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New technologies in the enhancement of an archaeological site: Virtual Archaeology experiences at the Punic site of Sarcapos

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Abstract:

The site of Sarcapos is located in the hamlet of S. Maria di Villaputzu, at the mouth of Flumendosa river, along the south-eastern coast of Sardinia. Since 2019, it has been systematically investigated by a team of University of Bologna. Today, this context is exposed to different environmental risks, resulting from the proximity of the riverbed and potential damage caused by specific climatic events. This situation calls for reasoned solutions for the proper conservation and enhancement of the archaeological remains, as well as for adequate accessibility, considering the distance from the modern urban center. To address these issues, the application of new technologies has played a key role in both conservation strategies and fruition, involving every phase of field research – from topographical mapping to the generation of 3D models through photogrammetric methods. The overcoming, in the virtual environment, of the destructive nature of the excavation action offers opportunities never explored in pre-digital research for data preservation, enabling continuous access and usability of the archaeological heritage over time. The integration of innovative methodologies has enabled a particular focus on the potential of 3D reconstructions and archaeogames. The implementation of multimedia documentation techniques, combined with elements of gaming and virtual reality, opens new perspectives for the enhancement of the Sarcapos site and, more broadly, Cultural Heritage. This approach enables the development of immersive and interactive experiences, offering particularly effective educational tools for new generations and contributing to a broader accessibility of the archaeological heritage.

Introduction:

The settlement of Sarcapos (Villaputzu) is mentioned in Roman literary sources and is located along the south-eastern coast of Sardinia, at the mouth of the Flumendosa River (Figs. 1-2). It is counted among the most important river ports on the Sardinian east coast and was likely founded as early as the end of the Bronze Age by Nuragic peoples. It became the seat of a nucleus of a Punic population in the 7th century BC and later entered the Roman orbit until its definitive abandonment in the 7th-8th century AD (Secci, 2024, pp. 387-389).

Throughout its history, Sarcapos constituted the fulcrum of a territorial system based on the exploitation of the argentiferous lead of the hinterland, widely sought after by the Phoenicians in their expansion to the West. For this reason, as well as for its strategic position controlling a route that united the Italic Peninsula with North Africa, it has always been of great importance in Tyrrhenian maritime traffic, as a centre of trade of inland goods and redistribution of raw materials and finished products for the hinterland and the other regions of the Mediterranean. Between the 7th and 3rd centuries BC, the extent of its trading horizons is evidenced by the discovery of conspicuous quantities of Punic and Etruscan transport amphorae, together with abundant Greek-Oriental, Attic, Etruscan and mid-Roman tableware (Secci, 2020; Secci *et al.*, 2023, with previous bibliography).

Until recently, the site had been explored only through surface surveys and the excavation of an important sector of the necropolis by the competent Superintendence. In 2017, it became the subject of a systematic research project by the University of Bologna in agreement with the Protection Agency and the municipality of Villaputzu.

An initial survey using geophysical methods created a preliminary map of the archaeological findings in the subsoil (Secci, Boschi, and Silani, 2022; Secci *et al.*, 2023, pp. 224-228). To verify the results of these instrumental surveys, regular excavation campaigns were subsequently carried out[1], which partially brought to light the remains of a building datable to the 3rd-2nd century BC (Fig. 3). This building had remained in use until the beginning of the Imperial Age and was renovated several times, being constructed with a small to medium-sized stone plinth cemented with mud mortar, on which an earthen elevation was set. In its last phase of use, it was equipped with a simple pounded floor and a roof of bent tiles and imbrexes supported by wooden beams.

A production facility was found inside one of the rooms that consisted of two vats measuring approximately 1 x 1 m. The vats were internally lined with several layers of plaster and equipped with a circular hollow at the bottom (Fig. 4). This type of vats was widespread in the Mediterranean between the first centuries of the Iron Age and the Roman Imperial Age, in wine and oil producing contexts. However, the results of gas chromatographic analyses (GC-HRMS) conducted on plaster samples suggested their usage for winemaking, a hypothesis also supported by the presence of some *Vitis vinifera* seeds in the layers of activity in the room. The excavation has yielded abundant pottery for the preparation, cooking and consumption of food, attesting to the building's residential use. Of particular interest are the numerous fragments of *tannur* (Punic ovens for baking bread), characterised on the outer surface by fingerprints. At the same time, a large quantity of animal bone remains and malacofauna was recovered, clear indications of an integrated diet based on animal husbandry and fishing. The remains of older wall structures emerged below the 3rd-2nd century BC levels, buried under thick layers of abandonment, possibly of alluvial origin. These structures were built with a stone plinth surmounted by an earthen elevation but remain to be dated with precision (Fig. 5) (Secci 2025).

[1] The excavations, directed by the author, took place during a 1-year and 3-years ministerial concession schemes (DG ABAP, Prot. no. 0013727-P of 15/05/2019; DG ABAP, Prot. no. 0023727-P of 07/08/2020; DG ABAP, Prot. no. 0006409-P of 22/02/2024).

In parallel with the archaeological investigation, the project's activities were also oriented towards promoting knowledge of the site among a wider audience. In this regard, any project for the public engagement with the settlement must take into account the location of the archaeological remains within the floodplain of the river and a region historically subject to frequent and ruinous flooding, which at times has also affected the modern city of Villaputzu.

Additionally, the area is now exposed to violent meteorological phenomena as a consequence of climate change, potentially capable of causing serious damage to the fragile masonry structures. The security of the site would thus require the construction of complex hydraulic engineering works, such as embankments and weirs to divert the river waters, as well as adequate protection from atmospheric events. However, these interventions would be difficult to carry out in the short term, especially considering the significant execution costs.

While waiting for an organic open-air musealisation project and the realisation of the Civic Museum of Villaputzu, new information technologies can significantly help with promotion through virtually reconstructing the archaeological contexts for public consumption. With this in mind, particular attention has been devoted to photogrammetrically documenting the excavation and creating a 3D model of the discovered wall structures. With the addition of archaeogaming systems, this model forms the basis for the virtual reconstruction of the settlement and its accessibility.

(R.S.)

The enhancement of the Sarcapos site in virtual environment: from topographic survey to 3D modelling

In light of the various environmental risks (see above), it was deemed essential to start an enhancement project for the site by applying modern information technologies alongside the excavation. These technologies offer new sources of information and innovative methods for formalising knowledge in archaeological research (D'Andrea and Barbarino, 2012, p. 229). For this reason, adopting the most advanced documentation and surveying techniques was considered the most appropriate choice, given the potential to create a digital replica of the existing remains over multiple stages. As is well known, the advantages of this approach are numerous, particularly in terms of data storage and the ability to explore the archaeological context at any time virtually, without any physical impact (Bondarenko *et al.*, 2024, p. 34).

The objectives of this approach at the Sarcapos site were to preserve the data over time without risk of alteration and to ensure high levels of virtual accessibility as part of a long-term public engagement strategy. The end goal was to reconstruct the Sarcapos archaeological landscape in a virtual environment, based on both existing data and additional information from new excavations.

A process consisting of distinct, interconnected, and essential steps for achieving the documentation and enhancement objectives of the site has therefore been outlined (Boschi and Silani, 2014, p. 40). These steps can be summarized as follows (Fig. 6):

- analysis of the starting background,
- development of a documentation project,
- conduction of a topographic survey,
- selection of methods and techniques,
- execution of the relief activities,
- data processing for long-term management, usability, and accessibility.

Regarding the starting background, given the absence of prior archaeological investigations in the area where the University of Bologna's research team is conducting his work, the lack of topographic data became immediately apparent (Secci, Boschi and Silani, 2022, p. 29). This highlighted the need for the development of a comprehensive documentation project based on several phases. Firstly, the integration of the Digital Terrain Model (DTM) with the Regional Technical Map (CTR) – freely available from the Sardinia Region web portal – enabled a detailed assessment of the excavation area's positioning, both in terms of its geographical context – specifically, its location within a flat terrain at the foot of a mountain range – and its relationship to modern urban settlements in the surrounding landscape (Figs. 7 a-b). Subsequently, a topographic survey of the area was conducted through the establishment of some ground control points, which were acquired via GPS[2] (Fig. 7). These points are essential for georeferencing the collected data. The ground reference points were selected based on their mutual visibility and proximity to environmental or anthropic features that allow for easy identification over time. Furthermore, they are strategically positioned to allow for potential future expansions of the research area, extending beyond the sector currently under analysis. In fact, a second-order reference network can be established at any time, depending on future needs.

All the subsequent documentation steps were based on these data, primarily aimed at preserving all the excavation phases. The objective was to create a digital archive of all the identified stratigraphic units, ensuring access at any time. In this way, long-term accessibility and queryability of the archaeological evidence are guaranteed, allowing for new readings and interpretations of the ancient remains, even after the conclusion of field activities.

To achieve this, a 3D documentation project was implemented at the site. The potential of such techniques is enormous, both for the scientific study of the exposed archaeological remains and for the reconstruction of the ancient landscape, but also for potential forms of communication and visibility in a context like Sarcapos where traditional forms of public engagement are particularly challenging (cf. Stanco and Tanasi, 2011, pp. 52-53, 56-57; Caro, 2012). Moreover, 3D documentation methods allow for overcoming the limits of manual survey techniques, although knowledge of such methods remains essential for making accurate assessments in the field. For example, one need only consider the inherent subjectivity of manual surveys and their tendency toward schematic representation, along with the challenges of comprehensively documenting the third dimension (cf., for example, Giorgi, 2009, p. 29; Marín-Buzón *et al.*, 2021, p. 2).

Among the various 3D documentation techniques, photogrammetric methods emerged as the preferred approach. As is well known, these techniques enable the reconstruction of an object's features without physical contact during the survey process (Fig. 8 a), making these methods non-destructive and non-invasive (Dubbini and Capra, 2009, p. 92; Remondino, 2014a; Bosco, 2022, pp. 7-11; Bondarenko *et al.*, 2024). This decision was influenced by several factors, including the low cost, the ease of handling, and the limited time required for field data acquisition (Remondino, 2011, pp. 94-97), as well as equipment availability. Specifically, uncalibrated photogrammetry systems were employed, for which the precision margins are considered satisfactory and compatible with the documentation needs of an archaeological excavation (D'Andrea and Barbarino, 2012, pp. 243-244). To ensure the correct roto-translation of the point clouds, this method was integrated with a total station[3] to acquire the ground control points. During the archaeological missions conducted thus far, both aerial photography – using UAV systems[4] – and terrestrial photography – with a reflex camera either handheld or mounted on a telescopic pole[5] – were integrated (Figs. 8 b-c). The choice of the proper equipment was strongly influenced by the meteorological variables of the area, as Sardinia is exposed to strong winds for most of the year (on this aspect, D'Andrea and Barbarino, 2012, p.

[2] A Stonex S9 GNSS receiver was used to acquire the ground control points of the polygonal.

[3] Based on availability, several total stations have been used since the beginning of the research: Topcon GPT-3107N, Topcon GPT-2009, Topcon OS-203 and Geomax Zoom 35 Pro.

[4] The drone used is a DJI Mavic Air 2S; the photographs were taken by Dr D. Frisoni.

[5] The reflex camera used is a Nikon D 610; the photographs were taken by Dr M. Marano.

243). In favourable weather conditions, UAV systems were preferred for several specific advantages, such as the ability to easily capture zenithal images of the ground and produce low-altitude aerial shots at both site and landscape scales (Nex and Remondino, 2014; Campana, 2017, pp. 278-279). The reflex camera proved essential in adverse weather conditions: although it requires longer acquisition times in the field compared to UAV systems and does not allow for comprehensive images of the entire excavation area in a single shot, it was deemed appropriate for documenting specific parts of the excavation that were particularly narrow and hard to reach with UAV systems (Bosco, 2022, p. 10). For instance, this was the case with certain walls, whose deeper sections would have been difficult to document in detail due to limited visibility caused by surrounding structures, which belonged to different occupation phases.

Moreover, the choice of the instrument influenced the number of shots taken, depending on the extent of the area to be documented and the sector covered by each photograph. In both cases, however, particular attention was paid to the quality of the images: photographs were captured from various angles and distances, both to provide general coverage of the excavation area and the immediately adjacent sector, and to capture more detailed images of the most significant archaeological features (Fig. 8 d). The quality and accuracy of the final models were primarily ensured through the careful attention given to this stage of the process (Stylianidis, Georgopoulos, and Remondino 2016, pp. 267-268; Bondarenko *et al*., 2024, p. 35). The process proceeded by applying photogrammetry techniques based on structure-from-motion algorithms, which allow for the creation of a 3D point cloud from a series of unordered and uncalibrated photographs. In addition, these techniques enable reconstruction of the camera's position at the time of the shot by identifying the same point across a series of partially overlapping images, which are taken with a moving camera around the surveyed object (Fig. 8 d) (Boschi and Silani, 2014, pp. 47-49; D'Andrea and Barbarino, 2012, p. 231; Jones and Church, 2020; Bosco, 2022, p. 8). To establish the relationship between the images, the position of the archaeological remains, and to proceed with the data georeferencing, several control points were selected and acquired. These were marked on the ground through target points that were evenly distributed within the area to be surveyed (Fig. 9 a) (cf. Stylianidis, Georgopoulos, and Remondino 2016, p. 268).

Sparse and dense point clouds were generated using the Agisoft Metashape Pro software. After the alignment of the photographs, the point clouds were cleaned of any elements that interfered with correct 3D visualisation. A mesh model of the surveyed sector was then created and textured using the acquired images (Figs. 9 b-c). The resulting 3D model was perfectly scaled using the absolute coordinates of the control points: when necessary, the georeferencing was refined by manually correcting the automatic positioning of the control points recognized in the photographs, ensuring that the margin of error remained within ½ cm[6]. This process enabled the creation of orthophotos for each stratigraphic unit, which were useful not only for providing an undistorted overview of the excavation area, but also for generating 2D documentation. To manage the data collected and ensure proper integration of the documentation over time, a GIS project was established that is updated with each new excavation campaign[7]. Managing such large volumes of data necessitated the immediate development of standardized data recording practices to prevent errors during the data entry phase. This led to the definition of precise terminology related, for example, to the different excavation years, the stratigraphic units investigated during each campaign, and the various material classes. The 3D documentation has thus enabled the reassembly of the excavation context: in this way, it is therefore possible to virtually overcome the inherently destructive nature of an archaeological excavation, as this is

[6] For instance, the final situation of the 2024 excavation is documented by a dense cloud of 17,834,366 points and a model composed of 1,199,008 faces; the georeferencing process was carried out using 59 markers, which ensured an accuracy of 0.005 m.

[7] Archaeological data are stored and managed in a GIS environment using the open source QGIS software.

"*un esperimento irripetibile [che] sopravvive solo nella documentazione*"[8] (Giorgi, 2009, pp. 30-31). This is clearly demonstrated, for instance, by the 3D stratigraphy performed by aligning different dense point clouds, which allows for virtual visualisation and navigation within the stratigraphic units that have already been excavated and are no longer preserved at the archaeological site (Fig. 10). The importance of this practice is also evident when considering the development of potential virtual reconstructions (see below), which, in 3D models, therefore have a metrically accurate and highly realistic foundation upon which to rely (Fig. 11).

(M.M.)

Landscape analysis and virtual reconstruction of the Sarcapos site: methodological aspects for the representation of anthropic and environmental evidence

The digital reconstruction of archaeological sites represents a significant methodological advancement in contemporary research, offering innovative solutions for visualising, interpreting, and disseminating knowledge about ancient contexts. This scientific approach integrates diverse data sources and technological applications, yielding a comprehensive 3D reconstruction that maintains scientific rigor while enhancing accessibility.

The reconstruction process of the wine production complex began with precisely documenting the excavated structural remains, primarily utilising photogrammetric data collected during the September 2024 field campaign (see above). This approach ensured the accurate representation of all the preserved architectural components in the digital model (Figs. 11-12). However, archaeological visualisations must inevitably deal with incomplete preservation, thus necessitating certain elements to be rebuilt conjecturally. For example, the buildings surrounding the complex were envisioned based on typological parallels from contemporary Phoenician and Punic settlements at Ibiza, Tharros (Fariselli *et al*., 2017, pp. 327-329), and Nora (Bonetto *et al.*, 2022) (Fig. 13). These and other conjectural elements were deliberately rendered in different colours from the excavated structures to distinguish the documented and inferential components, thus preserving intellectual transparency throughout the virtual restoration process.

Considerable focus was placed on incorporating material cultural elements associated with wine production activities into the model. The 3D rendering included various ceramic vessels that represent artefacts recovered during excavation, specifically Punic amphorae corresponding to Series 4 and 5 of the Ramon Torres typology (Ramon Torres, 1995), as well as bowls dating to the 3rd centuries BCE that are currently under analysis. The grape-pressing filter was conceptualised based on comparative evidence from the Iberian Peninsula (García Benito *et al.*, 2019, p. 172) as a systematically robust approach to interpretive visualisation based on functional analogies. To animate this environment, human figures were created using the MakeHuman Community software, with poses and movement developed through Blender, generating a dynamic representation of the ancient production sequence and enhances the experience of the 3D rendering.

The technical implementation employed a multi-platform approach. Architectural elements were initially crafted in Blender, while broader landscape CGI and the integration of structural components were accomplished using Unreal Engine 5 (UE5), a gaming platform that facilitated the transition from a static 3D to interactive experience (Rodríguez González, Casals and Pérez, 2023). This systematic decision enables a 3D archaeological model to transcend mere depiction and extend into sensory engagement with past material environments. The resulting interactive model permits users to navigate the ancient space from a

[8] An irreversible experiment [that] survives only in the documentation.

first-person perspective, fostering an immersive experience that surpasses traditional techniques (see below).

Comprehensive attention to landscape contextualisation is a significant methodological innovation from this project. Archaeological reconstructions frequently prioritize principal structures while neglecting their environmental setting, yet integrated scenery proves essential for a holistic understanding of ancient contexts. The morphologically diverse terrain surrounding Sarcapos encompasses multiple types of vistas; the site was situated along the southern bank of the Flumendosa River (Secci, Boschi and Silani, 2022, pp. 28-30; Secci, 2024, pp. 387-389), one of Sardinia's longest waterways; extensive plains suitable for agricultural cultivation extended east and west; a series of hills and characteristic plateaus covered with Mediterranean vegetation rose to the north; and the southern territory beyond the river is now occupied by the modern settlement of Muravera.

The procedural visualisation area integrated multiple data sources. Initial terrain modelling utilised drone photogrammetry and aerial photography to establish topographic parameters (see above). These were enhanced through UE5's sculpting tools, enabling refined representation based on cartographic databases and contemporary landscape assessment. The Cesium plugin facilitated the integration of Google Maps API satellite imagery with three-dimensional data in UE5, providing a cartographic foundation for DTM at the site and its environs. Specialised materials objects representing vegetation, rock formations, and soil types were incorporated based on field observations, creating an environmentally accurate representation (Figs. 14-15).

Hydrological reconstruction presented a distinctive methodological challenge, as the course of the Flumendosa River has been significantly altered over the last century, including course diversion and meander creation. The ancient surroundings of the river were reconstructed by analysing orthogonal satellite imagery scaled to follow the river's original channel, supplemented by historical cartography – specifically the 1889 geological-mining map of Sarrabus (De Castro, 1889) (Figs. 16-17). The virtually reconstructed watercourse has increased volume compared to the present to reflect probable ancient hydrological patterns. Agricultural field systems in the 3D model follow contemporary configurations, which approximate ancient land-use patterns given the environmental constraints of the region (Fig. 18).

This reconstruction methodology emphasizes the intrinsic complexity in comprehensive archaeological visualisation, requiring attentive consideration of the elements beyond the central focus of the dig. The integration of established data with conjectural reconstructions, representations of cultural material, animated human figures, and contextual topographic rendering produces a holistic representation that balances scientific accuracy with interpretive necessity. The first-person game prototype currently in development expands this approach towards experiential engagement, allowing users to navigate freely through portions of the ancient settlement and question the objects present in the reconstruction explained through pop-ups (Reinhard, 2024) (Figs. 19-20). For example, it will be possible to take on the role of a character and explore the site of Sarcapos, attempting to understand how the Punic and Roman centre might have been organized. In future developments, characters specifically created for the video game will be added, with whom it will be possible to interact to inquire about materials, crafts, and past customs.

The implementation of scientifically grounded archaeogaming systems within museum and heritage contexts offers substantial potential for engaging younger audiences who may experience “museum fatigue” (Gilman, 1916; Bitgood, 2009). These technologies facilitate immersive engagement with past environments while maintaining contemporary relevance. The methodological approach demonstrated in the Sarcapos reconstruction illustrates how archaeological visualisation can simultaneously serve documentation purposes and public engagement objectives, providing a model for future digital applications that maintain scientific rigor while enhancing experiential accessibility.

(D.F.)

Conclusions

Ultimately, the Sarcapos project therefore establishes an innovative paradigm for archaeological visualisation, combining the scientific documentation of the research process with immersive technologies. In fact, this "mixed" methodological approach has made it possible to develop modern and alternative solutions in the communication and accessibility of archaeological evidence, potentially overcoming problems related to the long-term preservation and management of excavation data and to site location, conservation and protection.

On the other hand, the rapid development of information technologies may allow further enrichment of the digital experience through intelligent interactive elements, always keeping interpretative rigour.

This approach could lead to a new type of museum experience, effectively linking specialised research and dissemination. The virtual reconstruction and enhancement project of the Sarcapos site can also therefore serve as a standardised protocol for other archaeological contexts to increase public participation and interest in Cultural Heritage, without sacrificing scientific integrity.

(M.M., D.F., R.S.)

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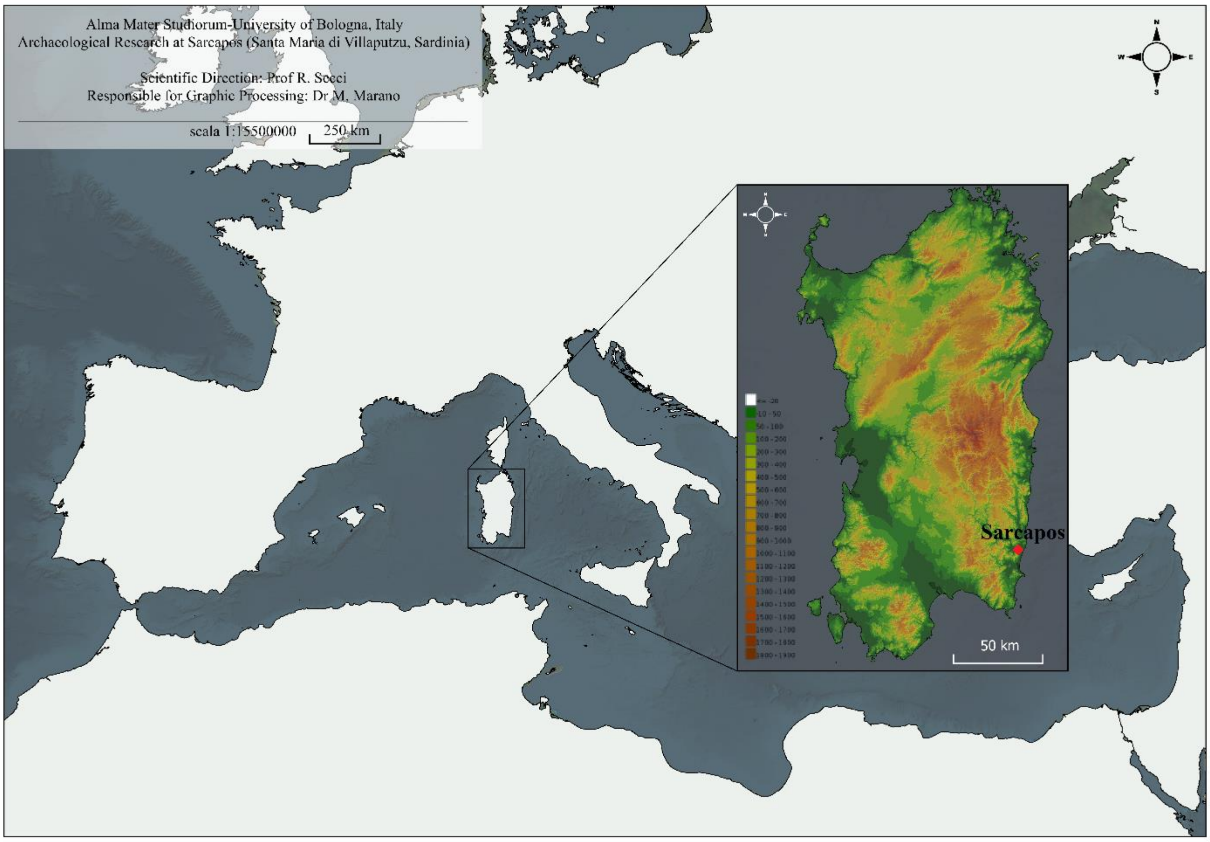

Fig. 1. Location of the site on the 10 m DTM of the Sardinia freely available from the Sardinia Region web portal (elaboration by M. Marano)

Fig. 2. Location of the excavation area from the north (photo by D. Frisoni)

Fig. 3. The excavation area at the end of the 2023 campaign (photo by D. Frisoni)

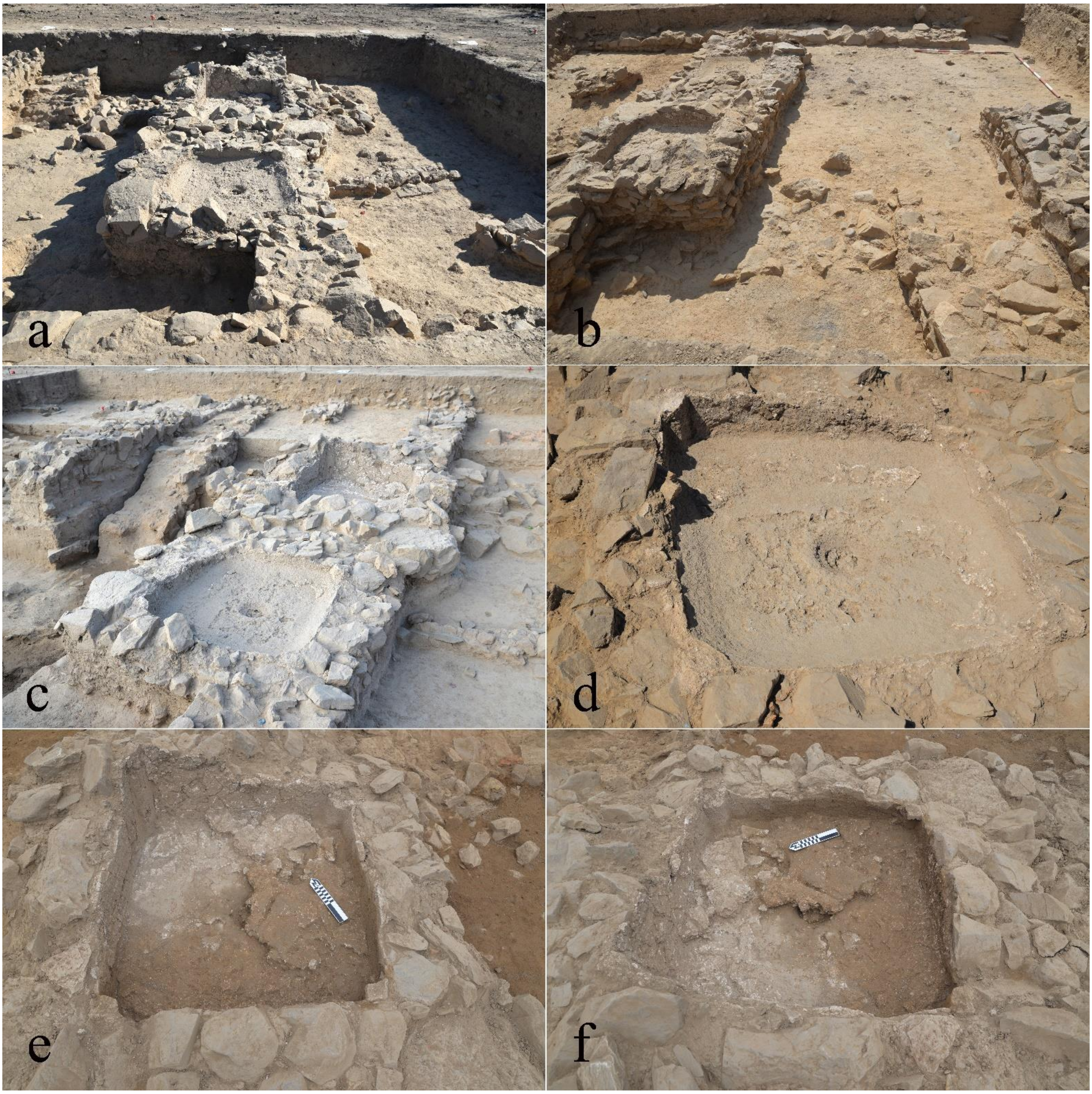

Fig. 4. The production facility from the south (a); the production facility from the north (b); the production facility from the south (c); Vat 1 from the east (d); tank 2 from the south-west (e); Vat 2 from the north-west (f) (photo by R. Secci)

Fig. 5. Pre-Late Republican wall structures, from the south (photo by R. Secci)

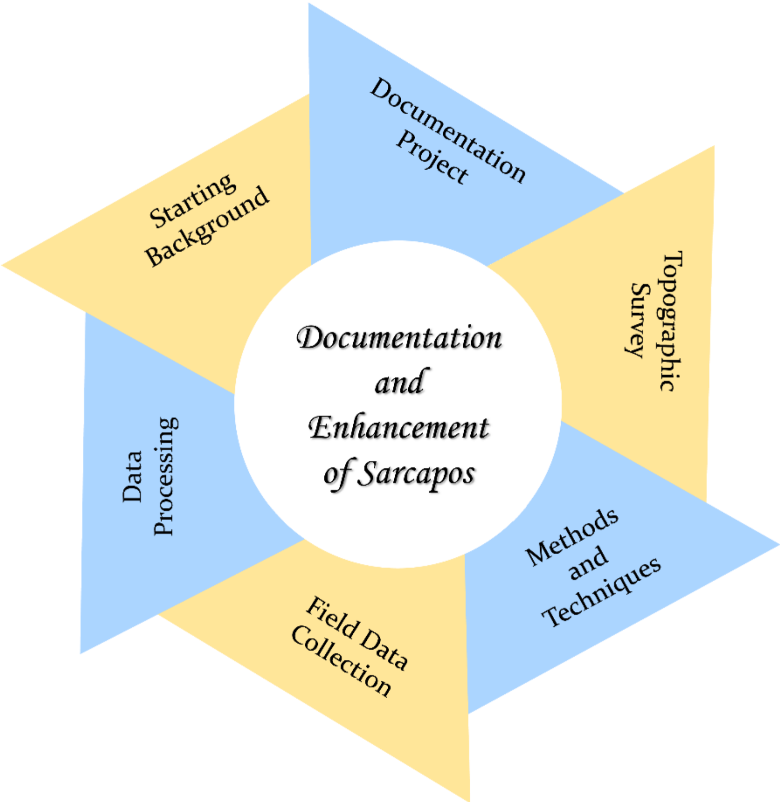

Fig. 6. Key steps in the documentation and enhancement project of the Sarcapos site

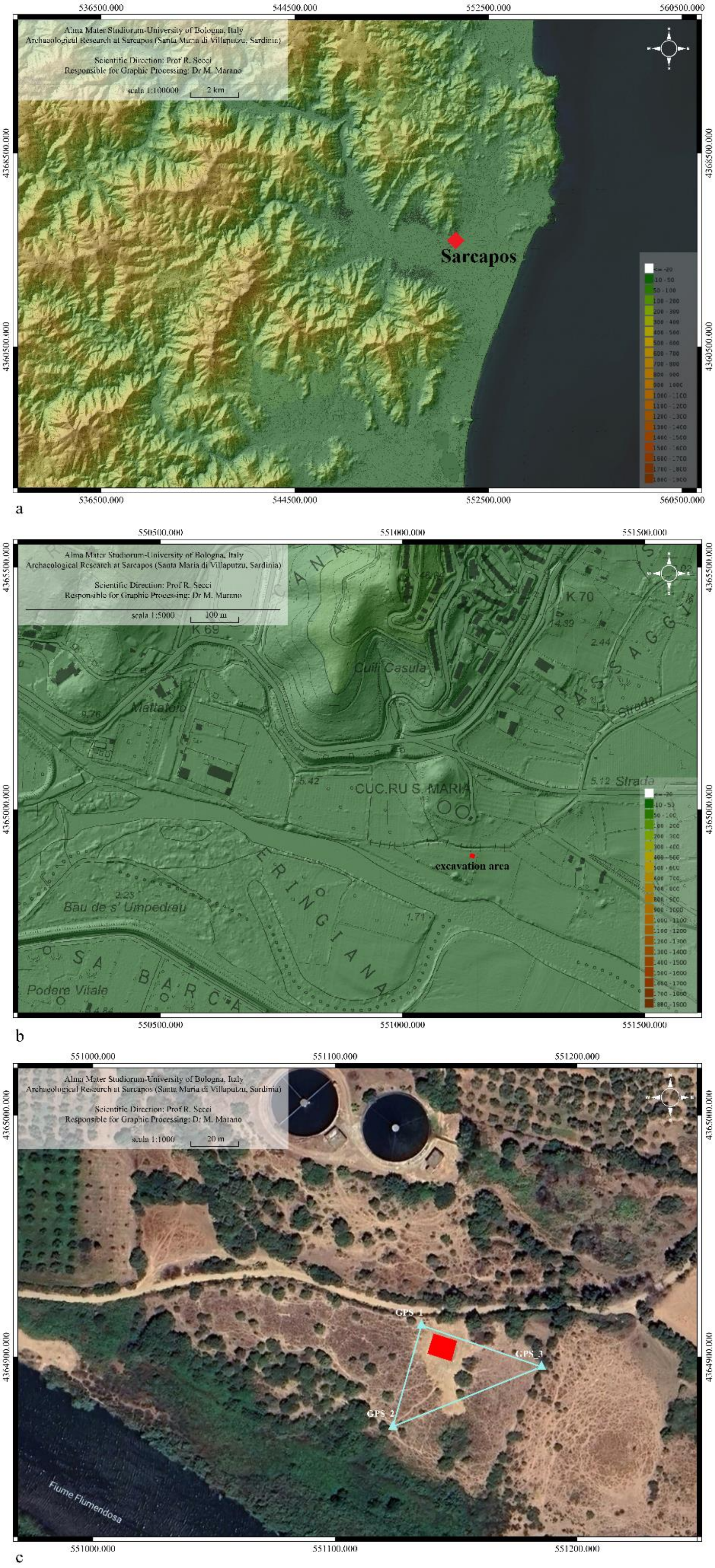

Fig. 7. Localisation of the Sarcapos site (a) and the excavation area (b) on 10 m (a) or 1 m DTM (b) and CTR freely available from the Sardinia Region web portal; positioning of the excavation sector and the ground control points (polygonal) on the Google satellite image (c) (a-c: post-processing by M. Marano)

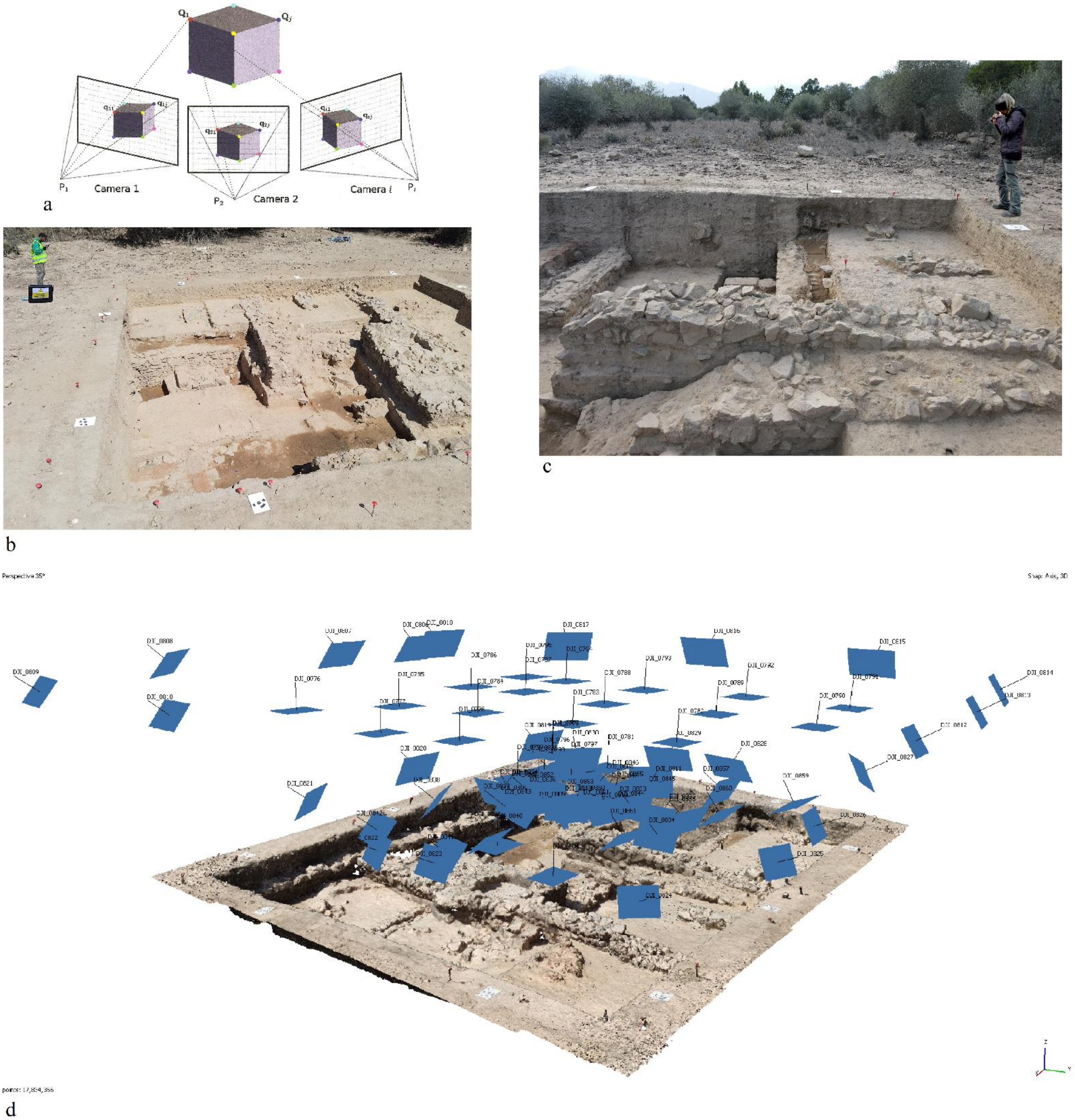

Fig. 8. Schematization of the shots for recording the position of a point (a); different photogrammetric relief phases using UAV systems (b) and the reflex camera (c); camera positions on the dense point cloud of the 2024 excavation area (d) (a: Bosco, 2022; b: photo by M. Marano; c: photo by D. Frisoni; d: post-processing by M. Marano using Agisoft Metashape Pro software)

a

b

c

Fig. 9. Example of the control points on a dense point cloud (a); mesh (b) and textured 3D model (c) of the 2024 excavation area (a-c: post-processing by M. Marano using Agisoft Metashape Pro software)

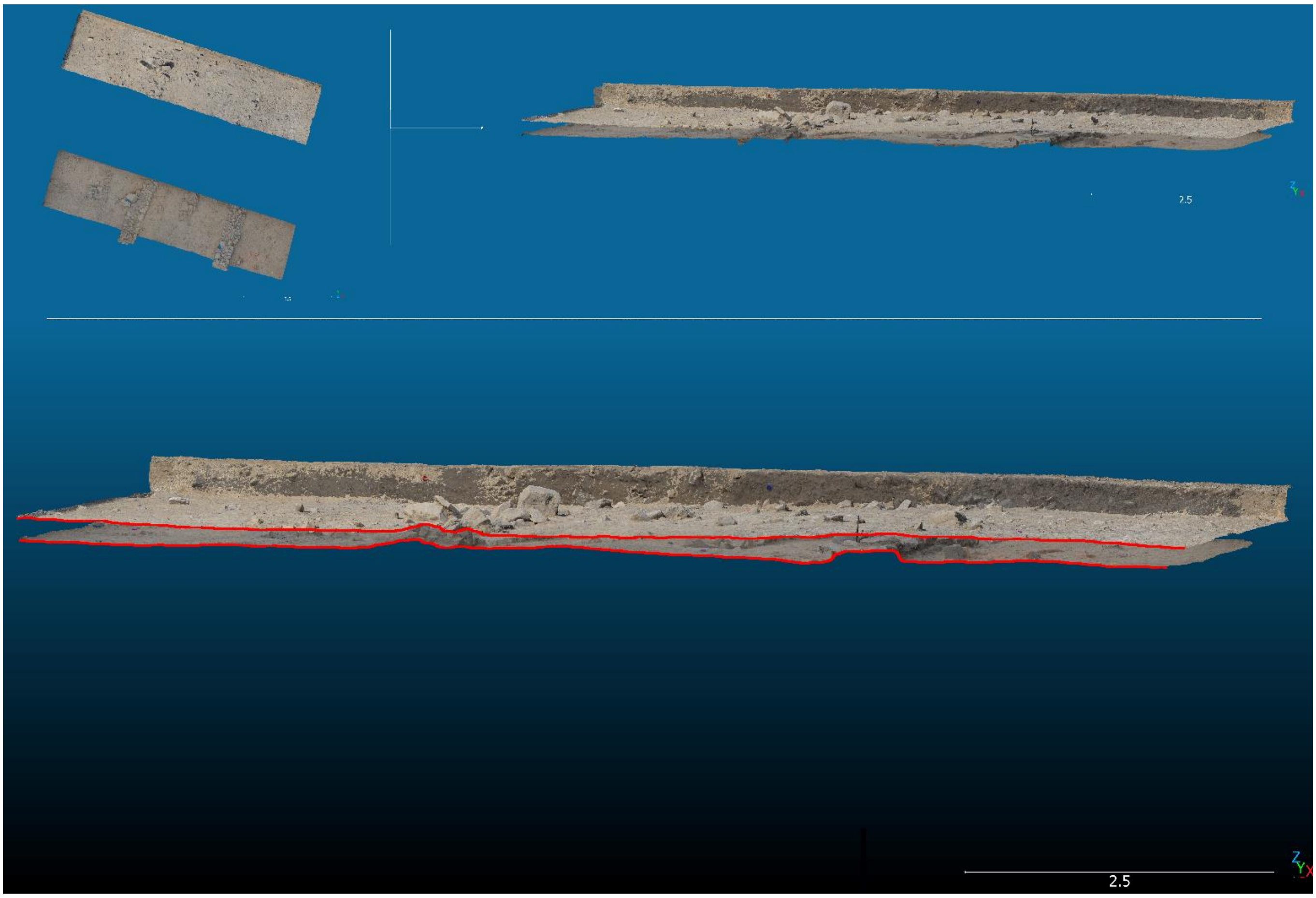

Fig. 10. Example of 3D stratigraphy performed by aligning dense point clouds of different stratigraphic units (post-processing by M. Marano using CloudCompare software)

Fig. 11. Reconstruction of the existing wall structures of the Sarcapos site, based on the photogrammetric model, zenith view (reconstruction by D. Frisoni using Blender software, photogrammetric processing by M. Marano using Agisoft Metashape Pro software)

Fig. 12. Rendering of the production facility at Sarcapos, perspective view from the west (reconstruction by D. Frisoni using Blender software)

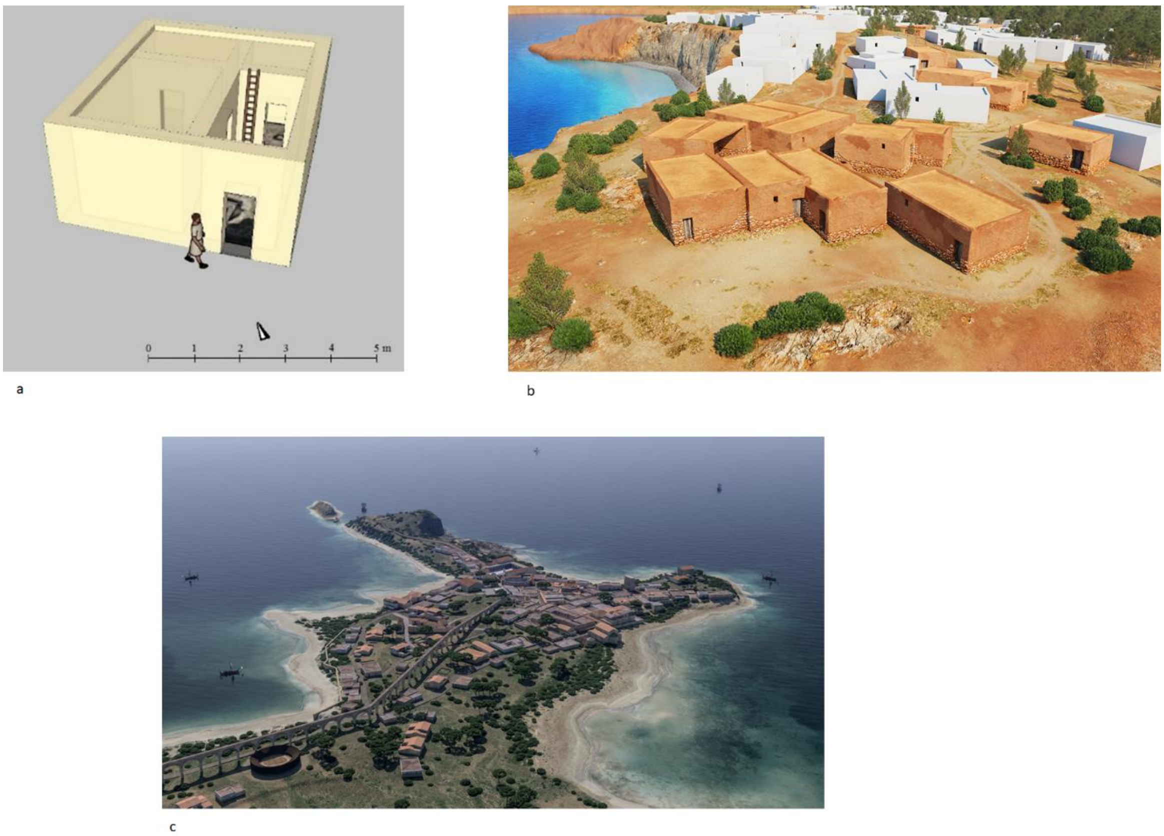

Fig. 13. Reconstruction of building 56 of Tharros (OR) (a); concept of the Sa Caleta settlement, Ibiza (b); aerial view of the Nora settlement as it would have appeared during the period of Roman domination (c) (a: Fariselli *et al.*, 2017, elaborated by M. Marano; b: https://www.behance.net/gallery/30281181/Phoenician-settlement-of-Sa-Caleta-Ibiza, elaboration by J.R. Casals; c: Bonetto *et al.*, 2022, elaboration by Università degli Studi di Padova - Katatexilux Project)

Fig. 14. Landscape modeling in Unreal Engine 5 (modeled by D. Frisoni)

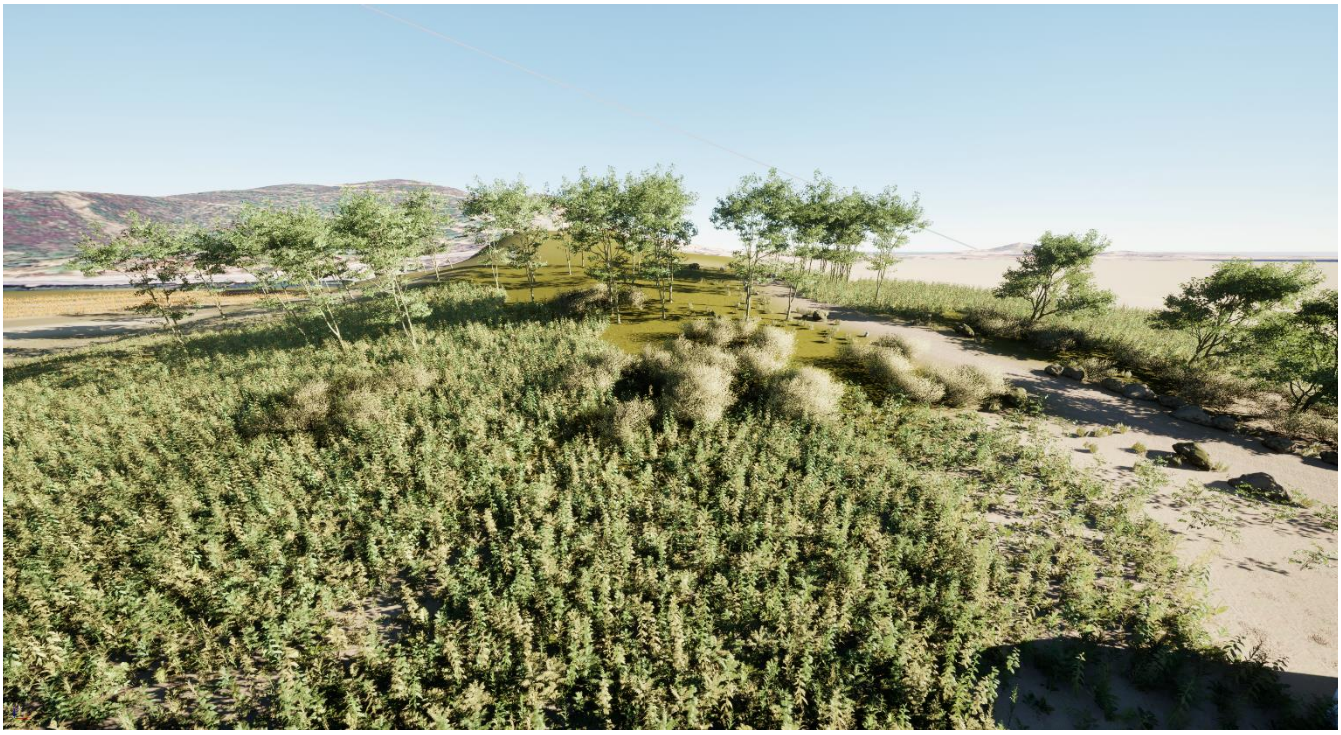

Fig. 15. "Vegetation" and "foliage" assets implemented in Unreal Engine 5 (modeled by D. Frisoni)

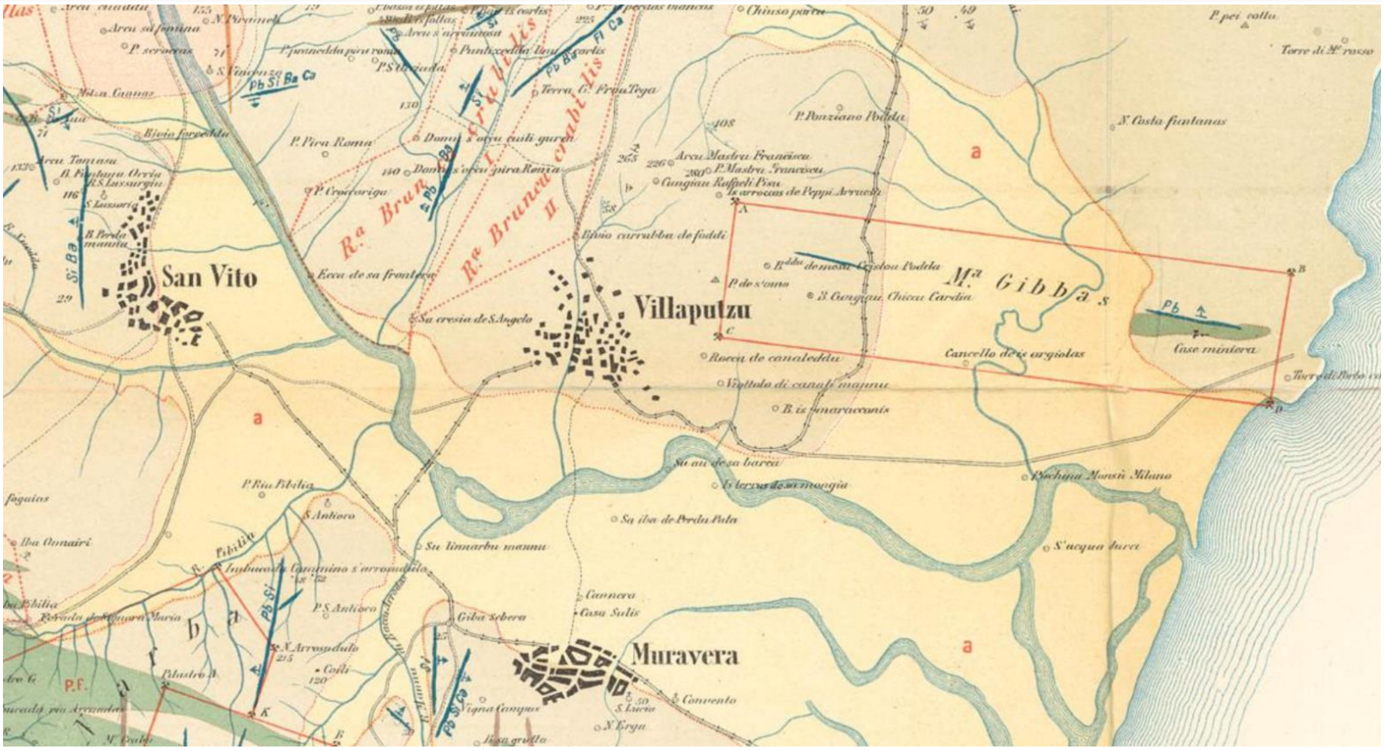

Fig. 16. Geological-mining map of Sarrabus, 1889 (De Castro, 1889)

Fig. 17. Realistic rendering of the Flumendosa River in Unreal Engine 5 (modeled by D. Frisoni)

Fig. 18. View of reconstructed agricultural areas in Unreal Engine 5 (modeled by D. Frisoni)

Fig. 19. Example of game environment with "player start" positioned above the cobblestone road and surrounded by reconstructed buildings (elaborated by D. Frisoni in Unreal Engine 5)

Fig. 20. Example of pop-up interface for object interrogation in the game environment (elaborated by D. Frisoni in Unreal Engine 5)