which we would not be able to fulfill the preliminary georadiolocation studies.

Source of funding: TSU, Institute of Geophysics.

გეოფიზიკა

ხობის წმ. სოფიოს ეკლესიის გალავნის შიდა ტერიტორიის არქეოგეორადიოლოკაციური კვლევის შედეგები

დ. ოდილავაძე*, ჯ. ქირია*, ნ. ღლონტი*, ო. იავოლოვსკაია*

*ივანე ჯავახიშვილის სახ. თბილისის სახელმწიფო უნივერსიტეტი, მ.ნოდიას გეოფიზიკის ინსტიტუტი, თბილისი, საქართველო

(წარმოდგენილია აკადემიის წევრის თ. ჭელიძის მიერ)

წმ. სოფიოს ეკლესია მე-17 საუკუნის დასაწყისში აუგიათ მცირე გორაკის მოსწორებულ ზედაპირზე, რომელიც ეზოს გადმოჰყურებს 3-4მ სიმაღლიდან და მნიშვნელოვანწილად იფარება ეკლესიის ნაგებობით. კვლევის მიზანს წარმოადგენდა გალავანსშიდა ტერიტორიის მონიშნულ ფართებზე რადიოსახეების მიხედვით ახლოქვეზედაპირული განთავსების ობიექტების რაობის განსაზღვრა, არქეოლოგიურად პერსპექტული უბნების დაფიქსირება. თსუ, გეოფიზიკის ინსტიტუტის მიერ ხობის წმ. სოფიოს ეკლესიის მიმდებარე ტერიტორიაზე ჩატარდა პირველადი არქეოგეორადიოლოკაციური გამოკვლევა. პირველადი გეორადიოლოკაციური გამოკვლევებისათვის შეირჩა ოთხი უბანი. შეიძლება ითქვას, რომ გამოკვლეული ერთ-ერთი უბანი, ოთხი პარალელური გეორადიოლოკაციური ერთმანეთის მსგავსი ჭრილით, გვაძლევს რთული არქიტექტურული კომპლექსის რადიოსახეს მიწის ქვეშ განლაგებულ არქეოლოგიური არქიტექტურული ობიექტისთვის. მიღებული შედეგების ორ და სამგანზომილებიანმა ინტერპრეტაციამ „Prism 2,5" და „Voxler 3D" პროგრამების გამოყენებით წარმოაჩინა ახლო ქვეზედაპირული განლაგების დაფარული რთული ნაგებობის ნაშთების არსებობის შესაძლებლობა. ორ- და სამგანზომილებიან სივრცეში გამოჩნდა პერიოდული განლაგების მქონე სტრუქტურირებული ობიექტის რადიოსახე, რაც შესაძლებელია არქიტექტურულ ობიექტს უკავშირდებოდეს. ეს შედეგი არის ისეთი ინტერდისციპლინარული მეცნიერების მნიშვნელოვანი მიღწევა, როგორიც არქეოგეორადიოლოკაციაა და შეიძლება გამოყენებულ იქნეს მიწის ქვეშ განლაგებული რთული არქეოლოგიური არქიტექტურული ობიექტების მოძიებარაობის დადგენის მიზნით ისეთ ისტორიულ ტერიტორიებზე, როგორიცაა საქართველო.

REFERENCES

1. Odilavadze D.T., Chelidze T.L. (2013) Fizicheskoe modelirovanie georadiolokatsionnogo polia v priamoi i obratnoi zadachakh elektrodinamiki. *Geophysical Journal*, 35 – 4: 154-160 (in Russian).
2. Odilavadze D.T., Chelidze T.L. (2017) Fizicheskoe modelirovanie lavovykh trubok v georadiolokatsii. *Transactions of Mikheil Nodia Institute of Geophisics*, LXVII: 129-142, Tbilisi (in Russian).
3. Odilavadze D., Chelidze T., Tskhvediashvili G. (2015) Georadiolocation physical modeling for disk-shaped voids. *Journal of the Georgian Geophysical Society. Physics of Solid Earth*, 18: 26-39.
4. Odilavadze D., Chelidze T., Ghlonti N., Kiria J., Tarkhnishvili A. (2018) Fizicheskoe modelirovanie modeli tipa sloistyi klin v priamykh i obratnykh zadachakh georadiolokatsii. *Transactions of Mikheil Nodia Institute of Geophisics,* LXIX: 44-61, Tbilisi (in Russian).
5. Odilavadze D., Chelidze T., Ghlonti N., Kiria J., Yavolovskaya O., Tarkhnishvili A. (2019) Results of GPR survey of buried archaeological objects on the southern part of territory of the Blessed Virgin Mary assumption Khobi Monastery. *Transactions of Mikheil Nodia Institute of Geophisics*, LXX: 16-25, Tbilisi (in Georgian).

Received October, 2020