

DOI: 10.5281/zenodo.4465472

# KASTROULI FORTIFIED SETTLEMENT (DESFINA, PHOKIS, GREECE): A CHRONICLE OF RESEARCH

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Received: 21/06/2020

Accepted: 20/12/2020

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## ABSTRACT

The archaeological site of Kastrouli in the town of Desfina, Phokis has been systematically investigated since 2016 until 2020 through an interdisciplinary and multiscientific means following an integrated approach. The archaeological excavation employed amongst others, cyber archaeology tools, archaeometric investigations concerning luminescence dating, spectroscopic and mineralogical analyses for the characterization and provenance of ceramic fabric, geophysical prospection. Major results include the documentation for the use of local clay sources, the dating by typology, C-14 and OSL to the Late Helladic/ Late Mycenaean III and reuse in the Geometric, and later periods. The successful application of archaeogeophysical prospection and accurate positioning of the unearthed finds via cyber archaeology tools, the anthropological and palaeontological study, all have produced important data which start to complete the puzzle for Kastrouli in the periphery of the Mycenaean World in Phokis. The concept of methodology, implementation and interpretation of the obtained data and work in progress are reviewed.

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**KEYWORDS:** Mycenaean, citadel, Phokis, archaeology, archaeometry, excavation, digital, interdisciplinary, methodology, spectroscopy, dating

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## 1. INTRODUCTION

Kastrouli's Late Mycenaean (Late Helladic III B-C) settlement is situated about 4 kilometers east of Desfina and southeast of Delphi, one of the most important shrines of Greek antiquity (Fig.1). Dasios

(1992) found the archaeological site of Kastrouli, and Raptopoulos (2012) continued with the rescue excavation and cleaning of three Mycenaean graves discovered therein (Fig.1).

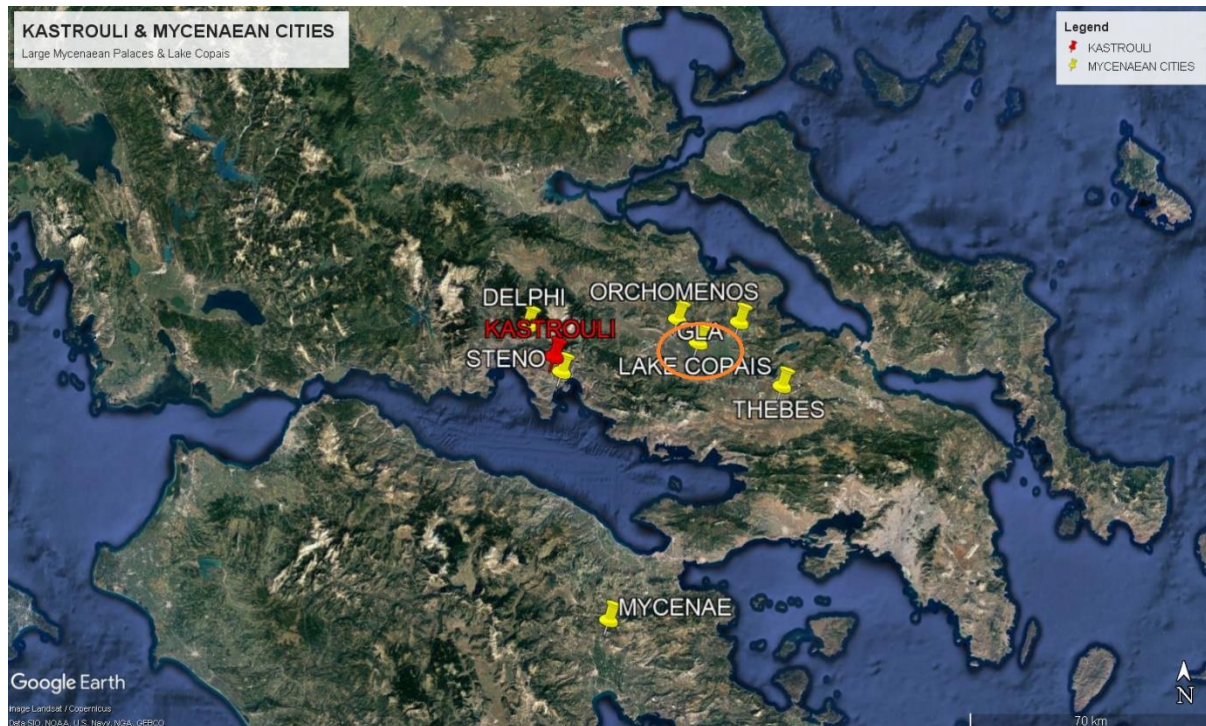


Figure 1. Mainland Greece and northern Peloponnese, with major Mycenaean Palaces, the Kastrouli and lake Copais.

A new project initiated in 2016 by the author from the laboratory of Archaeometry, University of the Aegean and was provided by the archaeological permit by the Ministry of Culture & Sports with the positive recommendation of the Ephoreia of Antiquities of Phokis.

The initial phase was co-organised by the author and prof. Tom Levy and his team from the University of California San Diego (Sideris et al 2017; Levy et al., 2018) and subsequent exploration in 2017 and 2018 (Sideris et al., 2018; Koh et al., 2020a,b) based on the comprehensive investigation of the site.

Kastrouli site lies on a 700 m high hill with a strategic location to dominate the Mesokampos plateau, the Mycenaean site of Kastrouli is situated and is certainly linked to other coeval settlements in the vicinity. A timeless checkpoint for contact between the two main harbours of Itea and Antikyra and probably a seaport at Steno was the Kastrouli fort (Sideris et al., 2017). It has recently been listed in Homer's Catalogue of Ships as Anemoreia's Homeric site, while the stature of Phokis is founded when it was said that 40 ships had joint the naval campaign under the leadership of Agamemnon against Troy (*Iliad*. 2.521). Homer, with his heroes, Schedius and Epistrophus, is

barely identified, remaining among the most obscure (Koh et al., 2020b).

Further to this, in our view the Mycenaean transliterated word from Linear B mentions the *anemoreia* which may be connected to the god of winds (*Anemoi* - attested through as *Anemohiereia* or *Anemon Hiereia*, "Priestess of the Winds" (Linear B: a-ne-mo-i-je-re-ja, a-ne-mo,i-je-re-ja)(for Linear B see Caulizio 2008; Hiller, 1997, 2011). Again, this is supportive of the strong prevailing northern winds from mount Kirfis across Kastrouli (Fig. 2). The southern Phokis has been historically "defined", but it has largely neglected, both in the Bronze Age as well as in subsequent periods, committed to relative obscurity and essentially neglected from contributing more substantively to our overall understanding of Classical and Mediterranean antiquity. This makes an archaeological and scientific approach mandatory to bring to light the rich past of southern Phokis starting from Kastrouli and expanded to coastal sites of Steno, Antikyra, Medeon, to serve as a necessary supplement to the present textual narrative (McInerney, 2011).

The chronicle of archaeological and archaeometric research is as follows.



*Figure 2. View from Kirfis mountain (alt 1245 m asl) with very strong winds, overlooking Kastrouli and the plateau and far top-left the Corinthian Gulf with natural harbours (antikyra, potamoi, valtos,) and Steno (I.Liritzis © 2019)*

## 2. THE CHRONICLE OF RESEARCH

The 1<sup>st</sup> stage of the systematic archaeological-archaeometric research in the prehistoric settlement of Kastrouli Desfina 2016-2020 has been completed with significant results.

Specifically, the timeline of the investigations is as follows:

In 2016 granting permission to the Lab. of Archaeometry, Department of Mediterranean Studies of the University of the Aegean for the start of geophysical survey and excavation research at the location "Kastrouli" Desfina, province of Phokis, Region of Central Greece, under the direction of the archaeological excavation of Dr Thanos Sideris, together with Professor Ioannis Liritzis, who was in charge of archaeological-geophysical research, and scientific responsible of the whole project in the framework of a five-year program (2016-2020) according to the ministerial order no. 5480/542 / 21-06-2016 (ΑΔΑ: Ψ3ΛΗ4653Π4-NAN) (Fig.3). In this stage American colleagues specializing in the Bronze Age participated in particular the University of California San Diego under the direction of Prof Tom Levy as co-PI

and his team. The excavation was also organized as an accredited summer school<sup>1</sup>.

In 2017, the excavation was made as an accredited summer school with participation of international students, under the co directorship of Dr A.Sideris (archaeological excavation) and Prof I.Liritzis (for archaeological research)<sup>2</sup>.

In 2018 the project was enriched with the participation of Dr. A Koh (Brandeis University and now at MIT), Dr K. Birney (Wesleyan Univ.), Dr Ian Roy (Brandeis Univ.) with specialized technical staff participated in the excavation as co-PI, and aerial images were taken by drone, cleaning and logging of the found materials and lectures provided as part of the accredited summer school<sup>3</sup>.

In all these three excavation seasons archaeologist Anthoula Tsarouha was in charge of the Ephorate of Antiquities of Phokis.

The findings are stored at the former Meteorological Station of the Community of Desfina (protected by an alarm system) with the permission of the Ministry of Culture & Sports. Some precious objects are kept in

<sup>1</sup> <https://summer-schools.aegean.gr/DigArch2016>.

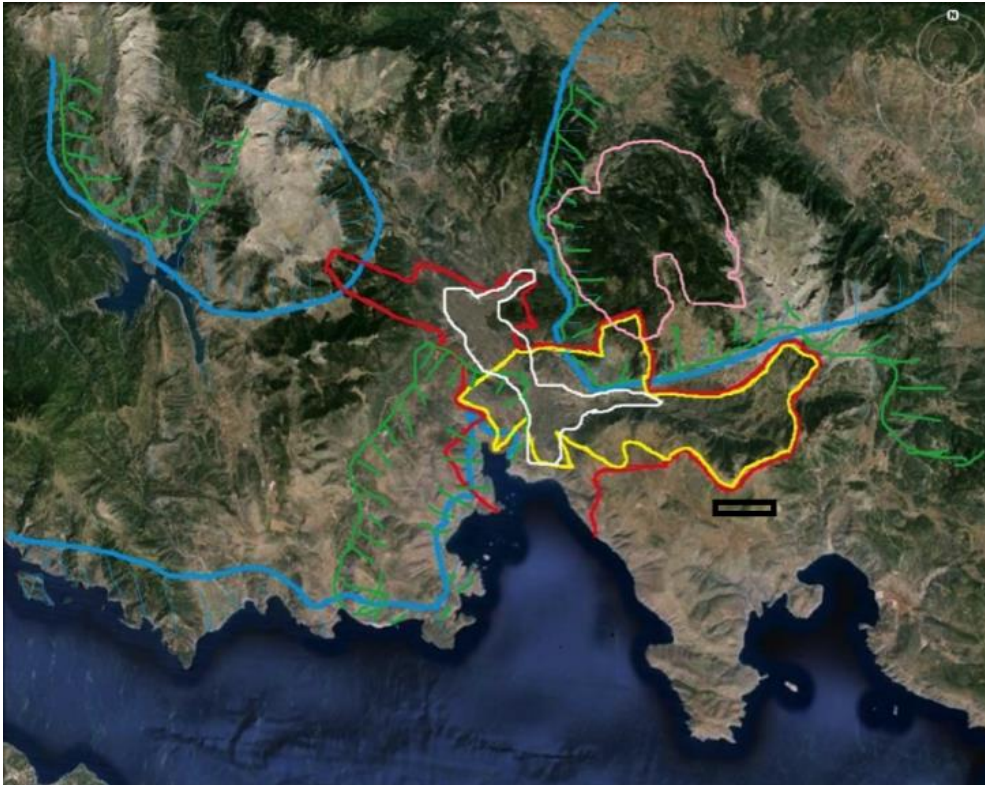
<sup>2</sup> <https://summer-schools.aegean.gr/KASTROULI2017>

<sup>3</sup> <https://summer-schools.aegean.gr/KASTROULI2018>

the conservation laboratory of the Archaeological Museum of Delphi.

The years 2019 and 2020 were dedicated to the conservation study, 3D images and cataloguing all materials found. From 2020 the Kastrouli Mycenaean Project is joining the Sino-Hellenic Academic Project, a collaborative programme which includes Chinese colleagues and students working on comparative archaeology under the coordination of Prof. Changhong Miao ([www.huaxiahellas.com](http://www.huaxiahellas.com);

[www.kastrouli.org](http://www.kastrouli.org)) and also it is affiliated to the Mycenaean Foundation and its president Prof. Christofilis Maggidis. The conservation project has been a major task with success in reassembling numerous pieces of hydria, oenochoe, cylix, parts of ceramic vases, and in cleaning ceramic sherds, bones and stone tools with the participation and direction of Dr Panagiota Manti, Dr Christos Karydis of the Ionian University, Dept. of Environment ([www.kastrouli.org](http://www.kastrouli.org)).

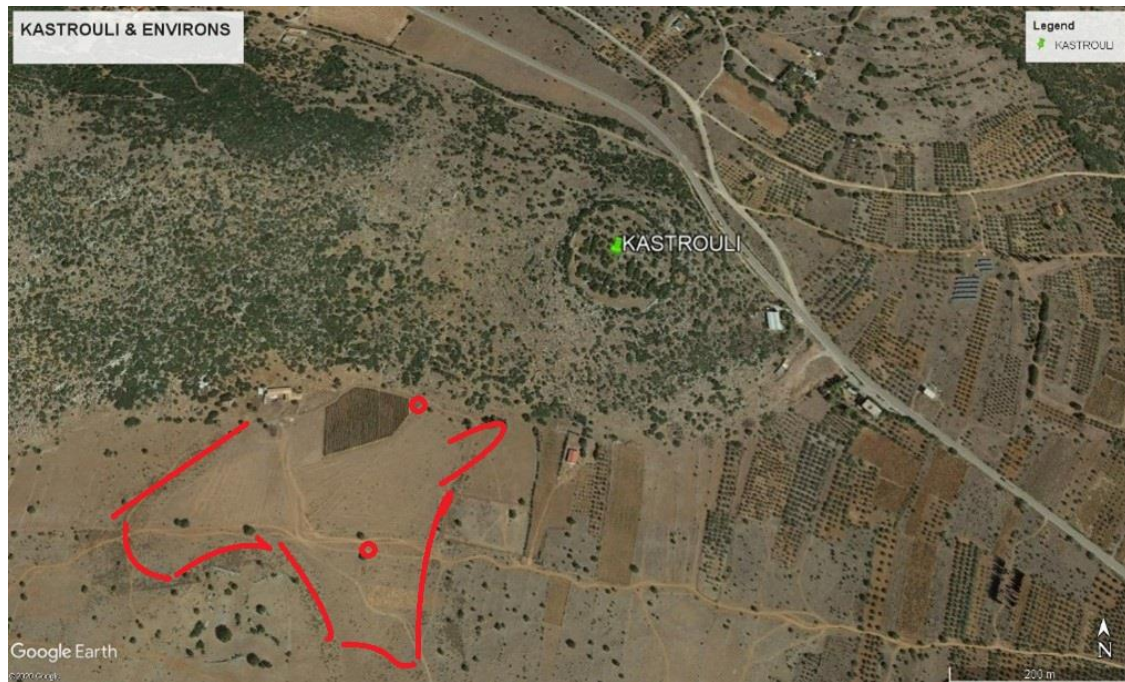


*Figure 3. The protected areas around Delphi (Red: Protected «Delphic landscape» (Decree 1985), Yellow: Monument of World Cultural Heritage UNESCO, Blue: NATURA SCI, Green: NATURA SPA, White: Traditional olive tree area funded by European Union, Pink: Locus of the Parnassus National Forest (Based on <http://www.ypeka.gr/Default.aspx?tabid=514&language=el-GR>)*

### 3. THE OBJECTIVES

This methodological concept was planned from 2005 on my occasional visits to the environs of Desfina (having a local origin), and my observation of the cyclopean fortified walls, with a walking exploration

of any visual surface structures and finds which intrigued my curiosity. Especially my observation of the striking circular structure from crop marks surrounding the site, using Google earth (Fig. 4).



*Figure 4. Kastrouli seen from satellite (Google Earth maps) and adjacent areas. Southern plain with apparent shedding borders delimits a modern-day swamp during winter months. Two build sinkholes imply ancient hydraulic works (work in progress) (N 38o 23' 56.7'', E 22o 34' 30'', 550 m asl).*

Then I reported the findings to the local Ephoreia of Antiquities of Phokis and proposed to undertake a systematic investigation with the University of the Aegean.

The methodological concept was:

- i) to document the value of this cultural site at risk, to the level to prevent any further looting (of two tombs) and surface finds by robbers,
- ii) to initiate a large project combining archaeological and archaeometrical-environmental investigations (GIS, isotopic, anthropological, chemical, mineralogical and dating analysis of artifacts, digital reconstructions, etc)
- iii) to collection valuable information from local old men shepherds about other relics as well an ethnoarchaeological information concerning husbandry, livestock and botanology; information which echoes traditions at least since the end of 19<sup>th</sup> century,
- iv) to investigate the causes that two depressions are becoming marshes; one at the foot of the Kastrouli hill called Meteles and the other at the eastern entrance of the town called limnos, because during the winter gather a lot of water making these two areas as swamps for 1-3 months,
- v) to investigate further what I was told by old shepherds regarding the presence of engineering (man-made) works in two opposite points at Meteles depression, which seemed

to serve as sinks to empty the “lake-like” seasonal marshes from stagnant waters. Obviously, this situation prevented cultivation and may have introduced infectious diseases from mosquitoes. The concept was to apply geophysical prospection (e.g. electrical tomography) and bore holing to study the sediments (dating, pollen, stratigraphy etc),

- vi) to make an areal survey in the Desfina plateau for the location of other sites on Late Mycenaean times and/or surface artifacts of other archaeological ad historical periods,
- vii) to connect the site with the nearby coast at the Corinthian Gulf.

The three targets of the Program as planned were the following:

- SOCIAL: participation of schools with guided tours, presentation every year in the village square of the findings of the research, harmonious cooperation with the progressive cultural association of Desfina and with the Community of Desfina on issues such as lectures to students, provision of transportation etc.
- EDUCATION: Undergraduate and postgraduate students, in the context of courses of the Department of Mediterranean Studies of the University of the Aegean were benefited.
- ACADEMIC: new material culture, analytical data (archaeological findings and archaeometric measurements) and innovative data were produced.

- **PUBLICATIONS:** Several publications were produced, from fast in situ or in the Laboratory measurements, co-authored with the participants in international journals with impact factor and a collective volume of the Springer Publishing House. A total of 10 publications and 4 are ongoing.

## 4. METHODS AND RESULTS

### 4.1 Brief excavation finds

The excavation at Kastrouli was so far successful in satisfying the goals of its research design. The exposed tomb in Area A was fully and systematically excavated down to its bedrock surface. All remaining material culture and human remains (following the looting and previous excavations) were excavated and will be critical in interpreting and dating the tomb. In addition, the site's large fortification wall was sectioned in two areas finding the foundations of its construction directly on the local bedrock. These excavations facilitated the collections of OSL samples

which provided an absolute date for the construction of the wall. Both looted Tombs (A, B) and buildings were excavated cleaned and finds properly catalogued and proper conservation was applied. (Fig.5) Based on the typology of the ceramics and stratigraphy of the site, the comingled burial represents a use span from ca. 1300 to 1150 BC. In addition, the site's large fortification wall was sectioned in two areas finding the foundations of its construction directly on the local bedrock.

From Building 1, the finds comprise mostly pottery sherds, stone mortars and grinders, clay and stone spindle whorls, stone beads, two small metal artifacts, animal bones, as well as, various sea-shells of edible molluscs and gastropods. In Building 2, in the area northwards of the long wall we collected several sherds of large vases, perhaps amphorae and pithoi, and a few sherds of fine pottery, mostly from cups. Fragments of sea-shells have been identified as *Hexaplex trunculus* (earlier denomination: *Murex trunculus*) (Sideris et al., 2017; 2018).

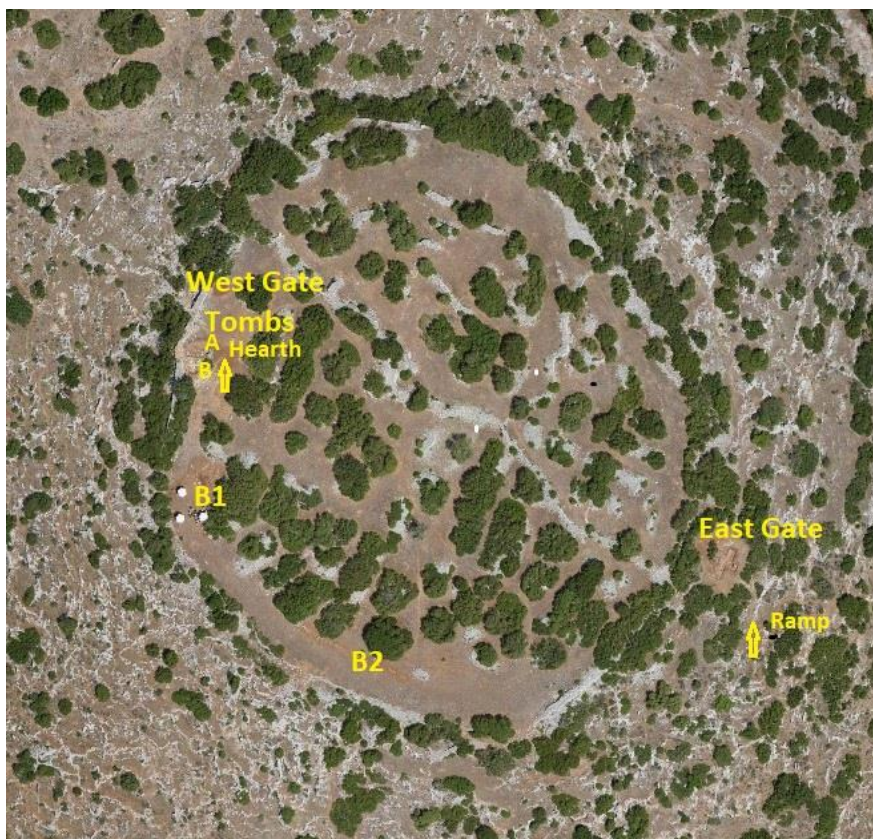


Figure 5. The Kastrouli settlement bounded by cyclopean walls indicated by crop marks that make the circle, the excavation loci (two tombs, a hearth, and two buildings) and two gates.

The archaeological excavation included Spatial/Context recording and artifact collection, aerial Photography from helium balloon and drone, Structure from Motion, CAVEcam Stereo Photography, C-

14 and OSL dating, XRF, XRD, mineralogy of ceramics, bone analysis (anthropological, collagen extraction and preservation, isotopes and aDNA), conservation, and interpretation.

The results brought to light by the excavation program include amongst others phi (Φ) and psi (Ψ) figurines, gold jewellery pieces, lead and bronze pieces, animal bones and human bones adhering to skeletons (degraded burials). The vast quantity of pottery discovered, containing fragments of amphorae, deep and shallow cups as well as alabasters is of particular interest. The pottery is dated to the Late Helladic III (LH III) period, on the basis of typology and decoration (Sideris et al., 2017, 2018; Levy et al., 2018; Koh et al., 2020b).

### 4.2 Digital applications

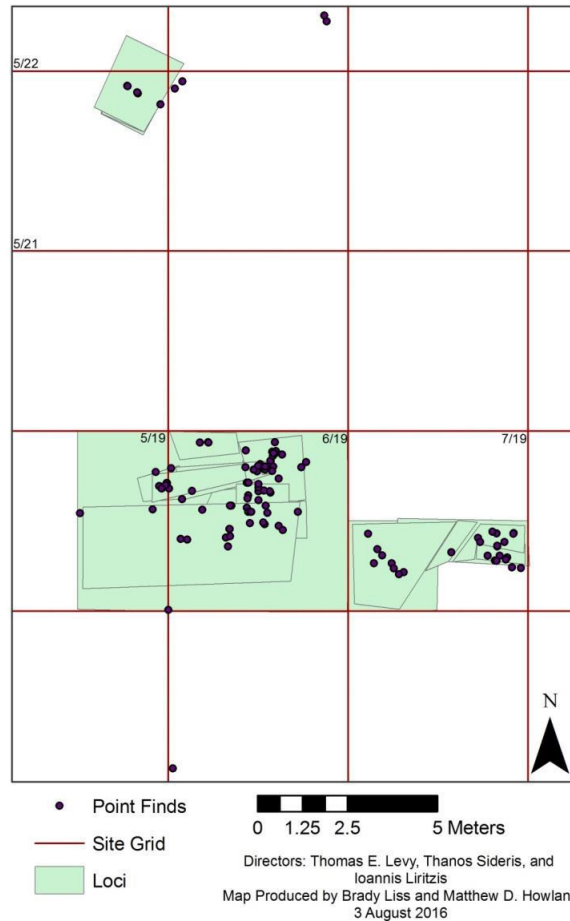
Excavations at Kastrouli employed the fully digital archaeological recording system developed by the Edom Lowlands Regional Archaeology Project (ELRAP) directed by Thomas E. Levy and Mohammad Najjar. The ELRAP on-site digital archaeology (OSDA) 3.0 system (Levy et al., 2010) melds together

off-the-shelf technologies and custom computer programs/hardware developed specifically for solving archaeology/cultural heritage problems that researchers face worldwide.

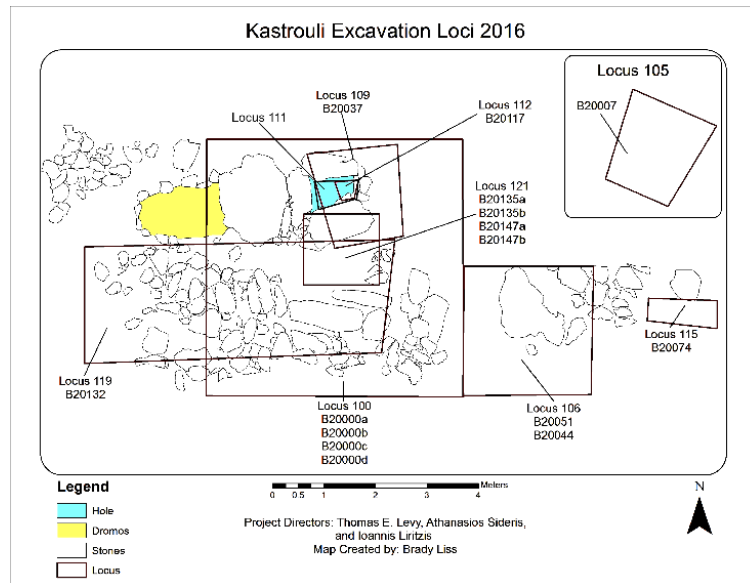
With a Leica TS02 total station and data interface software, ArchField (developed by Dr. Neil Smith), spatial data was collected, providing real-time data recording and field review in the field (the total station was connected to a Microsoft Surface with ArchField installed).

ArchField enables excavators to record and visualize in the field both points and polygons (i.e. artifact finds and loci), and the relevant data (i.e. locus type, artifact type, etc.) can be provided immediately and database-based. (Fig.6a,b). In addition, spatial information collected by ArchField is easily exported to a Geographic Information Systems (GIS) for further manipulation and analysis (Levy et al., 2018).

Final ArchField Points and Polygons from Kastrouli, 2016



(A)



(B)

Figure 6. a) Final export of all ArchField points and polygons (from Levy et al 2018, p.188, fig.9.38), b) Drawing of loci at the 2016 excavation. (Levy et al 2018, modified in 2020 By Mat Howland and Brady Liss).



Figure 7. Drone capture of Kastrouli and the vicinity (2017 c/o Dr D.Stefanakis)

Via aerial and SfM, the production of 3D models was carried out. The data collection for these models was subsequently geo-referenced here, facilitating the export of high-resolution orthophotos that serve as an excellent basis for architectural features digitization based on GIS. For the digitization of top plans, this approach was used. Furthermore, SfM was used for section drawing the walls in the dromos and tomb; orthophotos provided a base for digitization within in GIS rather than hand-drawing in the field.

All artifacts collected and recorded with ArchField were attributed a unique basket number and barcode

to facilitate entry into the ArchaeoSTOR artifact database, another custom application allowing for the categorization and sorting of artifacts in the field and in the lab, along with spatial visualization and statistics applications (Gidding et al. 2011).

The 2016 team adopted a two-part approach to SfM data capture: terrestrial and aerial SfM photography. In both approaches, overlapping photographs encompassing the area of interest are captured with complete coverage to facilitate the construction of a 3D model. For aerial photography, a Canon EOS 50D digital single-lens reflex camera (outfitted with a 18



mm lens) is attached by frame to a Kingfisher Aero-stat balloon using the UC San Diego helium balloon system, which is walked in overlapping transects over the area of interest. The same area was next year ortho photographed using drone (Fig.7).

In 2018 the southern Phokis Research Project (SPRP) team members completed one of the initial research aims; executed both archaeological and digital recording at the highest levels as part of their research interests e.g. ethnohistory, drone-assisted survey, ethnobotany, organic residue analysis, ceramic fabric analysis, 3D modeling, aiming to shed light to the cultural and natural landscape of southern Phokis (Koh et al., 2020a). SPRP carried out a preliminary on-site and drone survey of these remains in Kastrouli settlement as well as the surrounding area especially northern and southern of the hill, to serve as a model of how large study areas will be approached with relatively confined but obvious signs of material culture. Koh et al (2020b) in 2018 they used a DJI Phantom 4 Pro drone and Pix4D Capture to fly the drone. The default height was 70m above ground level (agl), with a camera angle of 80 degrees and an overlap of 60%. (Due to Greek drone laws, SPRP always drew a flight path grid with a diameter of less than 500m so that project members were always with-in 500m of the drone). The processed drone data photogrammetrically produced 3.66 cm per pixel resolution 3D models (Koh et al., 2020b, fig. 11 and <https://openarchem.com/3d-models>), which allows for year-round study of the landscape between field seasons. The drone data for nuanced GIS analyses such as hydrological simulations, viewsheds, least slope paths, etc, are in progress.

### 4.3 C-14 and OSL dating

A first attempt to date the Kastrouli settlement at Desfina (Delphi Phokis) has been made by optical luminescence dating (OSL) on three ceramic and radiocarbon (C-14) of one bone sample. An initial archaeological reconnaissance of the partially looted site has produced some indication of use during late Helladic and later periods. Our three ages by luminescence and one by C-14 have shown that this site was used initially in Late Helladic period, and reused during the Middle Geometric, the Early Archaic and the Classical periods. The single aliquot regeneration (SAR) protocol was used for ED determination. Fine grain (4-11µm) fractions were extracted from the three potsherds for OSL measurements. Equivalent doses (ED) ranged between 9.90 to 13 Grays, and within the overall error bars (~10%) the ages 1180 BC, 690BC, 420 BC indicate the periods of first occupation during Late Helladic, then use of the site during Geometric/Dark

Ages and Classical/ Hellenistic times (Liritzis et al., 2015).

A single bone sample (right femur) residual of the last looting of Tomb A was collected for radiocarbon dating. The dating of the bone was made by the Italian Center for the Development and Transfer of Innovation for Cultural and Environmental Heritage - INNOVA (Terrasi et al., 2008) (c/o Prof. Filippo Terrasi, Dipartimento di Matematica e Fisica - Seconda Università degli Studi di Napoli, Viale Lincoln 5, 81100 CASERTA, ITALY), as sample code DHS6605. The final obtained calibrated age is 810-760 BC which corresponds to the Greek Middle Geometric period (900-700 BC).

The ages per probability errors (based on intcal13.14c # Reimer et al. 2013) in cal AD/BC are:

68.3 (1 sigma) cal BC 801-781

95.4 (2 sigma) cal BC 810-760

( $\delta^{13}\text{C}$ :  $-22\pm 1\%$ )

Further luminescence dates were obtained on rock samples collected from the wall and the tomb A. The ED was estimated by applying the Single Aliquot Regenerative OSL (SAR OSL) protocol, after later modifications for polymineralic/mixed quartz-feldspathic samples ('double SAR' protocol). The 'double SAR' protocol procedure includes an infrared stimulated luminescence (IRSL) measurement at 50 °C before the main OSL. Individual ED values ranged between 3.2 to 16 Grays and were accepted based on the following acceptance criteria: recycling ratio between 0.90 and 1.05, recuperation < 10%, dose recovery within  $\pm 10\%$  uncertainties, limited IR response at room temperature, ability to recycle and recover a laboratory attributed dose. For all the measured aliquots, these criteria were fulfilled. Here, six (6) new dates were produced on well stratified archaeological sections and context; two TL dates of ceramics from Tomb A, two OSL dates from stone wall, and two OSL of in situ stone building material from the tomb; the latter four using the surface luminescence dating (SLD). The latter consisted of several aliquots and sub-surface areas making at the end six SLD ages; for the two ceramics TL ages of  $890\pm 240$  BC and  $1530\pm 290$  BC; for the external fortified wall three dates  $125\pm 145$ ,  $680\pm 130$ ,  $437\pm 140$  BC and for the tomb  $900\pm 138$  and  $1350\pm 310$  BC. The luminescence dating project reconfirms the Late Mycenaean age and reuse of the tomb almost uninterrupted in later periods (Liritzis et al., 2018).

### 4.4 Chemical and mineralogical analysis

A ceramic assembly chosen to include a broad range of possible household typologies was chemically analyzed and statistically elaborated. (fine painted pottery fragments from various Mycenaean pottery shapes and of plain vases, figurines, clay

loom-weight, wall- and floor-revetment clay fragment, were collected from among the bone cluster of a tomb, and excavated trenches of the settlement). The chemical composition of around 150 ceramic sherds, and briquettes made from local clays, was measured by using a calibrated non-destructive portable X-ray fluorescence (XRF) Bruker Tracer III SD set with a beam diameter of 3 mm (analytical conditions are given in set-up). Also, a critical assessment of chromatic index in archaeological ceramics by Munsell and RGB novel contribution was introduced to characterization and provenance studies for the Kastrouli ceramics (Bratitsi et al., 2018). Fired briquettes prepared from 8 local clay sources and several mixtures of them were similarly analyzed. A robust statistical analysis is applied based on 15 major and minor/trace elements employing hierarchical cluster analysis with several linkages, descriptive statistics, biplots and boxplots, principal component analysis (PCA), as well as, Euclidean and Mahalanobis distances on standardized ratio transformed data. The results obtained revealed that some local clay sources and their mixtures are placed within the archaeologically identified broad ceramics group, providing, thus, evidence for a local production of the studied pottery, and artisan's skills employed a variety of manufacture technologies. Eight local clay sources from the proximity ranging in color from whitish, to pink and brown, red, were sampled, making briquettes at certain firing temperatures (700–1050°C). The archaeological implications of the study for Kastrouli are multifold, judging from the archaeological finds and proximity and relationship to the near seaport, the suitable landscape for grazing, the protected headland, and the apparently use of local clay sources for making ceramic objects. Kastrouli, located in the periphery of the Mycenaean centres, seems to follow the known Mycenaean society tradition of being located in moderately rich agricultural regions, with an economy basically a self-contained agrarian one (Lirirtzis et al., 2018).

Eight selected ceramics have been also analysed by an electron probe microanalyzer (EPMA) equipped with four wavelength-dispersive spectrometers and one energy-dispersive spectrometer. The aim to unravel the "ceramo-genetic" processes was possible by integrating optical microscopy, and EPMA (with SEM capabilities) following a specific protocol narrowing down to  $\mu\text{m}$  scale. A detailed characterization of these ceramic sherds is made, including collection X-ray maps for different elements showing the zonation of minerals in relation to the adjacent matrix. Also, the temperature range was estimated – where possible – based on the observed mineral assemblage, texture and chemistry. The most favorable firing temperature

maxima for our samples are 900–1000°C. (Baziotis et al., 2020).

A detailed mineralogical study employing XRD, SEM-EDS and thin sections studied by PLM further reinforced this characterization investigation.

A set of 40 ceramic sherds and 8 clay raw materials were analyzed through mineralogical, petrographic and microstructural techniques. Experimental briquettes (DS) made from clayey raw materials collected in the vicinity of Kastrouli, were fired under temperatures (900 and 1050°C) in oxidizing conditions for comparison with the ancient ceramics.

The petrographic analysis performed on thin sections prepared by the sherds allowed six main fabric groups and a few loners to be identified. In all fabric groups, the aplastic inclusions were recognized, but one confirmed the local provenance since they are related to local geology.

Fresh fractures of representative sherds were further examined under a scanning electron microscope (SEM/EDS) helping us to classify them into calcareous ( $\text{CaO} > 6\%$ ) and non-calcareous ( $\text{CaO} < 6\%$ ) samples (low and high calcium was noted in earlier pXRF data). The mineralogy of all studied samples was determined by means of X-ray Powder diffraction (XRPD), permitting us to test the validity of the firing temperatures revealed by the SEM analysis. The results obtained through the various analytical techniques employed are jointly assessed in order to reveal potters' technological choices.

The samples are categorized into six classes of fabrics in which certain petrographic features have allowed us to draw the following conclusions on technical issues relating to the development of ceramics in the Kastrouli settlement.

The samples of fabric group 1 (fine whitish-yellow ware) could be considered as either imported, suggesting possible social or trade networks of the Kastrouli settlement, or another not yet identified local clay source, that is within the same geological background of the region. Regarding fabric groups 2, 3 and 4, it was observed the choice of a similar way of manufacturing (tempering), but the use of different additives, all relative with the local lithology. In contrast, fabric group 5 exhibits a completely different recipe and manufacturing, since it is characterized by a micaceous 614 clay matrix and a fine-grained groundmass.

The scanning electron microscopy (SEM) analysis of the microstructure allowed us to decide the prevailing firing conditions, which were primarily high, giving us an indication of the technical choices of potters for the maximum firing temperatures. XRPD complemented and helped us further test the validity

of the firing temperatures revealed by the SEM analysis, and ranged from less than 850°C, 850-950°C and 900-1100°C. The high skillfulness of Kastrouli people from possible use of various clay sources exploited in their environment and recipes, makes the peripheral Mycenaean settlement of particular importance. (Xanthopoulou, Iliopoulos & Liritzis 2021).

#### 4.5 Bone analysis

With most of the bones fractured beyond a degree to produce much details, the skeletal material was severely degraded. About the fact that almost no single bone was found intact, there are thus no metrics given here for stature calculation, a number of adequately preserved femur bones were reported along with various teeth which a mandible and allowed for MNI estimates for this commingled burial tomb A and tomb B (with only one adult and a fetus). It was identified at least 16 adults along with 2 subadults, an infant and four fetuses (in Building 1 and the two tombs). Skeletal remains of domesticated animals were also recovered from the same undisturbed context, for which the recovered archaeological artifacts suggest that the tomb was Mycenaean/Late Helladic in date (e.g. goat, sheep, hare).

Considering that Loci 112 and 121 (Fig.6b) represent the only undisturbed context, for which the recovered archaeological artifacts suggest that the tomb was Mycenaean/Late Helladic in date, the only animal bones identified in these Loci were attributed to domesticated cow and sheep/goat.

However, several bones of various animals have been unearthed commingled with the human skeletal remains. Among those that were identified as domesticated animals a large number of snake vertebrae and few different species of gastropod shells (snails) have also been recovered. With respect to the domesticated animals, bones and/or teeth belonging to *Gallus gallus domesticus* (two samples of chicken was rather modern infill as C14 revealed), *Bos taurus* (domesticated cow), *Sus scrofa domesticus* (domesticated pig) as well as *Ovis aries/Capra hircus* (sheep/goat) were identified. (Chovalopoulou et al., 2017).

Characteristics of bone diagenesis was also made, a necessary step prior to any aDNA extraction. In the secondary commingled burial in Kastrouli Tomb A, through the histological (light microscopy), physical (FTIR-ATR), and biochemical (collagen) analysis of seventeen human (including two petrous bones) and seven animal bones were measured. The two human petrous bones showed a lack of microscopic focal destruction (MFD) sites and generally good histological preservation, but although the sample size was small, there was no better preservation of bioapatite and collagen compared to human femora. Three main diagenetic patterns that show differences in histological

modifications, changes in crystallinity, and collagen degradation have been defined by intra-site variations. In the early taphonomic histories experienced by bones prior to secondary deposition, these different patterns were either related to different microenvironment conditions and/or influenced by possible differences.

In addition, this study highlights the significance of the infrared splitting factor (IRSF), the carbonate/phosphate ratio (C/P) and the general histological index (GHI) for archaeological bone qualitative assessment and the potential use of the amide/phosphate ratio (Am/P) as a predictor of collagen (Kontopoulos et al., 2019)

Recovery and study of ancient DNA and archaeological bone proteins is time-consuming and costly to carry out, whereas partial or total loss of important or rare specimens is involved. The fields of palaeogenetic and palaeoproteomic research will significantly benefit from techniques that, prior to sampling, can determine molecular efficiency.

Such screening procedures should be accurate, minimally disruptive and swift in order to be appropriate. A study reported results from six bone samples from Kastrouli based on spectroscopic (Fourier-transform infrared spectroscopy in attenuated total reflectance FTIR-ATR), palaeoproteomic (collagen content), and palaeogenetic (endogenous DNA content) techniques.

This research is a landmark in the discovery of suitable samples prior to genomic and collagen analysis, with major repercussions for biomolecular archaeology and palaeontology. This study proposed the use of FTIR-ATR for the successful identification of archaeological bone samples containing > 1% endogenous DNA, > 3% or > 2% collagen by weight, and establishes thresholds for three commonly used mid-IR indices (IRSF, C/P, Am/P) with significant implications for palaeogenetic and palaeoproteomic research costs (Kontopoulos et al., 2020).

#### 5. THE TWO SINKHOLES IMPLY EARLY HYDRAULIC MARSHLAND WORKS?

Through geophysical prospection (electrical tomography) and boreholing the origin of sediments and confirmation of the lake or marsh is in progress. (Fig.8 a-d). The investigation is driven from the observation of two depressions in Desfina at present day filled with rainwater during winter months (Fig.9), and the presence of surface remains implying intentional construction of drainage hydraulic works at Meteles plain. The surface structures include two sinkholes which are apparently constructed (Fig.10a, b). The southern one consists of a stony stair down to about 4 meters (Fig.10a).



(D)



(C)



(B)



(A)

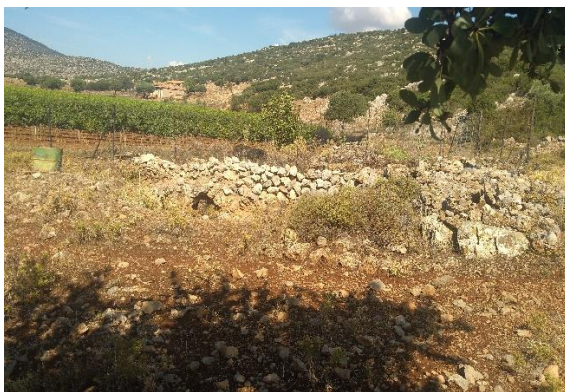
*Figure 8. Boreholing for the investigation of the Meteles depression a and b) the boreholing trailer across kastrouli hill, c) extraction of cores, d) the cores (now properly stored in the premises of the University of Patras, attention of collaborators Prof. M.Geraga and Prof. G.Papatheodorou)*



*Figure 9. Panoramic view of the so called Limnos (lake) depression at the western entrance of Desfina town, filled with water during winter, the town on the right and snowy Parnassus across the field. Meteles depression is on the eastern side of the town.(© Ioannis Liritzis 2019).*



(A)



(B)



(C)

Figure 10. a, b) The two sinkholes constructed to drain the lake/marsh, c) the Meteles plain depression the green vineyard and surrounding flat area, viewed from Kastrouli settlement on the hill. (© Ioannis Liritzis 2019).

## 6. ETHNOARCHAEOLOGICAL INVESTIGATION

On 8/14/2017, an interview was conducted with 2 old shepherds Boris Efstathios 89 years old and Leon-topoulos Konstantinos 88 years old (both passed away a year later) (Koh et al., 2020b) (Fig.11).

Numbers of sheep and goats were reported in the period 1900-1925 by mainly 53 families with large quantities. Every other family also had animals, but in smaller quantities for their needs. With an amazing complementary way regarding their memorizing events, when young, they estimated around 10,000 sheep and 6,100 goats in the turn of 18<sup>th</sup> to 19<sup>th</sup> c.

(documentary video is available at [www.kastrouli.org](http://www.kastrouli.org))

As they told us (myself, Dr A.Koh, and Sarah Schofield-Mansur from Brandeis University who recorded the video and set the questions), they supplied, Delphi, Itea, Arachova, Galaxidi in Phokis, and Loutraki (in Corinth), Chalkida (in Euboea), Patras in return of money. This may reflect the remote past and why not Kastrouli inhabitants where trade may have been made with the wider accessible (by sea in the Corinthian Gulf or land in Phokis, Boeotia) towns. They also recall at least four water springs in the town coming from the Prophet Elias hill. Plants and herbs used for various reasons, in the area includes mallow, sage, chamomile, pine and fir resin, laurel.



Figure 11 Documenting oral histories with two old shepherds for the village of Desfina (Koh et al., 2020b).

## 7. CONCLUSION

The Kastrouli Mycenaean Project has been initiated since 2013 and the onset of systematic investigation was in 2016. After five years of interdisciplinary work new archaeological finds were revealed and novel archaeometric approaches have been applied concerning the chronology and characterization, provenance of artifacts (ceramics, bones) and stone remains (tombs, fortified wall). The dating (by C-14, OSL, ty-

pological) provides a *terminus post quem* the Late Helladic III with partial reuse at post Iron age in Geometric, Classical and Hellenistic times. Preservation of collagen was satisfactory, and the work was successful in several analysed bone fragments, the use of local clays is of extreme importance especially the craftsmanship in producing various types of ceramic vessels applying recipes of properly mixing clays. The work is ongoing in the archaeological excavations and the environmental archaeometry data.

## ACKNOWLEDGEMENTS

I am thankful to my dear friend and colleague Tom Levy from California University at San Diego who managed to fund rising organized the team for the 2016 first excavation season. Without Tom the Kastrouli project would not have been successful. I thank Dr Athanasios Sideris the director of archaeological excavation under the permit from the Ministry of Culture for collaboration and archaeological supervision throughout these years. I am grateful to Andrew Koh, Kate Birney and Ian Roy from Brandeis and Wesleyan Universities for supporting the 2018 excavation season. The friendship, support and concern of the project since its start by Babis Kaliakoudas Head of the Municipality Unit of Desfina as well as by Dimitrios Masouras the president of Philoproodos Cultural association is much appreciated. I thank Dora Mavrogianni of the University of the Aegean for logistics support.

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