# Integrating Photogrammetry and Magnetometry for Archaeological Research at Argamum, Dobruja

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## *Abstract*

*This paper presents the results of an integrated photogrammetric and magnetometric survey conducted at the Argamum archaeological site, located in Dobrogea, Romania. Argamum, a significant roman ancient settlement, provides a rich tapestry of historical and cultural data. The primary objective of this study was to create a detailed digital terrain model (DTM) of two specific perimeters within the site, using advanced photogrammetric techniques, and to complement this with magnetometric data to uncover subsurface features. The photogrammetric survey involved capturing high-resolution aerial imagery using unmanned aerial vehicles (UAVs-PHANTOM IV PRO). The images were processed using specialized software to generate a high-precision 3D model of the terrain. This model provided a detailed and accurate representation of the surface topography, which is crucial for understanding the spatial relationships and structural layout of the archaeological features. In parallel, a magnetometric survey was conducted to detect and map subsurface archaeological remains. This non-invasive method measures variations in the Earth's magnetic field caused by buried structures and artifacts. The magnetometric data revealed several anomalies, indicative of potential archaeological features such as walls, foundations, and other buried structures. The integration of photogrammetric and magnetometric data offered a comprehensive view of the Argamum site, combining surface and subsurface information. This multi-method approach enabled a more detailed analysis of the site's layout and provided insights into the distribution and orientation of archaeological remains. The results of the survey highlighted the effectiveness of using photogrammetry and magnetometry in tandem. The high-resolution DTM facilitated precise mapping and documentation of visible features, while the magnetometric survey added depth by identifying hidden structures. This combined methodology enhances the overall understanding of the site and aids in the planning of future archaeological excavations. Moreover, the study demonstrated the potential of these technologies to significantly reduce the time and cost associated with traditional excavation methods. By providing a non-invasive means of site investigation, photogrammetry and magnetometry allow for the preservation of the site's integrity while still yielding valuable data. In conclusion, the photogrammetric and magnetometric survey at Argamum has provided a detailed and multifaceted understanding of the site. This research underscores the importance of integrating modern geospatial technologies in archaeological investigations. The findings contribute to the broader field of archaeological research by showcasing the benefits of combining different survey techniques to achieve a comprehensive analysis of historical sites.*

**Keywords:** *magnetometry, fotogrametry, drone, archaeology, magnetometer*

## 1. Introduction

The integration of advanced geospatial technologies in archaeological research has revolutionized our ability to explore and interpret historical sites with greater precision and depth. This paper presents the findings from an integrated photogrammetric and magnetometric survey conducted at the Argamum archaeological site, located in Dobrogea, Romania. Argamum, an ancient settlement with significant historical roots, provides a unique opportunity to study the interaction between Greek and Roman cultures in the region.

Argamum, known in antiquity as a prominent Greek and later Roman fortified settlement, was strategically situated near the Danube River in the Roman province of Moesia. Originally established as a Greek trading post, the site was later incorporated into the Roman Empire, where it evolved into a key military and administrative hub. The site features a rich elements of architectural and urban planning elements from both Greek and Roman periods, including defensive walls, public buildings, and residential areas, reflecting its dual heritage and strategic importance.

The primary aim of this study was to utilize advanced photogrammetric and magnetometric techniques to create a detailed digital terrain model (DTM) of two specific areas within Argamum. High-resolution aerial imagery was captured using unmanned aerial vehicles (UAVs), which was subsequently processed to produce a precise 3D representation of the terrain. This model offers crucial insights into the spatial relationships and structural layout of the visible archaeological features, enhancing our understanding of the site's historical development.

In parallel, a magnetometric survey was conducted to investigate subsurface features. This non-invasive method measures variations in the Earth's magnetic field caused by buried archaeological remains, revealing anomalies that suggest the presence of potential structures such as walls and foundations. The combination of photogrammetric and magnetometric data provides a comprehensive view of Argamum, integrating both surface and subsurface information.

The integration of these methodologies highlights the effectiveness of combining modern geospatial technologies in archaeological research. The high-resolution DTM enables detailed mapping and documentation of surface features, while the magnetometric survey uncovers hidden structures, offering a more complete understanding of the site's layout and historical context. This approach not only preserves the integrity of the site but also contributes to the broader field of archaeological research by demonstrating the value of integrating different survey techniques.

In summary, the photogrammetric and magnetometric survey at Argamum underscores the importance of advanced technologies in revealing the complexities of ancient settlements. By combining these techniques, this study provides valuable insights into the Greek and Roman heritage of Argamum, enhancing our knowledge of its historical significance and the interplay of cultures in this strategically important region.

## 2. Methodology

The methodology for this study involved the integration of advanced photogrammetric and magnetometric techniques to capture both surface and subsurface features at the Argamum archaeological site. The approach consisted of two main components: aerial photogrammetry and magnetometry.

### *2.1 Aerial Photogrammetry*

For the aerial photogrammetric survey, we employed a DJI Phantom IV Pro drone. This unmanned aerial vehicle (UAV) was chosen for its high-resolution camera and advanced flight capabilities, which are essential for capturing detailed aerial imagery. The drone was flown over the designated perimeters of the site in a systematic grid pattern to ensure comprehensive coverage[2]. The high-resolution images captured by the drone were processed using DJI Terra software.

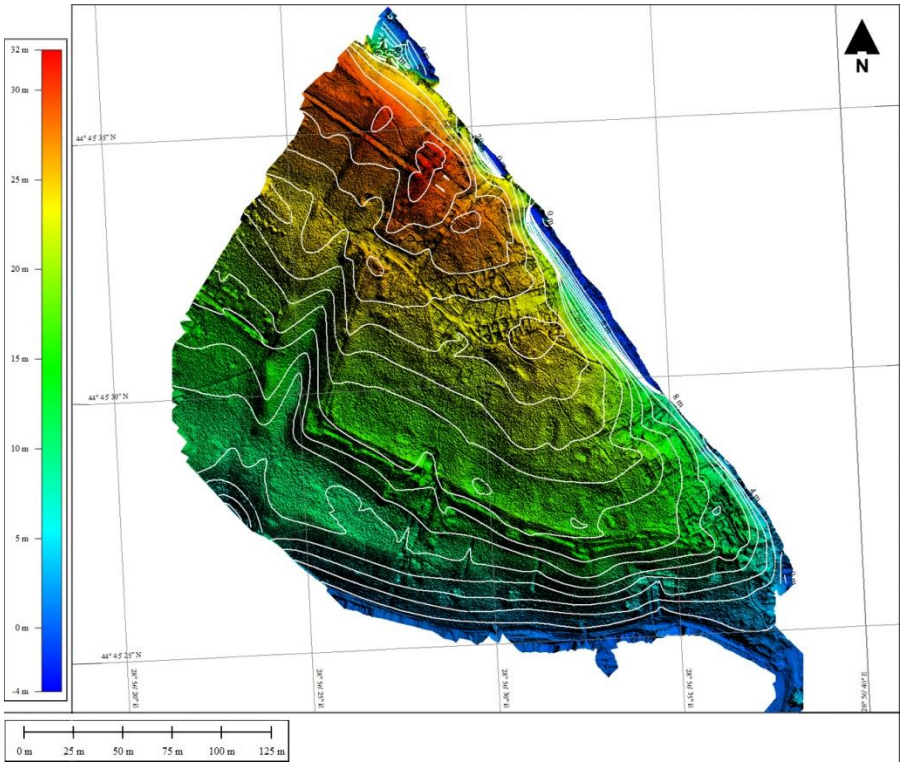


Fig. 1. Detailed digital terrain model (DTM) for Argamum archaeological site

This software was used to generate a detailed digital terrain model (DTM-Figure2) and a high-precision 3D model of the terrain [4]. The resulting models provided an accurate representation of the site's surface topography, which is critical for understanding the spatial relationships and structural layout of the archaeological features.

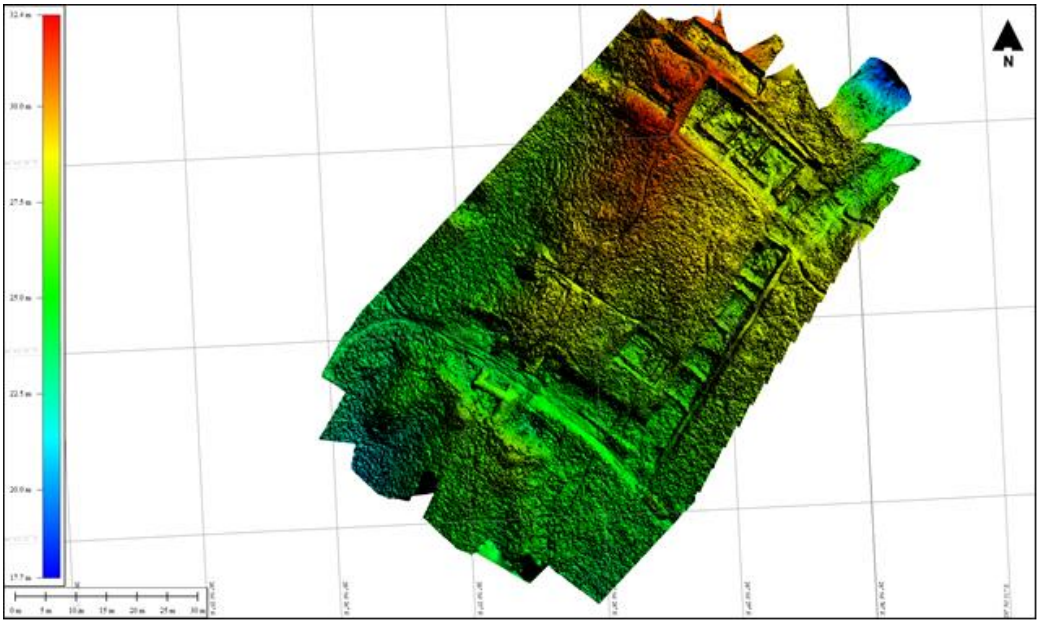

Fig. 2. Detailed digital terrain model (DTM) for investigated perimeter

***2.2 Magnetometry***

In parallel with the photogrammetric survey, a magnetometric survey was conducted using a cesium magnetometer system (G-864-figure 3) from Geometrics.


Fig. 3. Data acquisition using G864 cesium magnetometer

This system was selected for its ability to perform continuous measurements with high sensitivity and accuracy. The magnetometer was used to detect variations in the Earth's magnetic field caused by subsurface archaeological remains [6]. The system's integrated GPS ensured real-time positioning, allowing for precise mapping of magnetic anomalies across the site.

The magnetometric survey was carried out by walking the instrument in parallel transects across the survey area, ensuring comprehensive and systematic coverage. The data collected was processed and analyzed to identify magnetic anomalies indicative of potential archaeological features, such as walls, foundations, and other buried structures[1]. Additionally, during the data processing phase, a map of the vertical magnetic field variation was created for the investigated perimeters [5]. This map provided a detailed visualization of the subsurface magnetic anomalies(A-A', B-B', C-C', D-D'-figure4, offering further insights into the distribution and nature of the buried structures

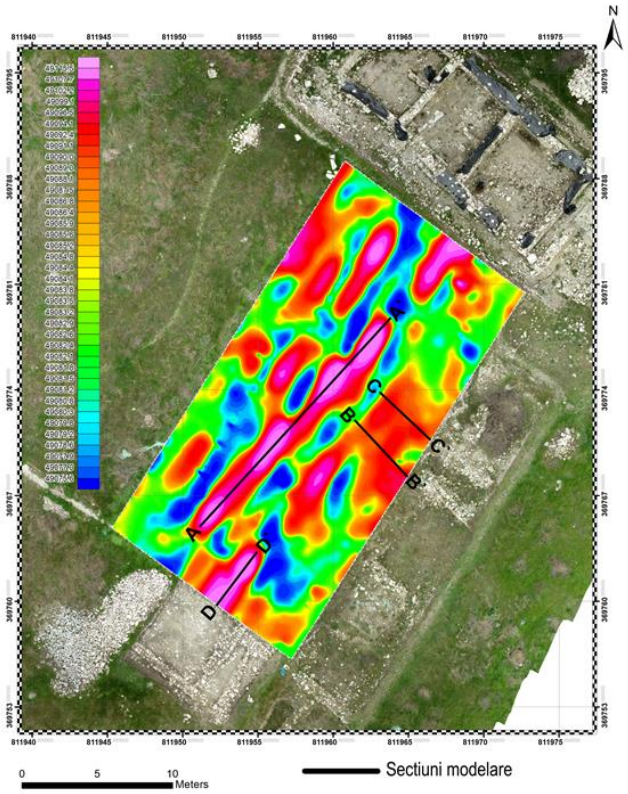


Fig. 4. Vertical magnetic field variation map for the investigated perimeter-Argammum archaeological site.

**3. Data Integration**

The integration of photogrammetric and magnetometric data provided a comprehensive view of the Argamum site. The high-resolution Digital Terrain Model (DTM) facilitated precise mapping and documentation of visible features on the site [3]. By analyzing the detailed topography, various surface characteristics could be identified and classified, leading to a deeper understanding of the site's layout(figure 4). Concurrently, magnetometric data uncovered hidden structures beneath the surface that were not visible through traditional investigative methods.

This combined approach enabled a more detailed analysis of the site's layout, offering valuable insights into the distribution and orientation of archaeological remains. The data obtained contributed to identifying subsurface structures and helped reconstruct the ancient layout of the site while minimizing direct physical interventions.

Fig. 5. DJI PHANTOM IV Drone

By leveraging UAVs (Unmanned Aerial Vehicles- figure 5) and high-sensitivity magnetometers, the study demonstrated the potential of modern geospatial technologies in uncovering and understanding complex archaeological landscapes. These advanced tools not only enhanced the accuracy and efficiency of archaeological investigations but also preserved the integrity of the site by reducing the need for invasive methods, thus protecting the cultural heritage.

**4. Conclusions**

The integration of photogrammetric and magnetometric data provided a detailed and accurate assessment of the Argamum site. Combining the advantages of visible topography with subsurface discoveries led to a deeper understanding of the site's configuration and distribution of archaeological remains.

Reduction of Invasive Methods: The use of advanced technologies, such as UAVs and high-sensitivity magnetometers, minimized the need for direct physical interventions on the site. This approach helped preserve the integrity of the site and safeguard cultural heritage.

Related to detailed site reconstruction, the data obtained were crucial for reconstructing the ancient layout of the site, revealing subsurface structures that were not detectable using traditional methods. This allowed for a more detailed analysis and comprehensive documentation of the archaeological site.

The combined approach of geospatial technologies improved both the accuracy and efficiency of archaeological investigations. These tools provided precise data and streamlined the research process, saving time and resources.

The study highlights the significance and effectiveness of modern technologies in exploring and understanding complex archaeological landscapes. Their use opens up new possibilities for archaeological research and site conservation. These conclusions emphasize the positive impact of advanced technologies on archaeological research and underscore the importance of continuing their use in future investigations.

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