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A New Project of Surface Survey, Geophysical and Excavation Research of the Mycenaean Drainage Works of the North Kopais: The First Study Season

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Abstract The attempt to drain the Kopais Lake is one of the most impressive and ambitious technical works of prehistoric times in Greece. The size and the importance of this achievement inspired myths and traditions referring to its construction and operation, as well as to its final destruction, which is attributed to Heracles. The impressive remnants of the Mycenaean hydraulic works that were discovered represent the most important land reclamation effort, of prehistoric Greek antiquity, attracting thus the attention of the international scientific community. Nevertheless, in spite of the minor or extended surveys that followed, the picture of the prehistoric drainage works in Kopais remained ambiguous, since the proposed theories as far as it concerns their function and their precise date within the Bronze Age, were based solely on indications from the surface survey and not on documentation depending upon archaeological or geophysical methods. The new project with an interdisciplinary approach and interpretation of the Mycenaean drainage works of Kopais, is conducted by the Greek Ministry of Culture and Tourism in collaboration with the Department of Water Resources and the Environmental Engineering of the National Technical University of Athens and the Institute of Geography of the University of Mainz. The results of the first study season will be presented here.

Keywords Drainage Systems; Hydraulic Works; Kopais, Mycenaean Civilization

INTRODUCTION

The attempt to drain the Kopais Lake is one of the most impressive and ambitious technical works of prehistoric times in Greece. The size and the importance of this achievement inspired myths and traditions referring to its construction and operation, as well as to its final destruction, which is attributed to Heracles (Diod. Sic., 4.18.7 "… *but in Boeotia he did just the opposite and damming the stream which flowed near the Minyan city of Orchomenos he turned the country into a lake and caused the ruin of that whole region. But what he did in Thessaly was to confer a benefit upon the Greeks, whereas in Boeotia he was exacting punishment from those who dwelt in Minyan territory, because they had enslaved the Thebans* ….").

Mycenaean Boeotia and the Kopais Lake

Boeotia is one of the most important regions of Mycenaean Greece (1600-1100 BC), as borne out by the finds from excavations and its significant place in mythology and ancient traditions. The geographical division of the Boeotian plain into two parts surrounded by mountainous massifs reflects also the political reality of Mycenaean Boeotia: in the northern part, which includes the Kephisos valley and the Kopais basin, Orchomenos was dominant, with a network of smaller satellite settlements, while in the southern part with the extensive fertile plain of Thebes, the plains of Asopos, Tanagra and the coast of the Euboean Gulf, Thebes was dominant with an analogous settlement pattern.

As excavation evidence and tradition attest (e.g. Bulle 1907; Iakovidis 1995), the most important centre in northern Boeotia was Orchomenos, in the northwest corner of the Kopais lake/plain. A mainland and primarily lakeside power, Orchomenos turned its attentions more towards central Greece, and was less concerned with overseas relationships than it was to master the unique natural resource it had on hand. Archaeological investigations in Orchomenos to date are exceptionally sporadic, and have brought to light only few remains of the Mycenaean settlement, but with finds, however, to indicate its special flourish (Schliemann 1881; Papazoglou-Manioudaki 1990) (**Fig. 1**).

Figure 1. Façade of the Mycenaean tholos tomb of Minyas at Orchomenos.

Furthermore, in the memory of the ancients, the legendary wealth of Orchomenos was due to the cultivation and exploitation of the drained Kopais Lake (Il. 9.381; Str. 9.2.40.). The power and plenty enjoyed by Orchomenos lasted, according to ancient tradition, until Heracles took vengeance on the King of Orchomenos, blocking the exit of the Kephisos River towards the sea, and thus flooding the Kopais once again (Apollod. 2.4.11, Diod. Sic. 4.18.6).

The enormous installation of Glas (E.g. Iakovidis 1983; 1998) is close to Orchomenos, built on a natural island in the east creek of the lake (**Fig. 2**).

Figure 2. Aerial photograph of the citadel of Glas.

The citadel was constructed by Mycenaeans from Orchomenos in the early thirteenth century BC, together with works to drain Lake Kopais. It is girt by a Cyclopean enceinte pierced with four gateways, while remnants of large buildings, clearly palatial, can still be seen. The installations on the citadel (Cyclopean wall, residences of officials and granaries) were built contemporaneously and the ensemble has been interpreted as part of an ambitious plan for supervising the drainage installations and collecting and storing the produce of the plain. Glas was destroyed in the late 13^{th} century B.C.

LAKE KOPAIS MAIN HYDROSYSTEM COMPONENTS

Several closed (endorheic) basins and plateaus exist in Greece, usually surrounded by mountains of karstic limestone and drained by natural sinkholes. The Boeotian Kephisos basin, on the Eastern Central Greece, north of Athens, is the largest among them, covering an area of about 2 000 km^2 (**Fig. 3**).

Figure 3. Topographic overview of the Kopais Basin in Boeotia with location of the main river courses.

Boeotian Kephisos, flowing from northwest to southeast is discharged at the south-eastern edge of the basin. It does not have an outlet to the sea and, thus, its water formed the Lake Kopais, from where either evaporated or drained through several sinkholes situated mainly in the eastern part of the basin. Furthermore, the basin represents a structural polje or intra-mountainous tectono-karstic depression in a limestone region (Tsodoulos et al. 2008). The polje is well known as a geoarchive for high-resolution palaeoclimatological proxies spanning the period since the mid Pleistocene (Tzedakis 1999; Griffiths et al. 2002). The shallow Lake Kopais increased in depth, area and storage during the winter as evaporation was minimal and the discharge capacity of the sinkholes was limited, and decreased in summer, sometimes spectacularly. The Kopais basin hydrosystem also includes Melas River, supplied from the homonymous springs of mount Akontion and discharging in karstic sinkholes of the northeastern fringe of Kopais basin. Spring altitude varied between 97.70 m and 101.50 m, whereas discharge varied from 2.80 m^3/s to 5.30 m^3/s (88.0 – 166.6 x 10^6 m^3/year) (Xanthopoulos et al. 1990). The hydrosystem also comprises of Erkyna, Pontza and several other small streams, flowing mainly from the south of the basin and various springs. The mean total annual discharge of the springs of Boeotian Kephesos is currently about 300 x $10^6 m^3$/year, but it used to be higher at the beginning of the 20th century (about 380 x 10^6 m^3/year) (see previous note). The altitude of the lake's bottom was 84 m a.s.l. but it did not exceed 92 m a.s.l. in its greater part. The water level of the lake usually did not exceed 97 m a.s.l., which was determined by the elevation of the sinkholes. The lake covered an area ranging from 150 km^2 to 250 km^2 (Constantinidis 1984). During the floods of 1852 and 1864, water level exceeded the altitude 97 m, resulting in the flooding of about 20 km^2 of the neighboring Levadeia basin, whereas the year 1856 drought led to the complete draining of the lake)

Prior to the construction of the 19th century drainage infrastructures, the Boeotian Kephisos emerged from the mountain valley onto Kopais river basin at Pyrgos, NS of Skripou – Petromagoula, jointed Melas river bed, and the combined flow slowly flowed towards the great sinkholes of Kefalari in the south of Topolia village (See note n. 9). Therefore the Mycenaean drainage works were based on the above natural mechanism. The Mycenaean inhabitants of Orchomenos, in their efforts to secure arable land, have realized that their main purpose must have been to convey the combined discharge of Boeotian Kephisos and Melas away from the Kopais basin towards the sinkholes to the northeast.

The history of research and the new interdisciplinary project for the Mycenaean works in Kopais

At the end of the 19th century, initially a French and then an English company (Karavasili 2000, Grypari 2000, Karavasili et al. 1996) constructed the extended drainage network of canals, drains and levees, as well as the Karditsa diversion tunnel, which effectively drained the lake, diverting the water into the adjacent lake Hylike. This was the first major hydraulic project in the Modern Greek state. As part of this project, Boeotian Kephisos, downstream of the site Veli, was realigned in an artificial channel (Grand Canal, Canal in the March, Emissary Canal). The cartographical and topographical surveys conducted by the French and English engineers of the companies that undertook the works to dry up the Lake have brought ground in the study of the Kopais' basin history (for the previous research in Kopais see Curtius 1892, Kambanis 1892, Kambanis 1893, Kenney 1935; Kahrstedt 1937; Wallace 1979). The impressive remnants of the Mycenaean hydraulic works that were discovered represent the most important land reclamation effort, of prehistoric Greek antiquity, attracting thus the attention of the international scientific community. Nevertheless, in spite of the minor or extended surveys that followed (E.g. Lauffer 1938/1939; 1939; 1940; 1985; 1986), the picture of the prehistoric drainage works in Kopais remained ambiguous, since the theories (Knauss et al. 1984) that have been proposed concerning their function and their precise date within the Bronze Age, were based solely on indications from the surface survey and not on documentation after archaeological or geophysical methods. Furthermore, the representation of the operational scheme of the Mycenaean hydraulic works is a quite difficult task, as they co-exist with (i) several subsequent (possibly incomplete) (e.g. Oliver 1971; Oliver 1989; Boatwright 2000) attempts to drain the lake over the centuries and (ii) 19th and 20th century drainage infrastructures.

The New Kopais project: first fieldwork results

The new project with an interdisciplinary approach and interpretation of the Mycenaean drainage works, realized by the Greek Ministry of Culture and Tourism (Director of the project, which is funded by the Institute for Aegean Prehistory [INSTAP], is Dr. Elena Kountouri) in collaboration with the Department of Water Resources and the Environmental Engineering of the National Technical University of Athens (Greece) and the Institute of Geography of the University of Mainz (Germany), aspires to answer several queries about the technological background of the inspired technical work in Kopais. Furthermore, hydraulic and hydrological analyses attempt to extract the exact operational scheme of the works. The archaeological field works were undertaken during the summer months of 2011 and comprised of surface survey, topographical mapping, geophysical survey, subsurface sampling of soils and three dimensional terrestrial laser scanning, combined with exploratory archaeological excavations in selected areas. The results of the first field season provided new evidence on the construction, the course, the size and mainly the dating of the Mycenaean hydraulic works.

This year a total area of 67.5 km^2 was covered, stretching from Orchomenos in the west to the modern village of Kastro in the east, and from the limestone slopes of the basin in the north to the village of Agios Demetrios in the south. Starting at the segments of the wall excavated by Dr. Elena Kountouri at the site of “Anteras”, the Mycenaean walls were traced and mapped west, towards Orchomenos, for a length of 2.5 km, and east, in the direction of the village Kastro, for 8.5 km. In addition, the hills Pyrgos, Stroviki, and Tourlogiannis were explored for possible auxiliary installations of the Mycenaean hydraulic works, such as guard posts or small forts, while at the same time in the entire aforementioned region, smaller drainage works were sought, as well as man-made water storage areas, whose existence had been postulated by other scholars. During this study, four new archaeological sites of the Classical, Roman and Post-Byzantine periods were located and mapped with GPS, in the northwestern section of the basin. Their particular geographical position is especially important, for it is related to the fluctuations of the water levels of the lake during the periods when the water management systems were in operation.

Several initial findings, which are verified by the preliminary hydrological analysis, the geoarchaeological research (Geo-scientific studies carried out in the Kopais basin by the Institute of Geography of the University of Mainz comprised vibracoring using an Atlas Copco Cobra mk 1 coring device. The maximum recovery depth reached 7 m below surface [m b.s.] with core diameters of 6 cm and 5 cm. Photo-documentation, description and sampling of the retrieved cores were carried out in the field. Core description comprised the analyses of grain size, sediment colour, calcium carbonate content and noticeable features such as plant and macrofaunal remains or ceramic fragments [Ad-hoc-Arbeitsgruppe Boden 2005: Bodenkundliche Kartieranleitung. 5th edition. Schweizerbart, Hannover, 438 pp]. For geochemical analyses, X-ray fluorescence measurements (XRF) were carried out during fieldwork using a hand-held XRF analyzer [type Thermo Niton Xl3t 900S, calibration mode SOIL]. Measurements were taken every 5 cm, if possible, to obtain a detailed vertical distribution pattern for the stratigraphical record. Earth Resistivity Tomography [ERT] measurements were carried out at different locations to detect buried segments of the Mycenaean wall and/or sedimentary structures below present ground surface. ERT transects were orientated perpendicular to the assumed course of the levee according to the survey that had preceded. The position and elevation of coring sites and ERT transects were measured by means of a TOPCON HiperPro FC-250 DGPS device.), and the older stratigraphical excavations, can be set forth.

First, at the site of Romeiko, around 2.5 km northeast of Orchomenos, one of the two branches of the lower reaches of the Boeotian Kephisos River was diverted from its old bed to a new one, one that was shared with the Melas River. The second branch of the Kephisos continued to flow into the western margin of the Kopais basin. This diversion, documented in the bibliography before the 19th century project to drain the basin, is likely to have been the work of the Mycenaeans. The idea was simple: with the diversion of part of the Boeotian Kephisos and the Melas Rivers towards the sinkholes which existed along the banks of the basin, the water level and hence the area of the lake were reduced, and thus, steadily, the northern portion of the basin could be turned over to cultivation.

Second, the diversion was accomplished with the help of a robust levee, carved from west to east, from the area of Orchomenos towards the sinkholes of the northeastern cove. The levee ran along the northern edge of the lake, in proximity to the limestone slopes of the basin, thus setting the boundaries of the region which was flooded by the waters of the Boeotian Kephisos and Melas Rivers, before they emptied into the sinkholes. In effect, the levee worked as a barrier and water retention dam at possibly the highest rim of the basin, leaving the land on the other side dry for agricultural exploitation.

Third, although the terminal point of the levee to the east, near Orchomenos, was not determined during this year’s field work, in the portion that was investigated, the levee’s course appears to follow, in parts, the modern country road linking Kastro and Orchomenos, and a farm road leading towards the village of Pyrgos. Furthermore, the remains of the levee discovered during the modern widening of the country road between Kastro and Orchomenos, as well as the stratigraphical excavations in Anteras, confirm the aforementioned course (Fig. 4).

Figure 4. 3D terrestrial laser scanning of the excavated parts of the levee.

Furthermore, the aquifer that feeds the Melas springs has significant storage capacity and extends to a depth of at least 100 m; therefore, the spring discharge is high even in dry periods (see note n. 9).

Fourth, the constancy of the water supply of the Melas River in yearly terms made it possible for use in irrigation and domestic settlements, without requiring more complicated artificial reservoirs for floodwater retention. Whether the Mycenaean infrastructures included the construction of polders and artificial reservoirs for floodwater retention and storage needs further examination.

Fifth, the exterior sides of the levee are invested with strong retaining walls, built in the Cyclopean masonry style (Fig. 5).

Figure 5. View from the North of the northern retaining wall of the levee (Doufexis plot.).

These walls both improved the resistance of the levee to the pressure of the water, and hindered the erosion of the soil. At the same time, they provided a strong retaining wall for the possible creation of a road along the top of the levee, creating artificial plateau. The exterior face of the retaining wall is sloped at an angle of 78 degrees, with the stones of the lower courses protruding markedly from those of the upper courses. Of careful construction, the walls are preserved to a height of 2.30 m, and have a width of 1.78 m at the top and 2.78 m at the base (Fig. 6).

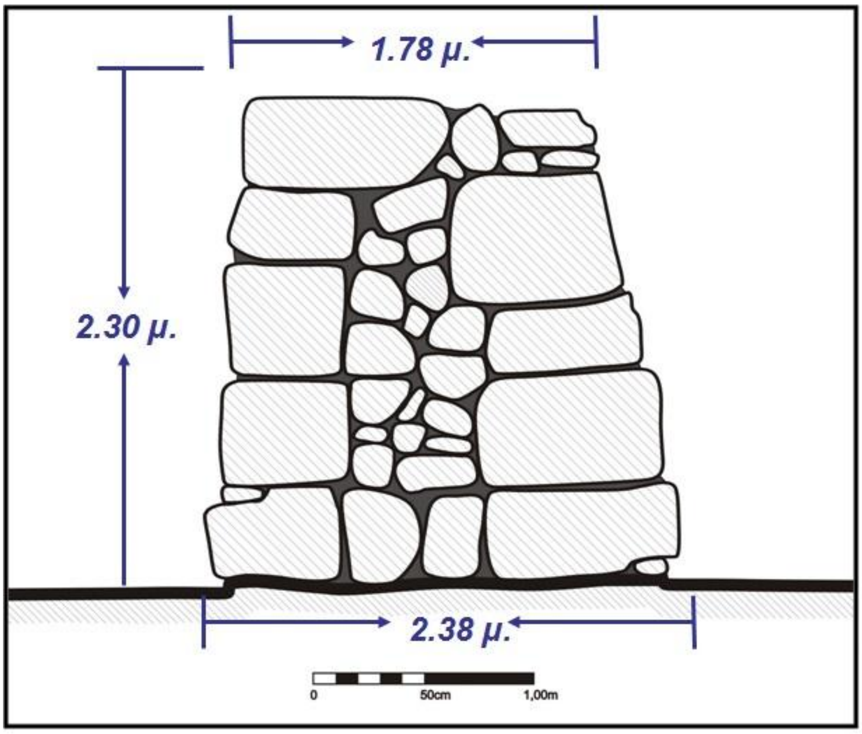

Figure 6. The northern retaining wall of the levee in section.

Given the quantity of stones found in the destruction layers, an original height of over 3 m can be postulated. The walls were created using large boulders, placed in more or less regular courses, with smaller stone chips used as filling. Initially, a foundation trench was dug, consisting of a shallow ditch somewhat wider than the retaining wall. This was then filled with small stones set into a thick layer of clay. Above this waterproof insulating infrastructure, the stones of the first courses were laid, with clay in between the joints. On top of this, the rest of the retaining wall was constructed. In opposition to the exterior face of the wall, the interior facade was erected vertically, without any particular attention to aesthetics, with uncut boulders protruding and receding at random, and a thick mass of small to medium stones and clay filling its interior.

Sixth, the core of the retaining wall makes extensive use of yellowish clay, from lake deposits, which is characterized by plasticity and waterproof qualities. A thick and compact layer of this clay, measuring a total of 2 m thick, reaches down to the foundation trench of the retaining wall, and was completely devoid of any ceramic material (Fig. 7).

Figure 7. Stratigraphy of the core of the levee.

In one case, at the lowest level of this layer of clay, a large stone was found, having fallen from a higher course of the retaining wall. Around it, a small quantity of stone chips indicates that the boulders were roughly hewn on the spot.

Seventh, the retaining walls did not have the same dimensions everywhere, which were often dictated by the geomorphology of the area and proximity to the limestone slopes and the sink holes. The total width of the wall at the site of Anteras, including the two Cyclopean walls which marked its northern and southern long sides, measures 30 m.

Eighth, often, the second retaining wall, on the side facing the dry valley, is omitted altogether. In these cases, the width of the wall is much smaller.

Ninth, *terminus ante quem* for the chronological determination of the construction of the retaining wall is provided by the cemetery found at the site of Stroviki, which is located at a level lower than that of the foundation trench, and dates to the MH period (Aravantinos et al. 2006). In addition, investigation of undisturbed layers of fill have provided ceramics which clearly place the period of construction and use of the corresponding portions of retaining wall in the LH IIIB period (the middle of the 13^{th} century B.C.), confirming that they belong to the same chronological horizon as that of the citadel at Glas.

Questions posed and future research

However, up to now this fieldwork has also posed as many new questions as it has answered. Several of these relate to the effectiveness of the functioning of these works, possible failures, the chronological sequence of the construction of various sections, as well as the joins between sections. In addition, a technological work of such a scale, which required extensive excavations and removal of huge quantities of dirt, not to mention the quarrying, transport, processing and lifting of such large boulders for the building of the retaining walls, makes the case that there must have been a particularly strong and centralized authority in the region. The fact that the stones for the construction of the retaining walls seem to have been hewn in place requires organized teams of personnel with clear and distinct responsibilities, while at the same time, it presupposes the existence of a steady flow of supplies. Is Orchomenos that center of power which mobilized human resources, means and materials, for the design, construction, and also logistics of such a prestigious work? Or was this the result of a cooperation of powers of the time, with the contribution of that other powerful administrative center in the region, Thebes? Presently, the former seems more likely.

Future fieldwork will focus on (1) further locating the western starting as well as the eastern terminal point of the levee, along with any secondary works, (2) identifying specific construction details of the levee, (3) excavating more selected sites and confirming the chronological framework and (4) clarifying the exact operational hydraulic pattern of the works, hopefully providing us with reliable answers.

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