Archeologia e Calcolatori
35.2, 2024, 323-332
doi 10.19282/ac.35.2.2024.34

OLD DATA, OLD METHODOLOGY AND NEW RESEARCH. A CASE STUDY OF LEGACY DATA INTEGRATION FROM THE CESTRINE REGION, EPIRUS

Verrà giorno in cui la schiera dei vecchi, accurati e «pignoli» disegnatori degli istituti cartografici sarà sostituita da qualche ragazza in guanti bianchi che preme soltanto dei pulsanti, e gli zinchi, le copivyti e i cristalli degli archivi cartografici saranno sostituiti da nastri magnetici, da bobine e da mazzette di schede perforate.

Traversi 1965, V

1. Introduction

The Çuka e Ajtoit/Kestría archaeological project is a collaboration between the Sapienza University of Rome and the Albanian Institute of Archaeology. The site of Çuka e Ajtoit, literally Eagle Mountain, is located in the municipality of Konispol, in the southern Albanian fringes, very close to the Greek-Albanian border. The steep conical shape of the hill dominates the flat landscape of the ancient region of Cestrine, located between the Ionian Sea and the Mile-Saraqin mountain range, an area renowned in ancient literary sources for its cattle and for the high quality of its winter pastures (Fig. 1). The area is also linked since the 5th century BCE, and possibly earlier, to the mythical narrations connected to the Trojan cycle (Bogdani 2022b). Cestria is probably the ancient name of the site of Çuka e Ajtoit, a site inhabited for a long timeframe. The most ancient artifacts found in the site date to the Paleolithic, while the most monumental remains, namely the fortification circuit and the polygonal masonry dwellings, date from the Hellenistic period. A second defensive fortification system was built during the Middle Ages.

The new research is actively contributing to the comprehension of the history of the site: the discovery of non-sporadic fragments of coarse pottery dating possibly to the Late Bronze Age is throwing new light a period largely unknown (Bogdani 2022a, 2023). On the other hand, the discovery of many fragments of Corinthian amphorae from the 5th and 4th centuries BCE is unique evidence of a pre-Hellenistic settlement. Excavations have also revealed a later settlement on the north-eastern feet of the hill: around 20 residential units, arranged on a low, flat ridge, date to the Venetian and Ottoman periods.

The survey campaigns at Çuka e Ajtoit revealed that traditional topographical survey techniques proved highly unsuitable due to the difficult

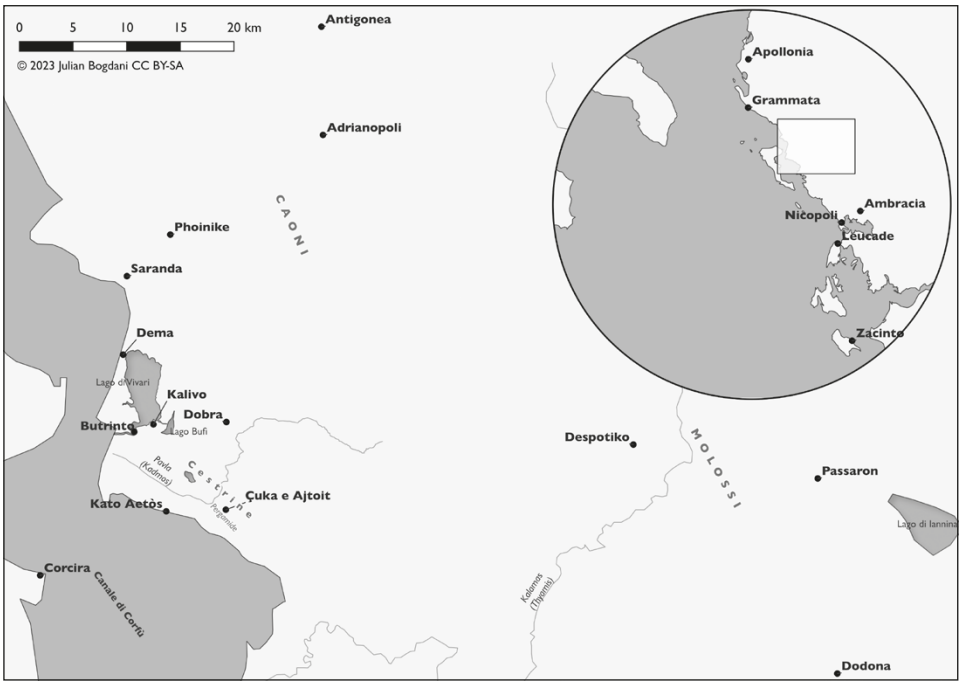


Fig. 1 – Geographical position of the region of Cestrine and of the site of Çuka e Ajtoit.

morphological conformation of the site, with very steep and heavily eroded rocky slopes. For this reason, aerial photogrammetry was chosen as the main documentation technique. Drones are being used to capture images and GNSS instruments, combined with the RTK service provided by the Albanian authorities, provided centimetric accuracy for the photogrammetric models. The remote sensing results are being verified by ground truthing campaigns, aimed at documenting the archaeological remains and, where possible, collecting surface pottery fragments for a broad definition of the chronology. The integration of all these methods, rather than a single tool, allowed a new perspective on the site. Trial excavations of limited sizes complete the overall picture and allow us to narrate a more complex and articulated history of the site.

The field work was flanked by a deep study of archive documentation from previous research, partially published (Hernandez, Hodges 2020), and the recovery of these data have proved fundamental for the reconstruction of various contexts, such as the city's necropolises (Bogdani, Aleotti 2024). Moreover, thanks to funding from the Sapienza University of Rome

(Small Research Grants 2022) and in collaboration with the Butrint Project of the University of Bologna (https://site.unibo.it/butrint/en) and the Albanian Institute of Archaeology, it has been possible to acquire new archive data, such as aerial photographs taken by the Italian Istituto Geografico Militare (IGM) at the end of the 1930s for cartographic purposes. These images were taken during the occupation of Albania by Fascist Italy (1939) and the preparations for the Greek-Italian War (1940-1941), and formed the basis of the Italian cartography of the area (Traversi 1965). Both the Italian cartography, which is available free of charge as a web service on the portal of the ASIG (Albanian Geospatial Information Authority: https://asig.gov.al/), and the aerial photographs form a unique historical document of the period in which they were made, and a valuable basis for understanding the landscape, which underwent radical changes in the following decades: during 1950s and 1960s the plain was subject to extensive land reclamation programs. As a result, riverbeds were moved, ponds and marshes drained, and forests and other vegetation uprooted to allow for intensive agricultural use of the land.

The aim of our project was to use modern photogrammetric methodologies such as Structure from Motion to virtually rebuild the shape of the landscape before these radical changes by creating a historical orthophoto mosaic and historical Digital Elevation Model (DEM) from the Italian aerial imagery. These outputs will allow a thorough analysis of the landscape through the last one hundred years.

J.B.

2. Description of the dataset

A total of 350 aerial photographs acquired in 1937 were purchased from the Italian Military Geographical Institute (IGM), covering the area corresponding to the ancient Cestrine, grouped into 8 aerial strips, each with a different number of images. The project was limited to an area of approximately 810 square kilometers, as individual photographs can be quite expensive. The already mentioned cooperation with the Butrint Project proved to be decisive, since it owned photographic coverage of the Butrint area, which was therefore included in the project dataset at no additional costs. Ideally, these photographs have a 60% overlap and a 20% sidelap, a method that ensures that each terrain point is present in at least three images. However, the individual images presented some critical issues that had to be addressed before they could be processed photogrammetrically. These issues profoundly affected the quality of the ideal overlay. All images had a black frame on which flight metadata including serial numbers were reported (Fig. 2). While this is the most useful information and metadata, the frames needed to be

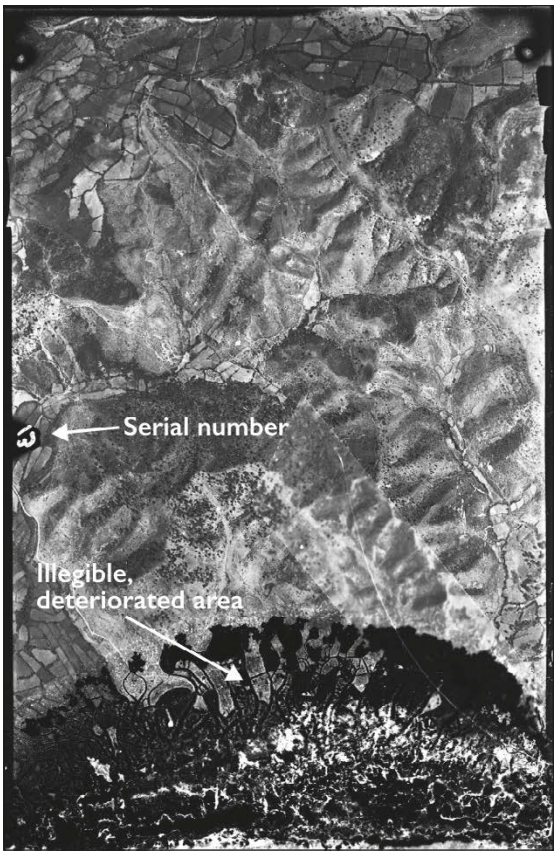


Fig. 2 – An example of the metadata reported in each frame and of the chemical deterioration of the support, which makes half of the image illegible.

removed before the images where processed, since these can be a hindrance to the image alignment process.

Moreover, many images presented chemical deterioration and severe preservation issues, either limited to small areas or in some cases covering more than half of the single image. The most severe preservation issues were found in strip 176, where 32 of the 46 images were extensively damaged (Fig. 2). This is unfortunately the strip that covers the area of the site Çuka e Ajtoit and its northern and southern surroundings. The damage is almost always located along the sides of the images, and makes automatic image alignment very problematic by significantly reducing the frontal and lateral overlap areas. Another issue concerns images representing large areas covered

by the water surface, especially the sea. Due to the ephemeral nature of the water surface, they show changing patterns that cannot be aligned by any software. Six images featuring large areas covered by water were excluded from the data set.

Finally, large areas of cloud shadows make automatic alignment very difficult. This is due both to the reduction in visibility in the shaded area and to the changing shape of the same shadow in neighboring images. These images required particular attention as well.

D.D.E.

3. Methodology

Agisoft Metashape Structure from Motion software was used for the photogrammetric processing of the images, since it has proved to be flexible and highly performing during the other activities of our field survey (Bogdani 2023). From a total of 350 purchased images, a final dataset of 187 images was manually masked to address the preservation issues already discussed and then processed to align the images, by calculating the outer

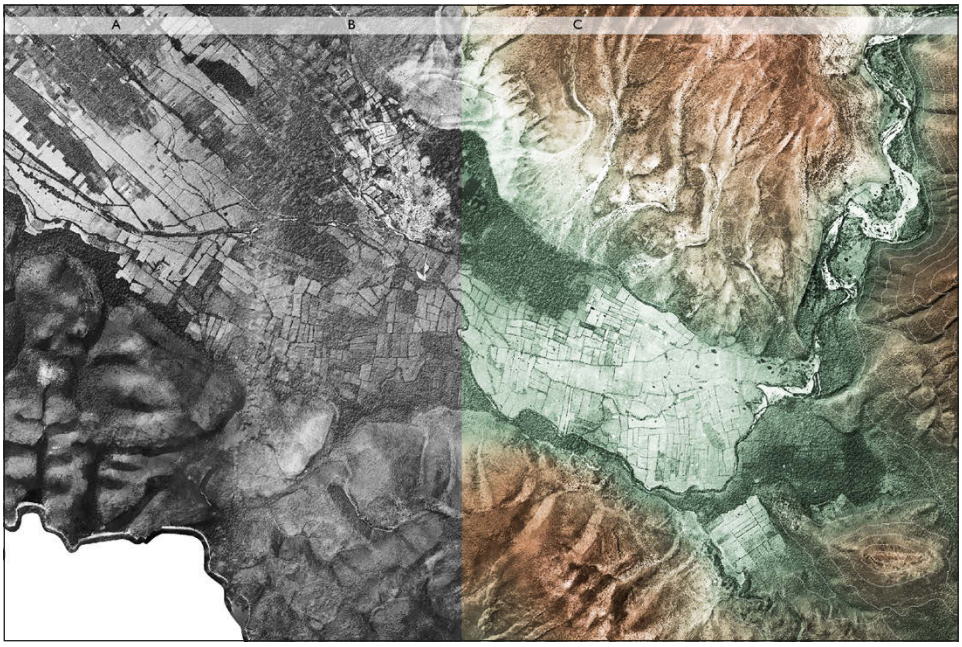
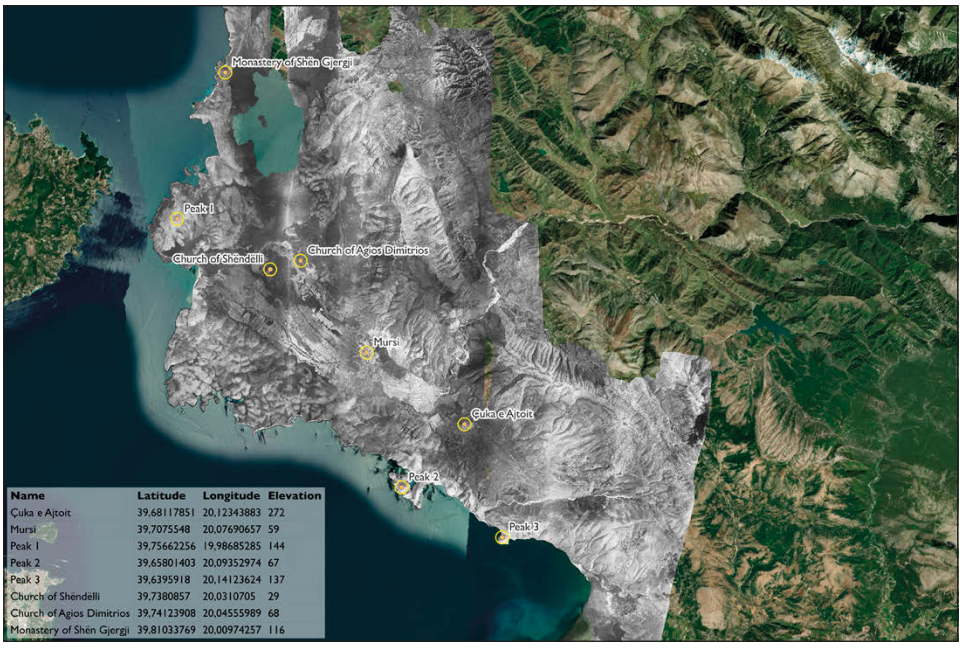


Fig. 3 – Compared view of: the orthophoto mosaic (a), overlaid with the DEM, as a hillshade view (b), and as false color view (c), and curves (d).

orientation and to create the sparse point cloud, i.e. a low resolution 3D model. Since image alignment determines the overall geometry of the model, it was by far the most sensitive step. Among the many possibilities offered by the algorithms, sequential alignment proved to be the most effective, even considering the small and not always homogeneous overlapping areas between images. A number of ground control points had to be added manually to assist the alignment process of areas with poor overlap that could not be resolved automatically. It is a very time-consuming task that requires in-depth and diachronic knowledge of the landscape. Finally, a dense 3D model was calculated from which the general orthomosaic and the digital elevation model (DEM) were processed.

The poor preservation of many images resulted in the presence of void areas in the 3D model (Fig. 3), which are more evident in areas where the mountain relief is more pronounced and therefore the difference of elevation is greater. These gaps are not the result of processing, and are determined by the lack of data, and as such they cannot be filled by the software. These limitations can be addressed by interpolation using specific GIS software, but for the moment we opted to limit our action to the information provided by the original dataset. The georeferencing of the model was performed using



Name	Latitude	Longitude	Elevation
Cuka e Ajtoit	39,68117851	20,12343883	272
Mursi	39,7075548	20,07690657	59
Peak 1	39,75662256	19,98685285	144
Peak 2	39,65801403	20,09352974	67
Peak 3	39,6395918	20,14123624	137
Church of Shendelli	39,7380857	20,0310705	29
Church of Agios Dimitrios	39,74123908	20,04555989	68
Monastery of Shën Gjergji	39,81033769	20,00974257	116

Fig. 4 – Position and coordinates (WGS 84) of the GCP used to georeference the 3D model.

coordinates and elevations extrapolated from the provisional map of the area published by IGM and made available as a WMS in open access by ASIG geoportal (https://geoportal.asig.gov.al/), a source of information contemporary and derived by the photographic images.

The following points were used for georeferencing (Fig. 4):

1. The mountain peak of Çuka e Ajtoit [39.68117851, 20.12343883 / 272 m asl].
2. The village of Mursi [39.70755480, 20.07690657 / 59 m asl].
3. The peaks of 4 hills/mountains:
    a. [39.75662256, 19.98685285 / 144 m als];
    b. [39.65801403, 20.09352974/67 m als];
    c. [39.63959180, 20.14123624/137 m als];
    d. [39.64197470, 20.16631620/288 m als].
4. The church of Shëndëlli [39.73808570, 20.03107050/29 m asl].
5. The church of Agios Dimitrios [39.74123908, 20.04555989/68 m als].
6. The monastery of Shën Gjergji [39.81033769, 20.00974257/116 m als].

The resulting DEM is available in the WGS84 (EPSG: 4326) coordinate system, using the same vertical datum as the IGM topographic map. It was then reprojected and made available in the Albanian national coordinate reference system, ETRS89 / Albania TM 2010 (EPSG: 6870), which is the official coordinate reference model of our project with an updated vertical datum.

D.D.E.

4. Conclusion: output e future perspectives

The project resulted in a high-resolution 3D documentation of the area, consisting of a DEM and of an orthomosaic (ground resolution of 0,647 x 0,841 m/px). This dataset has already proven to be a valuable source of information to document features of the landscape that have undergone radical changes during the land reclamation programs of the 1950s-1960s and for the detection of previously unknown archaeological sites, today still preserved or completely lost (Fig. 5). The DEM and orthophoto are the base of a new vectorizing activity of the paramount natural and cultural features of the orthomosaic in combination with the base cartography, an activity still ongoing at LAD (Fig. 6). The output of this research has been uploaded on the LAD's geodata portal (https://gis.lad-sapienza.it), but licensing issues by IGM prevent us from redistributing the resulting data as open access, an incomprehensible contradiction to the Italian law principle of enhancing open access to public data.

Finally, the same methodology is being applied to the historical aerial images of the same area acquired in the 1940s by the Royal Air Force and

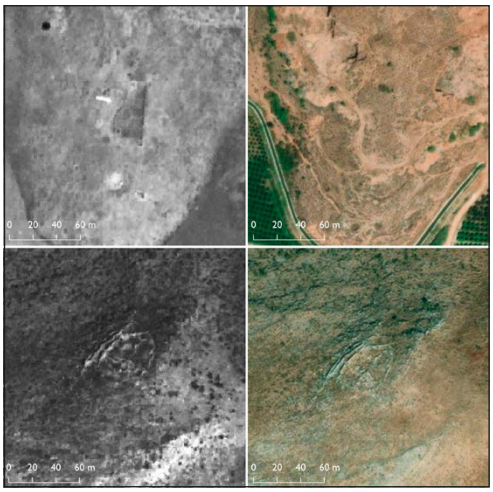


Fig. 5 – Compared view of two sites of archaeological interest detected on the historical orthomosaic, compared to present-day satellite images.

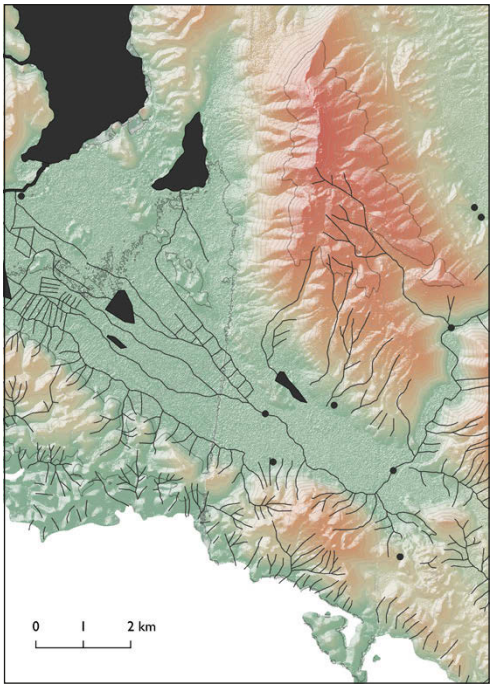


Fig. 6 – Detailed view of the vectorisation process of the historical images (vectorisation by Elena Urzì).

made freely available by the British School at Athens. As the British images were not specifically intended for cartographic purposes, their ground resolution and overlap is not comparable to that of the Italian images, nevertheless, they are important historical documents that deserve careful attention (D'Erasmo 2024).

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ABSTRACT

In the context of the joint archaeological project in Çuka e Ajtoit (Albania) by Sapienza University of Rome and the Albanian Institute for Archaeology, new archaeological field research is being conducted in the Southern fringes of the Albanian territory. The area of interest extends from the site of Butrint (UNESCO Heritage site) to the Albano-Greek border, and corresponds to ancient Cestrine, renowned in the literary sources for its pastoral resources and Trojan connections. The study integrates the freshly acquired information collected during the field campaigns, characterized by a high degree of technological innovation, with old research data poorly published up to present. This paper concerns the photogrammetric processing of historical aerial imagery acquired for mapping purposes by the Italian Military Geographical Institute (IGMI) in the 1930s, during the war context of the invasion of Albania by Fascist Italy. The process resulted in the creation of a DTM and

an orthomosaic by using SfM algorithms and GNSS topographical surveys, representing the shape of the landscape of the late 1930s, i.e., before the realization of extensive land reclamation programs by the socialist regime that have determined the radical changes of the current landscape.