GLOBAL JOURNAL
OF HUMAN SOCIAL SCIENCES - D: HISTORY, ARCHAEOLOGY & ANTHROPOLOGY

Volume 26 | Issue 2 | 2026 | Article ID: GJHSS-257126 | Language: English

CATALOGING

LCC • CC72.7, GN700-890 | DDC • 930.1 | ANZSRC FOR • 2101

Subterranean Construction and Closure Practices: A Comparative Analysis of Underground Systems in Turkey, Malta, Austria, and Bosnia and Herzegovina

Article Record

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RECEIVED	REVISED	PEER REVIEW
2026-05-09	2026-05-12	Double Blind

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Subterranean construction | underground systems | archaeological stratigraphy | anthropogenic backfill | closure practices | dry-stone walls | Ravne tunnel system

AI USE STATEMENT
No generative AI was used for analysis or results.

FUNDING
No external funding was declared for this work.

CONFLICT OF INTEREST
The authors declare no conflict of interest.

DATA AVAILABILITY
Not applicable for this article.

ETHICS
No ethics committee approval was required for this article type.

CONSENT
Not applicable for this article.

TRIAL REG.
Not applicable.

Crossref DOI: 10.34257/GJHSSD257126

How to Cite: Osmanagich (2026). Subterranean Construction and Closure Practices: A Comparative Analysis of Underground Systems in Turkey, Malta, Austria, and Bosnia and Herzegovina. Global Journal of Human-Social Science, 26(2), 9-17. DOI: 10.34257/GJHSSD257126

AR Experience Web Page | DOI

Print ISSN 0975-587X | Online ISSN 2249-460X

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METADATA CONTINUATION

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ARCHIVAL RECORD

GJHSS · Vol 26 · Issue 2 · 2026

Article ID GJHSS-257126 · DOI 10.34257/GJHSSD257126

Print ISSN 0975-587X · Online ISSN 2249-460X

Global Journal of Human-Social Science - Section D
GJHSS Volume 26 Issue 2

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Abstract

Subterranean construction is a recurring yet variably understood aspect of human activity across regions and periods. Underground systems in Turkey, Malta, Austria, and Bosnia and Herzegovina provide an opportunity to compare how such spaces were created, modified, and ultimately closed. The present study focuses on four representative contexts: the Derinkuyu Underground City, the Hypogeum of Ħal Saflieni, the Erdstall tunnel systems of Austria, and the Ravne tunnel system in the Visoko region of Bosnia and Herzegovina. Rather than assuming predefined functions, the analysis is based on observable structural and material characteristics, including construction methods, geological context, spatial organization, access control, and evidence of modification and closure. Particular attention is given to identifying patterns of intentional sealing, blockage, and infilling within these systems. The results indicate that subterranean construction is expressed through diverse architectural forms, ranging from carved multi-level complexes to narrow passage networks and modified underground corridors. While many systems demonstrate controlled access through architectural features such as constrictions or blocking elements, large-scale and systematic backfilling is comparatively rare. The Ravne tunnel system presents a distinct case characterized by extensive anthropogenic infill, complete floor-to-ceiling closure of passages, and the repeated use of dry-stone walls to segment and seal sections of the network. Stratigraphic evidence further suggests multi-phase modification and closure processes. The comparison supports the interpretation that the closure of subterranean space represents a deliberate, structured form of human activity rather than a passive consequence of abandonment. By focusing on construction and termination processes, this study contributes to a broader understanding of how underground environments are created, managed, and transformed.

Keywords: *Subterranean construction, underground systems, archaeological stratigraphy, anthropogenic backfill, closure practices, dry-stone walls, Ravne tunnel system, Derinkuyu, Hypogeum of Ħal Saflieni, Erdstall tunnels*

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DOI
10.34257/GJHSSD257126

1. Introduction

Subterranean spaces form a recurring but unevenly understood component of the archaeological record. Across different regions and time periods, human groups have created, modified, and reused underground environments in ways that reflect a wide range of technical capabilities and spatial strategies. These spaces include extensive underground complexes, narrow tunnel systems, and subsurface architectural features associated with larger constructions. Despite their diversity, many such systems share common characteristics, including controlled access, internal segmentation, and evidence of modification over time (Harris, 1989; Renfrew & Bahn, 2016).

Well-documented examples include the multi-level underground complexes of Derinkuyu Underground City, the carved subterranean chambers of the Hypogeum of Hal Saflieni, and the narrow Erdstall tunnel systems of Austria. Archaeological investigations in Cappadocia have demonstrated the presence of extensive subterranean networks with controlled access and internal organization (Özdoğan, 2011; Ousterhout, 2017). Similarly, studies of the Maltese Hypogeum have emphasized its complex spatial structure and long-term use, while also acknowledging that its full extent and original function remain only partially understood (Malone, Stoddart, Bonanno, & Trump, 2009). The Erdstall systems of Central Europe, including Austria, have been documented as anthropogenic narrow passage networks, although their purpose and chronology remain subjects of debate (Kusch & Kusch, 2009; Weiss, 2014).

Subterranean features are also documented in association with monumental architecture. Tunnels and underground chambers have been identified beneath pyramidal and ceremonial structures at sites such as Teotihuacan, within Egyptian pyramidal complexes, and in the gallery systems of Chavin de Huántar. Excavations at Teotihuacan have revealed deliberately constructed and later sealed tunnels beneath the Temple of the Feathered Serpent, suggesting controlled access and intentional closure (Gómez Chávez & Gazzola, 2014). In the Andes, the internal gallery systems at Chavin de Huántar demonstrate the integration of subterranean architecture within monumental construction (Rick, 2008). Comparable features have been documented in Egyptian contexts, where subsurface

chambers and passages form part of larger architectural complexes (Lehner, 1997).

While the creation of underground space has received considerable attention, the processes by which such spaces were altered, restricted, or closed have been less systematically examined. Evidence from multiple sites indicates that subterranean environments were not always left open after their initial use. Architectural blocking elements, constricted passages, and filled sections suggest that access could be deliberately controlled or terminated. These features point to closure as an active process, rather than a passive result of abandonment (Schiffer, 1987; Cameron & Tomka, 1993).

The Ravne tunnel system in the Visoko region of Bosnia and Herzegovina provides an opportunity to examine this process in detail. Systematic archaeological investigations conducted between 2006 and 2025 under the direction of the Archaeological Park: Bosnian Pyramid of the Sun Foundation and led by the principal investigator (the author) have documented an extensive network of underground passages (Osmanagich, 2026a). Excavations have revealed large quantities of anthropogenic infill, frequent dry-stone walls constructed within the tunnels, and stratigraphic evidence for repeated modification (Osmanagich, 2026b; Osmanagich, 2026c). In many sections, passages are filled from floor to ceiling, and structural elements are encountered only after the removal of overlying material. These observations suggest a systematic and staged process of closure.

The aim of this study is to compare construction and closure practices across selected subterranean systems in Turkey, Malta, Austria, and Bosnia and Herzegovina. Rather than assigning specific functions to these sites, the analysis focuses on observable features, including construction methods, geological context, spatial organization, access control, and evidence of modification and sealing. By examining both the creation and termination of underground spaces, the study seeks to contribute to a broader understanding of how such environments were managed and transformed.

2. Materials and methods

2.1. Research framework

This study adopts a comparative analytical approach to the construction and closure of subterranean spaces across selected archaeological contexts. The analysis focuses on four case studies: the Derinkuyu Underground City, the Hypogeum of Hal Saflieni, the Erdstall tunnel systems of Austria, and the Ravne tunnel system in the Visoko region of Bosnia and Herzegovina.

Rather than assuming specific functions for these sites, the study is based on the examination of observable structural and material characteristics. The approach emphasizes comparison of construction techniques, spatial organization, and evidence for modification and closure. The objective is to identify recurring patterns and significant differences in the way subterranean environments were created and transformed.

2.2. Data Sources

The analysis combines primary and secondary data.

Primary data derive from archaeological investigations conducted in the Ravne tunnel system between 2006 and 2025 under the direction of the Archaeological Park: Bosnian Pyramid of the Sun Foundation and led by the principal investigator (the author). These include field observations, excavation records, stratigraphic profiles, and documentation of architectural features such as dry-stone walls and infill deposits (Osmanagich, 2026a; Osmanagich, 2026b; Osmanagich, 2026c).

Secondary data for the comparative sites are drawn from published archaeological reports and scientific literature. These include studies of Cappadocian underground systems (Özdoğan, 2011; Ousterhout, 2017), research on the Maltese Hypogeum (Malone et al., 2009), documentation of Erdstall tunnel systems (Kusch & Kusch, 2009; Weiss, 2014), and investigations of subterranean features associated with monumental architecture (Gómez-Chávez et al., 2016; Rick, 2008; Lehner, 1997).

2.3. Comparative Parameters

The comparative analysis is structured around a set of observable parameters designed to allow consistent evaluation across different sites. These include:

- Construction method (carved, excavated, or modified underground spaces)
- Geological context (type of host material and its physical properties)
- Spatial organization (layout, scale, and internal segmentation)
- Access control (presence of constrictions, blocking elements, or restricted passages)
- Evidence of closure (architectural sealing, backfilling, or obstruction of passages)
- Stratigraphic relationships (layering, depositional sequences, and evidence of modification over time)

These parameters are selected to focus on physical and structural characteristics that can be observed and documented, independent of interpretive assumptions regarding site function.

2.4. Identification of Anthropogenic Modification

The identification of anthropogenic features is based on established principles of archaeological stratigraphy and formation processes (Harris, 1989; Schiffer, 1987). Particular attention is given to distinguishing between natural geological formations and introduced materials.

Indicators of anthropogenic modification include:

- clear stratigraphic boundaries between natural substrate and deposited material
- presence of transported material within enclosed underground spaces
- structural features such as walls or constructed barriers
- non-random spatial distribution of deposits

In the case of the Ravne tunnel system, the presence of backfill extending from floor to ceiling and the occurrence of dry-stone walls within tunnel passages are treated as key indicators of deliberate human intervention.

2.5. Analytical approach

The analysis is qualitative and comparative. It does not attempt to establish direct cultural or chronological connections between the sites but instead evaluates similarities and differences in structural characteristics and modification processes.

Interpretation is limited to what can be supported by observable evidence and published data. Where functions or meanings of subterranean systems remain uncertain, this uncertainty is explicitly acknowledged. The focus remains on identifying patterns of construction and closure as forms of human interaction with underground environments.

2.6. Scope and Limitations

This study is based on macroscopic observation and published data. It does not include laboratory analyses such as micromorphology, geochemical sourcing, or material testing. As a result, interpretations are limited to structural and stratigraphic evidence.

In addition, the comparative analysis relies on secondary sources for sites outside Bosnia and Herzegovina and is therefore constrained by the availability and scope of published data. The study does not aim to provide a comprehensive review of all subterranean systems, but rather to examine selected examples that illustrate key aspects of construction and closure. The number of figures assigned to each site reflects the availability of primary excavation data, with the Ravne tunnel system presented in greater detail as the principal dataset of this study.

3. Case Studies

3.1. Subterranean systems in Cappadocia (Turkey)

The region of Cappadocia in central Turkey contains extensive underground complexes carved into soft volcanic tuff. Among these, the Derinkuyu Underground City represents one of the most developed examples. The system consists of multiple levels extending to significant depth, with interconnected corridors, chambers, ventilation shafts, and vertical access points (Özdoğan, 2011; Ousterhout, 2017).

The construction method involves excavating relatively soft geological material, creating large internal spaces and narrow passages. Spatial organization is highly structured, with distinct zones connected through controlled access points. Circular stone elements, often interpreted as blocking stones, are positioned in corridors and can seal passages when moved into place.

While later phases of use are commonly associated with refuge or defensive purposes, the system's original function and chronology remain subjects of ongoing discussion. From a structural perspective, the presence of movable blocking elements and constricted passageways indicates the capacity to control access and restrict movement within the underground environment.

3.2. Subterranean architecture in Malta

The Hypogeum of Hal Saflieni is a carved subterranean complex dated to the Neolithic period. It consists of multiple levels of chambers, passages, and niches cut into limestone bedrock (Malone et al., 2009). The architecture includes both open spaces and more confined areas, with a high degree of internal articulation.

Only a portion of the complex is currently accessible, and the full extent of the underground system is not completely known. The Hypogeum is often interpreted as having served funerary or ritual functions, although the precise nature of its use remains debated. From a structural standpoint, the site demonstrates deliberate excavation, controlled spatial organization, and long-term use.

Unlike some other subterranean systems, there is limited evidence for large-scale backfilling or systematic closure of passages. However, the arrangement of chambers and restricted access points suggests that movement within the complex was carefully managed.

3.3. Erdstall Tunnel systems in Austria

The Erdstall systems of Austria consist of narrow underground tunnels characterized by low ceilings, constricted passages, and small chambers. These systems are typically found in regions with varied geological conditions, including compact sediments and more resistant rock formations (Kusch & Kusch, 2009; Weiss, 2014).

Construction techniques vary depending on local geology, with some tunnels carved into relatively soft material, while others are formed within more compact substrates that would require greater technical effort. The morphology of Erdstall tunnels is distinctive, often involving extremely narrow sections that restrict movement and limit accessibility.

The function and chronology of these systems remain uncertain, and multiple interpretations have been proposed. Some examples exhibit intentional closure, such as blocked or sealed passages, although these features are not uniform across all sites. From a structural perspective, Erdstall systems demonstrate controlled spatial design and the deliberate limitation of movement within subterranean environments.

3.4. Ravne Tunnel system (Bosnia and Herzegovina)

The Ravne tunnel system, located in the Visoko region of Bosnia and Herzegovina, represents an extensive network of underground passages developed within conglomerate formations. Systematic archaeological investigations conducted between 2006 and 2025 under the direction of the Archaeological Park: Bosnian Pyramid of the Sun Foundation and led by the principal investigator (the author) have resulted in the excavation and documentation of multiple interconnected sections (Osmanagich, 2026a).

Excavation has revealed that large portions of the tunnel system are filled with material that is distinct from the surrounding geological substrate. The natural conglomerate is compact and cohesive, while the infill consists primarily of loosely compacted pebbles, sand, and finer sediments. In many sections, this material extends continuously from the floor to the ceiling of the tunnels, indicating complete spatial infilling.

In addition to backfill deposits, numerous dry-stone walls have been documented within the tunnel passages. These structures are constructed from locally available stone and are positioned across corridors, effectively blocking access to the remaining sections. In several cases, such walls are encountered only after the removal of overlying infill material, suggesting a sequential relationship between deposition and structural sealing (Osmanagich, 2026b).

Stratigraphic observations indicate multiple phases of deposition and modification. Distinct layers of infill, along with interruptions and compositional variations, suggest that closure occurred through repeated interventions rather than a single event (Osmanagich, 2026c). Taken together, these features point to a systematic process of backfilling and sealing that distinguishes the Ravne tunnel system from other subterranean contexts considered in this study.

4. Comparative analysis

4.1. Construction methods and Geological Context

The sites examined demonstrate two primary approaches to creating subterranean space: excavation in relatively soft geological material and modification of existing subsurface environments. In Cappadocia and Malta, underground spaces were carved into volcanic tuff and limestone, respectively, allowing for the development of multi-level complexes and articulated chamber systems. The Erdstall tunnels of Austria exhibit variability, with some systems formed in softer

sediments and others within more compact substrates requiring greater effort and precision.

The Ravne tunnel system differs in that it combines natural geological formations with extensive anthropogenic modification. The host material, a compact conglomerate, contrasts sharply with the loose composition of the infill deposits identified during excavation (Osmanagich, 2026a). This distinction between natural substrates and introduced materials is central to understanding the system's structural characteristics.

4.2. Spatial Organization and Morphology

All sites exhibit deliberate spatial organization, although the scale and morphology vary significantly. The underground complexes in Cappadocia consist of multi-level systems with large chambers connected by corridors and vertical shafts. The Hypogeum in Malta displays a highly structured arrangement of chambers and passages, with both open and restricted spaces.

The Erdstall tunnels are characterized by narrow passages, constricted movement, and limited chamber space, suggesting a design that prioritizes restriction rather than expansion. In contrast, the Ravne tunnel system includes both wider passages and narrower segments, forming a network that combines linear and branching elements.

Despite these differences, a common feature across all sites is the presence of internal segmentation. Movement is not continuous or unrestricted but is guided through defined pathways, indicating intentional control over access and circulation within the subterranean space.

4.3. Access control and Restriction

Evidence for controlled access is present in all examined contexts, although expressed through different architectural means. In Cappadocia, circular stone elements positioned within corridors can seal passages, effectively restricting movement when in place. In Malta, access is managed through the configuration of chambers and passageways, including narrower entrances and transitional spaces.

The Erdstall systems emphasize restriction through extremely narrow passages that limit physical movement. Some examples also show blocked or sealed sections, suggesting that closure could be implemented in specific areas.

At Ravne, access control is expressed through a combination of architectural and depositional features. Dry-stone walls constructed across tunnel passages serve as barriers, while extensive backfill further limits or prevents movement beyond certain points. These elements indicate a deliberate approach to restricting access within the system.

4.4. Evidence of Closure

The most significant distinction among the examined sites lies in the nature and scale of closure practices. While all systems show some degree of access control, evidence for complete or largescale closure varies considerably.

In Cappadocia, closure is primarily achieved through blocking elements that seal individual passages, rather than widespread infilling. The Hypogeum in Malta shows limited evidence of closure beyond controlled access, and large-scale backfilling is not a dominant feature. In the Erdstall systems, closure appears in localized forms, with some passages blocked or sealed, although this is not consistent across all examples.

The Ravne tunnel system presents a markedly different pattern. Excavations have revealed extensive anthropogenic infill occupying entire tunnel sections, often extending from floor to ceiling. This material effectively eliminates accessible space rather than simply restricting it. In addition, dry-stone walls are frequently encountered within the tunnels, often in positions that suggest sequential blocking of passages (Osmanagich, 2026b).

This combination of complete infilling and structural sealing indicates a more comprehensive form of closure than that observed in the other systems.

4.5. Stratigraphy and Multi-Phase Modification

Stratigraphic evidence provides further insight into the processes of modification and closure. In the Ravne tunnel system, distinct layers of infill material with clear boundaries indicate multiple depositional phases (Osmanagich, 2026c). Variations in composition and layering suggest that infilling did not occur as a single event, but rather through repeated interventions over time.

Comparable stratigraphic detail is less consistently documented in the other sites, particularly where excavation has focused on architectural features rather than depositional sequences. However, evidence of re-use and modification is present in Cappadocia and Malta, indicating that subterranean spaces in these contexts were also subject to change over time.

The Ravne system stands out in the clarity with which stratigraphic relationships between natural substrate, infill deposits, and structural features can be observed. This allows for a more detailed reconstruction of the sequence of closure processes.

4.6. Scale and Organization of Closure processes

The scale of closure varies significantly across the examined sites. In Cappadocia and the Erdstall systems, closure is generally localized, affecting individual passages or sections. In Malta, closure is limited and does not involve extensive infilling.

In contrast, the Ravne tunnel system demonstrates closure at a much larger scale. The presence of infill across extensive portions of the network, combined with repeated structural barriers, indicates a coordinated process affecting multiple sections of the system. This suggests a level of planning and organization that extends beyond isolated acts of blockage.

4.7. Summary of Comparative Findings

The comparative analysis demonstrates that subterranean construction is a widespread phenomenon expressed through diverse architectural forms and adapted to different geological contexts. All examined systems exhibit intentional design, internal segmentation, and controlled access.

However, significant differences emerge in how these spaces are treated after their initial use. While most systems rely primarily on architectural features to regulate access, the Ravne tunnel system exhibits a distinct combination of large-scale backfilling and structural sealing. This pattern suggests that closure in this context was not limited to restricting movement but involved the systematic transformation of subterranean space through the introduction of material and the construction of barriers.

The main comparative characteristics of construction and closure across the examined subterranean systems are summarized in Table 1.

Table 1. Comparative characteristics of construction and closure in selected subterranean systems

Parameter	Cappadocia (Turkey) - Derinkuyu	Malta - Hypogeum	Austria - Erdstall	Bosnia and Herzegovina - Ravne
Construction method	Carved into volcanic tuff	Carved into limestone	Carved / excavated in varied substrates	Natural conglomerate modified with excavation and infilling
Geological context	Soft volcanic rock (tuff)	Limestone bedrock	Mixed geology (sediments and harder materials)	Compact conglomerate formation
Spatial organization	Multi-level system with chambers and corridors	Multi-level chambers and passages	Narrow tunnels with limited chamber space	Network of passages with linear and branching segments
Access control	Movable blocking stones and constricted passages	Controlled access through chamber layout and narrow openings	Extremely narrow passages restricting movement	Dry-stone walls and filled passages limiting access
Evidence of closure	Localized blocking of passages	Limited evidence of closure; primarily controlled access	Occasional blocked or sealed sections	Extensive backfilling and structural sealing
Fill presence	Minimal; not a dominant feature	Minimal; not a dominant feature	Limited and localized	Extensive anthropogenic infill (pebbles, sand)
Extent of closure	Partial and localized	Limited	Localized	Large-scale, often complete (floor-to-ceiling)
Stratigraphy	Limited published stratigraphic emphasis	Limited stratigraphic detail	Variable and limited	Clear multi-layered stratigraphy indicating phased deposition
Scale	Large, multi-level subterranean complex	Medium-scale underground complex	Small-scale tunnel systems	Extensive network with large-scale modification
Closure pattern	Blocking of individual passages	Restricted access without large-scale closure	Localized closure	Sequential, multi-phase closure with combined infill and wall construction

5. Discussion

5.1. Subterranean Space as a Managed Environment

The comparative evidence indicates that subterranean spaces were not incidental or marginal features, but environments subject to deliberate planning and control. Across all examined contexts, underground spaces display structured layouts, defined pathways, and mechanisms that regulate movement. These characteristics suggest that such environments were actively managed rather than passively used.

In the cases of Derinkuyu Underground City and the Hypogeum of Hal Saflieni, spatial organization reflects a high degree of intentionality, with access mediated through architectural features such as constricted passages and transitional spaces. Similarly, the Erdstall systems of Austria demonstrate deliberate restriction of movement through narrow corridors and segmented layouts.

The Ravne tunnel system fits within this broader pattern of controlled subterranean environments but extends it through the addition of large-scale modification processes that alter not only movement but the physical existence of accessible space.

5.2. Closure as a Deliberate process

One of the most consistent observations across the examined sites is the presence of features that restrict or terminate access. These include blocking elements, constricted passages, and, in some cases, sealed sections. Such features indicate that closure is not simply the result of abandonment or natural processes but can represent an intentional phase in the use of subterranean space.

At Cappadocian sites, closure is achieved primarily through movable or fixed blocking elements that can isolate specific sections. In Austrian Erdstall systems, closure appears more localized and variable, with some passages intentionally blocked. In Malta, evidence of closure is less pronounced, but access is clearly controlled through architectural design.

The Ravne tunnel system demonstrates a more extensive application of closure processes. The combination of complete backfilling and structural barriers suggests that closure was not limited to restricting access but involved the systematic elimination of open space within the tunnels. This indicates a different scale and intensity of intervention compared to the other systems.

5.3. Sequential Modification and Phased Closure

The presence of stratified deposits and structural features in the Ravne tunnel system indicates that closure occurred in multiple stages rather than as a single event. Layers of infill material, combined with the placement of dry-stone walls, suggest a sequence in which sections of the tunnels were progressively filled and sealed.

While detailed stratigraphic evidence is less consistently available for the comparative sites, indications of re-use and modification in Cappadocia and Malta suggest that subterranean environments were subject to ongoing change. The idea of phased intervention is therefore not unique, but the clarity with which it can be observed at Ravne provides a more detailed example of this process.

Sequential closure requires planning and organization, as well as an understanding of the underground system's spatial structure. It also suggests that closure was integrated into broader patterns of use rather than occurring only at the end of occupation.

5.4. Functional Ambiguity and Interpretive Limits

A notable feature of subterranean systems is the persistent uncertainty surrounding their original purpose. Interpretations such as refuge, ritual use, storage, or specialized activity have been proposed for different sites, but in many cases the available evidence does not allow for definitive conclusions.

This uncertainty is particularly evident in the Erdstall systems and, to a lesser extent, in the Hypogeum and Cappadocian complexes. Even in cases where later phases of use are better understood, earlier functions remain open to interpretation.

The Ravne tunnel system is similar in this respect. While the structural and stratigraphic evidence provides a clear basis for identifying processes of modification and closure, it does not, by itself, determine the original function of the system. For this reason, the present study avoids assigning specific purposes and instead focuses on observable features.

5.5. Scale and Organization of Closure

The scale of closure processes varies significantly across the examined sites. In most cases, closure is localized, affecting individual passages or sections. This is consistent with the use of blocking elements or restricted access points that can be implemented without extensive modification of the surrounding structure.

In contrast, the Ravne tunnel system exhibits closure at a much larger scale. The presence of extensive infill across multiple sections of the network, combined with repeated structural barriers, indicates a coordinated process that extends beyond isolated interventions. Such largescale modification implies sustained effort and organization, as well as the availability of material for backfilling.

This difference in scale suggests that closure practices are not uniform across subterranean systems, but vary according to context, purpose, and the nature of the constructed environment.

5.6. Subterranean Closure in a Broader Context

When viewed in a broader archaeological context, the deliberate closure of constructed spaces is not limited to underground systems. Comparable processes have been documented in other settings, including the intentional burial of architectural features at sites such as Göbekli Tepe and the sealing of subsurface chambers in monumental complexes such as Teotihuacan. These examples indicate that the transformation or termination of constructed space through filling or sealing may represent a more general pattern of human behavior.

Within this broader framework, the Ravne tunnel system can be understood as a particularly clear example of large-scale subterranean closure. Its combination of complete infilling, structural sealing, and stratigraphic complexity provides detailed evidence for processes that are less visible or less extensively developed in other contexts.

5.7. Implications for the study of Subterranean systems

The findings of this study suggest that greater attention should be given to processes of modification and closure in the analysis of subterranean environments. While the creation and use of such spaces have been widely discussed, their transformation and termination have received less systematic examination.

By focusing on closure practices, it becomes possible to identify patterns that cut across different sites and contexts, even where functions remain uncertain. This approach provides a framework for comparing subterranean systems without relying on assumptions about their original purpose.

The Ravne tunnel system contributes to this framework by offering well-documented evidence of large-scale, multi-phase closure. When considered alongside other underground systems, it highlights the variability of human responses to subterranean space and the importance of considering both construction and closure as integral aspects of these environments.

6. Conclusion

The comparative analysis of subterranean systems in Turkey, Malta, Austria, and Bosnia and Herzegovina demonstrates that underground space construction is widespread and structurally diverse. Across different geological and cultural contexts, these systems exhibit intentional design, controlled spatial organization, and mechanisms that regulate movement and access.

At the same time, the study highlights significant variation in the ways these environments were modified after their initial creation. While many subterranean systems rely primarily on architectural features such as constrictions or blocking elements to control access, evidence for large-scale closure through infilling is comparatively limited.

The Ravne tunnel system represents a distinct case in this regard. Archaeological investigations have documented extensive anthropogenic backfill occupying entire sections of the underground network, frequently extending from floor to ceiling. The presence of dry-stone walls within tunnel passages, often encountered beneath infill deposits, indicates a sequential relationship between structural sealing and material deposition. Stratigraphic observations further support the interpretation of multi-phase modification and closure.

These features suggest that closure at Ravne was not a localized or incidental process, but a systematic and organized intervention affecting substantial portions of the subterranean system. In contrast to other examined sites, where closure is generally partial or limited to specific access points, the Ravne system demonstrates a more comprehensive transformation of underground space.

The comparison also underscores the broader interpretive challenge posed by subterranean systems. In many cases, the original function of these environments remains uncertain, and available evidence does not support definitive conclusions. By focusing on observable structural characteristics and modification processes, this study avoids assumptions about function and instead emphasizes patterns of human interaction with underground space.

Within a wider archaeological context, the deliberate closure of constructed environments appears as a recurring form of human activity. Examples from sites such as Göbekli Tepe and Teotihuacan indicate that the sealing or infilling of architectural spaces is not limited to subterranean systems. The Ravne tunnel system contributes to this broader pattern by providing clear evidence of large-scale, multi-phase closure in an underground context.

Future research may benefit from greater attention to the processes of modification and termination in subterranean environments. Detailed stratigraphic analysis, material studies, and expanded comparative frameworks could further clarify the mechanisms and implications of closure practices. Such approaches have the potential to refine our understanding of how underground spaces were not only created and used, but also deliberately transformed.

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ACKNOWLEDGEMENTS

The author expresses sincere appreciation to all archaeologists, researchers, and field teams who participated in the long-term investigations of the Ravne tunnel system between 2006 and 2025. Their contributions to excavation, documentation, and interpretation form the basis of the dataset presented in this study.

Gratitude is also extended to international collaborators and colleagues who have contributed to the broader understanding of subterranean systems through field discussions and site visits, including investigations conducted in Turkey, Malta, and Austria.

The author acknowledges the institutional support of the Archaeological Park: Bosnian Pyramid of the Sun Foundation, which has coordinated and supported ongoing archaeological research in the Visoko region.

PERMISSIONS

All necessary permissions for archaeological investigations and fieldwork were obtained from the relevant authorities.

Figure 1. Location of the Visoko region in central Bosnia and Herzegovina, indicating the position of the Ravne tunnel system within its regional geological and archaeological context.

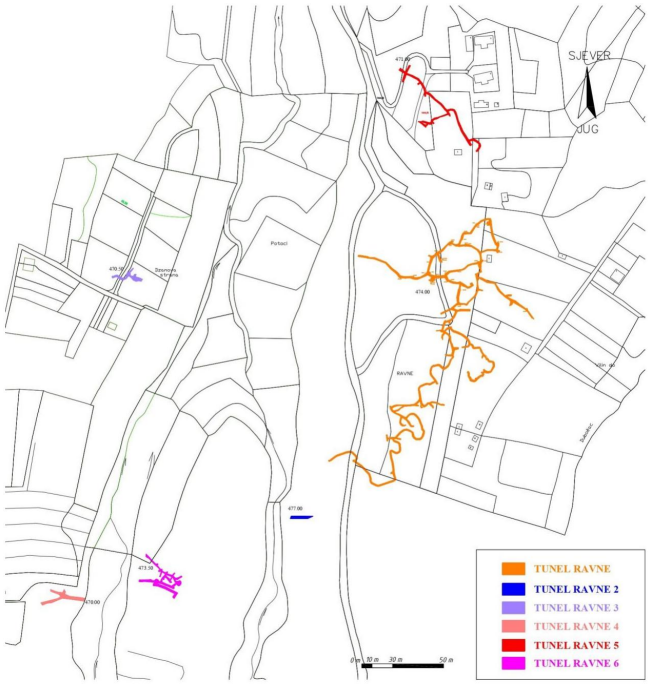

Figure 2. Plan of the Ravne tunnel system showing the distribution of explored passages and the spatial extent of the underground network documented during archaeological investigations (modified from Osmanagich, 2026a).

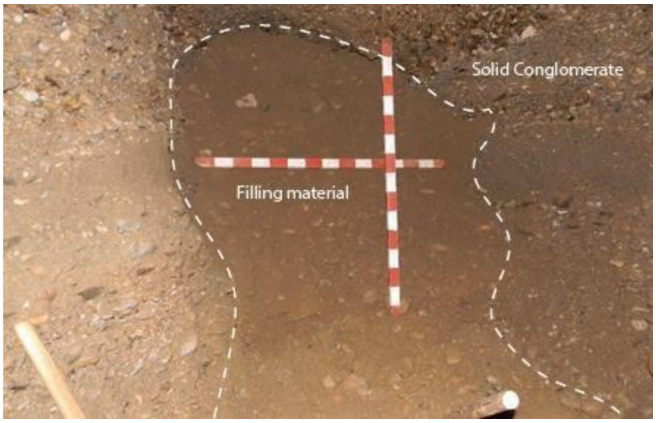

Figure 3. Contact zone between natural conglomerate and anthropogenic infill material within a Ravne tunnel section, illustrating the contrast between compact geological substrate and introduced deposits.

Figure 6. Dry-stone wall constructed within a Ravne tunnel passage, forming a structural barrier that restricts access to adjacent sections.

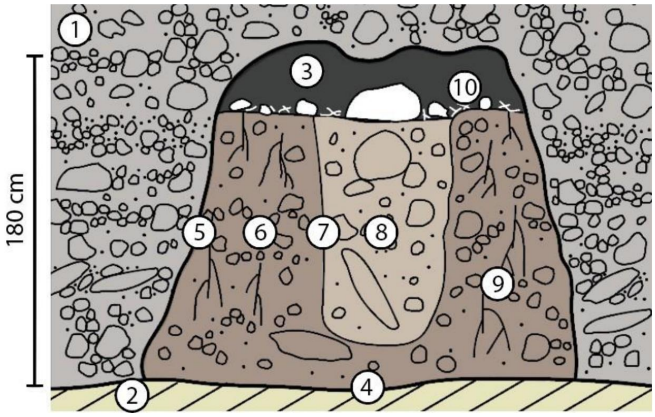

Figure 4. Schematic stratigraphic profile of a Ravne tunnel segment, showing layering of infill material and its relationship to the natural geological structure.

Figure 7. Dry-stone wall revealed following removal of overlying infill deposits, indicating a sequential relationship between structural sealing and subsequent backfilling.

Figure 5. Tunnel passage completely filled with sediment from floor to ceiling, demonstrating full spatial closure through extensive anthropogenic backfilling.

Figure 8. Interior view of Derinkuyu Underground City showing carved passageways and spatial organization characteristic of multi-level subterranean systems with controlled access.

Figure 9. Interior chambers of the Hypogeum of Hal Saflieni illustrating carved subterranean architecture and structured internal layout.

Figure 10. Example of an Erdstall tunnel in Austria showing narrow passage morphology and restricted movement within a confined subterranean system.

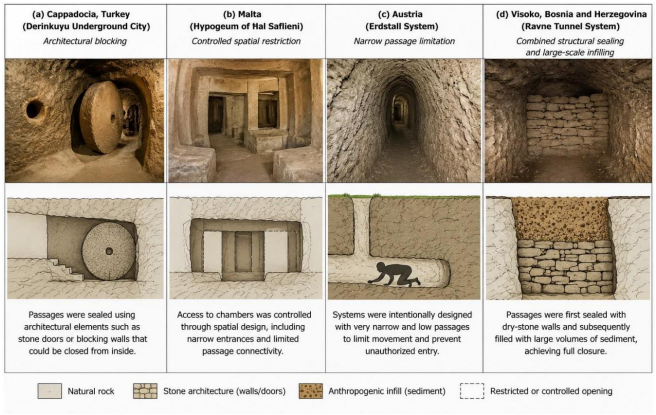

Figure 11. Schematic comparison of closure mechanisms in selected subterranean systems: (a) architectural blocking in Cappadocia, (b) controlled spatial restriction in Malta, (c) narrow passage limitation in Austrian Erdstall systems, and (d) combined structural sealing and large-scale infilling in the Ravne tunnel system.