

ORIGINAL ARTICLE

A comparative architectural study between
the Inca *Ilaqta* of Ollantaytambo (Peru) and the
Mogao Caves in Dunhuang (China)

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Abstract

This study addresses the lack of comparative architectural research on how different cultures transform rock into distinct ritual and symbolic spaces. The article presents a comparative analysis of rock as a ritual space in the Inca *Ilaqta* of Ollantaytambo, Peru, and in the Mogao Caves in Dunhuang, China. The study focuses on understanding how the same material acquires different architectural and symbolic meanings depending on cultural contexts and worldviews. The objective was to identify the ways in which rock was transformed into a ritual device both in an open Andean landscape and in the excavated environment of Central Asia. Methodologically, the study combined primary architectural surveying (manual planimetry, drone imaging, and field observation) conducted in Ollantaytambo with a systematic archival and image-based analysis of Mogao (photographic, conservation, and published documentation). We explicitly acknowledge a methodological asymmetry—richer empirical, metric, and tactile data for Ollantaytambo versus secondary-source-based spatial readings for Mogao—and mitigate this by applying a consistent analytical framework (rock morphology, bodily scale, and hydraulic/representational mediation) and by cross-validating findings against high-quality published reconstructions and conservation reports. This approach preserves comparative rigor while transparently delimiting the generality of inferences drawn for each case. The results show that in Ollantaytambo, rock is conceived as a living *huaca*, articulated with the mountain and water, producing a collective and expansive experience. In contrast, in Mogao, rock functions as the physical support for Buddhist iconography, structuring an introspective and narrative environment that differs from the spatial rituality and hydraulic sacralization characteristic of Ollantaytambo. The study concludes that rock can be understood as a mediator between the human body and the cosmos within specific ritual contexts, although its meanings depend on the worldview that activates it. This provides a comparative conceptual framework for the study of ritual architectures.

Keywords: Ritual rock; Inca architecture; Sacred landscape; Body scale; Ritual architecture; Spatial experience

1. Introduction

Architecture conceived in rock—whether through the monumentalization of rocky masses or the excavation of sacred grottoes—has served, in various civilizations, as a privileged means of ritual and symbolic articulation. In the Peruvian Andes, the *llaqta* of Ollantaytambo presents itself as a space where stone becomes both the support and stage for devotional practices, integrating with water, topography, and territorial control. Meanwhile, along the Silk Road, the Mogao Caves in Dunhuang express sacredness through excavation in conglomerate rock, pictorial decoration, and spatial organization that guides the pilgrim's body toward an immersive experience of contemplation. In both cases, rock becomes an active agent that orders movement, gaze, and meaning. However, comparative literature has yet to explore these convergences and divergences in depth, which constitutes the central problem this study seeks to address (Herring, 2013; W. Wang & Yan, 2023; Wright & Valencia Zegarra, 2018).

In this regard, the comparison between Ollantaytambo and Mogao is necessary because it enables the articulation of architectural traditions that, although distant in geography and chronology, share rock as a ritual medium. While previous studies have examined each site in isolation, no research has yet addressed how these architectures converge and diverge in their relationships to body, scale, and symbolism. This study therefore fills a gap in the literature by proposing a comparative framework that goes beyond regional analysis, connecting the Andes and the Silk Road to explore both the universal dimensions and the cultural specificities of rock-based ritual architecture.

The case of Ollantaytambo is particularly significant within the Andean world; it is an Inca *llaqta* (city) located in the Sacred Valley of Cusco, whose construction is linked to the reign of Pachacútec. Its importance extends to the resistance against the Spaniards in the 16th century. Hunter (2025; in press) demonstrates how the Inca ecology of Ollantaytambo transformed under colonial rule, revealing changes in the management of water and agricultural resources that nonetheless preserved ritual elements of spatial organization. Complementarily, Dillehay *et al.* (2023) show that the use of plants and peasant policies in the area reveals symbolic continuities in the ritualized landscape, allowing us to understand Ollantaytambo not only as a military or administrative center but as a complex where rock and the natural environment are transformed into a ceremonial stage.

The symbolic perspective is expanded with Herring's (2013) analysis, which examines Ollantaytambo as an object of an archaeology of abstraction, pointing out how the images of Edward Ranney and other scholars

have contributed to re-signifying the Inca stones in terms of modernity and esthetic perception. This approach is linked to the contributions of Ishizawa (2017), who studies the transformations in the landscape of the terraces, emphasizing how Ollantaytambo functions as an emerging landscape where urban, rural, and ceremonial elements converge, revealing the rock as an articulator of a sacred territory that extends beyond the archaeological site (Herring, 2013; Ishizawa, 2017). In addition, García (2018) documents the conservation and restoration interventions carried out in Ollantaytambo, showing how heritage preservation also involves recognizing the ritual and symbolic weight that the stone still holds in local memory.

A central aspect in the analysis of Ollantaytambo pertains to its complex hydraulic engineering. Wright and Valencia Zegarra (2018) conducted a detailed study of the Inca canal system in Cusco, including examples from Ollantaytambo, Tipón, and Moray, in which they demonstrate that water flows over carefully designed stone structures, articulating agricultural, political, and ritual functions within the same architectural device. Convergently, these researchers argue that water and stone form an architectural unity that transcends practical function, creating spaces for worship and ritual performativity (Wright & Valencia Zegarra, 2018). Consequently, Ollantaytambo can be understood as a synthesis where stone, water, and the bodily movement of the devotee produce a sacred setting that, as will be seen later, bears analogies to how Mogao transforms excavated rock into a container of spirituality.

The history of the Mogao Caves in Dunhuang dates back to the fourth century, when Buddhist monks began to excavate niches and caves in the cliffs of the Gobi Desert, aiming to create spaces for worship, meditation, and pilgrimage. W. Wang and Yan (2023) demonstrate how Cave 254 reveals an architectural design based on the relationship between body, scale, and space, where human dimensions guide the excavation and arrangement of images, generating an environment in which the pilgrim experiences the sacred through carefully calculated proportions. In parallel, Vilchez Cairo *et al.* (2025) analyze Cave 172 in terms of vision and site, showing how Pure Land Buddhism used mural painting to create transcendent landscapes that transformed the perception of the excavated rock space into a portal to symbolic worlds (W. Wang & Yan, 2023).

Recent studies have also addressed the material and conservationist dimension of Mogao. X. Wang *et al.* (2021) document the history of reinforcements and preventive actions to protect the cliffs of the caves, revealing how the rock itself poses a technical challenge and constitutes a vulnerable support that must be preserved.

Complementarily, Chai *et al.* (2022) employ virtual reconstructions to recover the original colors of degraded murals, demonstrating the importance of understanding the pictorial process as part of the ritual architecture. In turn, Song (2023) interprets Dunhuang as a religious and artistic center on the Silk Road, highlighting the centrality of Mogao as a node of cultural and spiritual exchange (Chai *et al.*, 2022; Wu, 2023; Li, 2024).

In the field of architectural iconography, Yang (2024) examines the caisson ceilings of Mogao, where the presence of mandalas and symbols such as the *viśvavajra* endows the excavated space with a cosmic character, while Zhang (2023) analyzes the representation of Mañjuśrī in Cave 220, highlighting the ritual efficacy of these images inscribed in the stone support to activate religious meanings. Both studies demonstrate that the rock in Mogao is not merely a passive container but an architectural and symbolic device that interacts with painting, sculpture, and human scale, generating a comprehensive experience of devotion (Yang, 2024; Zhang, 2023).

While Herring (2013) privileges the esthetic abstraction of stone in Ollantaytambo, Wright and Valencia Zegarra (2018) integrate it into a ritual hydraulic system. These perspectives rarely engage with one another, revealing an interpretive gap regarding the material agency of rock. A similar situation occurs in Mogao: whereas W. Wang and Yan (2023) prioritize bodily scale, Pérez (2024) emphasizes iconography without articulating the two levels. These tensions justify a comparative approach that goes beyond isolated descriptions to explore the interplay among technique, rituality, and symbolism (Table 1).

As observed in Table 1, both Ollantaytambo and Mogao transform rock into a ritual support; however, they differ in their modes of symbolic activation. In the Andean case, stone is linked to water and agricultural fertility, while in the Chinese case, rock is transformed through excavation, painting, and scale control. These differences demonstrate that stony materiality can assume different

functions depending on cultural tradition, which justifies the comparative analysis (Herring, 2013; Ishizawa, 2017; W. Wang & Yan, 2023).

The research justifies its relevance on three levels. First, it provides a bridge between Andean studies and Silk Road studies, which have rarely been connected. Second, it allows for an understanding of how different cultures construct sacredness through rock, whether by carving, excavating, or painting it. Third, it generates resources for heritage conservation, as shown by García (2018) in the case of Ollantaytambo and Li *et al.* (2021) in the case of Mogao. In both contexts, contemporary management requires recognizing the ritual dimension of the stony support to ensure its comprehensive preservation (García, 2018; Li *et al.*, 2021). In addition, the study contributes to the theory of comparative ritual architecture by proposing rock as a transversal category of analysis that transcends disciplinary regionalisms, opening a conceptual framework applicable to other contexts of rock-cut architecture and sacred landscapes.

Figure 1 illustrates how the ritual body relates to the rock in both cases. In Ollantaytambo, the path is traversed over stepped platforms and in dialog with water channels, while in Mogao, the spatial scale reduces perception and directs the gaze toward mural paintings and sculptures. In both scenarios, space cannot be understood without the body, and the rock becomes a mediator between matter and transcendent experience. This correspondence strengthens the argument that rock, beyond its material function, operates as an architectural device that organizes devotion (W. Wang & Yan, 2023; Wright & Valencia Zegarra, 2018).

The problem statement, the reviewed background, and the presented justification converge on the need to conduct a comparative architectural analysis between Ollantaytambo and Mogao. The objectives of this study are to describe the stone morphology, spatial organization, and symbolic elements in each case; to analyze the relationship between body, scale, and rituality; and finally, to reflect on

Table 1. Conceptual comparison of ritual architectural components

Component	Ollantaytambo (Peru)	Mogao Caves (China)
Lithic support	Terraces, platforms, carved rock outcrops	Excavation in conglomerate rock
Mediating element	Water (canals, ceremonial flows)	Mural painting, Buddhist figure, caisson ceilings
Bodily experience	Ritual movement across rock and water	Embodied perception shaped by reduced scale and temporality
Symbolic function	Fertility, landscape control, Inka power	Buddhist transmission, ritual sequencing

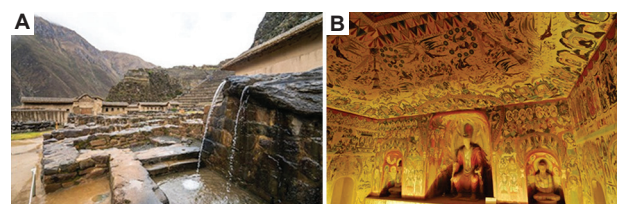


Figure 1. Comparative schematics of the ritual body in relation to the rock. (A) Processional progression and water relationship (Ollantaytambo) show how movement, hydraulic axis, and stepped platforms produce collective ritual sequencing. (B) Access sequence and visual focus toward mural iconography (Mogao) demonstrate body-scale reduction and directed gaze
Source: Photos taken by the authors (2025)

the convergences and divergences that enrich the theory of ritual architecture in rock. The original contribution of this research lies in demonstrating that, despite their cultural and temporal differences, Ollantaytambo and Mogao represent two architectural grammars in which rock is not an inert backdrop but an active agent that organizes sacred experience and cultural memory (Dillehay *et al.*, 2023; Herring, 2013; W. Wang & Yan, 2023).

Within this framework, the research is based on the hypothesis that, although Ollantaytambo and Mogao correspond to divergent cultural and geographical traditions, both configure rock as an active ritual device that mediates between the human body and the cosmos. This assumption guides the comparative analysis toward the interaction among materiality, scale, and iconography, thereby avoiding reductionist interpretations of an exclusively regional character.

2. Data and methods

The research adopted a comparative qualitative interpretative approach with a multiple-case design, in which the *llaqta* of Ollantaytambo and the Mogao Caves in Dunhuang serve as the units of analysis. This design allows for the examination of how different architectural traditions conceive and utilize rock as a ritual space. It is based on the methodology applied in the Ollantaytambo thesis, which employs architectural surveying, field observation, documentary analysis, and local interviews, complemented by techniques used in the study of Buddhist rock architecture that include high-resolution photographic documentation, mural recording, and body-scale analysis. A multiple case design strengthens the external validity of the comparison and aligns with methodological frameworks that recommend the parallel study of divergent cultural contexts to identify patterns and contrasts (Arikan & Olsvig-Whittaker, 2023; Mikayama *et al.*, 2018).

The unit of analysis for Ollantaytambo encompassed the ceremonial urban ensemble made up of temples, terraces, *kanchas*, *qolqas*, and water channels, defined in the thesis as a strictly Inca space excluding colonial modifications. In contrast, the unit of analysis for Mogao was defined as the excavated set of decorated caves, with special attention to those from the Northern Wei (386–534) and Tang (618–907) periods, which exhibit greater development in spatial and pictorial scale. This delimitation ensures coherence in the analysis, as it focuses on the rock as a ritual support while avoiding interference from later additions. Methodologically, this selection responds to the criterion of cultural and architectural relevance, an essential condition in the comparative research of archaeological and heritage sites (De Reu *et al.*, 2011).

In the case of Ollantaytambo, data collection included manual planimetric surveys, architectural observation forms, photographic records, and the use of drones for capturing aerial images. In addition, documentary sources such as chronicles and colonial maps were thematically coded. In Mogao, methodological studies report the intensive use of photogrammetry to document the excavated spatiality and its iconography (Moyano *et al.*, 2020; X. Wang *et al.*, 2021). The combination of traditional field techniques and digital technologies ensures that the data are comparable in spatial and functional terms. Nevertheless, it should be noted that there is a methodological asymmetry between the two cases: whereas primary data were generated in Ollantaytambo, the analysis of Mogao relied on secondary sources. This difference conditions the depth of the comparative analysis, although it does not invalidate the relevance of the multiple-case design; rather, it highlights the need to interpret the results within the bounds of these limitations.

The comparison contrasts two types of evidence: primary data (planimetric surveys, *in situ* observation, drone imaging, and local interviews) generated by the authors for Ollantaytambo, and secondary data (photographic archives, scientific publications, conservation reports, and digital reconstructions) for Mogao. This asymmetry is openly acknowledged as a limitation, but it does not invalidate the comparative approach. To maintain analytical coherence, three measures were adopted: (i) the use of an identical categorical framework (lithic morphology, construction technique, body scale, and sensory mediations); (ii) thematic triangulation among independent secondary sources (conservation, iconography, and spatial studies) for Mogao, and (iii) a sensitivity analysis that restricts universal inferences only to convergences documented by multiple sources. These safeguards allow for the comparison of interpretative processes without replacing the need for subsequent field research in Dunhuang.

The organization of the analysis was structured into three phases. In the first phase, thematic coding of documentary and graphic sources was conducted: in Ollantaytambo, categories such as defensiveness, spatial hierarchy, and water management were grouped, while in Mogao, categories related to bodily scale, pictorial sequencing, and visual orientation were identified. In the second phase, spatial analysis was applied: for the Andean case, this included visual schemes and access from elevated points, while for the Chinese case, architectural documentation and observation of the internal arrangement of the caves through site photographs were utilized. In the third phase, triangulation among primary sources, visual records, and specialized literature was carried out, ensuring that the final interpretation was supported by multiple pieces

of evidence. This approach aligns with the guidelines of landscape archaeology and digital archaeology, which recommend methodological triangulation processes (Conolly & Lake, 2006; Douglass *et al.*, 2017).

Figure 2 synthesizes the logic of methodological integration, illustrating the analytical sequence used in this study. In both cases, the rock becomes the core of observation, whether as a carved support in terraces or as an excavated mass. The graphic representation helps to visualize how data of different natures are integrated to arrive at an architectural and symbolic interpretation.

In terms of validity and reliability, the research ensures consistency through data triangulation, systematic organization of records, the establishment of a digital photo archive, and explicit coding of categories. These measures aim to mitigate interpretative subjectivity and guarantee traceability, practices that align with methodological standards in qualitative archaeological research. Braun and Clarke (2006) emphasize that clarity in coding procedures is essential for reliability, while De Reu *et al.* (2011) demonstrate that the integration of spatial and documentary analysis enhances the validity of interpretations regarding archaeological sites.

Likewise, the research incorporates ethical considerations related to the nature of the data. In the case of Ollantaytambo, interviews and observations were conducted in accordance with the principles of informed consent and with recognition of the cultural sensitivity of testimonies linked to the site's ritual memory. For Mogao, only academic sources and public archives were used, ensuring that no unauthorized manipulation of images or documents took place.

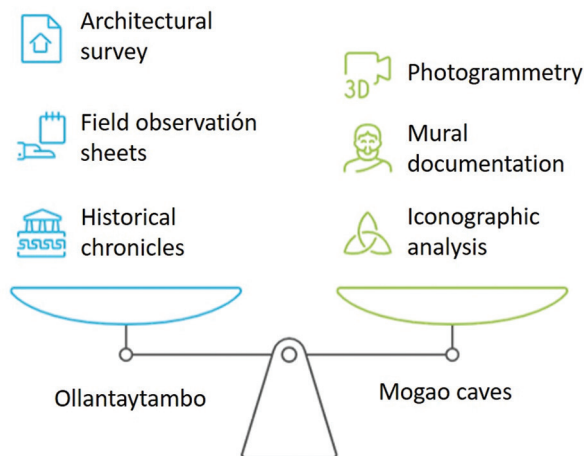


Figure 2. Comparative methodological scheme showing the sequence of data collection, thematic coding, spatial analysis, and triangulation used to align primary (Ollantaytambo) and secondary (Mogao) sites. Source: Diagram by the authors

Methodological limitations are acknowledged: in Ollantaytambo, no physical laboratory tests were conducted, whereas in Mogao, existing studies rely primarily on digital technologies that are not always accessible. However, these restrictions do not undermine the validity of the comparative research, as in both contexts, the techniques employed were consistent with their nature and with the resources available. It is important to note that the study is comparative and interpretive in character, grounded in documentary records and previous architectural surveys, which explains the absence of statistical metrics and experimental analyses. The tables included in the results section serve a purpose of systematization and contrast rather than quantification. Consequently, the emphasis remains on understanding rock as a ritual space, which justifies the methodological design adopted as the most appropriate for achieving the stated objectives, organizing spatial, technical, and iconographic evidence within a common framework, and thereby contributing to the international debate on sacred rock architectures through the identification of convergences and divergences with sufficient methodological traceability.

3. Results

3.1. Territorial configuration and location

The territorial analysis of Ollantaytambo confirms that the *llaqta* is situated at a strategic control node over the Vilcanota valley, allowing for visual dominance and direct connection with agricultural areas. The georeferenced planimetry shows that the platforms adapt to slopes ranging from 12 percent to 15 percent (Table 2, row “Predominant Slopes”), creating a stepped system that organizes both ceremonial and agricultural spaces. This can be observed in the representation of the settlement (Figure 3), where the correspondence between terraces and enclosures is evident.

The integration of hydraulic channels with the main access routes reinforces the sacred character of the site, as the water not only nourishes the agricultural terraces but also flows through plazas and gathering spaces. This axial nature of the central channel is evident in the planimetry verified in the field, confirming that hydraulics is not secondary but rather structural to the urban design. The location on a hillside with selected rocky outcrops for carving demonstrates advanced topographical knowledge, where adaptation to the natural morphology forms the basis of spatial organization.

The comparison with Mogao reveals significant divergences. In the Chinese complex, the caves are situated on a desert cliff lacking water and in a context that is difficult to access; while Ollantaytambo integrates agriculture,

Table 2. Territorial parameters and site metrics (analytical variables used to compare location and slope)

Variable	Measurement method	Observed result (according to thesis)	Interpretation
Topography and location	Georeferenced planimetry and field observation	Strategic node on hillside, at the confluence of ravines, with a dominant view over the valley	Central core articulating hydraulic, productive, and visual control
Predominant slopes	Topographic sections and DEM profiles	Hillsides transformed into terraces; main accesses with average slopes of 12–15%	Suitable for terracing and for generating processional sequences through ascent
Hydraulic integration	Mapping of channels contrasted with the photographic record	Channels and fountains integrated into axial layouts; a longitudinal channel in the plaza	Water as ordering axis and element of ritual legitimation
Visibility/visual control	Line-of-sight analysis from planimetry and observation	Platforms dominate agricultural plots and access routes	Political legitimation through visual dominance over the landscape
Land use and terracing	Planimetric survey and field records	Agricultural terraces contiguous to ceremonial enclosures and plazas	Integration of production and ritual within territorial continuity
Accessibility	Recording of paths, ramps, and stairways	Network of ramps and breaks with intermediate viewpoints	Ritual approach design with non-linear progression controlling perception and effort

Abbreviation: DEM: Digital Elevation Model

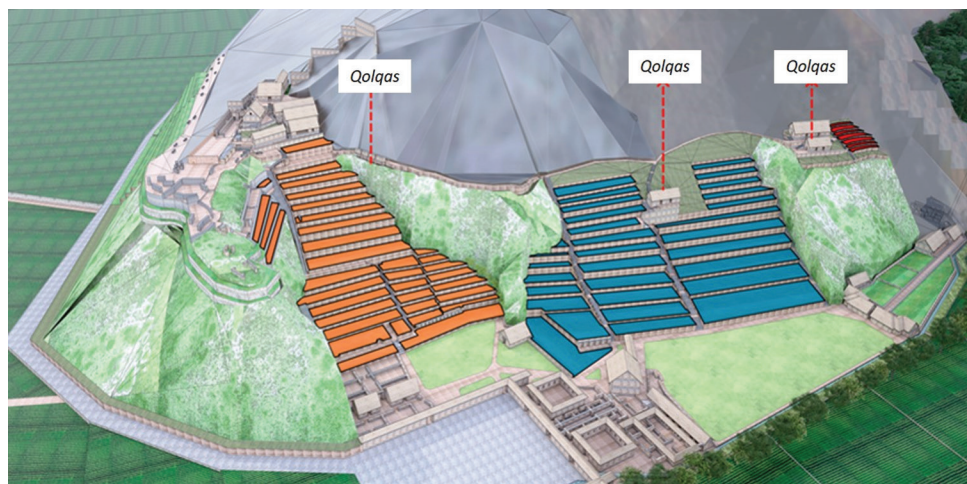


Figure 3. Plan view of the *llaqta* of Ollantaytambo highlighting terraces, hydraulic axes, and sightlines used in territorial argumentation (Table 2)
Source: Drawing by the authors

water, and ritual within the same territorial framework, Mogao is configured as an isolated devotional enclave in the desert, highlighting a cultural contrast. However, both cases share the choice of locations that compel the visitor to undergo a ritualized ascent.

3.2. Rock morphology and construction technique

The construction record of Ollantaytambo demonstrates the mastery of differentiated techniques based on function and hierarchy. The polygonal walls made of large blocks correspond to elite enclosures and ritual spaces, while rustic masonry of smaller stones with minimal shaping is used in agricultural terraces. Direct cutting into the bedrock is observed in platforms and wall bases, where outcrops are regularized to create flat surfaces that allow for the fitting of new structures. This logic is clearly illustrated in Figure 4, which documents the andesite cuts used to form platforms that integrate architecture with the natural

rock. Figure 4 also presents a synthesis of the techniques and their typological variation.

The quality of the surface finish varies according to the function of the space. In ritual areas, polished and smoothed surfaces with signs of abrasion are identified, while rough textures predominate in secondary areas. Analysis of topographic sections shows that the 5–10° inclination applied to the walls responds to drainage criteria, confirming a technical adaptation to local climatic conditions.

The comparison with Mogao reveals a contrast in construction methods: Ollantaytambo integrates the addition of blocks and rock cutting, while Mogao is based on hollowing out cavities in the limestone of the cliff. However, both sites share the principle of transforming rock into architecture, although with different material solutions. In Mogao, the monumentality of the carved

niches corresponds to iconographic programs, whereas in Ollantaytambo, monumentality is associated with territorial control and hybrid ritual functions.

3.3. Ritual pathways and accessibility

The study of access confirms that accessibility in Ollantaytambo was conceived as a processional sequence, where the average slope of between 12 percent and 15 percent necessitates a gradual ascent accompanied by visual landmarks. Figure 5 documents the main pathways, where the combination of ramps and stairways with landings provides intermediate viewpoints, generating a controlled perception of space (Table 4 for the quantitative parameters of slope and spatial sequence).

The physical effort of the ascent becomes part of the ritual experience, as the approach sequence is not direct



Figure 4. Cuts in the bedrock for the formation of platforms. Photographic and sectional evidence illustrating rock-cutting techniques and surface-finish variations used in the construction-technique comparison (Table 3)
Source: Photo taken by the authors (2025)

but designed to intensify the visitor's perception. This logic aligns with Mogao, where the processional access also involves an ascent, although in more abrupt contexts with slopes exceeding 20 percent.

The accompanying elements reinforce the ritual character of the journey. In Ollantaytambo, water channels run parallel to the access paths, while in Mogao, the accompaniment is provided through niches and statues carved into the façade. Table 4 summarizes these differences and allows observation of how both traditions understand accessibility as a tool for perceptual transformation, although through different resources.

3.4. Sacred hydraulics and water management

The hydraulic system constitutes one of the most notable features of Ollantaytambo, as the channels not only serve agricultural purposes but also structure plazas and ritual spaces. The main channel runs axially through the central plaza, as shown in Figure 6, confirming that water functions as an organizing principle of urban design (Figure 6 for the photograph/planimetry of the channel; Table 5 summarizes the comparative strategies of hydraulic management).

The stepped fountains (Figure 7 for details) located in the upper sectors reinforce the sacred dimension, as they produce a constant sound that transforms the spatial experience into a contemplative ritual. Figure 7 documents these fountains, where their integration with the retaining walls demonstrates a planning approach that incorporated hydraulics from the initial design.

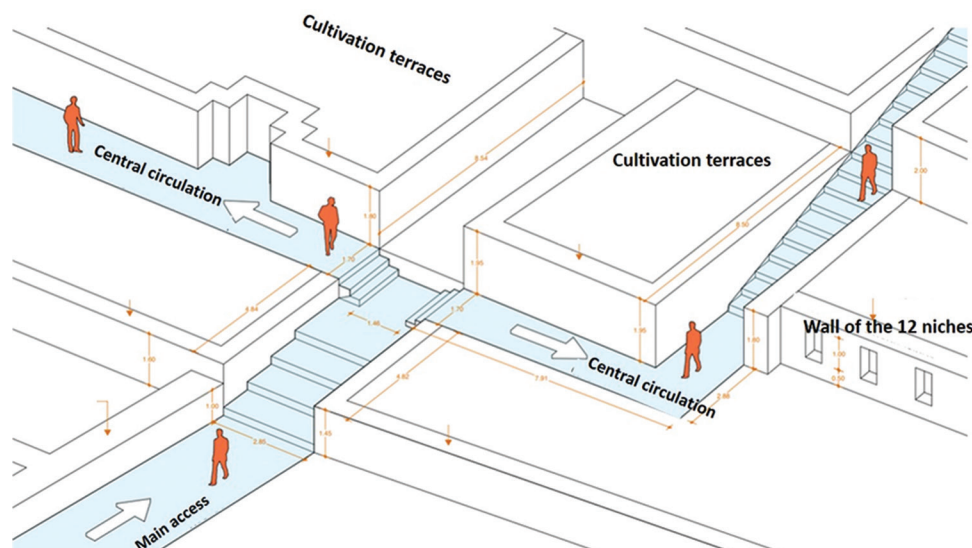


Table 3. Construction techniques and typological variation (evidence for differential rock intervention)

Variable	Ollantaytambo	Mogao	Convergence/divergence
Site location	Agricultural–ritual node with hydraulic integration	Desert cliff with devotional cavities	Divergence in environmental context
Construction technique	Rock cutting and addition of stone blocks	Excavation of cavities in limestone	Convergence in rock transformation
Accessibility	Processional agricultural ramps	Steep devotional pathways	Convergence in ritual function
Hydraulics	Functional channels and royal fountains	Pictorial representation of water	Divergence in material expression
Scale	Monumental and corporeal contrast	Contrast between monumental façade and intimate cave	Convergence in alternation of scale
Iconography	Minimal and localized motifs	Monumental narrative programs	Divergence in representational emphasis
Rock–environment model	Agricultural–ritual hybrid integrated with the landscape	Monumental devotional enclave	Cultural divergence

Table 4. Accessibility and ritual pathways (slope, sequence, and accompanying elements)

Variable	Ollantaytambo	Mogao
Average slope	12–15%	20–25% along processional ascents
Spatial sequence	Ramps with breaks and intermediate viewpoints	Direct pathways leading to cave portals
Accompanying elements	Channels and rocky outcrops	Niches and statues carved into the façade
Symbolic function	Agricultural and ritual ascent toward the central plaza	Devotional procession toward Buddhist spaces

Table 5. Hydraulic strategies and sensory functions (material water vs. representational water)

Aspect	Ollantaytambo	Mogao
Availability	Permanent rivers and springs	Desert context with scarce resources
Architectural device	Canals, fountains, and waterfalls	Pictorial representations of rivers and ponds
Symbolic function	Consecration of plazas and enclosures	Spiritual recreation of the Buddhist paradise
Sensory impact	Constant sound of flowing water	Visual evocation through murals

The comparison with Mogao reveals that the difference lies in the materiality of water. In the Chinese site, the desert environment prevented permanent streams, so water is represented in murals through ponds and lotus flowers. The comparative table highlights the opposition between hydraulic materiality in Ollantaytambo and iconographic evocation in Mogao.

3.5. Body scale and spatial interaction

The scale of Ollantaytambo is calibrated in relation to the human body (Figure 8); for the values and categories of comparative scale, Table 6. This calibration makes the



Figure 6. Main channel running through the plaza of Ollantaytambo. Photographic/planimetric evidence demonstrating water as an ordering device (Table 5)

Source: Photo taken by the authors (2025)



Figure 7. Stepped fountains in the upper sector of the *Ilaqta*. Close-up documentation illustrating the sensory components of ritual

Source: Photos taken by the authors (2025)

physical effort of ascent an essential part of the experience. The dimensions of the stairways and ramps reveal precise ergonomic calculations that regulate the interaction

between the visitor and the space. The contrast between the monumental walls and the domestic scale of the rooms creates a perceptual duality.

This alternation of scales reinforces internal hierarchies, as the monumental plazas convey collective grandeur, while the residential rooms induce proximity and visual control. A similar principle can be observed at Mogao, where the monumentality of the façade contrasts with the intimacy of the interior caves, producing a perceptual transformation. The comparative table confirms that both traditions employ scale as a ritual resource. This perceptual and sensory experience aligns with Pallasmaa's (1996) argument that architecture is not understood solely through vision but through the tactile, haptic, and bodily integration, which enhances ritual significance. Thus, although through different mechanisms, Ollantaytambo combines physical effort and spatial contrast, whereas Mogao creates impact through the transition from narrow access passages to spacious halls.

3.6. Iconography and cultural meanings

The iconographic record in Ollantaytambo is minimal, as linear motifs and marks associated with signaling functions or specific ritual interventions predominate. Broad narrative programs are not identified, which reinforces the idea of a setting where rituality is expressed through spatiality rather than graphic representation. In

Table 6. Spatial scales and bodily calibration (comparison of monumental, intermediate, and bodily levels)

Scale	Ollantaytambo	Mogao
Monumental	Plazas and high-rise walls	Cliff façade perforated with cavities
Intermediate	Terraces and agricultural enclosures	Transitional passages and galleries
Bodily	Ergonomically calibrated stairways	Narrow entrances requiring stooping
Ritual experience	Physical effort of ascent and spatial contrast	Impact of moving from narrow passages to expansive interiors

Table 7. Iconographic parameters (technique, scale, and symbolic function)

Variable	Ollantaytambo	Mogao
Main motifs	Lines and punctual marks	Buddhist narratives with multiple scenes
Technique	Incisions and selective polishing	Mural painting and carved sculpture
Symbolic function	Localized sacralization	Devotional and doctrinal teaching
Scale of representation	Reduced and focalized	Monumental and continuous

contrast, Mogao develops complex Buddhist iconographic programs that occupy walls and ceilings with continuous visual narratives.

The absence of large iconographic programs in Ollantaytambo coincides with the hybrid nature of its agricultural and ritual functions. The linear motifs identified on cuts and polished surfaces respond more to gestures of specific sanctification than to narrative intentions. This difference is summarized in Figure 9, which records minimal markings on the rocky outcrops. The comparative table (Table 7 for the iconographic comparison between both sites) organizes these differences and confirms that, while Ollantaytambo sanctifies rock through spatiality and water, Mogao does so through visual narration and monumental iconographic programs.

3.7. Comparative synthesis

The integration of the results (Figure 10) allows for the construction of a comparative framework between Ollantaytambo and Mogao; both sites represent rock-art traditions that transform stone into architecture, although



Figure 8. Scale relationship between monumental walls and domestic rooms. Visual comparison demonstrating alternation of scales and bodily calibration in ritual experience (Table 6)
Source: Photos taken by the authors (2025)



Figure 9. Linear motifs and ritual marks on rocky outcrops of Ollantaytambo. Photographic evidence of minimal iconography illustrating spatial and performative sacralization (Table 7)
Source: Photo taken by the authors (2025)

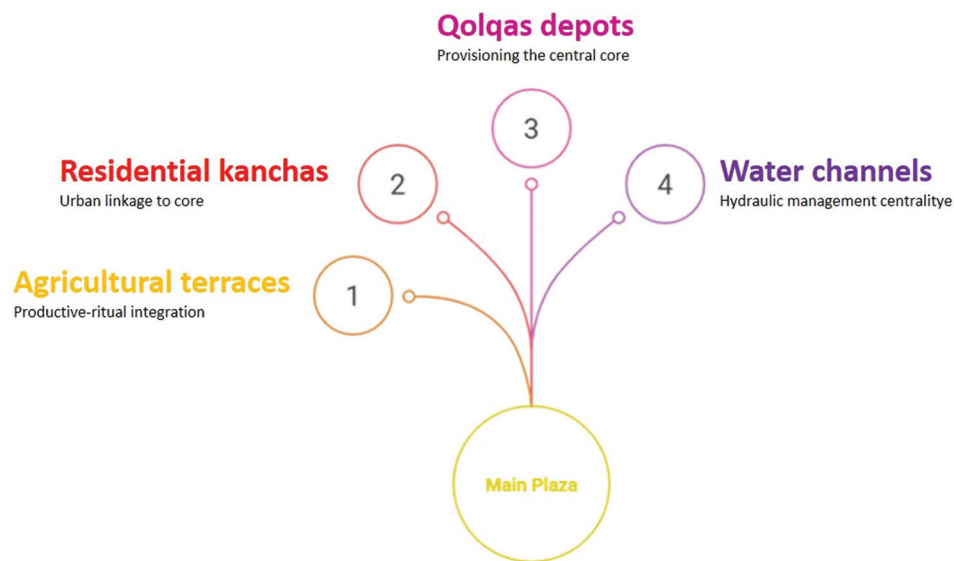


Figure 10. Graphic synthesis of spatial patterns in Ollantaytambo. Composite map synthesizing location, technique, accessibility, hydraulics, and iconography to support the comparative framework (Table 8)

Source: Diagram by the authors

Table 8. Comparative synthesis matrix (convergences/divergences across analytical variables)

Variable	Ollantaytambo	Mogao	Convergence/divergence
Location	Agricultural–ritual node with hydraulic integration	Desert cliff with devotional cavities	Divergence in environmental context
Construction technique	Rock cutting and block addition	Excavation of cavities in limestone	Convergence in rock transformation
Accessibility	Agricultural processional ramps	Abrupt devotional pathways	Convergence in ritual function
Hydraulics	Actual channels and fountains	Pictorial representation of water	Divergence in materiality
Scale	Contrast between monumental and bodily dimensions	Contrast between monumental façade and intimate cave	Convergence in scale alternation
Iconography	Minimal and localized motifs	Monumental narrative programs	Divergence in representational emphasis
Rock–environment model	Agricultural–ritual hybrid integrated into landscape	Monumental devotional enclave	Cultural divergence

with different purposes. Ollantaytambo articulates agricultural production, territorial control, and rituality, while Mogao is oriented toward religious devotion through monumental iconography. The final table (Table 8) synthesizes these differences and similarities, showing that despite cultural contrasts, there are clear parallels in the use of accessibility, scale, and location as ritual resources.

4. Discussion

The analysis of the spatial organization of Ollantaytambo confirms the thesis that the Incas conceived architecture as an extension of sacred geography. This principle aligns with Eliade (1959), who understood ritual centers as mediations

that hierarchize space and legitimize the distinction between the sacred and the profane. The arrangement of terraces, plazas, and temples in relation to the mountain resonates with Herring (2013), who identified formal abstraction as a strategy through which the Incas projected a notion of cosmic power onto stone. The findings of this study suggest that the monumentality of agricultural terraces not only fulfilled productive or defensive purposes but also embodied a symbolic order in which rock functioned as a mediator between territory and ritual. This contrasts with Mogao, where spatial organization is defined by the sequencing of caves carved into the cliff, a pattern that echoes the contributions of W. Wang and Yan (2023), who emphasize the bodily scale and the immersive experience of the devotee within the cave.

Theoretically, this reading benefits from Norberg-Schulz (1980) (*genius loci*) to articulate how matter (rock) produces place identity through relationships with light, topography, and ritual; and from Pallasmaa (1996) to highlight that the ritual experience is holistic and multisensory (haptic), explaining why Ollantaytambo emphasizes tactility and bodily effort, while Mogao organizes visual-spiritual immersion. These references reinforce the interpretive framework connecting technique and materiality with bodily experience.

The results obtained regarding the construction technique in Ollantaytambo reveal that the precision of the polygonal walls and the differentiated use of finishes respond to symbolic and hierarchical criteria. This is in agreement with Wright and Valencia Zegarra (2018), who demonstrated that Inca hydraulic architecture served both practical functions and ritual meanings. The present research reinforces this interpretation by showing that the cuts in bedrock and the ritual channels are part of the same integration system linking water and stone. Meanwhile, in Mogao, the excavation of the rock and the application of plaster for murals confirm Zhang's (2023) observation that the rocky surface functions as a sacred canvas intended to contain Buddhist iconography. The comparison suggests that, although the techniques differ, in both cases, the rock becomes a support for a spiritual discourse.

The ritual organization of space reveals significant differences between the two traditions. In Ollantaytambo, the ascending processional routes are linked to water control and fertility, shaping a collective and expansive ritual. In Mogao, the rituality is constructed through the interiority and sequencing of caves, with murals guiding visual perception. W. Wang and Yan (2023) highlighted that the spatial scale of the caves was designed to intensify individual meditative experience, a conclusion confirmed by the analysis of reference images from caves such as 254 and 172. In contrast, Wright and Valencia Zegarra (2018) argued that Inca spatiality was intended to lead communities around water, confirming that the contrast between the two contexts lies not in the absence of rituality but in the different ways the rock conditions the human bodily experience.

Regarding the symbolism of the rock, the results from Ollantaytambo show the persistence of stone as a *huaca*, imbued with meanings related to fertility and political power. This interpretation aligns with Herring (2013), who analyzed Inca formal abstraction as an architectural language filled with sacredness. In Mogao, the results indicate that the rock serves as a support for Buddhist iconography, consistent with Zhang (2023), who explained how the representation of Mañjuśrī in Cave 220 had a ritual efficacy that transformed inner perception. This

contrast highlights that in the Andes, rock is a living entity, whereas in Dunhuang, rock gains meaning as the material basis of religious art. In both cases, the stone is not neutral but functions as a medium of communication between humans and the cosmos.

The analysis of the relationship between the human body and spatial experience reinforces the contributions of W. Wang and Yan (2023), who argue that bodily scale was a fundamental parameter in the conception of Buddhist caves. The results obtained confirm that the devotee experiences Mogao through confined spaces that intensify concentration and introspection. In contrast, the bodily experience in Ollantaytambo is defined by physical effort and the monumentality of the terraces and platforms, which aligns with the findings of Wright and Valencia Zegarra (2018), who demonstrated that Inca hydraulic pathways were designed to engage moving collectives. The comparison reveals that ritual corporeality is key to understanding how each culture translated rock into spiritual experience—expansive in the Andes and confined in China.

This contrast should not be understood as a direct equivalence between Andean animism and Buddhist introspection. Both cosmological systems emerge from distinct premises: in the Andes, the sacredness of rock is inscribed within a logic of continuity among mountain, water, and agricultural fertility, whereas in Mogao, it is articulated through Buddhist doctrines and iconographic programs that foster interiorization. As Glowacki and Malpass (2003) and Mader *et al.* (2023) caution, the sacralization of stone in the Andes responds to a historicity specific to huaca landscapes, which cannot be straightforwardly equated with the doctrinal logic of Chinese Buddhism. This caveat compels us to frame comparison as a heuristic exercise rather than as an attempt at cultural homogenization.

The discussion of the iconographic dimension also allows us to observe convergences: in both sites, the rock supports cosmic narratives. In Ollantaytambo, these are linked to Andean duality and agricultural order, while in Mogao, they are related to Buddhist *sutras* and mandalas. Herring (2013) had already noted that Inca abstraction aimed to project an order in stone that transcended mere architecture, and the results obtained here reinforce that interpretation by linking the terraces and temples to fertility rituals. In parallel, Zhang (2023) explained that the murals of Mogao functioned as visual guides toward enlightenment. The comparative results show that, although the form is different, the symbolic intention of the rock as a means of access to the sacred remains consistent in both traditions.

The role of water in Ollantaytambo deserves particular discussion, as the findings confirm that hydraulic control was not only a technical innovation but also a ritual component of the space. This assertion aligns with the analyses of Wright and Valencia Zegarra (2018), which demonstrated the inseparability of hydraulic function and rituality in Cusco architecture. When comparing this finding with Mogao, it is observed that, although water does not directly intervene in the ritual organization of the caves, there is a parallel element in the interplay of light and shadow within the excavated spaces, reminding us that both cultures utilized material and environmental resources to enhance the symbolic dimension of ritual.

The results also allow for a discussion of the notion of monumentality. In Ollantaytambo, monumentality is expressed in the scale of terraces and polygonal walls, visible from the valley, while in Mogao, it is manifested in the accumulation of caves and the richness of interior painting. Herring (2013) noted that Inca monumentality was not based on decoration but on integration with the mountain, while W. Wang and Yan (2023) argued that monumentality in Mogao resided in the bodily immersion within small, decorated spaces. The results of this research confirm these perspectives and demonstrate how two distinct cultures achieved ritual monumentality through opposing architectural resources.

The comparison of the political dimension of rock provides another perspective. The results indicate that in Ollantaytambo, the carved stone legitimized Inca power and functioned as a sign of dominance over nature, which aligns with Herring's (2013) proposal. In contrast, in Mogao, the excavated rock served to promote Buddhism as a state ideology along the Silk Road, as shown by W. Wang and Yan (2023) in their analysis of Cave 254. This difference illustrates how the same material element can support distinct political discourses, focused on agriculture and territorial control in the Andes, and on religious propagation in China.

The overall discussion allows for situating the results within a broader comparative framework. Previous studies have shown that both in the Andes and in China, rock acquired ritual and symbolic functions, although mediated by diverse cultural and religious contexts. The results of this research confirm and enrich those interpretations by demonstrating how bodily experience, construction techniques, and spatial organization intertwine with symbolism, thus offering a comprehensive view of rock as a ritual space that transcends cultural and geographical differences. This addresses the central objective of the research and contributes to an interdisciplinary debate on the role of stone in sacred architecture.

In methodological terms, the comparison focuses on conceptual directions and architectural processes rather than on absolute metric equivalences. Whereas Ollantaytambo provides first-hand metric and sensory data, Mogao offers documentary examples that allow thematic contrasts (for example, the role of real water versus its pictorial representation). The conclusions emphasize interpretative patterns repeated across multiple sources (e.g., the alternation of scales as a ritual resource) and explicitly highlight those claims that require future empirical verification in Dunhuang (the manuscript indicates whenever a conclusion relies primarily on secondary sources).

5. Conclusion

The research on rock as a ritual space in Ollantaytambo and the Mogao Caves has established that shared materiality does not imply uniformity of meanings. In the Andean context, rock is regarded as a living *huaca* and a cosmic agent that organizes agricultural, political, and ceremonial life, while in the Chinese context, rock serves as the material support on which Buddhist iconography is inscribed, directing the spiritual experience inward. This finding addresses the research question and allows for the assertion that rock is a ritual architectural device that gains its meaning through interaction with specific worldviews and cultural practices.

The comparative analysis shows that in Ollantaytambo, the monumentality of the walls and terraces is oriented toward the relationship between body, water, and mountain, creating an expansive and collective space. In contrast, in Mogao, monumentality is internalized in the dimness of the caves and expressed through a sequencing of images that guide the devotee toward transcendence. This difference does not constitute an absolute opposition but rather demonstrates that rock can facilitate ritual experiences of a complementary nature—open and communal in the Andes, introspective and meditative in China. Thus, the understanding of how natural materials, when intervened on, become settings for the sacred is broadened.

The results also contribute to the discussion about the role of construction techniques in the production of ritual meanings. In Ollantaytambo, the precision of stone assembly and the integration of hydraulic channels demonstrate a conscious mastery of nature that legitimizes Inca power. In Mogao, the excavation of conglomerate and mural decoration express the ability to transform the interior of the rock into a pictorial cosmos. In both cases, technique is not merely a procedure but a strategy for inscribing meanings, confirming that ritual architecture

cannot be understood solely from form, but through the cultural intentionality that defines how materials are worked.

The research also enables a deeper interpretation of the dimension of the human body. In Ollantaytambo, the physical ascent through terraces and stairways entails an effort that symbolizes integration with the mountain, whereas in Mogao, the body adapts to narrow and dark caves that induce introspection. This experiential dimension resonates with the notion of “genius loci” developed by Norberg-Schulz (1980), for whom the identity of place is constructed in the relationship between materiality, light, and corporeality, reinforcing belonging and the existential meaning of ritual space. This finding reveals that corporeality is not merely a consequence of architecture but constitutes a design parameter. Rock is organized in relation to the ritual body, whether in collective journeys toward the horizon or in individual contemplations within the penumbra. This contribution enriches the field of ritual architecture by demonstrating the centrality of sensory and physical experience in the definition of the sacred.

The synthesis of the findings confirms that rock serves as a mediator between the human and the cosmic, but in each tradition, this mediation takes on different forms. In the Andes, stone is conceived as a subject with its own agency, linked to fertility and water; in China, rock supports sacred art that shapes visual universes. Both interpretations converge in recognizing matter as a means of communication with the transcendent world, but they diverge in their mode of activation. This conclusion not only contributes to the history of Andean and Chinese architecture but also aids in the comparative theory of ritual spaces, demonstrating that the sacred is constructed at the intersection of materiality, technique, and worldview.

The scientific context is enriched by this research, as it provides a model for comparative analysis between architectures that, despite being distant in geography and tradition, share the material foundation of rock. This model differs from studies focused exclusively on a single site by showing that comparison allows for the discovery of universal patterns, such as the hierarchization of pathways or the centrality of the body, alongside cultural differences that explain the diversity of architectural expressions. In this sense, the work contributes to debates on the universality and particularity of ritual architecture and opens avenues for rethinking the role of matter in the configuration of the sacred.

The research also allows for the recognition of the limitations that condition the results. In the case of Ollantaytambo, first-hand information was available and

documented in the thesis through surveys and direct analyses. In contrast, for Mogao, the study relied on reference images and archival sources, without virtual reconstructions or fieldwork. This methodological difference may have constrained the depth of the spatial analysis of the caves. Nevertheless, it is important to specify that the methodological disparities between the two cases directly affect the comparative validity of the findings. While Ollantaytambo benefited from architectural surveys and direct observation, the analysis of Mogao depended primarily on secondary archives and images. This asymmetry restricts the possibility of making universal claims about the sacrality of rock. However, the richness of prior scholarship and the available visual documentation allowed for a valid comparison, while simultaneously acknowledging that future research should address these shortcomings through systematic field observations or digital reconstructions.

At a higher level of abstraction, the findings affirm that rock is a universal element of architectural sacralization, but its meaning does not reside in its physical materiality; rather, it lies in the way it is intervened on and symbolized by each culture. This conclusion helps to shift the debate on ritual architecture from the formal to the ontological, showing that the sacred is not in the stone itself but in the network of relationships between body, technique, and cosmos that architecture activates. In this sense, the contribution of the study lies in offering a conceptual framework that can be applied to other cultural contexts to understand how natural matter becomes sacred.

The implications for heritage conservation derived from the findings indicate the need for conservation strategies that integrate ritual significance and technical requirements while adapting to the cultural and material differences of each site. Specifically:

- For Ollantaytambo (Peru), interventions should prioritize participatory conservation models that recognize the site's status as a living *huaca*—maintaining hydrological traces and processional routes, involving local communities in management decisions, and designing reversible interventions that respect the ritual continuity of water and space use.
- For Mogao (China), strategies should emphasize comprehensive protection of the rock substrate and iconography (microclimate control, substrate stabilization, high-resolution digital documentation, and virtual reproduction to reduce tourist pressure), recognizing that the materiality of the rock and its painting are inseparable for the devotional experience.
- In both contexts, technical preservation must be articulated with the safeguarding of meanings.

Intervention protocols should combine material criteria (stability and deterioration prevention) with cultural measures (participation and contextualized interpretation) to maintain both the physical integrity and the ritual efficacy of the site.

Finally, a promising avenue lies in studying the relationship between heritage conservation and the rituality of rock to understand how contemporary transformations affect the original meaning of these sacred spaces. In practical terms, these findings offer valuable criteria for heritage management in current contexts. In Ollantaytambo, the integration of rock, water, and rituality can guide interventions that recognize both materiality and living cultural meanings, strengthening models of participatory conservation. In Mogao, considering rock as inseparable from pictorial iconography provides a foundation for measures that respect the relationship between the excavated space and the visual narrative. Comparatively, the study underscores that heritage management must address not only the physical stability of sites but also their symbolic and experiential dimensions. Future research could extend these principles to other rock-based complexes worldwide, moving toward interdisciplinary methodologies that integrate archaeology, anthropology, and digital technologies to enrich both comprehensive conservation and architectural interpretation.

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Conflict of interest

The authors declare that they have no competing interests.

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Ethics approval and consent to participate

The study was conducted in accordance with established ethical principles for research involving human participants. Formal ethics committee approval was not required for this study because it involved minimal-risk interviews and did not collect sensitive personal data or biological samples (per institutional/national guidelines, as applicable). All participants were informed about the study objectives and procedures, and written/oral informed consent was obtained before the interviews. Participation was voluntary, and confidentiality was maintained throughout the research process.

Consent for publication

All participants provided informed consent to participate in this study. Consent for publication was obtained from participants whose data, images, or other information could identify them. The authors confirm that the relevant consent documentation has been obtained and is available for review by the journal/editorial office upon request.

Availability of data

The data generated and analyzed during this study are available from the corresponding author upon reasonable request. All datasets, field records, and analytical materials supporting the findings are securely stored and can be shared for academic and research purposes in accordance with institutional and ethical guidelines.

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