DATA MANAGEMENT AND RECONSTRUCTION OF FUNERARY LANDSCAPE IN PRE-ROMAN NECROPOLISES BETWEEN ESTE AND PADOVA

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1. Introduction

This contribution arises from various needs in our research. Firstly, the need to systematize data from necropolises that differ in excavation methods, documentation, and current state of the art. Secondly, to delve into the theme of the landscape, the skyline of ancient cities starting from their necropolises, which represented a 'theatrical scenery' reflecting the urban political organization and its power dynamics.

For our research group, the reconstruction of funerary landscapes has been a sort of pioneering experience. The first projects date back to the late 1990s, at the end of the excavation of Casa di Ricovero in Este, when the first attempts to reconstruct burial mounds were made (Fig. 1a-b). These reconstructive hypotheses were used in 1998 for the exhibition …*"presso l'Adige ridente"*…*Recenti rinvenimenti da Montagnana e Este* dedicated to the preliminary results of the excavation (Bianchin Citton, Gambacurta, Ruta Serafini 1998, figg. 4 e 7; Gamba, Gambacurta, Ruta Serafini 2015, for a different view on funerary structures, see Leonardi, Cupitò 2011). These first experiments established a precedent for recent developments, applying more advanced technologies for more 'refined' and significant results in terms of informational contribution.

Este and Padova stand as the two central places of the Veneto region, governing both internal and international relations while maintaining strong Venetic characteristics. For several decades, our research group has been conducting investigations on two of the main necropolises of these cities. In Este, excavations resumed between 1983 and 1993 following earlier findings from 1882 to the mid-20th century (Chieco Bianchi, Calzavara Capuis 1985, 19-32; Bortolami 2023, 36-39), focusing on the Casa di Ricovero area (Fig. 2). In Padova, a sector of the eastern necropolis was investigated in 1990-1991, with entire burials extracted along with their stratigraphy for laboratory analysis (Gamba, Gambacurta, Ruta Serafini 2014) (Fig. 3). Throughout restoration, study, cataloguing, and editing activities, the opportunity of georeferencing and data systematization has recently emerged, albeit with a delay compared to other situations in Italy (see other chapters in this volume). It was made possible through the support from the Venice Centre for Digital and Public Humanities, which approved two consecutive projects: VIAN (Venetic Iron Age Necroplises: mounds and graves) I in 2021

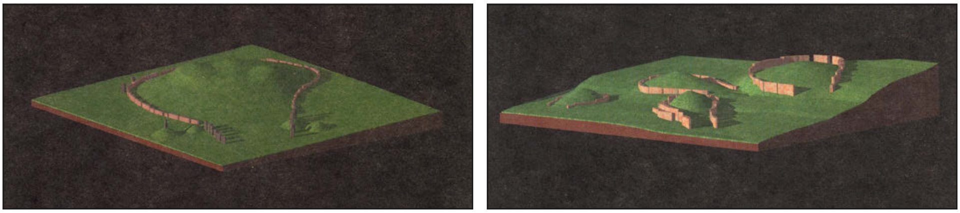

a b

Fig. 1 – Este, Casa di Ricovero 1983-1993. a) 3D reconstructions of burial mounds from the 7th-6th c. BC. b) 3D reconstruction of a burial mound from the late 6th c. BC. (after Bianchin Citton, Gambacurta, Ruta Serafini 1998).

and VIAN II in 2022. The former focused on Padova, while the latter on Este. The goals of these projects were twofold: firstly, the development of a GIS with a relational database to address many ongoing questions diversified for the two necropolises, spanning chronologically from the second half of the 9th century BC to the early Roman period. Secondly, the creation of new hypothetical reconstructions of burial mounds based on new methodologies and tools to provide detailed information.

The work was therefore adapted to suit the specific characteristics of the two necropolises, and the different stages of their investigation. The excavation in the necropolis of Casa di Ricovero in Este provided a unique opportunity to explore a section of the city's northern necropolises using stratigraphic methodology, after the well-known findings of the late 19th and early 20th centuries, primarily conducted by Alfonso Alfonsi (Chieco Bianchi, Calzavara Capuis 1985, 19-32). Throughout the excavation campaigns, efforts were made to refine stratigraphic methods, which still relied heavily on paper documentation – systematic yet sometimes muddled. This was likely influenced by the peculiar stratigraphy of the necropolis, located on the slope of a hill and affected as much by flooding events from the S as by landslides from the N. Another layer of complexity arose from the ancient practice of reopening burial boxes, aimed at reunification over time of the deceased linked by family or proximity ties (Balista *et al.* 1988; Bortolami 2023). The intricate depositional situation led to the decision to maintain the oldest and most preserved phases *in situ* resulting in the establishment of an archaeological area. Following extensive restoration efforts and the installation of suitable protection structures (Gambacurta, Ruta Serafini, Sainati, in press), this area is now accessible.

The situation of the eastern necropolis of Padova differs significantly. In 1990, a large sector measuring 4100 m² was investigated in an area known since the early 20th century for several occasional findings (Ruta Serafini 1990, 15-18). The excavation was carried out with emergency procedures due to construction-related reasons. Following geomagnetic surveys confirming

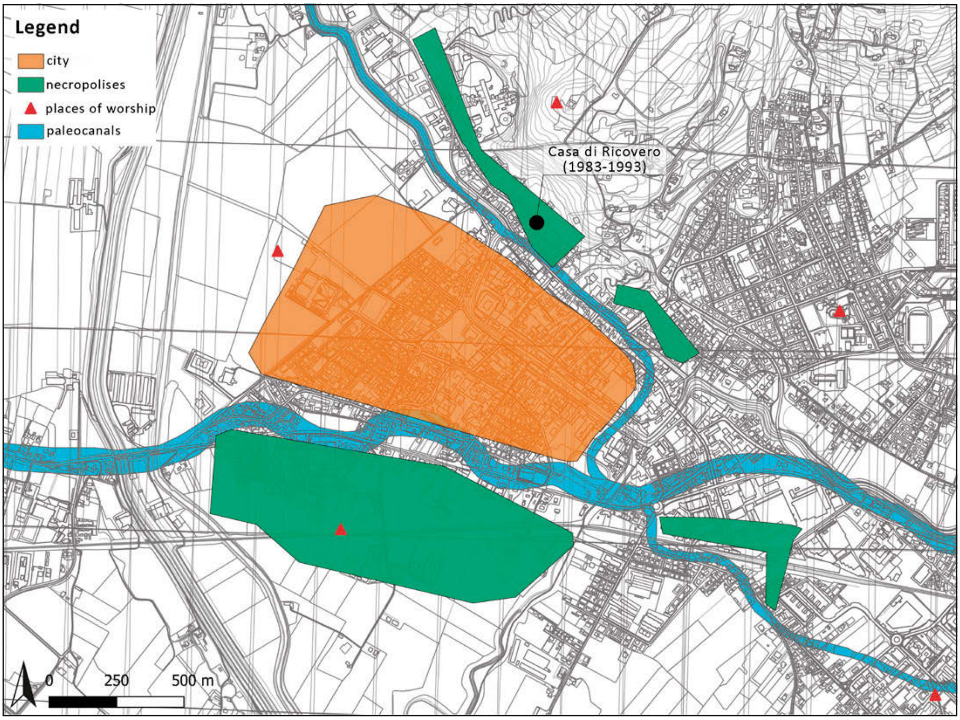


Fig. 2 – Location of the funerary area of Casa di Ricovero (1983-1993) in Iron Age Este (redrawn after Ruta Serafini 2002).

the hypothesis of a significant number of burials, a methodology was developed, which included:

1) identifying the main stratigraphic sequence;
2) documenting of all the burials and determining their chronological phase;
3) excavating some burials in the field (approximately two-thirds);
4) extracting a third of the tombs (about 120 out of 314) along with their stratigraphy in wooden boxes for laboratory investigation.

Following an interruption in funding, this investigation is still ongoing. With the support of the Municipality of Padova, the Superintendency conducted several laboratory excavation campaigns (1999, 2006, 2007, 2009). From 2017 to the present, investigations have resumed under a concession and then a convention with the Superintendency ABAP for the Metropolitan Area of Venice and the Provinces of Padova, Belluno, and Treviso, as part of the research funding of Ca' Foscari University of Venice. A total of 97 burials in 57 boxes were excavated, concurrently managing restorations,

Fig. 3 – Location of the funerary area between via Tiepolo and via S. Massimo (1990-1991) in Iron Age Padua (redrawn after De Min *et al.* 2005).

anthropological and anthracological analyses, and study and edition of some phases and groupings.

G.G., A.R.S.

2. A geodatabase for the Venetic necropolises

2.1 *Project overview: objectives and research questions*

Since the first applications in the early 1990s, Geographic Information Systems (GIS) have rapidly revolutionised archaeology, offering several advantages across various application fields (Moscati 1998; D'Andrea 2000; Bogdani 2009; Scianna, Villa 2011; Bogdani, De Mitri 2017; Howey, Brouwer Burg 2017; Dell'Unto, Landeschi 2022).

The application of GIS to the investigation of two funerary areas of the pre-Roman sites of Este and Padova has allowed to test this tool in contexts that share similarities, but some differences too. Due to the primary need to archive, analyse, and consult excavation data easily for research purposes, a dedicated database was conceived, extending beyond the attribute tables provided by GIS software. While tailored to the specific needs of our case studies, this database could also be used in the future for mapping other necropolises.

A critical aspect during the building and population of the database was the condition of excavation documentation. Both areas were investigated between the 1980s and the early 1990s, a pivotal period for the development of the stratigraphic method aimed at identifying depositional and post-depositional processes, as well as the interaction between natural and anthropic factors. This also implies that the documentation is often inconsistent because it developed in response to ongoing experiments, and it was predominantly paper-based or stored in obsolete hardware supports (e.g., floppy disks).

As mentioned earlier, the database was designed to address the needs of the different stages of investigation. After the excavation, all the artefacts from the funerary area of Este underwent restoration, cataloguing, and illustration, alongside osteological analyses of cremated remains. Currently, all data are available, and this sector of the necropolis is at an advanced stage of study, with some burials and groupings already published (Chieco Bianchi 1987; Bianchin Citton, Gambacurta, Ruta Serafini 1998; Bortolami 2023, 73-94).

The necropolis sector of Padova shows a more disorganized scenario. Since 2017, annual laboratory excavations have been conducted, followed by restoration, illustration and study of grave goods, as well as analyses of the osteological material. The selection of burials for excavation is heavily influenced by logistic rather than scientific criteria, due to the challenge of moving bulky, heavy boxes, often in a state of partial degradation. Thus, the use of the database proves crucial for monitoring the progress of different work phases and for consciously guiding the allocation of economic resources and the operations of restoration and study. In this case as well, digging and analyses have been accompanied, whenever possible, by the simultaneous publication of significant phases or groupings of burials (Gambacurta 2009, 2011; Gamba, Gambacurta, Ruta Serafini 2014, 123-220; Moscardo 2018-2019; Millo 2021; Gambacurta *et al.* 2023; Bortolami 2023, 68-71).

F.Bo.

2.2 *Geodatabase structure, data entry, and preliminary results*

For the database building, SpatiaLite (a spatial extension of SQLite) and QGIS were selected. Both are open-source and well-integrated, with a not too steep learning curve. These qualities seemed suitable for the project's needs since data entry and querying will involve students at different education levels. Additionally, the choice of open-source software and formats guarantees long-term interoperability and data access.

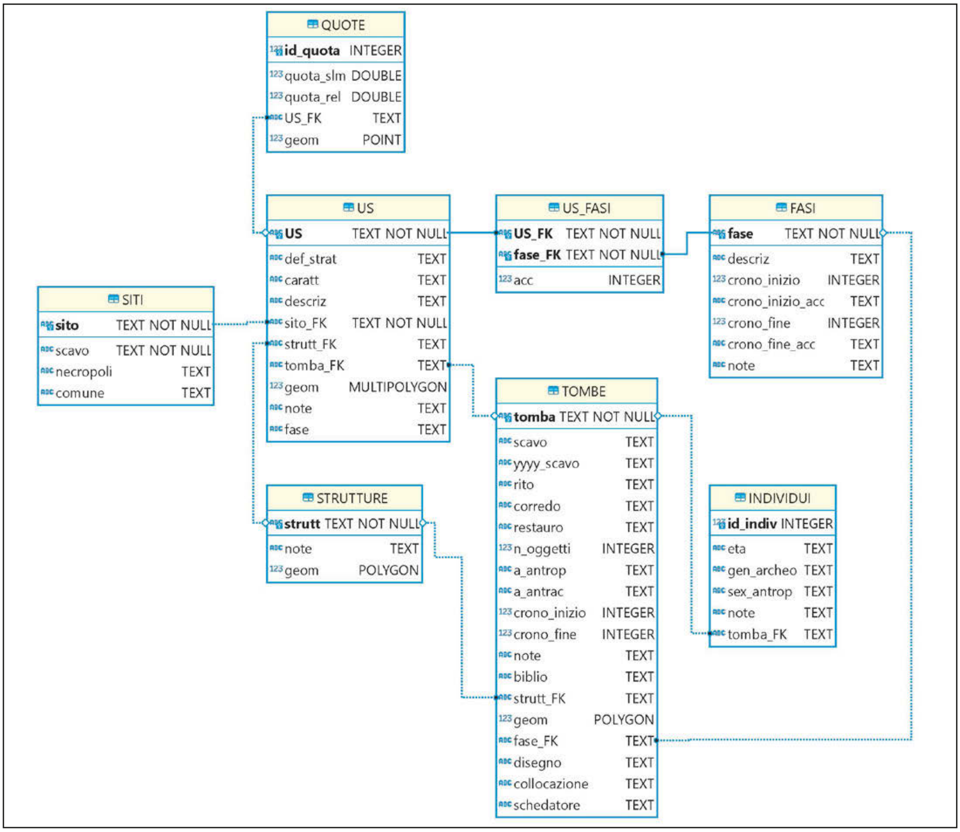
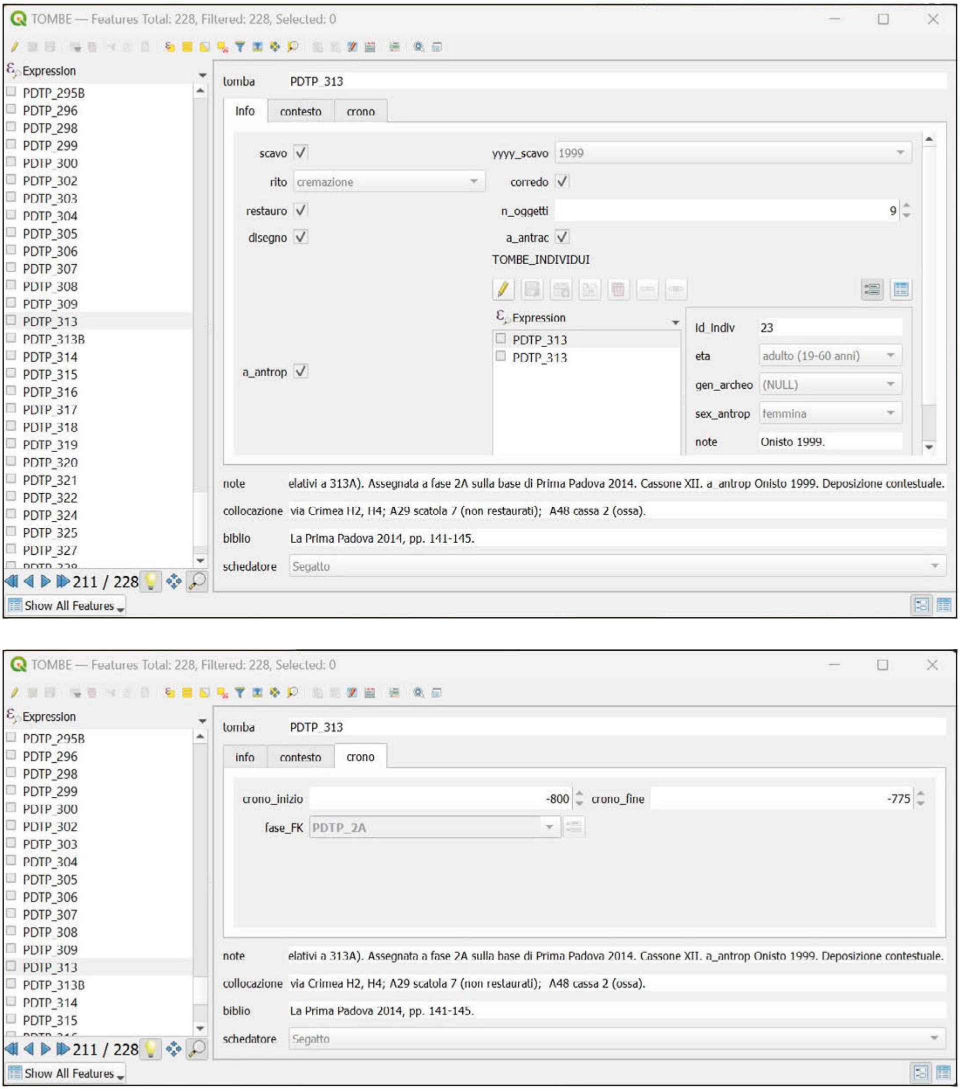


Fig. 4 – Diagram of the relational database.

A relational database consisting of seven tables was designed to gather data from the features that comprise the necropolis. Four geometric tables refer to elements with spatial extent: elevations ('QUOTE'), stratigraphic units ('US'), tombs ('TOMBE'), and funerary structures ('STRUTTURE'). Three non-geometric tables contain alphanumeric data without spatial extent: sites ('SITI'), individuals ('INDIVIDUI'), and chronological phases ('FASI'). Each table contains fields describing the attributes of each feature (Fig. 4). The tables are interconnected through various types of relationships, allowing the definition of association between different entities, such as the belonging of a tomb to a specific burial mound. Consequently, after data entry, it is possible to query the information structured in the database, ranging from simple to complex queries (e.g., which SUs are within Tumulus A?, but also, how many male individuals are buried into Tumulus A?) (Fig. 5a-b).



a

b

Fig. 5 – a-b) Data entry modules for the TOMBE table.

The data entry phase is currently underway, with different progress stages for the two case studies. The geodatabase was firstly applied to the eastern necropolis of Padova, where the excavation is still ongoing, urgently requiring efficient documentation management. To date, 57 out of 314 burials have been published; the majority (219 burials) have been excavated but not yet restored

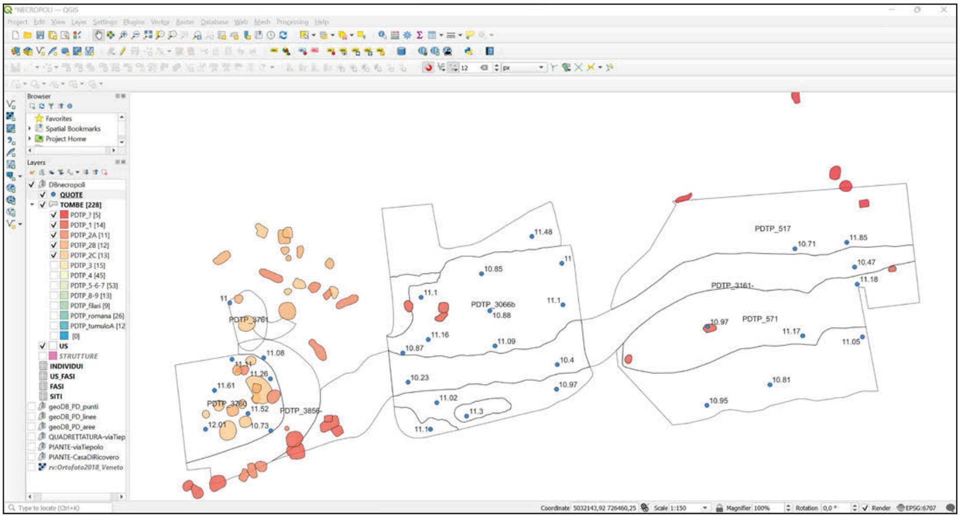


Fig. 6 – Preliminary plan of phases I and II of the excavation at via Tiepolo-via S. Massimo 1990-1991 (Padova).

and/or studied, while the remaining 38 are yet to be investigated. Given the characteristics of the archive documentation and the excavation workflow, data entry began with the tombs table. At present, all burials have been positioned and vectorized on the general plan, and information regarding the tombs from the earliest phases has been entered. This has resulted in a preliminary phase plan (Fig. 6), which may be modified in the future once excavation, restoration, and study of all burials are completed. Since the beginning, it has seemed fundamental to provide the database with a structure flexible enough not only to collect data but also to update and modify them over time. An example is the refinement of the burial's chronology, which can only be verified at the end of archaeological studies on stratigraphy and artefacts.

In the second phase of this work, the same system was applied to the sector of the Este necropolis. In this case, the same geodatabase serves solely for study purposes, as both excavation and restoration of all grave goods have been completed. For the Casa di Ricovero necropolis, the data entry phase is still in its early stages; however, among the main expected outcomes is the elaboration of chronological and distribution plans for an upcoming publication.

C.M.

2.3 *Database and legacy data: balancing flexibility and standardisation*

The geodatabase developed for the Iron Age necropolises of the Veneto region is a tool designed to collect, organise, and standardise archive data, integrating them with the latest information from ongoing excavations and research. It addresses the well-known challenge of managing legacy data (Gattiglia 2015, 5-6; Buscemi *et al.* 2020, 189-201; Figuera 2020, 37-44, 97-106; D'Andrea 2022) and, more broadly, information coming from archive documentation.

Although the database architecture was designed based on both the characteristics of documentation and the research purposes, inconsistencies and gaps in the documentary record become more evident during the data entry process (e.g., plans lacking elements for accurate georeferencing, or difficulties in converting relative elevations into AMSL values after 30 years). These issues are addressed on a case-by-case basis through an analytical review of the documentation and, if necessary, the development of new fields within the tables. As expected, the data entry process proves to be demanding in terms of time and energy, but also shows the solidity of the system and provides an opportunity for continuous refinement of the geodatabase architecture.

The research needs played a crucial role during the design phase, balancing the standardisation of old data with their ongoing updating, and addressing practical-organizational imperatives alongside study purposes. To meet these needs, a compromise was necessary to develop a tool that is formalised enough to be functional, while still acknowledging the specificities of archaeological data and documentation. Since the geodatabase's architecture has been successfully applied to two of the most important Iron Age necropolis in Veneto, its potential for application to other funerary areas in the future cannot be overlooked. Furthermore, by allowing the collection of large quantities of standardised data, it will be possible to easily compare such information across different necropolises.

C.M.

3. Hypothetical reconstruction of burial mounds – BIM application

3.1 *BIM applications in archaeology: limits and perspectives*

Virtual archaeology primarily aims to simulate reconstructive hypotheses of lost contexts through processes of interpretation, acquisition, analysis, and processing of 3D digital data. It constitutes a powerful research tool whose purpose goes beyond mere three-dimensional reconstruction (Demetrescu 2018; Ferdani *et al.* 2020; Demetrescu, Ferdani 2021). In line with the principles emphasized by the London Charter and the seventh Principle of Seville (Gabellone 2012, 2015), research in this field focuses on the development of semantically enriched three-dimensional models, where each geometric element is accompanied by transparent and accessible information.

Among the most promising methods in the field of virtual archaeology stands out the 'Extended Matrix' (EM) initiative, developed by CNR-ISPC in Rome. This methodology is based on extending the stratigraphic principle to virtual geometric units, implementing a standardized system capable of managing all phases of virtual reconstruction and integrating the sources used within it (Demetrescu 2018; Demetrescu, Ferdani 2021). Alongside EM, other approaches, such as adapting Building Information Modelling (BIM) to cultural heritage and archaeology, appear equally promising, aiming to achieve similar goals using different tools.

BIM is an integrated digital methodology originally developed for architectural design and the management of new constructions (Sacks *et al.* 2018), but it has subsequently been successfully employed to analyse historical buildings, assuming the designation of H-BIM (Heritage Building Information Modelling; Delpozzo 2023, 54-62). This approach is based on three-dimensional surveys of structures, from which a digital model founded on parametric elements is generated, usually created or adapted specifically for the buildings under study. However, a significant limitation of this approach is the need to produce and manage parametric elements that often fail to effectively capture the variability of historical or archaeological structures.

In the literature, there are still limited examples of BIM applications in largely incomplete archaeological contexts (Dell'Unto, Landeschi 2022, 31-32; Delpozzo 2023, 54-62), as in the case of the tumuli that were the subject of our project. The objective was to test the advantages and disadvantages of this approach in contexts characterised by limited and often incomplete data.

F.Be.

3.2 *BIM testing on the reconstruction of Este and Padova's burial mounds: problems and possible solutions*

The digitalisation of Este and Padova's burial mounds presented real challenges. The creation of the BIM model involves geometric-spatial digitisation but above all the insertion of information. The digitisation of funerary structures presupposes a different approach than that used for architectural design. In fact, a series of useful parameters have been introduced in order to define the archaeological and topographic character of the study.

In creating the informative model, it was fundamental to include geographic orientation, chronological phases, and the ground level with its elevation measures. The method of representation for both burial mounds is the same and its aim was to illustrate the structures at the moment of their greatest complexity. For Padova's Tumulus A, it was decided to reconstruct not only its later phase but also its previous three, so that we could show, in addition to its latest appearance, also its development over time.

The main digital elements included in the models are: topographical context, boundary structures (such as fences or slabs), and burials. Among the families of this digital system, the weaker one turned out to be 'topography', which was unable to reproduce the appearance of the structures. The information that was necessary for modelling the ground was scarce in relation to the extension of the area. By using the few available elevation measures, it was possible to obtain a very basic and poorly defined geometric shape. This was especially the case of Padova's Tumulus A, which was huge and even more impressive if compared to Este's burial mound. Only for the surfaces, it was decided to use an intermediary software specific for 3D modelling, which allowed the representation of the funerary structures more accurately and quickly. Once the 3D model was complete, it was imported and developed in the BIM software.

Nonetheless, for Padova's Tumulus A it was necessary to add hypothetical elevation measures for two main reasons: lack of information (the scans of the structure were partial because the burial mound was partially not included in the excavation area), and the volumetric compression of the burials over time, which could have caused in some cases biased measurements. After the preliminary surfaces were created and imported, they were used as a 'cast' for modelling the final surfaces. For Tumulus A, it was also possible to divide the main surface into sub-elements and illustrate its stratigraphic units (Fig. 7a).

Using the tool 'topography', it was not possible to represent the ground in a realistic way, as a volumetric object with an irregular surface. Rather, it turned out to be a simple solid, resulting from the projection of the shape of the stratigraphic units. This necessarily caused problems, given that the many stratigraphic units that were identified, appeared to be correct in plan but not in section. Only after surfaces were created, embankments and burials, such as small pillars, walls, and generic models (burials), were digitalized using basic families of the BIM software (Fig. 7b).

The most interesting phase was data entry. Thanks to its documentation, it was possible to create a model of Padova's burial mound that was almost completely accurate, but this was not the same for Este's Tumulus L (Fig. 7c). Each element composing the surface was categorised based on information linked to its historical aspects and its modelling: identification, typology, appearance, and texture of the material, adjacent SUs, and state of preservation. A different category of parameters is the one related to modelling. To avoid a misleading reconstruction, it was necessary to distinguish between areas that were reconstructed by analogy (those lacking a precise cartographic documentation) and those produced from plans drawn during the excavation.

Burials have less linked information: identification, typology, characteristics, and dimensions.

After the data entry, the software was able to elaborate dimensional information, such as the areas of burial mounds (Fig. 8a-b). Even if these objects were created automatically, this was not the case of their volumetry. The only solution could have been using intermediary elements, such as

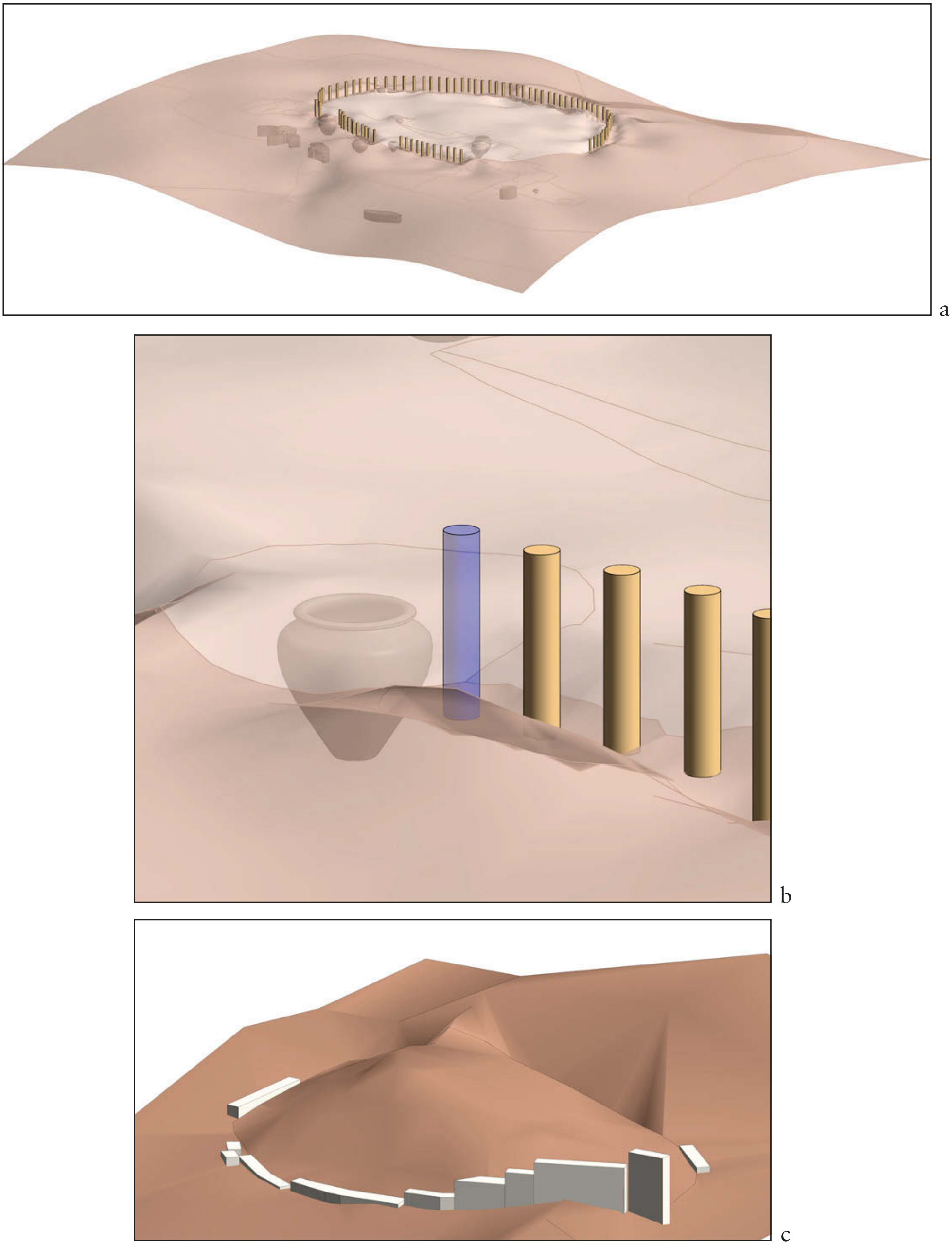


Fig. 7 – BIM reconstructions of burial mound. a-b) Tumulus A in Padova, via Tiepolo-via San Massimo 1990-1991, general and detail views. c) Tumulus L in Este, Casa di Ricovero 1983-1993.

<Superficie tumulo fase 5>

A	B	C
Fase	Area superficie	Posizione
Fase 5	0.87 m²	Esterno cordolo
Fase 5	1.41 m²	Esterno cordolo
Fase 5	1.49 m²	Esterno cordolo
Fase 5	1.22 m²	Esterno cordolo
Fase 5	1.88 m²	Esterno cordolo
Fase 5	20.24 m²	Esterno cordolo
Fase 5	551.02 m²	Esterno cordolo
Fase 5	7.88 m²	Esterno cordolo
Fase 5	5.18 m²	Esterno cordolo
Fase 5	6.09 m²	Esterno cordolo
Fase 5	0.66 m²	Esterno cordolo
Fase 5	2.13 m²	Esterno cordolo
Fase 5	2.71 m²	Esterno cordolo
Esterno cordolo: 13	602.78 m²	
Fase 5	13.35 m²	Interno cordolo
Fase 5	5.49 m²	Interno cordolo
Fase 5	65.79 m²	Interno cordolo
Fase 5	0.17 m²	Interno cordolo
Interno cordolo: 4	84.79 m²	
	687.57 m²	

a

<Superficie tumulo>

A	B	C
Fase di creazione	Area superficie	Posizione
Fase 1	15 m²	Esterno al perimetro
Fase 1	4 m²	Interno al perimetro

b

Fig. 8 – Surface areas of different phases and SUs of the reconstructed burial mounds. a) Phase 5 of Tumulus A at via Tiepolo-via San Massimo 1990-1991, Padova. b) Phase 1 of Tumulus L at Casa di Ricovero 1983-1993, Este.

masses, but these cannot be represented accurately and generate errors. This is the reason why this solution was temporarily left aside.

After the main phases of data entry and modelling were complete, it was possible to retrieve information through tables, so that the database could be easier to use.

What was clear at the end of these experiments, was the lack of tools appropriate for this kind of modelling. These attempts to recreate an archaeological object, which often differs from standard parameters, posed a variety of problems; although it was possible to produce models that are sufficiently accurate and that can represent a starting point for future experiments.

M.V.F.

3.3 *Potential and challenges of BIM in burial mounds reconstruction: results and possible developments*

The application of BIM to the reconstruction of two funerary structures from the necropolises of Padova and Este represented an experiment to evaluate the usefulness of this method in a peculiar archaeological context, which is very different from the architectural field for which it was originally conceived (Garagnani *et al.* 2021; Mancuso 2023). The funerary structures were chosen for their similarities and differences: both were built mainly with geological sediments; in the case of Este the enclosure consisted of limestone slabs, while in Padova it was made of plastic sediments reinforced by a wooden fence. The state of preservation of this perishable construction materials was a critical variable in the reconstruction process.

The objectives of the experiment were twofold: the acquirement of a digital copy of the structure containing all information, and subsequently, the creation of a virtual reconstruction as a dissemination tool. The two selected structures have different levels of documentation detail, providing a good basis for comparing method's effectiveness. Tumulus A proved to be an optimal case study, with numerous detail plans, four general phase plans, and a cumulative section. Tumulus L, on the other hand, highlighted several problems due to limited documentation (only a multi-layered plan and a section). In the latter case, the absence of phase plans prevented the collection of some data related to SUs and the computation of analyses, such as about extension. Thus, the limitations of BIM application to contexts with poor documentation became evident.

The results demonstrate that, despite BIM allowed for the acquisition of new relevant dimensional information, such as the extension areas of the structures, satisfactory volumetric data could not be obtained in the processing of both models.

In conclusion, the application of Building Information Modelling to reconstruct the burial mounds of Padova and Este must be considered experimental. Results are limited to a visual product and a data collection function. This experience clearly shows the need for further studies to focus on refining models for these unusual field of application, characterised by perishable construction materials. Among the possible scenarios, particular focus should be placed on the analysis of compressed soil deposits to determine the original volumes, in order to estimate the quantity of material used in the construction of the tumuli and, consequently, assess the required labour.

F.Bo.

4. Conclusions

It seems useful to draw some conclusions from these experiments, which started with some delay and as part of a work in progress, strongly influenced by the advancement of ongoing studies and research. There are two main themes, seemingly autonomous but actually intertwined: the georeferencing of findings, within the relational database, and the development of informative 3D models of funerary structures. The first one constitutes the basis for managing a plethora of sometimes inconsistent data, useful only if inserted into an organic framework. In the case of the necropolis of Padova, the geodatabase is already offering effective results in the planning of new excavation campaigns. The second research topic – concerning the challenging attempt of reconstructing a portion of the necropolis landscape – has shown issues and limits arising from some choices. We were aware that the field documentation was incomplete in some respects, nevertheless we believe that our study was useful to test the strengths and pitfalls of BIM. Indeed, this software proved to be effective given the quality of data. Anyway, a wider and deeper consideration may be necessary for selecting the right software and tools suited for the available documentary record, in order not to waste precious energies.

Overall, it can be considered a positive experience, as it has allowed us to lay the foundations for a comparison with other, more advanced realities in the Italic Archaeology, working towards the same direction and common goals.

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ABSTRACT

The results of two distinct projects on two pre-Roman funerary areas are presented: the eastern necropolis of Padova between via Tiepolo and via S. Massimo (excavations 1990-1991), and the northern necropolis of Este in the area of Casa di Ricovero (excavations 1983-1993). The first project focused on building of a geodatabase to manage and archive documentation data, as well as to consciously plan resources allocation and research steps. The second project, on the other hand, focused on 3D reconstructions of two burial mounds in a BIM environment, with both research and dissemination aims. Therefore, it was possible to experiment with the limits, potential, and effectiveness of this method in an unusual archaeological context, characterised by monuments built mainly with perishable materials and lacking architectural structures.