

DEMOCRITUS UNIVERSITY OF THRACE  
SCHOOL OF CLASSICS AND HUMANITIES  
DEPARTMENT OF LANGUAGES, LITERATURE AND CULTURE OF THE BLACK SEA COUNTRIES

# Surveying Aegean Thrace in the Digital Era

*Proceedings of the Workshop held for the Research Project  
Archaeological and Geophysical Research  
at the Peraia of Samothrace (HFRI-FM17-750)*

Edited by Amalia Avramidou and Jamieson C. Donati





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Design, design editing, montage, printing, production:

**TWO K Project LTD**

Behind Hephaestus settlement,

adjacent to Democritus University of Thrace Campus, 69150 Komotini

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ISBN: 978-618-81773-1-4 | ISBN E-BOOK: 978-618-81773-2-1



**ΕΛΙΔΕΚ.**  
Ελληνικό Ίδρυμα Έρευνας & Καινοτομίας

**H.F.R.I.**  
Hellenic Foundation for  
Research & Innovation

The project is supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the “1st Call for H.F.R.I. Research Projects to support Faculty Members & Researchers and the Procurement of High-cost Research Equipment Grant” (HFRI-FM17-750).



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Komotini 2023

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## Preface

Aegean Thrace has long been a focus of archaeological investigations, producing a remarkable array of new sites, monuments, and artifacts from Prehistory through the Early Modern Era. During recent decades, this archaeologically rich area has attracted the interest of multidisciplinary research teams to explore the landscape and its surroundings with complimentary methods of site analysis, including intensive pedestrian surveying, satellite and aerial remote sensing, and geophysical prospection using when applicable geographic information system (GIS), custom-made field applications, and other digital tools.

The workshop *Surveying Aegean Thrace in the Digital Era* was held on September 12, 2022, bringing together researchers currently active in fieldwork projects in Aegean Thrace with the intention of discussing the latest results and formulating comprehensive perspectives on the wider region. This one-day event was held within the framework of the research project *Archaeological and Geophysical Research at the Peraia of Samothrace* (HFRI-FM17-750). Participants included the members of fieldwork projects from Greece and abroad with an active research agenda on the archaeology and landscape of Aegean Thrace (for the program see <http://www.peraiasamothraceproject.gr/en/home-page/>).

The publication of the Workshop Proceedings marks an important milestone for the Peraia of Samothrace Project, which reflects the work of numerous people. Tzeni Katsari, Thanos Vafeiadis, and the editorial team at 2K Project are commended for the attention to detail and their assistance throughout the publication process. Special thanks are owed to the collaborators of the Peraia of Samothrace Project for joining this journey across the local topography, to our volunteers and administrators, and to the authors of this volume for readily contributing to a publication that aspires to become a reference point for the study of Aegean Thrace.

Abbreviations follow the standards of the *American Journal of Archaeology* <https://www.ajaonline.org/submissions/abbreviations>. Additionally, we use the following:

***AEMTh***

*Το Αρχαιολογικό Έργο στη Μακεδονία και τη Θράκη*

***Δινήεσσα***

P. Adam-Veleni – K. Tzanavari (eds), 2012, *Δινήεσσα – τιμητικός τόμος για την Κατερίνα Ρωμοπούλου*, Thessaloniki.

***Μνήμη***

Ch. Koukouli-Chrysanthaki – O. Picard – T. Petrides (eds), 1990, *Μνήμη Δ. Λαζαρίδη, Πόλις και Χώρα στην αρχαία Μακεδονία και Θράκη, Καβάλα 9–11 Μαΐου 1986*, Thessaloniki.

**Other Abbreviations:**

**ca** circa

**cf.** confer

**ed.** editor

**eds** editors

**et al.** et alii

**fig.** figure / **figs.** figures

**ha** hectare(s)

**i.e.** id est

**km** kilometer(s)

**m** meter(s) / **μ.** μέτρο(α)

**masl.** Meters above sea level

**Max.** Maximum

**Min.** Minimum

**n.** note / **nn.** notes

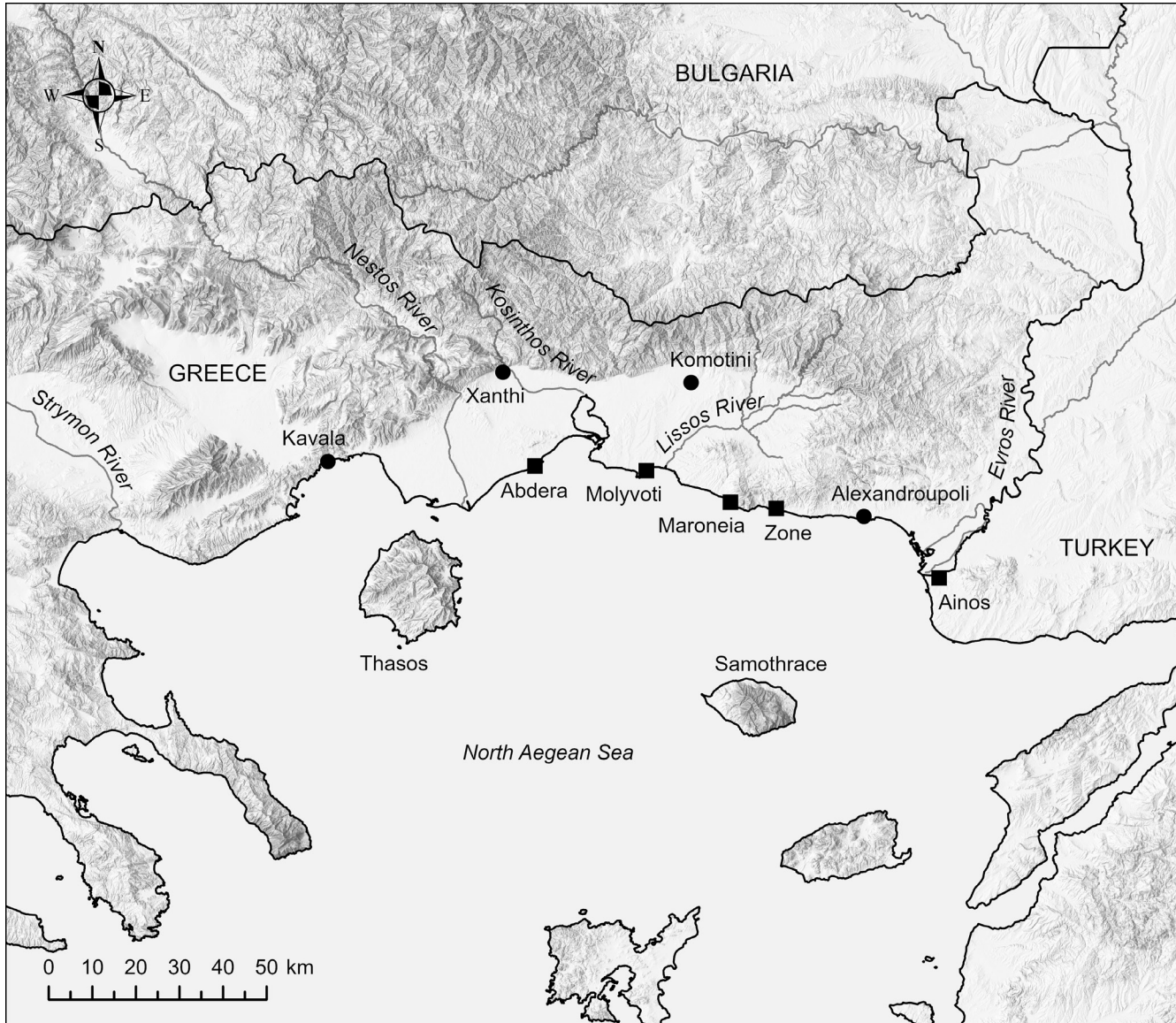
**no. number** / **nos.** numbers

**pl. plate** / **pls** plates

**sq m** square meter(s)

**sq km** square kilometer(s)





Map of Aegean Thrace with sites mentioned in the volume (figure by J. C. Donati)

# Introduction

«Οι γνώσεις μας, γενικά για την τοπογραφία της δυτικής Θράκης και ειδικά της περιοχής που μας ενδιαφέρει εδώ για τα παλαιότερα χρόνια του ιωνικού αποικισμού στο βόρειο Αιγαίο, είναι γνωστό πως είναι πολύ φτωχές [...] [Επανεξέταση του χώρου] δεν μπορούσε να γίνει σε μια παλαιότερη εποχή. Αλλά μόνο στα χρόνια μας, ύστερα από [...] τις αποξηράνσεις των ελών και τις διευθετήσεις των ποταμών [...] με επιμονή και επίπονη πεζοπορία.»

*“Our knowledge on the topography of western Thrace and especially on the region we are interested here regarding the earliest years of the Ionian colonization in the Northern Aegean, is indeed very limited [...] [Any revision] could not have taken place in the past but only during our time, following [...] the draining of swamps and river flow arrangements [...] with persistence and strenuous hiking.”*

(Bakalakis, G. 1959, *Προνασκαφικές έρευνες στη Θράκη*, Thessaloniki, 84–85  
Trans. by the editors)

**I**t is nearly a century since Georgios Bakalakis’s first, pre-WWII exploration of Aegean Thrace and almost 65 years since the publication of his pioneering work on the archaeology of the region.<sup>1</sup> Even though the landscape of the coastal zone between the Nestos and Evros rivers has changed significantly in the interim and our methodologies have vastly improved, the basic principles of surveying the land remain the same: walking the fields is still the key to understanding the local topography, observing how the environmental conditions affect the local economy and how human occupation is imprinted across spatial and temporal frames.

Today, land surveys have evolved from simple grabs into multi-disciplinary approaches to the archaeological landscape, involving complex methodologies that aim to complement each other. A pedestrian survey alone, no matter how intensive, cannot give us a satisfactory picture of the changes that have occurred in the landscape without the study of historical aerial photographs and satellite imagery. Moreover, no hypothesis can be built solely on ceramic density maps without the assistance of non-invasive techniques, such as geophysical prospection. Investigating traces of archaeo-fauna and -flora, as well as the geology of a region provides important information for a site’s diachronic occupation. When all this is combined in GeoInformatics and custom-made archaeo-tools, we gain more in-depth, accurate perspectives of the local topography, in formats that are easier to manage, visualize, and share.

The contributions to this volume reflect both the core principles of Bakalakis (perseverance

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<sup>1</sup> Bakalakis 1959, Preface. As expected, the bibliography on the archaeology of Aegean Thrace is very rich; it would be futile to list references here when bibliographical collections are available online on sites such as <http://arena.athenarc.gr> (Archaeological Research in the Northern Aegean) and <http://www.peraiasamothraceproject.gr/en/bibliography/> (Peraia of Samothrace Project).

and trekking) and the use of multi-disciplinary applications and technologies when studying Aegean Thrace. The volume comprises six papers arranged in geographical order from east to west. Starting with the Samothrace Archaeological Survey (SAS) and the Peraia of Samothrace Project (PSP) on the mainland opposite the island, we continue further west with the investigations at Maroneia (Tsokas et al.) and at Molyvoti, undertaken by the Molyvoti, Thrace, Archaeological Project (MTAP), and finish with two surveys at Abdera by the Nestos river, the multi-year project of the Archaeological Program of Abdera and Xanthi (APAX) and the targeted work at the Theater of Abdera (Tsokas et al.). Time constraints did not allow for the translation of all papers into English, but English abstracts provide descriptions of all projects and their outcome.

The focus of each paper varies as certain projects target site-specific locations, trying to shed light on archaeological questions with non-invasive methods as a precursor to or in lieu of excavations (e.g., Theater of Abdera, Maroneia), while others cover a much larger territory, the survey at the island of Samothrace for example. On the other hand, research at Abdera (APEX) and Molyvoti (MTAP) fans out from urban contexts to their *chora*, studying differences in settlement patterns and material diffusion between inland and coastal zones. On the Peraia of Samothrace Project (PSP), investigations comprise intensive surveying, sampling both coastal and mountainous territories with diverse topographical characteristics.

Legacy data and its multi-faceted exploitation are at the core of the Samothrace Archaeological Survey, while the results of previous pedestrian surveys, excavations, and/or geophysics are included to a larger or smaller extent in all projects. Since some surveys are relatively new (e.g., the Peraia of Samothrace Project [PSP], the Abdera Program [APEX]), the processing of the collected material (ceramics and other) is not as advanced as, for example, in the case of the Samothrace Archaeological Survey (SAS) or the Molyvoti Project (MTAP), where the treatment of the ceramic record is quite detailed. Conversely, for projects where geophysical prospection plays the primary role (e.g., the work of Tsokas et al. at the Theater of Abdera and Maroneia), it is the methodological innovations and the support these lend to the archaeological research that is highlighted.

The Peraia of Samothrace Project (PSP) explores four areas of interest between Mt Ismaros and the village of Makre, expanding from the coast to the slopes of the Rhodope mountain range. Intensive pedestrian surveying, remote sensing, as well as geophysics were used to investigate the diverse topography of the region. The results so far include a single cluster of Neolithic material; a distinct presence of local coarse ware at inland locations in most study areas; key areas with Classical, Hellenistic, and Early Roman finds, including a possible fortified, coastal settlement and a Roman Station by the Via Egnatia; and ample evidence for Late Roman, Byzantine, and post-Byzantine material scattered through most of the region. The scarcity of finds in certain areas of interest confirms the diachronic agricultural character of the land.

The Samothrace Archaeological Survey (SAS) integrates a rich legacy dataset from the 1980s into contemporary frameworks of geoinformatics, providing a plethora of evidence regarding the chronological horizon of the finds and a refined understanding of occupation patterns on the island over the centuries. The majority of the surface material dates to the Late Archaic through Hellenistic periods and can be primarily associated with activities related to agriculture and storage. On the other hand, the study of Roman and Early Byzantine amphoras and fine ware demonstrates the vital role Samothrace played in the regional trade network. Equally important must have been the participation of Samothrace during the Byzantine and later periods, according to the preliminary analysis of Medieval coarse and fine wares and their distribution on the island.

On the opposite coast, the geophysical prospection undertaken by Tsokas et al. at ancient Maroneia in 2004 included both magnetic and electrical mapping surveys, yielding linear anomalies and rectangular outlines that are most likely signatures of buried ancient features. These datasets were recently revisited and reprocessed, applying custom-built algorithms for image fusion. This new calculation model aimed to put together in a single image all the information produced by individual methods in a clear and comprehensive way. The quality of the results proves the efficiency of the image-fusion and its potential in archaeological investigations. At the same time, the survey enhanced our knowledge of Maroneia's urban fabric, confirming that it was a planned settlement.

Focusing on the peninsula where ancient Stryme is thought to be located, the Molyvoti, Thrace, Archaeological Project (MTAP) distinguishes itself from the programs active in Aegean Thrace by including systematic excavation to its multi-disciplinary approach. The ability to cap the investigations through ground-truthing offers a unique opportunity to compare the results of pedestrian surveys and geophysical prospection to material unearthed within closed stratigraphic frames. In addition, expanding the survey beyond the city to its *chora* allows for more nuanced observations regarding the typology and chronology of the material discovered on the coast (urban) and inland (countryside). Preliminary studies indicate that the peak of the site was in the Classical and Early Hellenistic periods, while occupation continued through the Byzantine and Ottoman periods, with agricultural and commercial activities being consistently characteristic of the site.

Moving to the westernmost site discussed in this volume, since 2015 the Archaeological Program of Abdera and Xanthi (APAX) pursues a diachronic, multi-disciplinary survey in the territory of the ancient coastal city of Abdera and its hinterland. The focus of the investigation lies on the city and its periphery during its peak in the Archaic period, while samples from neighboring coastal and mountain zones have also been included in the study for comparison. Satellite and remote sensing along with geophysical prospection and paleo-environmental analyses complement the intensive pedestrian survey, the results of which are integrated into computational and similar digital methods. This multifaceted investigation produces manifold information on settlement dynamics, landscape evolution, and land-uses as well as a more holistic approach to the topography of the region.

In contrast to the all-encompassing scope of APAX, a target-specific geophysical survey was conducted by Tsokas et al. at the ancient theater of Abdera from 2009–2010. The goal was to trace any subsurface architectural elements of the theater and any possible surrounding structures. Soil consistency and the estimated depth of buried remains dictated the use of geoelectrical tomography, producing a rather promising image of subsurface traces.

Overall, the papers in this volume demonstrate how the rich archaeological landscape of Aegean Thrace is an ideal venue for researchers to explore the local topography and the results of anthropogenic and natural activities through the application of combined methodologies. Whether aiming for a diachronic examination, a targeted investigation, or a modern approach to legacy data, this publication sheds new light on the archaeology of the North Aegean, while functioning at the same time as a unique node for scholars and students of various disciplines.

# A

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# The Archaeological Project of Abdera and Xanthi (APAX): Preliminary Update (2022) on the Survey Program

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**ABSTRACT:** This paper presents some preliminary results of the Archaeological Project at Abdera and Xanthi (APAX), a systematic regional survey in the territory of the ancient coastal Ionian colony of Abdera and its hinterland in Aegean Thrace. The application of diverse systematic and intensive pedestrian survey techniques provided the framework for the study undertaken in this region, ensuring that different dimensions will be highlighted. Also, the APAX project has employed geophysical analyses (e.g., Electrical and Seismic Tomography and Georadar) combined with the excavation of geoarchaeological trial trenches and the drilling of boreholes in the harbor areas. Digitized aerial imagery has been extensively used, including historical and present-day photos taken with drones. There has also been some experimental use of a drone automated survey for which Abdera provides the first ever attempted successful tests. This technique is in its first experimental phase, and further development is in process in order to be employed at a larger scale. In general, the preliminary results of our research have provided a plethora of quantitative and qualitative, multidisciplinary, reliable data. These datasets will be integrated and studied further in the following years in order to assess the geomorphological features and the imprint of human activities, and to investigate the traces of the two main cultural groups that were active in this region during most of the 1st millennium BCE, namely Greek colonists and indigenous Thracians.

## Introduction

Abdera, in the modern Prefecture of Xanthi, was a ‘double’ Ionian colony, initially founded in the mid-7th century BCE by citizens of the Greek city of Clazomenai on the peninsula of Erythraea in Asia Minor. A century later (ca 545 BCE) Abdera was recolonized by citizens of Teos, another Greek city located very close to Clazomenai.<sup>1</sup> The location of Abdera, on a peninsula in the vicinity of the ancient course of the Nestos River and the foothills of the Rhodope mountain range, offered both advantages, especially due to its natural harbor (one of the very few well-protected natural anchorages on the Northern Aegean coast) and

\* The authors would like to thank INSTAP, the Spanish Ministry of Science, Innovation and Universities (TransLands, PGC2018-093734-B-I00), and the BBVA Foundation (DIASur) for providing funds for the development of the project. M. Georgiadis is an MSCA Fellow (TransMed, H2020-MSCA-IF-2018, 839650), A. Garcia is a Beatriu de Pinós Fellow (TrackSherd, 2018 BP 00208/Marie Skłodowska-Curie COFUND, BP3, contract num. 801370), A. Mayoral is a Juan de la Cierva-Incorporación fellow (funding Spanish Ministry of Science, grant n° IJC2020-045609-I) and H. Orengo is a Ramón y Cajal Fellow (RYC-2016-19637).

<sup>1</sup> On the early history of Abdera and its two colonizations, see indicatively (with bibliography): Graham 1992; Chryssanthaki 2004; Koukouli-Chryssanthaki 2004; Kallintzi 2011, 97–102. Sailing between the two consecutive Ionian metropoleis and their colony in Abdera was relatively short, ca 200 nautical miles (1 NM = 1,852 m) which could have been covered in 2.5–3 days, depending on the weather and the in-between stops: Casson (1951) calculated a speed of 3–5 knots (i.e. nautical miles per hour); during the summer; thus with ca 14 hours of sunlight ancient ships could have covered ca 60–80 nautical miles per day.

disadvantages due to the surrounding swampy grounds, which may have been the cause of various diseases that decimated the infant population and exhausted the adults mainly during the late 7th–early 6th century BCE.<sup>2</sup>

Since the 1950s important archaeological research, such as systematic excavations within the ancient city of Abdera, several rescue excavations all over the Xanthi Prefecture (including the valley of the Nestos River) as well as many academic publications has significantly increased our knowledge of the history of the area. However, many issues remained open, and many gaps needed to be filled, especially through the implementation of integrated multidisciplinary methodologies and new technologies. As Constantina Kallintzi stated in regard to the region (*chora*) of Abdera up to 2011<sup>3</sup>: “No systematic excavation has to date [2011] been conducted in the southern part of the prefecture of Xanthi apart from very few investigations of a rescue or trial character ... no type of pre-excavation research has been carried out. The material at our disposal comes from the modern use of the place: public works, land reclamations, redistribution of farmland, and various excavation works that followed; also, from cultivation, suggestions, traditions, collection, and limited surface research during on-site inspections for administrative issues. We make special reference to the traumatic means of acquiring archaeological information through destruction, e.g., through illicit excavations or deep plowing of fields. In other words, information is based on surface evidence, which, by definition, is sparse and produces fragmentary material... There were similar problems involving interpretation. The finds normally discovered in the southern part of the prefecture of Xanthi are limited both in number and variety. A common find is pottery, in many instances atypical, which affords no possibility for dating or assessing the site. Surface material at many sites is widely disseminated due at least in part to cultivation. This can offer erroneous data about the total extent of an area. The elimination of a chronological phase due to erosion, or in contrast its concealment by later fill are also frequent phenomena...”

The above description is also valid in regard to most of the northern part of the Xanthi Prefecture which includes the mountainous region; in fact, systematic excavations had only been conducted within the city of Abdera and its immediate surrounding.<sup>4</sup> Since 2015, the initiation of the extensive survey of APAX (Archaeological Program of Abdera and Xanthi) aimed to rectify this gap of data. Indeed, it offered a large amount of new information on sites, settlement dynamics, landscape evolution, and land-use(s), which provide a rare opportunity to review, within a diachronic perspective, the history of this Thracian district and shed more light on specific scholarly questions, such as the relations and socio-cultural dynamics that developed between various cultural groups, especially between the Greek colonists from Ionia and the local Thracian tribes.<sup>5</sup> The project is conducted by the Ephorate of Xanthi of the Hellenic Ministry of Culture in collaboration with the National and Kapodistrian University of Athens – Faculty of History and Archaeology, the Catalan Institute of Classical Archaeology (ICAC), the Institute of Evolution Sciences of Montpellier (ISEM CNRS–University of Montpellier), and specialists from other Universities and Research Institutes.

## Methodology

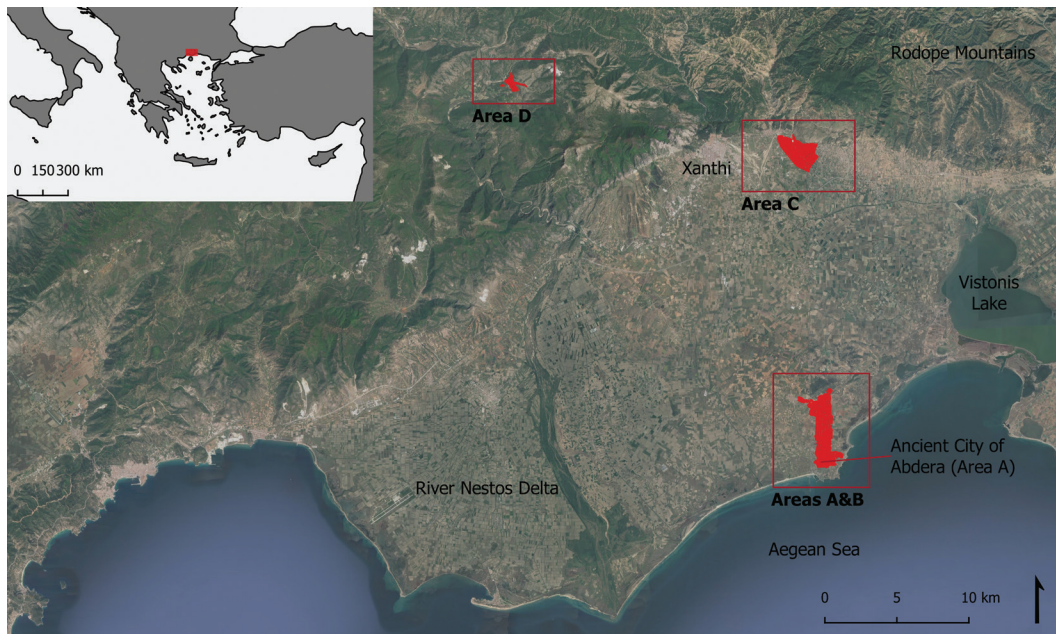
The initial results of APAX as well as the analysis of its overall methodology have been published in annual Greek conferences, international journals, and conference proceed-

2 Agelarakis 2012. Cf. also Kallintzi – Kefalidou 2022.

3 Kallintzi 2011, 1446–1447.

4 For overviews of more recent rescue excavations, see Kallintzi 2021a; 2021b.

5 For some relevant aspects, see Triantafyllos 2009; Ilieva 2018; 2019; Kallintzi *et al.* 2020.



**Fig. 1** The territory of the Xanthi Prefecture is bordered by the Nestos River (W), the Vistonis Lake (E), and the Aegean Sea (S) and it includes part of the Rhodope mountains until the Bulgarian border (N). APAX focuses on different historical/geographical sectors of the prefecture, including the coast (Areas A and B), inland Rhodope foothills (Area C), and intra-mountainous valleys (Area D) (Georgiadis et al. 2022, fig. 1).

ings.<sup>6</sup> In this paper, we focus on the integration of computational and similar digital methods used within the APAX regional survey context. The survey is based on the intensive pedestrian sample collection conducted in the territory of the ancient coastal city of Abdera and its hinterland in Aegean Thrace. There is a focus on the ancient city and its environs, dating from the Archaic times onwards (Areas A and B), but other areas and other periods are also represented and analyzed in order to reflect other geo-historical areas of the Xanthi Prefecture, i.e. the foothills and the mountains – Areas C and D, respectively (Figure 1).

Area A is separated from the rest of the surveyed region because it consisted of the early fortified *polis* of Abdera and thus its urban character set it apart. It is well defined by the wall that protected the site since the Archaic period and covers an area of ca 1 sq km. Area B was part of the ancient *chora* (countryside),<sup>7</sup> which included a portion of the ancient burial grounds that belonged to the *polis* (Area A). Part of it comprises wet coastal lowlands with marshes and other forms of wetland environments, which currently have been drained, while its northern part extends to the foothills of Profitis Ilias. The total size of this area is ca 5 sq km and is very rich in sites and cultural remains from Prehistory until modern times, with the vast majority belonging to the Graeco-Roman period. Of utmost importance is the large number of burial tumuli, some of which still dominate the landscape due to their position, size, and height (Figure 2). Areas A and B are directly associated with the coast, the foundation of the Greek *polis* of Abdera, and its immediate environment.

The second environmental zone, Area C, is a foothill area at the northern end of the Xanthi alluvial plain, immediately south of the hills and mountains of the Rhodope mountain

<sup>6</sup> See for example, Kallintzi et al. 2015; 2017; 2020; 2022; Georgiadis et al. 2022.

<sup>7</sup> For the *chora* of Abdera, see Kallintzi 2011.





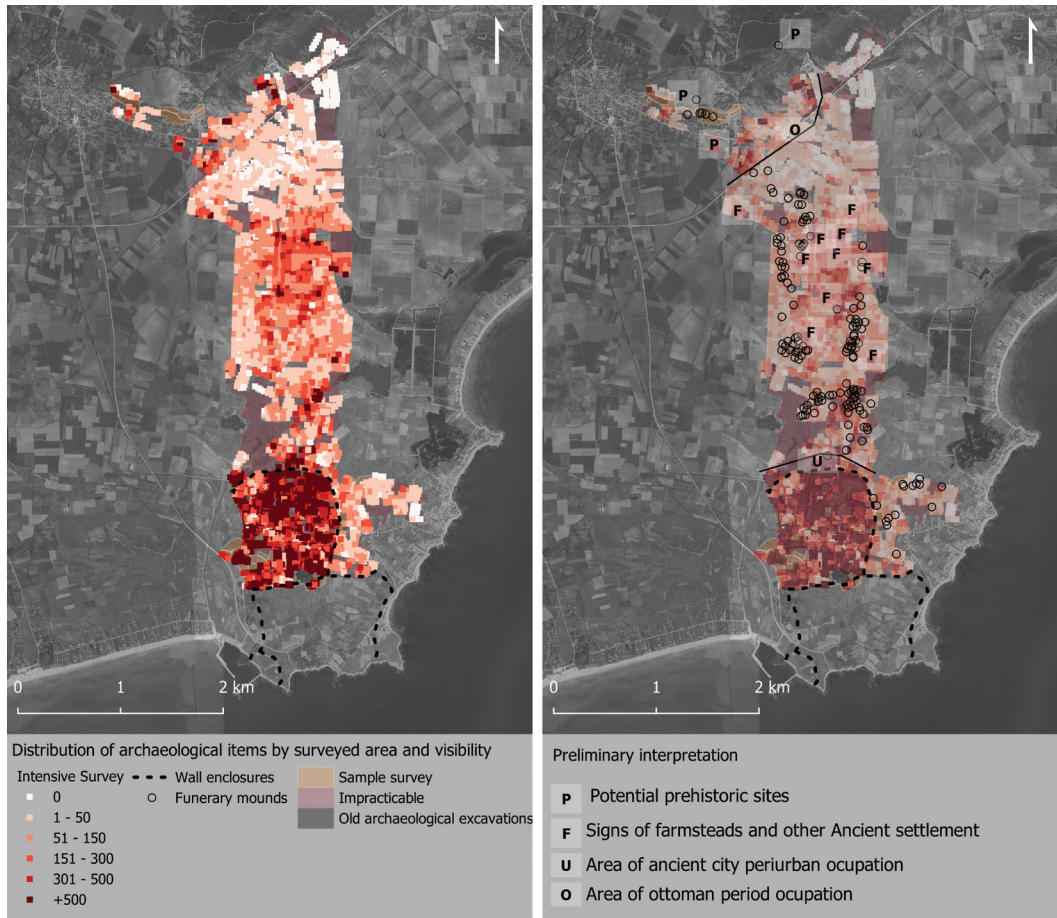
**Fig. 2** Burial tumuli in the chora of Abdera (Xanthi Ephorate of Antiquities).

range. This region with a total size of ca 3.5 sq km is situated between three modern villages and extends to the lower slopes of Zarkadia Hill to the north. The Zarkadia stream crosses this region in the middle and creates a deeply entrenched and wide streambed at its northern half, which is dry most of the year. Previous research in this area had provided very limited archaeological finds. However, this picture has changed after the APAX survey which revealed the presence of several sites of various periods in the lower slopes of the Rhodope, as well as buried palaeosoils containing archaeological material, visible on stratigraphic profiles cut by the dry streambeds in the foothills.<sup>8</sup> Finally, the third environmental zone, Area D, is located within the mountains in a small intra-mountainous basin next to the course of the Nestos River. It is currently ca 30 km away from the sea, separated by the barriers of the Rhodope peaks; inland routes and the Nestos valley acted as connecting paths with the lowlands and the coast. The area under survey is located on the gentle slopes and a small plain between three hills and covers an area of ca 0.5 sq km. Furthermore, its inland and mountainous landscape characteristics provide an additional understanding of the choices for establishing settlements in the hinterland of the Greek colony. In general, the total area that this project covered on the ground is approximately 10 sq km. Sampling from different environmental and cultural zones aimed to throw light onto potential similarities and differences in the economic exploitation of diverse landscapes and between the two main known contemporary cultural groups of this region, the Greeks and the Thracians.

The application of diverse systematic and intensive pedestrian survey techniques provided the framework with which the study of this region has been undertaken, ensuring that different dimensions will be highlighted. The topographic characteristics of each area, the visibility of the ground surface, and the quantities of finds have dictated the technique applied and the methodology followed during the survey. In total, approximately 80% of the 10 sq km study area was surveyed, in which more than 600,000 archaeological items were reported, and ca 45,000 diagnostic archaeological objects have been collected. The sample strategies were based on a grid of 20 x 20 m in urban Area A and 40 x 40 m in Areas B, C, and D.<sup>9</sup> In the first case, the aim was the detailed understanding of urban space, while in

<sup>8</sup> Georgiadis *et al.* 2022, 167.

<sup>9</sup> On the use of smaller survey units in urban spaces in order to provide a good surface resolution, see Whitelaw *et al.* 2007; Bintliff 2013, 195; Attema *et al.* 2020, 4. During the survey in all four regions, there were plots, as one would expect, where the visibility did not allow a systematic collection as described above. Thus, a grab sample collection was implemented, where only the diagnostic remains were collected to provide qualitative data for the determination of dating and the type of activity. In these examples, no comparison with the quantitative material collected in units can be made. However, once the overall pottery analy-



**Fig. 3** Geographical distribution of archaeological features recorded in the field in Areas A and B. The total amount of archaeological items is represented according to area and visibility (left) along with a first interpretation of the data (right) (Georgiadis et al. 2022, fig. 12).

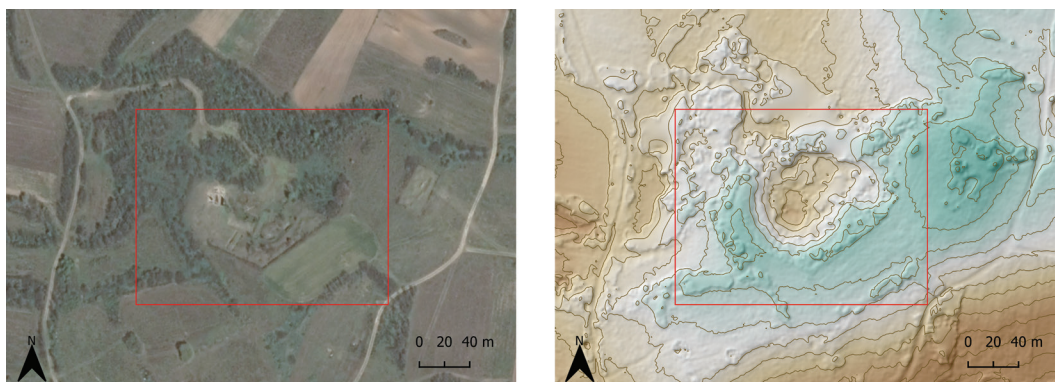
the latter the identification, dating, and characterization of sites. The large number of finds recorded and collected, as well as their diversity, inevitably translates to an extended processing period by several specialists. Preliminary results of their analyses provide an initial archaeological impression of this region, regarding the main period of the polis' occupation on one hand and the relation between the Greeks and the Thracians, on the other.

During the intensive survey, the recorded data included visibility, conditions of the plot, number of visible sherds, tiles and small finds, the number of objects collected, and any feature that may have existed in the survey unit under study.<sup>10</sup> This information was processed in the field using mobile applications and cloud-based GIS software synchronized to the project geodatabase.<sup>11</sup> Once imported into a GIS environment, geostatistical processing allows us to analyze the dispersion of different types of items and their contextual parameters (Figure 3).

sis is available, the diagnostic collected material could reveal whether the seplots were of similar date and character to the ones where more reliable data is available.

<sup>10</sup> Georgiadis et al. 2022.

<sup>11</sup> The main software used on the project includes GIS Cloud (<https://www.giscloud.com>) and QFieldCloud, which facilitates the synchronization with the main GIS project built in open-source QGIS.



**Fig. 4** The theater of Abdera in topographical data obtained from UAV aerial imagery (right), compared to standard aerial imagery. The semicircular shape of the theater's cavea is clearly visible in the UAV model.

APAX has employed digitized aerial imagery, including present-day satellite open-source and aerial imagery (that includes world repositories such as Google Earth, Bing, ESRI, and Greek National digital archives such as the Ktematologio), historical aerial photography (different flights covering Greece between the 1930s and 1990s stored in military archives), satellite imagery (Sentinel and Landsat), and aerial imagery obtained by the APAX team using UAV (drone) flights. Present-day imagery was integrated into the APAX GIS database and used in the design and development of the survey. Historical aerial photographs were digitized and analyzed in order to reconstruct the geomorphological settings of the coastal area of Abdera before extensive land reclamation of the coastal wetlands in the 1950s, and in monitoring the degree and rate of changes in the littoral plain. Furthermore, historical aerial photographs allowed us to detect more burial tumuli that were visible at the time across the area under study. Also, it revealed the presence of an older road system that started from the middle of the northern wall of the Northern Precinct (Area A), where there must have been a city gate, and extended further to the north. Excavations of a small portion of this road by the Xanthi Ephorate of Antiquities during the 1990s showed that it was ca 4.80 m wide and made from paved stones, proved that it belonged to the 5th century BC, providing a confirmation and a date to the image that was available to us.<sup>12</sup>

The use of drones provided good pictures of areas that were not easily accessible, like the theater in Area A (Figure 4). However, their main function was to produce detailed orthophotos and topographical models of the study areas by combining photogrammetrical reconstruction and computer-based visualization techniques,<sup>13</sup> thus making it possible to approach the micro-topography of the area. An experimental approach focusing on the identification, characterization, and contextualization of the leveled burial tumuli in Area B is currently in development.

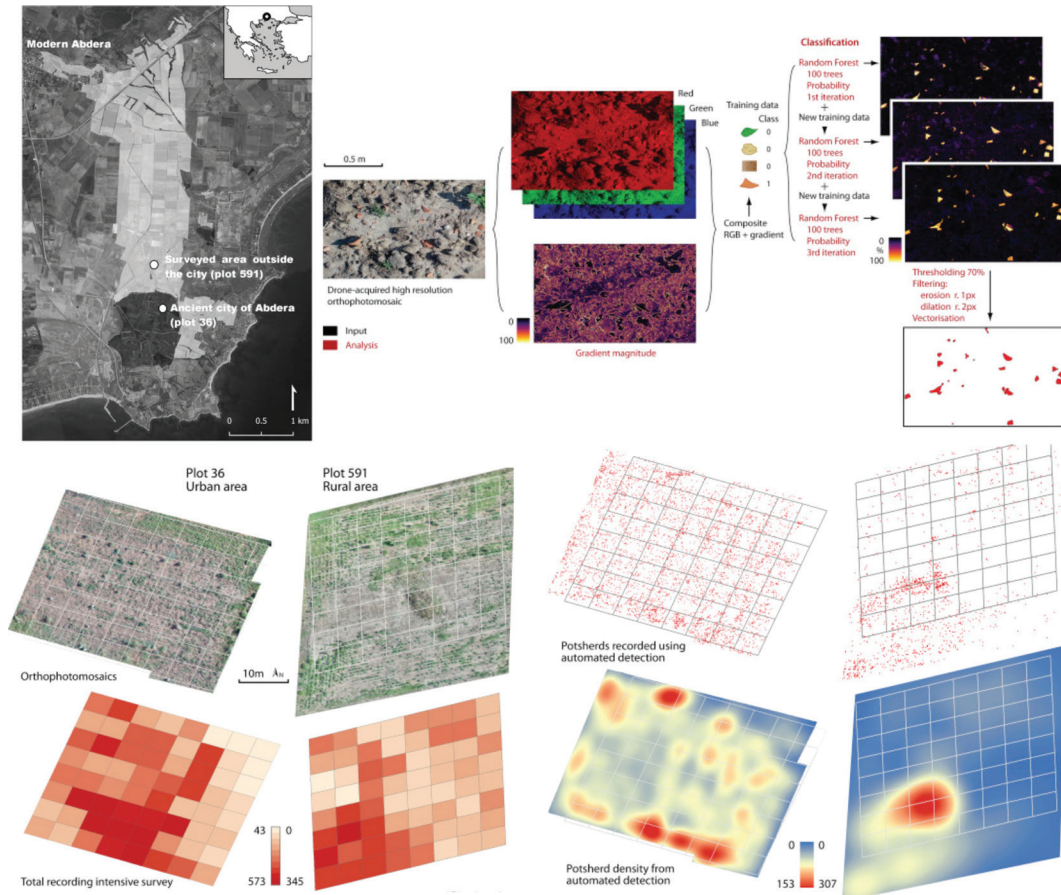
Experimental use of the UAV in the automated detection and recording of surface material was successfully tested in two plots of Areas A and B (Figure 5).<sup>14</sup> The workflow is based on combining very high-resolution aerial imagery (approximately 1mm per pixel) with Machine-Learning based detection algorithms developed to target the differentiation of potsherds in terms of color and textures in comparison to the surrounding soil matrix. This

<sup>12</sup> Kallintzi 2011, 783–786, 1276–1278.

<sup>13</sup> Orengo – Petrie 2018.

<sup>14</sup> Orengo – Garcia-Molsosa 2019; Orengo *et al.* 2021.





**Fig. 5** Workflow and first results of the automatic detection of potsherds. One plot inside the walled city and another outside were selected for a first test, and results were compared with a manual recording of the potsherds visible in a 5 x 5 m grid. Results were comparable in terms of the distribution of the archaeological materials (Orengo and Garcia-Molsosa, 2019).

method provided accurate data regarding the quantification of potsherds with results comparable to the intensive recording of all pieces of pottery visible in 5x5 m grids. Beyond that, it also provides interesting information on the way they were dispersed in the plot, helping us understand the specific post-depositional conditions. Data about the vegetation coverage and size, orientation, and shape of the potsherds can also be retrieved using this technique, opening new possibilities for the study of surface material. The method is in its experimental phase and further developments are planned at a larger scale.

Historical and modern aerial imagery is also being used together with satellite images, digital elevation models at different scales, and historical and present-day thematic cartography (topographic, geological) in the context of the research on the historical geomorphology and palaeogeographic and palaeoenvironmental reconstruction.<sup>15</sup>

Finally, mention must be made of the geophysical survey carried out by the Laboratory of Geophysical-Satellite Remote Sensing & Archaeoenvironment (GeoSat ReSeArch Lab),

<sup>15</sup> Mayoral et al. forthcoming. An M.A. Thesis on the subject (Canudas 2022), developed in the context of the APAX project, is in the process of publication.

FORTH using Electrical Resistance Tomography (ERT), Seismic Tomography, and Ground Penetrating Radar (GPR) in 2022. ERT and Seismic Tomography aimed at the geological stratigraphy of the area, e.g., the detection of the depth and shape of the ancient seabed in the now-silted port area, as well as other geomorphological features. This was combined with the excavation of geoarchaeological trial trenches and boreholes drilling in the harbor area. Thus, more reliable and accurate data regarding the geomorphological features of the port of Abdera and its evolution will become available to us from the integration of these multidisciplinary data in the following years.

### **Summary of Preliminary Results and Future Steps**

The Archaeological Project of Abdera and Xanthi (APAX) provides a unique opportunity for an innovative multidisciplinary study of a complete landscape of ancient colonization and the cultural, economic, and environmental processes that accompanied it. At the moment, we identified various activity areas and recognized numerous cultural finds diverse in character. The analysis of the finds recovered during the survey is still in progress and the results can only be considered as preliminary. Nonetheless, some aspects have already become clear. For example, the coexistence of two habitation models during most of the 1st millennium BCE revealed the presence of two parallel concepts of exploiting the landscape. These models were expressed by two distinct cultural groups, the Greeks and the local Thracians that were in close proximity to each other, and progressively became culturally entangled.

One of the main targets of the APAX research is in the next stage of study to recognize the degree and form of interaction these two groups had during most part of the 1st millennium BCE. Data from the collected finds, aerial and satellite imagery combined with palaeoenvironmental work will further enrich the discussion and provide new dimensions for the study of this region. The integration of archaeological and remote sensing data with the results of the palaeoenvironmental analyses (geoarchaeology, palaeoecology) will improve the characterization of ancient landscapes and geographies, their dynamics and evolution, but also help to define better the different activities developed around the city and their link with specific uses of natural resources. Moreover, the focus of geoarchaeological and palaeoenvironmental research since 2022 in the Archaic harbor area – the actual heart of the city – will provide a very close view of socio-environmental interactions, anthropogenic impacts in natural processes, and their potential relationship with short- and long-term landscape transformation.

The development of the APAX project has resulted in a fruitful framework in which experimental ideas and techniques are applied to archaeological survey. At the moment the main areas include: 1) recording and quantifying the number of archaeological items visible on the surface; 2) understanding the physical settings (mainly topography, geomorphology, and soils) of the area and its relation with the archaeological finds, and, in particular, 3) micro-topographical traces of disappeared archaeological features; 4) the study of large-scale geomorphological dynamics affecting the (paleo)hydrographic network and wetlands and 5) large-scale archaeological features such as roads; 6) integration of cultural heritage with palaeoenvironmental reconstructions. The combination of large digital datasets with computer-based visual analysis (including Machine-Learning) allows us to approach the landscape in a multi-scalar way (from subcentimetric to regional features), with a diachronic and interdisciplinary perspective (applying regressive analysis from the present-day landscape until prehistory), in which historical, archaeological and environmental data are analyzed to understand human-environment interactions through time.

Our research in Abdera is still a work in progress and most of the work mentioned here is

in the process of being more fully published.<sup>16</sup> In the following years, we will address specifically the different methods in specific publications. The advancement in the analysis of the material currently under study and the palaeoenvironmental analysis (including geoarchaeology and palaeoecology) will provide new and fruitful insights into the region's past and into the ways Greek colonization has shaped present-day Mediterranean landscapes.

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<sup>16</sup> Many aspects of our work were discussed during the *Landscape Advanced Workshop* organized by ICAC-GIAP (part of the TransMed Program) with the topic “Landscape, Display and Economy at Abdera and Thrace”, 24<sup>th</sup> November 2022 in Tarragona, Spain.

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ISBN: 978-618-81773-1-4 | ISBN E-BOOK: 978-618-81773-2-1



**ΕΛΙΔΕΚ.**  
Ελληνικό Ίδρυμα Έρευνας & Καινοτομίας  
**HFRI.**  
Hellenic Foundation for  
Research & Innovation

The research project was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the “1st Call for H.F.R.I. Research Projects to support Faculty Members & Researchers and the Procurement of High-cost Research Equipment Grant” (HFRI-FM17-750).