



AMERICAN JOURNAL OF  
**ARCHAEOLOGY**

656 Beacon Street, Boston, MA 02215 • Tel.: 617-353-9361 • [www.ajaonline.org](http://www.ajaonline.org)

---

This article is © The Archaeological Institute of America and was originally published in *AJA* 120(3):361–398.

This e-print is supplied to the author for noncommercial use only, following the terms outlined in the accompanying cover letter. The definitive electronic version of the article can be found at:

<http://www.jstor.org/stable/10.3764/aja.120.3.0361>.

Volume 120, Number 3  
July 2016

# AMERICAN JOURNAL OF ARCHAEOLOGY

The Journal of the Archaeological Institute of America



[www.ajaonline.org](http://www.ajaonline.org)

# Evidence for Two Planned Greek Settlements in the Peloponnese from Satellite Remote Sensing

JAMIESON C. DONATI AND APOSTOLOS SARRIS

*Includes Supplementary Content on AJA Online*

Satellite remote sensing at Mantinea and Elis in the Peloponnese has identified an extensive network of near-surface orthogonal streets and sections of city blocks. This new and valuable information reveals the general organization of urban space and its parameters, showing that Mantinea and Elis were planned settlements at some point in time. In presenting the evidence for buried archaeological features, the report describes the wider urban layout of each city and outlines a partial reconstruction of an orthogonal network of streets. As Peloponnesian settlements, Mantinea and Elis are considered more broadly within the traditions of Greek town planning. In particular, the report highlights the evidence for planned settlements in the Peloponnese and in doing so challenges the misconception that the region was disinclined to adopt trends in Greek town planning. Finally, an argument is made for the wider integration of satellite remote sensing applications in archaeological fieldwork projects throughout Greece, where until now they were generally lacking.<sup>1</sup>

## INTRODUCTION

This study uses satellite images as a primary archaeological tool to investigate the spatial organization and geographical extent of ancient Greek settlements, such as the arrangement of streets and city blocks, the interconnection between urban and rural space, and the potential transformation of urban patterns under changing sociopolitical conditions. One of the advantages of satellite remote sensing is the ability to explore large contexts covering in some cases hundreds of square kilometers. The tremendous range in scale is ideally suited for exploring whole settlement patterns in timely sequence, rather than just a targeted area gradually. Very high-resolution (<1 m) multispectral satellite images have been commercially available since the launch of QuickBird in 2001. This field of research is still in its nascent stages and has tremendous potential for further expansion in archaeological fieldwork. One of the newest satellite sensors, WorldView-3, launched in August 2014, has a ground sampling distance of 0.31 m panchromatic and 1.24 m multispectral.<sup>2</sup> The resolution quality is enough to identify small ground targets on an

*American Journal of Archaeology*  
Volume 120, Number 3  
July 2016  
Pages 361–98  
DOI: 10.3764/aja.120.3.0361

[www.ajaonline.org](http://www.ajaonline.org)

<sup>1</sup>Support for remote sensing research, the purchase of satellite imagery, and the reproduction of color images for this article was generously provided by the Alexander S. Onassis Public Benefit Foundation. Additionally, we extend our thanks to Yannis Lolos of the University of Thessaly for supervising the research of Jamieson C. Donati during an Onassis postdoctoral fellowship. Figures are our own unless otherwise noted. Additional figures can be found under this article's abstract on AJA Online ([www.ajaonline.org](http://www.ajaonline.org)).

<sup>2</sup>[www.digitalglobe.com](http://www.digitalglobe.com).

archaeological site. Another recent system, Google's Terra Bella, is a constellation of sensors offering daily coverage complete with high-definition video.<sup>3</sup> Thus, the impact of human and environmental factors on an archaeological site can be monitored more easily and regularly. It is indeed an exciting period for the application of satellite remote sensing in archaeology. Innovative technologies now help us confront ancient landscapes in ways that were not conceivable two decades ago.

For this report we present our work at Mantinea and Elis in the Peloponnese, where satellite remote sensing has uncovered new information about the cities' poorly realized (until now) urban dynamics (fig. 1). The evidence for buried archaeological features is striking in its clarity and composition. Most notably, we have had success in identifying networks of streets and sections of city blocks arranged in an orthogonal manner, an indication that Mantinea and Elis were planned cities. Previous archaeological fieldwork from excavations and limited geophysics found little evidence of town planning. To our knowledge, our work is the first instance in Greece where a planned ancient city has been identified only through satellite remote sensing methods. Feature enhancement indices created from high-resolution multispectral satellite sensors reveal dozens of surface anomalies, such as linear soil and crop marks, that mark the presence of buried ancient features. In some cases, the surface anomalies representing buried streets can be traced for hundreds of meters in the satellite imagery. One example at Mantinea extends for nearly 700 m from a city gate to the agora. These are significant discoveries that better contextualize the Peloponnesian cities within their local and regional environments. More broadly, the city plans of Mantinea and Elis have important implications for the history of Greek town planning 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 at present are known from the Peloponnese. Mantinea and Elis illustrate 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.

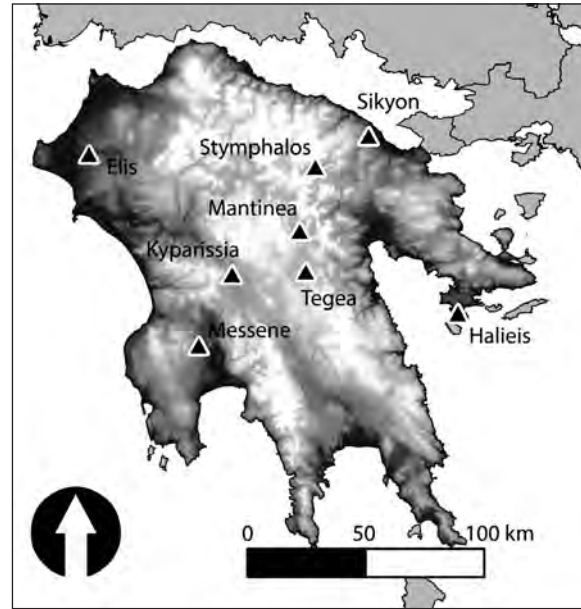


FIG. 1. Map of the Peloponnese. ASTER GDEM is a product of METI and NASA.

#### SATELLITE REMOTE SENSING WITHIN MEDITERRANEAN ARCHAEOLOGY

The conventional methods of exploring historical landscapes require archaeologists to have an intimate relationship with the targeted context(s) of study. Soil is carefully removed by a trowel to reveal architectural stone blocks. Pottery and other small finds from daily life are unearthed by hand and carefully analyzed by specialists. Surface artifacts are meticulously counted and recorded by survey field walkers. This kind of human contact with the past is a prerequisite for extracting and interpreting cultural material. In contrast are remote sensing methodologies that enable archaeologists to examine past landscapes from a distance. Aerial photography has been well established since the middle of the last century, particularly in recording larger contexts, such as a rural land organization.<sup>4</sup> Geophysical prospection is now standard in archaeological fieldwork.<sup>5</sup> One advantage is the ability to identify subsurface features on a large scale without irreversibly damaging the context. Recently, a growing number of geophysical surveys have been employed

<sup>3</sup><https://terrabella.google.com>.

<sup>4</sup>Castagnoli 1971; Ward-Perkins 1974; Montufo 1997.

<sup>5</sup>Sarris and Jones 2000; Sarris 2008.

as stand-alone methods to reconstruct entire ancient landscapes.<sup>6</sup>

Satellite remote sensing is another category of remote sensing and the one that forms the focus of our research. Like aerial photography, satellite remote sensing analyzes landscapes without coming into direct contact with the area of study.<sup>7</sup> It is astonishing to consider that the satellite sensors that extract data of archaeological interest are hundreds of kilometers away, far exceeding the distance of most airborne photography (<5,000 m) and near-surface geophysical prospection (<1 m). However, beyond just distance, the techniques and strategies of satellite remote sensing are fundamentally different from those of other forms of remote sensing applications. Most satellite sensors record the spectral wavelengths of features on the ground, such as vegetation, soil, and anthropogenic constructions. Depending on the specific sensor, this information is usually documented in panchromatic (grayscale) and visible multispectral bands (RGB = red, green, blue), as well as in bands not visible to the human eye, such as infrared. Radar sensors constitute a separate subcategory. Having a suite of spectral data is an advantage, because the color signatures can be filtered and manipulated to reveal natural and artificial features of historical significance otherwise undetectable on the ground or with standard aerial photography. Subsurface features that lie less than 3 m below the ground, such as a street or building, can potentially alter the soil composition and vegetation growth on the surface, which in turn may be measured by the multispectral satellite sensors.

The use of satellite remote sensing in Mediterranean archaeology has expanded to address various archaeological questions from the monitoring of archaeological sites to the detection of areas of archaeological interest. In Greece, one of the earliest satellite remote sensing projects was carried out as part of the Minnesota Archaeological Researches in the Western Peloponnese for studying the vernacular architecture and medieval sites of the Morea. The project successfully located ancient iron mines, limestone quarries, and an obsidian-rich fault based on biophysical signatures extracted from Landsat images.<sup>8</sup> The first wide-scale comparative use of satellite platforms (Hyperion, IKO-

NOS, Landsat TM/ETM+, ASTER) was carried out more recently to detect Neolithic settlements in Thessaly.<sup>9</sup> The only airborne surveillance project was conducted at Itanos in eastern Crete using hyperspectral scanners (Airborne Thematic Mapper and Compact Airborne Spectrographic Imager) and LIDAR (Light Detection And Ranging).<sup>10</sup>

#### METHODOLOGIES AND DATA PROCESSING

The use of satellite images to examine the urban mechanics of Mantinea and Elis involved various image-processing techniques. These ranged from the preprocessing of satellite data (image fusion) and supporting data sets, such as aerial photographs and historical maps (digitization, geometric correction, and vectorization), to the postprocessing of the multispectral bands to create feature enhancement indices.

#### *Data Sets*

High-resolution satellite images of submeter resolution from three different satellite sensors (GeoEye-1, QuickBird, WorldView-2) and historical aerial photographs formed the main data sets for our research. The satellite images cover a broad area between 25 and 30 km<sup>2</sup>, which was enough to include the entire urban zone and immediate rural territory of Mantinea and Elis. An effort was made to employ different satellite sensors for comparative purposes, since each has a different range of multispectral bands and resolution quality, among other factors (table 1). We were fortunate to have a broad choice of satellite images at Mantinea and Elis, and consequently we used multiple data sets extracted in different years and seasons. Because the results of satellite remote sensing are highly dependent on local climatic conditions (rainfall, heat, angle of the sun, moisture in soil) and the growth of vegetation, a subsurface feature might be undetectable during one month and one year but entirely visible some other time.<sup>11</sup> For example, a WorldView-2 image taken of a field at Elis on 13 December 2012 reveals no evidence of surface anomalies; however, a GeoEye-1 image taken 20 July 2009 shows anomalies in the same field (fig. 2). In this case, the anomalies are buried streets associated with the streets uncovered

<sup>6</sup>Sarris and Monahan 2012; Champan et al. 2014.

<sup>7</sup>Alexakis et al. 2012.

<sup>8</sup>Cooper et al. 1991.

<sup>9</sup>Rowlands and Sarris 2007; Alexakis et al. 2010; Agapiou et al. 2012.

<sup>10</sup>Rowlands and Sarris 2007.

<sup>11</sup>Agapiou et al. 2012.

TABLE 1. Satellite sensors used at Mantinea and Elis and their specifications.

Satellite Sensor	Extraction Date	Resolution (m)	Off-Nadir Angle
Mantinea			
QuickBird	13 September 2003	panchromatic 0.63 multispectral 2.50	9.4°
QuickBird	10 June 2009	panchromatic 0.64 multispectral 2.56	14.8°
QuickBird	3 June 2012	panchromatic 0.66 multispectral 2.65	14.8°
WorldView-2	11 September 2013	panchromatic 0.50 multispectral 1.90	10.1°
Elis			
GeoEye-1	20 July 2009	panchromatic 0.50 multispectral 1.86	9.1°
QuickBird	30 April 2010	panchromatic 0.63 multispectral 2.50	8.9°
WorldView-2	13 December 2012	panchromatic 0.50 multispectral 2.03	18.2°

by excavations to the north. Needless to say, there is some chance involved in the process, and one cannot entirely predict whether a satellite image of a specific extraction date will yield successful results.

Aerial photographs of Mantinea from the Hellenic Military Geographical Service from the 1960s and 1980s supplemented our satellite images.<sup>12</sup> The photographs proved valuable in tracing the modern land use around Mantinea over the past 50 years. Agricultural field boundaries inevitably change over time, and different crops are cultivated. It is important to recognize these changes when interpreting surface anomalies in satellite remote sensing. What might be understood as a subsurface feature of archaeological interest might in fact be the remnants of a (recent) land modification by human and/or environmental doings. In one instance at Mantinea, clusters of circular anomalies in the satellite imagery proved to be from trees long ago cut down and covered by other crops. In short, there is much to be gained from historical aerial photographs from different years in combination with satellite imagery. Note, however, that further processing and feature enhancement is limited. Newer technologies, such as LIDAR and infrared and radar sensors on cameras, do permit a greater range of image extraction and image processing that can even surpass the capabilities of satellite sensors.<sup>13</sup>

#### *Preprocessing*

A series of preprocessing techniques were applied to the satellite images for further data processing and

analysis. Depending on the type of data used, the preprocessing steps can include radiometric and geometric corrections to the satellite images and image fusion of the lower-resolution multispectral bands with the higher-resolution panchromatic image. Image fusion is a feature enhancement process that increases the spatial resolution of a satellite image by using another image of superior spatial resolution. This can occur as long as any two images are geometrically corrected with each other. Image fusion is frequently used to strengthen the spatial resolution of multispectral bands with a higher-resolution panchromatic (grayscale) image. For example, the spatial resolution of QuickBird multispectral bands is 2.5 m, while the panchromatic is 0.6 m. The difference in resolution quality between color and grayscale images is significant, and without image fusion a color image will have limited range in distinguishing fine surface details (online fig. 1).<sup>14</sup> Image fusion creates a high-resolution color and infrared image even though the raw multispectral data from the satellite sensor is of lesser quality.

#### *Postprocessing*

The capacity to enhance and distinguish surface features from satellite images rests largely on postprocessing techniques. Specific algorithms can be applied to the images to measure and magnify the range of spectral signatures reflected from ground targets. Vegetation in agricultural fields is particularly important to investigate, because the chlorophyll in plants absorbs

<sup>12</sup> www.gys.gr.

<sup>13</sup> Everaerts 2008; Masini et al. 2011.

<sup>14</sup> See AJA Online for all online-only figures accompanying this article.

and reflects spectral wavelengths differently depending on the local climatic conditions and the health of the vegetation. A subsurface feature, such as a buried stone building, might put stress on the vegetation growth directly above. This stress can in turn alter the spectral signature of ground vegetation and create surface anomalies or “crop marks” that betray the presence of a subsurface feature. Although it is entirely feasible to identify surface anomalies using true-color RGB images and different combinations of multispectral bands, feature enhancement indices maximize feature detection (fig. 3; online fig. 2).<sup>15</sup>

For our research, we applied a combination of vegetation indices to the multispectral satellite images. Table 2 summarizes the algorithms for each feature enhancement class, all of which are well-established processes in satellite remote sensing.<sup>16</sup> The result was a suite of new data sets that display a versatile range of surface and subsurface detail partly or wholly indiscernible in the original multispectral band combinations.

#### MANTINEA

##### *Archaeological and Historical Context*

Mantineia was established sometime before the middle of the fifth century B.C.E. in northeastern Arcadia (fig. 4; online fig. 3). The literary and archaeological evidence do not permit a more conclusive foundation date.<sup>17</sup> The earliest datable finds from the city are two fifth-century B.C.E. legal inscriptions reused as architectural members in buildings around the agora.<sup>18</sup> Mantineia was attacked and destroyed by a Spartan invasion in 385 B.C.E., and its citizens were forced to depopulate. These extraordinary events are described by Xenophon (*Hell.* 5.2.1–7), who recounts that the Spartans successfully breached the fortification walls by damming the Ophis River, which flowed through town. The exploit caused extensive damage to the fortification walls and flooded the urban center, ultimately leading to the surrender of the city. The Mantineans were forced to evacuate their city under Spartan duress. They were relocated to surrounding villages, and for 15 years Mantineia was abandoned. It

<sup>15</sup> Agapiou et al. 2012.

<sup>16</sup> Sarris et al. 2013.

<sup>17</sup> For a discussion on the historical background of Mantineia and a summary of the archaeological evidence, see Hodkinson and Hodkinson 1981; Winter 1987, 239–44; 1989, 189–92; Tsiolis 2002.

<sup>18</sup> IG 5 2 261–62.



FIG. 2. Satellite images of Elis: *top*, WorldView-2, 13 December 2012; *bottom*, GeoEye-1, 20 July 2009. Surface anomalies (indicated by arrows) are visible only in the GeoEye-1 image (© DigitalGlobe, Inc.; all rights reserved).

was reestablished in 370 B.C.E., after Sparta’s defeat in the Battle of Leuctra. The fortification walls and urban center were rebuilt (with the Ophis River now being diverted around the walls), and the city became a member of the newly established Arcadian League during the fourth century B.C.E. However, Mantineia, along with other Peloponnesian settlements, resisted the rise of Macedonian influence and was sacked by Antigonos Doson in 222 B.C.E. The city was subsequently rebuilt and renamed Antigoneia, a title that lasted more than three centuries, until the Roman emperor Hadrian changed the name back to Mantineia.

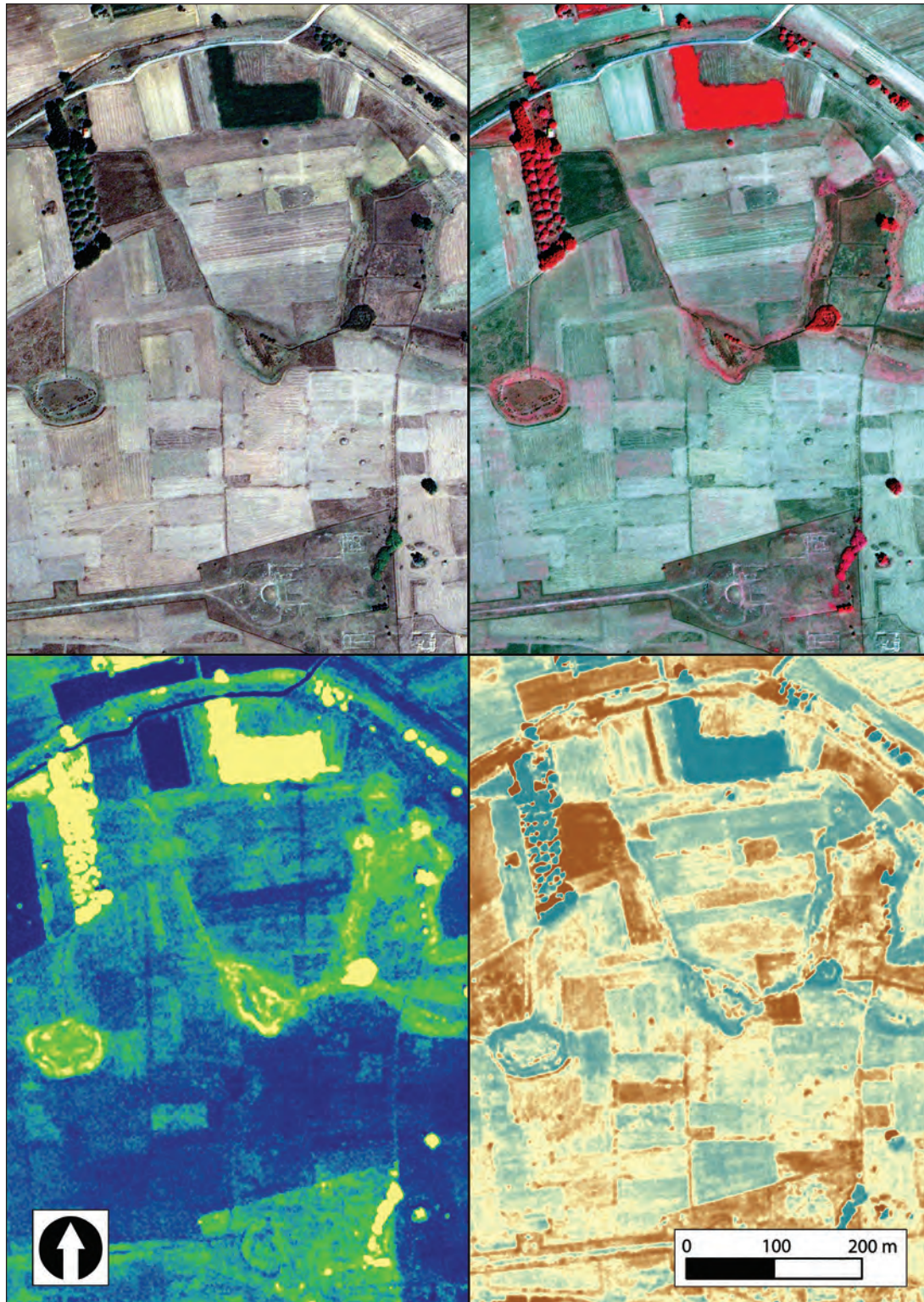


FIG. 3. Band combinations and feature enhancements applied to a QuickBird image taken 13 September 2003 of the northern region of Mantinea. Clockwise from top left: true-color RGB, false-color infrared, modified simple ratio (MSR), normalized difference vegetation index (NDVI). Note how linear anomalies are visible or disguised depending on the specific band combination or feature enhancement (includes copyrighted material of DigitalGlobe, Inc.; all rights reserved).



TABLE 2. Feature enhancement indices applied to the satellite imagery.

Feature Enhancement	Algorithm
Atmospherically resistant vegetation index (ARVI)	$(\text{PNIR} - (2 [\text{PRED} - \text{PBLUE}])) / (\text{PNIR} + (2 [\text{PRED} - \text{PBLUE}])))$
Enhanced vegetation index (EVI)	$((\text{PNIR} - \text{PRED}) / (\text{PNIR} + 6(\text{PRED}) - 7.5(\text{PBLUE}) + 1))$
Green normalized difference vegetation index (Green NDVI)	$(\text{PNIR} - \text{PGREEN}) / (\text{PNIR} + \text{PGREEN})$
Infrared/red (IR/R)	$\text{PNIR} / \text{PRED}$
Modified soil-adjusted vegetation index (MSAVI)	$((\text{PNIR} - \text{PRED}) / (\text{PNIR} + \text{PRED} - \text{L})) (1 + \text{L})$
Modified simple ratio (MSR)	$\text{PNIR} / \text{SQRT}((\text{PRED} / \text{PNIR} + 0.1) + 1)$
Normalized difference vegetation index (NDVI)	$(\text{PNIR} - \text{PRED}) / (\text{PNIR} + \text{PRED})$
Soil-adjusted vegetation index (SAVI)	$((\text{PNIR} - \text{PRED}) / (\text{PNIR} + \text{PRED} + 0.5)) (1.5)$
Square-root infrared/red (SQRT IR/R)	$\text{SQRT}(\text{PNIR} / \text{PRED})$
Transformed soil-adjusted vegetation index (TSAVI)	$(s (\text{PNIR} - s * \text{PRED} - a)) / (a * \text{PNIR} + \text{PRED} - a * s + 0.08 (\text{L} - s * s))$
Weighted difference vegetation index (WDVI)	$\text{PNIR} - \text{PRED} * s$

a = soil line intercept; L =  $1 - 2 * s * \text{NDVI} * \text{WDVI}$ ; P = band; s = soil line slope; SQRT = square root

The first extensive archaeological investigations at Mantinea were conducted by the French School at Athens from 1887 to 1889.<sup>19</sup> Many of the public buildings in the agora, including the theater, were unearthed, and the above-surface fortification walls and gates were documented and measured (fig. 5). Although excavations were conducted unsystematically and present uncertainties in the chronology of many buildings, a partial plan of Mantinea can be appreciated. Elliptical fortification walls approximately 4 km in circumference were built from limestone foundations that supported a mudbrick superstructure. Projecting square bastions were set at regular intervals to provide added protection. The walls were pierced by a minimum of seven gates. Today, the walls and gates are in a remarkable state of preservation, and they constitute an exceptional illustration of a near-complete defensive circuit on the Greek mainland. As a result, the urban boundaries of Mantinea are well defined. The French excavators estimated the area of the intramural city to be approximately 1.24 km<sup>2</sup> (124 ha).<sup>20</sup> The

agora stood effectively at the center along with various public and religious buildings. Nearby, the theater was built from an artificial earthen mound. Apart from these elements, which form the archaeological site today, very little of the settlement has been studied. Excavations by the Archaeological Ephorate of Arkadia have uncovered minimal evidence for domestic structures and roads around the city.<sup>21</sup> A geophysical survey was conducted by the University of Patras from 1988 to 1991, northwest of the theater (online fig. 4).<sup>22</sup> Even though the survey was limited to 1 ha, it did identify a few streets arranged at right angles together with buildings. Recently, a large geophysical survey (31 ha) was undertaken in 2014 by the authors and a team of researchers at the Laboratory of Geophysical, Satellite Remote Sensing and Archaeoenvironment of the

the exterior of the fortification walls in GIS from the satellite imagery, are comparable (1.19 km<sup>2</sup>, or 119 ha).

<sup>19</sup>Karagiorga 1963, 1965; Dimakopoulou 1967 (cleaning of theater and agora); Steinhauer 1979 (trial trenches southwest of agora). The Archaeological Ephorate of Arkadia was formerly known as the 7th and 39th Ephorate of Prehistoric and Classical Antiquities.

<sup>22</sup>Sarris (1992, 193–280) offers the most extensive commentary. For shorter reports, see Papamarinopoulos 1991, 1992, 1993.

<sup>19</sup> Fougères (1898) is the main publication of the 19th-century French excavations. For preliminary reports, see Fougères 1887, 1890a, 1890b, 1896.

<sup>20</sup> Fougères 1898, 139–40. Our measurements, taken from



FIG. 4. Mantinea from a WorldView-2 image taken 11 September 2013 (© DigitalGlobe, Inc.; all rights reserved).

Institute for Mediterranean Studies, Foundation for Research and Technology, Hellas (I.M.S.-F.O.R.T.H.). These results are currently being analyzed and are slated to be presented in a future publication.

#### *Results from Satellite Remote Sensing*

Satellite remote sensing at Mantinea has revealed almost 100 linear surface anomalies inside the forti-

fication walls (fig. 6; online figs. 5, 6). They range in length from 51 m (anomaly 33) to as much as 688 m (anomaly 66).<sup>23</sup> Although we detected a handful of diagonal anomalies, the majority of linear anomalies

<sup>23</sup> Linear anomalies less than 50 m in length were excluded from our study.

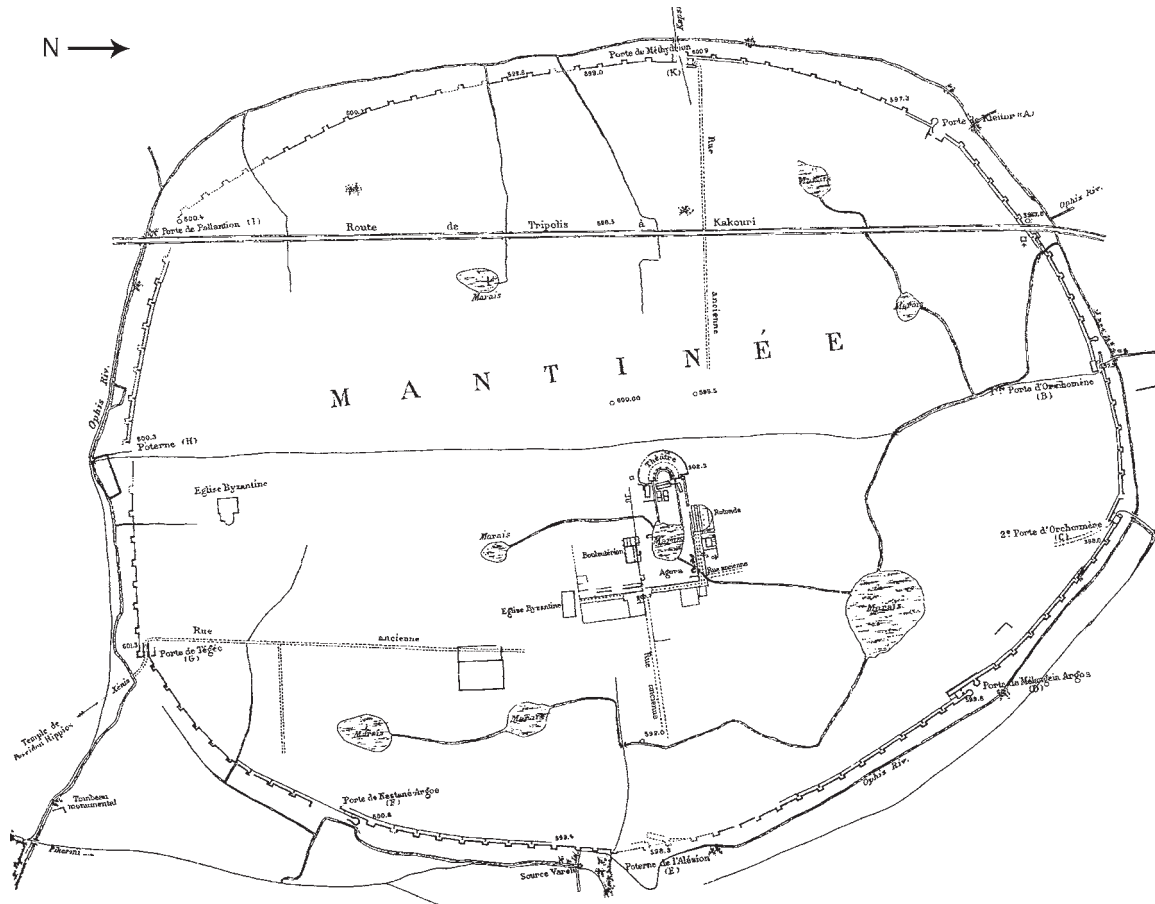


FIG. 5. Mantinea as published in Fougères 1898, pl. 8. Note that the buildings in the agora are oriented at magnetic north, unlike the rest of the urban features at true geodetic north.

are oriented near the cardinal points. To be more precise, the average orientation of north–south anomalies is  $-0.6^\circ$  west of true north, and the average orientation of east–west anomalies is  $89.6^\circ$ .<sup>24</sup> Because of the inherent constraints in interpreting and measuring surface anomalies in satellite imagery, these orientations should be considered approximations rather than fixed values. Nevertheless, the data demonstrate that surface anomalies at Mantinea cluster around the cardinal points and are orientated at perpendicular angles. This trend of uniform alignments is similar to that seen in above-surface buildings and venues within the city, most notably the agora. In addition, modern agricultural field boundaries at Mantinea align closely with the cardinal points, unlike field boundaries outside the fortification walls (see fig. 4; online fig. 3). As

documented elsewhere, it is not uncommon for modern field boundaries to retain the basic arrangement of an ancient system of land organization, even though millennia have passed.<sup>25</sup>

Supplementing feature detection within the city, remote sensing has clarified the position of city gates. The exact number of gates at Mantinea has been uncertain since the 19th century. The French excavators proposed reconstructing the city with 10 gates, even though there was sparse evidence for three of them (see fig. 5).<sup>26</sup> Gate E to the east and Gates H and I on the southern side of the city had little surviving architecture above ground. While we did not find definitive proof for these gates, the organization of linear anomalies

<sup>24</sup> These calculations exclude the four diagonal anomalies (1, 7, 15, 81) and an anomaly with a curved trajectory (41).

<sup>25</sup> Clavel-Lévêque 1983; Carter 2006; Smekalova and Smekalov 2006.

<sup>26</sup> Fougères 1898, 140–61.



FIG. 6. Surface anomalies at Mantinea identified from remote sensing. Numbers indicate surface anomalies, and letters A–K mark the location of gates (includes copyrighted material of DigitalGlobe, Inc.; all rights reserved).

near the fortification walls suggests the presence of roads leading into and out of the city.

*North–South Anomalies.* Linear anomalies with north–south orientations are distinct features of the urban environment at Mantinea identified from remote sensing. Many appear as vivid crop marks in true-color RGB and false-color band combinations, while

feature enhancement indices often intensify the details (see fig. 3). The central regions south and north of the agora best represent this phenomenon.

South of the agora there is compelling evidence for four parallel anomalies (66, 71–72, 74) of prolonged dimensions spaced at regular intervals (figs. 7, 8). Anomaly 66 extends from the fortification walls all

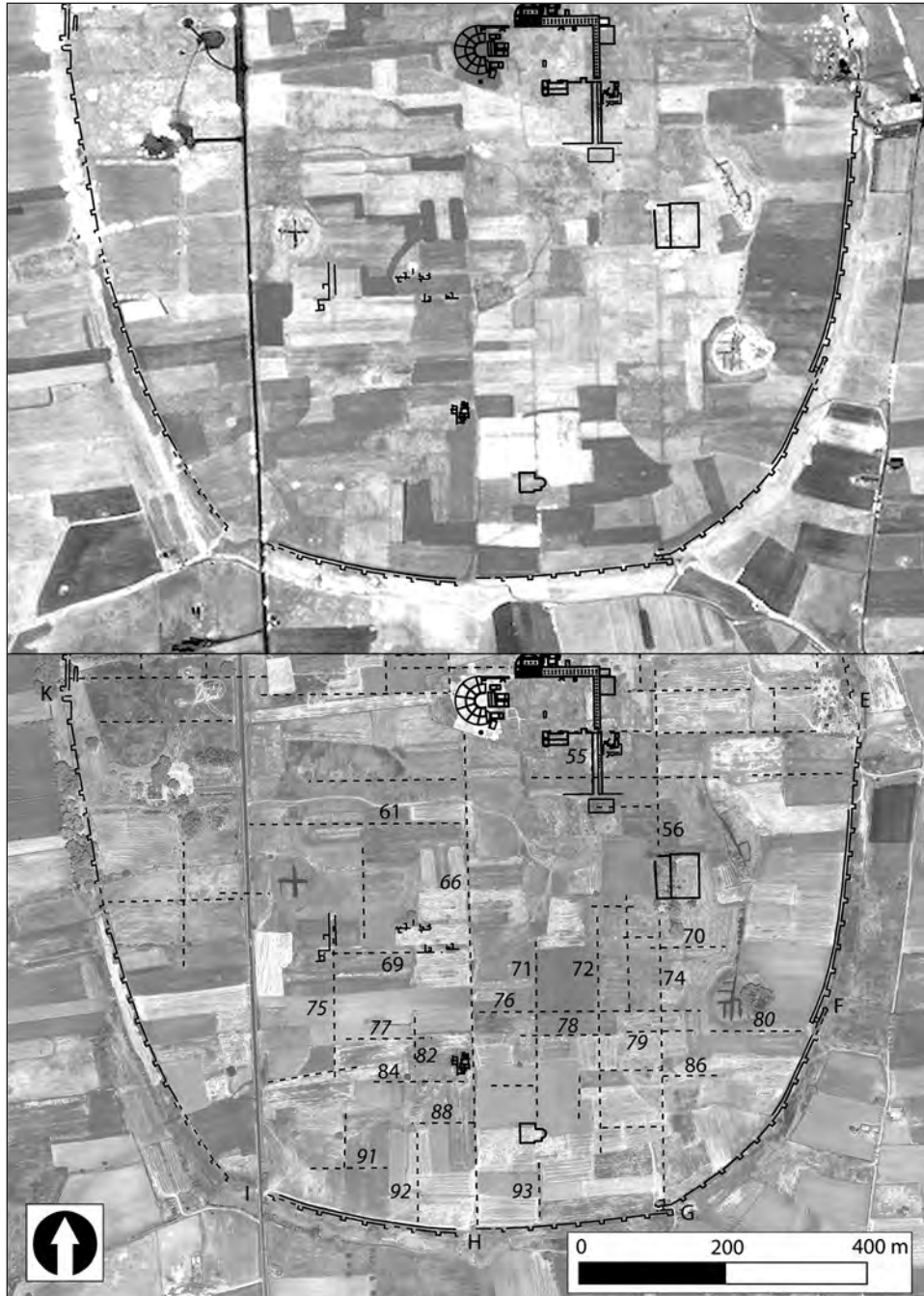


FIG. 7. The southern region of Mantinea from a QuickBird image taken 10 June 2009: *top*, with square root of infrared/red (SQRT IR/R) feature enhancement applied; *bottom*, with anomalies marked by numbers. Anomalies in italics are not easily viewable in this feature enhancement. Letters mark the location of gates (includes copyrighted material of DigitalGlobe, Inc.; all rights reserved).

the way to the theater. At 688 m in total length, it is the longest linear anomaly that we have identified at Mantinea. The point where 66 originates at the fortification walls is where the 1898 French plan situates Gate H. Today the walls are damaged in this area, and there are no architectural remains of the putative gate. Anomaly

71 stretches for 256 m from the remains of a Byzantine church until its course eventually disappears northward. South of the church, anomaly 93 picks up the same trajectory, continuing 88 m to the fortification walls. Anomaly 72 constitutes another north-south feature and is discernible for 336 m. It begins 100 m

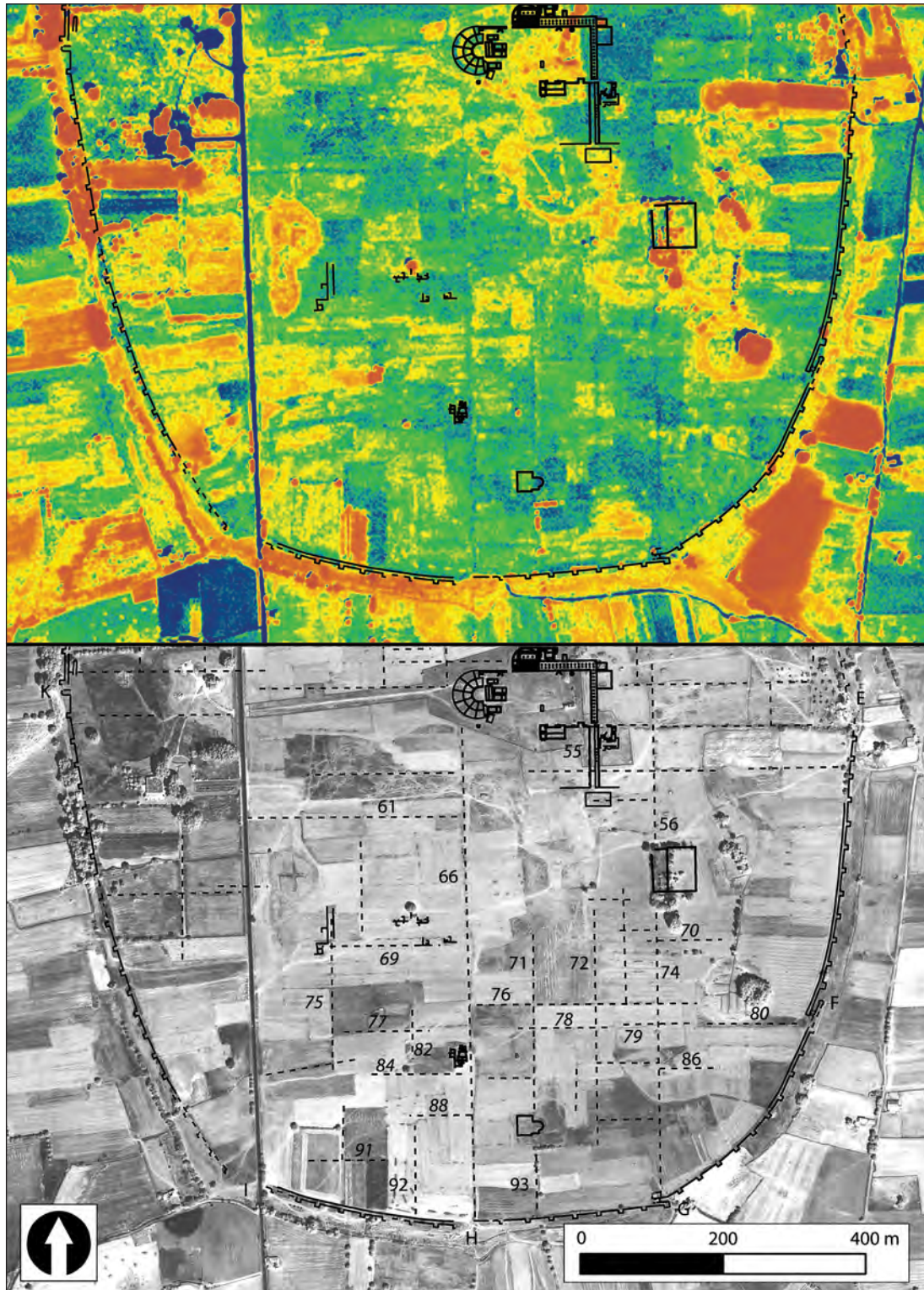


FIG. 8. The southern region of Mantinea from a QuickBird image taken 13 September 2003: *top*, with green normalized difference vegetation index (NDVI) feature enhancement applied; *bottom*, with anomalies marked by numbers. Anomalies in italics are not easily viewable in this feature enhancement. Letters mark the location of gates (includes copyrighted material of DigitalGlobe, Inc.; all rights reserved).

from the fortification walls and continues northward until it is no longer visible, near the same terminus as 71. Farther north, anomaly 55 appears to be a northern extension of 72. We recorded its extent for 84 m to the point where it stops, at the southeastern corner of the agora. The French excavators discovered a colonnaded street leading to the agora in the same location as 55. Although the street has since been reburied by flooding activity, 55 is likely associated with the remains excavated 125 years ago. Anomaly 74, the final in the sequence of four anomalies, originates at Gate G and extends for 405 m before terminating at a large structure thought to be from the Ottoman period. The feature then reappears north of the building as anomaly 56, where we traced its trajectory for another 260 m to its end east of the agora.

In addition to their extent and relative ease of detection, the four long anomalies south of the agora raise attention because of their uniform arrangement. Measured as accurately as possible from the center of each one, the distance separating the anomalies ranges between 87 and 90 m (table 3). This is a nominal margin considering that the widths of the linear features may be incomplete in the satellite imagery and that the resolution quality of the multispectral bands used to create most feature enhancement indices is between 1.90 and 2.65 m.

Two additional north–south anomalies are of interest in the southwestern region of the city. Anomaly 92 extends 125 m from the fortification walls west of Gate H to the north. After a brief pause, its northern course appears again as anomaly 82 for another 75 m. Farther west, anomaly 75 extends for 224 m to the north. Its course passes a Roman domestic complex excavated in the 1970s.<sup>27</sup> The excavations also unearthed a paved north–south street approximately 50 m in length and in the same location as 75. The distance between these additional anomalies diverges from the 87–90 m range of the other north–south anomalies south of the agora. The interval between anomalies 82/92 and 66 measures 80–83 m, while anomaly 75 is 112 m from anomaly 82/92 and 190–194 m from anomaly 66; therefore, their spacings are offset by 10–20 m compared with the other group.

Extended north–south groupings of linear anomalies are also a distinctive feature of the northern region of Mantinea (figs. 9, 10). Anomaly 12 is one of the

longest recorded features in the city. Easily viewable in several combinations of feature enhancement indices from different extraction dates, it is preserved unbroken for 464 m. Although evidence for this anomaly falls 100 m short of Gate B, its course probably extends all the way to the fortification walls. Imagery from a different extraction date might provide proof. At any rate, 12 carries on southward until terminating west of the theater. East and parallel to 12 there is a broken but no less clear north–south grouping of three related anomalies (6, 20, 43) that are discernible in various feature enhancement indices. Combined, their total preserved length is 288 m. This group originates from the northern region of the city and ends at the back of the theater. Sections of what appear to be the same north–south features as 12 and 43 were identified in the 1988–1991 geophysical survey (online fig. 7). The surveyors concluded that these features were likely subsurface streets with sidewalks.<sup>28</sup>

Farther east, anomalies 5 and 25 belong to the same feature and measure 288 m and 123 m in length, respectively. The vegetation stress related to 5 appears as vivid crop marks in RGB band combinations in the satellite imagery,<sup>29</sup> while feature enhancement indices bring the details out even more. The northern terminus of 5 stops 30 m before the fortification walls near Gate C. On its southern side, the evidence for 5 stops as it approaches one of the seasonal marshes that pocket the site today, only to reappear south of the marsh as 25. An extension of the trajectory of 25 southward would place it at the northwestern corner of the agora, west of a hypostyle hall (later converted into a Roman odeum) that some identify as the bouleterion.<sup>30</sup> We traced the paths of two shorter parallel north–south linear anomalies farther east. Anomaly 26 extends from just beyond the northeastern corner of

<sup>28</sup> Sarris (1992, 206, 213–16) identifies subsurface features 1 and 9, which correspond to our linear anomalies 12 and 43, as two parallel north–south streets. Feature 1 measured 80 m in length and 3 m wide and had at least one sidewalk. Since it appeared at the southeastern edge of the survey area, the evidence for feature 9 was more limited. However, enough data were extracted to show that the width of the feature was similar to that of feature 1.

<sup>29</sup> See, e.g., the historical imagery database of Mantinea in Google Earth (coordinates 37°37'0.86" N, 22°23'31.92" E), where the signature for anomaly 5 is distinct.

<sup>30</sup> Winter 1987, 239–44.

<sup>27</sup> Steinhauer 1979.

TABLE 3. Distance in meters between north–south anomalies in the southern region of Mantinea.

Anomaly	55	56	66	71	72	74	Average
55	–	90–91	177–178	–	–	–	89–90
56	90–91	–	267–268	–	–	–	89–90
66	177–178	267–268	–	87–92	175–179	262–266	88–89
71	–	–	87–92	–	86–88	173–174	87–89
72	–	–	175–179	86–88	–	87	87–89
74	–	–	262–266	173–174	87	–	87–88

the agora to the north for 120 m. The other example, anomaly 45, begins directly east of the agora and goes northward for 222 m before its trajectory is lost in the seasonal marsh. Beyond the central regions, there is little evidence for other clusters of north–south linear anomalies. One exception is anomaly 18, a feature that originates at Gate A and terminates 313 m to the south (online fig. 8). In this example, there is yet another indication of a north–south anomaly ending near a city gate (cf. Gates B, C, G, and H).

As in the southern region of Mantinea, the uniform spacing of north–south linear anomalies north of the agora is distinctive, ranging on average between 88 and 90 m (table 4). In certain cases, there is greater fluctuation between anomalies. So, for example, the distance between anomalies 12 and 6/20/43 varies between 83 and 90 m, while the range between anomalies 6/20/43 and 5/25 is 88–94 m. This fluctuation is largely attributed to anomaly 20, which is located a few meters farther to the west than 6 and 43. Although not included in table 4, anomalies 18 and 36 are separated by a distance of 90–91 m and follow the general trend of uniform spacing (see fig. 6). Overall, the 88–90 m range of major north–south anomalies north of the agora closely follows the 87–90 m spacing of north–south anomalies south of the agora.

It is curious how features in the southern region of the city do not extend to the northern region and vice versa (online fig. 9). This is the case despite the great length, often in the hundreds of meters, of numerous anomalies. We found no traces of the four elongated features in the south with the same paths anywhere in the north. Likewise, the prolonged and evenly spaced features in the north are absent in the south. The central zone of the city between Gates K and E, including the agora, appears to have been a division line. Where there is a break in the north–south course of a feature, another feature on the opposite side of the city contin-

ues the course with a deviation of 20–25 m. Anomalies 45 and 56 east of the agora and 43 and 66 west of the theater best represent this trend because of the close proximity of their endpoints (see fig. 6). But it is also manifest in the (reconstructed) paths of north–south anomalies that roughly align with one another, such as anomalies 5/25 and 71 and anomalies 26 and 72. Recognizing that the evidence is incomplete, we are inclined to see in these examples a shift in the position of north–south features once they reach the agora. The only feature that advances beyond the central region is anomaly 56, and it does so for only 37 m.

*East–West Anomalies.* East–west linear anomalies are abundant in the satellite and aerial data sets. In terms of total count, remote sensing identified more east–west linear anomalies (n=59) than north–south anomalies (n=30). In terms of size, 28 east–west anomalies measure more than 100 m in length compared with 19 north–south anomalies in the same class. Still, the east–west anomalies tend to be shorter (118 m) on average compared with the north–south anomalies (181 m), because the latter group has several features in excess of 300 m. The arrangement and organization of east–west anomalies are of interest, since many intersect the north–south anomalies at perpendicular angles. We also detected a sequence of regular intervals between many of them. The frequency and pattern of regularly spaced east–west anomalies is not confined to the central regions of the city; these anomalies are dispersed throughout Mantinea.

The city's northern district illustrates the prevalence of groupings of east–west anomalies (see figs. 9, 10). Here, we identified anomalies 9, 11, and 14 as three features that are evenly spaced from one another. To this group we might also include anomalies 10 and 13, both candidates for the western extensions of 11 and 14 near Gate A. The preserved length of these anomalies, which does not exceed 110 m for any given one,





FIG. 9. The northern region of Mantinea from a QuickBird image taken 3 June 2012: *top*, with infrared/red (IR/R) feature enhancement applied; *bottom*, with anomalies marked by numbers. Anomalies in italics are not easily viewable in this feature enhancement. Letters mark the location of gates (includes copyrighted material of DigitalGlobe, Inc.; all rights reserved).

is not as striking as their regularity of placement and their clarity in the feature enhancement indices. The most reliable measurement comes from 9 and 11, the only two anomalies in this area that are side by side. The distance separating these two anomalies is 60 m.

A reconstruction of the projected trajectory of 14 provides a similar distance of 57 m between 11 and 14. No traces of these features were noted on the eastern side of the city. Farther north, the evidence for anomalies 2, 3, and 4 is no less clear, and they intersect anomaly

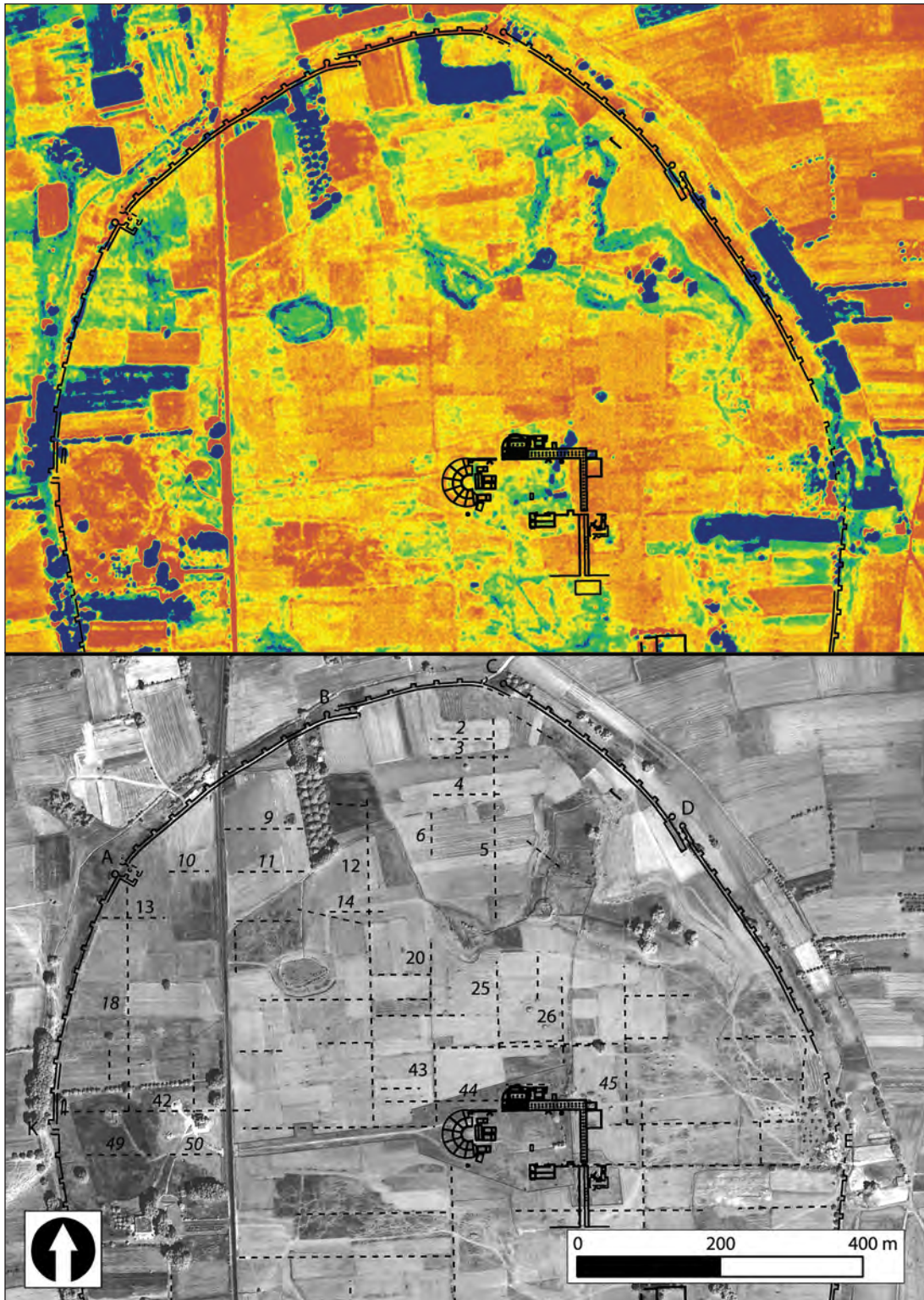


FIG. 10. The northern region of Mantinea from a QuickBird image taken 13 September 2003: *top*, with weighted difference vegetation index (WDVI) feature enhancement applied; *bottom*, with anomalies marked by numbers. Anomalies in italics are not easily viewable in this feature enhancement. Letters mark the location of gates (includes copyrighted material of DigitalGlobe, Inc.; all rights reserved).

TABLE 4. Distance in meters between north–south anomalies in the northern region of Mantinea.

Anomaly	12	6/20/43	5/25	26	45	Average
12	–	83–90	177–178	268	355–356	88–89
6/20/43	83–90	–	88–94	180–184	268–272	88–91
5/25	177–178	88–94	–	90	178	89–90
26	268	180–184	90	–	87–88	89–90
45	355–356	268–272	178	87–88	–	89

5 at right angles. Yet the intervals between them are different: 2 and 3 are separated by 26–27 m, and 3 and 4 are 52 m apart.

The region east of the agora further demonstrates that there is an organized system of east–west anomalies at the site (fig. 11). So far, we have identified six groupings of parallel anomalies separated on average by a small range of 59–60 m. These are anomalies 23, 32/33/34, 40, 47/48, 52/53, and 58/59 (table 5). The trajectory of many of these groupings synchronizes with that of other anomalies north and west of the agora. North of the agora, this includes anomalies 21 and 22 (aligned with 23), 28 (aligned with 32/33/34), and 39 (aligned with 40). Anomaly 22 is in approximate alignment with the subsurface feature identified as an east–west street in the 1988–1991 geophysical survey (see online fig. 7).<sup>31</sup> A cluster of east–west anomalies with a similar orientation, 37/29/31, is situated 6–10 m south of 28/32/33/34 (see fig. 6). It is possible, but not certain, that they are related yet slightly deviating features.

West of the agora, anomaly 46 continues the trajectory of 47/48. If these features are related, then their arrangement in the city could be significant. The western extension of 46/47/48 stretches toward Gate K, and its eastern extension ends at the now-destroyed Gate E. In this grouping, there is a direct line of communication between two gates with the agora at the center. Anomaly 51, located 5 m north of anomaly 52/53, is another curious feature. The 1898 French plan of Mantinea notes the presence of a street, now no longer visible above ground, which leads into the agora from Gate E (see fig. 5). We suspect that 51/52/53 is the same feature. Before entering the southeastern

corner of the agora, 51 passes north of a Roman bath. Once inside the agora, its path aligns with the northern stylobate of a small stoa with projecting wings that is sometimes identified as the bouleterion.<sup>32</sup> At any rate, the minor deviation in position between 51 and 52/53 may indicate a divergence in the trajectory of this feature. Beyond the agora to the southwest, anomaly 57 looks to mark the western course of 58/59, while still farther 61 is an extended anomaly separated from 57 by 59–61 m.

Additional east–west anomalies raise interest around the agora, despite the uncertain relationship with the usual sequence of east–west features in this region of the city. Anomalies 42 and 49/50 are two parallel anomalies close to Gate K, measuring 277 m and a combined 168 m, respectively (see figs. 9, 10). They are separated by 61 m, which by now should be recognized as a common interval between east–west anomalies at Mantinea.<sup>33</sup> No traces of these features have been identified on the other side of the agora, although anomaly 44 northwest of the agora may plausibly be related to 42. It is peculiar that 42 and 49/50 are not evenly spaced with the regular sequence of east–west anomalies, but they are positioned exactly in the middle.

It is more difficult to categorize the organization of east–west anomalies in the southern region of Mantinea, because surface features tend to be varied in the feature enhancement indices (see figs. 7, 8). Anomalies 69 and 70 appear to be from the same feature, and their extent can be traced for a combined 273 m. We note

<sup>32</sup> Winter 1987, 239–44.

<sup>33</sup> An east–west linear anomaly appears north of anomaly 42 (see fig. 9), but it was not included in our analysis since its length falls below the 50 m threshold. It is separated from anomaly 42 by 59–60 m.

<sup>31</sup> Sarris (1992, 206, 213) identifies subsurface feature 23, which corresponds to our linear anomaly 22, as an east–west street.



FIG. 11. The central and eastern regions of Mantinea from a QuickBird image taken 10 June 2009: *top*, with modified soil-adjusted vegetation index (MSAVI) feature enhancement applied; *bottom*, with anomalies marked by numbers. Anomalies in *italics* are not easily viewable in this feature enhancement. Letters mark the location of gates (includes copyrighted material of DigitalGlobe, Inc.; all rights reserved).

that the combined anomaly is 180 m south of 61; this distance is an even multiple of the common spacing (59–60 m) encountered in the majority of east–west anomalies. Farther south, anomalies 77 and 78 are associated features in line with Gate F. It is possible that

anomalies 79 and 80 should be included in this group, since their position is only a few meters to the north. Even farther south, there is a series of modest east–west anomalies with intervals that range between 58 and 61 m. These include 84/86, 88, and 91. At 319 m,

TABLE 5. Distance in meters between east–west anomalies east of the agora at Mantinea.

Anomaly	23	32/33/34	40	47/48	52/53	58/59	Average
23	–	59	–	179–180	239	300–301	60
32/33/34	59	–	57–60	118–120	177–180	238–240	59–60
40	–	57–60	–	59–60	119–121	179–181	59–60
47/48	179–180	118–120	59–60	–	59–60	120–122	59–60
52/53	239	177–180	119–121	59–60	–	60–62	59–60
58/59	300–301	238–240	179–181	120–122	60–62	–	60

one of the longest east–west anomalies in this region of Mantinea is 76; however, we cannot find any obvious relationship with other features in the area.

*Diagonal Anomalies.* Very few linear anomalies diverge from the prevalent north–south and east–west axes. Nonetheless, there are some interesting observations to be made regarding the position and alignment of these scarce features. One diagonal anomaly (15) appears in the northwestern region of the city. It has a northwestern–southeastern orientation that slants down toward the east for 95 m. A continuation of its northwestern trajectory leads straight to Gate A (online fig. 10). This gate is the only preserved gate at Mantinea that provided direct access into the city; other gates approached the city from an oblique angle.<sup>34</sup> We are tempted to see here a connection between the location and orientation of Gate A and anomaly 15, although the exact nature of this connection cannot be determined at this point.

#### *Urban Organization of Space*

The majority of linear anomalies appear to define a subsurface system of organized streets at Mantinea. Their frequency, ordered arrangement, and metrology are too coincidental for us to presume otherwise. Many are spaced at regular intervals and join at right angles. In certain cases, groups of linear anomalies begin to form the outlines of long rectangles, which we presume to be from city blocks. So far, however, we have been unable to detect a complete example. A repeated pattern that emerges is a system of north–south anomalies spaced between 87 and 91 m and east–west anomalies spaced between 59 and 60 m. From the 93 linear anomalies that we have identified at Mantinea, the majority (n=48) fall within 2.5 m of this range. Expanding the margin of error to include anomalies that

fall within 5 m of this range, such as 79 and 80, which are likely related to 78, the total count (n=54) increases to nearly 60% of all linear anomalies.

Many anomalies appear to correlate with the location of streets identified in previous fieldwork. Prior to satellite remote sensing, archaeological excavations and the 1988–1991 geophysical survey found limited evidence for streets at Mantinea. The 19th-century French excavators discovered small sections of paved roads leading into the city from gates, as well as hard-packed dirt roads in close proximity to the agora.<sup>35</sup> One road originating from Gate K was found to extend 400 m toward the agora, while another originating at the agora's southeastern corner headed 200 m toward Gate E. The most extensive road the excavators found began at Gate G and carried on 500 m to the north. Brief mention of the roads appeared in the 1898 monograph, and the only indication for their location came from the published city plan (see fig. 5). Today, these roads (assuming they were correctly identified as such) are no longer visible. In the 1970s, the Archaeological Ephorate of Arkadia excavated the remains of a 46 m long road constructed from packed dirt in the southwestern region of Mantinea.<sup>36</sup> The road was bordered to the west by three domestic structures dating to the second and third centuries C.E. Two parallel stone curbs 8.10 m apart defined the combined width of the road and sidewalks. The excavators estimated the width of the road to be approximately 5 m. Another series of roads were identified during the 1988–1991 geophysical survey northwest of the theater. Electrical ground resistance found evidence for two parallel north–south roads intersected at right angles by two or more east–west roads.<sup>37</sup>

<sup>35</sup> Fougères 1898, 163–64.

<sup>36</sup> Steinhauer 1979, 296–98.

<sup>37</sup> Sarris 1992, 193–280.

<sup>34</sup> Fougères 1898, 153.

All the streets identified through previous archaeological excavations and the 1988–1991 geophysical survey correspond to linear anomalies that we have discovered through remote sensing. Anomaly 56/74 marks the location of the extensive street that the French excavators identified running north from Gate G. On the 1898 plan, a shorter east–west street bisects this street southwest of Gate F. The smaller street overlaps with anomaly 86 and aligns with 84. Farther west, anomaly 75 overlies and extends the trajectory of the street excavated in the 1970s near the Roman-period structures. Closer to the agora, anomaly 51/52/53 corresponds to the east–west street that exited the southeastern corner of the agora and continued toward Gate E. Two other streets identified around the agora match the trajectory of linear anomalies. The colonnaded north–south street departing the southeastern corner of the agora overlaps with anomaly 55 and is aligned with 72. A second north–south street that the 1898 plan shows leaving the northeastern corner of the agora may correspond with anomaly 26, although this street appears to be positioned a bit farther east than the linear anomaly. Perhaps the clearest example of a linear anomaly betraying the presence of a probable street is anomaly 12, which overlaps the street identified in the 1988–1991 geophysical survey (see online fig. 7). The same survey shows that anomaly 6/20/43 joins the smaller north–south street, while 21/22/23 and 28/32/34 match the two east–west streets.

There is a correspondence between the placement of linear anomalies and the location of city gates, implying that Mantinea had a highly organized system for the circulation of traffic (see fig. 6; online fig. 11). Several anomalies originating near the city gates lead straight to the agora and theater at the heart of the urban center. Anomalies 12 and 5/25 provide access from the two northernmost gates, Gates B and C. On the southern side, anomalies 66 and 56/74 serve the same function by linking Gates H and G with the city center. In particular, anomaly 66 lends support for reconstructing Gate H in this section of the fortification walls. Flanking the agora, anomalies 46 and 51/52/53 provide a straight line from Gate K and Gate E to the agora, respectively. It is also possible that anomaly 42/44 plays some role in the communication of Gate K with the agora, but its placement is more difficult to assess. What we see from these examples is that six of the putative 10 gates at Mantinea have a direct line of communication with the center of the city. The remaining gates (A, D, F, I) are aligned with anomalies as well, but not those that go to the agora. Anomalies

10/11 and 18 head to Gate A from the east and south, while the still-hypothetical eastern extension of 11 joins with Gate D. Likewise, anomaly 77/78/79/80 communicates with Gate F, and 91 falls in the vicinity of the now-destroyed Gate I. In this context, we also draw attention to 7 and 15, two diagonal anomalies whose courses project toward Gate B and Gate A. It is not possible to advocate the presence of diagonal streets communicating with gates at this time, but it is a hypothesis that should be explored in future fieldwork.

A partial reconstruction of the urban street system of Mantinea is possible from remote sensing with the realization that future ground truthing and remote sensing may alter the picture to some extent (fig. 12). The sequence of regularly spaced anomalies and those that overlap with known streets identified from previous fieldwork are the best indicators of the general organization of space in the city. Our reconstruction is based on a uniform distribution of north–south and east–west streets spaced 89 m and 60 m from one another, respectively. These are median values within the familiar 87–91 m range of north–south anomalies and 59–60 m range of east–west anomalies. For all streets, we applied directional orientations of  $-0.8^\circ$  and  $89.2^\circ$  based on the average alignments of certain (and extensive) linear anomalies that are clear in the satellite data sets.<sup>38</sup> The interval spacing and orientation values are meant to be estimates of the urban structure of streets at Mantinea, and they provide a picture of an idealized system without regard to the variations that are inherent in ancient city planning.<sup>39</sup> Solid black lines on figure 12 indicate coverage from anomalies within 2.5 m of the spacing of 89 m and 60 m, while dotted black lines show the possible but still theoretical extension of the same streets. Preferring to be conservative, we reconstruct streets only where linear anomalies have more than 100 m of coverage.<sup>40</sup>

The central zone of Mantinea, as reconstructed, is defined by a series of extended north–south streets, five in the north (N1–5) and four in the south (S1–4).

<sup>38</sup> The directional orientations applied to the plan by averaging a select number of anomalies differ slightly from the cumulative average orientations of all anomalies by a few tenths of a degree:  $-0.8^\circ$  and  $89.2^\circ$  compared with  $-0.6^\circ$  and  $89.6^\circ$ .

<sup>39</sup> Konecny et al. (2012) demonstrate the fluctuations in street widths and orientations in Greek city planning from a geophysical survey at Plataiai in Boeotia.

<sup>40</sup> For this reason, we do not reconstruct streets around some anomalies (e.g., 67, 88, 90) even though they are within the parameters.

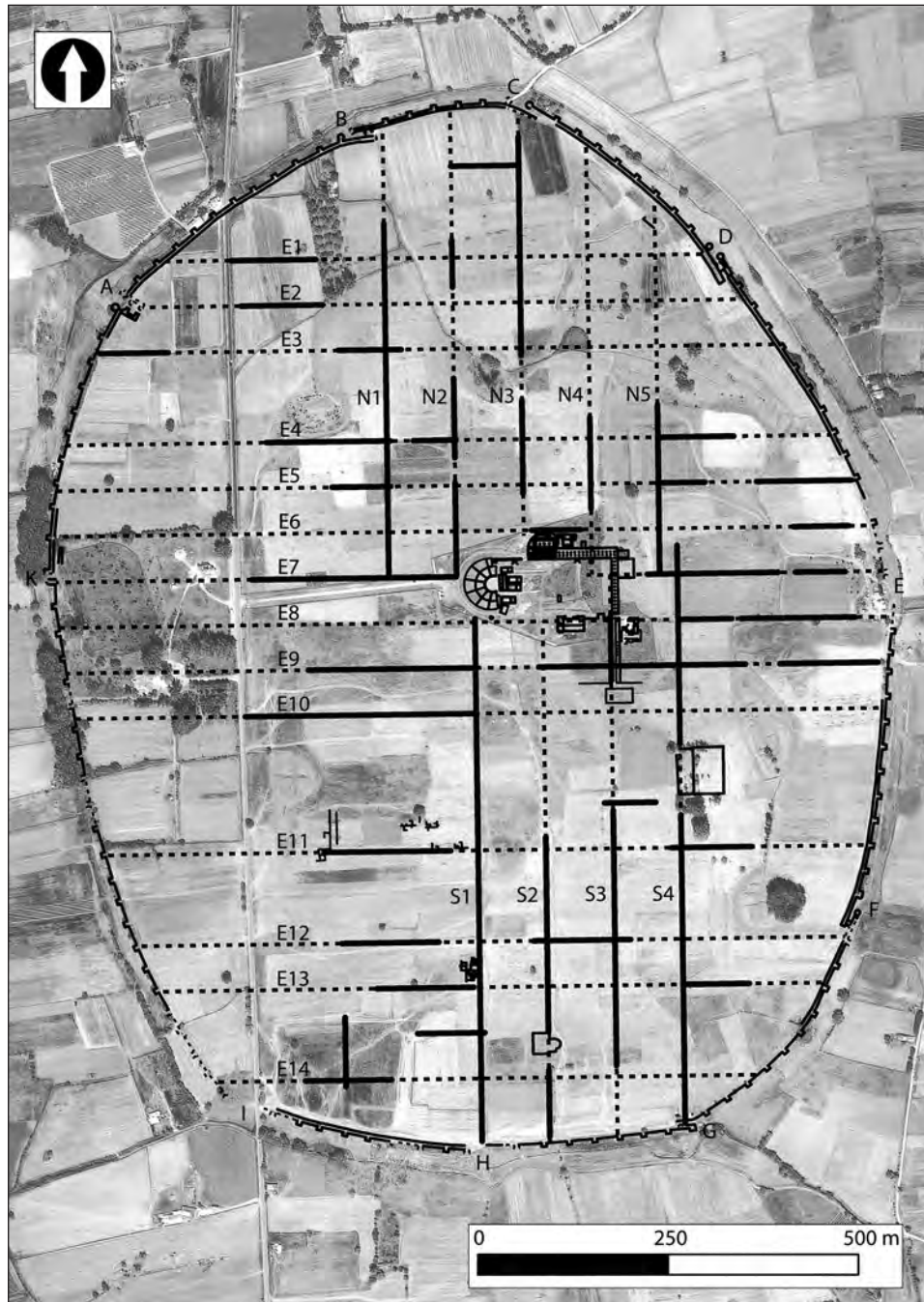


FIG. 12. A partial reconstruction of the orthogonal street system at Mantinea based on a system of north-south streets with 89 m intervals and east-west streets with 60 m intervals. North-south streets are marked as N1–5 and S1–4, and east-west streets are marked as E1–14. Letters mark the location of gates. Solid black lines indicate coverage from anomalies within 2.5 m of the spacing sequence of 89 m for north-south streets and 60 m for east-west streets; dotted black lines show the possible but still theoretical extension of the same streets (includes copyrighted material of DigitalGlobe, Inc.; all rights reserved).

The length of the thoroughfares varies between 500 and 800 m depending on where they begin inside the fortification walls and where they end near the agora (table 6). On average, about two-thirds of the street lengths (62%) are verified by linear anomalies,

while one street (S1) has full coverage. Although the alignments of the streets are the same, the four in the southern zone are positioned 23 m farther east. We suspect that the reason for the shift was to optimize the communication between city gates and the agora. The

TABLE 6. Characteristics of north–south streets at Mantinea.

Street	Anomaly	Anomaly Length (m)	Projected Street Length (m)	Coverage
N1	12	464	594	78%
N2	6, 20, 43	288	615	47%
N3	5, 25	411	550	75%
N4	26	120	507	24%
N5	45	222	494	45%
S1	66	688	688	100%
S2	71, 93	344	686	50%
S3	55, 72	420	799	53%
S4	56, 74	665	771	86%
	Average	402	634	62%

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 thoroughfares, we reconstruct a string of 14 east–west streets (E1–14) that are dispersed throughout Mantinea (table 7). The length of east–west streets varies between 700 and 1,100 m. On average, about one-quarter of the street lengths (27%) are verified by linear anomalies. The highest concentration of coverage (57%) comes from Streets E7 and E9 around the agora. While we believe there to be a good degree of certainty in the reconstruction of Streets E1–14, the lack of extensive coverage (and confirmation) by anomalies leaves doubt whether the courses of E1–14 should extend uniformly across the city. In particular, there are large gaps in the southwestern and northeastern regions of Mantinea. As reconstructed here, the streets form rectangular city blocks that measure 5,340 m<sup>2</sup>. Again, we emphasize that remote sensing has yet to identify a complete example of a city block. There are instances of three sides of a rectangle from adjoining linear anomalies (e.g., 52, 56, 58), but not all four.

One striking curiosity of our reconstruction is that there is no evidence of uniform north–south streets extending to the western and eastern sides of the city. It is entirely possible that this can be attributed to the inherent chance discoveries in remote sensing; however, we are inclined to suspect, based on the available evidence, that different spacings were applied in the arrangement of north–south streets at the city’s periphery. Anomaly 18 probably betrays the presence of a subsurface street

linked to Gate A (see online fig. 8). It is separated from 36, a parallel anomaly to the east, by 91 m. This distance falls within the 87–91 m range of north–south streets in the central region of Mantinea; however, the interval between anomalies 36 and 12 is 251 m. Assuming that two streets existed between the parallel features, the average width here contracts to 83 m. We note a similar occurrence with anomaly 75, which overlaps with an excavated street. The distance separating 75 from 66 is 190–194 m, which increases the average width to 96 m, assuming that one street stood between. Nearby, anomalies 82/92 and 66 are separated by 80–83 m. What we observe, then, is greater diversity in the spacing of north–south anomalies at the periphery. The evidence at present is too sparse for us to commit to a particular reconstruction, beyond stating the likelihood of a different spacing sequence somewhere in the western (and possibly eastern) region, maybe to accommodate the movement of people within the elliptical fortification walls and the location of gates.

Other points of interest are east–west anomalies that do not fit into our reconstruction. Near Gate K, anomalies 42 and 49/50 are separated by 61 m, but they are positioned in the middle of the orthogonal street system as reconstructed. Is this evidence for a modification to the street system? Elsewhere, anomalies 62 and 76 have no apparent relation with other east–west streets, while anomalies 3 and 4 at the northern edge of the city are separated by 52 m. If some of these east–west anomalies betray the presence of subsurface streets, regional variations to the orthogonal street system at Mantinea may be a real possibility. These variations may either be



TABLE 7. Characteristics of east–west streets at Mantinea.

Street	Anomaly	Anomaly Length (m)	Projected Street Length (m)	Coverage
E1	9	111	703	16%
E2	11	108	789	14%
E3	13, 14	173	893	19%
E4	21, 22, 23	318	1,004	32%
E5	28, 32, 33, 34	276	1,051	26%
E6	39, 40	138	1,076	13%
E7	46, 47, 48	507	886	57%
E8	52, 53	223	1,096	20%
E9	57, 58, 59	614	1,080	57%
E10	61	304	1,061	29%
E11	69, 70	273	1,005	27%
E12	77, 78	255	930	27%
E13	84, 86	213	874	24%
E14	91	113	713	16%
	Average	259	940	27%

contemporary with the reconstruction proposed here or date to a different period in the city's history.

Considering the various political upheavals that the city experienced before the Roman period, it is possible that Mantinea underwent different phases of city planning. After the initial foundation of Mantinea, the city suffered two major military defeats that severely damaged the urban environment. The Spartans razed the city and expelled the population in 385 B.C.E., and the Macedonians laid waste to the city a century and a half later. In both cases, Mantinea was rebuilt, but the ancient sources do not elaborate on the extent and nature of reconstruction. In describing the refoundation of Mantinea in 370 B.C.E., Xenophon (*Hell.* 6.5.3–5) mentions that the city walls were quickly rebuilt with the help of Elis and other city-states. He also states that the Mantineans redirected the course of the Ophis River around the fortification walls rather than let it pass through the city and leave themselves vulnerable to another Spartan siege. Xenophon's intimation of a hasty reconstruction indicates the likelihood that the Mantineans rebuilt the walls in the fourth century B.C.E. to follow the course of the original circuit. This is a reasonable conclusion, but it cannot be disproved or proved before there has been a systematic study of

the walls and gates. In our present state of knowledge, the walls date to the fourth century B.C.E. based on the masonry style (isodomic trapezoidal) of the surviving stone socle.<sup>41</sup> In our view, one of the peculiarities of the city is the relationship between an orthogonal street system and an elliptical defensive circuit. The two systems, rectilinear and curvilinear, do not entirely cohere with each other and present challenges in the equal allocation of orthogonal streets, especially along the margins. Moreover, the distribution of gates around the curvilinear fortification walls necessitated adjustments to the orthogonal street system. This is most obvious with a shift in position of the major north–south streets (N1–5, S1–4) to accommodate the location of northern and southern gates. The critical question to ask in this context is why the gates and streets are not aligned. Is this an indication that the orthogonal streets

<sup>41</sup> Hodkinson and Hodkinson (1981, 257–58) review the evidence for the chronology of the walls. As they indicate, part of the southern circuit is not in trapezoidal masonry but in a coursed polygonal style, which may predate the Spartan destruction. For architectural parallels with the fortifications at other Arcadian cities (in particular Stymphalos), see Maher 2014.

were inserted to coordinate with the location of pre-existing gates? It could be, but this would need to be confirmed with a better understanding of the architectural phases of the city, especially the buildings in the agora that align with our proposed orthogonal grid.

Another important question concerns the original course of the Ophis River through Mantinea, before Spartan destruction. A schematic plan of the city published in 1831 by Gell shows the river flowing around the city from the southeast to the northwest.<sup>42</sup> Gell identifies the Spartan dam as a modest rise in the topography to the northwest of the city between Gates A and B. The 1898 French plan of Mantinea does not conjecture the location of the Spartan dam, but it illustrates the Ophis River flowing around the city from southeast to northwest (see fig. 5). Unfortunately, there is no clear indication of how it crossed the urban center in classical antiquity. Any reconstruction of Mantinea in the fourth century B.C.E. would likely have built over the previously uninhabited zone of the river's urban course. Satellite images show the location of seasonal marshes and streams inside the city walls, as well as some paleochannels (online fig. 12), but it would be premature to speculate on the ancient course of the river without a proper geoarchaeological study.

Remote sensing at Mantinea has made significant progress in revealing the organization of urban space, but it is challenging to establish the chronology of the orthogonal street system without ground truthing. Ongoing investigations by the Archaeological Ephorate of Arkadia in the agora may prove decisive, since the position of the public square and the alignment of its buildings appear to coordinate with the urban street system. Most structures on the 1898 French plan date to the Roman period, based on the architectural use of brick and mortar; however, the square hypostyle hall and the stoa with projecting wings are probably constructions of the Classical or Hellenistic period. Both are aligned with the orthogonal street system, and two city blocks separate the back of the hypostyle hall and the front of the stoa. If these buildings are contemporary with the orthogonal street system, then they reveal an inclination toward the rational organization of public space.

## ELIS

### *Archaeological and Historical Context*

Elis is located south of the Peneios River within the northwestern Peloponnese (fig. 13; online fig. 13). In

the sixth century B.C.E., the Eleans expanded their influence through warfare or favorable alliances and imposed *perioikic* status on neighboring communities.<sup>43</sup> The assimilation of Pisatis into the sphere of Elean control ca. 570 B.C.E. ensured that the Eleans became the overseers of the Panhellenic Sanctuary of Zeus at Olympia.<sup>44</sup> The expansionist policy of the Eleans is remarkable considering the political organization of the Elean state. According to ancient tradition, the Eleans resided in several small communities.<sup>45</sup> They apparently lacked a large urban center until after the Persian Wars, when a synoicisms in 471/0 B.C.E. led to the creation of Elis. According to Strabo (8.3.2) and Diodorus (11.54.1), Elis was established as the capital and center of the polis in this year.<sup>46</sup> However, the archaeological evidence reveals that a (small?) settlement existed before the synoicisms.<sup>47</sup> A modest collection of Bronze Age and Geometric graves, bronze objects, and pottery attests to an earlier phase in the city's history, as do some archaic painted architectural terracottas and an early sixth-century B.C.E. bronze judicial inscription.

Archaeological fieldwork at Elis was initiated by the Austrian Archaeological Institute at Athens from 1910 to 1914.<sup>48</sup> The aim was to reveal the agora and public heart of the city much like the French had done at Mantinea. The Austrians found many public and religious buildings, including the stone foundations of two monumental stoas that appeared to define the agora's western and southern sides. They also found an artificially constructed theater northeast of the agora.<sup>49</sup> Since Pausanias (6.23.1–6.26.3) gives an incredibly detailed description of the Elean agora as it was in the

<sup>43</sup> Roy 1997; 2002, 251–52.

<sup>44</sup> Paus. 6.22.4.

<sup>45</sup> E.g., Homer (*Il.*, 11.671–81; *Od.*, 21.347) characterizes the Eleans as making their living in the countryside and tending to their animals. Polybius (4.73.5–10) states that the Eleans did not live in cities for a long time.

<sup>46</sup> Diodorus and Strabo are the main sources for the 471/0 B.C.E. synoicisms. Potentially relevant passages are also found in Pseudo-Skylax 43 and Leandr(i)os (*FGrHist* 492). Roy (2002) summarizes the evidence and offers a critical assessment of the validity of the synoicisms.

<sup>47</sup> Eder and Mitsopoulos-Leon 1999; Eder 2001; Minon 2007, 15–17.

<sup>48</sup> Walter 1913, 1915; Tritsch 1932. For a general summary of the archaeological remains (largely known from the Austrian excavations), see Yalouris 1996; Heiden 2006; Andreou and Andreou 2007.

<sup>49</sup> Glaser 2001.

<sup>42</sup> Gell 1831, 69–70, pl. 35.

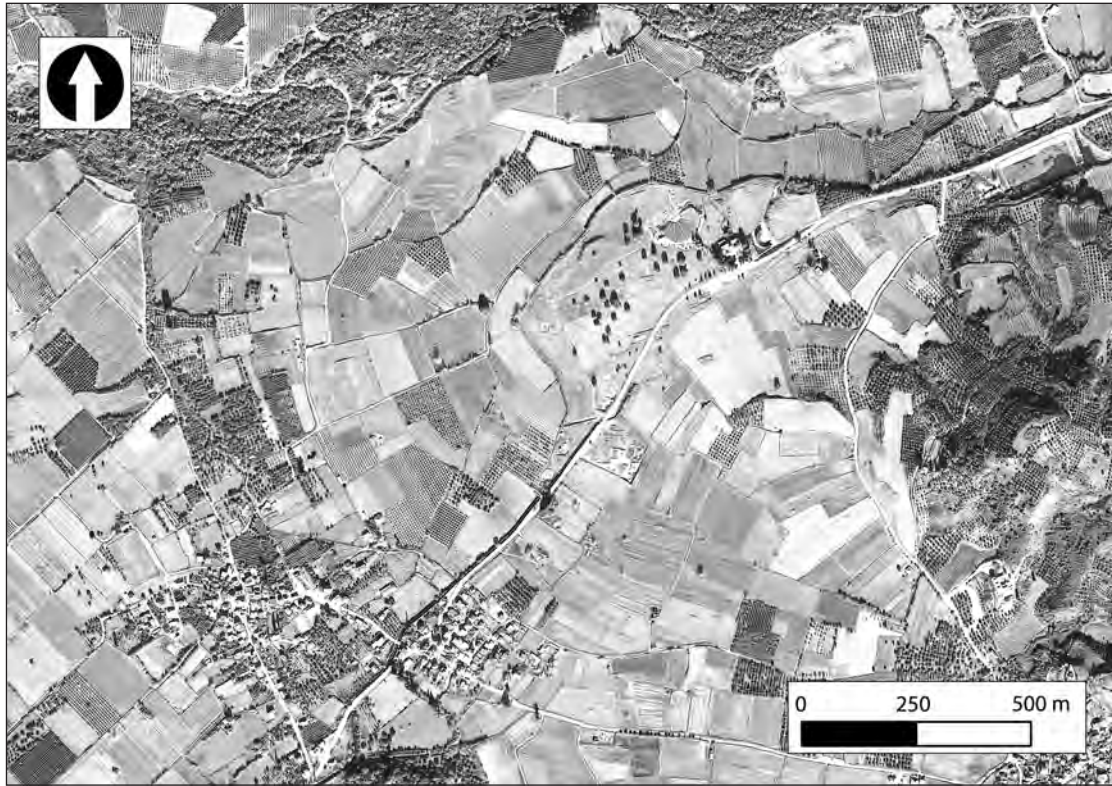


FIG. 13. Elis from a WorldView-2 image taken 13 December 2012 (© DigitalGlobe, Inc.; all rights reserved).

second century C.E., there was great interest at the time in correlating the excavated remains with Pausanias' travel narrative.<sup>50</sup> The Austrians uncovered a series of long, parallel foundations west of the agora, which they tentatively (and perhaps wrongly) attributed to the famous gymnasia of Elis where athletes trained before the Olympic Games.<sup>51</sup> The Austrians returned from 1960 to 1990 to conduct an architectural and chronological analysis of the buildings within the agora.<sup>52</sup> During this time, the Archaeological Society at Athens and the Archaeological Ephorate of Eleias broadened the area of archaeological exploration to include the region of the theater and other regions of the city.<sup>53</sup> The most significant of these efforts was the

1967–1968 excavation of a zone south of the agora, where three streets are arranged in an orthogonal manner (see fig. 2; online fig. 2). The roads and buildings date to the Roman Imperial period, but probings beneath the streets confirm that they were first surfaced as early as the fifth century B.C.E.<sup>54</sup> An expansion of excavations has been ongoing since 2002 in the same zone. A geophysical survey using magnetics and electrical ground resistance was conducted in 2003 by the Aristotle University of Thessaloniki and I.M.S.-F.O.R.T.H. around the northern and western periphery of the agora and in the western part of the city (fig. 14).<sup>55</sup> The survey succeeded in identifying near-surface streets extending westward from the agora. More recently, a geophysical survey (13 ha) was undertaken

<sup>50</sup> The most notable publication on this subject is Tritsch 1932.

<sup>51</sup> Walter 1913, 145–46. In our view, the foundations that the Austrians identified as being from the gymnasia could also be associated with the streets and city blocks revealed through remote sensing and a geophysical survey carried out in 2003.

<sup>52</sup> Annual excavation reports by V. Mitsopoulou-Leon appeared in *ÖJh* almost every year from 1960 to 1983.

<sup>53</sup> The Archaeological Society at Athens published frequent

summary reports of their work in *Ergon* from 1960 to 1990. For work by the Archaeological Ephorate of Eleias, previously the 7th Ephorate of Prehistoric and Classical Antiquities, see Yalouris 1968a, 1968b; Papathanasopoulos 1969, 1970, 1972; Karagiorga 1974.

<sup>54</sup> Andreou and Andreou 2007, 22–3; 2012.

<sup>55</sup> Tsokas et al. 2012.



FIG. 14. Elis: agora and the results of the 2003 geophysical survey (after Tsokas et al. 2012; includes copyrighted material of DigitalGlobe, Inc.; all rights reserved).

in 2014 by the authors and a team of researchers at I.M.S.-F.O.R.T.H. Like our survey at Mantinea, the results will appear in a future publication upon the completion of analysis.

#### *Results from Satellite Remote Sensing*

More than 50 linear surface anomalies were identified at Elis, ranging in length from 25 m (anomalies 10, 30) to 208 m (anomaly 24) (fig. 15; online fig. 14).<sup>56</sup> The anomalies are divided among those whose alignments closely follow the cardinal points (57%) and those whose alignments do not (43%). For those that do, the average orientation of north–south anomalies is 0.8°, and that of east–west anomalies is 90.5°. Anomalies concentrate predominantly in regions south and southwest of the agora. We found only a limited number in the northern and eastern regions. This can be explained in part by erosion activity from the Peneios River. Today the river banks are more than 300 m from

the agora, but undulating lines in the arrangement of modern field boundaries north of the agora likely betray an earlier course of the river, perhaps a course caused by seasonal flooding (see fig. 13). Likewise, the eastern terrain has low hills with orchards that could affect the detection of subsurface features.

*North–South Anomalies.* Surface anomalies with north–south orientations are not as abundant at Elis as they are at Mantinea. Nonetheless, the 10 that do appear in the satellite imagery and feature enhancement indices display some interesting characteristics (figs. 16, 17). In a field south of the current excavations, we traced anomaly 39 for 87 m. No traces of the anomaly appear in the neighboring fields. However, anomaly 44 continues the same north–south trajectory more than 300 m to the south (online fig. 15). Despite the distance between the two, 39 and 44 may be related features. We note in particular that both align with a street excavated in the current archaeological zone. Approximately 500 m west of the agora, another group of north–south anomalies have shared alignments. The longest (anomaly 19) stretches for 167 m over three fields with assorted vegetation. Farther north, anomaly

<sup>56</sup> Linear anomalies less than 25 m in length were excluded from our study.

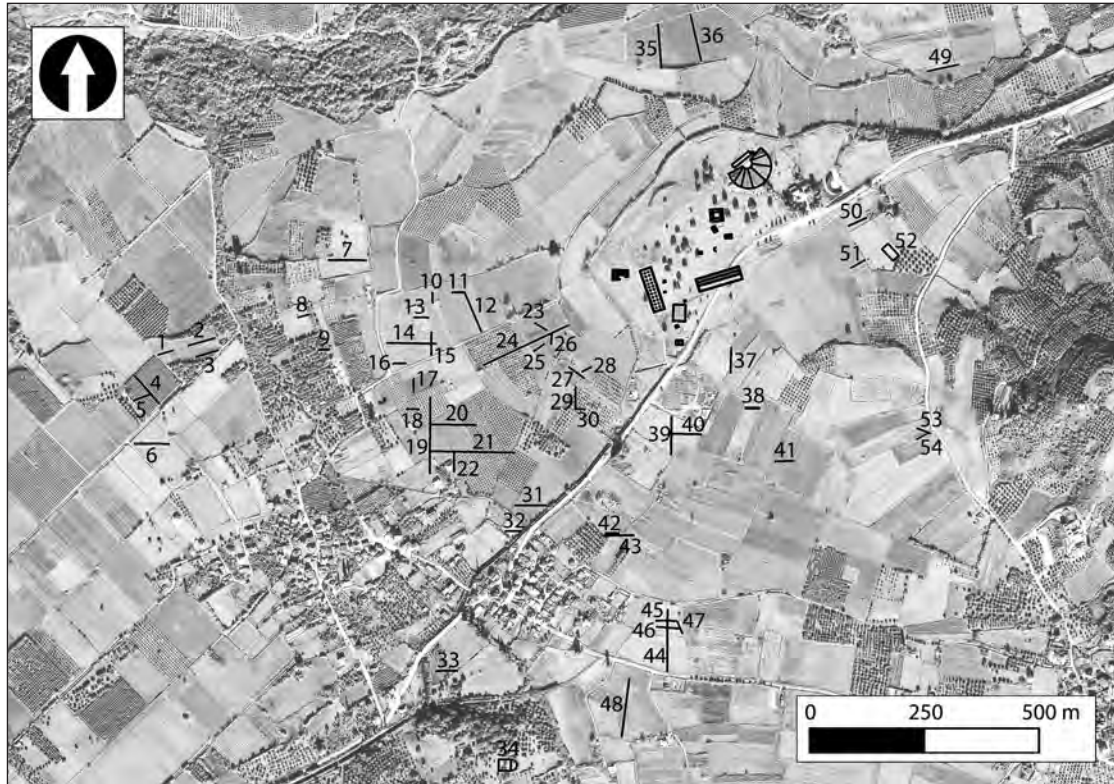


FIG. 15. Surface anomalies at Elis identified from remote sensing. Numbers indicate the surface anomalies (includes copyrighted material of DigitalGlobe, Inc.; all rights reserved).

15 continues the same course for another 53 m, while 10 may be interpreted as a smaller yet related feature.

*East–West Anomalies.* East–west linear anomalies are more abundant at Elis (see figs. 16, 17). We identified 21 east–west anomalies compared with 10 north–south anomalies. Their arrangement and organization raise attention because of reoccurring patterns. This is most evident in the southwestern region, where east–west anomalies intersect north–south anomalies at right angles and are often spaced at systematic intervals. Significant, too, is the relationship between east–west anomalies and near-surface streets identified in the 2003 geophysical survey, as well as streets south of the agora identified from excavations.

In the southwestern region, anomalies 20 and 21 are parallel features that intersect 19 at a right angle (online fig. 16). They continue eastward for 102 m and 186 m, respectively. Farther north, we traced the course of east–west anomalies 13 and 14 for 36 m and 110 m, respectively. Although the length of 13 is small, it aligns with a street identified in three different zones in the 2003 geophysical survey. Two other streets known from the same survey also relate to east–west

anomalies that we have identified. Anomaly 14 aligns with a street at the southwestern corner of the agora, even though more than 400 m separate the features. Anomaly 11 continues the course of a street ending at the stoa along the western side of the agora. Near the current archaeological zone, anomaly 40 intersects with 39 at a right angle before going eastward for 66 m. This anomaly is parallel with two streets revealed through excavations just to the north. One anomaly, 38, appears to be an eastern continuation of one of these excavated streets.

Where measurements are possible, the spacing of east–west anomalies and near-surface and excavated streets is consistent, ranging between 57 and 59 m. The three streets identified in the 2003 geophysical survey southwest of the agora have intervals of 57–58 m, while anomalies 13 and 14 are separated by 57 m. To the south, a distance of 59 m stands between anomalies 20 and 21; near the archaeological zone, anomaly 40 is approximately 57 m from the southernmost excavated street. The only deviation from the range noted here is the 53 m that separates anomaly 11 from the street immediately to the south.



FIG. 16. The southwestern region of Elis from a GeoEye-1 image taken 20 July 2009: *top*, with soil-adjusted vegetation index (SAVI) feature enhancement applied; *bottom*, showing some anomalies marked by numbers and the 2003 geophysical data. Anomalies in italics are not easily viewable in this feature enhancement (after Tsokas et al. 2012; includes copyrighted material of DigitalGlobe, Inc.; all rights reserved).

*Diagonal Anomalies.* A final category of anomalies is not organized along the cardinal points. For the most part, there is nothing in the placement and organization of these diagonal features that would suggest a consistent pattern. In fact, most appear to be ran-

domly dispersed through the landscape and may have been caused by recent farming activity. One exception is anomaly 24, which is the longest feature (208 m) we recorded at Elis (see fig. 17). Its course runs parallel to a modern dirt road 60 m to the north. Two small



FIG. 17. The southwestern region of Elis from a QuickBird image taken 30 April 2010: *top*, with modified simple ratio (MSR) feature enhancement applied; *bottom*, showing some anomalies marked by numbers and the 2003 geophysical data. Anomalies in italics are not easily viewable in this feature enhancement (after Tsokas et al. 2012; includes copyrighted material of DigitalGlobe, Inc.; all rights reserved).

diagonal anomalies, 23 and 26, radiate outward near its eastern end. Nearby, the 2003 geophysical survey detected a diagonal road originating 20 m from the western end of the agora and continuing westward for 150 m. Because the orientation of 24 is not perfectly aligned with the street, it is not possible to make a

definitive connection between the two features, but some kind of association cannot be excluded. The diagonal orientations of 24 and the street are noteworthy for another reason: both share more or less the same diagonal axes of the two monumental stoas in the agora.

### *Urban Organization of Space*

Many of the anomalies at Elis designate a system of organized streets in the southern and southwestern regions of the city. The arrangement and metrology of these anomalies, together with their relationship to streets identified in the 2003 geophysical survey and through excavations, are good evidence even if on a more limited scale compared with Mantinea. A recurring pattern at Elis is a system of east–west anomalies spaced between 57 and 59 m. The streets identified in the 2003 geophysical survey fall within this range, and, in every instance, we have found additional evidence for their projected courses from remote sensing. Anomalies 11, 13, and 14 confirm the western extension of the streets more than 500 m from the agora. South of the agora, anomalies 38 and 39/44 continue the path of an east–west street and the north–south street found from excavations.

Based on this evidence, a partial reconstruction of the urban street system of Elis is possible (fig. 18). Our reconstruction is based on a uniform distribution of east–west streets spaced 58 m from one another. This is the median value within the 57–59 m range of east–west anomalies and streets. At this point, there is not enough evidence to offer a reconstruction of north–south streets, beyond the example south of the agora and one farther west. For all streets, we apply directional orientations of  $1^\circ$  and  $91^\circ$  based on the average orientations of north–south ( $0.8^\circ$ ) and east–west ( $90.5^\circ$ ) linear anomalies rounded up to the nearest degree. As we caution in our reconstruction of Mantinea, the spacing and orientations are meant to be approximations of the organized street system at Elis. Solid black lines on figure 18 indicate coverage from anomalies within 2.5 m of the 58 m spacing of streets. Dotted black lines show the expected but still conjectural extension of the same streets.

The southern and southwestern regions of Elis have two north–south streets (N1–2), eight east–west streets (E1–8), and one diagonal street (D1). Since the urban extent of Elis is poorly established in the archaeological record, it is not possible to know the full extent of the street system. On figure 18, east–west streets end 100 m beyond Street N1 at the western termination of anomaly 14. We cannot be sure the remaining east–west streets cover the same distance. Likewise, we do not conjecture about the northern and southern extension of N1 or the southern course of N2 beyond the evidence from the anomalies. The eastern courses of Streets E6–8 have been reconstructed to go as far as anomaly 38. It is challenging to interpret the

eastern termination points of E1–5 and the western termination points of E6–8. These street groups do not align with one another. For example, a hypothetical convergence of E4 and E8 would be more than 10 m apart. Streets E6–8 intersect N2, but it is not clear in the satellite imagery (or from excavations) whether they continue westward. The 2003 geophysical survey confirms that E1–3 stop near the western side of the agora. Street E1 originates at the back of the western stoa, and E2–3 commence 30–40 m from N2. Street N2 or an undiscovered north–south street must have acted as a line of division between the two orthogonal street systems; however, this does not explain the reasons for such a discrepancy. At Mantinea, we justify a similar occurrence of offset streets by noting the location of city gates, but at Elis there is no obvious explanation. Finally, we do not conjecture about the southwestern extension of the diagonal street (D1) beyond the evidence from the 2003 geophysical survey.

The locations of anomalies marking an orthogonal network of streets are particularly useful in estimating the urban extent of Elis. Streets in the southwestern region are at a minimum distance of 500 m from the agora. Their orthogonal arrangement is very much indicative of an organized network of streets inside the city. The possibility that they constitute a rural street system is less probable, but it cannot be entirely excluded thus far. Any evidence for the fortification walls at Elis is very limited in the archaeological record. Fragments of wall sections on the slopes of the acropolis, southeast of the agora, have been interpreted as a fortification circuit; however, these are localized features that do not provide as much information about the urban extent of the city as we have for Mantinea.<sup>57</sup> Our analysis did not find anomalies that might betray the presence of a buried defensive circuit. Xenophon states that during the Spartan invasion of Elean territory in ca. 400 B.C.E., the Spartan king Agis reached the city and did harm to the suburbs (προάστια) and the gymnasia but declined to invade the city itself, even though Elis was unwalled (ἀτείχιστος γὰρ ἦν).<sup>58</sup> Elis helped finance the reconstruction of fortification walls at Mantinea in the fourth century B.C.E. as protection against Spartan aggression, but it is unknown whether the Eleans perceived a similar threat to their own city.<sup>59</sup> Lacking additional evidence

<sup>57</sup> According to Xenophon (*Hell.* 3.2.23–3), Elis was an unfortified settlement as late as 400 B.C.E., when the Spartan king Agis led an invasion near the city.

<sup>58</sup> Xen., *Hell.* 3.2.27.

<sup>59</sup> Xen., *Hell.* 6.5.3–5.



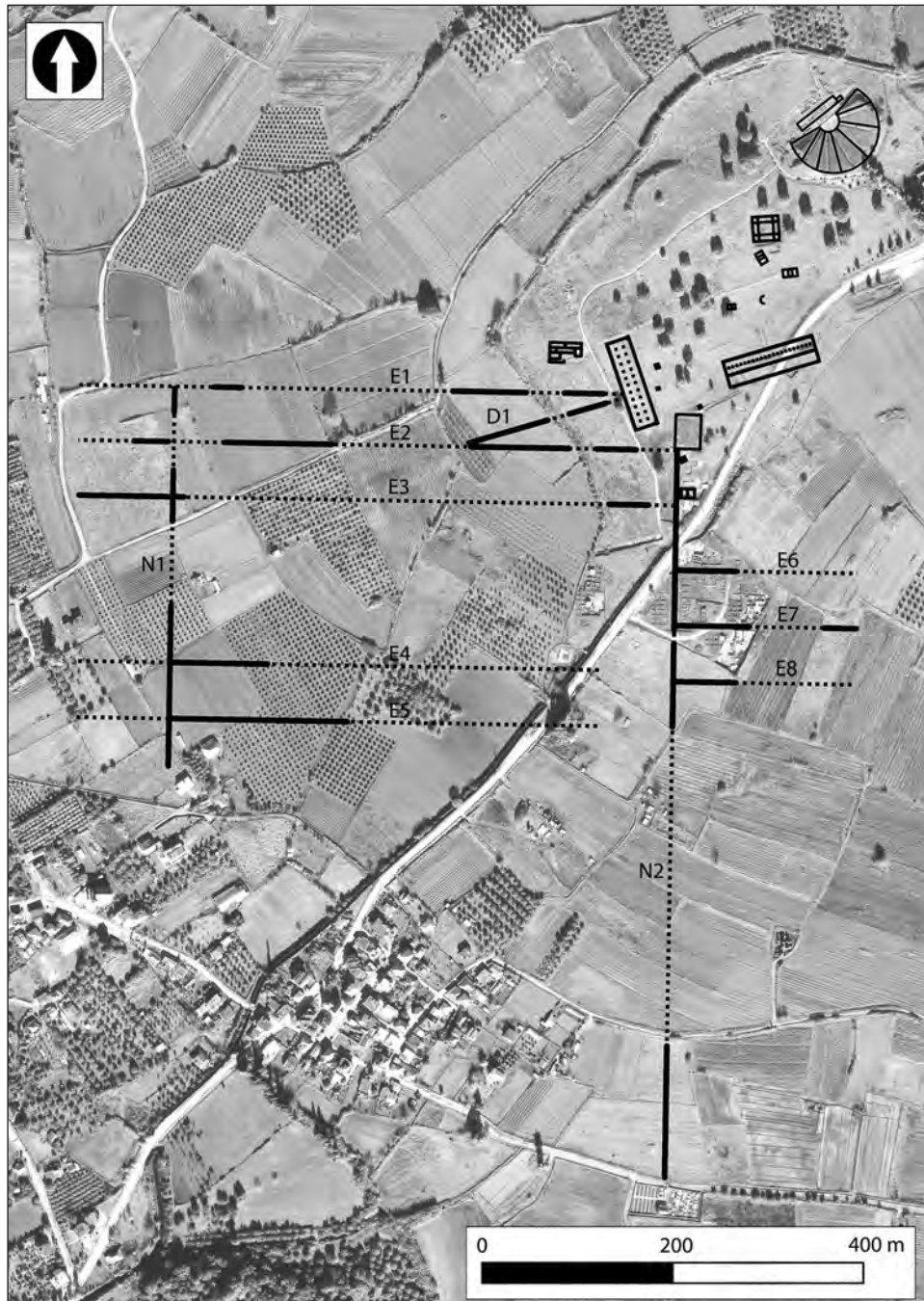


FIG. 18. A partial reconstruction of the orthogonal street system at Elis based on a system of east–west streets with 58 m intervals. North–south streets are marked as N1–2; east–west streets are marked as E1–8; and the diagonal street is marked as D1. Solid black lines indicate coverage from anomalies within 2.5 m of the spacing sequence of 58 m for east–west streets; dotted black lines show the expected but still conjectural extension of the same streets (includes copyrighted material of DigitalGlobe, Inc.; all rights reserved).

in the literary and archaeological record, we are inclined to place the western limits of the city more than 500 m from the agora, where remote sensing has identified the extension of an organized street system. The southern

parameters of the city are more opaque. Street N2 extends 560 m beyond the recent excavations, but, as it is an isolated feature, it would be premature to speculate whether its whole course falls within the city.

Of course, the chronology of the street system, as exposed through remote sensing, is an important issue to confront, but it cannot be resolved with our methodologies. The dating of the buildings in the agora and the streets excavated farther south should shed light on phases of town planning at Elis. In preliminary (and brief) presentations of the archaeological evidence, the earliest surfacing of the streets has been dated to the fifth century B.C.E.<sup>60</sup> If this is indeed the case, it is tempting to place the town planning at Elis, as revealed through remote sensing, in the same period. A fifth-century B.C.E. date would also correspond to the synoicism of Elis in 471/0 B.C.E. referred to by historical sources.

#### AN OVERVIEW OF TOWN PLANNING IN THE PELOPONNESE

In studying the history of Greek town planning, the Peloponnese does not immediately come to mind as a region rich in representative examples of orthogonally planned settlements with residential blocks of roughly equal dimensions. Archaeology documents far more examples in the Greek West, where a major wave of colonization in South Italy and Sicily during the eighth and seventh centuries B.C.E. triggered new conceptual approaches in cohabitation.<sup>61</sup> 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 of mainland Greek cities compared with colonial foundations. Indeed, archaeological excavations have shown that prominent places such as Corinth and Eretria remained without formal planning over much if not all of their histories.<sup>62</sup> Nevertheless, an incomplete archaeological sample and the modest scale and methods of site exploration in the Peloponnese and elsewhere are factors that likely shape conventional narratives on Greek urban practices. The contributions of cities on the Greek mainland, in regions such as the Peloponnese and Thessaly, are often downplayed, or even worse completely ignored, in favor of the more extensive archaeological record of the Greek West.<sup>63</sup>

<sup>60</sup> Andreou and Andreou 2007, 22–3; 2012.

<sup>61</sup> Greco and Torelli 1983, 149–232; Hoepfner 1999, 129–99; Donati 2014.

<sup>62</sup> Roebuck 1972; Krause 1979.

<sup>63</sup> Martin (1974) and Hoepfner and Schwandner (1994), who arguably wrote the most influential works on Greek urbanism, ignore the Peloponnese altogether. Greco and Torelli

Even though examples show that organized cities were prevalent on the mainland before the Hellenistic period (e.g., Halieis, Kassope, Orraon, Tanagra), they are frequently overlooked.

In addition to the new evidence presented here for Mantinea and Elis, there are at least six more cases of Greek planned settlements in the Peloponnese that are known from archaeological excavations and geophysical prospection (see fig. 1). One of the better-documented examples, and perhaps the earliest, is the modestly sized (18 ha) fortified harbor settlement of Halieis in the southern Argolid.<sup>64</sup> Two different orthogonal street systems, each with parallel streets and a smaller number of avenues, were discovered through excavations in the western and eastern regions of the lower town; an upper part of the city remained unplanned. The eastern street system dates to the first half of the sixth century B.C.E. based on stratified deposits. This initial phase of town planning followed an episode of destruction at the beginning of the same century. The destruction is documented in the upper town. The western street system dates to the fifth century B.C.E. in an apparent phase of expansion. Apart from the fortification walls and gates, most of the preserved architecture on the site comes from domestic structures that date to the Late Classical period.<sup>65</sup> Halieis was ultimately abandoned ca. 300 B.C.E.

In Arcadia near the village of Kyparissia, approximately 8 km northwest of Megalopolis, rescue excavations from 1998 to 2001 discovered a planned settlement dating to the Classical period.<sup>66</sup> The town, whose name remains uncertain, was fortified with a curvilinear defensive wall and consisted of an organized network of streets and city blocks. Six parallel streets with blocks 54 m wide were identified from the excavations. Houses filled the city blocks, and a small alleyway divided the blocks into equal sections. This

(1983) include little about mainland Greece compared with the extensive treatment they give to the Greek West. De Polignac (1995) and Hölscher (1998) broaden their perspectives more, although the focus is on the conventional examples of Argos, Corinth, and Sparta.

<sup>64</sup> Boyd and Jameson 1981; Rudolph 1984; McAllister 2005.

<sup>65</sup> Ault 2005.

<sup>66</sup> Karapanagiotou 2005. Mining activities by the Public Power Corporation of Greece have since destroyed a large portion of the archaeological site. One can view the progress of damage by observing the sequence of archived satellite images in Google Earth (coordinates 37°26'51.87" N, 22°4'20.41" E).

kind of arrangement of residential quarters with blocks of houses split by central alleyways is reminiscent of the classical settlement of Olynthus in Macedonia, among others.<sup>67</sup> A preliminary analysis of pottery from the site tentatively dates the initial phase of town planning to the first half of the fifth century B.C.E. Occupation continued into the following century, when the site was largely abandoned. The political situation in Arcadia during the fourth century B.C.E. initiated great changes to urban life. The inhabitants of many villages in the region, which may or may not have included the planned town near Kyparissia, were compelled to move to the new city of Megalopolis.<sup>68</sup> It is noteworthy, then, that there is evidence of town planning in Arcadia from a period that precedes the major synoicism initiatives of the fourth century B.C.E. at places such as Megalopolis and Mantinea.

Two additional Arcadian cities indicate the practice of formal town planning. At Stymphalos, geophysical prospection and excavations have revealed a partial grid system that dates to the middle of the fourth century B.C.E.<sup>69</sup> A series of parallel north–south streets and (fewer) east–west streets create long and narrow city blocks about 30 x 100 m. The organized plan appears to include most of the level area inside the curvilinear defensive walls; the steeper acropolis was not included in the plan. Excavations of some city blocks have uncovered residential buildings with phases as late as the Roman period. One interesting aspect of the street system at Stymphalos is that north–south streets do not extend from the southern side of the city to the northern side in an unbroken line. Instead, they are offset by 15 m somewhere near the city center. We have observed this same phenomenon at Mantinea with its north–south streets and at Elis with its east–west streets. The excavators at Stymphalos explain this circumstance by citing Aristotle’s advice in the *Politics* (7.10.4–5) on the layout of urban streets, where he recommends partly offsetting orthogonal streets to delay the advancement of an invading force.<sup>70</sup> With regard to Mantinea, we offer the suggestion that the variation in orthogonal street alignments could relate to different phases of town planning to accommodate

the proper circulation of traffic from city gates to the central agora. In truth, these questions at Mantinea and Stymphalos cannot be sufficiently answered until more urban features have been studied and a better chronology for them is established. At Tegea, a magnetic survey identified organized streets and city blocks in the northern region of the city around the agora and possible sections of fortifications.<sup>71</sup> City blocks are long and rectangular, measuring 25 x 75 m. It is hoped that targeted excavations in the future will help date the street system. The surveyors have tentatively proposed a date in the sixth century B.C.E. based on a surface survey, adding that Tegea may be one of the earliest planned settlements on mainland Greece.

The most extensive evidence for town planning in the Peloponnese comes from Hellenistic Sikyon. Here, a combination of geophysical prospection, surface survey, and (ongoing) excavations by the University of Thessaly has brought to light a widespread orthogonal grid of square city blocks measuring between 60 and 65 m per side.<sup>72</sup> Despite the precipitous terrain of the upper plateau, fieldwork has noted evidence for orthogonal streets that continue uninterrupted from the lower plateau. Large urban venues, such as the agora, theater, a gymnasium, and a (still buried) sanctuary, are firmly integrated into the city’s urban plan. The whole grid system strictly follows the cardinal points, even though, as the surveyors note, a northeastern orientation would have been more appropriate on the terrain.<sup>73</sup> At its current location on a plateau overlooking the Corinthian Gulf, the city of Sikyon was established by Demetrios Poliorketes following his 303 B.C.E. destruction of the classical town in a still-unidentified location within the lower coastal valley. The strict grid system set on the cardinal points (even on a hilltop), with square city blocks and urban venues in exact alignment, is a characteristic of the more mature and standardized forms of Greek town-planning initiatives that became common by the Hellenistic period.<sup>74</sup> Orthogonal planning was exploited at this time as a means of emphasizing the increasingly monumental nature of the Greek city. Elsewhere, geophysical prospection and excavations at Messene have revealed further (yet limited) evidence for a similar kind of town planning

<sup>67</sup> Cahill 2002.

<sup>68</sup> Roy 2005, 2007.

<sup>69</sup> Williams 2005 (with earlier bibliography). The final publication of the material from Stymphalos will appear in a forthcoming monograph series.

<sup>70</sup> Williams 2005, 399.

<sup>71</sup> Whitley et al. 2007, 23–4.

<sup>72</sup> Lolos et al. 2007; Lolos and Gourley 2011.

<sup>73</sup> Lolos and Gourley 2011, 131.

<sup>74</sup> Greco and Torelli 1983, 313–74; Hoepfner 1999, 441–525.

on a hilltop.<sup>75</sup> Based on the incomplete data, it appears that some streets at Messene had northeast–southwest orientations framing rectangular city blocks of about 36 x 99 m that were further subdivided into equal housing units.<sup>76</sup> Excavations at the heart of the city show that the agora and other conspicuous public venues were integrated into the city’s orthogonal grid system. The foundation of Messene in 369 B.C.E. is more or less contemporary with the refoundation of Mantinea in 371 B.C.E. The surveyors therefore have proposed a fourth-century B.C.E. date for the town plan to coordinate it with the city’s foundation.

Viewed within the framework of Greek town planning in the Peloponnese between the sixth and the third century B.C.E., the new evidence from Mantinea and Elis are clearly part of a broader trend of rational town planning in the region. The establishment of new cities (Elis, Messene, Sikyon) and the refoundation (Mantinea) or reconstruction (Halieis) of older cities appear to have been the main catalysts for the implementation of planned settlements. One striking element from the Peloponnese is the variation in the kinds of settlements that adopted rational plans. Places as small as Halieis (18 ha) and as large as Mantinea (119 ha) equally embraced orthogonal streets and regular city blocks in their urban environments. The largest and most influential cities were not the only ones to adopt trends in Greek town planning. In fact, the earliest town plans in the Peloponnese, based on our present state of knowledge, are the small settlements of Halieis and the town near Kyparissia, which correspondingly date to the sixth and fifth centuries B.C.E.<sup>77</sup> It is counterintuitive from conventional discourses on the history of Greek urbanism to count modest settlements at the vanguard of town-planning initiatives, but this appears to have been the case in the Peloponnese. Although appreciation of their urban plans is still limited, older and celebrated cities, such as Argos, Corinth, and Sparta, simply did not have the same opportunities to build from scratch or radically

transform their urban environments; therefore, they had to make modifications within a deep-rooted tradition of organic urban development transpiring over many centuries. Thucydides (1.10) famously characterizes fifth-century B.C.E. Sparta as a collection of villages arranged “κατὰ κώμας,” while the archaeological evidence from Argos and Corinth before the Hellenistic period paints the picture of a similar trajectory of piecemeal development.<sup>78</sup> Despite the obvious gradations in the conception and implementation of the built environment, it is primarily the traditional Peloponnesian centers, such as Argos, Corinth, and Sparta, that continue to frame discourses related to town planning here. We hope that our presentation of the new material from Mantinea and Elis begins to alter these entrenched perspectives.

Another conspicuous feature from the Peloponnese is the variation in town-planning configurations. Some cities favored elongated city blocks with a width-to-length ratio of approximately 1:3 (Messene, Stymphalos, Tegea), while remote sensing indicates that Mantinea likely had a ratio of approximately 2:3; Sikyon made use of square city blocks. The absence of north–south streets near Kyparissia might indicate that the town had elongated city blocks as well. At Halieis, the metrology of the orthogonal street system was variable: the eastern section of the lower town had streets with uniform widths but varying lengths. Most cities (with the exception of Sikyon) appear to have made modifications to their orthogonal plans rather than implement a strict across-the-board system. There are offset north–south streets at Mantinea and Stymphalos and offset east–west streets at Elis despite the level terrain. In addition, remote sensing at Mantinea suggests that peripheral city blocks close to the fortification walls adopted different dimensions than those at the city center. Discrepancies in the organization of streets and city blocks should be expected in Greek town planning before the Hellenistic period, and they are probably a result of local environmental factors (topography of the site, hydrology) and specific urban requirements (city defense, circulation of traffic) and realities (position of city gates, existing architecture).<sup>79</sup>

<sup>75</sup> Hoepfner 2002–2005; Müth 2007.

<sup>76</sup> A certain amount of caution must be applied to Hoepfner’s (2002–2005) proposed city plan of Messene based on the geophysical survey. The results from magnetics were ambiguous, and they do not support at present the extensive city grid reproduced by him.

<sup>77</sup> The town plan at Elis may also date to the fifth century B.C.E., but we feel that further fieldwork is necessary for confirmation.

<sup>78</sup> On the urban history of Corinth, see Roebuck 1972; Sanders 2005. On that of Argos, see Viret Bernal 1992; Marchetti 1993; Pariente et al. 1998.

<sup>79</sup> Regarding variations in the urban grid at Plataiai, see *supra* n. 39.

One reason for rational city plans in the Greek world was for the construction of residential city blocks with comparably sized housing plots.<sup>80</sup> This element of urban planning is often attributed to the (supposed) inclusive nature of Greek social and political life, most notably during the Classical period with the (again supposed) proliferation of democratic ideals and concepts of ἰσονομία.<sup>81</sup> The archaeological evidence from which these views are based weighs heavily on the planned settlements in the Greek West and Ionia.<sup>82</sup> The Peloponnese has played a predictably marginal role in forming these discourses. Satellite remote sensing at Mantinea and Elis has yet to identify subsurface architectural remains from domestic structures; however, there is ample evidence of organized domestic quarters at the other planned settlements in the Peloponnese. Block-style houses have been found at Halieis, the town near Kyparissia, Messene, Sikyon, and Stymphalos. The fourth-century B.C.E. houses at Halieis stand out as offering rich insights into the spatial organization and domestic activities of classical households.<sup>83</sup> More extensive archaeological fieldwork at the other cities will likely produce constructive results as well, drawing further attention to the traditions of Greek town and residential planning in the Peloponnese.

#### CONCLUSION

Surface anomalies identified with remote sensing methods at Mantinea and Elis unmistakably relate to a subsurface system of orthogonal streets in both cities. The evidence demonstrates rather lucidly that these settlements were planned according to Greek urban trends during the second half of the first millennium

B.C.E. More importantly perhaps, the town-planning initiatives of Mantinea and Elis are not isolated examples in the Peloponnese by any stretch of the imagination. In the context of other planned settlements in the region, the cities were clearly integrated into a wider Peloponnesian disposition, even tradition, toward rational urban designs. This inclination remains woefully unappreciated in archaeological discourses on Greek urban practices.

In addition to presenting new archaeological data, our study highlights the benefits of implementing satellite and aerial remote sensing in archaeological fieldwork. Remote sensing at Mantinea and Elis was able to extract valuable information about buried features of archaeological interest on a vast scale. Traditional fieldwork and geophysical prospection using conventional equipment would require many months, if not many years, to obtain similar results with much higher operational costs. Of course, the remote sensing evidence for town planning at Mantinea and Elis should be only the starting point for unraveling the urban dynamics in these Peloponnesian cities. Geophysical prospection and targeted excavations can and should be employed to confirm our results with greater resolution, most notably in the detection of architectural features, such as residential houses, and to better establish the chronology of the town plans. Although we strongly feel that remote sensing can be implemented quite effectively as a stand-alone method for understanding past landscapes, it is arguably used to even greater effect in conjunction with conventional fieldwork methods.

Jamieson C. Donati  
Laboratory of Geophysical, Satellite Remote Sensing  
and Archaeoenvironment  
Institute for Mediterranean Studies, Foundation for  
Research and Technology, Hellas  
Melissinou and Nikephorou Foka 130  
74100 Rethymno, Crete  
Greece  
jcdonati@ims.forth.gr

Apostolos Sarris  
Laboratory of Geophysical, Satellite Remote Sensing  
and Archaeoenvironment  
Institute for Mediterranean Studies, Foundation for  
Research and Technology, Hellas  
Melissinou and Nikephorou Foka 130  
74100 Rethymno, Crete  
Greece  
asaris@ret.forthnet.gr

<sup>80</sup> Hoepfner and Schwandner 1994; Cahill 2002.

<sup>81</sup> Hoepfner and Schwandner's *Haus und Stadt im klassischen Griechenland* (1994, originally published in 1986) is a key proponent of this view. Although *Haus und Stadt* has been roundly criticized for exaggerating the impact of democracy and basing its conclusions on (at times) scant archaeological data (see, e.g., Cahill 2002, 194–222), its basic premise in identifying the characteristics of Greek town planning and domestic architecture is valid, and the book stands out as one of the most influential works on Greek urbanism.

<sup>82</sup> Only the exceptional cases of Olynthus in Macedonia and Kassope in Epirus, both creations of the late fifth and the fourth century B.C.E., have a noticeable role in modern discourses on Greek town planning and domestic architecture.

<sup>83</sup> Ault 2005.

## Works Cited

- Agapiou, A., D. Hadjimitsis, D. Alexakis, and A. Sarris. 2012. "Observatory Validation of Neolithic Tells ("Magoules") in the Thessalian Plain, Central Greece, Using Hyperspectral Spectroradiometric Data." *JAS* 39:1499–512.
- Alexakis, D., A. Agapiou, D.G. Hadjimitsis, and A. Sarris. 2012. "Remote Sensing Applications in Archaeological Research." In *Remote Sensing—Applications*, edited by B. Escalante, 435–62. InTech. [www.intechopen.com/books/remote-sensing-applications/remote-sensing-applications-in-archaeology](http://www.intechopen.com/books/remote-sensing-applications/remote-sensing-applications-in-archaeology).
- Alexakis, D., A. Sarris, T. Astaras, and K. Albanakis. 2010. "Application of GIS, Remote Sensing, and Geomorphology to the Reconstruction of Habitation in Neolithic Thessaly, Greece." *Society for Archaeological Sciences Bulletin* 33:2–4.
- Andreou, E., and I. Andreou. 2007. *Ἡλις: η πόλη των Ολυμπιακών αγώνων*. Athens: Ministry of Culture, Greek Archaeological Receipts Fund.
- . 2012. "Αρχαία Ἡλις." *ArchDelt* 56–59:479–96.
- Ault, B.A. 2005. *The Excavations at Ancient Halieis*. Vol. 2, *The Houses: The Organization and Use of Domestic Space*. Bloomington: Indiana University Press.
- Boyd, T.D., and M.H. Jameson. 1981. "Urban and Rural Land Division in Ancient Greece." *Hesperia* 50:327–42.
- Cahill, N. 2002. *Household and City Organization at Olynthus*. New Haven: Yale University Press.
- Carter, J.C. 2006. *Discovering the Greek Countryside at Metaponto*. Ann Arbor: University of Michigan Press.
- Castagnoli, F. 1971. *Orthogonal Town Planning in Antiquity*. Cambridge: MIT Press.
- Champan, J., M.Y. Videiko, D. Hale, B. Gaydarska, N. Burdo, K. Rassmann, C. Mischka, J. Müller, A. Korvin-Piotrovskiy, and V. Kruts. 2014. "The Second Phase of the Trypillia Mega-Site Methodological Revolution: A New Research Agenda." *EJA* 17:369–406.
- Clavel-Lévêque, M., ed. 1983. *Cadastrés et espace rural: Approches et réalités antiques*. Paris: Editions du Centre National de la Recherche Scientifique.
- Cooper, F.A., M.E. Bauer, and B.C. Cullen. 1991. "Satellite Spectral Data and Archaeological Reconnaissance in Western Greece." In *Applications of Space-Age Technology in Anthropology*, edited by C. Behrens and T. Sever, 63–79. [Bay St. Louis], Miss.: NASA Science and Technology Laboratory, John C. Stennis Space Center.
- de Polignac, F. 1995. *Cults, Territory, and the Origins of the Greek City-State*. Chicago: The University of Chicago Press.
- Dimakopoulou, A. 1967. "Εργασίαι καθαρισμού και διαμορφώσεως χώρου αρχαίας Μαντινείας." *ArchDelt* 20:177–78.
- Donati, J.C. 2014. "The City in the Greek and Roman World." In *Oxford Handbook of Greek and Roman Art and Architecture*, edited by C. Marconi, 269–93. New York: Oxford University Press.
- Eder, B. 2001. "Die Anfänge von Elis und Olympia: Zur Siedlungsgeschichte der Landschaft Elis am Übergang von der Spätbronze- zur Frühheisenzeit." In *Forschungen in der Peloponnes*, edited by V. Mitsopoulos-Leon, 233–43. Athens: Österreichisches Archäologisches Institut.
- Eder, B., and V. Mitsopoulos-Leon. 1999. "Zur Geschichte der Stadt Elis vor dem Synoikismos von 471 v. Chr. Die Zeugnisse der geometrischen und archaischen Zeit." *ÖJh* 68:1–39.
- Everaerts, J. 2008. "Unmanned Aerial Vehicles for Photogrammetry and Remote Sensing." In *Advances in Photogrammetry, Remote Sensing and Spatial Information Sciences: 2008 ISPRS Congress*, edited by Z. Li, J. Chen, and E. Baltasavias, 117–24. London: Taylor and Francis Group.
- Fougères, G. 1887. "Fouilles de Mantinée (juin–septembre 1887)." *BCH* 11:485–90.
- . 1890a. "Fouilles de Mantinée: I. L'enceinte et ses environs." *BCH* 14:65–90.
- . 1890b. "Fouilles de Mantinée: II. Topographie intérieure." *BCH* 14:245–71.
- . 1896. "Inscriptions de Mantinée." *BCH* 20:119–66.
- . 1898. *Mantinée et l'Arcadie orientale*. Paris: A. Fontemoing.
- Gell, W. 1831. *Probestücke von Städtewauern des alten Griechenlands*. Munich: J.G. Cotta.
- Glaser, F. 2001. "Das Theater von Elis und das Problem einer Hölzernen Skene." In *Forschungen in der Peloponnes*, edited by V. Mitsopoulos-Leon, 253–56. Athens: Österreichisches Archäologisches Institut.
- Greco, E., and M. Torelli. 1983. *Storia dell'urbanistica: Il mondo greco*. Rome: Editori Laterza.
- Heiden, J. 2006. "Die Agorai von Elis und Olympia." In *Die griechische Agora*, edited by W. Hoepfner and L. Lehman, 53–8. Mainz: Philipp von Zabern.
- Hodkinson, S., and H. Hodkinson. 1981. "Mantineia and the Mantinike: Settlement and Society in a Greek Polis." *BSA* 76:239–96.
- Hoepfner, W., ed. 1999. *Geschichte des Wohnens*. Stuttgart: Deutsche Verlags-Anstalt.
- . 2002–2005. "Der Stadtplan von Messene." *AAA* 35–38:223–27.
- Hoepfner, W., and E.-L. Schwandner. 1994. *Haus und Stadt im klassischen Griechenland*. 2nd rev. ed. Wohnen in der klassischen Polis 1. Munich: Deutscher Kunstverlag.
- Hölscher, T. 1998. *Öffentliche Räume in frühen griechischen Städten*. Schriften der Philosophisch-Historischen Klasse der Heidelberger Akademie der Wissenschaften 7. Heidelberg: C. Winter.
- Karagiorga, T.G. 1963. "Καθαρισμός και διαμορφώσεις αρχαιολογικού χώρου Μαντινείας." *ArchDelt* 17:86.
- . 1965. "Αρχαία Μαντινεία." *ArchDelt* 18:88–90.
- . 1974. "Αρχαία Ἡλις." *ArchDelt* 26:138–42.
- Karapanagiotou, A.V. 2005. "Preliminary Notices on the Discovery of a Planned, Classical Town near Kyparissia, Gortynia." In *Ancient Arcadia: Papers from the Third International Seminar on Ancient Arcadia Held at the Norwegian Institute at Athens, 7–10 May 2002*, edited by E. Østby, 331–50. Athens: Norwegian Institute at Athens.
- Konecny, A.L., M.J. Boyd, R.T. Marchese, and V. Aravantinos. 2012. "The Urban Scheme of Plataiai in Boiotia: Report on the Geophysical Survey, 2005–2009." *Hesperia* 81:93–140.
- Krause, C. 1979. "Structure et développement urbanistique d'Éretrie archaïque." In *Gli Eubei in Occidente: Atti del diciottesimo convegno di studi sulla Magna Grecia, Taranto*,

- 8–12 *Ottobre 1978*, 37–52. Taranto: Istituto per la Storia e l'Archeologia della Magna Grecia.
- Lolos, Y., and B. Gourley. 2011. "The Town Planning of Hellenistic Sikyon." *AA*:87–140.
- Lolos, Y.A., B. Gourley, and D.R. Stewart. 2007. "The Sikyon Survey Project: A Blueprint for Urban Survey?" *JMA* 20:267–96.
- Maher, M. 2014. "In Defense of Arkadia: The City as a Fortress." In *Urban Dreams and Realities in Antiquity: Remains and Representations of the Ancient City*, edited by A.M. Kamezis, 15–45. Leiden: Brill.
- Marchetti, P. 1993. "Recherches sur les mythes et la topographie d'Argos, 1: Hermès et Aphrodite." *BCH* 117:211–23.
- Martin, R. 1974. *L'urbanisme dans la Grèce antique*. Paris: A. & J. Picard.
- Masini, N., R. Coluzzi, and R. Lasaponara. 2011. "On the Airborne Lidar Contribution in Archaeology: From Site Identification to Landscape Investigation." In *Laser Scanning, Theory and Applications*, edited by C.C. Wang, 263–90. InTech. [www.intechopen.com/books/how-to-link/laser-scanning-theory-and-applications](http://www.intechopen.com/books/how-to-link/laser-scanning-theory-and-applications).
- McAllister, M.H. 2005. *The Excavations at Ancient Halieis*. Vol. 1, *The Fortifications and Adjacent Structures*. Bloomington: Indiana University Press.
- Minon, S. 2007. *Les inscriptions Éléennes dialectales (VIe–IIIe siècle avant J.C.)*. Geneva: Droz.
- Montufo, A.M. 1997. "The Use of Satellite Imagery and Digital Image Processing in Landscape Archaeology: A Case Study from the Island of Mallorca, Spain." *Geoarchaeology* 12:71–85.
- Müth, S. 2007. *Eigene Wege: Topographie und Stadtplan von Messene in spätklassisch-hellenistischer Zeit*. Rahden: Marie Leidorf.
- Papamarinopoulos, S. 1991. "Μαντινεία." *Ergon* 37:21–3.
- . 1992. "Μαντινεία." *Ergon* 38:23–5.
- . 1993. "Μαντινεία." *Ergon* 39:20–2.
- Papathanasopoulos, Y.A. 1969. "Ηλεία." *ArchDelt* 23:162–65.
- . 1970. "Αρχαία Ηλεία." *ArchDelt* 24:152–54.
- . 1972. "Αρχαία Ηλεία." *ArchDelt* 25:193–94.
- Pariante, A., M. Piérart, and J.-P. Thalmann. 1998. "Les recherches sur l'agora d'Argos: Résultats et perspective." In *Argos et l'Argolide: Topographie et urbanisme*, edited by A. Pariante and G. Touchais, 211–31. Paris: École Française d'Athènes.
- Roebuck, C.A. 1972. "Some Aspects of Urbanization in Corinth." *Hesperia* 41:96–127.
- Rowlands, A., and A. Sarris. 2007. "Detection of Exposed and Subsurface Archaeological Structures Using Multi-sensor Remote Sensing." *JAS* 34:795–803.
- Roy, J. 1997. "The Perioikoi of Elis." In *The Polis as an Urban Center and as a Political Community*, edited by M.H. Hansen, 282–320. Acts of the Copenhagen Polis Centre 4. Copenhagen: Royal Danish Academy of Sciences and Letters.
- . 2002. "The Synoicism of Elis." In *Even More Studies in the Ancient Greek Polis*, edited by T.H. Nielsen, 249–64. Papers from the Copenhagen Polis Centre 6. Stuttgart: Franz Steiner.
- . 2005. "Synoikizing Megalopolis: The Scope of the Synoicism and the Interests of Local Arkadian Communities." In *Ancient Arcadia: Papers from the Third International Seminar on Ancient Arcadia Held at the Norwegian Institute at Athens, 7–10 May 2002*, edited by E. Østby, 261–70. Athens: Norwegian Institute at Athens.
- . 2007. "The Urban Layout of Megalopolis in Its Civic and Confederate Context." In *Building Communities: House Settlement and Society in the Aegean and Beyond*, edited by R. Westgate, N. Fisher, and J. Whitley, 289–95. British School at Athens Studies 15. London: British School at Athens.
- Rudolph, W.W. 1984. "Excavations at Porto Cheli and Vicinity: Preliminary Report, 6. Halieis, the Stratigraphy of the Streets in the Northeast Quarter and Lower Town." *Hesperia* 53:123–70.
- Sanders, G.D.R. 2005. "Urban Corinth: An Introduction." In *Urban Religion in Roman Corinth: Interdisciplinary Approaches*, edited by D.N. Schowalter and S.J. Friesen, 11–24. Harvard Theological Studies 53. Cambridge: Harvard University Press.
- Sarris, A. 1992. "Shallow Depth Geophysical Investigation Through the Application of Magnetic and Electric Resistance Techniques: An Evaluation Study of the Responses of Magnetic and Electric Resistance Techniques to Archaeogeophysical Prospection Surveys in Greece and Cyprus." Ph.D. diss., University of Nebraska.
- . 2008. "Remote Sensing Approaches/Geophysical." In *Encyclopedia of Archaeology*. Vol. 3, edited by D.M. Pearsall, 1912–21. New York: Academic Press.
- Sarris, A., and R. Jones. 2000. "Geophysical and Related Techniques Applied to Archaeological Survey in the Mediterranean: A Review." *JMA* 13:3–75.
- Sarris, A., and E. Monahan. 2012. "Matters of Integration and Scale: New Efforts in Magnetometry Data Management at a Late Neolithic Settlement Site in Hungary." In *Proceedings of the 16th International Conference on Cultural Heritage and New Technologies*, edited by W. Börner, S. Uhlirz, and L. Dollhofer, 213–28. Vienna: Museen der Stadt Wien–Stadtarchäologie.
- Sarris, A., N. Papadopoulos, A. Agapiou, M.C. Salvi, D. Hadjimitsis, W. Parkinson, R. Yerkes, A. Gyucha, and P. Duffy. 2013. "Integration of Geophysical Surveys, Ground Hyperspectral Measurements, Aerial and Satellite Imagery for Archaeological Prospection of Prehistoric Sites: The Case Study of Vésztő-Mágor Tell, Hungary." *JAS* 40:1454–70.
- Smekalova, T.N., and S.L. Smekalov. 2006. "Ancient Roads and Land Divisions in the Chora of the European Bosphoros and Chersonesos on the Evidence of Air Photographs, Mapping and Surface Surveys." In *Surveying the Greek Chora: The Black Sea Region in a Comparative Perspective*, edited by P.G. Bilde and V.F. Stolba, 207–48. Aarhus: Aarhus University Press.
- Steinhauer, G. 1979. "Αρχαία Μαντινεία." *ArchDelt* 29: 296–301.
- Tritsch, F. 1932. "Die Agora von Elis und die altgriechische Agora." *ÖJh* 27:64–105.
- Tsiolis, V. 2002. *Mantineia-Antigonea: Aspectos históricos de una ciudad arcadia*. Toledo: Bremen.
- Tsokas, N., A. Sarris, A. Stampolidis, G. Vargemezis, and

- L. Kolonas. 2012. "Geophysical Exploration in Ancient Elis." In *Πρακτικά του 5ου συμποσίου της Ελληνικής αρχαιομετρικής εταιρείας*, edited by N. Zacharias, M. Georgakopoulou, K. Polikreti, G. Fakorellis, and T. Vakoulis, 41–55. Athens: Ekdoseis Papazisi.
- Viret Bernal, F. 1992. "Argos: Du palais à l'agora." *Dialogues d'histoire ancienne* 18:61–88.
- Walter, O. 1913. "Vorläufiger Bericht über die Grabungen in Elis 1911–1912." *ÖJh* 16:145–51.
- . 1915. "Vorläufiger Bericht über die Grabungen in Elis 1914." *ÖJh* 18:61–76.
- Ward-Perkins, J.B. 1974. *Cities of Ancient Greece and Italy: Planning in Classical Antiquity*. London: Sidgwick and Jackson.
- Whitley, J., S. Germanidou, D. Urem-Kotsou, A. Dimoula, I. Nikolakopoulou, A. Kamava, and D. Evely. 2007. "Archaeology in Greece 2006–2007." *AR* 53:1–121.
- Williams, H. 2005. "The Exploration of Ancient Stymphalos, 1982–2002." In *Ancient Arcadia: Papers from the Third International Seminar on Ancient Arcadia Held at the Norwegian Institute at Athens, 7–10 May 2002*, edited by E. Østby, 397–411. Athens: Norwegian Institute at Athens.
- Winter, F.E. 1987. "Arkadian Notes I: Identification of the Agora Buildings at Orchomenos and Mantinea." *EchCl* 31:235–46.
- . 1989. "Arkadian Notes II: The Walls of Mantinea, Orchomenos and Kleitor." *EchCl* 35:189–200.
- Yalouris, N. 1968a. "Ηλεία." *ArchDelt* 21:170–73.
- . 1968b. "Ηλεία." *ArchDelt* 22:208–10.
- . 1996. *Ancient Elis: Cradle of the Olympic Games*. Athens: Adam Edition.