

High-Resolution 3D Digitization and Analysis of the Mesolithic Site of Latnija (Malta)

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Abstract – This paper presents the high-resolution 3D digitization of the Mesolithic archaeological site of Latnija (Ghar Tuta), located in a doline in northern Malta. The study employed terrestrial laser scanning using the Faro Focus s150 scanner to generate a precise digital representation of the site's complex geological and archaeological context. The resulting point cloud data, meticulously processed in Faro Scene, was optimized, filtered, and transformed into a detailed 3D mesh model. Despite challenges such as geological instability and limited scan overlap, the digitized model achieved high accuracy and visual continuity. Furthermore, the model serves as a crucial tool for preserving this fragile archaeological context against ongoing environmental threats, enabling detailed spatial analyses, and facilitating public engagement. This research highlights the effectiveness and critical importance of integrating advanced digital methodologies into archaeological practice, ensuring long-term preservation and enhanced accessibility of significant prehistoric sites.

I. INTRODUCTION

The site of Latnija (also known as Ghar Tuta) is situated within a large doline, a karstic depression characteristic of Malta's limestone-dominated landscape, in the Meliieha region of northern Malta (35°58'38.80"N, 14°19'42.82"E) (Fig. 1). This doline, formed through the dissolution of underlying limestone, creates a natural basin that likely served as a focal point for human activity due to its topographic and environmental advantages. The doline's morphology includes steep, rocky walls and a relatively flat base and a protective overhang on the north-western edge, which shielded the site from prevailing winds and provided a stable microenvironment for occupation. The overhang, formed by differential erosion of the softer limestone layers, extends over the trench, preserving the underlying sediments from excessive weathering and erosion. The potential for prehistoric habitability of the site

is underscored by a series of factors, such as the proximity to freshwater sources and a coastline with both sandy beaches and rocky shorelines that facilitate access to marine resources such as gastropods and fish. Additionally, past sea levels [1], reconstructed from previous studies, indicate that the coastline during the Early to Middle Holocene (ca. 8.5–7.5 years ago or ka) was comparable to the present, with the site approximately 100 km from Sicily across open water, underscoring the significance of the doline's strategic location for seafaring populations. Recent archaeological excavations produced the outstanding evidence of human occupation of the site dating back to the Mesolithic period (with a mean start date of approximately 8.5 ka.), drastically reversing the traditional hypothesis of the earliest population of the Maltese archipelago in the Neolithic. Like all dolines, Latnija presents significant structural risks due to its geological nature. Dolines, formed by the dissolution and collapse of underlying limestone bedrock, inherently pose stability concerns, making the archaeological site susceptible to sudden collapses and extensive structural damage. Ongoing erosion processes, exacerbated by climatic factors such as heavy rainfall, further compromise the integrity of the site's walls and stratigraphic layers, threatening both archaeological deposits and researchers' safety. Given the fragile geological context and the dynamic environmental conditions and the invaluable archaeological importance of the site it was decided to use terrestrial laserscanning to 3D digitize Latnija for digital preservation purposes and to generate visualizations to inform future archaeological excavations.



Fig. 1. The doline of Latnija (Ghar Tuta) with indication of its location on the island of Malta in the inset.

II. MATERIALS

Although the archaeological investigations at Latnija are ongoing, current published results were conducted over multiple field seasons (2019-present) [2]. The focus of the work was a 5×5 m trench (Trench 4) excavated beneath an overhang on the north-western edge of a large doline, sheltered from prevailing northwesterly winds. Faunal remains were recovered from early-to-mid-Holocene sediments within Trench 4, primarily consisting of red deer (*Cervus elaphus*), small mammals (e.g., *Apodemus sylvaticus*), marine gastropods, fish, and avifauna. Stable carbon ($\delta^{13}\text{C}$) and oxygen ($\delta^{18}\text{O}$) isotope analyses were performed on ungulate and rodent teeth to reconstruct paleoenvironmental conditions, indicating a stable mixture of dry C_3 grassland, scrubland, and woodland. Archaeobotanical samples were obtained through systematic flotation of all excavated sediments to recover macrobotanical remains, phytoliths, and pollen. Charcoal was collected in situ, with large pieces recorded using a total station for chronometric dating. Macrobotanical analysis identified carbonized seeds of wild herbaceous plants, including small-seeded grasses (Poaceae), legumes, *Chenopodioidae*, *Mercurialis* cf. *annua*, and *Vaccaria hispanica*, all native to Malta. Phytolith analysis revealed a predominance of C_3 grass morphotypes, with some C_4 plant morphologies, and spheroid echinate phytoliths likely from *Chamaerops humilis* (Mediterranean fan palm), suggesting its use as fuel (Extended Data Fig. 9). Pollen samples from the Mesolithic Phase V indicated open shrub vegetation dominated by *Erica multiflora*, *Euphorbia melitensis*, and *Pistacia lentiscus*, consistent with Early to Middle Holocene humid conditions in the Central Mediterranean. Anthracological analysis identified *Pistacia* cf. *lentiscus*, *Juniperus*, and *Tetraclinis* as dominant fuel sources, reflecting a shrubby, open scrubland environment. Radiocarbon dating was employed to establish the chronology of the Mesolithic Horizon

(Phases III–V), with a Bayesian model indicating a most likely start date of approximately 8.5 ka. The chronological model was constructed using OxCal 4.4. The model delineates phase boundaries and confirms human occupation from approximately 8.5 ka to 7.5 ka, predating the Neolithic transition in the region.

III. METHODS

The 3D digitization of Latnija was carried out via a time-of-flight Faro Focus s150 terrestrial laser scanner mounted on a tripod, capturing up to 2 million points per second, at a range of 0.6 m to 150 m. The scanner, also equipped with a built-in camera, GPS, a compass, an altimeter, and a tilt sensor, generates 3D point cloud datasets with a maximum distance accuracy of ± 4 mm. A total of 11 scans were carried out, starting from the access point of the doline and then continuing along the internal perimeter of it in a clockwise direction, with an emphasis on the mapping of the overhang area (Figs. 2–4).



Fig. 2. Terrestrial laserscanning of the exterior of Latnija.



Fig. 3. Terrestrial laserscanning of the interior of

Latnija.

IV. DISCUSSION

3D data were processed at the University of South Florida's Institute of Digital Exploration-IDEX (www.usf.edu/idex). First, a new project was created in Faro Scene 2024.1.1, 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 automatic 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 to apply color balancing. These processes allowed for the creation of a final 3D point cloud dataset that accurately represents Latnija at the time of scanning and meets 3D metrology industry standards for quality and precision (Fig. 5) The total project consists of 11 scans, with 68,623,172 points, and consumes 30.8 GB of storage space. The Registration Report generated by Faro Scene 2024.1.1 indicates a successful scan workflow. With a mean point error of 3.8mm, maximum point error of 11.2 mm, and a minimum overlap of 7.1%, the Latnija dataset mostly falls within the recommended standards set by Faro Scene of <8mm point error and >25% overlap. The scans that created the maximum point error of 11.2mm were taken at the surface of Latnija, which explains the elevated point error. The low overlap between the scans is due to the limited number of scans taken in the short amount of field time that was available. Nevertheless, the model has outstanding overall visual continuity considering the minimal number of scans. Digital elevation models (DEM) were created using ArcGIS Pro 3.4.2 and CloudCompare v2.13.2 (Figs 6-7). The point cloud was exported from Faro Scene as an .E57 and subsequently imported into CloudCompare. Once imported, the .E57 was converted into .las and exported. This exported .las file could then be brought into ArcGIS for processing. A new LasDataset (LASD) was created in the project, and the .las of Latnija was added. After the creation of the Latnija LASD the symbology was adjusted to display elevation with an Elevation #1 color scheme.

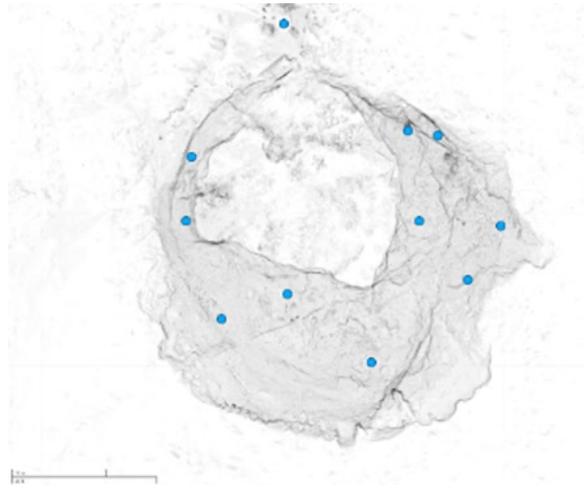


Fig. 4. Map of Latnija with indication of the 11 scan-positions.

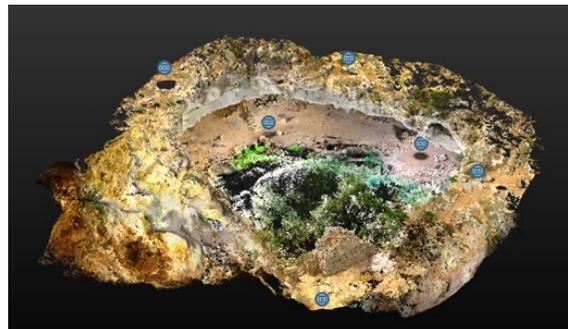


Fig. 5. Colored dense 3D point cloud of Latnija

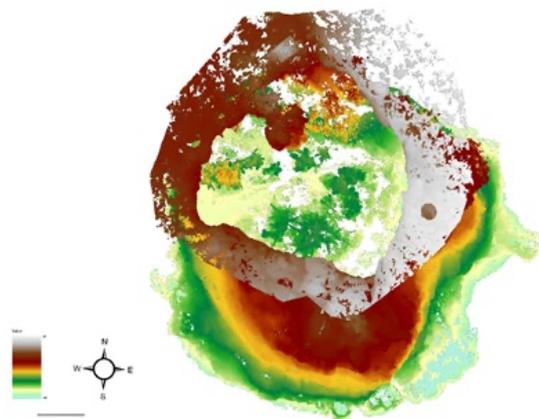


Fig. 6. Digital Elevation Model of Latnija, top view.

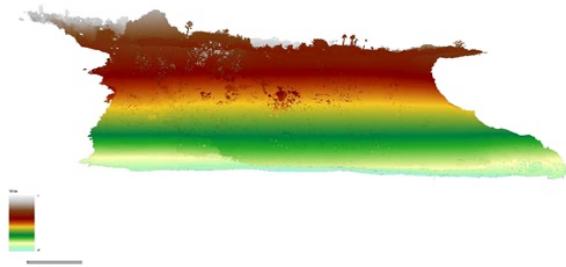


Fig. 7. Digital Elevation Model of Latnija, side view.

Additionally, once the acquired scans were imported and accurately registered within Faro Scene 2024.1.1, the software triangulated the optimized point cloud data by connecting individual points into a mesh composed of triangular surfaces, based on their spatial relationships and proximity. The mesh was then refined using smoothing and decimation procedures to simplify geometry while preserving essential structural features. Finally, the completed mesh was exported in .obj format and uploaded to the University of South Florida's Institute of Digital Exploration-IDEx Skecthfab account for public outreach purposes (<https://skfb.ly/pwHnM>) (Fig. 8).



Fig. 8. 3D model of Latnija generated from the point cloud data, available on the University of South Florida's

Institute of Digital Exploration-IDEx Skecthfab account

IV. CONCLUSIONS

The high-resolution 3D digitization of the Mesolithic site of Latnija demonstrates the immense value of advanced digital technologies in archaeological preservation and research. Utilizing terrestrial laser scanning, detailed point cloud data were effectively captured, processed, and transformed into a precise 3D mesh model. This comprehensive digital documentation not only provides an essential safeguard against ongoing environmental threats and structural risks posed by the doline's geological instability but also creates an invaluable resource for future analytical and interpretative studies. Moreover, by making the digitized model publicly accessible online, this research significantly enhances public engagement and fosters broader dissemination of Latnija's archaeological significance, reinforcing the critical role digital methodologies play in contemporary heritage management.

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