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Research Article

Geophysical Investigations at the Fortress of Aghia Maura in Lefkada (Greece) Revisited

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ABSTRACT

The aim of this research is to imagine the buried antiquities within the fortress of Aghia Maura, on the island of Lefkas in Greece, through the application of geophysical prospection methods. Resistance mapping was applied and reported here. The survey was carried out employing the twin probe array at the nodes of a 1-m grid established on the ground surface. After processing, grey scale maps were compiled showing more or less the ground view of the concealed architectural remains. These are presumably linear and articulated anomalies resembling the ground view of vestiges. The presentation of the results was carried out through the use of Geographical Information Systems (GIS). As a visualization tool, GIS offer the advantage of representing more than one layers at the same time, in this case the different construction phases of the fortress in relation to the results of the geophysical survey. The results include, among others, the high resistance values arranged in clear geometric shapes, such as rectangular, semicircular and linear layouts. Their shape in combination with their dimensions allows their attribution to the existence of foundation remains and therefore the presence of buried antiquities. Additionally, an attempt was made to identify the possible buried antiquities with certain chronological periods based on past available plans of the fortress. The geophysical results are expected to make a decisive contribution to any future archaeological excavation.

Keywords: Archaeometry, Geophysical Survey, Archaeological Prospection, Non-destructive Testing, Electrical Resistivity Mapping, Lefkas.

INTRODUCTION

Geophysical surveys for the detection of buried antiquities have been going on for a long, with particularly useful results to archaeologists, stakeholders, cultural tourism, sustainability; these techniques also are continually improved (Levy et al., 2018; Liritzis & Korka, 2019; Liritzis et al. 2020; Alexakis, Lampropoulos, Doulamis, Doulamis, & Moropoulou, 2022; Psalti et al., 2022). Resistance and magnetic mapping are globally the most commonly employed methods for detecting and imaging buried antiquities (Gaffney, 2008). The first one is energetic because the current is introduced into the ground and the created potential differences are measured. The second consists in recording weak and spatially confined anomalies of the Earth's magnetic field and thus is a passive method (Fassbinder, 2015). Both these methods were introduced after the Second Great War (Aitken, 1974). In general, the methods of surveying remain almost unaltered but the instrumentation, processing and visualization methods and software have been advanced greatly (Becker, 1995; Neubauer, Eder-Hinterleitner, & Melichar, 1999; Becker, 2001; Linford, 2006; N. Linford, P. Linford, Martin, & Payne, 2007, Aspinall, Gaffney, &

Schmidt, 2008; Tsokas, Vargemezis, Tsourlos, Drougou, & Saatzoglou-Paliadeli, 2009; Trinks, Neubauer, & Hinterleitner, 2014). Further, the use of GPS has added flexibility, accuracy and new interpretation capabilities (Gaffney, 2008).

A plethora of cases confirm the importance of the implication of geophysical methods in archaeological sites. Currently, the so called "Archaeological Prospection" methods and techniques comprise a necessity at site exploration (Jones & Sarris, 2000; Donati & Sarris 2016; Donati et al., 2017). They are capable of providing important clues and perhaps evidence on several archaeological issues regarding the extent and organization of abandoned and buried old occupation sites (Benech, 2007, 2010; Liritzis et al. 2020).

Indicatively listed are the Ancient Europos in Kilkis and the site Platania in Aghia Paraskeui Lamia, where the geophysical survey detected the presence of ancient tombs (Savvopoulou, 1993) and stone-built foundation (Tsokas et al., 2015) respectively, finds that the subsequent excavations confirmed. A variety of geophysical methods are applicable to the investigation of archaeological sites. Archaeological geophysics involves the measurement of certain physical properties in the near-surface of the earth in order to detect and characterize buried archaeological features (Ernenwein and Hargrave, 2009). Choosing an appropriate survey strategy is never straightforward: it will depend upon the interplay of many factors, and will therefore vary from one site to another (Schmidt, 2004; Tsokas et al., 2006; David, L. Linford, & P. Linford, 2008; Tsokas, Tsourlos, & Papadopoulos, 2008).

The geophysical survey which was carried out in the fortress of Aghia Maura, on the island of Lefkas, Greece, is presented in this work. This survey was conducted in three phases in 1994 and 1995, in the framework of the research plan, which referred to the compatibility of interventions and new usages of masonry buildings in relation to the historicity of the monument (Savvaidis, Tsokas, Liritzis, & Apostolou, 1999). The aim of the survey was to detect and map buried ancient remnants and structures. Further, the current study is focused on the correlation of the geophysical results, i.e. the geometrical anomaly shapes reflecting buried ruins of the shape, to the ground views of specific historical phases. Further, since GIS was not developed at the time of the survey, which took place in1994, another potential has been given to the original data. Also, the data were re-processed employing techniques and software not available at that time.

Resistance mapping was exclusively used for this survey since magnetics could not be applied due to power lines and the modern watering pipes and electricity cables that are present in the castle. Further, at the time of the survey, the GPR method was in its infancy and not capable of covering swiftly large areas.

Lefkada (or Lefkas) is an island in the Ionian Sea on the west coast of Greece, connected to the mainland by a long causeway and floating bridge. Fortress of Aghia Maura, also known as the "Castle of Santa Maura", is located at the northeast edge of Lefkas, right at the edge of the low, conglomerate Isthmus of Gyra, near the Acarnanian coast (Figure 1) (Lambrinou, 2009). It is a coastal fortress, built on an islet, founded upon sandy ground and surrounded by marshes, which protect it. The Fortress of Lefkas is a particularly important monument in terms of the art of fortification (Savvaidis et al., 1999). The fortified area has a surface of 45.000 sq.m. and its' shape is an irregular heptagon (Figure 2). The heptagon is surrounded by very important defensive works, such as ditches, ramparts and outer fortifications to the east and west. The maximum length of its sides is no greater than 75 meters, the width of the walls varies between 20 and 1.70 meters and the walls' height reaches 10 meters (Lambrinou, 2009, 2018).

The island of Lefkada had a long lifespan throughout history. It was first inhabited in the Paleolithic Ages and traces of habitation have been found also from the Neolithic and the Bronze Age (Andreou, 2016). After being in the domination by Corinthians (7th century BC), Macedonians (4th century BC) and Romans (2nd century BC) it became a part of the Byzantine Empire from the 4th until the 11th century AD when invaders from the West occupied the island in the framework of their expansion to the East. Firstly, was under Orsini's rule, then Angevin's and after them under Toccos' rule (Rontogiannis, 1988). The island seems to had a pivotal position for its' dominants, for the reason that they could control a whole area, part of which was the east mainland of today's Greece and also a big part of the Mediterranean Sea (Rontogiannis, 2006).

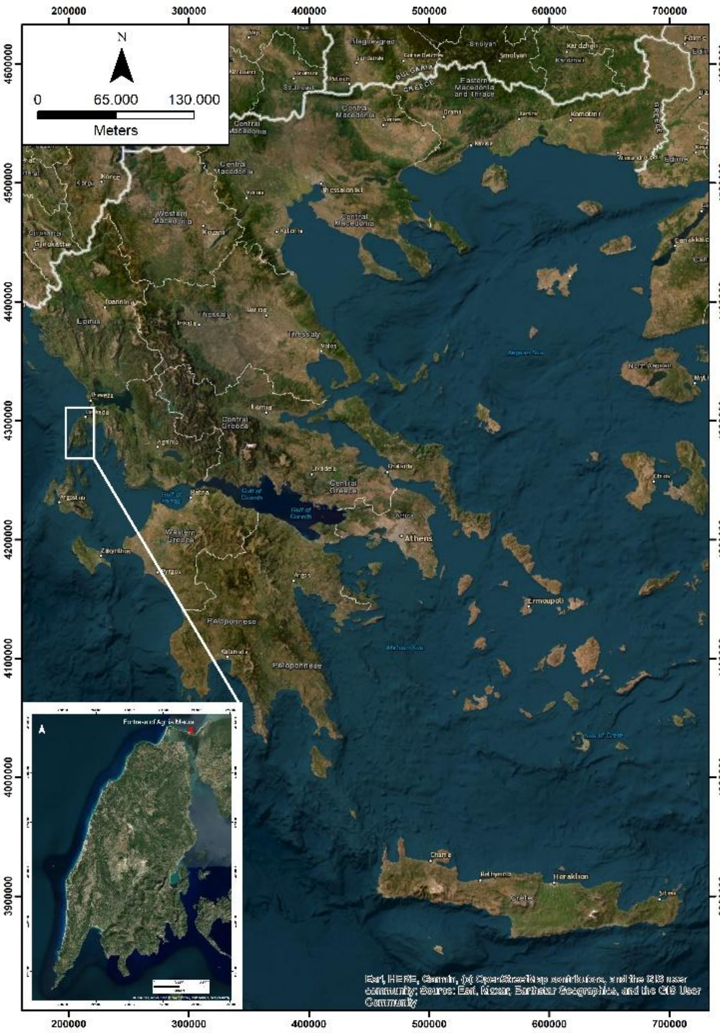

Figure 1. The Island of Lefkas

Figure 2. The Fortress of Aghia Maura

The fact that the island is of high geostrategic importance seems to be the reason for the Count palatines of Cephalonia and Zakynthos that led them to the founding of the castle at the beginning of the 14^{th} century, a time at which the island was under the rule of Orsini, who made the new castle its' capital (Rontogiannis, 2006). At that time, the castle began as a small fortification to control access to the island and to face continuous attacks from other potential conquerors, before it was expanded to become a walled town with 200 ca. houses, under Tocco's rule (Rontogiannis, 1988). Tocco's main goal was the development of a settlement within the fortress that would host his family and vassals (Rontogiannis, 1988).

During 1479–1684 the fortress was occupied by the Ottomans. It seems to be that the fortress was of high importance for the Ottomans as it functioned as a base of operations for their attacks on the mainland and moreover, it developed by them into an important administrative and commercial center (Rontogiannis, 2006). In this period a lack of water led to the construction of a 3 kilometers long aqueduct from the island's interior to the town. Bringing water to the walled town as well as to the much larger—700–800 houses—open town that had grown around it, was one of the most important works of Ottoman civil architecture in the western Balkans (Lambrinou, 2009, 2018).

In the period 1623–1668, the city suffered significant disasters, due to earthquakes and enemy attacks and also there was a decrease in population due to the spread of the plague in the city. At the same time, the decline began in the maritime-commercial activities of Aghia Maura, due to pirate attacks. All these facts, seem to have contributed to the occupation of the fortress by the Venetians in 1684 (Rontogiannis, 1988). After the occupation, they evacuated the walled town and demolished both the intra and extra muros houses. The inhabitants were transferred into the modern city of Lefkada and the fortress functioned as a military and administrative center, with the construction of new buildings for these purposes. During 1717–1719 all the buildings in the fortress area were demolished except for those that served the French activities (Lambrinou, 2009, 2018). The transfer of the new capital from the castle had a decisive effect on the inhabitants, as they gradually began to move away from their maritime and commercial activities, i.e., the sea, and to connect exclusively with the lagoon and the land. This led to the Venetians being promoted to absolute protagonists in the sea - commercial front. The residents must now engage in activities of the primary sector and the cultivation of the land and especially the olive (Rontogiannis, 1988).

Later on, the fortress will come under British rule, who are going to construct new rectangular buildings, which will be used to accommodate military units. In 1864, after the union of the Ionian islands with Greece, the castle was garrisoned by the Greek army until 1922, when Asia Minor refugees were housed there. In 1932 the fortress was characterized as a Historical Monument and in 2018 is taking place important restoration and conservation work from the Ephorate of Antiquities of Aitoloakarnania and Lefkada (Lambrinou, 2009, 2018).

In the framework for this research plan, in November 1994, after the rainy season, an electrical resistivity (ER) survey was carried out which covered the NW, the west and the central area. In April 1995 a complementary resistivity survey was carried out in order to cover almost the whole area of the fortress (Savvaidis et al., 1999).

Here a revisit of the measurements is made employing new software. The purpose of the review is twofold. The data were reanalyzed to produce more distinct results with the aid of modern software capabilities. The novelty, however, concerns the attempt made to identify the possible buried antiquities with certain chronological periods, based on available plans of the past. The conclusions of this process are expected to be a particularly important tool for archaeologists, as they will not only be able to know the exact location of the remains in the subsoil, but also the chronological period to which they probably belong, in advance and with the absence of an archaeological excavation.

The fortress of Aghia Maura constitutes a monument on which the most important historical events of the Ionian islands are recorded. Through the detection of its' constructions of the past, what can be recorded are not only the historical alterations, but also the economic and sociopolitical ones. The significance of this revisitation concerns the need for proof that an archaeological site must be surveyed in a multidisciplinary way, to obtain the aforementioned data. Until recently, an archaeological investigation used to be limited to a surface survey at first, then in excavation, afterwards in the recording of the finds and finally in the interpretation. This procedure is time and effort consuming and also one dimensional. The joint application of archaeological and geophysical methods is not only useful for the detection and mapping of the antiquities, but also for their presentation and interpretation. In this work, the interest is focused on the revisiting of old data, so that a more distinct image of the buried antiquities will be acquired. Moreover, through the try to identify the possible remnants with structures of old maps, an innovation is made in regard to the manipulation of archaeological data in a non-destructive and non-invasive way.

METHODOLOGY

For the survey in the castle of Aghia Maura a two-phase geophysical survey was chosen. One of the two applicated methods was that of Electrical Resistivity (ER)[1]. These methods were chosen for a plethora of reasons, which mainly concerned the extent of coverage of the research area and the material of the targets and the quality of the environment. The most determinant was that the buried remains possibly belonged to masonry foundations. More specifically,

Electrical Resistivity Method

In terms of the method's operating principle, electrical resistance is the degree to which a material restricts the passage of an electric current, and is measured in Ohms. The electrical resistance of the ground is almost entirely dependent upon the amount and distribution of moisture within it (Clark, 1990). Electrical resistance is useful on archaeological sites because cultural features represent localized disturbances to natural soil strata, and often include concentrations of organic materials, rocks, and other artifacts. These disruptions to the natural soils are associated with a localized contrast in moisture retention and therefore electrical resistance (David et al., 2008).

For the acquisition of the data via the electrical method, what is needed is to apply electric current to the ground with the help of two electrodes and measure the potential difference across two others. In this way, what is recorded is the measurement of the resistance ($R=\Delta V/I$), which, through a mathematical relationship, can be reduced to a specific electrical resistance value of the sampled area ($\rho=2\pi rV/I$) (Linford, 2006; Tsokas et al., 2006). The current electrodes and the voltage electrodes can be arranged in a number of different arrays. For archaeological surveys, the most practical is that of the twin probe array. This array utilizes a pair of mobile probes and a pair of remote ones located at a certain distance far from the grid (at least 30 times the distance between mobile probes) (Ernenwein & Hargrave, 2009).

Data acquisition

The geophysical survey took place at the intra-muros free of remnants area. The RM-15 of Geoscan Research was employed. The electrical measurements were carried out in a 1m equidimensional network, which was established on the ground in the form of a grid. The grid was divided into squares (cells) 20 × 20 m^2 with the aim of facilitating the data acquisition process. In some parts of the grid, the cells have dimensions of 10 × 10 m^2, as it was not possible to implement them spatially in dimensions of 20 × 20 m^2 due to building debris on the surface of the ground that hindered the process (Figure 3). A grid was implemented separately in each square cell. This process facilitated the treatment of topographical anomalies as it provided relative flexibility (Liritzis et al., 1997).

Data Processing

The data collected after the application of the geoelectric method were processed for the first time during the years 1994–1997. More specifically, the data were analyzed spectrally to identify the noise in the higher wavenumbers, but also the regional trends of the field. They were then band-pass filtered and unwanted effects were cut off. The filtered data were transformed into dot density maps (Liritzis et al., 1997, 5; Savvaidis et al, 1999).

In the context of this work, the data were reprocessed using modern software. Firstly, the data were converted into modern formats. Next, they were reprocessed under the light of modern technologies. The first stage of the analysis included the removal of the discontinuities present at the edges of the cells (Edge Match). This analysis aims at the smooth display of the resistance values between the grid squares. The second stage included the removal of extreme values (Despike), as they interfere negatively with the actual display of electrical resistances. The data were then subjected to a High Pass Filter so that unwanted effects were removed. Nest, compression of the dynamic range took place using an arctan function. Enlarging the data matrix in each cell in both dimensions (Interpolate) took place afterwards. The enlargement was implemented by two-dimensional interpolation using the function sinx/x, resulting in the visualization of the data with greater smoothness and clarity. The final stage of data processing involved the application of the Wallis filter (Wallis, 1976; Schollar, Weidner, & Segeth, 1986).

During the processing of the data a limitation arose, which had to do with the union of the three measured areas into one composite. More specifically, the Edge Matching analysis could not be applied between two sets of data because of the different conditions under which the measurements had been done. The weather conditions were not stable during both the campaigns and dry days alternated with wet those days. Additionally, various parts of the castle were exposed to the sun differently, some of them being permanently in shadow. Thus, the

[1] Ground Penetrating Method was also applied to a very limited extent. In this paper are presented the results of the electric method.

moisture content was not the same for all areas of the castle at the same time. Thus, different resistivity levels were created (Savvaidis et al., 1999).

Figure 3. The Established Grid of Cells on the Ground

Data Representation

The technical report by Liritzis et al. (1997) includes the first cartographic presentation of the data, which were obtained during the conduct of the measurements by the electrical mapping method. After processing the data, they were transformed into dot density maps and the final results of the method were captured on photographic paper, which was superimposed on the topographic map of the study area (Figure 4).

In this work, the cartographic presentation of the results was carried out in a Geographical Information Systems (GIS) environment. As a basic cartographic background, an orthophoto of the study area was used, which was taken from Google Earth, then imported into the GIS software and finally submitted to the georeferencing process based on the Greek Geodetic System EGSA '87. Additionally, existing topographic maps of the study area were scanned and georeferenced based on the orthophoto used as the base map background. Finally, the topographic map of the study area was digitized in order to serve as a cartographic background for the presentation of the results.

Figure 4. First Presentation of the Results. Image of the Resistivity Distribution in the Fortress of Lefkas (Liritzis et al., 1997)

RESULTS

The results of the geoelectric mapping are presented in Figure 5. The distribution of the apparent resistances in the subsoil is presented in grey scale mode, as they were yielded after the processing of the measurements mentioned in the previous chapter. The distribution of apparent electrical resistances reflects the local variation of the flow of electrical current in the subsoil. Dark tones correspond to high values of electrical resistance and reflect the possible existence of buried structures (e.g., remains of archaeological interest).

The materials used for the construction of the walls and buildings of the fort are local limestone, sandstone from the area of Gyras (isthmus), large carved stones from the ruins of buildings of ancient Lefkada and Nirikos, slabs from Paxos for the paving stones that were formed during the English period and large stone slabs for paving the corridors at the level of the cannons (Lambrinou, 2018).

All the above structural materials present a higher resistivity value than the soils, therefore than the surrounding soil formations within which they are lying (Scollar, Tabbagh, Hesse, & Herzog, 1990). This fact is the element that leads to the interpretation of high values of electrical resistance as possible underground structures.

According to the results of the geophysical survey, there are several cases in which the high resistances are arranged in clear geometric shapes, such as rectangular, semicircular and linear layouts. The fact that these elongated anomalies seem to be narrow allows their attribution to the existence of foundation remains.

In addition, at the northeastern end of the research area, a concentration of high resistance values can be seen in a semicircular arrangement, the width of which reaches 2 m. It is possible that this anomaly is due to some building structure - a ruin. On the other hand, in the surveyed area, certain concentrations of high resistances are found, but without being arranged in clear geometric shapes. These anomalies are probably due either to buried ruins, or to concentrations of stones, which were covered over time and today are presented as underground elements.

Another concentration of high resistance appears in the southern part of the research area. The high resistance values here also seem to be arranged in a rectangular shape, an element that contributes to the attribution of this anomaly to the possible existence of building remains. Additionally, concentrations of high resistances that appear both in this area, and in the area in contact west of the eastern wall are not arranged in clear geometric shapes. They are probably due to concentrations of stones coming from any destruction of various structures.

Figure 5. Resistance Distribution in the Fortress of Aghia Maura in Grey Scale Mode. Dark Tones Represent High Resistances

DISCUSSION

In this work, in addition to the presentation of the results, an attempt is made to relate them to a certain chronological period based on old topographic maps. The oldest plan, in which the settlement of the castle is depicted, is that of Verneda (Lambrinou, 2009), a plan that was reproduced a year later by Coronelli (1687). In these plans, the fortress of Aghia Maura is depicted as it was shaped in 1684, when it was conquered by the Venetians (Lambrinou, 2009). Immediately after the capture of the fortress of Aghia Maura, the Venetians proceeded to reform both the fortifications and the area enclosed within them as is depicted in Dapper's plan (Lambrinou, 2009). The possible underground remains should be later than those on both the aforementioned plans. In the first case, the remains have both different direction and shape from the depicted ones (Figure 6). In the second case, resistivity anomalies appear in an area with no structures depicted on the plan. Only on the NW edge, there is a coincidence of high resistance values with a depicted structure, but they are of different layout (Figure 7).

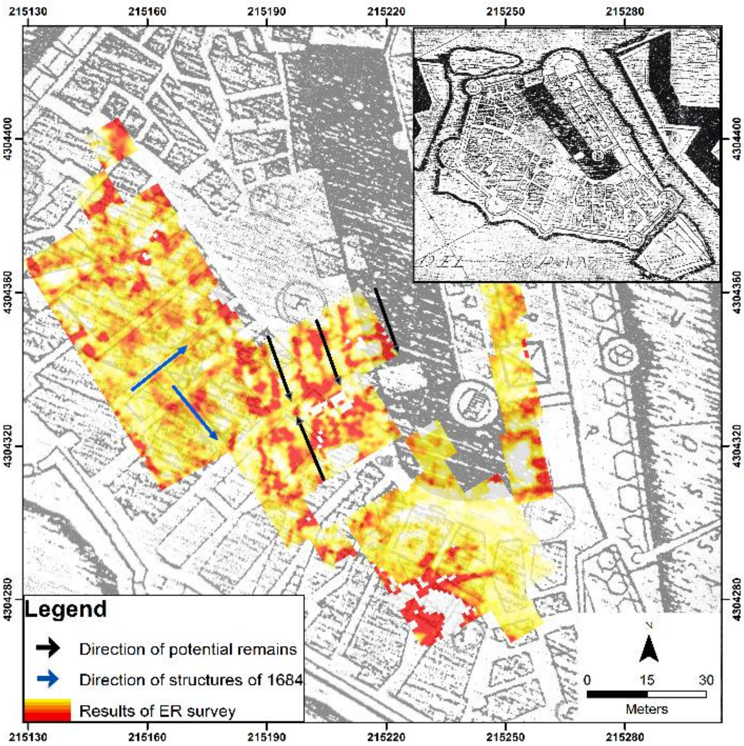

Figure 6. ER Results on the Topographic Map of 1684

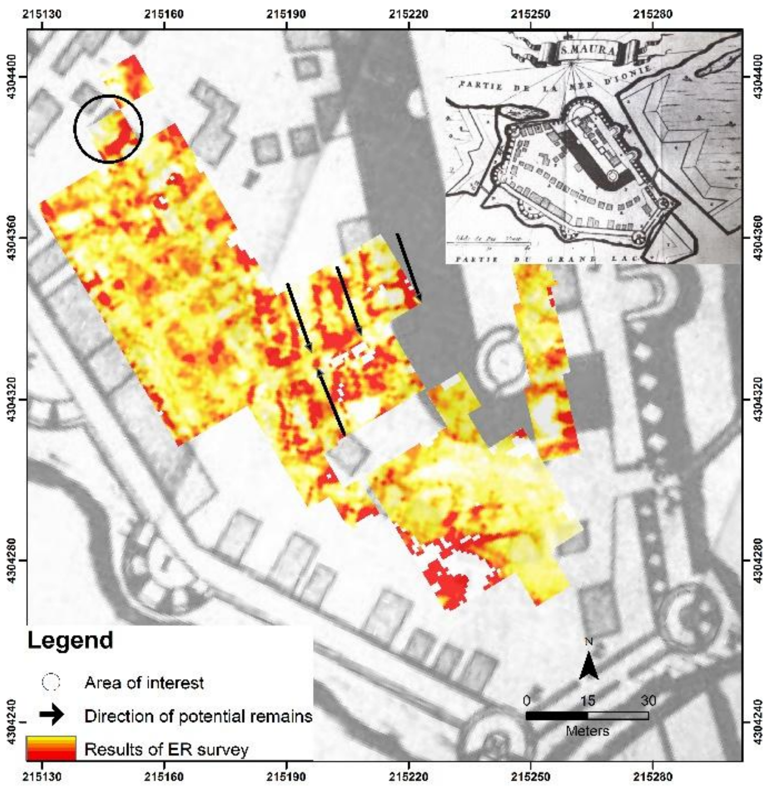

Figure 7. ER Results on the Topographic Map of 1687

During 1717–1719, Venetians proceeded with further modifications to the fortress, which included, among other things, the demolition of the citadel and all buildings no longer needed, in order to accommodate the Venetian authorities. The ground plan of the fortress of that period is depicted in a plan by Santo Semitecolo (Lambrinou, 2009). In this case, as well, the concentrations of high resistances arranged in clear rectangular geometric shapes, coincide in plan with the large water tank built in the central area of the fortress during the second Venetian phase (Figure 8). Therefore, they should belong chronologically to a later period. No other concentration of high resistances coincides in plan with any structure.

In a plan of 1722, the above-mentioned tank seems to be replaced by two elongated buildings, in the context of the works that continue to be carried out by the Venetians in the area of the fortress. From 1779 to 1810, the last Venetian buildings were erected in the fortress of Aghia Maura (Lambrinou, 2009). After superimposing the survey results on both the aforementioned plans, what one notices is that, for the first time, the subsurface resistive structures can be correlated with structures depicted on the plans. In particular, the concentrations of high resistances which are marked with red boxes in Figure 9 and Figure 10, are identical both in orientation and dimensions, with the structures of the plans at the specific points. It is estimated that the possible subsurface remains reflect the foundations of these structures, both of the building seen in the central part of the research area, and of the building at its southern end. In this, the identification seems to refer to the northern wall of the building, which once functioned as a temple. Therefore, it is possible that the construction of these subsurface remains can be dated to around 1722.

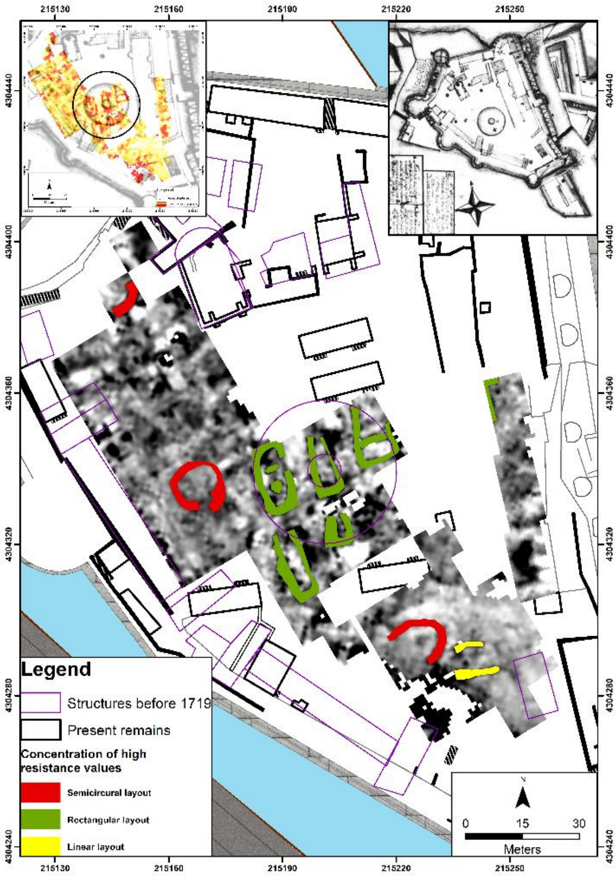

Figure 8. ER Results Combined with Features of 1719. Features of Interest are Illustrated with Color

As for the possible underground construction located in the central part of the research area, it is identified with the corresponding structure of the 1779 plan (Figure 10). More specifically, the northern part of the rectangular shape formed by the high resistance values is completely identified with the first internal wall of the building there from 1779, which should have been built in the framework of its configuration, in order to better serve the needs of the Venetian authorities.

In addition to the above, the results of the electrical survey also include other points in the research area, where the resistivity anomalies appear not to be arranged in clear geometric shapes in the majority of them. These anomalies are likely due to accumulations of stones that were created by the destruction of older buildings. Of course, the fact that there are underground tanks and wells inside the fortress should not be overlooked. The concentrations of high resistances in the semicircular layout marked in Figure 11 as unidentified could reflect such constructions, mainly due to their shape. These structures could be from the Ottoman period when they constructed a 3 kilometers long aqueduct for the water needs of the fortress (Lambrinou, 2009, 2018), but this is just a hypothesis.

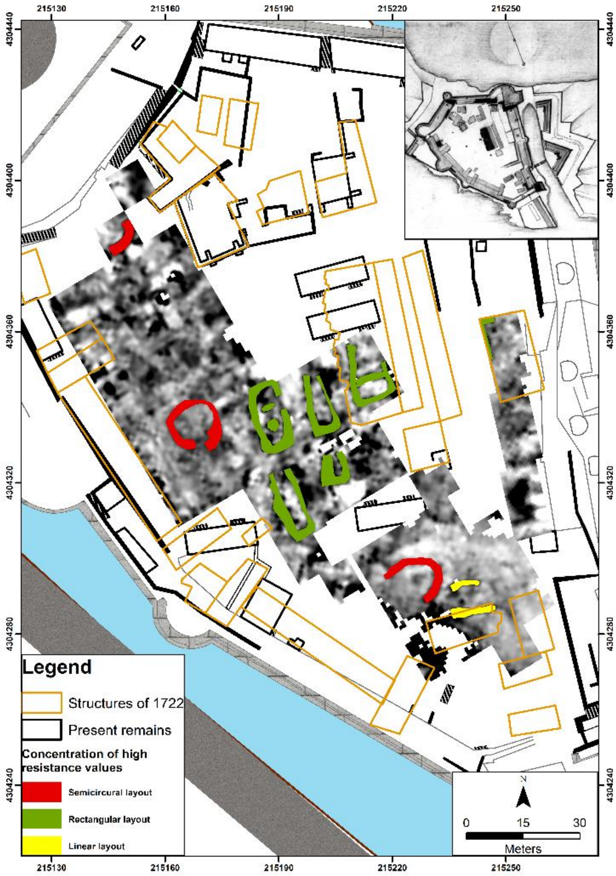

Figure 9. ER Results Combined with Features of 1722. Features of Interest are Illustrated with Color

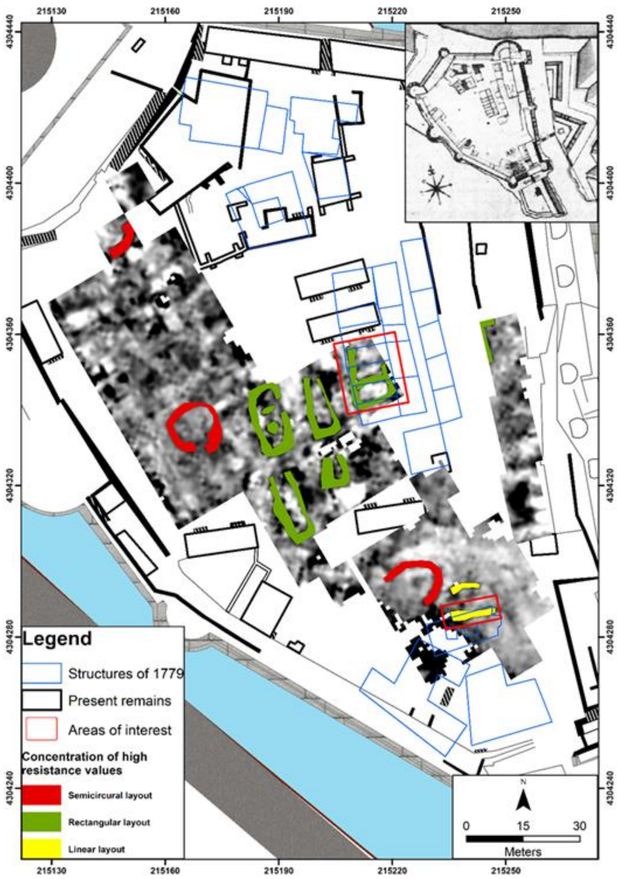

Figure 10. ER Results Combined with Features of 1779. Features of Interest are Illustrated with Color

Figure 11. ER Results Combined with Features of All Phases. Unidentified Shapes are Emphasized

Finally, some concentrations of high resistances, which are arranged in clear rectangular shapes in the center of the investigated area, could not be identified with any structure that can be seen on the existing plans. These possible subsurface archaeological structures should either have been constructed after 1779, the year of the last available plan of the fortress, or earlier, during 1687–1719, from when there are no available plans either.

CONCLUSION

The Fortress of Aghia Maura counts almost seven centuries of life. During this long period a lot of changes and transformations have taken place as a result of all these historical phases in which the fortress was in use. Thus, the maintenance of all the structures that have been constructed through these years is not possible. As a result, only a few structures are visible at present on the surface. This is where the importance of the application of geophysical analysis methods lies. The purpose of their use is, first of all, to try to locate any antiquities whose traces are no longer on the surface, but instead remain buried in the subsoil. The ultimate goal of the geophysical survey is to contribute and/or guide the excavation work, so that the buried archaeological remains are brought to light.

The use of geophysical techniques illustrates their importance in the management of archaeological sites. The case discussed here shows that the use of the resistivity method provided information that resolved several issues concerning the past use of the fortress (Savvaidis et al., 1999).

The resulting maps showed the existence of anomalies, which are probably due to architectural remains. The derivation of this conclusion is based on the fact that the anomalies form clear geometric shapes with dimensions similar to those that should have the remains of the foundations from the third phase of the Venetian occupation, that is from 1722 onwards. Based on the results and the available plans, this date is a terminus post quem for the buried remains. The fact that possible subsurface archaeological structures do not appear to be captured in any plan before 1722, and therefore they cannot be identified with any building of those periods, leads us to the conclusion that their construction should not be placed chronologically before this limit.

On the other hand, knowing that the fortress ceased to be used from 1930 onwards, a terminus ante quem was also created for the buried remains. Therefore, the possible buried antiquities must have been constructed in the period between 1722 and 1932, when the fortress was declared a preserved historical monument. It should be emphasized here, that this chronological assessment is based on the plans of the fortress available so far and contains reservations.

After all, in the distribution maps of the specific electrical resistance, patterned anomalies appear which could not be identified with any structure known from the plans. This fact leads to two hypotheses. Either these anomalies indicate structures that may date from the period between 1687 and 1719 and for various reasons were not captured in the plans up to that time, or they are the imprint of structures that were built after 1779, the year of the last-known until now-available plan. The safest answer will be given after the conduct of any future archaeological excavation, in which the geophysical results are expected to make a decisive contribution, as the figures clearly show the location of the underground archaeological structures, which are probably the remains of the past constructions in the fortress area. What is suggested, in terms of saving effort and time, is a further application of remote sensing techniques or/and other geophysical methods, such as Ground Penetrating Radar or Electric Tomography, so that a three-dimensional model of the buried antiquities can be obtained, in order to guide a possible future excavation towards a more targeted direction. Otherwise, the results of the present study are equally decisive in prompting the initiation of an excavation to reveal the buried remains.

The reveal of the possible buried antiquities is considered an issue of high importance for three reasons. Primarily, the presence of buried remains means that the current image of the fortress of Aghia Maura is incomplete, for the reason that lacks a piece of its' history which lies underground. Additionally, this reveal is estimated to contribute to the understanding of how defensive reasons were determinant not only for the formation of the fortress itself, but also for the urban form of the city of Lefkada, after the transfer of the capital from the fortress and how this transfer influenced the socioeconomic conditions both of the citizens and the whole subsequent march of the island. Finally, the reveal will confirm the utility of geophysical methods in the investigation of the past. Besides, geophysical analysis methods are not important only as they can be used as a simple tool to reveal antiquities, but are also important, as non-destructive techniques which can ensure to the archaeologist important amounts of time and effort.

AUTHOR CONTRIBUTIONS

Conceptualization, G. N. T. and M. A; methodology, G. N. T. and A. S.; V. M. and I. L.; formal analysis, M. A. and A. S.; data acquisition, G. N. T. and A. S.; data curation, M. A. and A. S.; writing—original draft preparation, M. A.; writing—review and editing, G. N. T., V. M. and I. L.; visualization, M. A.; project administration, G. N. T. and I. L. All authors have read and agreed to the published version of the manuscript.

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