The Locating of an Unknown Archaeological Site in the Valley of Filippi, Eastern Macedonia, Greece with the Use of Aerial Photographs, Satellite Images and GIS

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Abstract

This paper presents marks of an unknown buried settlement in the study area between the ancient Amphipoli and up to the area of Philippi (Eastern Macedonia, Greece), which covers approximately 0.275km^2.

The research started with the processing and study of diachronic archive aerial photos of different scales. In this data, only few diachronic weak crops and soil marks were located, whose geometrical characteristics (size, shape etc.) implied further research. Thus, three satellite images (QuickBird-2 and WorldView-1) were studied, revealing a group of marks of specific (organized) formation (Hippodemean system). The size and the arrangement of marks imply the existence of a buried settlement. During the survey conducted in the places where the marks were found, a lot of roman surface ceramics were collected, that confirms the initial hypothesis of the unknown archaeological site. Excavation cuttings are being programmed and will soon take place.

Keywords

Aerial and Remote Sensing Archaeology, diachronic aerial photos, diachronic-seasonal satellite images, crops and soil marks, survey, unknown buried settlement

1. Introduction

Over the last few years, the Laboratory of Photogrammetry and Remote Sensing of the Department of Surveying Engineering, Polytechnic School of the Aristotle University of Thessaloniki, Greece has pursued systematic research of Aerial and Satellite Archaeology to locate the ancient Via Egnatia from Amphipoli up to the area of Philippi (*Figs. 1* and *2*), in the area of Eastern Macedonia, Northern Greece (Kaimaris 2006). This is an area of major archaeological interest, because it has been inhabited from the Paleolithic era, and it flourished during the Hellenistic and Roman years. Hundreds of black-and-white, vertical, diachronic aerial photos, satellite images, historical and modern maps etc. were used. The methodical development of the data derived from the research resulted in the new Geographical System of Mark Management (Roustanis *et al.* 2007) for locating and managing the ancient road network. Along the road many covered marks and well-preserved, probably ancient constructions were found.

Excavations (Karadedos and Nikolaidou 2007) that took place (*Fig. 3*) during the first stage of the research to locate the ancient Egnatia road reinforced, based on the marks found, the initial hypotheses and confirmed the capacity of the methodological procedure of locating buried monuments.

This paper concentrates upon the locating marks of a hitherto unknown buried settlement in the valley of Philippi (*Fig. 2*).

2. Data

Aerial photos were on the following scales: 1945 at 1:42,000, 1965 at 1:7,000, of 1993 (24/6/1993) at 1:30,000 and 1996 (2/10/1996) at 1:15,000, and two satellite images QuickBird-2 (2/5/2002 and 24/11/2003), and a satellite image WorldView-1 (1/12/2007) cover the geographical position of the buried settlement. Furthermore, the oldest land distribution map dates back to 1928, and is on a scale

Fig. 1. Map of Greece.

Fig. 3. Excavation cutting. Via Egnatia. (Karadedos and Nikolaidou 2007).

of 1:5,000. The geographical position of the buried settlement (*Fig. 2*, frame with red color) is covered.

3. Photogrammetric processing and photo interpretational study of the diachronic-seasonal remote sensing data

After the digitisation and the classification of the images (aerial photos), their mediocre quality (lighting and low contrast) required their digital processing (histogram equalization, brightness/ contrast, sharpen, unsharp mask, convolution, Wallis filter) to improve their photometric characteristics. The aforementioned proceedings were followed by the photogrammetric processing of the images

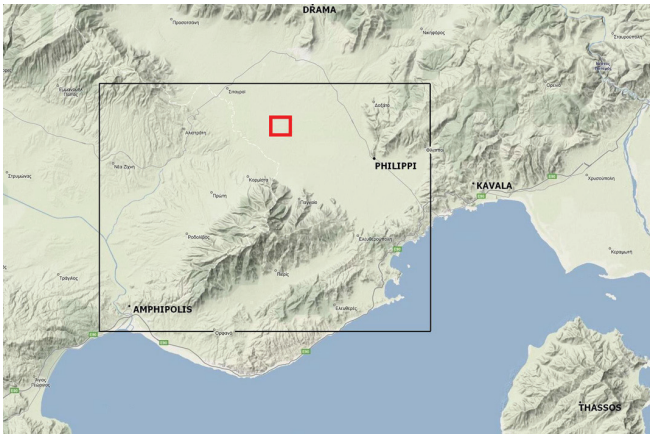

Fig. 2. Eastern Macedonia. Frame with black color, the corresponding wider region of study of Fig. 1. *Frame with red color, the geographical position of the buried settlement.*

(aerial photos and satellite images) using Ground Control Points (GCPs) and the Digital Terrain Model (DTM) of the area. Besides these, with the processing of the initial satellite data, fusion images were created, where the spectral information of the initial multispectral images was preserved (Georgoula *et al.* 2004). The spatial accuracy of the geo-referenced images (GGRS '87, Greek Geodesic Referencing System 1987) was better than 50cm.

There are two stages of photo interpretation. In the first stage the analog images were monoscopically and stereoscopically observed with the use of a mirror stereoscope. In the second stage, the transformed digitally shaped analog images and the primary digital ones were observed on a PC not only monoscopically, but also stereoscopically.

4. New Geographical System of Mark Management

For the optimum management, correlation and development of research data, such as the diachronic aerial photos and satellite images, historical maps, land distribution, the results of the survey (photos, videos, coordinates of archaeological places etc.) of the images of ground archaeological sensing etc., a new Geographic System of Mark Management was created (Roustanis *et al.* 2007). With user-friendly interfaces, it permits a quick and easy use of the system for researchers with minimum computer knowledge. The attribution of marks is conducted within the system (to the surface of the geo-referenced images) and permits their chronological and morphological classification. Furthermore, the identity of the remote sensing image, in which the mark was detected, is

included in the database system. All the marks that were observed and attributed are projected to the surface of a new image that will be photo interpreted. Consequently, the position of the marks is located, their probable presence is detected and new marks are attributed. Finally, the correlation of marks with the historical maps permits the mark identification of buried constructions (e.g. old rural road of 1930 presented on the maps of land distribution) and their grouping to marks of known and unknown buried constructions.

5. Marks of an unknown buried settlement

Within the framework of the research hundreds of buried constructions were located by crop or soil marks in the diachronic remote sensing data. Besides the Via Egnatia, which was the main target of the research, a lot of potential archaeological sites, like burial remains, ancillary roads of the Egnatia road, ditches etc. were also located. This paper will focus on the marks of a so far unknown archaeological site, remains of a settlement that is located by the negative crop and soil marks (presence of a concrete construction below the ground, humidity absence resulting in the presence of negative crop and soil marks).

In the aerial photo of 1945, scale 1:42,000 (*Fig. 4*), weak negative rectilinear marks in the middle and right of the image and an intense negative mark of an irregular shape to the lower part of the image were observed. The scale and the quality of the aerial photo did not permit the differentiation of the crop and the soil. Also, the lack of knowledge at the time the image was taken did not provide information about the intensity and the number of marks. The superimposition with the land distribution map of 1928 (*Fig. 5*), revealed the preservation of properties from 1928 till 1945. Apart from that, the non-identification of marks with constructions of 1928 was established.

In the aerial photo of 1965, scale of 1:7,000 (*Fig 6*), the marks were preserved not only on the ground, but also on the cultivations. At the same time, a drain ditch to the lower part of the image (northern-eastern direction) was also observed. The lack of knowledge at the time the image was taken did not allow for any information about marks to be taken.

In the aerial photo of 1993 (24/6/1993), scale of 1:30,000, weak crops marks were located (*Fig. 7*). The covering of a ditch was observed at the lowest part of the image and the appearance of a positive crop mark in the relevant location (retention of humidity, growing of crop, presence of positive crop mark). The crops were at the last stage of their growth, which explained the low intensity of observation and the small number of marks. Analytical archival information (National Meteorological Service)

Fig. 4. Aerial photo of 1945, Hellenic Military Geographical Service (HMGS), scaled 1:42,000. Soil or/and crop marks. Right: designing of marks with white color.

about the meteorological-climatological conditions before and until the date the image was taken does not exist. Finally, with the help of superimposition on the distribution map (*Fig. 8*), the changes to the properties dimensions, that took place from 1965 till 1993, were defined.

In the aerial photo of 1996 (2/10/1996), scale of 1:7,000, the time the image was taken revealed the existence of marks of buried constructions (*Fig. 9*). Also in this case, there is no detailed meteorological-climatological information.

At this stage of the research, the first conclusions related to the marks were:
– continuous presence of marks, in the same places, from 1945 until 1996,
– attribution of rectilinear marks on buried roads, that were constructed before the year of 1928.

When the scientific team completed processing the analog archival data, it decided to take into account contemporary satellite data, in order for them to research further on the geographical place of the marks.

Two satellite images QuickBird-2 (spatial resolution panchromatic 0,6m and multispectral image 2,4m) were selected for the mark area dated 24/11/2003 (*Fig. 10*) and 2/5/2002 (*Fig. 11*).

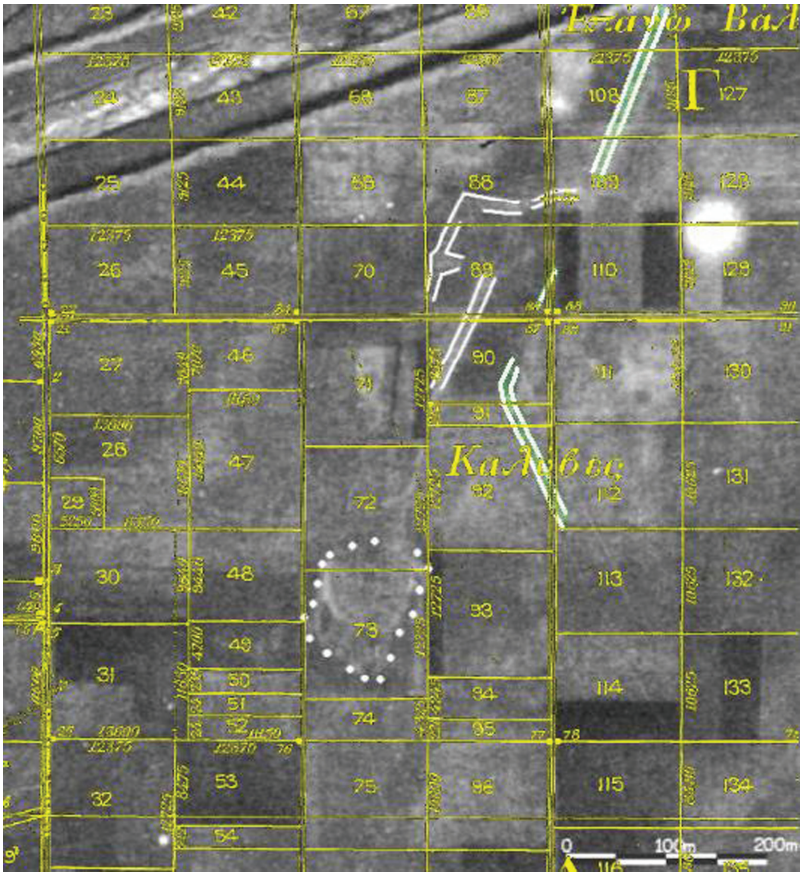

Fig. 5. Aerial photo of 1945 and map of land distribution 1928 (yellow color).

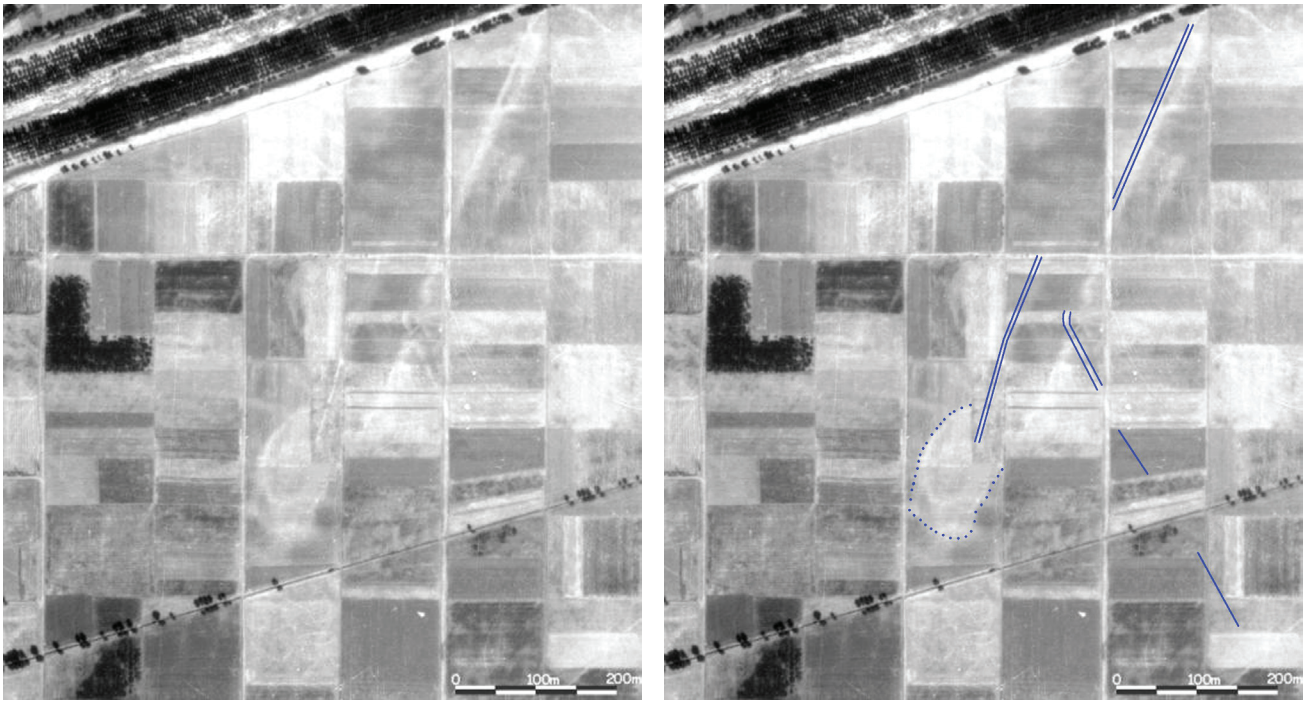

Fig. 6. Aerial photo of 1965, Hellenic Mapping and Cadastral Organization (HMCO), scaled 1:7,000. Soil and crop marks. Right: designing of marks with blue color.

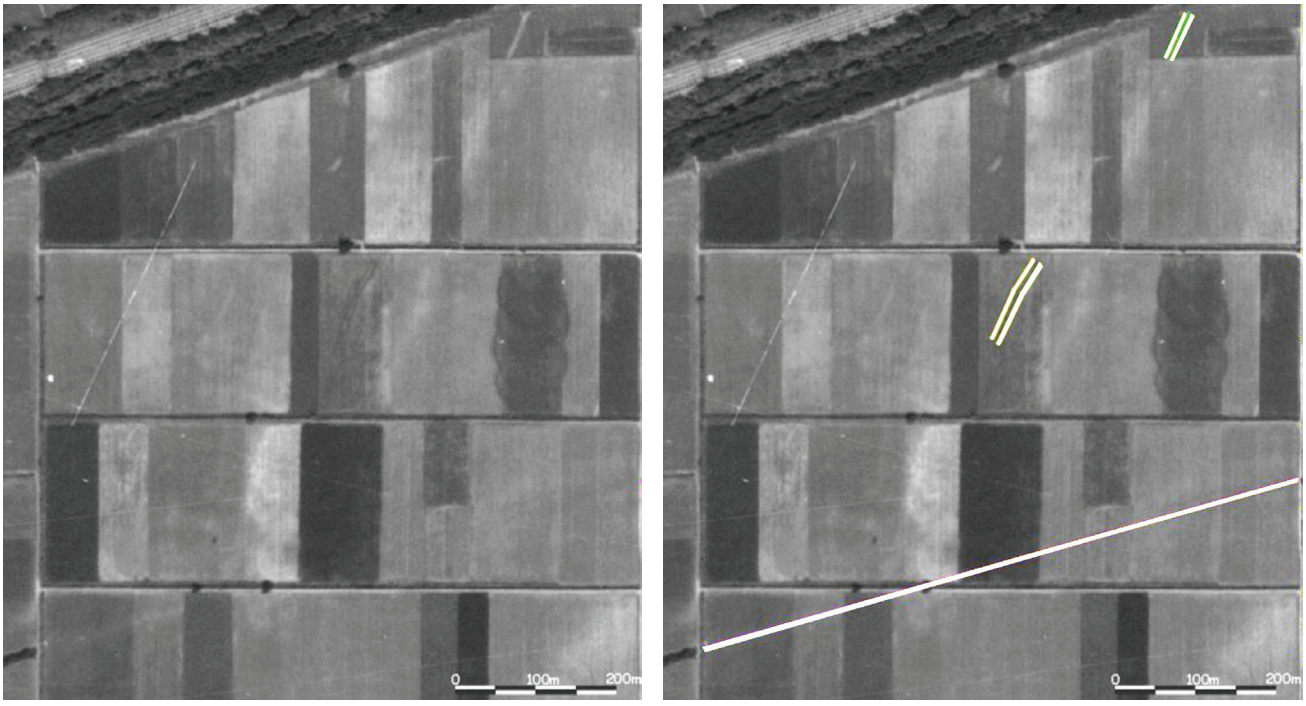

Fig. 7. Aerial photo of 1993, HMGS, scaled 1:30,000. Weak crop marks.

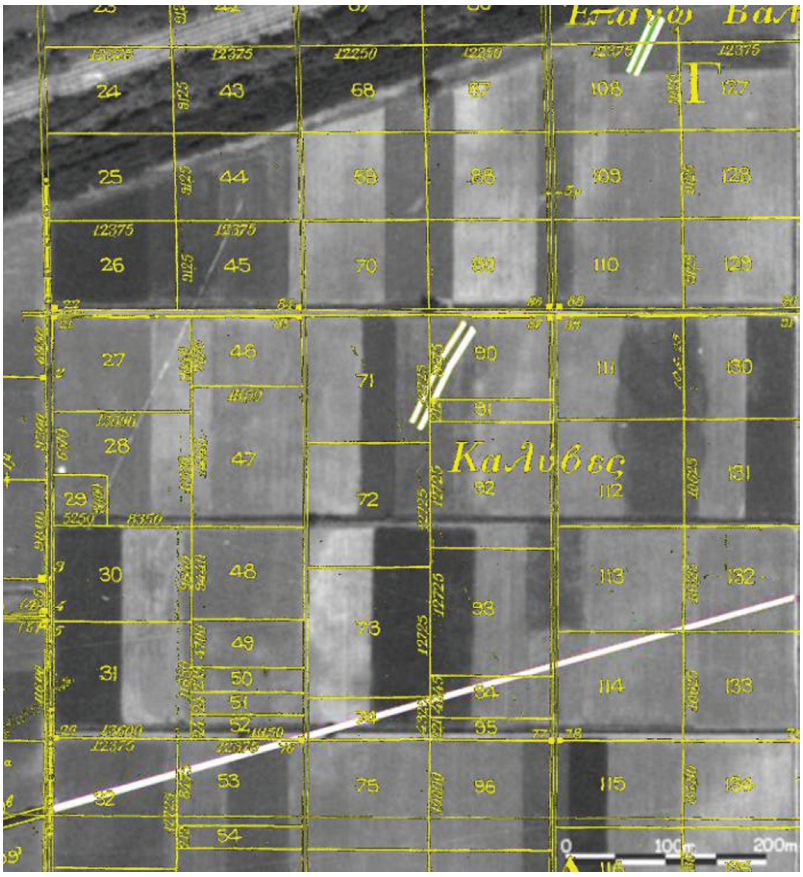

Fig. 8. Aerial photo of 1993, HMGS, scaled 1:30,000 and map of land distribution 1928.

In the satellite image QuickBird-2, taken at 24/11/2003 (*Fig. 10*), a low number of crop marks (use of infrared channel) were located in the same places that were located on the diachronic aerial photos. The detailed meteorological-climatological data showed that there were normal conditions for the season, for a long period before and until the moment the image was taken. This fact in conjunction with the dense vegetation can interpret the weak tension and the small number of marks.

In the satellite image QuickBird-2, taken at 2/5/2002 (*Fig. 11*), a group of linear negative ground marks (in the infrared channel) of 4-5m width, that create rectangles of approximately 50x50m, was discovered. The arrangement and the geometry of the marks refer to the Hippodamean system. Their surface covers almost 0.275km^2. The superimposition of the land distribution map of 1928 on the satellite image (*Fig. 12*) proved that the marks were not formed because of the boundaries of the old properties or the covered rural roads. Consequently, they were formed by concrete constructions, before 1928 and it is possible that they come from the remains of a so far unknown, buried settlement. The time the image was taken and the vegetative period ended up constituting the best conditions for the observation of buried constructions marks in the particular research area. This fact is reinforced by the detailed meteorological-

Fig. 9. Aerial photo of 1996, HMCO, scaled 1:7,000. Crop marks.

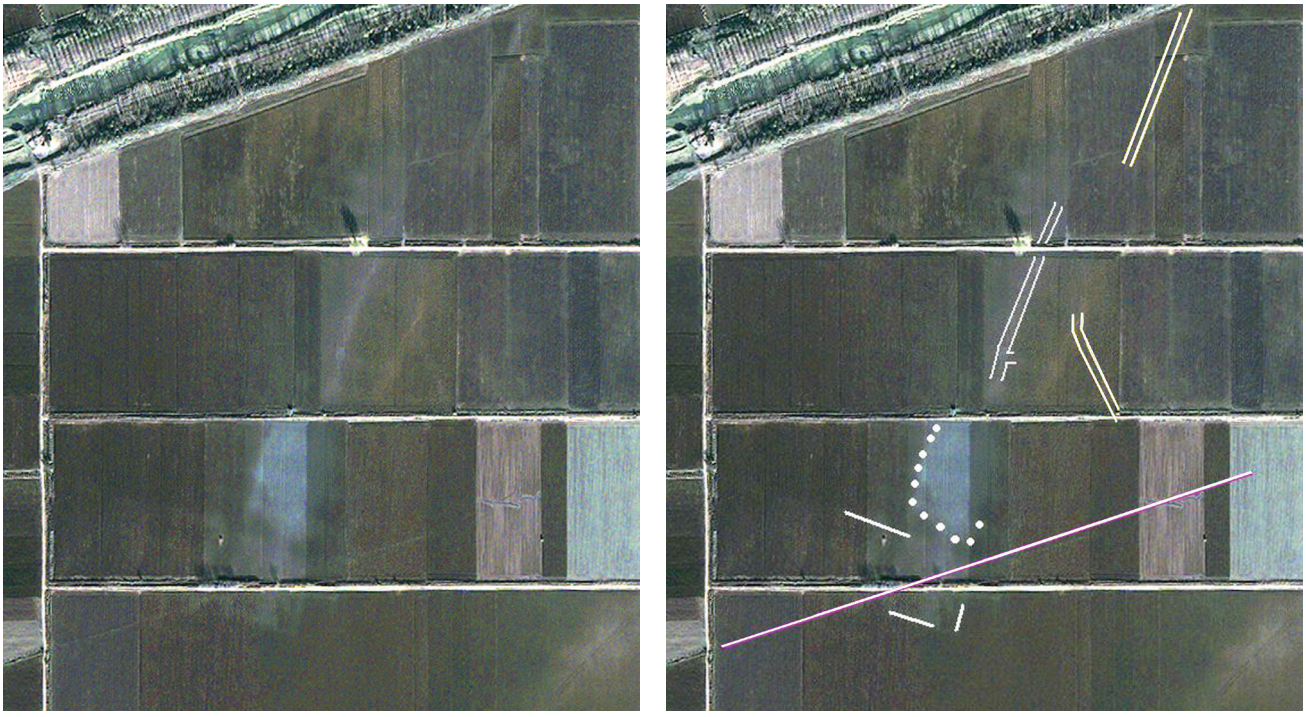

Fig. 10. QuickBird-2, 24/11/2003. Fusion image, spatial resolution 0,6m. Crop marks.

climatological data and if confirmed that during the period of taking the photo there were normal climatological conditions for this particular season.

While the marks of the settlement have been revealed in the satellite image QuickBird-2 of 2002, the interest of the team in the study of new satellite visual systems led to the collection and photo-interpretation of the only satellite image of the area of the WorldView-1 system (panchromatic image, spatial resolution 0,5m), dated 1/12/2007 (*Fig. 13*). In this image a lot of the marks of the buried settlement have been detected. Whereas the date of taking is almost the same as that of the satellite QuickBird-2 of *Fig. 10* (different year), a higher tension and a higher number of marks were observed. Because of the absence of a multispectral image, the distinctness of the cultivated area from the bare ground was not objective. The research team considers that, on

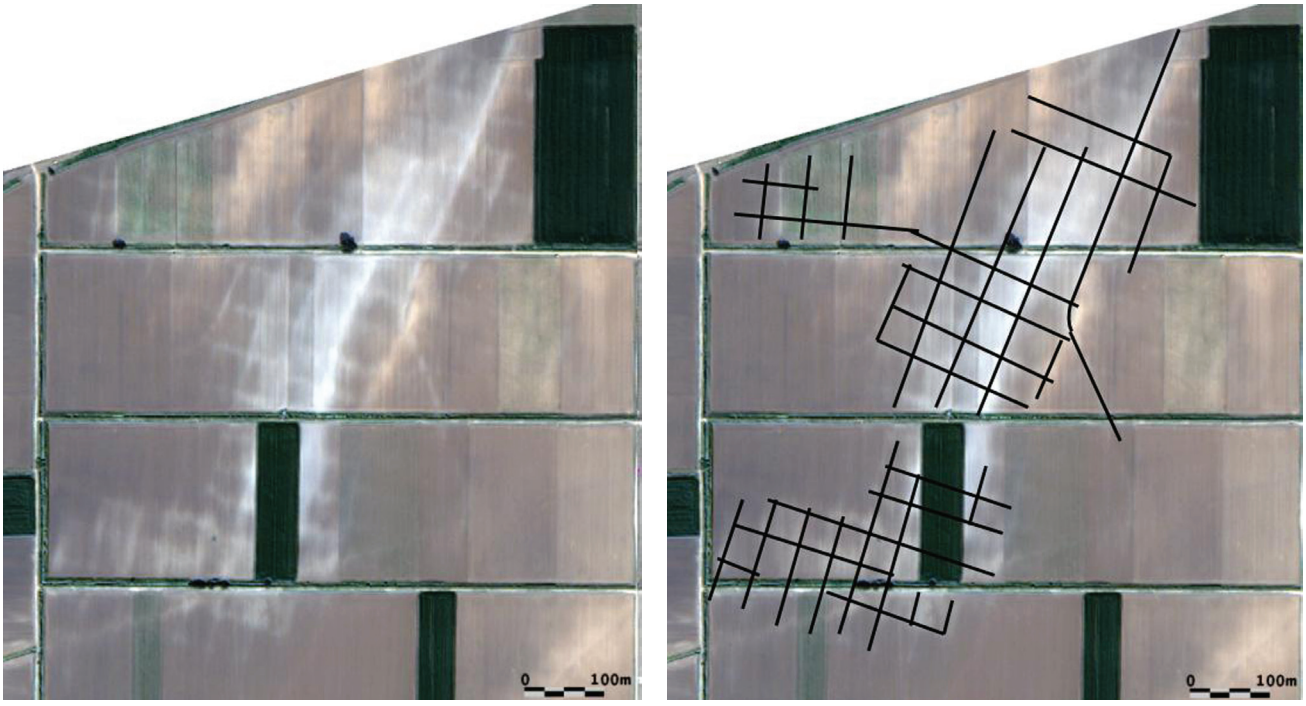

Fig. 11. QuickBird-2, 2/5/2002. Fusion image, spatial resolution 0,6m. Soil marks, buried settlement and designing of marks with black color.

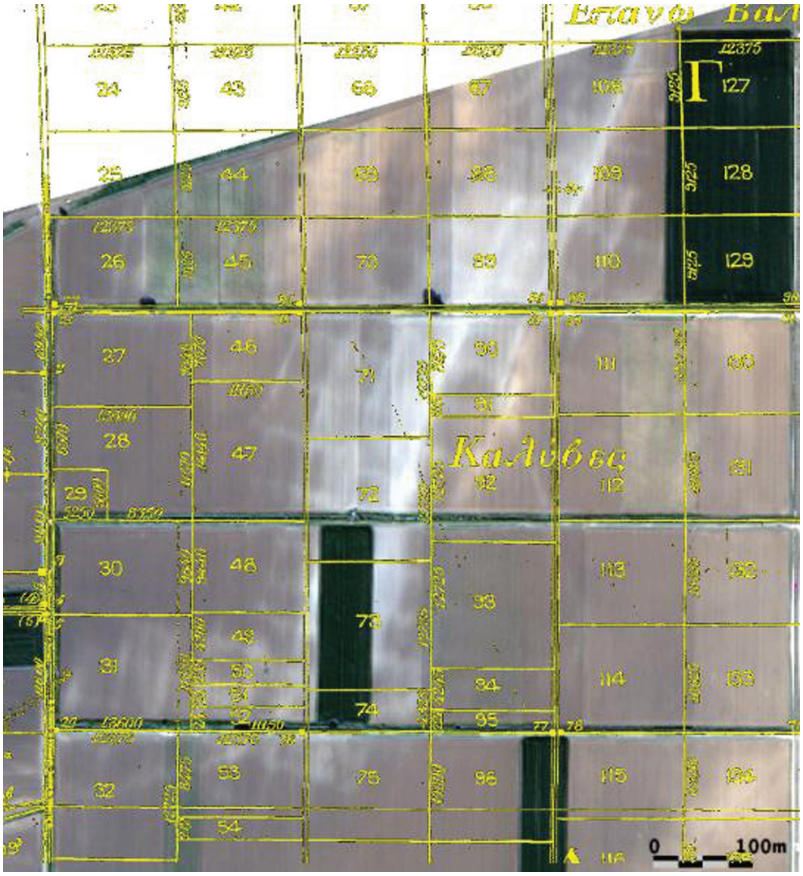

Fig. 12. Superimposition of the land distribution map of 1928 (yellow color) on the satellite image (QuickBird-2, 2/5/2002).

the one hand, the marks were located in the crops and on the other hand that they manifest because of some unusual meteorological-climatological phenomena for the season (absence of analytical data). In no case did the marks not uncover the structure and the normality of the buried settlement that was revealed by the satellite image QuickBird-2 of 2002 (*Fig. 11*).

6. Survey

During the survey conducted by the team in the areas of marks of the buried settlement, a rich variety of Roman ceramics was found (*Fig. 14*). Because of the geo-referencing of the remote sensing data, the transition to the wider area of the settlement and to the locations of the axes of the linear marks was performed with the use of GPS.

7. Conclusions

The research led to the location of an unknown buried settlement in the Valley of Philippi. It is, thus, from here an imperative that the excavation areas for the documentation of the archaeological site take place.

The use of diachronic remote sensing data and historical maps (e.g. land distribution map of 1928) permits the removal of marks of current, buried

Fig. 13. WorldView-1, 1/12/2007. panchromatic image, spatial resolution 0,5m. Crop marks.

constructions, like the drain ditch of the aerial photo of 1965, the mark of which was found in the aerial photo of 1996 and in the satellite images. Besides this, some other marks of unknown constructions were located by their diachronic presence, that need further research.

The vegetative period and the season that αντιστοιχούν to the period of taking the satellite image QuickBird-2 of 2002, are the best for the observation of buried constructions marks in the study area. Finally, the new satellite WorldView-1 has the potential of locating buried constructions marks and it is expected that its future contribution will be important.

Fig. 14. Roman ceramics.

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