



Decoding Archaeological Spaces: A Space Syntax Study of the Hellenistic Baths in Syracuse

MEI YANG

ZHIWEI JI

*Author affiliations can be found in the back matter of this article

CASE STUDY

ubiquity press

ABSTRACT

The Baths of Syracuse (3rd century BC), located in the ancient city of Syracuse (modern Siracusa) in Sicily, Italy, are an important representative of Hellenistic public bath architecture. This study examines the spatial configuration of the Baths of Syracuse to identify architectural type and spatial hierarchy.

Comparative spatial analyses with other Hellenistic baths in Sicily and a Roman imperial bath situate the Syracuse baths within a broader archaeological research context.

This study integrates architectural design theory with space syntax methods and the Depthmap software (Turner 2001) to analyze the archaeological remains of the Syracuse baths, offering a quantitative and visual approach to understanding their spatial organization. By converting the bath spaces into Justified Plan Graphs (JPGs), this study applies three data models — connectivity, Integration, and Visibility Graph Analysis (VGA) — to examine the complex's spatial configuration. This approach combines visual representation with quantitative analysis to evaluate the bath complex's spatial organization.

Comparison of the case study demonstrates the value of space syntax as a quantitative tool for spatial analysis. The results contribute to discussions on the development of Mediterranean public bathing architecture from Greece to Rome.

CORRESPONDING AUTHOR:

Zhiwei Ji

School of Civil Engineering
and Architecture, Hainan
University, China; IUSD, CityU,
Macau, China

16388425@qq.com

KEYWORDS:

Case study; Space Syntax;
Public Baths; Architectural
Spatial Analysis

TO CITE THIS ARTICLE:

Yang, M and Ji, Z. 2026.
Decoding Archaeological
Spaces: A Space Syntax Study
of the Hellenistic Baths in
Syracuse. *Journal of Computer
Applications in Archaeology*,
9(1): 184–197. DOI: [https://doi.
org/10.5334/jcaa.197](https://doi.org/10.5334/jcaa.197)

1. INTRODUCTION

Hellenistic Greek cities were distributed across the Mediterranean, spanning the Greek mainland, the Aegean, Asia Minor, the eastern Mediterranean, and the western Mediterranean (Kemezis 2015; Larguinat-Turbatte 2018). Public baths were an important architectural institution in Hellenistic Greek cities, serving not only hygienic but also social and cultural functions. The internal circulation pattern and spatial hierarchical structure of the building have largely shaped the methods of use and social patterns of the public baths (Krencker & Krüger 1929; Nielsen 1990).

Previous research on Hellenistic baths has focused on excavation results, typological classification, and historical interpretation, and has provided valuable insights into construction techniques and urban context (Holloway 2002). However, these studies rarely employ quantitative methods that can analyze spatial layout as a variable. Moreover, the relationship between the architectural layout of public bathing rooms and social activities remains underexplored (Lucore 2013).

To address this gap, this study applies space syntax analysis, an established analytical framework for examining architectural space through quantitative and visual models (Hillier & Hanson 1984; Lorenzon, Pytkäinen & Artto 2023). Developed by Bill Hillier and Julienne Hanson, space syntax enables the systematic investigation of spatial configuration by analyzing connectivity, Integration, and Visibility Graph Analysis (VGA), thereby treating architectural space as a structured

system rather than a collection of isolated rooms (Ostwald 2011; Turner & Gardner 2015). Space syntax, an important analytical tool in archaeology for studying architectural spaces, has been shown to effectively decode the social logic of classical architectural spaces (Cortés & De Soto 2022; Lorenzon, Pytkäinen & Artto 2023). It quantifies spatial indicators, translating abstract configurations into evidence for interpreting social practice, thus addressing the insufficient link between spatial data and social interpretation in traditional studies of Hellenistic baths.

Sicily is an island in southern Italy. In 734 BC, the ancient Greek city-state of Corinth established the colony of Syracuse on the southeastern coast of Sicily. It was part of ancient Greek colonial expansion (Figure 1). Meanwhile, numerous important independent Greek cities existed in Sicily, such as Morgantina, Gela, Megara, and Hyblaëa. As economic prosperity and urban development increased, city rulers invested in public infrastructure to improve residents' quality of life, including the construction of public baths (Lucore 2013).

Cicero, writing in 70 BC in the Verrine Orations, described Syracuse as “the greatest and most beautiful Greek city” (In Verrem 2.4.118). Cicero’s description underscores Syracuse’s prominence and cultural richness, making it an ideal case study for understanding the evolution of public baths in the Hellenistic world. According to Cultrera’s archaeological findings (Cultrera 1938), the Syracuse baths were undergoing renovation and expansion in 212 BC, when construction was stopped due to Roman occupation (Fagan 1999).

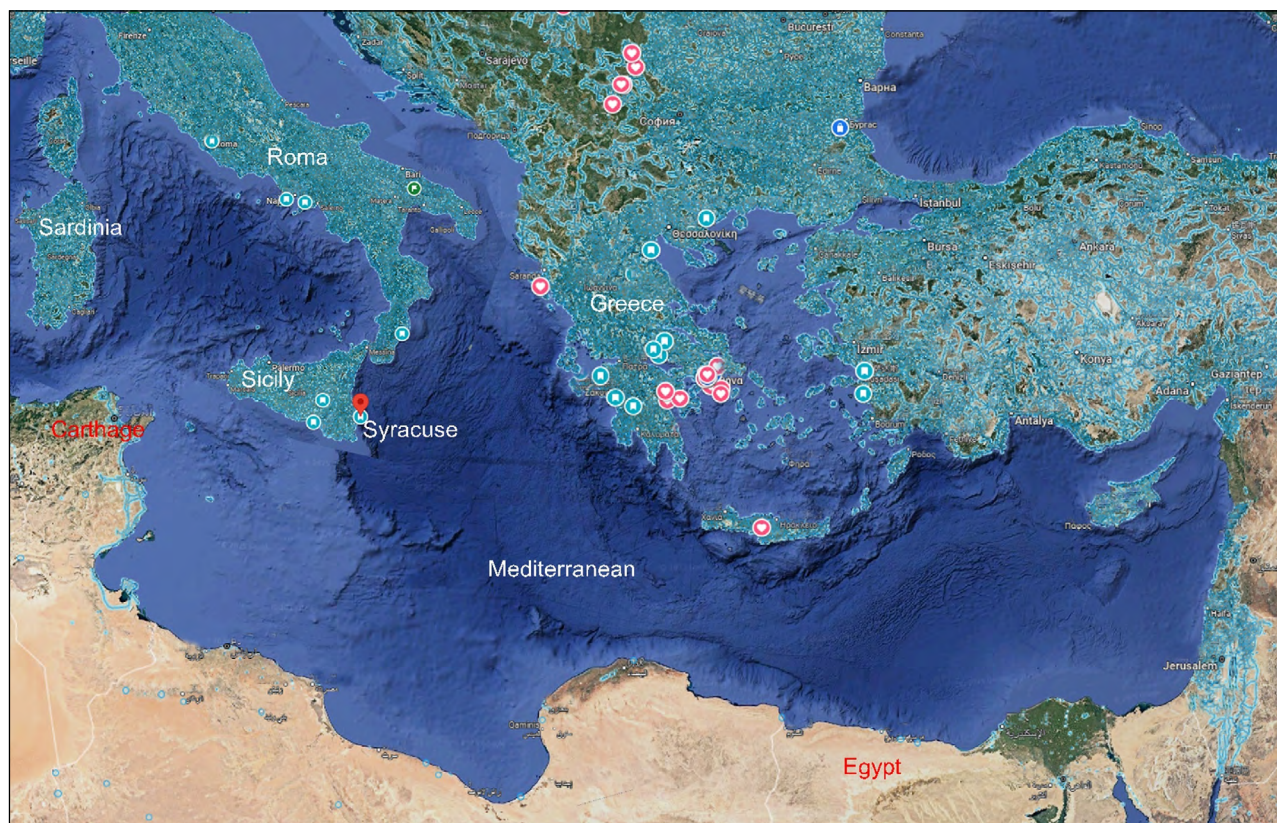


Figure 1 The location of Sicily and Syracuse. Authors' elaboration.

This study focuses on the Hellenistic baths of Syracuse (3rd century BC), a major urban complex developed during the reign of Hieron II. Comparative references to other bath complexes in Sicily and the Roman world are employed to contextualize the findings within broader Mediterranean bathing traditions.

By examining the spatial configuration of the baths through space syntax analysis, this article investigates how the layout of the Syracuse baths structured circulation patterns and spatial hierarchy. It further conducts comparative space syntax analyses of bath complexes at Morgantina in Sicily and the Baths of Trajan in Rome. The discussion section also includes a comparative examination of the architectural plan of the Tell el-Herr Baths in ancient Egypt (Fournet & Redon 2017).

Through these comparisons, the study addresses the following questions: “How did the architectural spatial organization of the Hellenistic baths in Syracuse reflect circulation patterns, potential social differentiation, and experiential sequences? What insights does it provide on the transformation of bathing cultures from Greece to Rome?”

2. HISTORY OF INVESTIGATION

2.1 MAIN EXCAVATION

Archaeological investigation of the Syracuse baths began in the late nineteenth and early twentieth centuries, primarily through the work of Italian archaeologists, including Paolo Orsi and Giuseppe Cultrera. Early excavations focused on documenting architectural remains and situating the baths within the broader urban development of Syracuse. Cultrera’s work, in particular, produced detailed plans of the bath complex at Contrada Zappalà, which remain a fundamental source for subsequent research (Cultrera 1907, 1938).

Later scholars, including Luigi Bernabò Brea and Giuseppe Voza, contributed to the preservation, reinterpretation, and museum display of the remains, ensuring the survival and accessibility of the archaeological record. More recently, Sandra K. Lucore has contextualized the Hellenistic baths of Syracuse within a wider regional framework, emphasizing their significance within western Greek bathing traditions (Voza 1999; Lucore & Miles 2016; Basile & Crispino 2017; Lucore et al. 2021).

Despite this long history of investigation, previous studies have primarily adopted descriptive and typological approaches, focusing on chronology, construction techniques, and architectural form. The spatial organization of the baths and its implications for movement, social interaction, and cultural practice, however, have not been systematically analyzed.

2.2 RECENT ACADEMIC RESEARCH

Against this background, the social and experiential dimensions of architectural space have emerged as major themes in recent research on archaeological and architectural history. Among them, studies on circulation patterns, social differentiation characteristics, and experience sequences have provided new theoretical perspectives for the academic exploration of ancient Roman baths.

Since its inception in the 1980s, the theory of space syntax has continually expanded its application to architectural design analysis. This theory cannot only accurately analyze the layout of architectural spaces but also reveals the potential influence of spatial configurations on human movement trajectories, visual ranges, and interaction patterns (Hillier 1996). At the methodological level, Ostwald’s criticism of the Justified Plan Graph (JPG) Theory (especially the discussion on circular and tree-shaped architectural plans) laid an important foundation for the study of the social experience of architectural spaces (Ostwald 2011). In recent decades, as the research perspective has become more user-oriented, the application of space syntax has further expanded. Letesson (2013) emphasized the perceptibility and experience of architectural spaces, focusing on how physical movement and visual relationships jointly shape the spatial experience of users. Turner and Gardner (2015) developed the visibility graph analysis method, providing a key tool for analyzing the movement logic and spatial control mechanisms in public buildings. Gath-Morad’s research on visual behavior in complex buildings and Ferguson’s exploration of the interaction relationship between architecture and social spaces have further enriched the analytical framework of this field (Ferguson 1996; Gath-Morad et al. 2024).

The traditional archaeology of bathhouses has a profound academic foundation. Krencker and Krüger (1929) and Nielsen (1990) conducted classic studies that laid the groundwork for the architecture type of bathhouses. Ward-Perkins, Fagan, Yegül, and others conducted more in-depth thematic discussions of ancient Roman bathhouses (Ward-Perkins 1994; Fagan 2001; Yegül 2015). Additionally, the online academic platform Ancient Baths (<https://ancientbaths.com/>), maintained by Sadi Maréchal and Konogan Beaufay, serves as an important digital resource in this field, systematically organizing many archaeological data on ancient Roman bathhouses and providing robust data support for comparative research by scholars worldwide.

The influence of space syntax on archaeological research is also profound. Lorenzon, Pytkäinen and Artto (2023) applied it to the analysis of ancient Egyptian architectural archaeology, while Cortés and De Soto (2022) used this method to interpret the space of ancient Roman residences. Yang Mei and Ji Zhiwei analyzed the architectural layout of the Monastery of Santa Maria de

Pedralbes using space syntax, revealing its implicit social difference (Yang & Ji 2025). In the field of bathhouse studies, Stöger (2014) presented the most representative analysis of the space syntax of the Roman Ostia Bathhouse. Her research clearly revealed the intrinsic connection among flow-line organization, spatial hierarchy, and social uses of the bathhouse, thereby fully confirming the strong explanatory potential of this method in Roman bathhouse studies (Stöger 2014).

Although space syntax has demonstrated significant value in Roman bathhouse studies, systematic research on space syntax in the public bathhouses of the Hellenistic period is still relatively scarce, especially in the research of related sites in Sicily. There is also a clear gap in research on the role of such buildings in the transformation of Hellenistic to Roman bathing culture. This paper aims to fill this methodological gap and introduce space syntax analysis into the study of public bathhouses in the Hellenistic period. Under the premise of incomplete archaeological records, it carefully interprets the spatial structures and potential use logic of four bathhouses in Syracuse.

3. ARCHITECTURAL DESCRIPTION

The ancient public baths of Syracuse are situated along the modern Via Zappalà, adjacent to the northern side of the Neapolis district — the “New City” — one of the city’s four main districts. Neapolis is in the northwest of the city center and was the principal cultural and entertainment district in the Hellenistic period. The other three districts are: the oldest district, Ortigia; the commercial and residential district, Achradina; and the religious and burial district, Tyche.

This location, in the immediate vicinity of the Greek Theatre, suggests that the baths primarily served the city’s middle-class residents for both hygiene and social engagement. The Tomb of Archimedes is near here. Only the core area of the baths has been excavated (Basile & Crispino 2017). The Zappalà area was densely populated, with cemeteries dating from the 4th century BC into the late Roman period.

The excavated area covers approximately 900 square meters, with the bath complex measuring 35 meters in length and 25 meters in width. The site includes 21 rooms, such as aisles (d), dressing rooms (o, q), a heated communal immersion pool (h), a luxury bathing room (g), *tholos* (f, k), basin or pool (i), furnace (j), and storage area(c), arranged around a central corridor.

Two entrances can be found in the bath complex. One of these, thought to be the main entrance, is on the eastern side. It opens from the rectangular reception hall into space e, then runs through spaces o and q before reaching aisle d. A small storage room can be found on the southern side of aisle d. Beyond this space a U-shaped

corridor leads farther into the main bathing zone. On the right side, at the far end of this corridor, a bathing room (g) is located. Within this room, stone benches run along the northern and eastern walls. These benches are 6.0 meters long, 1.2 meters wide, and 0.5 meters deep, and would have accommodated approximately 6 to 8 people for bathing together. The heated communal immersion pool (h) extends west of the bathing room (g). Behind this pool sits a second basin (i), which is similar in both scale and function (Cultrera 1938; Figure 2).

Archaeologists have identified a secondary entrance on the bath complex’s western side, directly opposite the main entrance. Significantly, deep wheel ruts preserved at this entrance suggest it likely functioned as the principal access to an adjacent cemetery. From this western entrance, a 9.0-meter-long and 2.0-meter-wide passage (p) leads inward. A right turn opens into the furnace room (j), which was serviced by a subterranean hot-water pipe. Beyond lies the striking western *tholos* (k), its perimeter lined with individual terracotta-tile bidets. This circular room also connects eastward to room d, which in turn links to the bath complex’s eastern half and provides access to a second *tholos* (f). Within these spaces, the two central pillars not only provided essential structural support, but also — as Lucore (2009) argues — may have been adapted to enhance the bathing ritual, possibly serving as stations for assisted washing or even massage (Lucore 2009).

Taken together, these spatial components and circulation paths reveal the baths’ carefully planned design. Beyond their layout and functional arrangements, the Syracuse Baths are distinguished by innovative structural features.

4. STRUCTURE

The baths of Syracuse are defined by two major advances in architectural design: a novel, luxurious model of heated communal bathing (g, h) and the earliest recorded use of complex domed and vaulted structures (k, f) (Lucore 2013).

Most public baths in Sicily had a rectangular plan with a central circular sitting room, but Syracuse is the only bath known to have two circular rooms. The furnace built in the middle of the baths is also an architectural feature of Sicilian baths. These large heating systems, often referred to as bottle systems, pass hot water through spliced terracotta bottles and drain it. Although a nearby water channel has been discovered, it remains unclear how the bathhouse accessed such a substantial water source. The two circular vaults in the center of the bathhouse are also constructed from tiled pipes. The interior of the bathhouse has been plastered. Archaeologists did not find a *caldarium*, *tepidarium*, or *frigidarium* in Syracuse, a significant departure from the typical layout of ancient

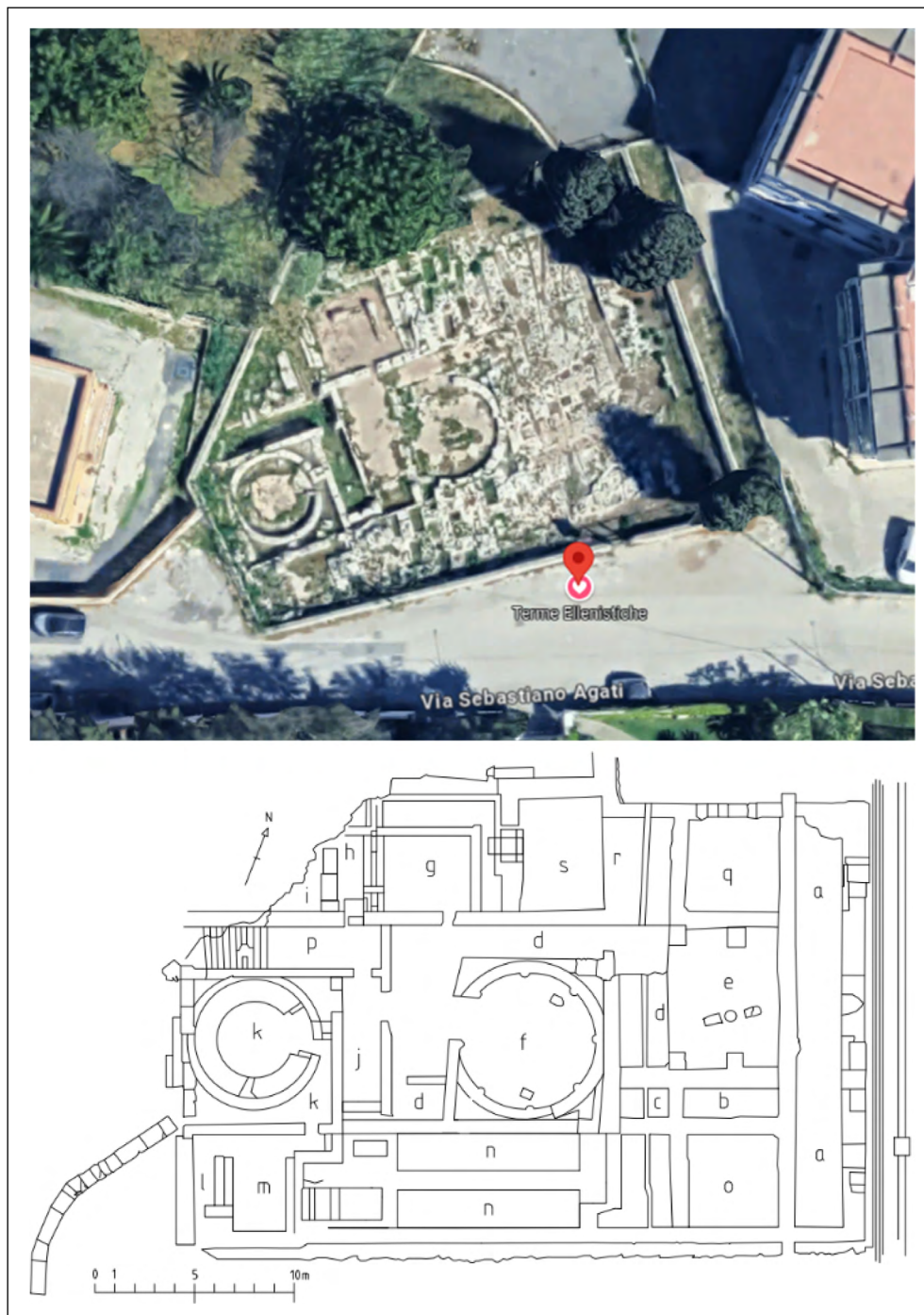


Figure 2 Top: aerial view of the Syracuse Baths. Source: Google Maps, accessed December 27, 2025. Bottom: Plan of the Syracuse baths. Authors' elaboration based on data from Cultrera (1938, pl. XXI). Letters denoting buildings following Broise (1994, 21, Figure 6): a: main entrance; b: storage area; c: storage area; d: aisle areas; e: hall; f: *tholos*; g: baths room; h: immersion pool; i: comparable basin or pool; j: furnace; k: *tholos*; o: dressing rooms; p: secondary entrance; q: dressing rooms.

Roman baths (Delaine 1989; Lucore 2013). After entering the baths, people went straight to the hot baths. This architectural plan is also reflected in the public baths of the same period in Sicily (Lucore et al. 2021).

5. SPACE SYNTAX ANALYSIS

While the preceding section outlines the architectural characteristics of the Syracuse baths, these features alone do not fully reveal their spatial organization. To examine this issue systematically, the following section applies

space syntax analysis, beginning with an explanation of the calculation procedures before comparing the topological layouts and data of three bath complexes.

5.1 CALCULATION PROCEDURE

In theoretical research on space syntax, a complex architectural space is first converted into Justified Plan Graphs (JPGs), which represent the topological relationships between spaces and provide the basis for subsequent quantitative analysis (Ostwald 2011). In archaeological applications, JPGs have been widely used to formalize spatial depth, accessibility, and hierarchical

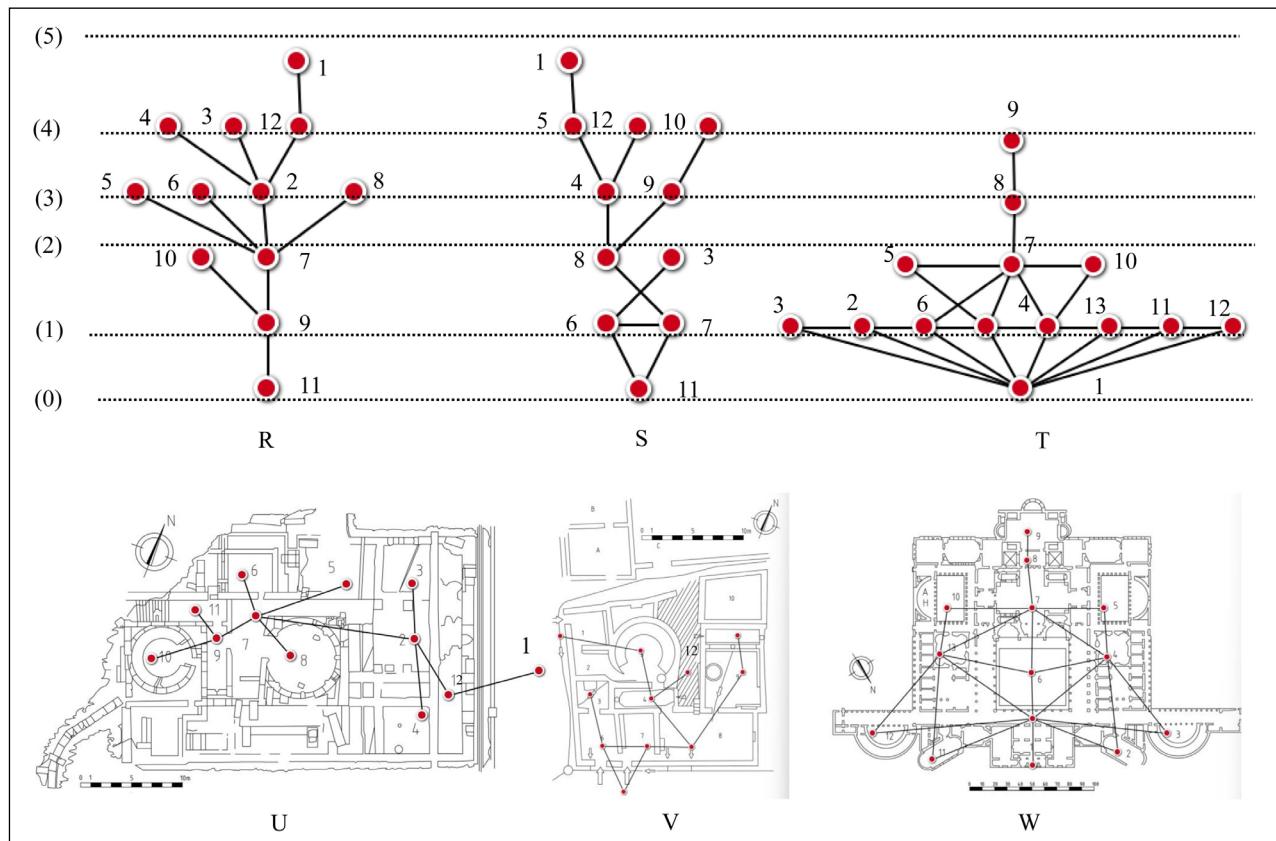


Figure 3 Analysis results for 3 baths, from left to right: the Syracuse Baths (**R, U**), North Morgantina baths (**S, V**), and the Baths of Trajan (**T, W**). Top: Topological space analysis diagrams. Bottom: architectural plans. Legend: ● = space; 1 = space number; — = space connection. Authors' elaboration.

Note: The space numbers in this diagram are simplified labels assigned for the purpose of visualizing the topological structure and hierarchy in this graph. These labels are independent of the space ID in [Table 1](#).

relationships within buildings, allowing architectural plans to be analyzed as structured spatial networks rather than as purely geometric drawings ([Fladd 2017](#)).

In this study, the bath complexes were converted into JPGs by defining each enclosed room or functional space as a node and each direct spatial connection as an edge. The main entrance of the bath was selected as the root node, reflecting its primary role in regulating access and circulation ([Figure 3](#)). All other spaces were then assigned depth levels (D) based on their topological distance from this entrance, yielding a hierarchical representation of spatial organization ([Letesson 2013](#)). Based on these JPGs, several key space syntax metrics were calculated. Total depth (TD) was computed by summing the depth values of all nodes (nX) relative to the entrance, following standard formulations in archaeological space syntax studies. TD values for the different rooms of the Syracuse Baths are presented in [Table 1](#). The calculation follows ([Ostwald 2011](#)):

$$TD = (0 \times n_0) + (1 \times n_1) + (2 \times n_2) + \dots + (X \times n_X) \quad (1)$$

Connectivity, Integration, and Visibility Graph Analysis (VGA) are the most frequently mentioned and used parameters in space syntax theory and quantitative analysis.

Connectivity indicates the number of direct spatial adjacencies within a building, and thus reflects spatial hierarchy. A higher connectivity value corresponds to greater spatial permeability, while a lower value indicates more restricted access and poorer circulation potential ([Stöger 2009](#); [Figure 4A, D, G](#)).

Integration reflects the degree to which space is positioned centrally within the overall system and thus reveals underlying circulation patterns. It is widely used to assess the extent to which space is embedded within a spatial system and its capacity to shape movement and access. Spaces with higher integration values tend to be more accessible and central, whereas those with lower values are more segregated and peripheral, with limited impact on broader circulation ([Criado-Perez et al. 2020](#)).

However, integration values are fundamentally derived from mean depth (MD) and are therefore sensitive to variations in system size and topological complexity ([Table 1](#)). Direct comparisons of raw integration values across buildings with different numbers of spaces and depth structures can be misleading. To address this problem, Real Relative Asymmetry (RRA) is used as a normalized measure that adjusts mean depth relative to system size, enabling valid comparisons between buildings of different scales. RRA values for the individual rooms of the Syracuse Baths are reported in [Table 1](#).

Space ID	CONNECTIVITY	CV	TDn	MDn	INTEGRATION	RA	RRA
1	1	0.5	112	5.39474	0.413864	0.54386	2.41625
8	1	0.5	106	5.07895	0.442407	0.508772	2.26036
16	1	0.25	96	4.55263	0.499862	0.450292	2.00055
18	1	0.25	96	4.55263	0.499862	0.450292	2.00055
2	2	1.25	94	4.44737	0.513192	0.438596	1.94859
0	1	0.25	90	4.23684	0.542104	0.415205	1.84466
15	1	0.333333	76	3.5	0.675252	0.333333	1.48093
19	1	0.25	90	4.23684	0.542104	0.415205	1.84466
7	2	1.25	88	4.13158	0.557817	0.403509	1.7927
13	1	0.333333	86	4.02632	0.574468	0.391813	1.74074
3	1	0.25	80	3.71053	0.630973	0.356725	1.58485
12	1	0.25	80	3.71053	0.630973	0.356725	1.58485
17	4	2.833333	78	3.60526	0.652362	0.345029	1.53289
4	4	2.75	72	3.28947	0.726215	0.309942	1.377
14	1	0.333333	76	3.5	0.675252	0.333333	1.48093
11	3	1.75	68	3.07895	0.785498	0.28655	1.27308
5	4	2.583333	62	2.76316	0.895102	0.251462	1.11719
10	2	0.666667	62	2.76316	0.895102	0.251462	1.11719
6	3	1.583333	58	2.55263	0.986907	0.22807	1.01327
9	3	1.833333	58	2.55263	0.986907	0.22807	1.01327

Table 1 Data analysis of the Syracuse Baths (calculated by the authors).

Calculations of integration and RRA follow the standard formulations set out by Ostwald (2011), as shown in Equation 2–5.

$$RA_i = \frac{2(MD_i - 1)}{n - 2} \quad (2)$$

$$D_n = \frac{2\{n[\log_2((n + 2)/3) - 1] + 1\}}{(n - 1)(n - 2)} \quad (3)$$

$$RRA_i = \frac{RA_i}{D_n} \quad (4)$$

$$I = \frac{1}{RRA_i} \quad (5)$$

Visibility Graph Analysis (VGA) models lines of sight by accounting for architectural boundaries and human visual parameters, generating visibility values that range from blue (low visibility) to red (high visibility) across the spatial field. VGA has been increasingly applied in archaeological research to explore movement, perception, and the experiential qualities of built environments (Stöger 2007; Turner & Gardner 2015). In the present study, visibility values are examined alongside circulation routes and depth levels to understand how visual accessibility may have shaped movement and social interaction within the baths. Notably, visual access patterns captured by VGA may also reflect patterns of social differentiation. The

computational procedures employed in the analysis are illustrated in Figure 5 (Cortés & De Soto 2022; Lorenzon, Pykkänen & Artto 2023).

5.2 TOPOLOGICAL ANALYSIS

To explore the spatial organization of the Syracuse Baths during the Hellenistic period, this paper conducts a comparative analysis of the Syracuse Baths and the nearby North Morgentina Bathing Place, both located on the same island and dating to the same period. This comparison within the same region helps to reveal common characteristics in the layout and spatial hierarchy of public bathing places in Sicily during the Hellenistic period. On this basis, this paper further compares the spatial structures of Syracuse and North Morgentina Baths with those of the Baths of Trajan in the Roman period to examine changes in the spatial organization and functional logic of public baths during the transition from the Hellenistic to the Roman period.

The topological analysis results indicate that both the Syracuse Baths and the North Morgentina Baths exhibit a distinct tree-shaped architectural type in their overall spatial structure, with six levels of spatial hierarchy (Figure 3R, S). As noted earlier, the Syracuse baths lack the standard Roman sequence of *caldarium*, *tepidarium*, and *frigidarium* (Lucore 2013). In this respect, the Morgentina baths are similar: both sites have two independent entrances and feature heated bathing areas, lacking the full suite of cold, warm, and hot pools.

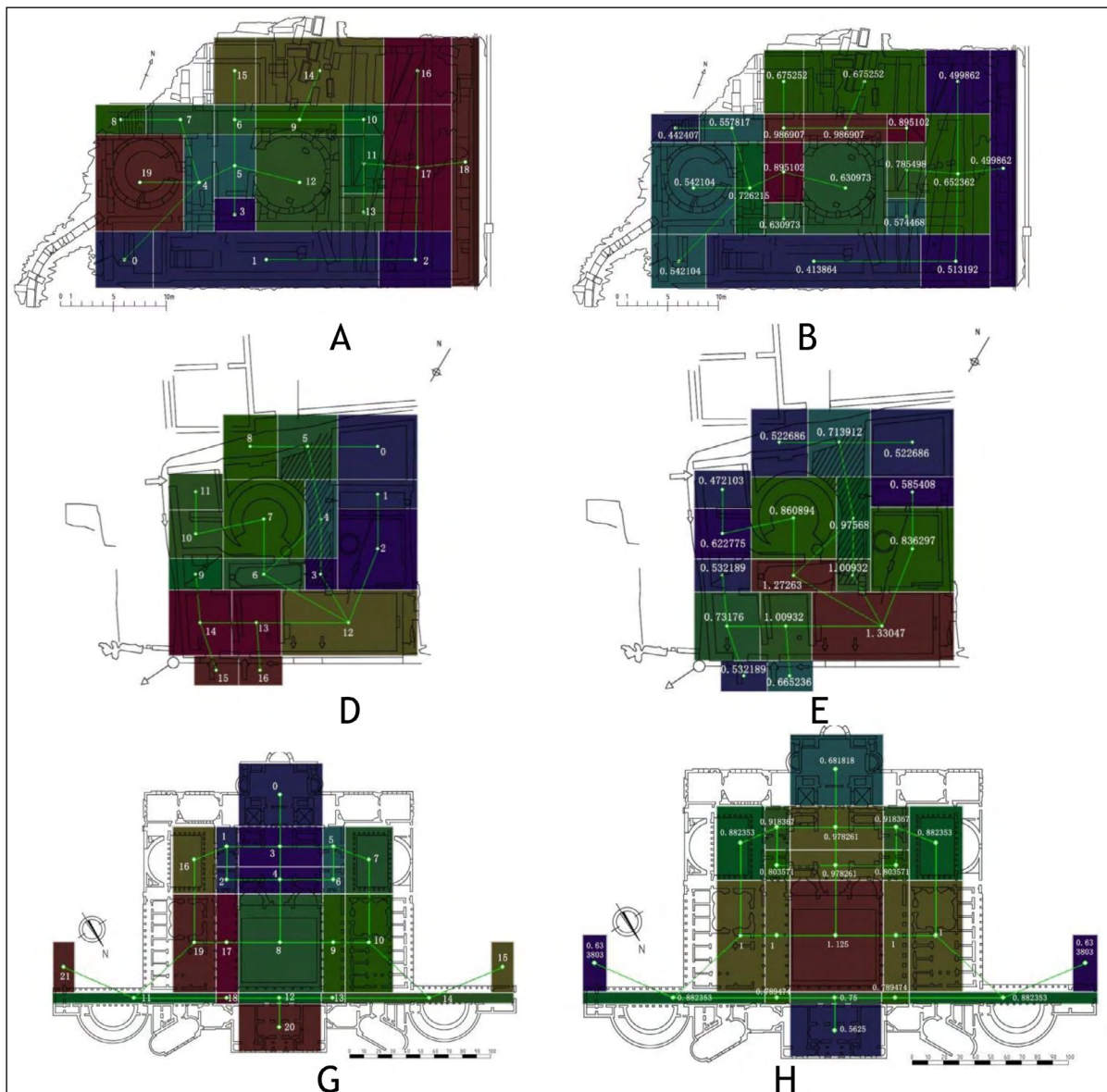


Figure 4 Connectivity and integration of the 3 baths. Authors' elaboration.

Note: **A, B:** Syracuse Baths; **D, E:** North Morgantina baths; **G, H:** Baths of Trajan.

This spatial structure, centered on a passage and divided into multiple bathing-room units, reflects the relatively concentrated functional layout and lower degree of spatial integration of public baths in the Hellenistic period compared to the Roman period.

In terms of specific composition, the Syracuse Bath includes two circular bathing rooms (nodes 10, 8) and two hot water bathing rooms (nodes 5, 6), forming the main bathing room units, while nodes 2, 7, and 9 undertake key traffic organization functions (Figure 3R, U). In contrast, the North Morgantina Bath has only one circular bathing room and one rectangular hot water bathing room, with nodes 4, 8, and 7 serving as main passageways, and nodes 5, 9, and 10 as main bathing rooms (Figure 3S, V). Although there are differences in the number and geometric form of bathing rooms between the two, their overall topological logic is consistent.

Building on this, the paper further compares the Hellenistic baths with the Roman-period Baths of Trajan.

These have a symmetrical plan height and a spatial structure organized in a ring shape, with a five-level spatial hierarchy. Its interior not only fully accommodates the *caldarium*, *tepidarium*, and *frigidarium* sequences (nodes 7, 8, 9) but also integrates various functional spaces, such as the sports field (nodes 10, 5) and the swimming pool (node 6) (Figure 3T, W). Compared to Hellenistic baths, the Baths of Trajan show marked increases in scale, functional complexity, and spatial integration, suggesting a more developed approach to social use and spatial control in Roman public baths.

5.3 DATA ANALYSIS

Based on the established topological structure framework described above, the subsequent space syntax analysis diagram examines indicators such as connectivity, integration, and Visibility Graph Analysis (VGA) to compare activity patterns and spatial use across the three baths (Figures 4 and 5).

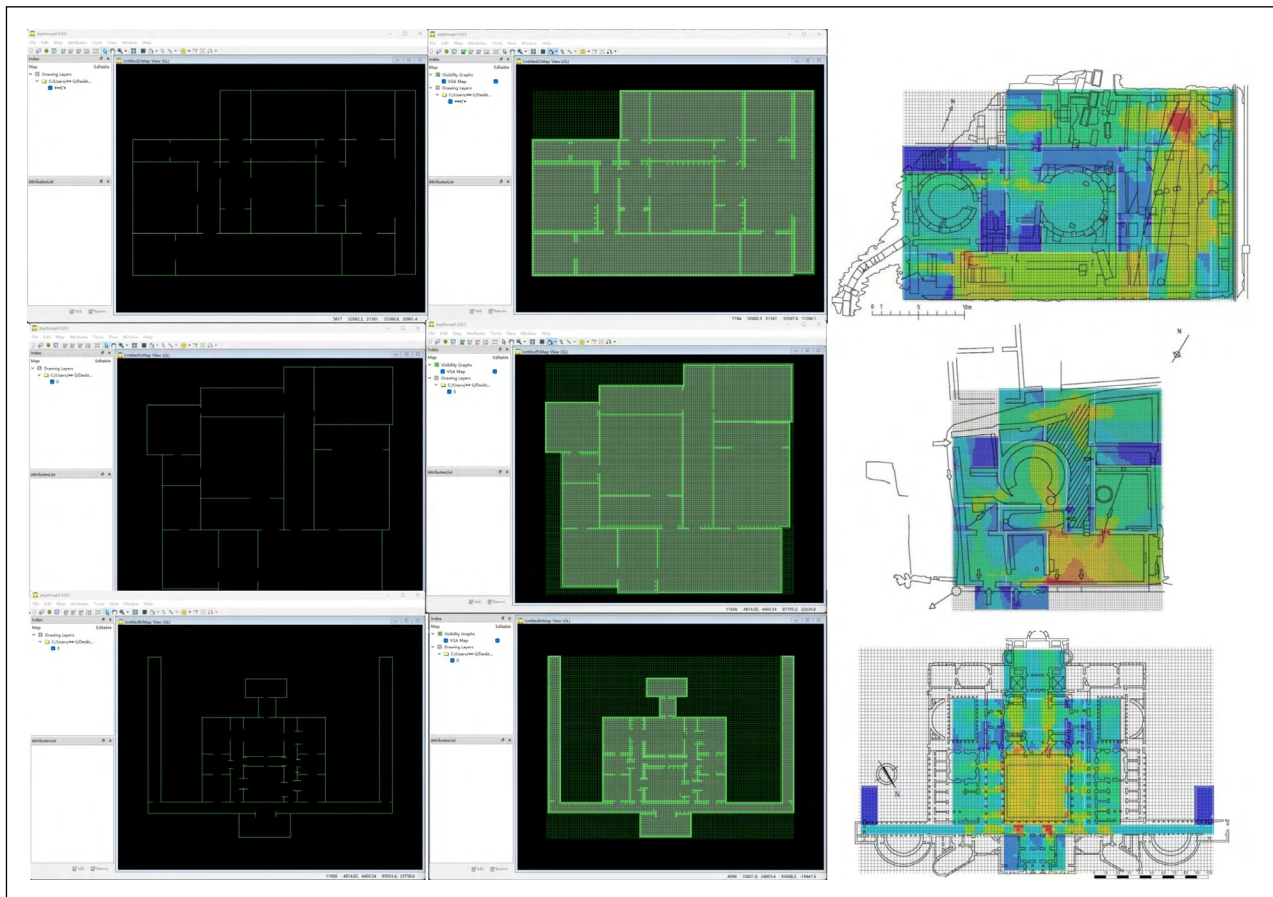


Figure 5 Visibility Graph Analysis (VGA) of the 3 baths. Authors' elaboration.

The connectivity of the hall at Syracuse Baths is 4 (ID 17). This higher indicator implies that this area served as a central hub for social activities, reflecting Syracuse's bathing customs. Although the circular rooms on the left (ID 19) and right (ID 12) share the same connectivity of 1, the warmer coloration of the left room suggests more frequent use (Figure 4A, B; Table 1). In the North Morgantina baths, the connectivity in the single circular room (ID 7) appears green, whereas the hot-water pool (ID 2) is blue. This difference highlights that the circular room accommodated far more frequent hygienic and bathing activities (Figure 4 D, E; Table 1). At the Thermae Traian, the entrance (ID 20) exhibits the reddest tone, indicating the most actively used area (Figure 4 G, H; Table 1).

The highest integration value for Syracuse is 0.986907, located in the central corridor, which connects the massage area, the hip baths, and the immersion baths, indicating that this area was the most frequently used. The North Morgantina baths had only a single circular room; its highest integration value is 1.33047, located in the public transit section between the entrance and the circular bath and the soaking pool. The highest integration value for Thermae Traian is 1.125, occurring in the open-air swimming pool along the central axis (Figure 4B, E, H).

The corridor between the east entrance of Syracuse and the two circular rooms was the best viewing point, indicating that this space was spacious and easy to traverse and that people could see a broader area. The place with the widest field of vision in the North Morgantina baths was also at the entrance of the bath building. In contrast, at the Baths of Trajan, it was in the open-air swimming pool along the building's central axis (Figure 5).

Taken together, the analyses reveal clear differences in circulation patterns, social differentiation, and experiential sequences between Hellenistic and Roman bath architecture (Figures 4 and 5).

6. DISCUSSION

The following discussion addresses three interrelated issues concerning the spatial organization of Hellenistic and Roman bath complexes.

The first issue concerns how the baths of Sicily evolved into the architectural layout of the Baths of Trajan in Rome. A Ptolemaic (Greek) bath complex was unearthed at Tell el-Herr in Ismailia, Egypt (near the Nile Delta), during excavations conducted by French archaeologists (Fournet & Redon 2017). This is a typologically transitional public bath building, representing an intermediate

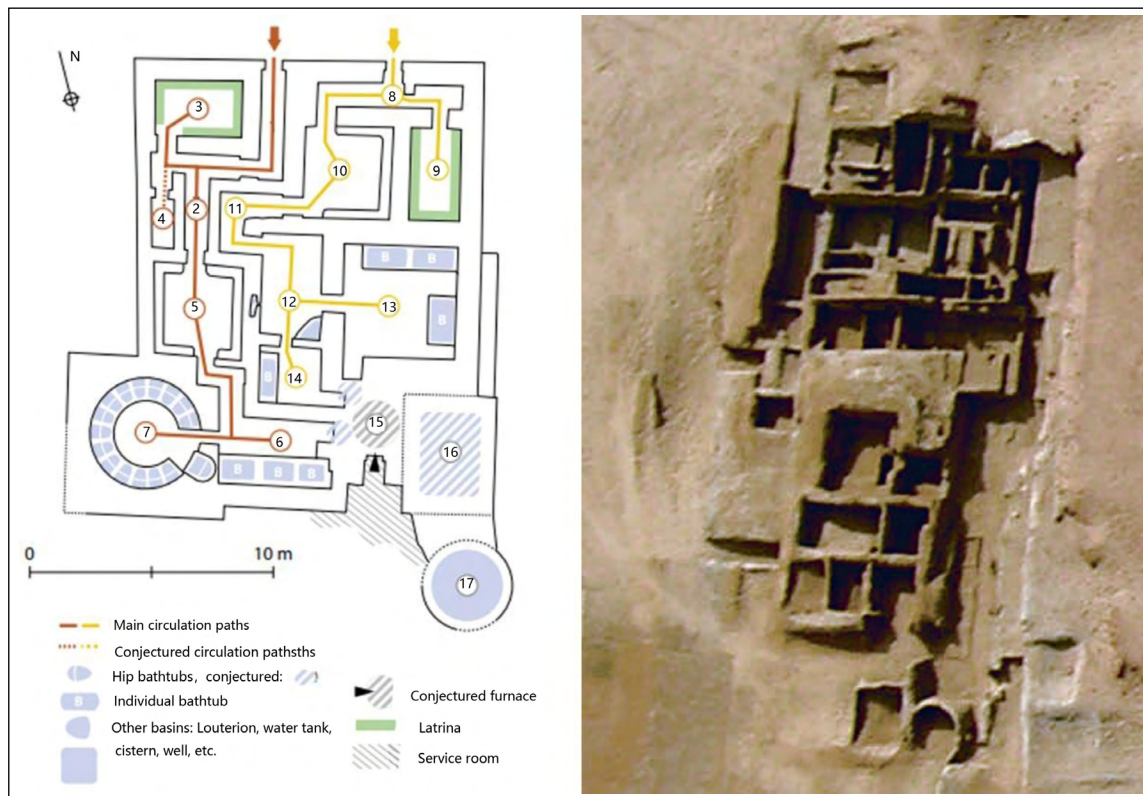


Figure 6 Plan (left) and photograph (right) of the Tell El-Herr baths. Data from [Fournet & Redon, 2017](#), Figure 13.

stage in the evolution of bathing architecture from the Hellenistic to the Roman era.

Like the baths on the island of Sicily, the Tell El-Herr baths retained circular bathing rooms. However, unlike those on Sicily, the Tell El-Herr baths placed the circular and rectangular heated rooms in two separate, parallel spaces, each with its own one-way straight-line route, and these two systems did not intersect. Tell El-Herr baths' layout resembles two simple, tree-shaped structures. It does not achieve the fully integrated, symmetrical layout characteristic of Roman imperial baths, but lies in between the Sicilian baths and the Baths of Trajan ([Figure 6](#)).

From this perspective, the Tell El-Herr baths demonstrate how the circular bathing rooms, originally embedded within a tree-shaped spatial structure, were replanned as parallel, independent circulation systems. This architectural layout provides important evidence for understanding the spatial and social reconfiguration of bathing customs in the Mediterranean region during the transition from the Hellenistic to the Roman era ([Figures 3 and 6](#)).

The second issue concerns the distinction between tree-shaped and ring-shaped structures in ancient public baths. According to [Ostwald \(2011, 460, figs. 11–12\)](#), spatial structures can be broadly classified as tree-shaped or rhizomorphous. In the present study, the latter is referred to as a ring-shaped structure to emphasize its circular circulation and integrated spatial organization.

From a behavioral perspective ([Osborne 2012](#)), tree-shaped structures often support controlled, hierarchical, and possibly ritualized usage patterns, while ring-

shaped structures facilitate parallel circulation, social interaction, and flexible use of space. By comparing spatial grammatical indicators ([Figures 4 and 5](#)), we can also obtain empirical evidence.

In the dendritic spatial structure, the space gradually deepens vertically, while the horizontal connectivity between rooms is restricted, and the terminal spaces are mostly isolated from each other. This explanation is confirmed by the spatial grammatical indicators. For example: in the Syracuse and North Morgantina baths, the highest values of connectivity and integration are concentrated at the corridor nodes rather than in the bathing rooms, indicating that movement and control are concentrated in specific areas of the space rather than being uniformly distributed ([Figure 4 and Table 1](#)). There, entering the bathing room requires passing through a limited number of control nodes, thereby reinforcing the sequential movement and the hierarchical structure of the space ([Figure 7 top; Ostwald 2011](#)).

In contrast, the ring-shaped spatial structure has a shallower depth but enhances the visibility and accessibility between rooms. Through symmetrical or ring-shaped layouts, these structures provide multiple pathways for movement and promote spatial transparency. For example, in the space syntax analysis diagram of the Trajan Baths ([Figure 5](#)), this logic is reflected in the distribution of integration and visibility values, with the peak not occurring in a specific commonly used room (such as the hot water room), but at the open-air swimming pool located on the central axis. This indicates a shift from a controlled to an integrated space, allowing

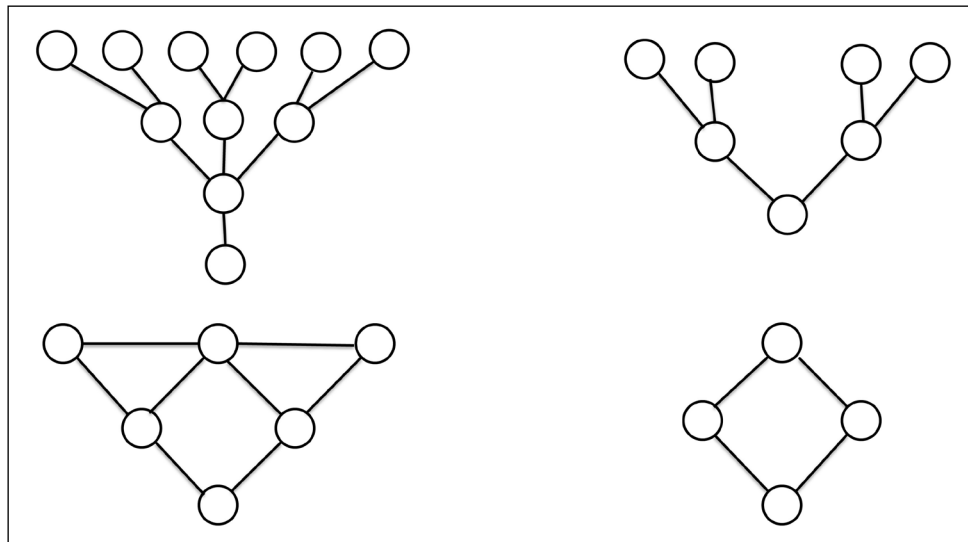


Figure 7 ‘Tree-shaped structures’ (top) and ‘ring-shaped structures’ (bottom), adapted from Ostwald (2011, figs. 11 and 12). The latter are termed “rhizomorphous structures” in the original study.

many users to gather and interact simultaneously, and reflects the broader strategy of managing social diversity within a unified architectural framework (Figure 7 bottom; Ostwald 2011).

The third issue concerns the relationship between spatial layout, functional complexity, and social relations in public baths.

STRUCTURAL CHARACTERISTICS SUGGESTED BY SPACE SYNTAX DATA

First, Space syntax data provides objective evidence of the structural characteristics of these four cases. All examples feature multiple independent entrances leading to the bathing area. In the Syracuse baths, quantitative analysis reveals notable differences in spatial structure: the two entrances (nodes 1 and 11) display distinct Real Relative Asymmetry (RRA) values—2.41625 for node 1 and 1.27308 for node 11. These values suggest that the two entrances differ in their degree of integration within the overall spatial layout, which may correspond to divergent passage patterns (Figure 4 and Table 1).

SOCIAL PRACTICES ARE POTENTIALLY INFERRABLE FROM SPACE SYNTAX DATA

These structural variations imply that the spatial layout was configured to accommodate distinct activity patterns. The presence of multiple structurally differentiated entrances supports the hypothesis that different entrances may have been intended to separate users. This aligns with broader scholarly discussions of social differentiation in the Hellenistic period — including potential distinctions based on gender, social status, or other forms of group categorization (Grahame 2000; Stöger 2009).

In this respect, the spatial structure provides a formal architectural foundation for interpreting social differentiation within the bathhouse.

LIMITATIONS: WHAT SPACE SYNTAX CANNOT CONFIRM WITHOUT ADDITIONAL EVIDENCE

Although space syntax provides a systematic quantitative research framework for analyzing the architectural space and functions of bathhouses, it cannot independently verify the actual social dynamics. For instance, in the Syracuse baths, we cannot determine the identities or statuses of users who used different entrances, their actual social behaviors, or the norms that constrained passage.

Space syntax analysis must account for uncertainties in modeling archaeological remains, including the reconstruction of JPGs and their limitations in capturing ancient use and social significance. While it can generate plausible hypotheses about social practices from spatial differences, it is subject to inherent methodological constraints.

Robust interpretations, therefore, require supplementary evidence from archaeology, ancient texts, and historical sources.

7. CONCLUSIONS

Through a syntactic analysis of the spaces of the Syracuse baths, the North Morgantina baths, and the Baths of Trajan, a key finding of this study is that tree-shaped and ring-shaped spatial prototypes appear to represent not merely abstract classificatory forms, but plausible spatial logics that may have structured bathing practices from the Hellenistic to the Roman period. Based on previous research (Krencker & Krüger, 1929; Nielsen, 1990), the present research empirically assesses the applicability and explanatory potential of established spatial topological models using four archaeological cases. This approach provides a consistent empirical foundation for

investigating the long-term developmental trajectory of bathing architecture from the Hellenistic to the Roman periods.

The Hellenistic baths of Sicily consistently display a tree-shaped structural organization. This pattern is marked by a strong axial sequence leading into deeper spaces, limited lateral connectivity, and structured circulation via controlled corridor access. By contrast, large-scale imperial Roman baths tend to employ more symmetrical, ring-shaped plans and highly integrated spatial layouts that appear conducive to parallel circulation, intensive co-presence, and expanded social interaction. Comparison with the Tell El-Herr baths in Egypt further suggests that the shift between these two prototypes was gradational, unfolding through intermediate forms in which ring-shaped configurations emerged from tree-structured systems and reorganized into parallel, semi-independent circulation pathways.

A typological comparison across the four sites indicates a further significant finding: these spatial prototypes are not determined solely by building size but instead correlate closely with functional complexity and social orientation. Although the Syracuse baths are relatively modest in scale, their tree-shaped layout is consistent with bathing practices structured around ordered movement and spatial differentiation. By contrast, the monumental scale of the Baths of Trajan entails not only greater functional complexity, but also a qualitatively distinct spatial logic that seems oriented toward integrating diverse activities and user groups within a unified architectural framework.

Finally, while space syntax cannot directly verify specific social categories such as gender or class, it offers a rigorous method for linking values of integration, relative asymmetry (RRA), and visibility. This allows bath complexes of differing scale, date, and preservation to be compared within a shared analytical framework. By revealing how architectural layout may have facilitated or constrained movement, encounter, and visibility, Space syntax permits a more structured and critical evaluation of the spatial and temporal plausibility of social interpretations — including those concerning gender and class. In this way, it provides a valuable methodological reference for archaeologically grounded spatial research.

Crucially, however, space syntax illuminates spatial potential rather than empirically proven use. Its results support plausible inferences about social practice, but cannot independently confirm the actual identities, behaviors, or social dynamics at play. Future work incorporating more detailed archaeological evidence, refined architectural reconstructions, and expanded regional comparisons will further test, validate, and refine this quantitative approach.

DATA ACCESSIBILITY STATEMENT

Access to the spatial data and analysis outputs generated in this study using Depthmap is restricted for reasons of ongoing research. They can be made available from the corresponding author upon reasonable request.

DECLARATION OF AI USE

Language was improved with the assistance of Grammarly (v1.2.243.1862).

ACKNOWLEDGEMENTS

This research was carried out within the Doctoral Program in Ancient and Medieval Science at the Autonomous University of Barcelona. Great gratitude is owed to supervisors Prof. Dr. Cèsar Carreras and Dr. Pau de Soto Cañameres, for their support throughout the entire research process.

FUNDING INFORMATION

The authors declare that no specific funding was received for this research (including institutional research grants, external funding bodies, open access publication funds, or other financial support) to conduct the study, collect the data, analyze the results, or prepare this manuscript for publication in the *Journal of Computer Applications in Archaeology* (JCAA).

COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

Yang Mei (First Author)

Formulated the core research topic and theoretical framework focused on Roman architectural archaeology, defined research objectives, and integrated the methodological approach. Led the in-depth analysis of Roman architectural remains, spatial patterns, and contextualization within urban archaeological frameworks. Directed archival and archaeological literature research, including critical evaluation of early excavation records. Drafted the full manuscript, including literature review, data analysis, discussion, and conclusion sections. Designed and prepared all figures, tables, and architectural graphical materials for the manuscript.

Ji Zhiwei (Corresponding Author)

Provided access to relevant archaeological archives, literature resources, and supplementary research materials. Performed detailed research on early excavations, architectural documentation, and relevant archaeological literature.

AUTHOR AFFILIATIONS

Mei Yang  orcid.org/0009-0000-9731-0635

Department of Antiquity and Middle Ages Studies, Autonomous University of Barcelona (UAB), Spain

Zhiwei Ji  orcid.org/0009-0005-9516-1265

School of Civil Engineering and Architecture, Hainan University, China; IUSD, CityU, Macau, China

CLASSICAL SOURCES

Cicero. *In Verrem*. Translated by L.H.G. Greenwood. Loeb Classical Library. Harvard University Press, 1928.

REFERENCES

- Basile, DB** and **Crispino, A.** 2017. 'Giuseppe Cultrera e l'archeologia a Siracusa fra Paolo Orsi e Luigi Bernabè Brea'. In: Panvini, R and Sammito, A (eds.), *Atti del Convegno di Studi Archeologia in Sicilia tra le due guerre, Modica, 5–6–7 Guigno 2014*. Modica: Arti Grafiche Cannizzaro, pp. 57–74.
- Broise, H.** 1994. 'La pratique du bain chaud par immersion en Sicile et dans la péninsule italique à l'époque hellénistique'. *Xenia Antiqua*, 3: 17–32.
- Cortés, A** and **De Soto, P.** 2022. 'Who lived in that Roman house? Computational analysis on the domestic space to identify a new hybrid house in the Roman Empire'. *Digital Applications in Archaeology and Cultural Heritage*, 25: e00222. DOI: <https://doi.org/10.1016/j.daach.2022.e00222>
- Criado-Perez, C, Collins, CG, Jackson, CJ, Oldfield, P, Pollard, B** and **Sanders, K.** 2020. 'Beyond an 'informed opinion': evidence-based practice in the built environment'. *Architectural Engineering and Design Management*, 16(1): 23–40. DOI: <https://doi.org/10.1080/17452007.2019.1617670>
- Cultrera, G.** 1907. *Saggi sull' Arte Ellenistica e Greco-Romana. I. La Corrente Asiatica*. Rome: Ermanno Loescher & Co.
- Cultrera, G.** 1938. 'Restauro di una colonna dell'Olympieion a Siracusa'. *Le Arti*, I(VI): 604–606.
- Delaine, J.** 1989. 'Some Observations on the Transition from Greek to Roman Baths in Hellenistic Italy'. *Mediterranean Archaeology*, 2: 111–125.
- Fagan, GG.** 1999. *Bathing in public in the Roman world*. Ann Arbor: University of Michigan Press. DOI: <https://doi.org/10.3998/mpub.14923>
- Fagan, GG.** 2001. 'The genesis of the Roman public bath: recent approaches and future directions'. *American Journal of Archaeology*, 105(3): 403–426. DOI: <https://doi.org/10.2307/507363>
- Ferguson, TJ.** 1996. *Historic Zuni architecture and society: an archaeological application of space syntax*. Tucson: University of Arizona Press.
- Fladd, SG.** 2017. 'Social syntax: An approach to spatial modification through the reworking of space syntax for archaeological applications'. *Journal of Anthropological Archaeology*, 47: 127–138. DOI: <https://doi.org/10.1016/j.jaa.2017.05.002>
- Fournet, T** and **Redon, B.** 2017. 'Bathing in the shadow of the pyramids. Greek Baths in Egypt, Back to an Original Bath Model'. In: Redon, B (ed.), *Collective Baths in Egypt 2. New Discoveries and Perspectives*. Cairo: Institut français d'archéologie orientale. pp. 279–322.
- Gath-Morad, M, Grübel, J, Steemers, K, Sailer, K, Ben-Alon, L, Hölscher, C** and **Aguilar, L.** 2024. 'The role of strategic visibility in shaping wayfinding behavior in multilevel buildings'. *Scientific Reports*, 14(1): 3735. DOI: <https://doi.org/10.1038/s41598-024-53420-6>
- Grahame, M.** 2000. *Reading space: social interaction and identity in the houses of roman pompeii: a syntactical approach to the analysis and interpretation of built space*. Ann Arbor, MI: University of Michigan Press. DOI: <https://doi.org/10.30861/9781841710860>
- Hillier, B.** 1996. *Space is the machine: a configurational theory of architecture*. Cambridge: Cambridge University Press.
- Hillier, B** and **Hanson, J.** 1984. *The social logic of space*. Cambridge: Cambridge University Press. DOI: <https://doi.org/10.1017/CBO9780511597237>
- Holloway, RR.** 2002. *The Archaeology of Ancient Sicily*. London: Routledge. DOI: <https://doi.org/10.4324/9780203469620>
- Kemezis, AM.** (ed.) 2015. *Urban dreams and realities in antiquity: remains and representations of the ancient city*. Leiden: Brill. DOI: <https://doi.org/10.1163/9789004283893>
- Krencker, D** and **Krüger, E.** 1929. *Die Trierer Kaiserthermen: Ausgrabungsbericht und grundsätzliche Untersuchungen römischer Thermen*. Augsburg: Filser.
- Larguinat-Turbatte, G.** 2018. 'Les espaces vides dans les villes grecques: Ionie et Carie principalement, IVe–Ier s. a.C.'. *Histoire Urbaine*, 52(2): 121–136. DOI: <https://doi.org/10.3917/rhu.052.0121>
- Letesson, Q.** 2013. 'Minoan halls: A syntactical genealogy'. *American Journal of Archaeology*, 117(3): 303–351. DOI: <https://doi.org/10.3764/ajja.117.3.0303>
- Lorenzon, M, Pylkänen, C** and **Artto, AV.** 2023. 'Architecture, reality and perception: The multicultural nature of Egyptian domestic architecture in the Roman period'. *Journal of Computer Applications in Archaeology*, 6(1): 51–61. DOI: <https://doi.org/10.5334/jcaa.95>
- Lucore, SK.** 2009. 'Archimedes, The North Baths At Morgantina, And Early Developments In Vaulted Construction'. In: Scott, A and Kosso, C (eds.), *The Nature and Function of Water, Baths, Bathing, and Hygiene from Antiquity through the Renaissance*. Boston: Brill, pp. 43–59. DOI: <https://doi.org/10.1163/ej.9789004173576.i-538>

- Lucore, SK.** 2013. 'Bathing in Hieronian Sicily'. In: Lucore, SK and Trümper, M (eds.), *Greek Baths and Bathing Culture: New Discoveries and Approaches*. Leuven: Peeters. pp. 151–180.
- Lucore, SK, Karivieri, A, Campbell, P, Göransson, K, Tusa, S and Prescott, C.** 2021. 'The Morgantina baths in their urban context'. In: Prescott C, Karivieri, A, Campbell, P, Göransson, K and Tusa, S (eds.), *Trinacria, 'an island outside time'*. *International Archaeology in Sicily*. Oxford: Oxbow Books. pp. 71–84. DOI: <https://doi.org/10.2307/j.ctv24q4z4h.13>
- Lucore, SK and Miles, MM.** 2016. 'Greek Baths'. In: Miles, MM (ed.), *A Companion to Greek Architecture*. 1st Edn. Chichester: John Wiley & Sons, pp. 328–341. DOI: <https://doi.org/10.1002/9781118327586.ch23>
- Nielsen, I.** 1990. *Thermae et balnea. The architecture and cultural history of Roman public baths*. Aarhus: Aarhus University Press.
- Osborne, JF.** 2012. 'Communicating power in the *bīt-hilāni* palace'. *Bulletin of the American Schools of Oriental Research*, 368: 29–66. DOI: <https://doi.org/10.5615/bullamerschoorie.368.0029>
- Ostwald, MJ.** 2011. 'The mathematics of spatial configuration: Revisiting, revising and critiquing justified plan graph theory'. *Nexus Network Journal*, 13(2): 445–470. DOI: <https://doi.org/10.1007/s00004-011-0075-3>
- Stöger, H.** 2007. 'Roman Ostia: Space Syntax and the Domestication of Space'. In: Posluschny, A, Lambers, K and Herzog, I (eds.), *Layers of Perception. Proceedings of the 35th International Conference on Computer Applications and Quantitative Methods in Archaeology (CAA), Berlin, Germany, April 2–6, 2007*. Bonn: Dr. Rudolf Habelt GmbH, pp. 322–327.
- Stöger, H.** 2009. 'Clubs and Lounges at Roman Ostia: The Spatial Organisation of a Boomtown Phenomenon (Space Syntax Applied to the Study of Second Century AD 'Guild Buildings' at a Roman Port Town)'. In: Koch, D, Marcus, L and Steen, H (eds.), *Proceedings of the 7th International Space Syntax Symposium*. Stockholm: KTH, pp. 108.1–108.12.
- Stöger, H.** 2014. 'The Spatial Signature of an Insula Neighbourhood of Roman Ostia'. In: Paliou, E, Lieberwirth, U and Polla, S (eds.), *Spatial Analysis and Social Spaces: Interdisciplinary Approaches to the Interpretation of Prehistoric and Historic Built Environments*. Berlin: De Gruyter, pp. 297–316. DOI: <https://doi.org/10.1515/9783110266436.297>
- Turner, A.** 2001. 'Depthmap: A program to perform visibility graph analysis'. In: *Proceedings of the 3rd International Space Syntax Symposium, Atlanta 2001*. Atlanta: Georgia Institute of Technology, pp. 31.1–31.9.
- Turner, MG and Gardner, RH.** 2015. *Landscape ecology in theory and practice: pattern and process*. Second Edn. New York: Springer. DOI: <https://doi.org/10.1007/978-1-4939-2794-4>
- Voza, G.** 1999. *Nel segno dell'antico: archeologia nel territorio di Siracusa*. Palermo: A. Lombardi.
- Ward-Perkins, JB.** 1994. *Roman Imperial Architecture*. New Haven (CN): Yale University Press.
- Yang, M and Ji, Z.** 2025. 'Interpretation of the archaeological and architectural space of the Monastery of Santa Maria de Pedralbes based on space syntax'. In: Lloveras, L, Rissech, C, Nadal, J and Bank, P (eds.), *Reconstructing past monastic life, Volume 2. Diet, Landscape and Monastic Space: New Trends from Archaeological, Bioanthropological and Documentary Perspectives*. Oxford: Oxbow Books, pp. 117–125. DOI: <https://doi.org/10.2307/jj.30297091.15>
- Yegül, FK.** 2015. 'Roman baths at Isthmia and Sanctuary baths in Greece'. In: Gebhard, ER and Gregory, TE (eds.), *Bridge of the untiring sea: The Corinthian Isthmus from Prehistory to Late Antiquity*. Princeton (NJ): The American School of Classical Studies at Athens, pp. 247–269.

TO CITE THIS ARTICLE:

Yang, M and Ji, Z. 2026. Decoding Archaeological Spaces: A Space Syntax Study of the Hellenistic Baths in Syracuse. *Journal of Computer Applications in Archaeology*, 9(1): 184–197. DOI: <https://doi.org/10.5334/jcaa.197>

Submitted: 09 January 2025 **Accepted:** 21 February 2026 **Published:** 08 May 2026

COPYRIGHT:

© 2026 The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC-BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited. See <https://creativecommons.org/licenses/by/4.0/>.

Journal of Computer Applications in Archaeology is a peer-reviewed open access journal published by Ubiquity Press.