

Research Article

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The Role of Archival Aerial Photography in Shaping Our Understanding of the Funerary Landscape of Hellenistic and Roman Cyprus

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Abstract: This study deals with the investigation of the Eastern necropolis of Nea Paphos in western Cyprus, employing archival and recent aerial photographs for the identification of surface/near-surface ancient architectural remains. The analysis of the primary archival aerial photograph employed for this study reveals the archaeological visibility of the site as it had been captured approximately 15 years before its rescue excavation in the 1980s. The outcomes from the enhancement and interpretation of the archival aerial photograph supplement known archaeological information of the area and elucidate the understanding of the spatial distribution of the tombs as well as the geographic extent of the necropolis.

Keywords: Eastern necropolis of Nea Paphos, aerial investigation, archive aerial datasets, architectural feature detection, Hellenistic and Roman Cyprus

1 Introduction

Several parameters, such as weather conditions, agricultural activities and modern development that are taking place over ancient landscapes strongly affect material evidence of the past and particularly surface (i.e. ground level) and near-surface (i.e. shallow) ancient architectural remains. A way to re-view these landscapes before any alteration is possible by studying aerial photographs. Both archival and more recent, these aerial photographs are essential in detecting unknown and understanding known archaeological sites and their natural environment, as well as in documenting recent changes that occurred in a given area. It is important to emphasize that the interpretation part is the most critical step in this process, in order for the aerial data to be successfully transformed and seen as archaeological information (Rączkowski, 2014).

Aerial photography for archaeological needs dates back to the end of the 19th and beginning of the 20th century (Bourgeois & Meganck, 2005; Ceraudo, 2013). Especially in Europe, aerial reconnaissance programs from aerial photographs of the Second World War have been used in the past to support landscape investigations (Cowley, Ferguson, & Williams, 2013). In Cyprus, however, such photographs are rare since only a few systematic aerial campaigns have been made over the island (Agapiou et al., 2016). These were performed by the Department of Lands and Surveys (i.e. 1963, 1993, 2008, 2014) and by military air forces for aerial reconnaissance (i.e. aerial photographs prior to 1960). It is important to highlight that none of these aerial campaigns was initiated as part of an archaeological research project, but rather to support the needs of the Department of Lands and Surveys and other local authorities responsible for land use and planning. Even today, despite the fact that aerial survey specifically commissioned to support archaeological research and archaeological heritage management is a well-established scientific domain (Bewley & Rączkowski, 2002;

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Bewley, 2003; Brophy & Cowley, 2005; Kennedy & Bewley, 2009; Cowley & Ferguson, 2010; Ferguson, 2011; Ceraudo, 2013; Musson, Palmer, & Campana, 2013), Cyprus still lags behind.

This study employs a series of aerial photographs as a primary archaeological tool in order to investigate the area of the Eastern necropolis of Nea Paphos in western Cyprus (Lysandrou & Agapiou, 2017). These photographs were taken over the last 70 years and therefore a diachronic investigation is undertaken, providing insights into the use of the specific landscape, which has changed in terms of the exploitation of the topography over time. Particular focus is given to the interpretation of a recently discovered aerial photograph of 1968, which captured the area of interest approximately 15 years before its large-scale rescue excavation of the 1980s, and more than 70 years from today. The Historic Environment Scotland archives (National Collection of Aerial Photography) (Cowley & Stichelbaut, 2012) provided the photograph.

Processing, refinement and interpretation of the aerial datasets were performed, revealing a series of surface and near surface architectural formations. The main objective of the work was to detect and identify potential tomb patterns based on secure archaeological information. A series of archaeological proxies, possible indications of tombs, were identified through interpretation, based on known data from the specific necropolis such as tombs' location, shape and dimensions (metrics). Recently published results of part of the unpublished archival material of the rescue excavations that took place in the Eastern necropolis during the 1980s validated—where possible—the information retrieved from the interpretation of the aerial photograph, providing additional reliability for the detected features and for the methodology followed (Lysandrou, *in press*; Lysandrou, Agapiou, Michaelides, & Pappasavvas, 2018; V. Lysandrou, *The Eastern necropolis of Nea Paphos through the Space project*. Talk presented at the University of Cyprus, Feb 10th. 2018).

Additionally, the research targeted the detection of hitherto unknown tombs. These “new” discoveries permitted reflection, primarily on the tombs' architecture and typological consistency and secondarily on the tombs' spatial arrangement and the extent of the necropolis.

2 Archaeological and Historical Context

This study deals with the aerial investigation of a significant ancient cemetery of Nea Paphos (Nicolau, 1966), known as the Eastern necropolis of the Hellenistic-Roman capital of Cyprus (Młynarczyk, 1990) (Figure 1). This funerary landscape, extramural itself, lies to the east of the city of Nea Paphos on relatively flat ground. The Eastern necropolis has been excavated by the Department of Antiquities mainly during the 1980s as a result of large-scale rescue excavations (directed by Prof. Emeritus Dimitrios Michaelides), due to the urgent development and expansion of the modern city of Paphos at that time (Lysandrou, Agapiou, & Hadjimitsis, 2015; Lysandrou et al., 2018).

The Hellenistic and Roman tombs excavated in the Eastern necropolis are exclusively underground structures, formed within the natural bedrock and thus wholly integrated into the surrounding landscape. Approximately 400 tombs had been investigated between the years 1983–1990, and morphologically these belong primarily to simple rectangular shafts and secondarily to chambered tombs (Lysandrou, *in press*).

Although a discussion of specific features—with particularly spatial value—found in Hellenistic and Roman cemeteries, such as tomb markers, wells and funerary enclosures, lies outside the scope of this article, it appears that topography was fundamental to the development of ancient cemeteries, as it was for the cities. A landscape-oriented approach of ancient cemeteries could shed light on the interconnection between the ‘city of the dead’ to the ‘city of the living’ (Lysandrou & Agapiou, 2016). The merging of traditional archaeological information with spatial datasets could further enhance such a landscape approach.

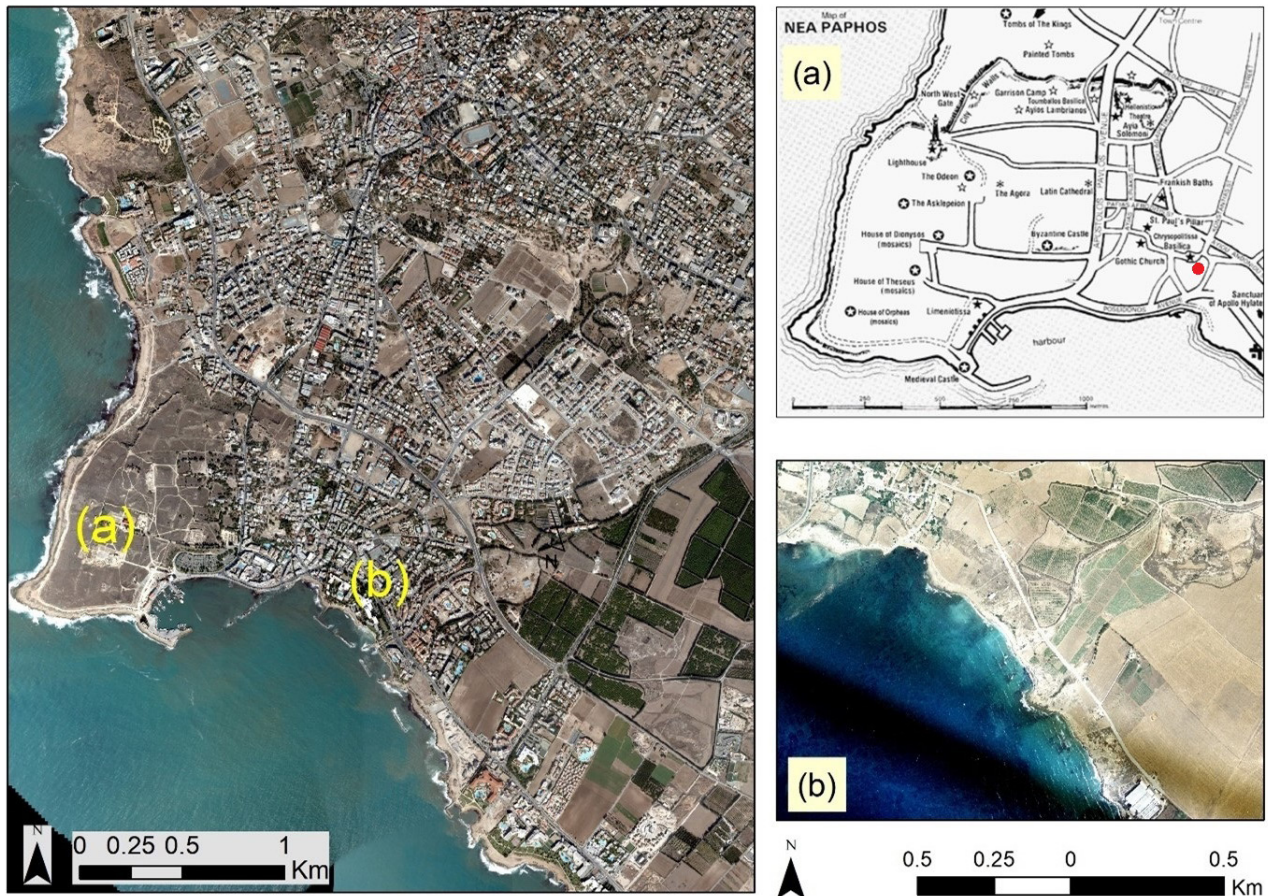


Figure 1: Left: The wider area of Paphos town in western Cyprus (Aerial Orthophoto 2014, Department of Land and Surveyors, Cyprus); (a): Map of Nea Paphos ancient city and suburbs (retrieved from Christou, 2008). The red dot shows an indicative starting point of the Eastern necropolis; (b): The Eastern necropolis of Nea Paphos seen in an archival aerial photograph of 1968 (Historic Environment Scotland).

3 Data and Methodology

3.1 Data

Aerial photographs, both archive and more recent, formed the primary datasets for this research. At a local level, aerial data are available from the systematic mapping of Cyprus, performed by the Department of Lands and Surveys through airborne campaigns during the years 1963, 1993, 2008 and 2014. From these, the 1963 archival photograph series is vital for archaeological investigation since it has been produced before the modern development of the coastal areas of the country. It, therefore, provides an unadulterated view of the landscape. However, this archive photograph series is lacking in terms of spatial resolution compared to the more recent photographs (i.e. 1993, 2008 and 2014), which are characterised by a higher spatial resolution and a broader landscape coverage. Considering the above, it is evident that each series of photographs presents both benefits and drawbacks. Therefore, their co-examination is mandatory to recover as much information as possible.

Apart from the local datasets, other aerial photographs over Cyprus were searched in European repositories. Archive aerial data were found at the Istituto Geografico Militare (Italy), the Royal Air Force Cyprus (UK), and at the National Collection of Aerial Photography (Scotland), as a result of past airborne campaigns over the island, for military or other purposes.

The sum of the available data collected, examined and finally used for the aerial investigation of the Eastern necropolis are presented below in Table 1. They are displayed in chronological order based on the production year of each aerial photograph. The provenance and the accuracy in terms of spatial resolution of each photograph are also provided.

Rows with no highlight in Table 1 refer to occasional/sporadic aerial photography of the area of interest, frequently a result of military reconnaissance, while the rows of Table 1 in grey highlight indicate systematic aerial campaigns that covered the entire island.

The “resource” column refers to the provider of the photograph. It is clarified that the creator of each photograph is not always the same as the provider and it is not always known. Specifically, all systematic campaigns over the island for the years 1993, 2008 and 2014 have been commissioned by the Department of Lands and Surveys to private companies and institutions and covered only the southern part of Cyprus (controlled by the Republic of Cyprus). The 1963 campaign is the only one performed by the Department of Lands and Surveys and the only one that covers the entire territory of the Republic of Cyprus, since it was performed prior the 1974 Turkish invasion and consequent occupation of the northern part of the island.

The “accuracy” column refers to the spatial resolution of each photograph, in terms of a pixel size dimension. The last column shows a preview over the area of the Eastern necropolis.

The oldest known photograph above the area of interest is the one provided by the Italian Istituto Geografico Militare. Even though there is no capture date in the record card of the specific photograph, the Istituto acknowledges 1937 as its creation year. The photo capture perhaps is of German origin, generated for the Stato Maggiore R. Aeronautica - Superaereo - Ufficio Cartografico of the Italian Ministry of Defence, which is documented as the photograph’s author in the relevant record card.

As shown in table 1, the quality of the data varies in terms of the noise level. This noise is primarily due to the means employed for data acquisition and processing. Raw datasets of table 1 from no.1 to no. 6 were produced using analogue air photogrammetric acquisition. These analogue photographs were subsequently converted to digital images by scanning the tape films. This digitisation procedure can also affect the quality of the scanned images due to the scan settings (i.e. dpi resolution; scan distortion) which can then obstruct the final interpretation. The more recent datasets of table 1 (numbers 7 to 9) were produced through digital means (digital photography) (Hammer & Ur, 2019; Hammer & Lauricella, 2017). These specific digital datasets happen to be of better quality in terms of radiometric resolution and sharpness. A parameter that defines the quality of the data is the spatial resolution of the pixel size of the images. Due to the increased capabilities of the sensors over the years, a more detailed capture of the landscape is possible. This sub-meter spatial resolution facilitates the extraction of information, as well as the final interpretation.

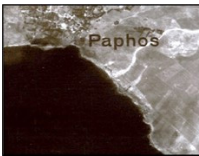
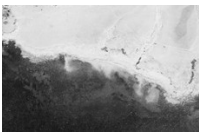
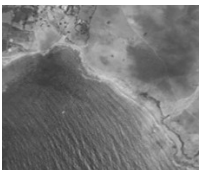
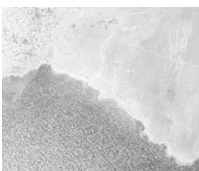





3.2 Methodology

The archival aerial photograph of 1968 was the central information resource of this study, used as the base map on which the rest of the information was layered. The aerial investigation primarily considered areas within the necropolis with concentrations of archaeological proxies, namely: (a) arable, but vegetation-free areas for the detection of soil marks, and (b) areas where the geo-location of tombs was known from previous research (for further explanation refer below to the “Results” section). The overall methodology followed is diagrammatically shown in Figure 2 and includes the following three main steps:

Step 1: Technical preparation

Initially, the archival aerial photograph of 1968 was geometrically corrected using the ArcMAP v.10.2.2 GIS (Geographical Information System) environment. The 1968 aerial photograph was rectified (Figure 3) in a GIS environment using common control points from a recent aerial orthoimage of 2014. The rectification was performed using a second-order polynomial distribution transformation, and the total root mean square (TRMS) error was estimated to approximately 2 meters. To achieve a uniform and accurate rectification of the photograph more than 20 control points were used. Then it was radiometrically enhanced in order to provide a finer visual photointerpretation of the photograph. This procedure involved several linear and non-linear enhancement methods, such as linear and standard deviation histogram stretching and image edge enhancement. Also, various combinations of the red-green-blue (RGB) composites

Table 1: Available aerial data of the Eastern necropolis of Nea Paphos, Cyprus.

No.	Resource creator	Resource provider	Provider's Country	Capture date	Accuracy	Preview
1.	Istituto Geografico Militare	Istituto Geografico Militare	Italy	1937 (?)	Few meters (scale 1:25000)	
2.	Royal Air Force Cyprus UK	Department of Lands and Surveys	Cyprus	12.1941	Few meters (scale 1:20000)	
3.	Royal Air Force Cyprus UK	Department of Lands and Surveys	Cyprus	08.1942	Few meters (scale 1:20000)	
4.	Unknown	Department of Lands and Surveys	Cyprus	08.1957	1 m	
5.	Department of Lands and Surveys	Department of Lands and Surveys	Cyprus	10.1963	1 m	
6.	Unknown	National Collection of Aerial Photography, Historic Environment Scotland	Scotland	1968	Few meters (scale 1:22000)	
7.	Private company	Department of Lands and Surveys	Cyprus	08.1993	0,5 m	
8.	Private company	Department of Lands and Surveys	Cyprus	2008	0,5 m	
9.	Private company	Department of Lands and Surveys	Cyprus	2014	0,2 m	

were implemented and again enhanced. Besides, a Principal Component Analysis (PCA) was performed using the three spectral bands of the aerial image 1968, namely the blue, green and red bands. Subsequently, the various features were digitised directly on the corrected and enhanced aerial photograph. A cartographic symbology was defined to mark these features, based on their shape and geometry. The latest was adopted, taking into consideration previous knowledge on the specific landscape. The symbology included two types of features as follows: (a) archaeological proxies, and (b) topographic/natural features. As far as the archaeological proxies are concerned, those have been further grouped in three sub-categories, namely the concise close forms features (a1), the concise, open forms features (a2) and finally the extensive features (a3). Then the manual digitisation, through interpretation, of the features was performed. It should be noted that the enhancement and filtering process of the rectified aerial photograph was continuous and concurrent with the digitisation and interpretation process. Indeed, during the filtering and interpretation procedures, potential archaeological evidence was directly digitised on the rectified aerial photograph with different colouring based on the above-explained symbology.

Step 2: Collection and correction of auxiliary and supportive datasets

During this stage, recent aerial photographs, existing maps and cartographic products complemented the archival aerial photograph. These datasets also underwent correction and technical preparation as stated above, creating thus a series of orthophotos where accurate measurements were possible. Recent aerial images such as the 2014 orthophoto, Google historic maps, and topographic plans were employed to support understanding and interpretation, as well as to document landscape changes. The overlay of these data into the GIS environment, permitted an assessment on the overall transformation of the area, and helped in understanding major topographic and natural features of the site.

Step 3: Archaeological interpretation

During the last step, existing archaeological knowledge of the area complemented the previous outcomes. The comparison with known excavated and georeferenced tombs followed, together with assumptions and suggestions for the archaeological landscape findings digitised during step 1. The latest was applied while taking significant landscape changes tracked during step 2 into consideration. Apart from the correlation with known tombs, the identification of hitherto unknown archaeological proxies, as well as the dimensioning of the detected features, were carried out.

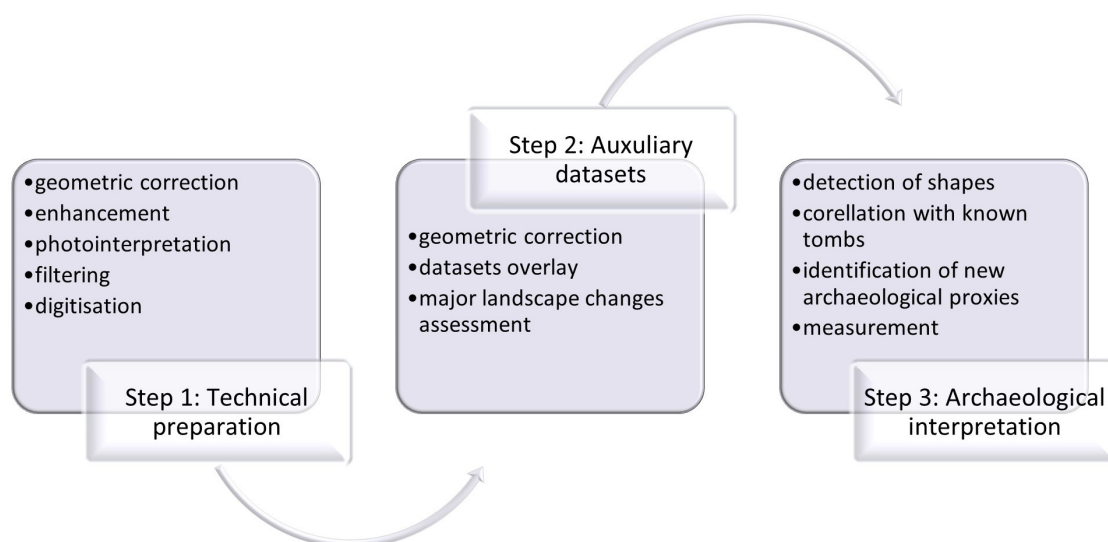


Figure 2: Methodological workflow of the present study.

4 Results

In Figure 3 the rectified 1968 aerial photograph is shown, over the area of the Eastern necropolis. The photograph is presented both in RGB and grey scale for visual clarity.



Figure 3: Geometrically corrected aerial photograph of 1968, showing the wider area of the Eastern necropolis. (RGB left; grey scale right). (Original photo source: Historic Environment Scotland).

The aerial investigation was limited to the cultivated areas in which no vegetation was visible in the 1968 aerial photograph. The detection of any proxies over these areas was more reliable and feasible, in comparison to areas with dense or mature vegetation or to non-arable areas with rough natural bedrocks. A normalised vegetation index was used to map vegetated areas automatically, utilising both the green and red spectral bands of the aerial image of 1968. Indeed, for the implementation of the “Green-Red Vegetation Index (GRVI)”, the $GRVI = (Green-Red)/(Green+Red)$ equation was employed. This approach is common in images where the near-infrared (NIR) information is missing (Agapiou et al., 2012), as is the case under examination here. The GRVI image provides a new greyscale image with a range of value from -1 to 1 . From the inspection of the area and concerning the GRVI values, a threshold was set to defined vegetated areas. The results are shown in Figure 4.

Afterwards, several values along a colour ramp and different spectral bands were tested and applied in order to retrieve the maximum of information, as earlier explained (refer to the Methodology section, step 1). The preliminary results from the investigation of the aerial data of the Eastern necropolis provided compelling insights regarding the funerary landscape. Most concentrations of near-surface proxies were detected to the south and the north of the current Poseidonos Avenue, towards the west end of the necropolis (Figure 5). Several features of specific shape and size were spotted on the 1968 aerial photograph, revealing a remarkable consistency in geometric patterns and their size. Both the shape of the features and their dimensions recall known examples of a specific tomb type and metrics attributed to it. Most of these features (Figure 5, blue dots) have a rectangular form of few meters long, and frequently the same orientation within a cluster. Indeed, the most common tomb type of the Eastern necropolis is the simple, single rectangular grave tomb. These are near-surface tombs seemingly sunken in the surface of the natural bedrock (Lysandrou, 2014). Since the rectified aerial photograph offers the possibility to achieve measuring of the detected features directly on the photo, it was possible to cross-check and therefore verify that the dimensions of the detected tombs correspond to known tomb metrics of the specific tomb type (Lysandrou, in press).

Several other features with compact but irregular or more complex shape, with a vague outline and relatively larger than those of the previous category, are marked in Figure 5 with green dots. Of great interest are also some “extensive



Figure 4: Arable areas and dense vegetation zones within the Eastern necropolis of Nea Paphos are shown in green colour.

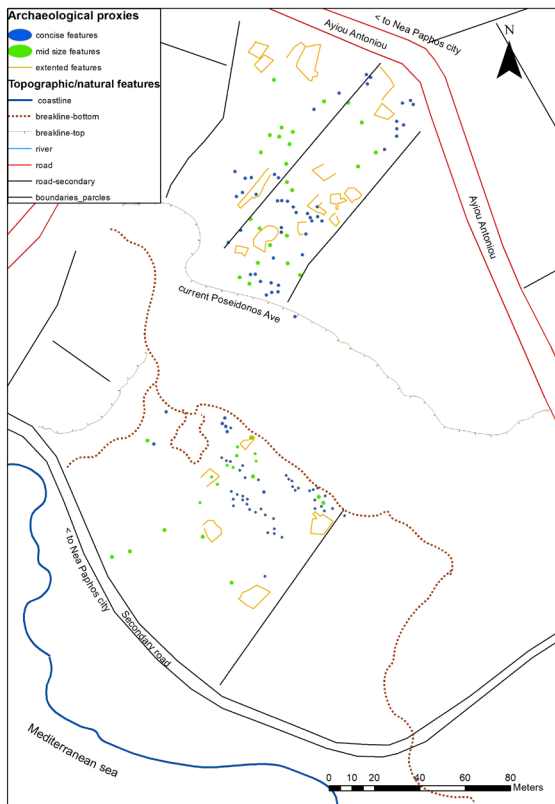


Figure 5: Map showing areas with the main concentrations of archaeological proxies (after authors' interpretation based on 1968 aerial photograph), and the most significant topographic and natural features (after authors' digitisation of the 1968 aerial photograph, also in conjunction with related cadastral maps) of the Eastern necropolis of Nea Paphos.



Figure 6: 1968 aerial photograph: red dot on bottom left view indicates a specific area within the Eastern necropolis, with notable archaeological proxy concentration. A closer view of this area is shown in the background image. Yellow circles denote archaeological proxies further explained in Table 2 below.

features” shown in Figure 5 with an orange polyline. They present several close or open forms of several meters long or wide, and in some cases are merely straight lines. Some of these could be possibly connected to auxiliary constructions within the necropolis (i.e. precincts, pathways, meeting venues), even though such information is not known from the archaeological reports of the Eastern necropolis and deserve further investigation.



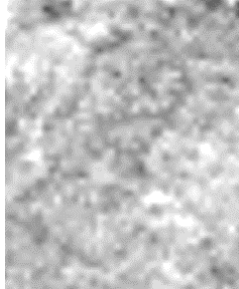
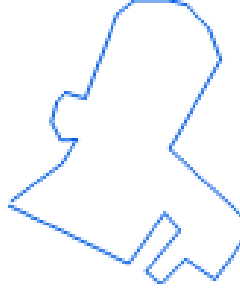
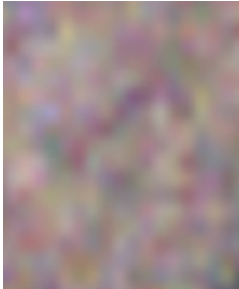

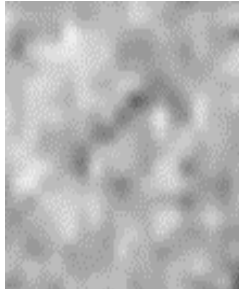

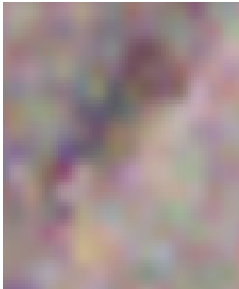
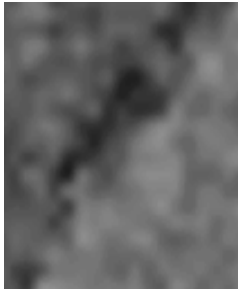
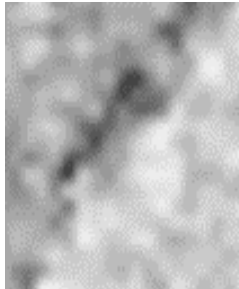


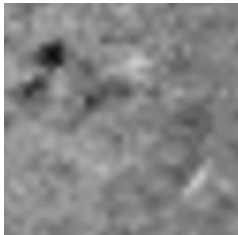
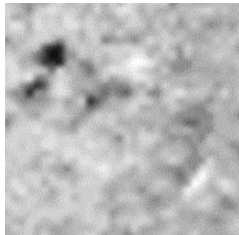
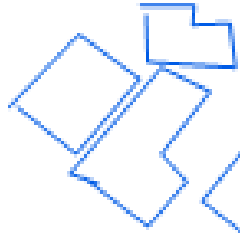
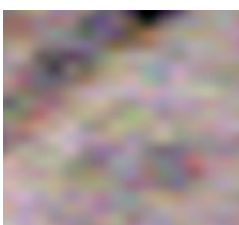
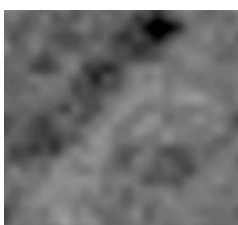
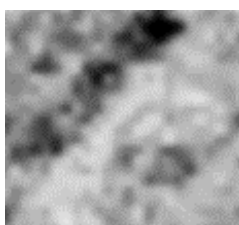

While some of the detected features/‘tomb-shaped marks’ were geometrically and geographically associated with known individual tombs (Figure 6 and Table 2) and finally confirmed as such, others were also associated with tombs, based on their geometry and geospatial distribution, but deserve further investigation. Figure 6 and Table 2 below reproduce indicative examples of archaeological proxies’ interpretation, detected on the 1968 aerial photograph, after enhancement.

The numbering in the first column of Table 2 refers to the numbering shown in Figure 6 above. Columns 2–4 reproduce a preview of the aerial photograph in RGB composite and greyscale stretched values, respectively. The last column exposes the outline of the features identified.

Figure 7 below shows an indicative processing implemented for Example 1 of Table 2. Similar processing has been carried out for several examples of features spotted on the aerial photograph of 1968.

Example number 5 of table 2 (Figure 8 below), is a case in point of archaeological proxies spotted on the 1968 aerial, that were afterwards successfully correlated with a specific, known, and georeferenced Hellenistic and Roman tomb. Indeed, both the position and the shape of example no 5, corresponds to T(omb) 83/84 P.M. (Paphos Museum) 2670 (excavated by Prof. Michaelides on behalf of the Department of Antiquities between 02–11 May 1984). This is a large rock-cut single chamber tomb, hosting *sarcophagi* on all lateral walls of the chamber. The tomb is on the north-south axis, with a NE to SW orientation, having its entrance on the south side.

Table 2: Indicative examples of archaeological proxies' interpretation, after image enhancement. These proxies were detected on the 1968 aerial photograph.

No.	RGB composite Stretch type: standard deviations	Stretch values along a color ramp (Bands 1–3)	Sharpen/soften – brightness/contrast corrections	Digitised outline
1				
2				
3				
4				
5				

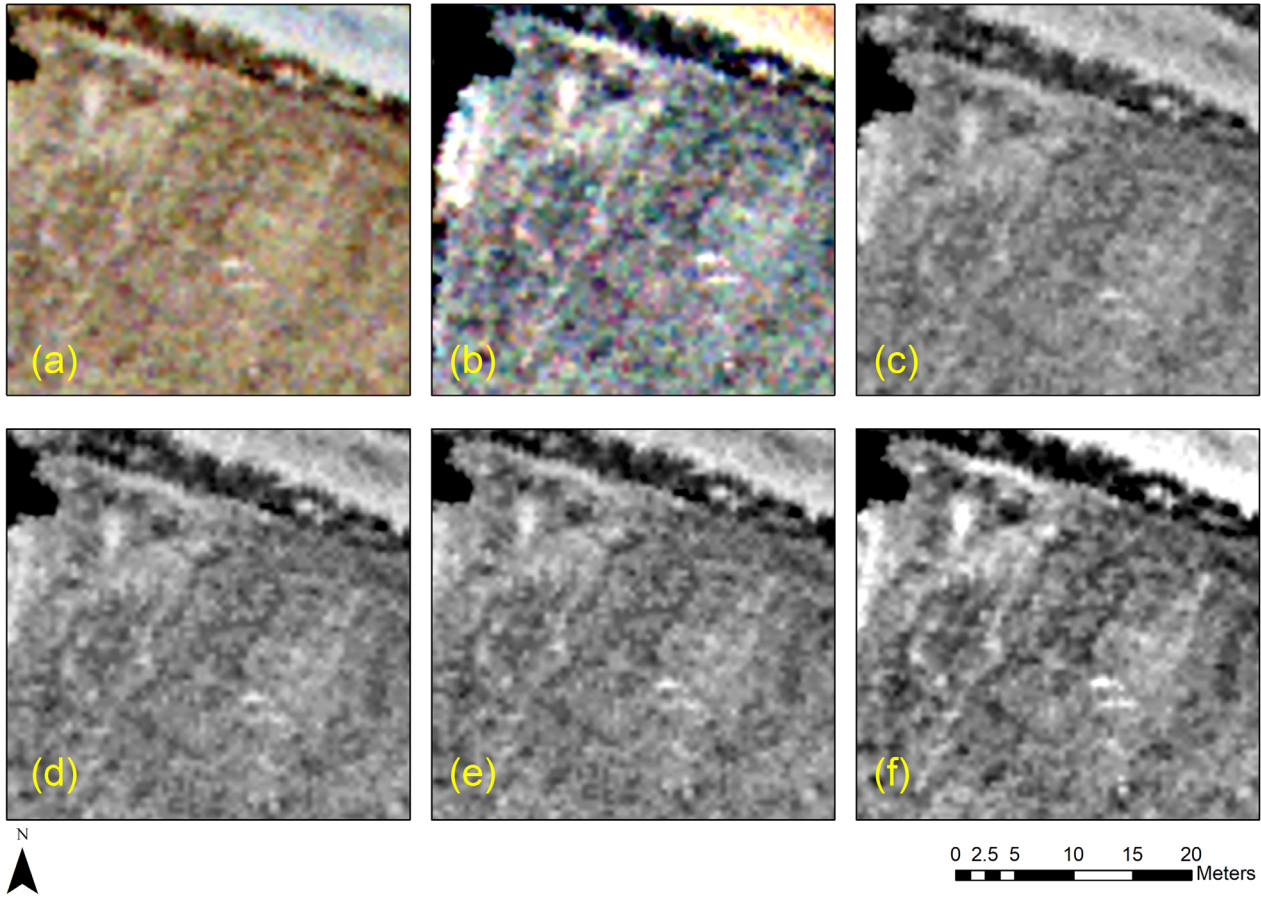


Figure 7: (a) R-G-B pseudo colour of the aerial image 1968 (standard deviation histogram stretch); (b) B-G-R pseudo colour of the aerial image 1968 (standard deviation histogram stretch); (c) Blue band of the aerial image 1968 (standard deviation histogram stretch); (d) Green band of the aerial image 1968 (standard deviation histogram stretch); (e) Red band of the aerial image 1968 (standard deviation histogram stretch); (f) First Principal Component (PC1) of the aerial image 1968 (standard deviation histogram stretch).

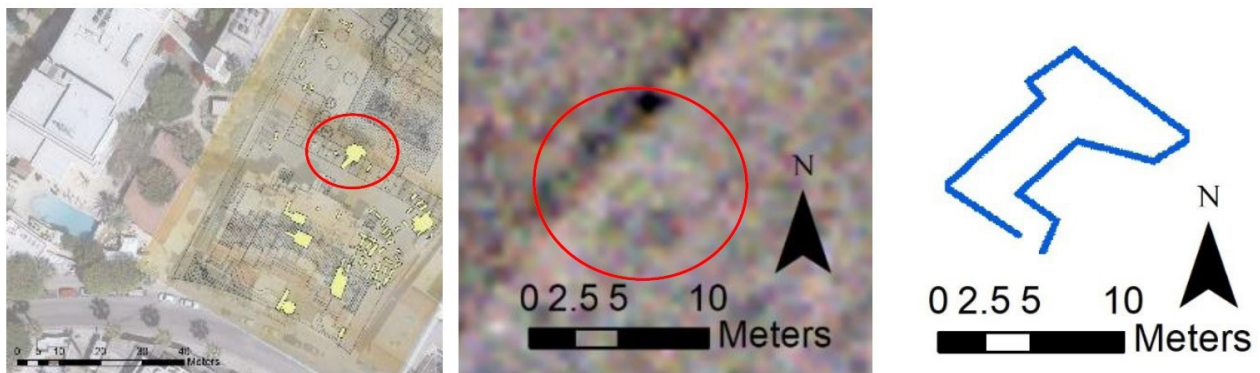


Figure 8: Correlation between known georeferenced tombs (left; Lysandrou et al., 2018) and near-surface archaeological proxies detected in the 1968 aerial photograph (middle); digitisation of the detected feature (right). (Background image: Aerial Orthophoto 2014 overlaid with the cadastral map with the georeferenced tombs (left); rectified 1968 aerial photograph (middle).

5 Discussion

The afore presented results are primarily referring to areas where past research has successfully georeferenced ground plans of excavated tombs, revealed during the 1980s rescue excavations (Lysandrou et al., 2018; Lysandrou, in press). After that, it was possible to evaluate the results of the aerial investigation here presented, using the georeferenced tombs as ground-truthing information. Indeed, similarly to example no 5 (refer to the previous section: Results) are also other near-surface features recognised on the aerial image, which were afterwards confirmed by the ground truthing data, thus evaluating and verifying the procedures and methods followed for the present study.

However, a plethora of unknown archaeological proxies has also been detected in the surrounding areas. For instance, Figure 9, indicates two plots North of Ayiou Antoniou street, approximately 200 meters further to the North from the area above examined. This area appears to be quite dense in terms of potential archaeological remains, including both ordinary rectangular shapes and notably plenty of extensive features as well.

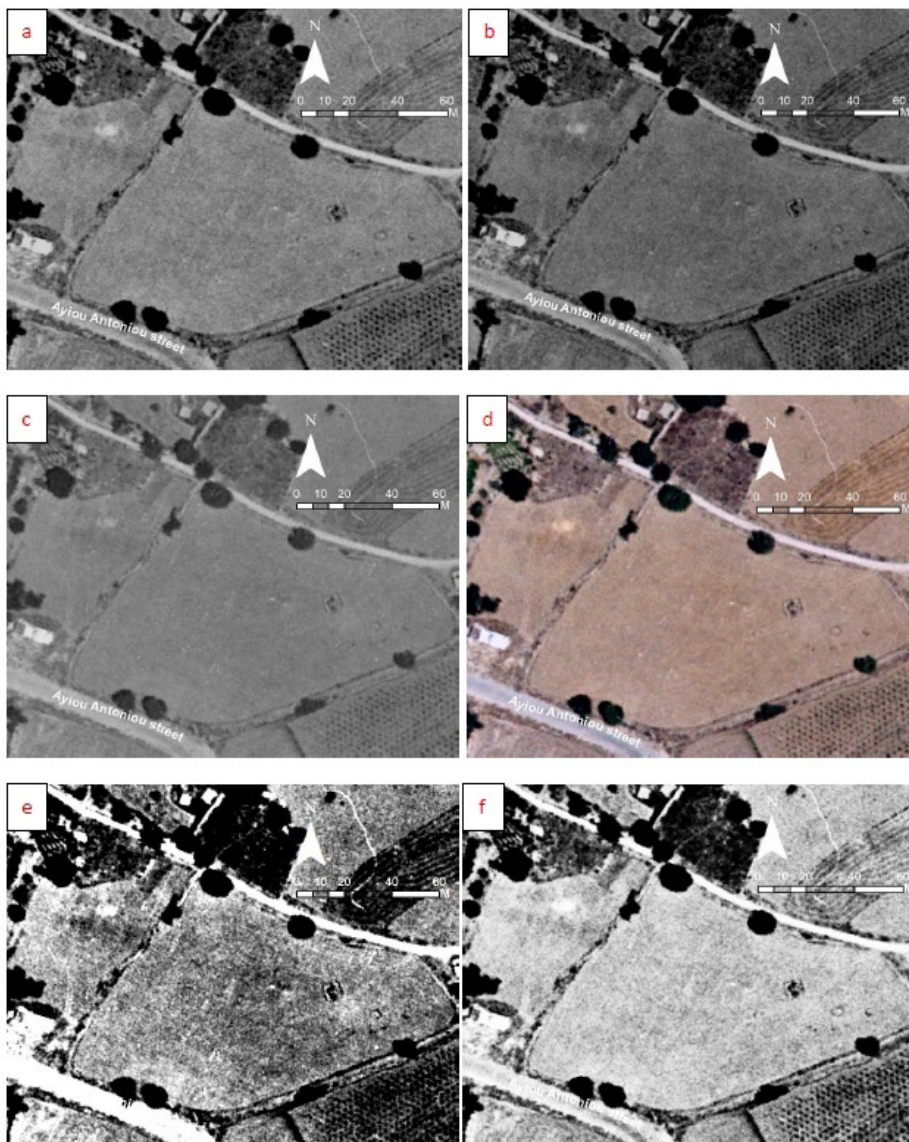


Figure 9: Archaeological proxies' concentrations on the rectified 1968 aerial photograph: Band 1–3; RGB; histogram enhancement (a–c; d; e–f respectively).

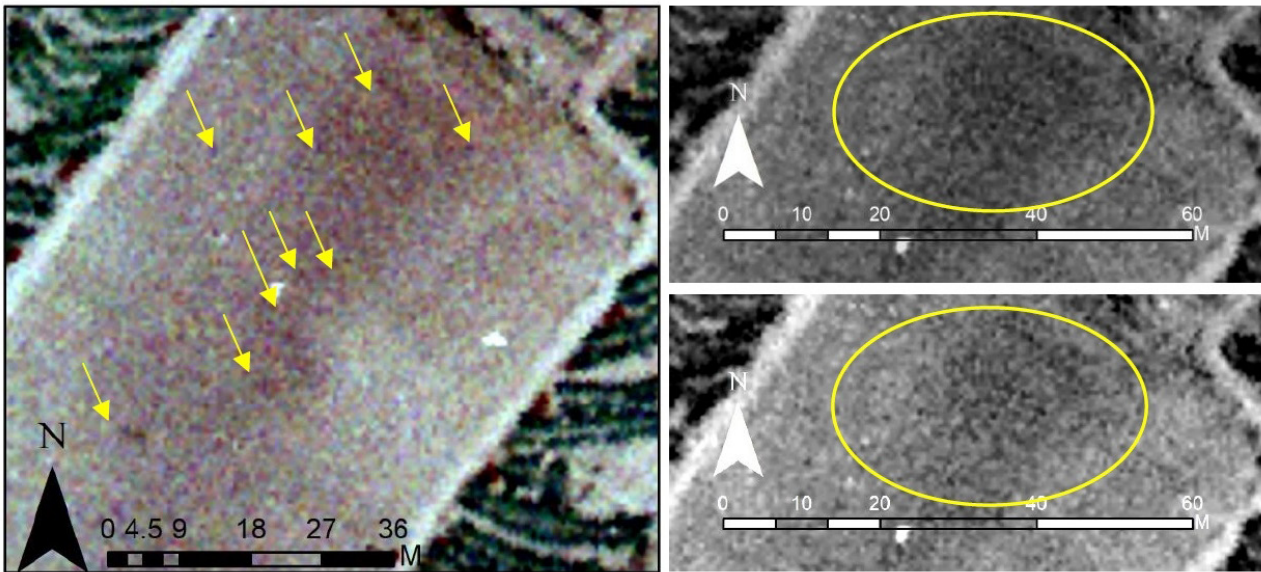


Figure 10: Proxy concentration (and *loculi* tomb-shaped feature) identified on the 1968 aerial photograph, at the easternmost area of the necropolis.

Also, Figure 10 shows another example of proxies' concentration (including several features as above explained, i.e. close concise "shaft tombs"). The same photograph in grey scale (Fig. 10, right column pictures) and after colour enhancement reveals (with lack of ground conviction) a feature which alludes to *loculi* tombs, an architectural type frequently encountered in tomb architecture of Cyprus during the Hellenistic period (Lysandrou, 2014, including all previous bibliography). This concentration is located in the easternmost end of the necropolis, in an area less investigated through archaeological excavation.

It is worth noting that even though the tomb-shaped concentrations were more confidently spotted in arable but vegetation-free areas, vegetated or recently cultivated areas (referring to the 1968 photograph) further to the east, are also hosting potential archaeological features (Figure 10). Nevertheless, the interpretation over these areas cannot be substantiated with excavation data, and therefore is problematic.

The digitisation of the topography, as shown in Figure 5 above, evidences some significant changes that occurred in the landscape since the aerial capture of the site back in 1968. For instance, it is evident that the main road leading from the East Gate outside of the Nea Paphos city walls to the east could be the current Ayios Antonios street and not Poseidonos Avenue, as someone would expect. The two streets meet and merge further to the east somewhere in the middle of the necropolis. If so, then lavish tombs and tomb markers should be searched along Ayios Antonios street. A secondary coastal path ended up and merged with Ayios Antonios street and Poseidonos Avenue, further to the east. The current Poseidonos Avenue took the place of a small pathway north of a low hill approximately 12 m (maximum height) above sea level. This area has undergone flattening and replaced by the current enlarged Poseidonos Avenue. The significant alteration of the landscape is evident. Even though a few tombs excavated back in the 1980s were preserved by authorities and are visible today, it has been challenging to trace them on the aerial photograph of 1968. Figure 11 below gives an example.

Also, other architectural features, possibly pathways or other infrastructure related to the necropolis' functions, were searched for giving an idea of the overall urban organisation system of the necropolis of that time. Further investigation, as well as additional archive aerial data are necessary towards this direction. Nevertheless, in light of the above analysis and results presented, it can be said that the Eastern necropolis might have been more extensive than is currently known. This extension covered the landscape both to the east and to the north of the studied and up to date recognised necropolis. This suggestion is supported by the archaeological proxies found both within the plots with known tombs (Fig. 12 red dots), as well as elsewhere nearby (Fig. 12 green dots). Another piece of evidence supporting this suggestion is the topography and the pathways leading out of the ancient city of Paphos (refer to Fig. 5 and related

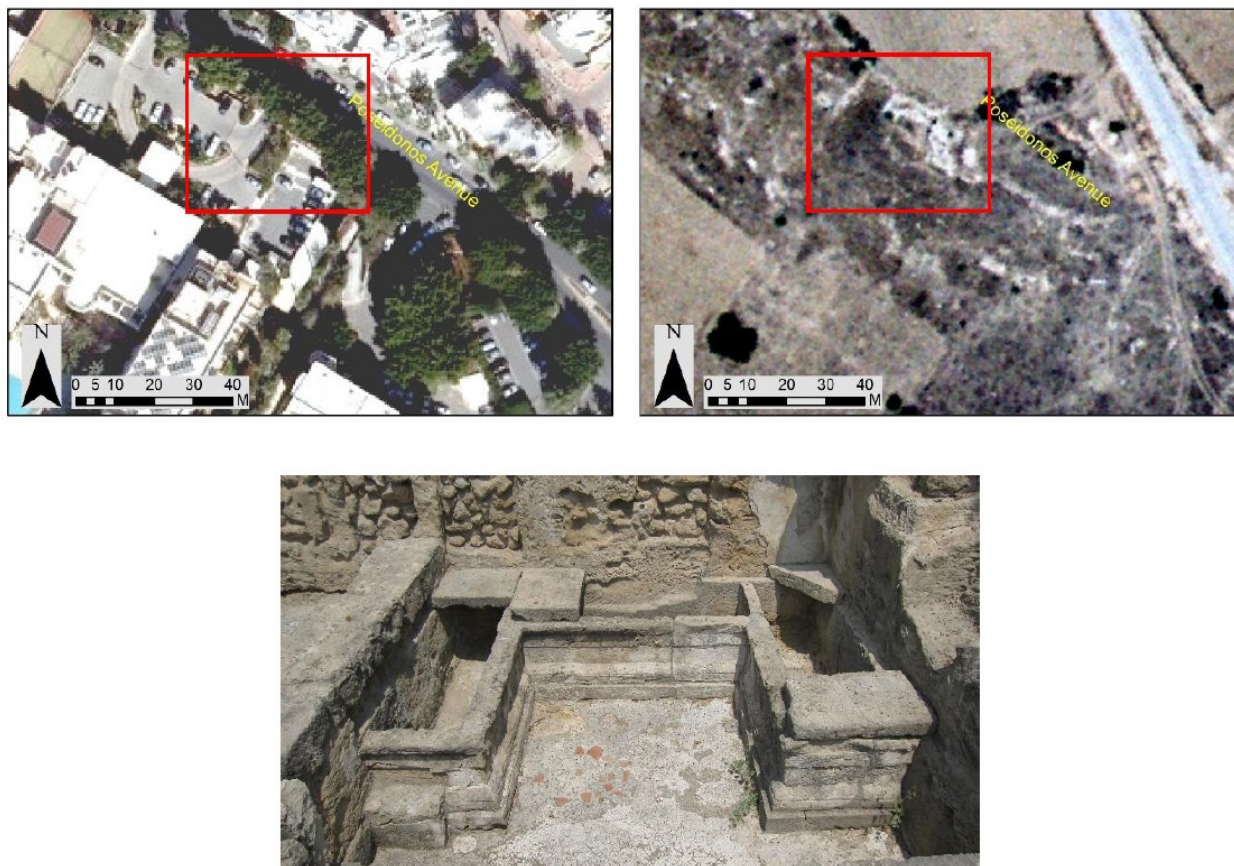


Figure 11: Aerial Orthophoto 2014; source: Department of Land and Surveyors, Cyprus) (left) and the 1968 aerial RGB (right). The rectangle refers to bottom picture, which shows a tomb partially preserved to this day within a private parking place.

discussion earlier in this section) through the eastern city walls and specifically the North/East and East gates (Fig. 12). The possible existence of more than one pathway leading from the city into the necropolis, would facilitate the development of tombs along these streets and the related comings and goings.

For the current investigation, a notable obstacle has been the limited primary information resources. Particularly, apart from limited archaeological data available only for specific areas within the ancient cemetery, the archive aerial investigation was restricted only to one single photograph. Nevertheless, the archaeological proxies detected through the interpretation process of this aerial photograph and with the support of the secondary/auxiliary data, could be understood as a conceptual inference based on solid archaeological knowledge of the site, all grey areas and doubts that essentially condition every aerial investigation of this kind notwithstanding.

6 Conclusion

This paper presented the results from the study of aerial datasets over the Hellenistic-Roman Eastern necropolis of Nea Paphos in Cyprus, providing fascinating insights into the funerary landscape, by evidencing new features. Rectangular shapes of specific geometry and size recalling tomb structures were spotted on the aerial image of 1968 (from the National Collection of Aerial Photography of the Historic Environment Scotland). Then, examples of these shapes were validated with already known georeferenced tombs, while others were correlated to still existing ones. Also, most of the detected features conform in dimensions, shape, and orientation to tombs as we know them from the specific burial



Figure 12: Visualization of the relation between the Eastern necropolis enlarged in the bottom figure (imagery source: ©Google Earth Engine, imagery date: 8/2/2017) and the ancient city of Nea Paphos (map after Nicolaou, 1966). Within red and blue circles are shown the East and North East gates, respectively. The names of the streets leading outside the city walls are given in yellow colour. Red dots indicate the investigated areas of the necropolis, with considerable number of tombs (including tombs both georeferenced and not). Green dots indicate new areas where archaeological proxies were spotted during the aerial investigation (beyond the already known concentrations which were also seen on the aerial photograph).

ground. These key findings uncovered that the necropolis was quite dense and spatially extended, in relation to what we know to date. Also, a better understanding of the funerary landscape has been achieved, providing an impetus for new interpretations of the site with respect to its connection with the urban centre of Nea Paphos, as well as with nearby satellite habitation sites.

The methodology (aerial photograph processing and photo interpretation) employed for this study and the visualisation of the landscape before its excavation underlines the potential of aerial photography and computer-based image techniques (i.e. image analysis, filtering, GIS) for the investigation of lost archaeo-landscapes. The importance of introducing this kind of investigation methods to archaeological research and the systematic integration of aerial and geo-data into archaeological research information sources, especially in cases where the actual archaeological evidence is not available, such as the case study presented here, becomes evident. Indeed, as argued by Cowley et al., 2013 “on a global level these photographs remain a largely unexplored resource for a number of reasons, including problems of access and research traditions”, in this case, the search of more photographs could shed light on the “problematic” or less “visible” areas of the site. Accessibility and democratisation of remote sensing data, as well as the potential of a negative impact of such an action, was recently discussed by Cohen, Klassen and Evans (2020).

Therefore, another critical outcome of this article is the excellent utility of aerial photography when commissioned especially for archaeology, and the lack of such a practice in Cyprus. Aerial photography can play a fundamental role in several stages of archaeological research, starting from the identification of new sites, rediscovery of known ones and the appropriate archaeological inference, to the documentation, safeguarding and monitoring of heritage sites. An added value of aerial investigation is that it can be combined with ground measurements and targeted geophysical prospection in order to identify and indicate possible sites for future archaeological excavation, protection and strategic planning in light of modern infrastructural development.

Specifically for Cyprus, the presented study is a unique case, where an organised ancient site, which currently is lost in a way that no other means employed (i.e. archaeological excavation, geophysical prospection) could easily or at all reveal it, was re-seen through the integration of aerial investigation methods and archaeological knowledge. While some of the detected features/‘tomb-shaped marks’ were geometrically and geographically associated with known individual tombs and were finally confirmed as such (upon georeferencing and digitisation of the plans of Hellenistic and Roman tombs (excavated during the 1980s) on the rectified 1968 image, other identified features were also associated with tombs, based on their geometry and geospatial distribution, but deserve further investigation. The extensive features detected also merit further investigation. In addition, the case of Nea Paphos necropolis was a unique opportunity to assess this blending of traditional and novel techniques in archaeological research as this is practiced on the island, since information retrieved from the archaeological excavation records of the 1980s was reliable and irrefutable information to validate the results of the aerial image analysis.

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References

- Agapiou, A., Hadjimitsis, D. G., & Alexakis, D. D. (2012). Evaluation of Broadband and Narrowband Vegetation Indices for the Identification of Archaeological Crop Marks. *Remote Sensing*, 4(12), 3892–3919. <https://doi.org/10.3390/rs4123892>
- Agapiou, A., Lysandrou, V., Themistocleous, K., Nisantzi, A., Lasaponara, R., Masini, N., Krauss, T., Cerra, D., Gessner, U., Schreier, G., & Hadjimitsis, D. (2016, April 4–8). Searching data for supporting archaeo-landscapes in Cyprus: an overview of aerial, satellite, and cartographic datasets of the island. In K. Themistocleous, D. G. Hadjimitsis, S. Michaelides, G. Papadavid (Eds.), *Proceedings of The Fourth International Conference on Remote Sensing and Geoinformation of the Environment (RSCy2016)*. SPIE <https://doi.org/10.1117/12.2241973>
- Bewley, R. H. (2003). Aerial survey for Archaeology. *The Photogrammetric Record*, 18(104), 273–292. <https://doi.org/10.1046/j.0031-868X.2003.00023.x>
- Bewley, R., & Rączkowski, W. (Eds.). (2002). *Aerial archaeology. Developing future practice*. Amsterdam: IOS Press.
- Bourgeois, J., & Meganck, M. (2005). *Aerial Photography and Archaeology 2003: A Century of Information*. Archaeological Reports Ghent University 4. Ghent: Academia Press.
- Brophy, K., & Cowley, D. (2005). *From the air: understanding aerial archaeology*. London: The History Press Ltd.
- Ceraudo, G. (2013). Aerial Photography in Archaeology. In C. Corsi, B. Slapšak, & F. Vermeulen (Eds.), *Good Practice in Archaeological Diagnostics* (pp. 11–30). Switzerland: Springer International Publishing. https://doi.org/10.1007/978-3-319-01784-6_2
- Christou, D. (2008). *Paphos: Archaeological guide and historical review*. Nicosia.
- Cohen, A., Klassen, S., & Evans, D. (2020). Ethics in Archaeological Lidar. *Journal of Computer Applications in Archaeology*, 3(1), 76–91. <https://doi.org/10.5334/jcaa.48>
- Cowley, D., & Ferguson, L. (2010). Historic aerial photographs for archaeology and heritage management. In M. Forte, S. Campana, & C. Liuzza (Eds.), *Space, time, place. Third international conference on remote sensing in archaeology* (BAR, International Series 2118, pp. 97–104). Oxford: Archaeopress.
- Cowley, D. C., & Stichelbaut, B. (2012). Historic Aerial Photographic Archives for European Archaeology. *European Journal of Archaeology*, 15(2), 217–236. <https://doi.org/10.1179/1461957112Y.0000000010>
- Cowley, D. C., Ferguson, L. M., & Williams, A. (2013). The Aerial Reconnaissance Archives: A Global Aerial Photographic Collection. In W. Hanson & I. Oltean (Eds.), *Archaeology from Historical Aerial and Satellite Archives* (pp. 13–30). New York: Springer. https://doi.org/10.1007/978-1-4614-4505-0_2
- Ferguson, L. (2011). Aerial archives for archaeological heritage management: The aerial reconnaissance archives – A shared European resource. In D. C. Cowley (Ed.), *Remote sensing for archaeological heritage management* (pp. 205–212). Budapest: Archaeolingua.
- Hammer, E. L., & Lauricella, A. (2017). Historical Imagery of Desert Kites in Eastern Jordan. *Near Eastern Archaeology*, 80(2), 74–83. <https://doi.org/10.5615/neareastarch.80.2.0074>
- Hammer, E. L., & Ur, J. A. (2019). Near Eastern Landscapes and Declassified U2 Aerial Imagery. *Advances in Archaeological Practice*, 7(2), 107–126. <https://doi.org/10.1017/aap.2018.38>
- Kennedy, D., & Bewley, R. (2009). Aerial Archaeology in Jordan. *Antiquity*, 83(319), 69–81. <https://doi.org/10.1017/S0003598X00098094>
- Lysandrou, V. (in press). Tomb architecture and distribution in the Eastern necropolis of Nea Paphos, Cyprus. *Studies in Ancient Art and Civilization*.
- Lysandrou, V. (2014). *The tomb architecture during the Hellenistic and Roman period in Cyprus [Η Ταφική Αρχιτεκτονική κατά την Ελληνιστική και Ρωμαϊκή περίοδο στην Κύπρο, English translation]*. (Unpublished Ph.D thesis). Cyprus: University of Cyprus.
- Lysandrou, V., & Agapiou, A. (2016). Cities of the dead: approaching the lost landscape of Hellenistic and Roman necropoleis of Cyprus. *Archaeological and Anthropological Sciences*, 8, 867–877. <https://doi.org/10.1007/s12520-015-0267-y>
- Lysandrou, V., & Agapiou, A. (2017, September 13–15). *An aerial investigation of the Eastern necropolis of Nea Paphos, Cyprus* [Poster session]. The Aerial Archaeology Research Group 2017 Annual Conference, Pula, Croatia.
- Lysandrou V., Agapiou, A., Hadjimitsis, D. (2015, March 16–19). Impact of modern evolution of Paphos town to its ancient necropoleis. A multi-temporal GIS and earth observation analysis. In: D.G. Hadjimitsis, K. Themistocleous, S. Michaelides, G. Papadavid (Eds), *Proceedings of The Third International Conference on Remote Sensing and Geoinformation of Environment (RSCy2016)*. SPIE. <https://doi.org/10.1117/12.2192514>
- Lysandrou, V., Agapiou, A., Michaelides, D., & Pappasavvas, G. (2018). The Eastern necropolis of Nea Paphos: Overcoming challenges in a lost landscape. *Journal of Archaeological Science, Reports*, 19, 552–561. <https://doi.org/10.1016/j.jasrep.2018.03.027>
- Młynarczyk, J. (1990). *Nea Paphos in the Hellenistic period*. Warsaw.
- Musson, C, Palmer, R., & Campana, S. (2013). *Flights into the past. Aerial photography, photo interpretation and mapping for archaeology*. The Aerial Archaeology Research Group (Occasional Publication No. 4) in partnership with the ArchaeoLandscapes Europe (ArcLand).
- Nicolaou, K. (1966). The Topography of Nea Paphos. In K. Michałowski, M. L. Bernhard *Mélanges offerts a Kazimierz Michalowski* (pp. 561–601). Warszawa, Państwowe Wydawn. Naukowe.
- Rączkowski, W. (2014). Aerial Archaeology. In C. Smith (Ed.), *Encyclopaedia of Global Archaeology*. New York: Springer. https://doi.org/10.1007/978-1-4419-0465-2_1504