A Historical Mortars Study Assisted by GIS Technologies

Panagiotis Vryonis(✉), George Malaperdas, Eleni Palamara, and Nikos Zacharias

Laboratory of Archaeometry, University of the Peloponnese, Tripoli, Greece
vrionpan@yahoo.gr, envcart@yahoo.gr,
el.palamara@gmail.com, zacharias@uop.gr

Abstract. Geographic Information Systems (GIS) have a vital role on broadening the understanding of the relationship of space, place, and culture. In recent years, a steady increase in the use of GIS in the fields of Archaeology and Cultural Heritage Management can be attested [1]. GIS has nowadays become one of the most versatile and comprehensive analytical tools in Archaeology in terms of handling archaeological data and exploring human space [2].

In this paper we will present the contribution of GIS in the study of the historical mortars of one of the most important castles in the Peloponnese, the castle of Androusa in Messenia. GIS was used in the documentation of the fortification of the castle and in the organization and archiving of the analyses of mortars. An interactive database was created, including the fortification ground plan, photographs and the results of the analytical study of eleven mortar samples. This database offers an easy access platform of the archiving data, with the potential of continuous update, while maintaining the historical and archaeological data in the same time.

Keywords: Castle of Androusa · Mortars · Construction phases · GIS · Interactive database

1 Introduction

1.1 Historical Information About the Castle

The castle of Androusa is located in the homonymous local community of the Municipality of Messenia in the Peloponnese. It occupies the northeastern edge of a low flat plateau (128 m. height) at the western slopes of the plain of Messenia. According to the Aragonese version of the Chronicle of Morea[1], the erection of the castle dates back to the middle of the 13th century and is attributed to the renowned Frankish ruler William Villehardouin [3][2]. During its history, the castle came under the

[1] The Chronicle of Morea is a long history text that contains a great amount of information regarding the Frankish conquest of mainland Greece. It was probably first written in French, but there are also versions in Greek, Italian and Aragonese, all of which have slight differences [15].

[2] The Aragonese version of the Chronicle of Morea mentions in paragraph 216: «…et en la castelania de Calamata fizo fer el castiello de Druges…» (meaning the castle of Androusa) [3].

A. Moropoulou et al. (Eds.): TMM_CH 2018, CCIS 961, pp. 532–540, 2019.
https://doi.org/10.1007/978-3-030-12957-6_37

control of different conquerors (Franks, Byzantines, Venetians, Ottomans), resulting to several additions and alterations to its initial fortification design. More specifically three building phases can be distinguished: 1st building phase during the Frankish period (southeastern tower), 2nd building phase during the Byzantine period (eastern and southern fortification), and 3rd building phase during Ottoman period (northern fortification) (Fig. 1) [4].

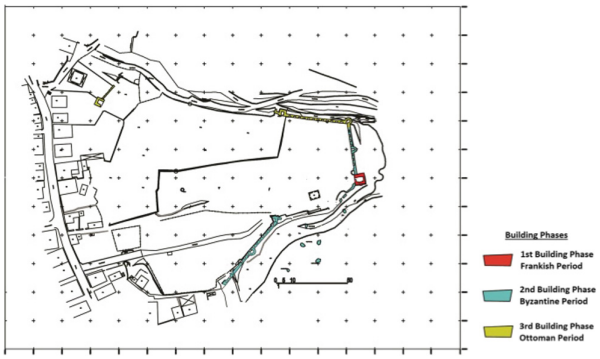

Fig. 1. Plan of the castle of Androusa depicting the building phases of its fortification

As most medieval castles, the ground plan of the curtain wall is trapezoidal and generally follows the contours of the terrain. The walls are reinforced by towers of various shapes placed in unequal intervals. The inner face of the walls has a series of blind relieving arches on which the wall-walk of the castle is housed. Unfortunately, only a small part of the castle remains today, mainly due to the modern village of Androusa, built in the northern and western sides of the castle. The only parts of the castle that are preserved are the eastern wall, parts of the southern and northern wall and six towers, whereas the western part of the fortification is completely missing [5].

During recent years, the castle underwent a series of restoration works aiming to its preservation. The most recent restoration project lasted from 2012 until 2015 and included the restoration of the eastern section of its fortification.

1.2 The Use of GIS

The study of the castle of Androusa was implemented as part of a research project, involving the use of new technologies and archaeometric analytical techniques and focusing mainly on the fortification of the castle, the mortars used for its construction and the relation of the castle with its landscape [6].

An essential tool in the study of the castle was GIS (Geographic Information Systems). GIS is a computer-based technology that is used to produce, organize and analyze spatial information. The capabilities of GIS include database management, mapping, image processing and statistical analysis [7]. GIS provides the potential to update geographical information index in a continuous and interactive way, to process and store large volume of different source data and to create thematic maps based on specific inquiries [8]. In our case, the use of GIS served a twofold purpose: (1) to

represent the ground plan of the castle and (2) to aid the organization, documentation and archiving of the analyses of the historic mortar samples that were collected from the masonries of the monument. More specifically, GIS helped in the identification of parts of the castle that were missing and in the examination of the historic mortars that had been used in each building phase, establishing some chronological relationships between the different fortification areas.

2 Methodology and Results

2.1 The GIS Map of the Castle

As already mentioned before, the castle of Androusa is not preserved intact. Large parts of the northern and southern sides of its fortification are missing or lying in ruins. However, the biggest problem is located on the western side of the castle, where there are no visible traces of the fortification, except from a single tower. As a result, the whole image of the castle looks quite fragmented, providing limited information about it.

Initially, an effort was made to create a representation of the castle by employing the GIS ArcMap10 program and various maps, as well as, satellite and aerial photos of the region. The idea was to use the collected data and the geomorphology of the landscape as guidelines to make a hypothetical representation of the actual form and shape of its fortification ground plan. The datasets containing different type of information had to be digitized in different layers in the GIS program in order to be used in the process.

Georeferencing, the initial step when using GIS, is the procedure of transforming a map image to a reference coordinate system in order to be used by GIS software [9]. All the maps and the photos of the castle were georeferenced on the EGSA'87 coordinate system that is used in Greece and were inserted as layers in the GIS program.

An excerpt map of the region of Androusa was obtained from the LandSat (2007) and was used as the basic reference map. Two extra maps of the castle were also used: (1) a topographical map provided from the Ephorate of Antiquities of Messenia, and (2) an old hand made map[3] made by the French expeditor A. Bon during his visit in Androusa published in 1969 (Fig. 2) [10]. The topographical map depicted the parts of the castle that are preserved today and provided an accurately coordinated ground plan of the fortification, since it had been created with the use of new GPS systems. The old map of A. Bon proved to be an excellent source of information about the missing parts of the fortification of the castle, since it depicted remnants of the western, southern and northern sides that today are not visible or preserved. Both maps were digitized in different layers and then they were overlaid and correlated, resulting to a more complete image of the castle[4].

[3] Old maps constitute a valuable source of information regarding the historical landscape. In recent years, they are widely used in archaeology, mainly due to the rapid increase of the use of GIS and the potentials it offers [9].

[4] The correlation of the maps was based on the coordinates of the digitized fortification plan of the topographical map, provided by the Ephorate of Antiquities of Messenia since it was more accurate.

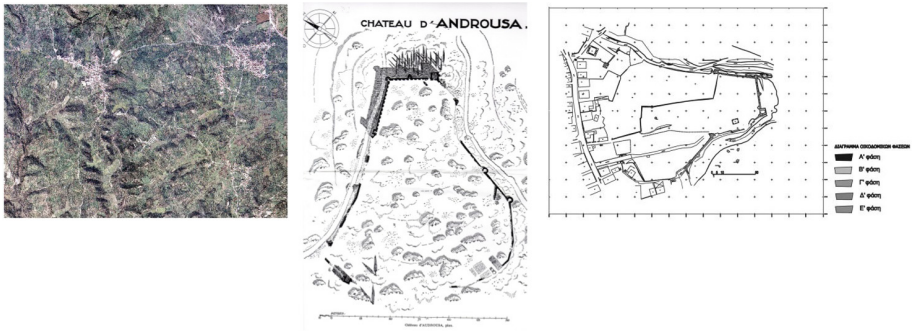

Fig. 2. Maps of the castle of Androusa. From left to right: Excerpt map of the region of Androusa (LandSat 2007); Depiction of the castle according to A. Bon [10]; Topographical map of the castle [4]

The final step was to connect the parts of the castle using polylines, thus completing the missing sections. This process was based on the geomorphology of the terrain and the orientation of the existing fortification parts. The result was a hypothetical representation of the castle, which seems to cover an area of approximately 20.000m^2 (Fig. 3).

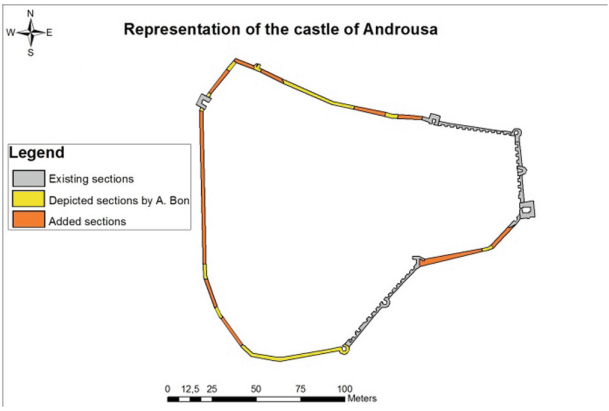

Fig. 3. Representation of the castle of Androusa based on the use of GIS

Based on the digitized map which was produced a landscape and viewshed analyses were carried out, showing that the location of the castle had been carefully selected in order to be: (1) well protected, (2) have proximity to fertile lands and natural water sources, (3) provide a good oversight of the wider area. However, the details of these analyses are beyond the scope of this paper (Fig. 4).

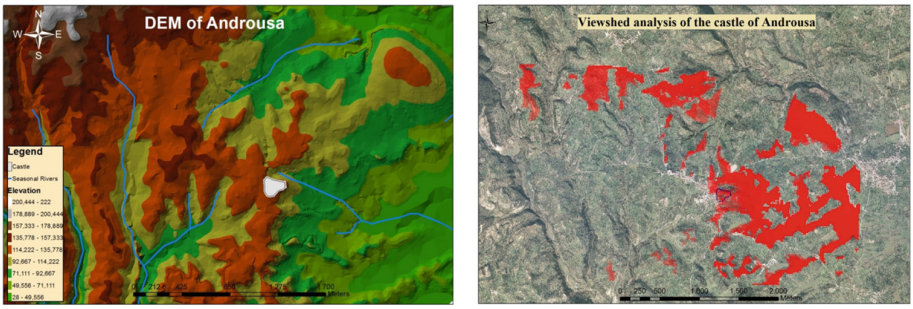

Fig. 4. Maps of Androusa in GIS: On the left the Digital Elevation Model (DEM) made for the landscape analysis; On the right the Viewshed analysis of the castle [6]

2.2 The GIS Database

Having acquired a clearer image about the fortification of the castle, the study focused on the analysis of the historical mortars of the castle. Eleven mortar samples were collected from different areas of the fortification covering all 3 building phases (Frankish, Byzantine and Ottoman). As shown in the Fig. 5, the examination of the mortar samples was conducted using a multi-technique approach: Optical Digital Microscopy LED, Electronic Scanning Microscopy (SEM) equipped with X-ray Microanalyzer (EDX), X-ray Fluorescence (XRF) and Granulometric Analysis. The analyzed mortars were lime mortars and were mainly consisted of fine aggregates. The samples collected from areas built in the same building phase appear to have the same chemical composition. Samples from different building phases exhibited relative heterogeneity mainly in the concentration of silica and calcium. The final results of the aforementioned analytical techniques are presented in detail elsewhere [6].

GIS was used for the creation of a database where all the resulted information could be stored, processed, analyzed and updated in an interactive and dynamic way. The application of GIS in a similar way is well known and has been widely employed in archaeological research [11–13]. The geographical location of all mortar samples were recorded on the digitized ground plan of the castle and were joined with their respective datasets. The exact location of each sample was measured with the use of a Differential GPS device and was marked with a point in the GIS map. The datasets were inserted in attribute tables in GIS in form of texts, tables, diagrams and photographs (raster graphics). The user can have access to information about: the different areas of the fortification of the castle (naming, building phase/period, photos), the sampling process of mortars (date of sampling, sampling area, building phase/period, photo of the area), the macroscopic characteristics of the samples (weight, color, preservation state, OM-LED photos), the results of the XRF analysis [type of device and settings, major oxides (wt% normalized to 100%), trace elements (ppm)], the results of the SEM-EDS analysis (chemical composition of the major oxides, photos under SEM microscopy) and the results of the Granulometric Analysis (grain size distribution,

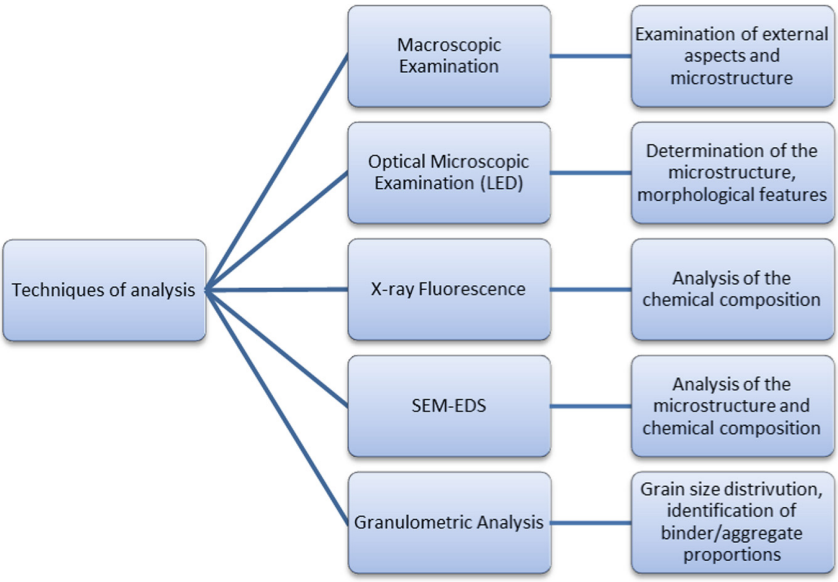

Fig. 5. Flowchart illustrating the analytical techniques used for the characterization of mortar samples

diagrams). All the above information is available just by clicking on the areas of interest on the map or on the table of contents in the GIS program. The user can also select the desired type of information to be displayed and have a quick overview of them (Fig. 6).

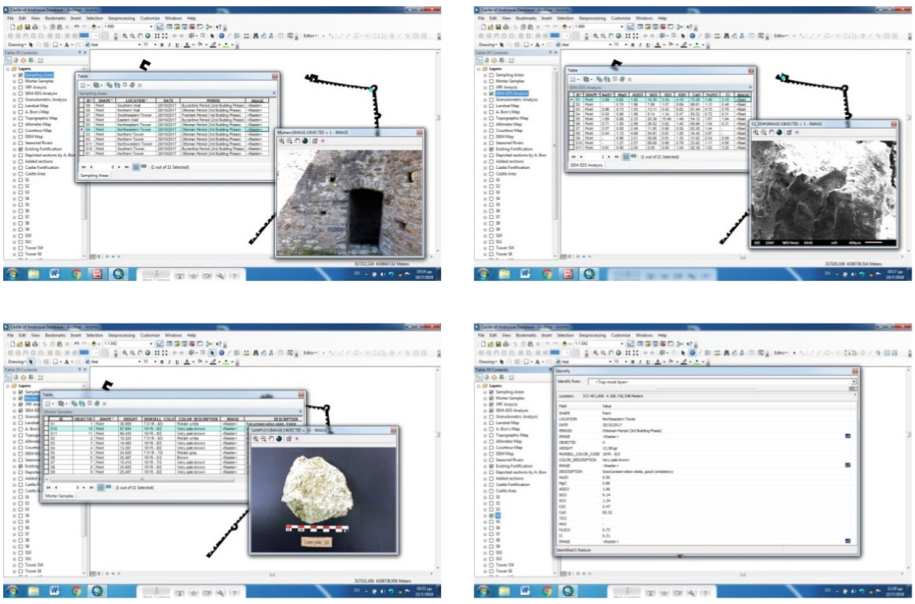

Fig. 6. Demonstration of the GIS database in use

3 Discussion

The use of GIS proved particularly useful in the study of the mortar samples from the castle of Androusa.

By combining data elements from different sources in GIS, we managed to get a geographically accurate ground plan of the castle. The use of GIS can assess the accuracy of old maps drawn by travelers during the past [14]. In our case, the sections of the castle that were depicted in Bon's map were georeferenced and became more accurate geographically. In addition, the combination of information from different maps provided a more holistic view of the fortification of the castle, thus helping the archaeological research by indicating areas of interest. By achieving detailed mapping, the spatial analysis and hence the preservation and management of the site can be enhanced.

The creation of a database in a GIS environment was proved to be very useful in organizing, documenting and archiving the analyses of the mortar samples. One of the main benefits is that it provided a spatial interconnection of the analytical data of the samples with their exact geographical location. Through this, the examination of mortars from different areas and building phases of the castle can be done easier, faster and in a more efficient way compared to the traditional methods. In our case, the recording and classification of the mortar samples in a GIS database helped us to compare their composition and to highlight the homogeneity or heterogeneity they presented with each other, simplifying and facilitating the whole process. In addition, the visualization of data helped the identification of spatial patterns associated with the composition of mortars, the different areas of the fortification and the likely building phases.

This GIS database can offer more possibilities in the future. For example, it can be used in restoration and conservation works at the castle of Androusa. The analysis of the samples in relation with their geographical position can be taken into account in restoration projects, contributing to the selection and application of a proper mortar mix compatible for each particular area of the castle, based on the GIS database. Moreover, the geographical interconnection of mortars and analytical results can offer better monitoring of their preservation state per area of the fortification and thus help the identification and organization of conservation projects when needed.

The most important aspect of a database made in GIS is that it can store large volumes of data that can be continuously updated and enriched with more datasets. Future projects in the castle of Androusa may include the examination of more mortar samples from other areas of the fortification or the application of more analytical techniques. All of these data can be used and examined in many different ways, leading to important conclusions about the history of the castle and its building phases.

4 Conclusions

In the work presented here, GIS helped to better understand the fortification of the castle of Androusa. A representation of its fortification ground plan was made by combining data from different sources. The produced map was used to extract important information about the monument by utilizing and combining the

archaeological knowledge with spatial information and the visualization techniques offered by GIS.

In addition, GIS was implemented in the management of the information collected from the analytical study of the historic mortar samples. The positions of the samples were documented in GIS and were linked with their respective datasets. As a result, a database was created where all the acquired information can be stored and processed in a dynamic and interactive way. This database offers easy access and the potential of continuous update of the archiving data, while protecting and preserving the historical and archaeological data in the same time. In the future the database can be further enriched with more information about the castle.

The joining of GIS with the archaeological and archaeometrical studies allows a better approach of the history, archaeology and the cultural heritage in general. In our case, GIS has proved to be an excellent tool for processing, synthesizing, analyzing and interpreting archaeological information that can lead to the creation of new knowledge. The flexibility of the GIS applications is what makes them such a valuable tool for research and knowledge in the field of archaeology.

Acknowledgements. The authors of the paper are thankful to the personnel of the Ephorate of Antiquities of Messenia for providing access to the archaeological and bibliographical material.

References

1. Petrescu, F.: The use of GIS technology in cultural heritage. In: Georgopoulos, A. (ed.) XXI International CIPA Symposium, Athens (2007)
2. Tsiafakis, D., Evagelidis, V.: GIS as an Interpretative Tool in Greek Archaeological Research. Nottingham (2006)
3. Fernández de Heredia, J., Morel-Fatio, A.: Chapitre VI: Citation de G. de La Roche. In: Morel-Fatio, A. Libro de los Derechos et Conquistas del Principado de la Morea. Imprimerie Jules -Guillaume Fick. Geneva (1885)
4. 26th Ephorate of Byzantine Antiquities: Κάστρο Ανδρούσας - Τροποποιητική Μελέτη Νότιου Τείχους. Ministry of Culture and Sports. Kalamata (2013)
5. Ephorate of Antiquities of Messenia: Restoration of the eastern section of the Androusa castle. Information brochure. Ministry of Culture and Sports. Kalamata (2016)
6. Vryonis, P.: The castle of Androusa: Characterization of mortars and application of the Geographical Information Systems (GIS). Master Thesis. University of the Peloponnese, Kalamata (2018)
7. Box, P.: GIS and Cultural Resource Management: Manual for Heritage Managers. UNESCO, Bangkok (1999)
8. Hadjimitsis, D.G., Themistokleous, K., Ioannides, M., Clayton, C.: The registration and monitoring of cultural heritage sites in the Cyprus landscape using GIS and satellite remote sensing. In: The 7th International Symposium on Virtual Reality, Archaeology and Cultural Heritage. VAST (2006)
9. Cajthaml, J., Pacina, J.: Old maps as source of landscape changes, georeferencing, accuracy and error detections. In: 15th International Multidisciplinary Scientific Geo-Conference SGEM 2015, pp. 1004–1009 (2015)
10. Bon, A.: La Moree Franque recherches historiques, topographiques et archaeologiques sur la principalite d' Achaie (1205–1430). Edditions E De Boccard, Paris (1969)

11. Malaric, I., Gasparovic, M.: GIS of the Crikvenica - “Igraliste” Archaeological Site. Kartografija i Geoinformacije, Zagreb (2009)
12. Tantillo, M.D.: GIS application in archaelogical site of Solunto. In: XXI International CIPA Symposium, Athens (2007)
13. Khan, Z.L., et al.: Geoinformatics for cultural heritage mapping - A case study of Srinagar city, Jammu and Kashmir. Int. J. Technol. Res. Eng. **2**, 1234–1241 (2015)
14. Sarris, A., Déderix, S.: GIS for archaeology and cultural heritage management in Greece. Quo Vadis? In: Zacharias, N. (ed.) 3rd Symposium Archaeological Research and New Technologies ARCH_RNT. University of the Peloponnese, Kalamata (2012)
15. Hetherington, P.: Byzantine and Medieval Greece – Churches, Castles and Art of the Mainland Peloponnese. John Murray Ltd., London (1991)