2025 IMEKO TC26 International Conference on
Metrology for Archaeology and Cultural Heritage
Bergamo, Italy, October 15-17, 2025

Digital Strategies for the Protection and Valorization of Prehistoric Landscapes: 3D Metrology at Cozzo del Pantano (Sicily)

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***Abstract* – This paper presents an integrated digital documentation strategy for the Middle Bronze Age necropolis of Cozzo del Pantano (Sicily), employing terrestrial laser scanning and digital photogrammetry to capture and analyze fragile archaeological features embedded in a complex natural landscape. The project identified and modeled twenty-four tombs, revealing evidence of diachronic reuse and transformation. The resulting 3D data, publicly disseminated via Sketchfab, supports both scholarly analysis and heritage valorization. This work highlights the potential of non-invasive digital metrology to protect endangered prehistoric landscapes while fostering public engagement and interdisciplinary research in Mediterranean archaeology.**

I. INTRODUCTION

Prehistoric archaeology presents unique methodological challenges, especially in contexts where fragile remains are embedded in natural landscapes subject to both anthropogenic and environmental transformations. The necropolis of Cozzo del Pantano at the spring of the Ciane River by Siracusa (Sicily) exemplifies such complexity (Fig. 1). While originally investigated in the late 19th century [1, 2] when several Middle Bronze Age pluricellular chamber Tombs were explored (Fig. 2), the site's reinterpretation has been hindered by outdated documentation and erosion. In response, our research leverages advanced 3D digitization technologies, such as terrestrial laser scanning (TLS) and terrestrial digital photogrammetry, to non-invasively document, interpret, and cemetery and its transformations through time. These digital techniques serve both research and conservation goals, enabling the rapid and precise cataloguing of archaeological evidence in the face of increasing threats posed by climate change and land use.

Fig. 1. Map of the Syracuse hinterland with indication of the Cozzo del Pantano plateau the Ciane River course

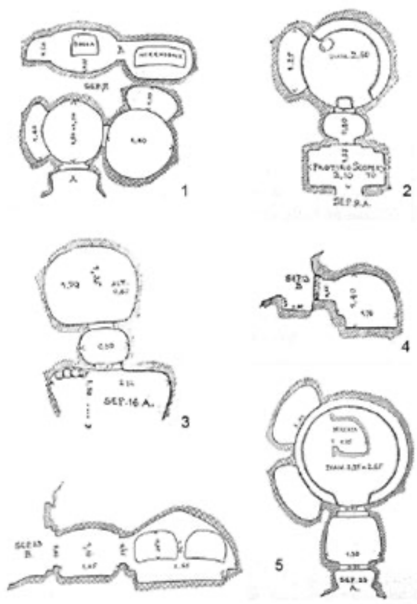

Fig. 2. Cozzo del Pantano prehistoric tombs, plans and section views (Orsi 1893).

II. MATERIALS

The Cozzo del Pantano site comprises approximately sixty Middle Bronze Age rock-cut chamber tombs (16^{th} – 13^{th} century BCE) distributed across a limestone ridge. Excavated in 1892 by Enrico Caruso under Paolo Orsi's direction, the necropolis yielded a wide range of ceramic and luxury materials from Malta and the Aegean. Despite its significance, the site was never fully surveyed with modern tools, and much of its architecture remained obscured by vegetation or misidentified as part of the natural landscape. A new initiative led by the Institute for Digital Exploration (IDEx) at the University of South Florida focused on the southern sector, aiming to digitally capture the site’s morphology and assess the cumulative anthropogenic impact on the terrain. The first step of this initiative consisted in a terrestrial survey of the southern slope of the plateau where 24 chambered tombs were identified [3]. The analysis of the features of these tombs compared with the documentation provided by the excavations report of Paolo Orsi in 1893 allowed us to identify three tombs explored by Orsi, 16, 30 and 31 (Fig. 3).

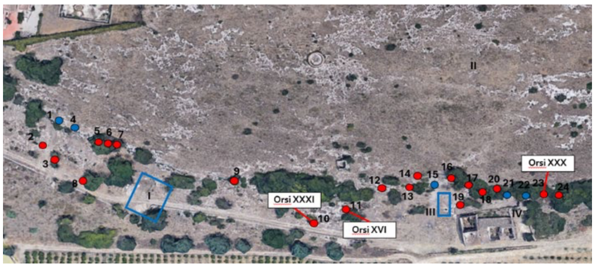

Fig. 3. Map of the southern slope of the plateau with indication of 24 tombs identified doing the survey; tombs 10, 11 and 23 correspond namely to tombs XXXI, XVI and XXX according to the Orsi 18932 numbering system.

III. METHODS

Our approach combined terrestrial laser scanning, terrestrial digital photogrammetry, and DSLR-based close-range documentation. Using FARO Focus 3D-X330 scanners, we performed 110 high-resolution scans capturing all the site features with a 6 mm accuracy at 10 m. The scanners, able to capture up to 2 million points per second, at a range of 0.6m to 150m, are equipped with a built-in camera, GPS, a compass, an altimeter, and a tilt sensor, generating 3D point cloud datasets with a maximum distance accuracy of +/- 4mm. All scan data was processed at the University of South Florida Institute of Digital Exploration. First, a new project was created in Faro Scene 2025.0.0, and the raw scan data was imported from the Faro Focus scanner. Each scan was processed with a dark point filter and a stray point filter. The scan cluster was then registered using Scene’s manual registration. The data was cleaned by manually removing floating data, obstructions, and noise, and a project point cloud was created with parameters to eliminate duplicate scan points, homogenize point density, and apply balancing (Figs. 3-4). From the general point cloud, sixteen individual 3D models of tombs with special architectural features related to phases of later user were also extrapolated. Such stand-alone 3D models were used to generated technical plans and section views (Figs. 6-8). The Registration Report generated by Faro Scene 2025.0.0 indicates a troublesome scan workflow. With a mean point error of 18.2mm, maximum point error of 56.4mm, and a minimum overlap of 1.5%, the Cozzo del Pantano dataset mostly falls outside the recommended standards set by Faro Scene of <8mm point error and >25% overlap. The high point error and minimal overlap are due to the hasty nature of the scan plan. The equipment was relatively new to the operators, and time at the site was severely limited. Those two factors combined to make processing more difficult for the team in the lab. Nevertheless, the model has outstanding overall visual continuity considering the high point error and low overlap. One digital photogrammetry dataset of 167 photographs captured with a Canon EOS 2000D was processed with Agisoft Metashape to generate the 3D model of a staircase excavated in the southern slope of the Cozzo del Pantano plateau.

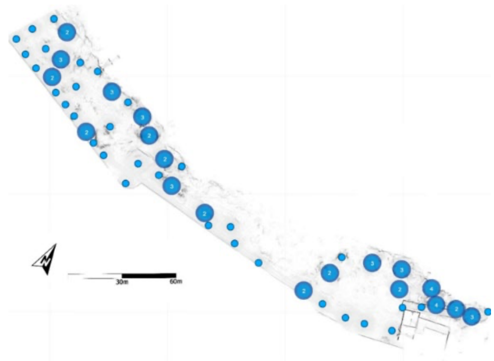

Fig: 4. 3D Point cloud of the southern slope of Cozzo del Pantano with indication of the scan positions.

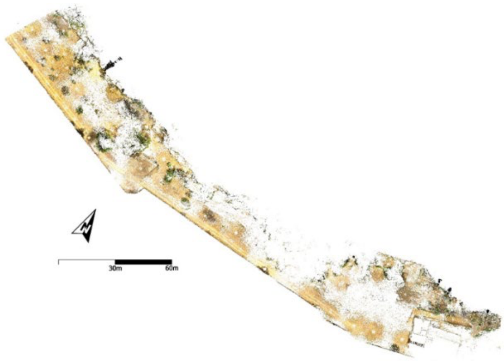

Fig. 5. 3D Dense and colored point cloud of the southern slope of Cozzo del Pantano.

IV. DISCUSSION

The 3D models revealed twenty-four key archaeological features, including previously undocumented tombs, architectural modifications, and industrial reuses. Digital metrology allowed us to reassess their function and chronology with unprecedented precision. For instance, Tomb 4 exhibited adaptations consistent with post-prehistoric domestic reuse, including new partition walls, feeding troughs, and skylight apertures. Tomb 21 was repurposed as a Christian hypogeum with carved arcosolia, while Tombs 1 and 22 showed signs of quarrying and wine production, respectively. Tomb 15 was transformed into a silo pit—evidence of agrarian exploitation in later periods.

The ability to model these transformations digitally facilitated the distinction between anthropogenic and geomorphological alterations. Stratigraphic overlays generated from the point clouds were used to visualize diachronic usage and material deposition, supporting hypotheses about site reoccupation and land-use continuity. Our methodology thus addresses a key challenge in prehistoric archaeology: the identification of archaeological features camouflaged within natural landscapes.

Importantly, these 3D resources were disseminated via public platforms, including Sketchfab, with the creation of an *ad hoc* collection (https://sketchfab.com/usfidex/collections/cozzo-del-pantano-tombs-2025-1f957d3b466d47be8bf978e0c8019235), allowing both scholars and the general public to engage with the site through immersive, inclusive narratives. Such accessibility enhances site valorization while supporting ongoing conservation monitoring. The dataset also provides a robust baseline for future AI-assisted classification of features and artefacts, an area of increasing relevance to the field.

Fig. 6. Tomb no. 4, interior of the first chamber transformed into a stable.

Fig. 7. Tomb no. 4., re-textured 3D model extrapolated from the point cloud.

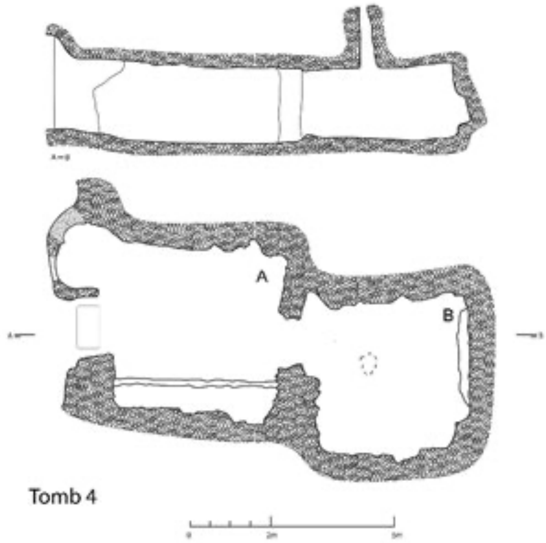

Fig. 8. Tomb no. 4, section view and plan generated on the basis of the 3D model.

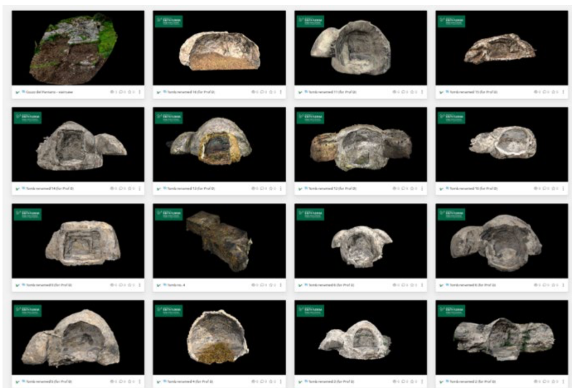

Fig. 9. Sketchfab collection with the collections of 3d models of sixteen relevant tombs and the staircase feature.

V. CONCLUSIONS

The Cozzo del Pantano project underscores how digital metrology, especially when integrating TLS and photogrammetry, can address the unique methodological needs of prehistoric archaeology. Our approach demonstrates the importance of rapid, non-invasive documentation techniques that protect and enhance fragile archaeological landscapes while providing the precision necessary for scientific analysis. Furthermore, the project contributes to the broader promotion of prehistoric cultural heritage by generating accessible digital surrogates for research, education, and public engagement.

In the face of accelerating climate change and ongoing landscape transformation, projects like this serve as critical models for sustainable archaeological practice. They exemplify the session's three foundational values: protecting the archaeological record through non-invasive technologies, enhancing interpretation with multidimensional data, and promoting prehistoric heritage through digital outreach and interdisciplinary collaboration.

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