

Survey for the enhancement of the archaeological sites of the Phlegraean Fields: the “Agrippina Sepulchre” in Bacoli

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Abstract – In conjunction with a collaboration with the Superintendence for Archaeological Heritage of Naples for an updating of previous surveys with advanced and integrated methodologies and techniques, we would like to present the first results of the study on the “Agrippina Sepulchre” in Bacoli inside the Archaeological Park of Baia Terme.

For a long time closed to visitors the monument, known as the Sepulchre of Agrippina in Bacoli, is part of a restoration and musealization programme that regards the entire archaeological area of the Park of Baia Thermae - in synergy with the Municipal Administration - and which aims to preserve and enhance the site, as well as a historical deepening and knowledge about the original consistency of the Roman-era architecture existing on the area of influence of Baia.



Fig. 1. The Agrippina Sepulchre, aerial view

The monument we are talking about, wrongly known from the 16th century as “Sepulchre of Agrippina”, represents most probably some remains of a Roman-era monument, an important Odeon, most likely executed in Julio-Claudian period and subsequently used as a semi-circular Nymphaeum between the end of the 1st and the beginning of the 2nd century A.D. (Fig. 1). It was a part of a no longer existing monumental maritime villa, overlooking the sea, where, from its surface, some remains are still visible. The scheme of the semi-circular cavea had three storeys, connected by internal and hidden staircases: the lower annular corridor, covered by a barrel-vault and still well-preserved, is characterised by

the presence of three small exhedras which faced three openings, called “vomitoria”, that nowadays are narrow openings at ground level.

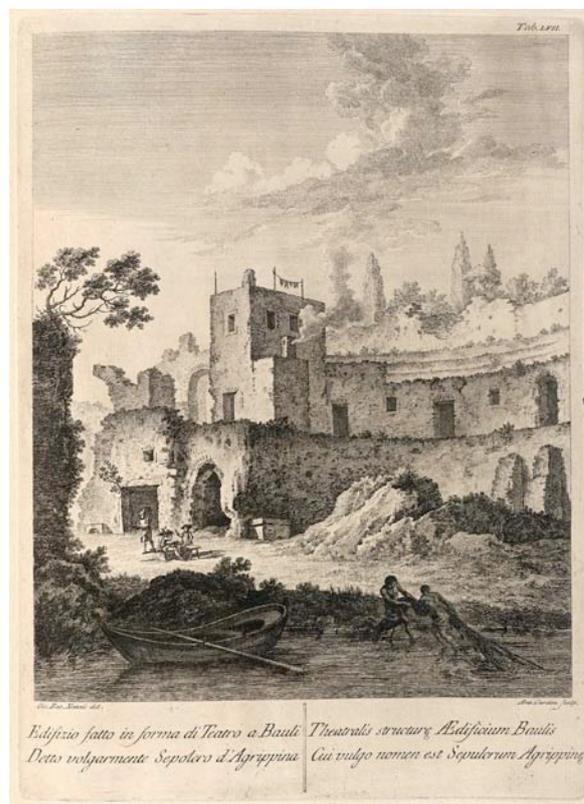


Fig. 2. Paolo Antonio Paoli, Agrippina Sepulchre, 1768.

In the middle of the lower annular corridor there is another straight corridor inserted into the ground, in alignment with the centre of the cavea, which is a remarkable example of fine decorations (female figures, sea monsters, swans and dolphins) recalling the theme of water architecture and of the water games that took place inside. This corridor probably led to some rooms behind the Odeon, but in the successive transformations it was closed: this particular circumstance may have meant that

the discovery in the 16th century of the hypogeum environment was confused with a tomb, the Sepulchre of Agrippina, who died in this area. Paolo Antonio Paoli himself, who produced in 1768 valuable prints and historical information, hypothesizes this possibility.

The upper hemicycle, covered by a barrel-vault, led to the median cavea and it opened with doors alternating with windows which are still preserved. The no longer existing summa cavea dominated the odeon bleachers and maybe it didn't exist anymore when the monument became a Nymphaeum. Behind the upper annular corridor there was the third hemicycle, whose some remains are still visible, like in particular the ornamental semicolumns in brick and stucco.

The building transformation from Odeon to Nymphaeum, which occurred between the 1st and the 2nd century, determined the elimination of a part of the steps, the creation of a large terrace with an axial staircase (still visible) and the significant alteration of the orchestra level, which is currently set one meter underground.

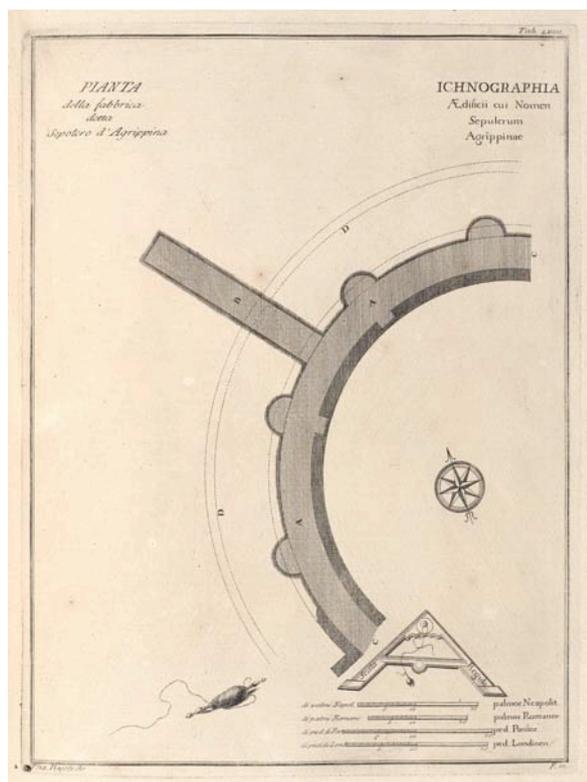


Fig. 3. Paolo Antonio Paoli, *Agrippina Sepulchre*, the plan of the hypogeal corridor, 1768.

The unsafe working conditions of the structure do not yet allow the access to the hypogeal environments, which will be addressed in detail in the next studies; therefore a no-contact survey (with a Drone) has been used for the analysis of the structure, along with a study of the previous surveys. The investigation among them has been

addressed especially to the Paoli's meaningful survey of 1765, which shows a plan at the first-ring level, the hypogeal environments, and an overall view represented in two prints that belong to the collection of the ancient remainders in the area of Naples, Pozzuoli and Baia (Fig. 2-3).

This view deals with the substance of the structure above-ground in the middle of the 1700's and its state of conservation, it shows also some no longer existing elevated structures.



Fig. 4. *The Agrippina Sepulchre*, aerial view

The northern part of the cavea appears to be missing and in its place stands out a modern building.



Fig. 5 *Agrippina Sepulchre*, inside the ambulatory.

The complexity of the surviving rooms and their hypothetical reconstruction is widely reported by Amedeo Maiuri, who conducted an archaeological excavation in the middle of the last century, where he pointed out the preciousness of the decorations on the annular corridors intradoses; in fact he formulated a method of documentation and of in-depth knowledge of this monument, to whom our study wants to give a contribution, more linked to technological innovation of survey techniques which allows new investigations even in limited-access areas where the architectural structures are in precarious conditions.

For the acquisition of morphometric data of the archaeological site in question, Structure from Motion (SfM) algorithms were used to reconstruct the shape of the artefact by collimating points from a dataset of images taken with a non-metric chamber, both on the ground as well as in flight.

Structure from Motion is a digital technology based on feature recognition algorithms (SIFT, SURF), developed under Computer Vision, which allows the creation of a dense stereo matching (raster image) from raster images. The innovation in this technique and its peculiarities can be summarized in the low-cost principle that characterizes this technology, which uses much cheaper instrumentation compared to 3D laser scanner equipment. In fact, for the acquisition, a common digital camera can be used, with appropriate arrangements. In addition, the development of software for processing and post-processing of data is carried out both in the commercial and open source domains.

Photomodeling does not replace the other methodologies but, above all in the archaeological field, it needs to be integrated with 3D data acquisition systems such as photogrammetry or 3D laser scanning. Experimenting and using these new technologies requires the coding of a pipeline for defining a standard during the acquisition phases and, above all, the post-processing of data.



Fig. 6. View of the archaeological complex of the Agrippina Sepulchre.

SAPR (remote pilot aircraft systems) acquisition of aerial images was made nadir at different angles to be used in photo-modeling software. The process was aimed at reconstructing the current state of the monument and at creating three-dimensional models and orthophoto map of the site.

The acquisition of frames with SAPR required a preliminary shooting plan, based on a mapping of areas of interest with Mission Planner, a tool for creating the flight plan via waypoints, by setting the path, the number of shots, and the value of the ground resolution (GSD ground sample distance). Frames have been scanned in succession and in several steps to completely map the surface. Photos were grouped into datasets and subdivided into chunks to be included in the software.

It was therefore possible to ensure maximum coverage of the area to be detected. The factors to be taken into account when drawing up the project, depending on the software chosen for managing the acquired data, are influenced by the lighting condition of the context, the material characteristics of the object to be detected, the correct putting on focus of the objects to be detected in all the frames to use, from the correct shooting position and overlay of images so that the overlapping of frames is approximately 70% and the overlap between the strips is approximately 80 % and, finally, at the required resolution scale for the survey the GSD was 1cm / pixel.

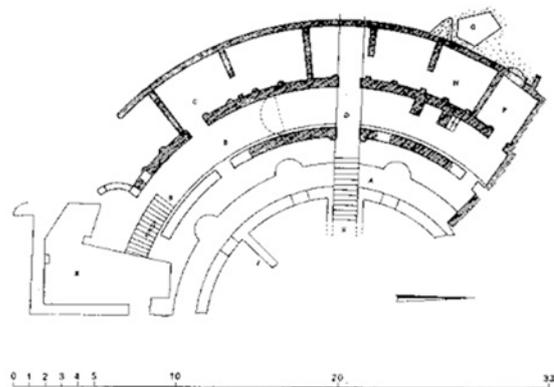


Fig. 7. The Agrippina Sepulchre, plan from Forma Italiae, Florence 1979.

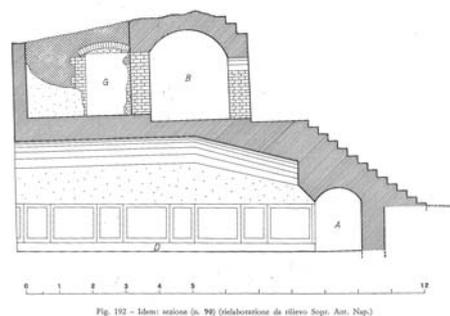


Fig. 8. The Agrippina Sepulchre, cross section from Forma Italiae, Florence 1979.

The workflow is divided into two parts: capturing frames using passive sensor technology and extracting captured data and post-processing them through multiple dedicated software.

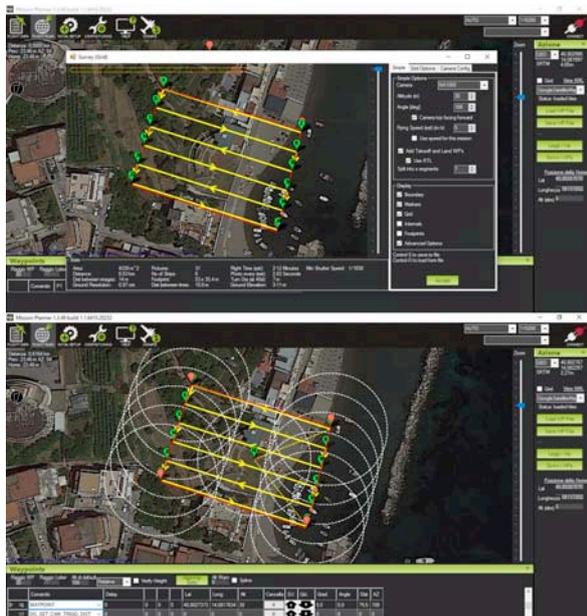


Fig. 9. Mission Planner, Flight Scheduling. Both the input and output parameters determined by the software are visible.

During the first step, the various phases in which it is subdivided can be synthesized, on-site, in the lookout to plan the flight, in the choice of the most appropriate methodologies and technologies, in planning the project of shooting and in the acquisition of metric and photographic data.

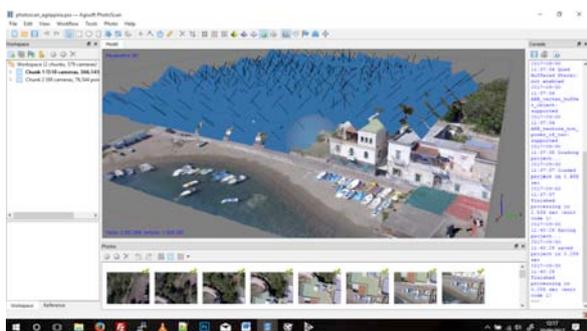


Fig. 10. Agisoft Photoscan, point cloud with position frames from GPS coordinates.

The planned operations consist of capturing image datasets, chunks per single flight, or sequential shots, camera calibration using Agisoft's Agilens software to locate the internal orientation and external orientation of the camera, the calibration can take place both before and after capture by extracting information from the frames.

After selecting the datasets to be inserted, the tie points are extracted for the calculation of correspondence, the

construction of the sparse cloud that in some software coincides with the extraction of homologous points, the dense cloud construction.

Due to the complexity of the site in question, it has been chosen as Agisoft's dot-processing software, Photoscan, which allows to extract a mesh of the entire project and texturize it and extract orthophotos and sections.

Number of images:	521	Camera stations:	510
Flying altitude:	28.9 m	Tie points:	366,145
Ground resolution:	1.02 cm/pix	Projections:	1,083,978
Coverage area:	0.0106 km ²	Reprojection error:	5.47 pix

Camera Model	Resolution	Focal Length	Pixel Size	Precalibrated
FC330 (3.61 mm)	4000 x 3000	3.61 mm	1.56 x 1.56 μm	No

Fig. 11. Processing parameters in Agisoft Photoscan.

The use of such technologies in the archaeological site is increasingly common for the acquisition of dimensional, colorimetric and material information, and for the writing of descriptive documentation (graphic and textual).

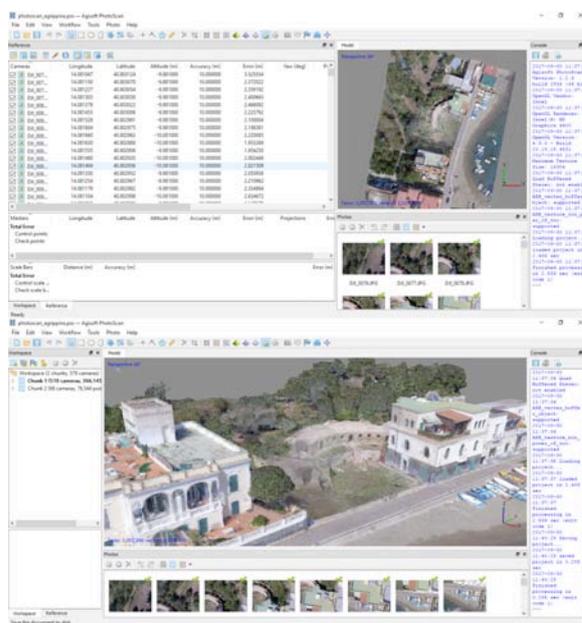


Fig. 12 Dense cloud in Agisoft Photoscan.

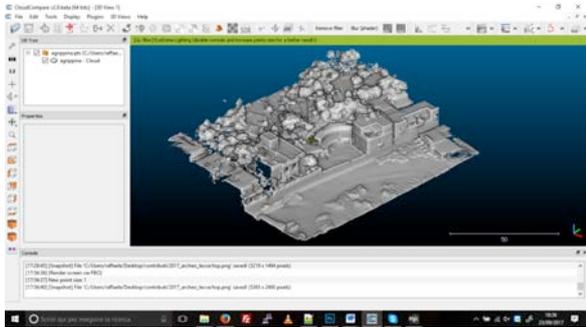


Fig. 13. 3D Model, processing in CloudCompare.



Fig. 14 Orthophoto of the archaeological complex of the so-called Sepulchro di Agrippina, 2017, GSD.

About the workflow we know the limits of use both in the acquisition and in after-processing phase of data. The considerations that arise after having acquired a sufficiently comprehensive knowledge of the archaeological site of the so-called Agrippina Sepulcher are the necessity of direct survey as a fundamental instrument of knowledge of this artefact.

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