Magnetic Mapping and Seismoacoustic Investigations in the Altinum Submerged Archaeologic Site

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Abstract. The roman fortress from Măcuca Hill, identified by Romanian archaeologists, until now, as the garrison Altinum, north of Oltina village, northeast of Oltina Lake, has no observable features to be ascribed to late Roman period. On the eastern bank of the lake the team in charge with the archaeological research in Capul Dealului site made land surveys on the northern slopes of Măcuca Hill, looking to the Danube’s Island Ostrovu Iepurașu (Rabbit’s Island), some hundred meters north of the timber and earth playing-card fort described a century ago by Pamfili I Polonic. The archaeologists from Constanța found in 2006 survey convincing remains of a monumental stone wall, hidden in the forest. If the remains depend of a fortress, or of a harbor facility, only the seismoacoustic and magnetometric investigation research will answer. In this work we present the results of a multidisciplinary study for characterising the archaeological site of Altinum (Dobrudja, Southern Romania). The investigation has been performed by means of the integrated use of two different high resolution and non invasive geophysical techniques: magnetic mapping, and sidescan sonar measurements. The integrated approach allows us to detect submerged archaeological structures. In particular, our results helped to define spatial pattern of the submerged remains, to define the geometry of the anthropogenic settlements and to obtain detailed information about the composition and the manufacturing processes of different building materials. Magnetic prospecting represents one of the widest employed tools in the geophysical research applied to the archaeological studies. This technique provides a great amount of high-resolution magnetic data in a very small time: up to ten measurements per second. Moreover, because the magnetic equipment is a portable instrument assembled by the user, it may be used in every configuration for investigation the submerged archaeological site. Sidescan sonar profiling is widely applied to support the magnetometric investigation and archaeological prospection. In particular, three-dimensional modelling of sidescan sonar surveys are increasing in popularity, in fact 3D models are much more valuable for archaeological feature interpretation. However, to obtain a higher horizontal and vertical resolution, a sub-metre line spacing is generally needed, making the 3D acquisition more expensive in time in respect of magnetic measurements. The magnetic survey on the water has been carried out using a caesium vapour marine magnetometer G-882 GEOMETRICS and proton magnetometer G-856 for diurnal variations of the natural magnetic field. The sidescan sonar system (Klein Sonar Pro) has two working frequencies (445 KHz and 900 KHz). The 445 KHz frequency was used for discover submerged walls and other archaeological structure. The integration between these two techniques allowed us to define the geometry and the depth of a buried structures.
1. Introduction
Most of third century AD history is taken by military anarchy. The great Roman Empire was already too large, impossible to manage. The role played by the army in society became a plague within the fights for supremacy, each provincial commander taking his chances in deposing or imposing a certain emperor, looking for fortune [1]. In time, barbarian tribes became restless and hungry, being more active as ever. On the Lower Danube the Romans had to face a strong coalition led by Goths, the war raged several times between 247–251 and ended with the disastrous battle from Abrittus were the emperor Decius perished on the field. During late third century, Diocletian initiated reforms meant to put an end to disaster. The one we are referring here is the administrative reform which supposed the split of the ancient provinces [2]. So happened with Moesia Inferior, from which most of its maritime territories were detached, becoming the new province Scythia Minor; later on, its name was changed to Moesia Secunda. In short, the reform imposed by Diocletian, separating the eastern and southern parts of the former Moesia Inferior by its northeastern territory – Scythia Minor – was then not arbitrarily, but according to an old distinction between forested west and steppe-like east. The thesis is illustrated by a map, redrawn and reloaded here as figure 1. The second set of arguments came from the Late Roman sources, mainly Notitia Dignitatum, providing a firm assignation of the main landmarks from the border area either to Moesia Secunda (Odessus, Marcianopolis, Abrittus, Durostorum, Cimbriana, Sucidava, Altinum) or Scythia Minor (Dionysopolis, Zaldapa, Tropaeum, Flaviana, Axiopolis).

![Figure 1. Archaeological situation in the region of the border between Scythia Minor and Moesia Secunda (redraw after [3])](image-url)
At the northern end there is the military port [4] of *Altinum* (figure 2), known from *Notitia Dignitatum* as being the most eastern on Danube from *Moesia Secunda*. The fortress from Măcuca Hill, identified by Romanian archaeologists, until now, as the garrison *Altinum*, north of Oltina village, northeast of Oltina Lake, has no observable features to be ascribed to Late Roman period.

![Figure 2. Photograph of the Altinum archaeological site area](image)

2. **Description of the analysed magnetic field data**

Archaeological geophysical prospection techniques have not previously been applied as part of archaeological investigations in Altinum archaeological site, despite an extensive history of archaeological research in this area. In particular, they have the potential to extend site information beyond the limited spatial extent usually obtained through excavation, and thus promise to enable understandings of village sites as spatially extensive landscapes rather than more restricted spatial nodes [5].

Geophysical investigations were conducted using a Geometrics G-882 marine cesium magnetometer (figure 4) with data collected on a regular grid (density 10m) an area of approximately 100 by 50 meters [6]. Was used a base station location situated outside the survey area to allow the calculation of a diurnal correction value, Geometrics G-856 proton precession magnetometer.

![Figure 3. Magnetic field anomaly map](image)
Positioning information for the survey can be acquired by differential GPS, depending on site conditions, required precision and accuracy of survey information desired survey and speed. The magnetometer data show a number of both discrete and diffuse anomalies which may correlate to submerged artefacts [7] or anthropogenic structure (pipes or metallic objects). The most distinct is a positive monopolar anomaly (yellow circles-east part) of up to approximately 23 nanoteslas (nT) above background centered on the area of the channel and excavation, in an area found to produce the most ceramic material (Figure 3). 

This anomaly continues, with a more diffuse boundary and slightly lower magnetic intensity of between 13-15 nT above background down river (Figure 3- west part).

A negative monopolar anomalies [8] with a minimum intensity of -10 nT below background is located to the south west of the main anomalies (Figure 3) [6]. The results of the magnetometer survey suggest that despite the initial removal of the anthropogenic effects, a significant amount of archaeological artefacts remained in the riverbed [9]. Continuation of the positive anomalies to the west the edge of the survey area leaves open the possibility that other significant archaeological submerged artefacts can be located outside the researched area.

3. Seismo-acoustics method (side scan sonar)
The sidescansonar (figure 6) data also suggests that they are significant the regions in the survey area do not have a large area anthropogenic increase in their magnetic intensity and therefore, it justify a further direct investigation [6]. The sidescansonar results confirm the ability of magnetometer surveys to define the spatial extent of locations (submerged artefacts –possible the walls of the harbour) with rich buried walls in river beach area (figure 5, yellow circles).

The seismo-acoustics surveying has been accomplished using the Klein Side scan sonar system 3900 [10]. Seven possible submerged archaeological objects (more probable of 1-3th century age, with lengths between 6m-8m), have been mapped, scanned and stored in the data base. Some of these objects will be checked by divers and by ROV surveying in the future.
4. Conclusions
The employment of interdisciplinary research methods in archeology has, once again, proven to be highly valuable and effective, as exemplified by the magnetometric and seismo-acoustic prospections of the Altinum archaeological site.

That the use noninvasive techniques and their correlation with topographical information can be used to pertinently elaborate an excavation strategy for the archaeologist, constitutes the main idea advanced in this paper.

Furthermore, the magnetic and side scan sonar methods amply presented above proved to be adequate for identifying possible fortification elements of an ancient harbour.

As the data was registered and processed, there have been notable similarity especially with regard to the submerged artefacts and buried artefacts on the land.

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