# 9.3 WATER-BORNE ARCHAEOGEOPHYSICAL INVESTIGATIONS AT LAKE İZNIK

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**ABSTRACT**

Waterborne geophysical investigations are playing an increasingly prominent role in various applications, including mineral exploration, solving engineering challenges, and the detection of buried objects. With the continuous development of methods and procedures, the accuracy of results, particularly in shallow research, has significantly improved. This particular study focuses on the investigation of a basilica structure located 20 meters from the shoreline of İznik Lake in the Bursa province, employing geophysical methods as its primary approach. The study utilizes two main geophysical techniques: direct current resistivity and ground-penetrating radar. For the DC resistivity method, we employed both multi-channel setups with 11 mobile electrodes and 32 fixed electrodes. Additionally, we utilized antennas operating at 200 and 500MHz frequencies for the ground-penetrating radar. Data collection was carried out along profiles, with real-time GPS data used to pinpoint each data location. Both datasets were subsequently processed using appropriate data analysis techniques, and the results are presented in the form of depth slices. It's worth noting that İznik Lake has been affected by a recent decline in water levels due to drought and excessive water consumption. Consequently, some of the structures under investigation now lie above the water's surface. While this situation has improved signal penetration for the ground-penetrating radar method, it has presented challenges for surface measurements, particularly in conducting electrical resistivity measurements using mobile setups. In the results we present, sections of the existing basilica structure's walls are clearly visible. Below the water floor, we've observed linear features that do not align with the visible structure boundaries. It is recommended that these anomalies be further explored through underwater excavations.

**KEY WORDS :** water-borne resistivity, GPR, underwater archaeology

**INTRODUCTION**

Archaeological research is predominantly conducted on land; however, underwater archaeology plays a crucial role in uncovering submerged structures and artifacts for various purposes. Conducting underwater excavations requires distinct methods and specialized equipment, contributing to increased research costs and slower progress. Geophysical studies conducted on the water's surface or seabed offer unique insights compared to land-based research. In some cases, adaptation of land-based archaeological geophysics measurement systems can be applied to underwater environments (Lawrance et al., 2004; Boyce et al., 2006; Müller et al., 2009; Passaro, 2010; Papatheodorou et al., 2011; Kritikakis et al., 2015; Smyrdanis et al., 2016; Qin et al., 2018). However, investigating man-made structures submerged beneath sediments on the water floor poses challenges related to water chemistry and depth, limiting measurement resolution and sensitivity. This project focuses on the basilica structure discovered when Lake Iznik's water level receded in 2014. Subsequent scientific research revealed multiple phases of the basilica's construction, making it a significant element in the Christianization of Nikaia. It is believed to have been the site of the First Council of Nicaea in AD 325 (Şahin, 2020). Moreover, being one of the few known churches from the Early Christian period in Anatolia adds to its historical importance. Consequently, a project was initiated to explore other structures associated with the Iznik Lake Underwater Basilica Church using geophysical methods, as indicated in Figure 1.

Figure1 Aerial view of the basilica structure, known as the Sunken Church, determined in 2014 in Lake Iznik

During the project's preparation phase, measurements were initially planned to be conducted by floating equipment on the water surface, allowing for rapid scanning of large areas. However, due to portions of the building protruding up to 50 cm above the water surface in some areas, creating continuous measurement profiles proved challenging. As a result, a fixed measuring system was employed for electrical resistivity measurements, enabling more precise data collection. The project utilized direct current resistivity and ground radar measurements to survey the basilica's perimeter, facilitating research up to a depth of 2 meters beneath the shallow water floor, leading to various significant discoveries.

**METHOD and APPLICATION**

In the geophysical investigations conducted at Lake Iznik, a combination of ground-penetrating radar and direct current resistivity methods were employed for shallow subsurface exploration. Additionally, Side Scan Sonar (SSS) was utilized to determine water depth and obtain a comprehensive overview of the lakebed. For the Direct Current Resistivity method, a measurement device equipped with two current electrodes and nine potential electrodes was deployed, with the equipment mounted at the rear of a boat. During the fieldwork, electrode spacing was consistently set at 2.5 meters. The measurements were conducted using a dipole-dipole array configuration, and a total of eight dipole levels (n=8) were recorded with the nine potential electrodes integrated into the system. Figure 2 provides a visual representation of the measurement setup along with a photograph captured during the data acquisition process.

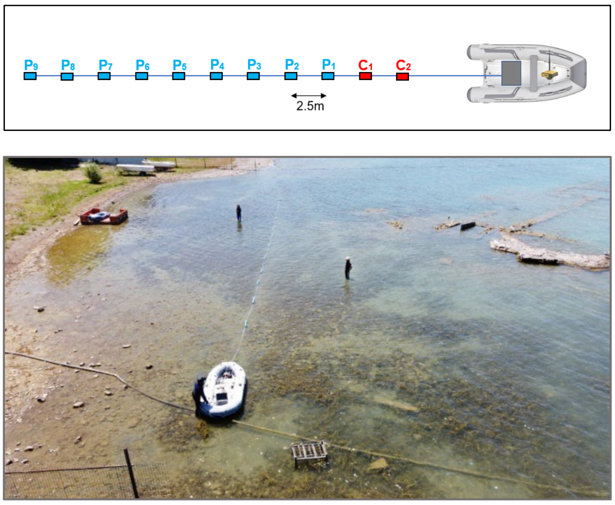


**Figure2** Aerial view of DC resistivity measurements at Lake İznik

The current water depth in the study area ranges from 0 to 2 meters. Given these conditions, ground-penetrating radar was deemed suitable for the study. The radar system's antennas were floated above the water surface using an inflatable boat, allowing signals to penetrate beneath the lakebed (see Figure 3). The depicted antenna operates at 200MHz, and measurements were also conducted using a 500MHz antenna.


**Figure3** GPR measurement setup with 200MHz antenna

## DISCUSSION and RESULTS

The resistivity data measured at Lake İznik was inverted with a 3D smoothness-constrained least squares algorithm. The final data misfit was 3.2% which was satisfactory. A depth slice from the 3D resistivity model is given in Figure 4a. GPR data were also processed and depth slices are generated. A sample GPR depth slice for the same depth is given in Figure 4b.

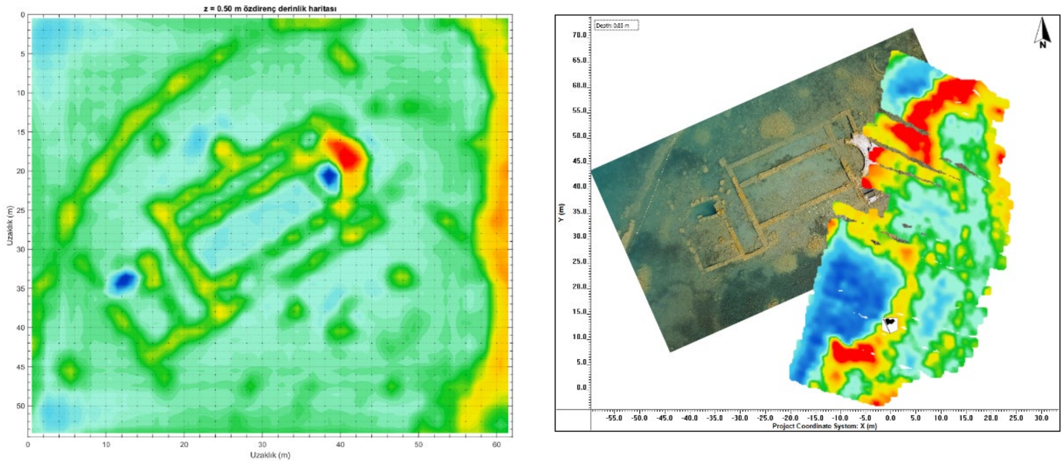


**Figure4** (a) Resistivity and (b) GPR depth slices from 0.8m below water surface

## CONCLUSION

GPR and DCR are highly suitable methods for near-surface research. In this study, we explore their application in an aquatic environment. Our research focuses on utilizing these methods to image submerged archaeological remains within Lake Iznik. Notably, various indicators and findings were uncovered during our investigations, which were subsequently reported to the excavation team.

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