THE URBAN PLAN OF MANTINEA IN THE PELOPONNESE: AN INTEGRATED GEOPHYSICAL AND SATELLITE REMOTE SENSING FIELDWORK CAMPAIGN

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Abstract

This paper presents the results from the first campaign of remote sensing fieldwork at Mantinea in the Peloponnese. Geophysical prospection, using new generations of multicomponent equipment, has been used in tandem with satellite image processing to reveal an extensive network of buried orthogonal streets, sections of city blocks, and residential and public buildings. This new and valuable information reveals much about the wider urban dynamics of Mantinea and shows that the city was a planned settlement. Rather than conform to a strict Hippodamian system, Mantinea appears to have experienced different phases of city planning, possibly as a reaction to sociopolitical upheavals during the fourth and third centuries B.C.E., when the city was twice destroyed and rebuilt. The discovery of city blocks of different dimensions and irregularities in the positioning of roads are indicative of a multilayered urban environment. On a broader scale, the new city plan of Mantinea has important implications for the history of Greek town planning in the Peloponnese during the second half of the first millennium B.C.E. While the rational organization of cities is a defining feature of Greek urban culture, especially in colonial foundations, few examples are known from the Peloponnese. Mantinea illustrates that the organization of space and conceptual approaches in cohabitation are characteristics of Greek urban culture in the Peloponnese as much as they are elsewhere in the ancient Mediterranean.

(Slide1) In 2014 the Laboratory of Geophysical, Satellite Remote Sensing and Archaeoenvironment of the Institute for Mediterranean Studies based in Crete completed the first phase of an integrated campaign of satellite remote sensing and geophysical survey at Mantinea in the Peloponnese. The objective was to document the physical composition of the entire settlement which largely remains unexplored. This includes the arrangement of streets and city-blocks, the makeup of buildings, and a general appreciation of the city's urban dynamics. A second and far-reaching objective was to develop non-invasive methods for uncovering and exploring past landscapes in a timely manner by using new generations of equipment. **(Slide2)** Our work at Mantinea falls under a broad study of Greek and Roman urban centers using these methodologies. In 2014 we also conducted geophysics at Demetrias, Elis, Gortyn, and Pherai, and satellite remote sensing at a dozen other sites. In its synthesis, we aim for a better understanding of the variable nature of cities and town planning in classical antiquity from Mainland Greece. This morning, we will focus on Mantinea and highlight some of our significant findings.

(Slide3) First a background on the history, current state of research, and topography of the city. Mantinea was established between 550-450 BCE within a fertile valley of northeastern Arcadia. The literary and archaeological evidence do not permit a more conclusive foundation date. Mantinea was twice destroyed and rebuilt. First by a Spartan invasion in 385 and later by the Macedonians in 222. The Spartan destruction instigated a forced depopulation of Mantinea and relocation of its citizens to surrounding villages. According to Xenophon (*Hellenica* 5.2.1-7), the fortification walls and many of the buildings were deliberately demolished. Mantinea was reestablished in a synoicism fifteen years later after the Battle of Leuctra. Afterwards, the city was a member of the Arcadian League and played a long and active role in the region's politics well into the Roman period. Hadrian was particularly fond of Mantinea, since it was reputed to be the mother-city of Bithynia, the hometown of Hadrian's favorite Antinoos. The latter history of the city is poorly documented. A scattering of Byzantine and Ottoman structures attest to post-Roman occupation, although probably on a limited scale.

(Slide4) The only extensive archaeological investigations at Mantinea were conducted by the

French School at Athens from 1887-89. Excavations were frequently stalled and eventually abandoned by outbreaks of malaria. The extreme flatness of the site in combination with Arcadia's wet climate produces seasonal streams and ponds (with mosquitoes) that characterize a marshy landscape even today. The French focused on the agora and its public monuments, including a theater. They discovered civic and religious buildings and porticos arranged around a rectangular square with phases spanning the Classical to Roman periods. Many of these buildings have since been reburied by seasonal flooding. **(Slide5)** Beyond the agora, the most significant architectural feature at Mantinea is the elliptical fortification walls, approximately 4 km in circumference. Today, the walls and gates, which number ten, are in a remarkable state of preservation. They constitute an exceptional illustration of a near complete Greek defensive circuit. As a result, the urban boundaries of Mantinea are well defined and comprise an area of 119 ha. Little else of the remaining settlement has been studied and today the site is predominantly cultivated for wheat and vegetables.

(Slide6) Before on-site fieldwork, a remote sensing campaign was conducted using four high-resolution multispectral satellite images. The Quickbird and WorldView-2 satellite images cover a broad area of 25 sq km. Feature enhancement filters were applied to optimize the spectral signatures reflected from ground targets. **(Slide7)** Since chlorophyll in plants absorbs and reflects spectral wavelengths differently depending on the climate and health of vegetation, subsurface features, such as a building with stone walls, can put stress on vegetation thereby creating "crop marks" that betray the presence of a subsurface feature. Although it is entirely feasible to identify anomalies using true color images, feature enhancement algorithms, including vegetation indices like NDVI, maximize feature detection. **(Slide8)** At Mantinea, this method proved valuable in identifying an extensive system of orthogonal streets, showing that the city was a planned settlement. The frequency, ordered arrangement, and metrology of anomalies are clear, and many begin to form the outlines of long rectangles, which we presume to be from city-blocks.

(Slide9) South of the agora there is evidence for four parallel streets of prolonged dimensions. The westernmost can be traced in the satellite imagery for almost 700 m from a gate to the theater. We identified a similar arrangement and metrology of streets in the northern half of the city. **(Slide10)** East-west anomalies that mark buried streets are also apparent, with many intersecting the north-south anomalies at right angles. Regions to the northwest and east of the agora best demonstrate this.

Mantinea is an excellent example of the benefits of using satellite remote sensing during an initial phase of site exploration. **(Slide11)** We did not know that the city was a planned settlement before, but now a partial reconstruction of the grid system is possible. The central zone of Mantinea, as reconstructed, is defined by a series of extended north-south streets at 89 m intervals. Two-thirds of these street lengths (62%) are verified by linear anomalies. Note that the ones in the southern zone are positioned some 20 m further east. We suspect that the reason for the shift was to optimize the communication between city gates and the agora. The two northern gates (B, C) are not on axis with the two southern gates (H, G); therefore, a slight modification to the arrangement of the southern streets was required for proper circulation. Completing the north-south roads, we find a string of east-west streets that are dispersed throughout Mantinea at 60 m intervals. One-quarter of the street lengths (27%) are verified by linear anomalies. As you can see, there are still gaps in the data that present ambiguities in the grid plan. **(Slide12)** And some anomalies likely from streets do not fit into this reconstruction. Therefore, we suspected at an early stage that Mantinea did not adopt a uniform Hippodamian plan; rather there were modifications to a prototype of either single or multiple phases.

The geophysical survey was implemented to confirm and modify the findings of satellite remote sensing, while uncovering additional urban features at a higher resolution. **(Slide13)** The Lab of the Institute for Mediterranean Studies has a distinct advantage in archaeological geophysics. First, we employ a multi-method, integrated approach to maximize the detection of buried features. This includes magnetics, electromagnetics (EM), ground-penetrating radar (GPR), resistivity, and electrical resistivity tomography (ERT). Second, our scope of geophysical exploration is extensive since we employ new generations of equipment that survey more surface area per day compared to conventional equipment. **(Slide14)** At Mantinea fieldwork was limited to 11 working days during May and November, but during this time we covered 40 hectares with seven people: an average of 3.5 hectares per day. Total coverage without overlap came to 31 hectares. This is more than 25% of the entire city in less than two weeks. Our aim is to map the whole urban area, and we estimate 25 more working days. Total or near total geophysical

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coverage of a large site, such as Mantinea, is rare even after many seasons of fieldwork. But multi-component equipment upgrades make this possible, opening up new avenues for exploring and mapping ancient cities in their entirety.

(Slide15) In the field, we combine geophysical techniques of rapid spatial coverage with targeted techniques to clarify subsurface features. For large area coverage we use a SENSYS Magnetometer MX, controlled by a team of two operators, and a Geophex GEM-2 EM, operated by a single person. The SENSYS consists of an array of eight fluxgate gradiometers accompanied by a GPS rover station. The flat topography and low vegetation density at Mantinea are ideal for the SENSYS push-cart system. The EM was used to map more challenging terrain, such as recently plowed fields or dense vegetation. An advantage of the EM is that it measures both electrical conductivity and magnetic susceptibility, giving a broader picture of the subsoil. **(Slide16)** GPR and resistivity targeted smaller areas. They are generally slower in operation, but their ability to map architectural features can often be superior to magnetic methods.

(Slide17) Magnetics and EM were effective in mapping the orthogonal street system at Mantinea because of their rapid area coverage. Most streets are characterized as positive magnetic anomalies (here in white) in comparison to the surrounding soil matrix. This probably indicates that road surfaces consist of hard packed dirt with crushed tiles, pottery, and slag. In some instances, darker anomalies of lower magnetic values on the edges are likely from limestone curbings or sidewalks. **(Slide18)** A comparison of the geophysical and satellite results shows good overall correspondence in the position of roads. Several new details emerged, however. First, city-blocks vary greatly in their dimensions. The orthogonal grid adopts a tiered or stepped arrangement of streets along the margins. In the west, for example, many north-south streets are broken up into smaller units. **(Slide19)** A variety in configuration produces rectangular city-blocks of various dimensions that range from 89 m to upwards of 200 m in width. We suspect that some may be even wider, but further confirmation is needed. The shorter sides of city-blocks are usually 60 m, but even here there are discrepancies.

(Slide20) Another discovery is that many city-blocks are divided in half by smaller streets. Mantinea apparently had small alleyways in the middle of insulae, in the same fashion as classical cities like Olynthus. **(Slide21)** Elsewhere we found evidence that a ring road, or intervallum, encircles the interior of the fortification walls, apparently as a means to optimize the circulation of traffic. The French first proposed this as a hypothesis in the 19th century, but here we have confirmation. **(Slide22)** Perhaps the most surprising discovery over the course of our survey was the identification of diagonal streets. One begins as a north-south road only to turn abruptly in a northwest direction toward Gate A. Another example has a southwest-northeast orientation that extends toward gates E and C. However, we did not find additional evidence for this road in intermediary fields.

(Slide23) Along with roads, architectural features are well represented in the geophysical data. At the northeastern side of the agora, GPR was successful in detecting public buildings excavated in the 19th century but since reburied. These include two stoas with internal colonnades and square buildings behind the eastern stoa. These must be the same buildings that appeared on the French plan of the agora, although the plan lacks many details clear in the GPR. For example, the larger square structure has an internal division of rooms and the smaller structure has a slanted orientation.

(Slide24) I show here another concentration of structures at the city's southern end. GPR time slices indicate the depth of these features, which appear about 50 cm below the surface. In this example, a large complex of one or more structures appears at the southern end of the grid. Finally, it is worth noting that what we don't find is often just as helpful as what we do find. In many cases, architectural features appear to be absent in the geophysical data. In the GPR example here, the southern concentration of buildings contrasts with the apparent lack of architectural features to the north. We found many similar cases elsewhere. This raises questions on the nature of urban life at Mantinea, and how densely built the urban environment really was, even within an organized system of streets.

(Slide25) While noting the preliminary nature of the data at an intermediate stage of fieldwork (and an even earlier stage of interpretation) some generalizations about the city's urban mechanics can be proposed. Most obviously, Mantinea was a planned settlement in Arcadia, and is now one of only a handful of planned settlements in the Peloponnese that we know of. Its urban grid did not adopt a uniform Hippodamian system, such as at Hellenistic Sikyon also in the Peloponnese. The discovery of city-blocks of different dimensions and irregularities in the positioning of roads indicate a

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multifaceted system. In our analysis, one peculiarity is the relationship between an orthogonal street system and an elliptical defensive circuit. The two systems are not entirely coherent with one another and present challenges, especially along the margins. Moreover, the distribution of gates around the walls necessitated adjustments to the position of streets. The critical question to ask in this context is whether everything was planned in a single phase (walls, gates, streets) or were streets inserted (or modified) to coordinate with a preexisting urban scheme? The notion of different phases of city planning at Mantinea becomes a possibility considering the various political upheavals that the city experienced before the Roman period, being twice destroyed and rebuilt in the 4th and then 3rd century. But these suspicions cannot be resolved with our methodologies. They must be confirmed with ground truthing and a better understanding of the city's architectural phases, which are poorly documented. The fortification walls and gates are usually dated, based on masonry style, to the 4th century, but they appear to follow the walls destroyed by the Spartans. The public buildings in the agora are integrated at the heart of the city and align with the streets, but the earliest building phases date broadly to the 5th and 4th century from a lack of stratified deposits. The wide chronology falls either before or after the Spartan destruction.

We would like to conclude with two thoughts that touch upon larger issues in Greek urban studies. **(Slide26)** First, on mainland Greece, including the Peloponnese, planned settlements are not as widespread in the archaeological record. This is often attributed to the older and continuous occupation at mainland Greek cities compared to colonial foundations. Indeed excavations have shown that prominent places like Corinth and Eretria remained without formal planning over much if not all of their histories. However, an incomplete sample and the modest scale and methods of site exploration are factors that shape conventional narratives. Besides Mantinea, we found evidence from fieldwork in 2014 that Elis in the Peloponnese and Pherai in Thessaly were planned settlements. It will be interesting to see how newer methods of site exploration, such as the ones we use here, can contribute to a greater range of awareness. **(Slide27)** And second, the total or near total remote sensing approach implemented at Mantinea exposes the inherent variation in built environments. The 40 hectares scanned at Mantinea to date is an extensive area. But most reconstructions of planned cities rely on a much smaller sample. One has to wonder, therefore, whether our conception of rational city planning and Hippodamian systems are only partly true, while a fuller examination would expose irregularities. **(Slide28)**

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