ISSN: 2687-8402
Open Access Journal of
Archaeology and Anthropology
DOI: 10.33552/OAJAA.2023.04.000600
Iris Publishers

Research Article
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Field Surveying, Geostatistical and GIS Methods in Archaeology. The Mycenaean Spercheios-Valley Project (MY.SPE.AR. Project 2018-2022)

George Malaperdas[1]*, Christofilis Maggidis[2] , Efi Karantzali[3] and Nikolaos Zacharias[1]

[1]*Department of History, Archaeology and Cultural Resources Management, University of the Peloponnese, Greece*

[2]*Mycenaean Foundation, Mycenae Lower Town Excavation, Greece*

[3]*Ephorate of Antiquities of Phthiotida and Eurytania, Greece*

***Corresponding author:** George Malaperdas, Department of History, Archaeology and Cultural Resources Management, University of the Peloponnese, 24 133 Kalamata, Greece

Received Date: April 04, 2023

Published Date: August 17, 2023

Abstract

The systematic survey of the Spercheios Valley in central Greece is one of the original goals of the Mycenaean Spercheios-Valley Archaeological Project (MY.SPE.AR.). The comprehensive and extensive survey's major objectives were to find, catalog, map, and analyze environmental factors in association with the nearby Mycenaean sites' archaeological finds. Under the direction and supervision of the local Ephorate of Antiquities, systematic field survey began in the Lamia municipality in June 2018. It originally concentrated on sites that had been previously reported in field reports and publications.

Sites that had been previously excavated or discovered were located, identified, and documented using DGPS and mobile GPS devices, together with any new sites uncovered within the survey region. These coordinates were imported into ArcGIS along with images and descriptions for additional geospatial and geomorphological study of the area's aspect, slope, hydrology, geoseismic evidence, geomorphology, and geology. The utilization and accessibility of mobile GPS devices, mobile internet network connections, mobile computing and portable photographic devices enable the MY.SPE.AR research team to conduct the examination of various terrains in remote regions. By combining environmental and spatial context with archaeological data, this method sheds light on the patterns and minute-scale circumstances that shaped the development and interaction of these sites.

Keywords: GPS; Field Survey; Mycenaean; Lamia; mobile computing; spatial analysis

Introduction

Under the direction and supervision of the local Ephorate of Antiquities, a new five-year field project began in 2018 with the collaboration of Dickinson College, the Geophysics Lab of the Aristotelian University of Thessaloniki, the Architectural Design and Research Lab of the Democritus University of Thrace, the Archaeometry Lab of the University of the Peloponnese, and the support of the Municipality of Lamia and the Mycenaean Foundation. The Mycenaean Spercheios-valley Archaeological Project (MY.SPE. AR.) combines extensive and intensive archaeological survey, aerial reconnaissance, geophysical survey, targeted excavation, and digital technology to locate, identify, and map all Mycenaean locations in the Spercheios valley region (Figure 1).

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Figure 1: Study Area (Spercheios Valley) with surveyed sites highlighted in red.

The geocumulative approach (which includes archaeological, geomorphologic, paleo-environmental, hydrographic, and paleo-climatic variables) is used to investigate the interaction between environment and site distribution [1,2]. In addition, statistical, frequency, and spatial distribution models are used to trace contact patterns and hierarchical dynamics among the sites, as well as to identify second-order administrative centers and possibly a first-order administrative center in the region [3,4].

Geomorphological pattern and archaeological background

Figure 2: Survey area.

The Spercheios valley, which stretches for about 80 kilometers east-west, divides the regions of central and southern Greece and allows only a narrow shoreline passageway between them (Figure 2). The Spercheios valley, with a flat area of 370 square kilometers, is nearly landlocked, surrounded on three sides and protected by mountain ranges that delineate clear regional boundaries, but allow eastward access to the sea. The Spercheios River's hydrologic system, meandering toward its delta-shaped outlet in the Maliakos Gulf, forms a well-watered fertile valley with rich alluvial soil (described by Homer as "large-lumped") and its own micro-climate, agronomically ideal for large-scale agriculture in terms of land size, irrigation, and soil quality.

The Spercheios valley region contains environmental, geomorphological, agrarian, and geopolitical parameters that, when taken together, can be interpreted as diagnostic formative elements of Mycenaean palace states. Because of its strategic location at the crossroads of powerful Mycenaean palace states on either side (Iolkos to the north and Orchomenos, Thebes, and Glas to the south) and other adjacent areas with a strong Mycenaean presence (Lokris, Euboea), this region could exert control over land routes and regulate local and interregional trade [4-8].

However, the archaeological map of the Spercheios region contradicts its geopolitical significance and economic potential. Archaeological fieldwork was carried out sporadically in the Spercheios valley over the last two centuries, with rather poor results, partly because field research was often aimed not at the surrounding hills (habitual location of Mycenaean settlements), but at the modern valley floor, and thus was hampered by local geological processes (deep silting from the river and sinking of the southern part of the valley floor by 10-20 meters due to the earthquake fault of mountain Atalanti). Recent archaeological studies of Ephorate [9-15] have identified several Mycenaean sites and cemeteries, including the important cemetery of Kompotades.

partially excavated. Places that have given way include large chamber tombs with exquisite finds, imported luxuries and artifacts of high social status, combining regional autonomy and self-sufficiency with supra-regional contacts. , indicating regions that are reasonably distant but may not be isolated [13,16,17].

Materials And Methods

The analysis presented in this paper can be divided into different stages to illustrate the methodology applied to collect, process, and interpret data in the survey area.

The systematic field survey of the Spercheios valley is based on a complex, dynamic, and adaptable combination of intensive and extensive methods in correlation with the extant information about known sites, regional environmental features, and local behavioral and transformative, natural or cultural processes. The field survey aims at a diachronic view of the designated geographic region in various periods (extensive or regional survey) as well as a microscopic and synchronic examination of particular Mycenaean sites (intensive or local survey).

The extensive field survey of a designated region whose geomorphology and topography offer indications for potential inhabitation, aims

(i) to investigate the intraregional interaction of settlements, cemeteries, and other sites, and their relationship with the natural environment diachronically, and

(ii) to study the spatial distribution and concentration of archaeological sites as potential indicators of historical, sociopolitical, and economic change.

The regional survey in the Spercheios valley involves satellite images and aerial reconnaissance (with a drone-mounted camera); field walking and recording of inhabitation traces; mapping, plotting and georeferencing (with use of GPS and mobile computer technology); tracing density or frequency patterns of sites and surface material; finally, random or systematic sampling of surface material.

The intensive field survey, on the other hand, aims to define the number and size of sites, investigate their spatial distribution in different periods, assess the relative environmental impact on their geographical distribution, detect their intraregional interaction and extra regional relations, and identify potential second-order or first-order administrative centers. The intensity of the local field survey depends on various qualitative and quantitative parameters of the data collection process. The intensive field survey of sites in the Spercheios valley involve controlled conditions of systematic surface material collection in predetermined, fixed transects to secure statistical integrity; forming quantifiable observations and quantification of data; identifying temporal and spatial fixed parameters and variables; correlating and evaluating environmental parameters in archaeological data analysis (geomorphology and ground inclination, soil composition and micromorphology, local geology and hydrology, mineral sources, use of land).

At the first stage of the extensive regional field survey, the maps of the survey area were collected and digitized, highlighting the geomorphological, environmental and geological characteristics that would later assist in assessing each location separately, but also the area as an integrated unit. For this purpose, we created a GIS based map that could accurately represent the overall landscape, while at the same time would provide the diversity of information required for spatial analysis (Figure 3).

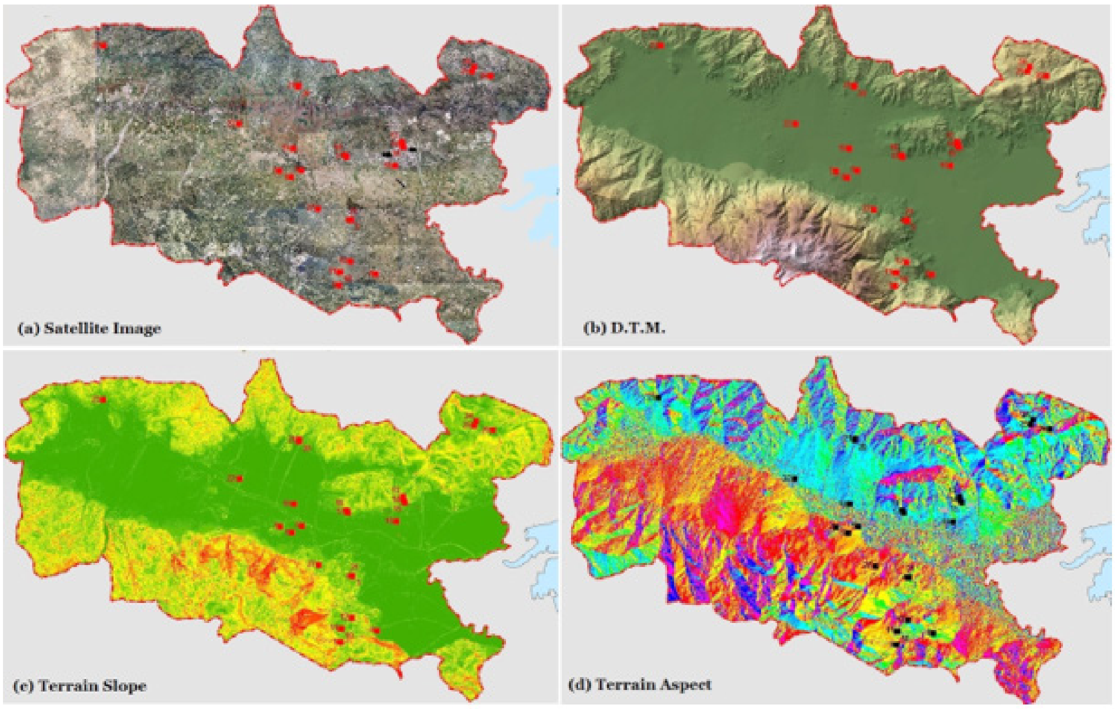

Figure 3: Sample of Maps (created in GIS environment).

Subsequently, the archaeological information was represented spatially on the survey area map to acquire accurate position of the archaeological sites. The initial phase of field survey was carried out for three main reasons, first and foremost to obtain the exact coordinates of known locations as recorded in the bibliography (Table 1), secondly to enrich the spatial and archaeological data with photographs and drawings, and thirdly, to recognize the characteristics of the surrounding landscape (Figure 4).

Figure 4: (a) Coordinates Recording, (b) Photographic Material, (c) Landscape Recognition.

Table 1: Analysis index where elevation above sea level, aspect, the local geology and distance from water resources is given.

#	Name	Place Name	Elevation(m)	Aspect	Slope	HydroDistance(m)	Geology
1	Stergiopoulos Property	Frantzi	138	Northeast	Flat Land	150	Alluvial Deposits
2	Pagoni/Delopoulos Property	Frantzi	141	Northeast	Flat Land	161	Alluvial Deposits
3	Doka Property	Frantzi	139	Northeast	Flat Land	134	Alluvial Deposits
4	Pavlaki/Tsona Property	Frantzi	146	Northeast	Flat Land	78	Alluvial Deposits
5	Kompotades Cemetery	Profitis Elias	31	Southeast	SemiSteep	350	Alluvial Deposits

6	Kompotades Derkina	Profitis Elias	54	Northeast	Flat Land	60	Alluvial Deposits
7	Mexiates	Koutsouraki	55	North	Flat Land	30	Alluvial Deposits
8	St Nicholas Church	Vardates	72	South	Flat Land	224	Flysch
9	Dema (walls)	Dyo Vouna	483	Northeast	SemiSteep	318	Alluvial Deposits
10	Dema (tombs)	Dyo Vouna	413	Southeast	SemiSteep	155	Limestone
11	Dema (ceramics)	Dyo Vouna	416	South	Flat Land	117	Limestone
12	Dema (observatory)	Dyo Vouna	404	Northeast	SemiSteep	94	Limestone
13	Lamia Castle	Akrolamia	205	Southeast	Flat Land	248	Ophiolithic Com-plex
14	Lamia	Epichomata	180	Southwest	SemiSteep	100	Ophiolithic Com-plex
15	Bikiorema	Bikiorema	44	West	SemiSteep	183	Alluvial Deposits
16	Sfyri Property	Valogourna	17	South	Flat Land	349	Alluvial Deposits
17	Stavros (chamber tomb)	Lamia	46	West	SemiSteep	237	Alluvial Deposits
18	Stavros	Lamia	43	West	SemiSteep	234	Alluvial Deposits
19	Amouri	Agia Triada	34	South	Flat Land	6	Alluvial Deposits
20	Lygaria	Paliochora	168	South	Flat Land	66	Alluvial Deposits
21	Lygaria	Tsolpanata hill	184	South	SemiSteep	43	Alluvial Deposits
22	Lianokladi	Paliomylos	49	Southwest	Flat Land	101	Alluvial Deposits
23	Archani	Paliomylos	150	Southwest	Flat Land	28	Alluvial Deposits
24	Paliochori	Agios Georgios	780	South	Flat Land	189	Limestone
25	Paliochori	Matsouki	754	South	Flat Land	115	Limestone
26	Limogardi	Acropolis	873	Southeast	SemiSteep	302	Limestone
27	Kostalexi	Forest	203	Northeast	Flat Land	127	Limestone

To this end, a TOPCON GPS Total Station was used for the collection of archaeological data, the spatial integration of data into the area, and the on-site recording of the coordinates of archaeological sites. The GPS Total Station operates using the phase kinematic technique (RTK - Real Time Kinematic) and can accurately determine a location with a deviation between a few millimeters to 1 centimeter. For the collection of coordinates and the processing of data, the Transverse Mercator Projection TM87 of the Greek Geodetic Reference System 1987 (EGSA '87) was used. The Greek Geodetic Reference System is the unified projection system used in Greece, both in the private and public sectors of the country and is the required and unique reporting system acceptable to all services in Greece.

In the field survey, priority was given to visiting sites that were excavated or located in the past. The research team physically visited these locations that were only mentioned descriptively in the bibliography. These field trips were organized in collaboration with the local Ephorate of Antiquities and with the guidance of local guards and workmen. During these visits, the research team would also inspect the local geomorphology and environment (on foot and with the use of a drone-mounted camera) in order to identify significant natural features or essential sources in the vicinity of the located sites (e.g., low hills and water sources for settlements, soft bedrock for necropolis of rock-cut chamber tombs) as potential diagnostic evidence for inhabitation. As a result, many more new sites, unknown so far, were located and identified in the process, thus enabling the application of geocumulative geospatial analysis and frequency/spatial distribution models to explore interaction between environment and site distribution, trace contact patterns and hierarchical dynamics among sites, and identify second-order centers and possibly a first-order administrative center in the region. The use of GPS in the field was highly effective for recording coordinates and georeferencing, but also for plotting, positioning, laying out, and measuring equal parallel transects for systematic field survey of select sites by the research team (Figure 5).

The methodology followed was to divide the area into grids consisting of equally sized segments

(squares), perpendicular lines and equally spaced points forming a rectangle, whose size always depended on the area to be surveyed. This way, the survey team had a better perception of the space they had to walk in and remained committed to it, thus maximizing systematic sampling of surface material, and securing statistical integrity.

The targeted area was surveyed according to standard extensive and intensive surface surveying (walking survey) methodology. The survey area was divided into equal transects with two subgroups walking in cardinal directions, the first one heading south to north in the relevant grid and the other west to east, respectively, thus ensuring that the area would be carefully and methodically surveyed twice.

While collecting surface material (small artifacts, stone tools, pottery sherds, roof tiles, or Eco facts such as bones and shell), or locating cultural ruins or natural features, finds were marked using different colored survey flags for each of the two groups that moved W- E (red) and N-S (blue) (Figure 6).

Figure 5: Field survey.

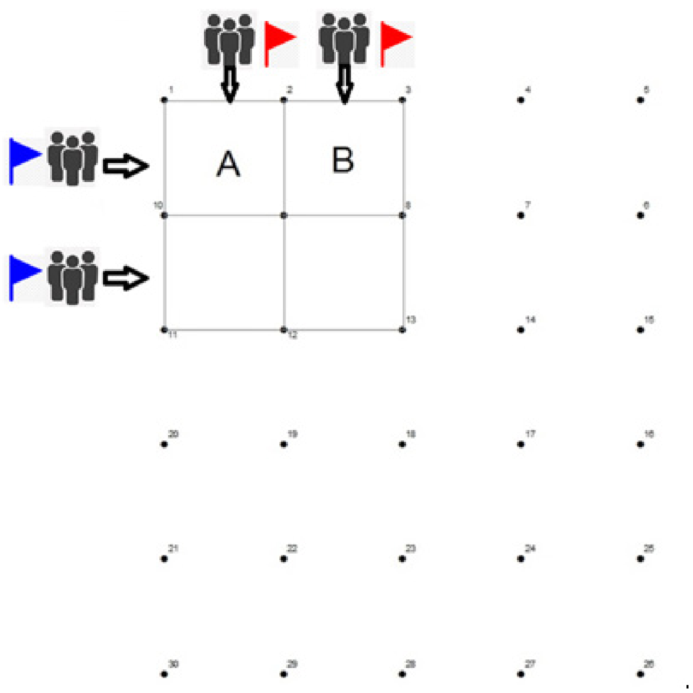

Figure 6: Systematic Field Survey (crossing transects).

This method of flagging resulted in an exact number of occurrences per group, which facilitated the assessment of efficiency of each team and evaluation of the individual students in the field; in cases where their locations marked by two different flags, we knew that both groups located and identified the object or feature as an archaeological find. Each of those findings was evaluated by the lead archaeologist of each team in order to record it or not; in the recording forms of Arch Data application The purpose of this methodology of double checking of each predetermined square grid is happening as the project, in addition to research purposes, aims to train students in archaeological field survey. With this in mind; as the first team with red flags completes the survey in each of the squares of the grid, the flags are collected and the records on forms are completed, the next team with blue flags starts immediately after in the same space. In this way, more students are trained and also the fieldwork they contribute to the project is more appropriately evaluated.

For those finds deemed significant, the flag remains on the ground while the find is tagged and coded with a prearranged purpose tag (Figure 7). Due to the fact that the accuracy we need for the exact location of each finding is the highest possible and because mobile GPS in our days do not offer the possibility of high accuracy, which we have determined for our case only in a few centimeters; at the end of the process each location is recorded with the precision GPS in terms of its position and elevation. This purpose of high accuracy for the program is extremely important as the senior staff coordinators strongly believe that it is preferable to accurately record the position of each finding that has been found, since there is indeed the possibility of absolute accuracy of the measurements. So, in the generated maps (both in digital and analog form) we want to render and present the location of the finds exactly where they were found, whether we are talking about pottery (which obviously may have been carried away), or whether we are talking about architectural parts which are most often in place.

Figure 7: Field survey (flags in the ground).

Also, it should be mentioned that the recording forms were not made in the usual, conventional way but a special archaeological application was created called ARCH_DATA; the function and advantages of which are presented immediately below.

At the end of the process there is the collection team which, after passing the GPS that will take the coordinates for each find, will store it in a special storage bag together with the coding tab and collect the flags from the ground.

Application technology in the service of archaeological research.

Mobile computing is a new form of computing in which the functions of computing systems are transferred to mobile phones or mobile devices with high processing power, thus providing new forms of services and applications to their users. Over the years, mobile phone users have asked for more, more creative and original applications. The Android platform is a game changer for the mobile application development community, as it is an innovative and open platform that is able to address the growing needs of the mobile market [18]. Within the framework of the MY.SPEAR. 5-year research project and aiming at a more manageable and simplified process of data collection through surface survey, the ARCH_DATA application was designed and developed in the form of a mobile computing application.

The name is derived from Archaeological Data and identifies the functions of the application in archaeological fieldwork. It is an application for collecting, processing, and managing all the necessary, as judged by the project team, archaeological, cultural and environmental data of the field survey and the creation of the project database; and includes the export of the records to a database, the online process of sending all the data directly via email, and the photographic documentation of each object (Figure 8).

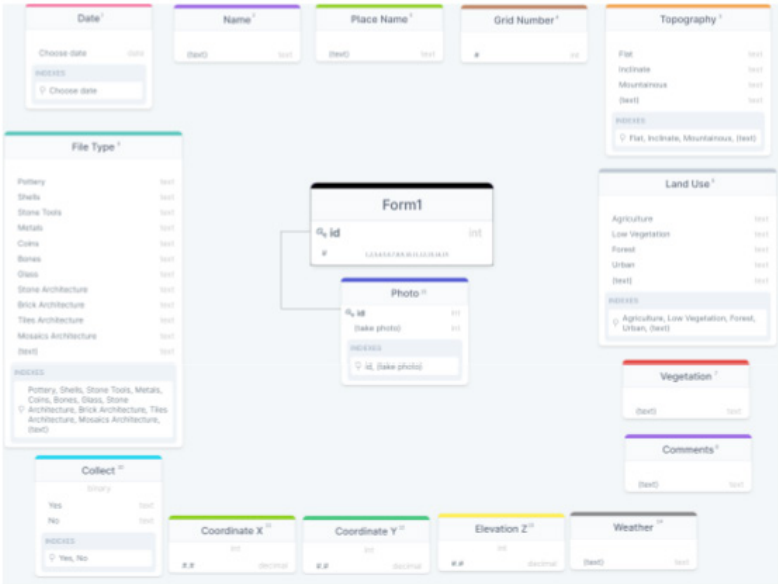

Figure 8: ARCH_DATA (SQL Database Creation Workflow Diagram).

It works under the form of creating an object form, in which all the information is recorded and the photographic documentation which can be done in two ways. Either directly, by photographing through the application in low resolution settings for easy extraction of the photographic material, or indirectly with the Choose from gallery option, which gives you the possibility to have high-resolution photographic material. Another great advantage is the identification of form and photographic material as they follow the same name to have a connection between the descriptive and photographic objects of the application.

Once the fields are filled in, the form is saved in serial number order. This automated process makes it easier as the user in this way does not have to go back to his notes and check which form number he had used, saving time in the field and avoiding double entries. All forms are designed as separate entities to make them easy to edit but at the end and during the export process they no longer create our single database with each form being a record (Figure 9).

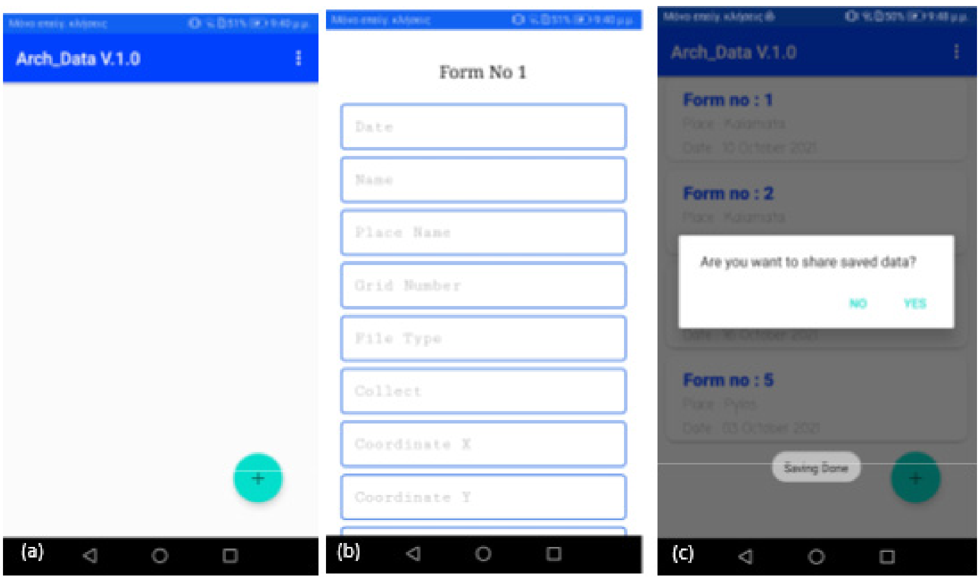

Figure 9: (a) Start menu of ARCH_DATA Mobile Archaeological Application, with the plus symbol you can add a New Form, (b) The New Form window *for adding all findings Information including Photographs and Sketch from the Field Survey*, (c) Export and Share Forms for all the recorded findings, an easy way to export and share all Forms Information in one Excel File.

Key advantages of the ARCH_DATA application is that it is very easy to use and can be used by anyone without any special knowledge and like all mobile applications it does not require you to have any other logging object with you other than your mobile phone. It is easily adaptable and changeable to the needs of each archaeological survey, by simply varying the fields of interest according to the needs of each team. It automatically connects all descriptive information of the findings (via Forms) with the photographic material, so the user can easily match these two different kinds of information. Also, the user doesn't need to carry any other equipment such as a photographic camera, as all mobiles now provide this feature. There is no limit to the number of forms we want to import, but there is also no limit to the number of users using the app at the same time. So, since the program also has an educational purpose, it can be used simultaneously by multiple users who will survey a certain study area in parallel, saving time in the field, while they can easily export and share their file in multiple ways either with the help of the internet (email, google drive), but also in offline situations (Bluetooth, wireless communication). In the final stage of the process, a pre-designated user is required to coordinate the database, bringing all the files together to create the final single file per project day (Figure 10).

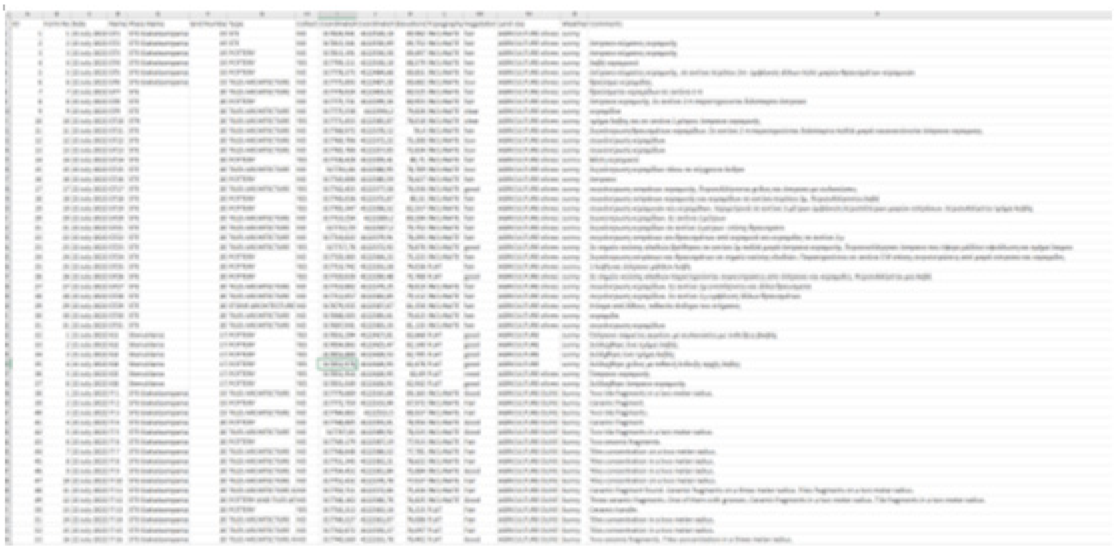

Figure 10: The final Excel File exported by ARCH_DATA application. Its great advantage is that is connecting all forms and photographic material and creates automatically an Excel Spreadsheet.

Results

The MY.SPE.AR. project has already located and identified many Mycenaean sites (settlements and cemeteries), situated mainly on low hills in the periphery of the Spercheios valley or near the river (agricultural settlements), and sporadically higher up on the mountains (sites guarding mountain crossings or pastoral settlements). The spatial distribution of sites suggests that in the Mycenaean period, just like in later ancient, Byzantine, and medieval times, the valley settlements were interconnected and served by a peripheral road that facilitated communication and transportation of people and commodities, while river crossings at narrow points (via bridges or floating rafts) would have connected the northern and southern banks of the river. The Spercheios river must have been navigable in antiquity, thus facilitating fast and efficient transportation of agricultural products from the valley to the port of Lamia in the Euboean Gulf.

Furthermore, several geopolitical and topographical parameters, promising geophysical data, and old trial trenches that yielded Mycenaean wall remains and palatial ceramic evidence may potentially indicate the presence of a regional administrative center strategically situated in the ancient citadel of Lamia ("Akrolamia"), once controlling land trade routes and the entrance to the Spercheios valley, commanding access to the shore, and regulating the regional agricultural production [4]. The Homeric poems, epic poetry, Greek mythology, and the folklore tradition traditionally connect the Spercheios River with Achilles and his kingdom in Phthia, thus preserving the collective memory of a palace state in the region. The strategic and economic potential of the region practically eliminates even the remote possibility of a geopolitical vacuum in this key area; if only the presence of a regional administrative center is further attested by excavation in the "Akrolamia" soon, that would drastically change the political geography in the periphery of the Mycenaean world.

In conclusion, the benefits of using GPS in the geoarchaeological research program are multiple and readable in different levels of the study. Firstly, precisely determining the location of the points of interest and creating virtually the framework on which the research will focus. Secondly, documenting in a fast and relatively simple process, using the HEPOS network which only requires the presence of the ROVER station, while internet coverage is secured through 4G and other available cellular networks. Thirdly, identifying -by using the exact positions with their elevation- other functions of the points of interest conveying a specific prearranged message or label (e.g., watch towers, beacon towers or "phryctoriai," roads, settlements, cemeteries). Also, recording the coordinates of the geophysical survey grids for GIS integration and future excavation.

Lastly, but equally important, contributing substantially to the surface field working group, by clearly defining the survey area to be covered effectively and identifying the coordinates of the finds, thus creating specific zones of archaeological interest.

Within the framework of the project, several new innovative archaeological field survey methods were used, including full mapping of extreme precision (accuracy under 1 cm) for each find and the use of mobile computing through the ARCH_DATA application that was created. Mobile apps are the trend of the future. Already, every day many different scientific groups and disciplines trust the wide range of applications on mobile phones to simplify and make their daily life more functional. The ARCH_DATA application aims to do just that. To simplify archaeological fieldwork through easy and efficient data collection which leads to the creation of the project's Database through automated processes. The process is faster than conventional recording methods while eliminating significant errors that can result from them (misreading of handwritten notes, poor transfer to the database, double entries, loss of forms or photographic material, etc.). Although archaeology studies the past, it belongs to the sciences of the future and is therefore bound to evolve. Mobile applications such as ARCH_DATA contribute decisively to this evolution, setting the tone for a new era in archaeological fieldwork and its implications [19].

Acknowledgment

This project was implemented within the scope of the "Exceptional Laboratory Practices in Cultural Heritage: Upgrading Infrastructure and Extending Research Perspectives of the Laboratory of Archaeometry", co-financed by Greece and the European Union project under the auspices of the program "Competitiveness, Entrepreneurship and Innovation" NSRF 2014-2020.

Conflict of Interest

No conflict of interest.

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