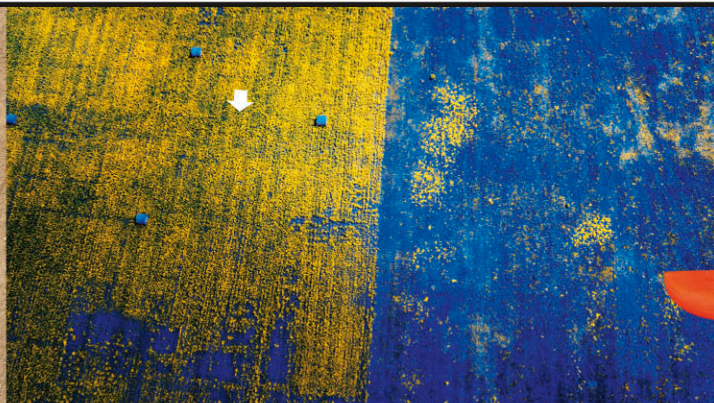


Studi di Aerotopografia Archeologica

# Archeologia Aerea



0'15

Studi di Aerotopografia Archeologica

# Archeologia Aerea 9<sup>15</sup>

*a cura di*  
Giuseppe Ceraudo

Claudio Grenzi Editore

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“Archeologia Aerea. Studi di Aerotopografia Archeologica” è una Rivista Internazionale fondata nel 2004 da Giuseppe Ceraudo e Fabio Piccarreta.

Dotata di *referees* anonimi (*peer-reviewed*), raccoglie studi e ricerche di archeologia basati sull'ampio utilizzo di fotografie aeree, immagini satellitari e dati telerilevati in genere. L'opera – unica nel suo genere in Italia – segue la disciplina sin dai suoi esordi e, passando attraverso contributi di metodologia e applicazioni di fotointerpretazione archeologica e fotogrammetria finalizzata, giunge sino alle modernissime applicazioni specialistiche legate alle nuove tecnologie di *remote sensing* e fotointerpretazione satellitare.

Ampio spazio è assegnato nella Rivista agli studi sui pionieri o sull'attività pionieristica legata alle riprese aeree, allo studio del materiale aerofotografico storico, ai lavori di fotointerpretazione archeologica classica di respiro internazionale, ai progetti di archeologia aerea avviati di recente in Italia e nel Mondo, nonché alle attività e allo stato dell'arte della materia e alle prospettive future di ricerca legate alle immagini telerilevate da piattaforma aerea e satellitare.

La Rivista si propone di presentare l'Aerotopografia Archeologica – disciplina che utilizza a fondo lo strumento aereo e tutte le immagini aerorilevate con le sue varie applicazioni ed elaborazioni – come una parte fondamentale di una materia, la Topografia Antica, che affonda le sue radici storiche molto indietro nel tempo.

Studi di Aerotopografia Archeologica

## Archeologia Aerea 9<sup>15</sup>

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## Sommario

- Introduzione
- 5 Archeologia aerea. Studi di Aerotopografia archeologica, IX  
*Giuseppe Ceraudo*
- 7 Abstracts  
*Chris Musson*
- 
- Studi e ricerche 9.15  
*Studies and Researches 9.15*
- 
- 13 **La fotografia aerea nelle Scienze della Terra**  
*Maurizio D'Orefice, Roberto Graciotti*
- 24 **La fotografia aerea da aquilone per l'archeologia**  
*Paolo Nannini*
- 40 **Fortificazioni antiche e moderne di Genova**  
Esperienze per lo studio, localizzazione e georeferenziazione dei siti  
*Massimo Rossi*
- 44 **I fossati circolari di Acquaviva di Cagli (PU)**  
Analisi aerofotografica e saggi d'accertamento  
*Gabriele Baldelli, Giorgio F. Pocobelli*
- 57 **S. Palomba (Roma). La villa romana in località Fontanile di Palazzo nel fundus Soranianus**  
*Leonardo Schifi, Maria Cristina Ricci*
- 66 **Archeologia Aerea e Telerilevamento di prossimità con Sistemi Aeromobili a Pilotaggio Remoto**  
*Veronica Ferrari, Paola Guacci, Alfio Merico*
- 69 Post-produrre, leggere, interpretare  
**Tecniche di Enfaticizzazione dell'immagine nella fotointerpretazione aerea: il caso di Aquinum**  
*Giovanni Murro*
- 82 **L'insediamento di località Petrore nel territorio di Cutrofiano (Lecce)**  
*Claudio Martino*
- 86 Where... goats dare  
**Aerial survey in mountainous landscapes between history and ethnography**  
*Gianluca Cantoro*
- 93 **Synergistic use of UAV based photogrammetry and topographic survey for archaeological site mapping at a LBA settlement at Chalandritsa, Greece**  
*Konstantinos G. Nikolakopoulos, Konstantina Soura, Ioannis Koukouvelas, Nikolaos G. Argyropoulos*
- 101 Riprese aeree con pallone aerostatico frenato e droni  
**Esperienze tra ricerca e documentazione archeologica a Hierapolis di Frigia**  
*Giacomo Di Giacomo, Giuseppe Scardozzi*
- 117 **Il contributo delle fotografie cosmiche alla conoscenza della topografia antica delle città della Cilicia Pedias**  
I casi di Soloi-Pompeioupolis e Tarsos  
*Michele Cotugno, Giuseppe Scardozzi, Rita Scognamiglio*
- 141 **Shahr-i Sokhta 2014-2015 Excavations**  
The new Results in Areas 1, 20, 26 and 28  
*Seyed Mansour Seyed Sajjadi, Hossein Moradi*



Introduzione

## Archeologia aerea. Studi di Aerotopografia archeologica, IX

Il 9° numero di Archeologia Aerea accoglie, con la consueta e consolidata formula adottata in passato, contributi di studiosi affermati e lavori di giovani ricercatori, italiani e stranieri, e tocca tutti quei punti che hanno caratterizzato i passati volumi della rivista: con contributi di metodologia ed applicazioni di fotointerpretazione archeologica e con le modernissime applicazioni specialistiche legate alle nuove tecnologie di *remote sensing*.

Sempre più spazio trovano i droni in archeologia, nel contesto delle più moderne tecnologie sono sempre più lampanti le straordinarie potenzialità del telerilevamento di prossimità attraverso l'impiego di Sistemi Aeromobili a Pilotaggio Remoto (SAPR). I SAPR o droni, come più semplicemente sono conosciuti al grande pubblico, sono sempre più diffusi ed utilizzati nel settore dei Beni Culturali e testimoniano il valore aggiunto che questo tipo di strumento può apportare, sia nell'individuazione che nella documentazione e monitoraggio di monumenti e resti archeologici. In prospettiva futura si prevede una grande esplosione nell'utilizzo di questi velivoli, dal momento che tali strumenti si caratterizzano per i loro considerevoli vantaggi in termini di tempi, costi e semplicità di intervento.

Il Volume si apre con un contributo dedicato all'uso della fotografia aerea negli studi di Scienza della Terra (Maurizio D'Orefice, Roberto Graciotti), strumento investigativo fondamentale da combinare con ricognizioni geologiche e geomorfologiche sul campo per definire le caratteristiche fisiche ed antropiche di un territorio. Segue un articolo sulla fotografia aerea da aquilone per l'archeologia, con splendide immagini realizzate con maestria dall'Autore soprattutto in alcuni territori della Toscana (Paolo Nannini). Il terzo lavoro vede uno studio archeologico e topografico sulle fortificazioni antiche e moderne di Genova (Massimo Rossi). Seguono due interessanti contributi legati alla foto interpretazione e al riconoscimento di un grande numero di tracce archeologiche, il primo sull'analisi aerofotografica con saggi di accertamento di alcuni fossati circolari ad Acquaviva di Cagli nella provincia di Pesaro e Urbino (Gabriele Baldelli, Giorgio Pocobelli), mentre il secondo presenta uno studio con splendide immagini aeree prospettiche sulla monumentale villa romana di S. Palomba nei pressi di Roma (Leonardo Schifi, Maria Cristina Ricci). Seguono due articoli strettamente legati all'attività di ricerca condotta ad *Aquinum* nel Lazio meridionale nell'ambito del Progetto Ager Aquinas; entrambi traggono spunto dall'organizzazione di una Summer School di "Archeologia Aerea e Telerilevamento di prossimità con Sistemi Aeromobili a Pilotaggio Remoto (droni)" avviata nell'agosto del 2015 all'interno dell'area archeologica di proprietà del Comune di Castrocielo (FR): il primo è un interessante e pionieristico lavoro di archeologia aerea e telerilevamento di prossimità con Sistemi Aeromobili a Pilotaggio Remoto utilizzati per soddisfare molteplici esigenze in campo archeologico e nei diversi ambiti applicativi, come la topografia di aree archeologiche, il rilievo di monumenti e di scavi, la mappatura e il monitoraggio di porzioni anche vaste di territorio (Veronica Ferrari, Paola Guacci, Alfio Merico); il successivo dimostra come alcune tecniche di enfaticizzazione delle immagini, anche queste acquisite con i droni, possano arricchire il quadro della conoscenza, con tracce di edifici e di strutture sepolte, di una

città o di un territorio, attraverso l'impiego di software specifici nel trattamento delle foto aeree (Giovanni Murro). Segue un inedito lavoro di fotointerpretazione collegato ad un notevole insediamento di età romana situato in località Petrore nel territorio di Cutrofiano in provincia di Lecce (Claudio Martino).

La seconda parte del volume è caratterizzata da una serie di articoli di respiro internazionale: si parte dalla Grecia con ricognizioni aeree effettuate in territori di montagna a Creta (Gianluca Cantoro) e con indagini su un sito della Tarda Età del Bronzo a Stavros, Chalandritsa, 20 Km a S di Patrasso (Konstantinos G. Nikolakopoulos, Konstantina Soura, Ioannis Koukouvelas, Nikolaos G. Argyropoulos); per passare in Turchia con peculiari indagini a *Hierapolis* di Frigia con pallone frenato e droni (Giacomo Di Giacomo, Giuseppe Scardozi) e indagini collegate all'utilizzo di immagini "cosmiche" su due città della Cilicia Pedias quali *Soloi-Pompeioupolis* e *Tarsos* (Michele Cotugno, Giuseppe Scardozi, Rita Scognamiglio); per chiudere con un contributo in Iran che vede l'utilizzo dei droni quale strumento importante per indirizzare e finalizzare le attività di ricerca, con la presentazione di attività di scavo del 2014 e 2015 a Shahr-i Sokhta, insediamento dell'Età del Bronzo iraniano, inserito nella lista UNESCO dei siti Patrimonio dell'Umanità, che ha una particolare valenza storica e identitaria per il popolo iraniano ed è considerato per estensione (circa 150 ettari) il secondo sito archeologico di tutto il Medio Oriente (Seyed Mansour Seyed Sajjadi, Hossein Moradi).

Giuseppe Ceraudo

## Abstracts

a cura di Chris Musson

MAURIZIO D'OREFICE, ROBERTO GRACIOTTI

### **Air photography and the Earth Sciences**

Air photo interpretation is a valuable investigative tool for use in combination with geological and geomorphological field survey to define the physical and anthropic features of a territory.

A pair of air photographs, made according to appropriate techniques, if observed and examined through a stereoscope, can provide a three-dimensional synoptic vision of both small and larger areas.

This methodology for spatial analysis can complement and enhance field survey activities but cannot entirely replace them.

The use of photo-interpretation is especially valuable when the area under investigation is difficult to access for inspection by normal means on account of its particular morphometric characteristics or because physical access is for one reason or another impossible.

Interpretative analysis of black-and-white air photographs is essentially based on the assessment of differences in a number of common parameters that express themselves within the individual frames. These parameters, which vary according to the camera coverage angle and perspective and which can be detected on the adjacent frames of any 'run' of aerial photographs, are: tone, texture, pattern and drainage density, along with vegetation and principal alignments.

These characteristics demonstrate the great importance of this working method in the Earth Sciences as well as in geo-environmental studies aimed at both land use planning and protection. The technique of photo-interpretation in geological and geomorphological contexts has today achieved the status of a genuine discipline within the university sphere, under the name of Photogeology or Aero-geology.

PAOLO NANNINI

### **Kite Aerial Photography (KAP) for Archaeology**

A brief history and technical summary of this 'green' technique and its archaeological applications. This contribution describes the basic steps of KAP through a number of case studies, using images taken by the author. The contribution ends with a critical comparison of kites as compared with drones (UAVs) in aerial photography.

MASSIMO ROSSI

### **Genoa's modern and ancient fortifications**

#### **Recent work on the study, identification and georeferencing of sites**

The archaeological and topographical study of fortifications usually focuses on 'ancient' examples but, since the 1990s, the study of 'modern' fortifications has received increasingly wide attention in Italy.

Genoa and the surrounding territory present many examples of 'modern' military structures from the 19th and 20th centuries, such as the 'Vallo Sud', a defensive circuit built by the Germans in 1944. Here, volunteers, experts and researchers, supported by the municipality of Genoa, have come together to study and map all of the related military features through the detailed analysis of archival sources, historical aerial photographs and ground-based survey in order to increase knowledge and understanding of these kinds of heritage features.



GABRIELE BALDELLI, GIORGIO F. POCOBELLI

**The circular ditches of *Acquaviva di Cagli* (PU)**

**Air photo analysis and trial excavations**

Numerous annular cropmarks were first observed in 2005 on an aerial photograph taken 5 years before over the eastern territory of Cagli (province of Pesaro and Urbino). In 2009 the Soprintendenza per i Beni Archeologici delle Marche, within its site protection program, entrusted the Authors with the analysis of aerial photographs, the cartographic mapping of the detected traces and the direction of preliminary excavations.

The study of the aerial photographs resulted in the discovery of a complex hydrographic situation, in some respects different from that of the present day, and revealed the presence of two further areas of annular cropmarks to add to those already recorded in 2005. Excavations at two of the circles, A and B, demonstrated that they were indeed involve circular ditches and were not 'elf circles' or 'fairy circles' created by mushrooms. They did not, however, reveal the expected graves but (in A) the stake holes of a large rectangular but rounded hut, dating from the early Iron Age to the 7th century BC, and (in B) the foundations of a square building, originally roofed in coarse tiles and dated to the 6th-5th century BC. This complex and important settlement, to which some 4th century BC tombs found in the past must be referred, was perhaps related to the place of worship evidenced by the well-known votive deposit of bronzes at Coltona di Cagli.

LEONARDO SCHIFI, MARIA CRISTINA RICCI

**S. Palomba (Rome). The Roman Villa of Fontanile di Palazzo in *fundus Soranianus***

Along the via Ardeatina, about 1800 m east of Km 20.800, lie the remains of a large suburban Roman villa of the 1st century B.C. – 1st century AD.

In June 1965 the 31st Helicopter Wing of the Aeronautica Militare carried out a survey flight over the settlement, taking a series of low-altitude oblique aerial photographs. These images were captured immediately after the wheat harvest and, thanks to the negative cropmarks produced by the wall structures in the rejuvenating alfalfa, it was possible for the first time to outline the remains of the villa.

In 1970 Giulio Schmiedt of the Istituto Geografico Militare at Firenze published a single photograph of the remains of the villa, one of those acquired in 1965, and this became considered in all subsequent bibliographic references as the only photographic source for the site.

In the same year Giovanni M. De Rossi published in the *Apiolae* of the *Forma Italiae* a study of this area which, for the first time, included data and a plan of the Fontanile di Palazzo villa.

Now, fifty years after the discovery of the settlement, a review of the photographic documentation in the Aerofototeca Nazionale has updated the plan of the villa.

VERONICA FERRARI, PAOLA GUACCI, ALFIO MERICO

**The use of drones in aerial archaeology**

After the first pioneering applications, mainly focused on photogrammetric aerial survey, the use of UAVs has expanded into topographical survey and geomatics, 3D scanning, technical architectural drawing, mapping and the monitoring of both individual sites and wider landscapes. These platforms have now become highly effective instruments for data-capture, site management and documentation, as well as for environmental heritage preservation and management. Today, UAVs constitute indispensable tools for producing detailed documentation, speedily and at low cost, and for efficient mapping of archaeological and architectural heritage features, offering a range of scales and resolutions adapted to many specific needs. As a result they have become progressively more important as instruments for site detection and topographical survey. UAVs (or drones) are enjoying growing exploitation thanks to their ease of use and low cost. A wide range of models and types is available on the market but only few of them are suitable for scientific applications in the sector of Cultural Heritage.

The Summer School 'Archeologia Aerea e Telerilevamento di prossimità con Sistemi Aeromobili a Pilotaggio Remoto (droni)' took place in August 2015 at the archeological site of *Aquinum*-Castrocielo (FR) under the aegis of the Laboratorio di Topografia Antica e Fotogrammetria of the University of Salento. The school dealt with the use of drones in archaeology and especially in topographical and digital recording from the air. Workshops were offered on flight preparation, data acquisition and the preparation of 3D models. In addition, targeted aerial surveys over ancient *Aquinum* were successful in identifying a number of 'new' cropmarks related to roads and buildings in the central areas of the town.

GIOVANNI MURRO

**Post-processing, photo-reading and interpretation**

**Techniques of image enhancement in archaeological photo-interpretation: a case study from Aquinum**

Drones are now standard working instruments for a variety of Cultural Heritage functions. The automation of flight-planning and photo-capture has made it possible to deal with the production and processing of photographic images in a planned and systematic way. Aerial photographs, understood both as 'technical images' and 'written text', contain a range of topographic and spatial data that can be decrypted by the archaeologist. Valuable help in the reading of aerial photographs is provided by Image Enhancement: a process to define and improve the reading of the displayed data through a clearer definition of shapes and colour or tonal differences, particularly in areas rich in archaeological features. The use of digital Image Enhancement on aerial photographs of the urban area of ancient *Aquinum* has made it possible to read and understand new cropmarks and other relevant traces, to revise earlier maps of the urban area and to reconstruct the plans of a number of previously unknown buildings.

CLAUDIO MARTINO

**Satellite imagery and aerial photography for the study of Roman settlement in Località Castelli (Cutrofiano)**

The Roman settlement of Località Castelli is situated in the Cutrofiano countryside, south of the town, alongside an important road, known as the via di Santa Cesaria, which links the central part of Salento with the coast between Santa Cesarea Terme and Castro Marina. To achieve a better understanding of the ancient settlement, a number of aerial photographs and satellite images were analysed, producing a fairly detailed topographical representation of the buried archaeological structures, in particular a quadrangular structure displaying an approximately east-west orientation.

GIANLUCA CANTORO

**Where... goats dare**

**Aerial survey in mountainous landscapes between history and ethnography**

During the summer of 2012 five aerial archaeological sorties (of about two hours each) were planned to document the current condition of known cultural heritage features on the Greek island of Crete. These site-oriented flights provided the occasion for the first extensive aerial sorties over the mountainous landscape of Crete. They were also used to capture imagery of parts of the landscape that remain underexplored or barely accessible but which were nevertheless rich in information about the past. The paper presents some results from the analysis of a small subset of the 3000 and more images captured during these flights, with a particular focus on ethnographical aspects of the modern approach to architectural remains from the past. The paper also aims at stimulating research or simple curiosity about cultural heritage evidence from above the tree line, in what is often seen as the kingdom of the goat (and shepherds).

KONSTANTINOS G. NIKOLAKOPOULOS, KONSTANTINA SOURA,

IOANNIS KOUKOUVELAS, NIKOLAOS G. ARGYROPOULOS

**Synergistic use of UAV based photogrammetry and topographic survey for archaeological site mapping at a LBA settlement at Chalandritsa, Greece**

Excavations at Stavros, Chalandritsa, 20 Km south of Patras, Greece, have brought to light an extensive Late Bronze Age settlement, inhabited at least during the 13th and 12th centuries BC.

As highly accurate mapping and 3D reconstructions are fundamental for analysis and further interpretation in archaeology, the specific area was used as a test bed for a synergistic survey combining classical topographic survey and UAV photogrammetry.

The city was mapped by traditional surveying methods using a tachymeter and a geodetic GNSS receiver. At the same time an Unmanned Aerial Vehicle (UAV) campaign was carried out. Computer vision techniques along with photogrammetric analysis were used to perform bundle adjustment with ground control points collected with a GNSS receiver. 3D models were created from the imagery captured by the UAV and these were then validated in terms of geometric accuracy. In addition, the effects of the camera's lens distortion on the models were also investigated. The results are presented and discussed in this paper.

GIACOMO DI GIACOMO, GIUSEPPE SCARDOZZI

**Aerial photography using a tethered balloon and drones  
Experience in linking archaeological research and documentation  
at Hierapolis in Phrygia**

In the course of research work undertaken from 2008 onwards by the Laboratory of Ancient Topography, Archaeology and Remote Sensing of CNR-IBAM for the production of an archaeological map of Hierapolis in Phrygia (Denizli, south-western Turkey), extensive use has been made of low altitude aerial photography, both for archaeological photo-interpretation and for documenting excavation projects. Thus, in the field work campaigns of 2008-2011 and 2013-2014 at least a week during each season was dedicated to the execution of systematic air-photo survey, using both a tethered balloon and from 2011 also radio-controlled drones. In addition, during 2014 the balloon was also used to carry out survey with an infrared thermographic camera. These campaigns of aerial survey resulted in the acquisition of a rich body of vertical and oblique photographs, aimed at documenting the excavation areas and at studying the ancient urban complex along with its surrounding cemeteries and countryside, in partnership with ground-based archaeological and topographic survey. Thanks to these photographs it has proved possible to highlight mutual topographic relationships between archaeological structures despite their often being almost imperceptible on the ground, and many ancient buried or semi-outcropping remains have been documented. These data have now been georeferenced in the digital archaeological map of the city.

MICHELE COTUGNO, GIUSEPPE SCARDOZZI, RITA SCOGNAMIGLIO

**The contribution of space imagery in the understanding of the  
ancient topography of the cities in Cilicia Pedias  
The case studies of Soloi-Pompeioupolis and Tarsos**

In the last few years the use of 'historical' satellite images in archaeological studies has become increasingly widespread, especially in research into ancient urban sites and their territorial contexts in the Near East and North Africa. In this contribution we will refer in particular to space imagery taken by USA spy satellites between 1959 and 1980 and subsequently declassified for civil use between 1996 and 2002. Today, these images make it possible to investigate the contexts of intended study areas as they were before the radical transformations of recent decades in response to the extension of urban areas, the impact of large infrastructure projects and the spread of mechanized agriculture. The case studies examined in this contribution concern two of the main cities of Cilicia Pedia in southern Turkey, Soloi-Pompeioupolis and Tarsos, along with their territorial contexts, including the area of ancient Zephyrion, present-day Mersin. The city of Soloi-Pompeioupolis is now abandoned but Tarsos (present-day Tarsus) remains in active occupation. There exists for the study area a rich dataset of satellite images from the 1960s and 1970s at both medium (Corona KH-3 and KH-4, Hexagon KH-9) and high spatial resolution (Corona KH-4A and KH-4B, Gambit KH-7). These images have not previously been used in the archaeological investigation of the study area but their analysis and interpretation, in close integration with historical maps and the data acquired during previous archaeological surveys and excavations, has made it possible to recover highly interesting data on the ancient topography of Soloi-Pompeioupolis and Tarsos and on the paleo-environmental contexts within which they existed.

SEYED MANSOUR SEYED SAJJADI, HOSSEIN MORADI

**Shahr-i Sokhta 2014-2015 Excavations  
The new Results in Areas 1, 20, 26 and 28**

Shahr-i Shokhta (the Burtn City) is one of the largest and richest Bronze Age sites in Iran and it is located in the province of Sistan-Baluchestan, 57 km away from the modern city of Zabol. With its 150 hectares of area, the city has been attracting from various archaeological missions, in particular from the Italian team of IsMEO, who led an extensive archaeological investigation between 1967 and 1979, but, since 1997, an Iranian archaeological mission studies the city.

In this paper, the works of the Iranian team are presented and were focused on understanding the architecture, the topography, the economic growth and urban process development of Shahr-i Shokhta and its area in the Third Millennium BC by various studies on the main craft activities and archaeological campaigns in 2014-2015.

**Studi e ricerche 9.15**  
Studies and Researches 9.15