

DIAGNOSTICS AND CONSERVATION OF COASTAL ARCHEOLOGICAL SITES: THE CASE STUDY OF THE ROMAN VILLA OF CASIGNANA, REGGIO CALABRIA (ITALY)

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Abstract: The conservation of coastal archaeological sites, like the Roman Villa of Casignana in southern Italy, dating back to the 4th century AD, faces various threats, including erosion, rising sea levels, and urbanization. To preserve this site's valuable mosaics, a multidisciplinary approach involving archaeology, environmental science, engineering, and community engagement is necessary. The University of Calabria, particularly through its Restoration academic course and Heritage Science research group, focuses on conserving and valorizing the Villa. As part of the national PNRR Tech4U project, the Villa of Casignana has been chosen as a pilot site for the development of innovative technologies for the conservation of cultural heritage, also taking into account the evolution of conservation problems related to climate change and the evolution of coastal lines. Once validated in the laboratory, these technologies will undergo field testing. Community involvement and education are emphasized for the sustainable conservation of coastal archaeological sites.

Keywords: Coastal Archaeological site; Roman villa of Casignana; Diagnostics; innovative materials for restoration

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Introduction

The conservation of coastal archaeological sites is a critical endeavor that aims to preserve and protect the rich cultural heritage embedded in these locations. One such site of great historical significance is the Roman Villa of Casignana, a testament to the ancient Roman civilization that once thrived along the shores.

The Roman Villa of Casignana, located in the Calabria region of southern Italy. Dating back to the 4th century AD, this coastal villa has endured centuries of natural and human-induced threats, ranging from erosion and rising sea levels to modern urbanization. Dating back to the 4th century AD, this coastal villa has endured centuries of natural and human-induced threats, ranging from erosion and rising sea levels to modern urbanization. Moreover, the site is characterized by several valuable mosaics.

Preserving such a site demands a multidisciplinary approach that encompasses archaeology, environmental science, engineering, and community engagement. The archeological site is crossed by the 106 Ionian Road and by the railway as well. Some structures of the Villa are submerged close to the seashore. In the last years the University of Calabria, through the Restoration academic course, and the Heritage Science research group, is focusing its effort on the conservation and the valorization of this site. For this reason, several research theses are carried out, they were focused on the conservation of the mosaics which suffer several degradation forms such as salt crystallization, deformation, deposits and lacks. This activity is assisted from the diagnostic analysis of the mosaic tesserae in order to gain information about the composition and the provenance of the stone materials that constituting the tesserae [1].

In addition to these activities, within the framework of the national PNNR project called Tech4U, the Villa of Casignana has been chosen as a pilot site for the development of innovative technologies for the conservation of cultural heritage, also taking into account the evolution of conservation problems related to climate change and the evolution of coastal lines. Such problem is quite critical in the case of Casignana, due to the proximity to the sea, therefore here the coastal erosion represents a significant risk.

These ongoing technologies, once validated in the laboratory, will be tested in the field. All of the above activities will be disseminated to the local community, as community involvement and education play a key role in the sustainable conservation of coastal archaeological sites. Local communities are often the stewards of these heritage sites, and their active involvement is crucial for long-term success. Educational programs, guided tours, and outreach initiatives not only raise awareness of the historical significance of the Roman Villa of Casignana, but also foster a sense of ownership and pride among the local population.

The Roman Villa at Palazzi di Casignana

The extensive complex of the Roman Villa of Casignana is located south of Calabria, 15 kilometers south of Locri, between the towns of Bianco and Bovalino, in the area known as Palazzi (Figure 1A) [2]. It experienced a period of activity

from the 1st to the 4th century AD, with traces of activity persisting until the 7th century [3]. Its enduring occupation can be attributed to its privileged position.

The strategic location, chosen in accordance with Roman agronomists' principles, reflects the significant exploitation of Calabrian territories during the Roman period, recognizing their agricultural potential. In line with ancient sources, the villa stands 300 meters from the Ionian coast, facing east-west orientation (Figure 1B). Abundant water sources were likely provided by the nearby Bonamico River and possibly by an aqueduct. Moreover, the discovery of massive walls at the mouth of the Bonamico River suggests the possibility of a villa harbor, facilitating inland access via the navigable ancient river. Proximity to the main Roman road along the Ionian coast, stretching from Rhegium to Metaponto and Tarentum, was another influential factor in site selection.



Figure 1 – A) Location of Casignana in the Calabria region; B) Aerial view of the archaeological site of Casignana.

In the 4th century, the Roman Villa at Palazzi di Casignana consisted of a central courtyard, with thermal baths in the western part, service areas including latrines in the southern part, and residential area facing the sea in the eastern area. Only limited data is available for the northern area due to the presence of a modern construction [4]. Upstream from the villa, several structures were unearthed, including a monumental fountain and water collection basins/cisterns.

Internationally renowned for preserving the largest collection of Roman mosaics in Calabria, the Roman Villa of Casignana provides insight into the social status of its owner through intricate geometric and figurative compositions adorning different areas of the residence (Figure 2). Notable examples include the mosaic floors in the thermal area depicting sea nymphs riding sea monsters, geometric mosaic patterns in the caldarium of the western baths, and figurative mosaics in service areas depicting the triumph of Dionysus [5]. The complexity of the geometric and figurative motifs, along with the use of different-colored tesserae, reveals the technical skill of the mosaicists capable of fulfilling the commissions of the dominus.



Figure 2 – Some of the geometric and figural mosaics of the Roman Villa. A) Opus sectile floor; B) *Frigidarium* of the Western Baths mosaic floor; C) Polychrome geometric mosaic of *calidarium* room of Western Baths; D) Mosaic with Dionysus and Satyr; E) The Indian Triumph of Dionysus Mosaic; F) Nereid mosaic floor of frigidarium of the Eastern Baths; G) Mosaic with the Four Seasons; H) Mosaic with floral motif.

Since 2019, the University of Calabria, in collaboration with the Municipality of Casignana and relevant authorities, has actively participated in the conservation of the villa's mosaic floors. Students of the degree course in Conservation and Restoration of Cultural Heritage, at the University of Calabria, engage in practical conservation activities on-site, ensuring stabilization and various preservation operations including consolidation, cleaning and plastering of mosaic floors (Figure 3).



Figure 3 – Restoration works of the mosaics inside the Roman Villa of Casignana carried out by the students of the degree course in Conservation and Restoration of Cultural Heritage, at the University of Calabria.

The Tech4You PNR Project

The primary focus of the Tech4You ecosystem falls within the scope of the "Climate, Energy, Sustainable Mobility" area of the National Research Plan (PNR). Its main objective is to stimulate innovation potential in two of Italy's "Less Developed Regions," Basilicata and Calabria, currently classified as "Regions in Transition."

Specifically, the project aims at: building a model of sustainable economic growth that enhances the specificities of Calabria and Basilicata, making them a reference point for the revitalization of Southern Italy; promoting and strengthening collaboration between the research system, the productive system, and the territorial institutions in the Calabria and Basilicata regions; supporting processes for valorizing the results of scientific research by facilitating technology transfer, increase the dissemination of low-impact environmental technologies and improve territorial resilience [6].

The base of the project is the creation of an innovative ecosystem where scientific research conducted by universities and research centers can be transferred into commercially marketable products developed and utilized by local companies.

Tech4You stems from a project proposal presented by the University of Calabria, as the lead partner, in partnership with two other Calabrian universities, one Lucanian university, the Calabria Region, CNR, and various public and private partners. The project focuses on scientific and technological areas that focuses on the adaptation/mitigation of climate change and improvement of quality of life in different field of research.

Spokes are the operational part of the project and represent the place where the transfer of technology to the economic system is achieved.

In particular, among these, *Spoke 4*'s mission is to enhance the adaptation of cultural heritage by improving the sustainability and accessibility of natural and cultural heritage (both material and immaterial) in Calabria and Basilicata. The primary goal is to mitigate the impact of climate change on particularly vulnerable sites.

The Pilot Project 4.4.1

The pilot project 4.4.1, within *Spoke 4*, aims at monitoring and mitigating the impact of climate change on cultural heritage. The actions related to the pilot project are diverse and have the general objective of preserving cultural heritage, especially those exposed to an increasing risk.

In more detail, the pilot project focuses on experimenting, validating, and prototyping sustainable and green conservation products, sensors, hybrid robots for diagnostic activities and mathematical models to verify the structural stability of culturally significant buildings over the 36-month project duration.

Among the 9 *azioni* of the pilot project, 6 of them have selected the Roman villa at Palazzi di Casignana as the real case scenario to validate the results and prototypes. Thus, there exists a synergy and an interdisciplinary approach involving various professionals such as civil engineers, environmental engineers, computer engineers, restorers, archaeologists, and microbiologists working

together and sharing the same site, each with a different approach but with a shared goal of conserving the archaeological site.

Delving into further detail, the archaeological site of Casignana is the focal point of ongoing research activities aimed at diagnosis, understanding, and assessing the risks to which the site is exposed, in order to implement a series of measures aimed at least to reduce future losses in the perspective of preventive conservation. Among these measures, the development of an archaeology map of the Calabrian Ionian coast is underway, which will then be overlaid with the hydrogeological risk map to identify archaeological sites most at risk and in need of monitoring and protection.

Additionally, numerical models are being developed for the analysis of the structural stability of culturally significant buildings, aiming to determine the vulnerability of structures exposed to extreme events such as earthquakes and landslides.

Prototyping of sensors for monitoring environmental parameters, particularly developed for the coastal marine environment, is also in progress.

Furthermore, there are several research lines aimed at mitigating the degradation of cultural heritage. Among these, the experimentation of new green and sustainable products for the protection of cultural assets in the coastal marine area is being carried out. Basing on the characterization of the microbial community of the mosaics present on the site, these products exploit the ability of certain microbes to produce biomolecules known as biosurfactants capable of slowing down degradation induced by microbial growth.

Other research theme involves the experimentation of mortars supplemented with waste materials from agricultural industries with the aim to strengthen the circular economy by promoting the recovery of waste materials. Additionally, smart devices are being developed for the application of conservation products on artifact surfaces.

Another research theme focuses on creating protective barriers against saline intrusion, both on a small scale near archaeological sites, through the application of specific films, and on a large scale through the evaluation of marine intrusion into the archaeological site.

Conclusions

The preservation of the Roman Villa of Casignana, a site of immense historical and cultural significance, highlights the critical importance of multidisciplinary approaches in the conservation of coastal archaeological sites.

The recent collaborative efforts between the University of Calabria, the Municipality of Casignana have demonstrated the effectiveness of integrating archaeology, environmental science, engineering, and community engagement.

Through detailed diagnostic analyses, conservation techniques, and innovative technologies, significant strides have been made in stabilizing and preserving the mosaics, which are central to the villa's historical narrative.

Moreover, PNR Tech4You project, and in particularly *Spoke 4* research field, has provided a robust framework for addressing the challenges posed by climate

change to cultural heritage sites. The *azioni* within the pilot project have not only focused on mitigating immediate risks through advanced monitoring and prototyping sustainable conservation products but have also laid the groundwork for long-term strategies aimed at enhancing the resilience of cultural assets.

In conclusion, the ongoing research and conservation activities at the Roman Villa of Casignana exemplify a model approach for the preservation of coastal archaeological sites. The interdisciplinary collaboration, innovative technological applications, and strong community engagement represent a comprehensive strategy for confronting the multifaceted challenges of cultural heritage conservation in the face of environmental changes. As these methodologies continue to evolve, they promise to enhance the resilience and longevity of heritage sites, ensuring their preservation to the future generations.

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