Available Online: 22 April 2026 DOI: 10.54254/2753-7080/2026.33019

From stone to spirit: cultural sustainability, ritual practice, and digital preservation of the Dazu Rock Carvings in Chinese heritage

Ying Sun

Chongqing University of Posts and Telecommunications, Chongqing, China

ceryssun@163.com

Abstract. The Dazu Rock Carvings in Chongqing, China, represent a unique confluence of artistic innovation, religious practice, and socio-cultural continuity from the Late Tang through the Southern Song periods and into the present day. This study investigates the carvings' stylistic evolution through five principal typologies—monumental narrative reliefs, votive niches, lay feast shrines, protective deity niches, and hybrid forms—each revealing shifts in religious expression, political context, and community engagement. By applying iconographic and spatial analysis, the paper explores how visual culture functioned as a tool for moral instruction, social cohesion, and identity construction. Framed within the broader discourse of cultural sustainability, the study also considers how contemporary digital technologies—such as 3D scanning and virtual preservation—contribute to the safeguarding and revitalization of this living heritage for future generations.

Keywords: cultural sustainability, Dazu Rock Carvings, Chinese buddhist art, ritual space, iconography, digital preservation

1. Introduction

Rock carvings, as enduring expressions of human creativity, belief, and identity, embody one of the most sustainable forms of cultural heritage. Carved directly into the natural landscape, these artworks require no additional materials, rely on minimal environmental alteration, and persist across centuries with remarkable resilience. Beyond their physical longevity, rock carvings represent a deeply embedded form of cultural sustainability—preserving worldviews, moral systems, and community memory through visual narratives that transcend written language. As both historical documents and living traditions, such sites offer critical insights into how societies have engaged with nature, spirituality, and collective identity over time. In an era increasingly focused on sustainability and cultural preservation, the study of rock carvings—including their stylistic evolution, ritual function, and digital conservation—offers a vital lens through which to explore the continuity and innovation of human expression across generations.

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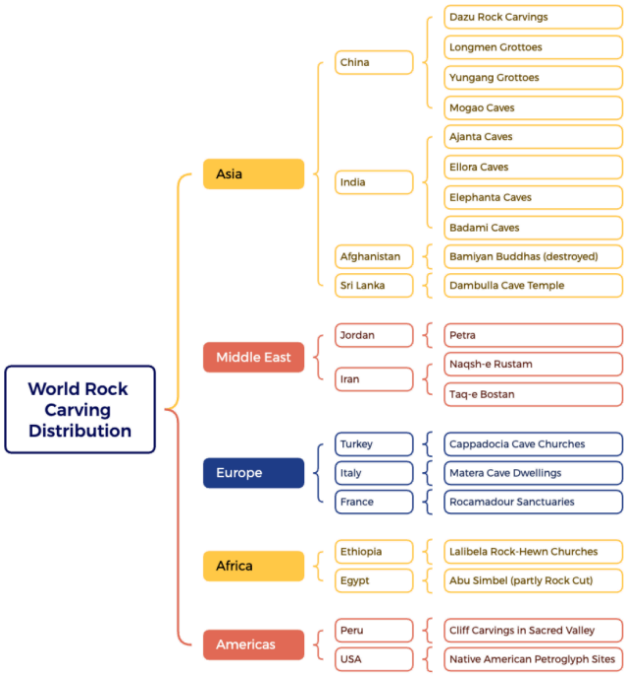

Figure 1. Overview of world rock carving distribution

Figure 1 provides a global overview of significant rock carving and cave temple sites, categorized by continent and country. It highlights key cultural and religious rock-cut monuments—from Buddhist grottoes in Asia to Christian cave churches in Europe and petroglyph sites in the Americas—underscoring the geographical expanse and cultural diversity of rock carving traditions worldwide [1-4]. Among these, the Dazu Rock Carvings in Chongqing, southwest China, stand out as one of East Asia's most prominent and well-preserved ensembles of religious rock art [5-10]. Recognized as a UNESCO World Heritage Site in 1999, the carvings span from the ninth to the thirteenth century and comprise over 50,000 individual sculptures distributed across more than 75 locations. Notably, the Beishan and Baodingshan complexes are celebrated for their intricate iconography, spatial sophistication, and exceptional artistic craftsmanship [11-15].

Unlike the imperially sponsored grottoes of Dunhuang or Yungang, the Dazu Rock Carvings emerged within a decentralized sociopolitical landscape, where local elites, monastic leaders, and lay communities played an active role in religious patronage and artistic production. This grassroots model of cultural creation fostered a pluralistic visual language that seamlessly integrated Buddhist, Daoist, and Confucian elements into a coherent yet diverse iconographic system [16-19]. The resulting artistic expressions not only reflect doctrinal syncretism, but also demonstrate a deep sensitivity to regional religious practices, local identities, and evolving community values.

Although previous scholarship has addressed the religious symbolism and historical background of the Dazu carvings, relatively little attention has been paid to the stylistic mechanisms and spatial strategies through which these works transmitted moral, social, and political meanings over time [5, 20]. This study argues that the artistic development of the Dazu Rock Carvings represents a dynamic mode of visual communication, wherein changes in sculptural form, niche architecture, and iconographic emphasis were closely tied to shifting patterns of ritual practice, social structure, and cultural resilience.

Centering on the Beishan site's Fowan Cliff, this paper examines the carvings' stylistic and functional transformation through five interrelated domains: (1) typological differentiation of artistic forms; (2) iconography as a tool for ethical and metaphysical education; (3) ritual activation of sculptural space,

particularly in lay Buddhist feasting; (4) visual responses to warfare and collective trauma; and (5) the role of digital technologies in the sustainable preservation and reinterpretation of the site. By integrating historical analysis with contemporary approaches to digital heritage, the study positions the Dazu Rock Carvings as a vital case of culturally embedded sustainability—where tradition, innovation, and community engagement converge across centuries [21-23].

2. Artistic typologies of the Dazu Rock Carvings

The artistic typologies of the Dazu Rock Carvings reflect a complex and sustainable visual system shaped by evolving religious beliefs, ritual practices, and socio-political dynamics. Distributed across major sites such as Beishan and Baodingshan, these carvings developed into five principal categories: monumental narrative reliefs, votive niches, ritual feast shrines, protective deity niches, and hybrid or syncretic compositions. Each typology exhibits unique iconographic conventions, spatial configurations, and community-oriented functions, illustrating how visual forms were adapted to meet changing cultural needs over time.

By embedding religious ideology and ethical instruction into enduring stone media, these typologies served as durable vehicles for intergenerational knowledge transfer, moral education, and identity reinforcement. Moreover, the carvings' site-specific spatial arrangements supported inclusive communal worship and localized ritual performance, offering a model of cultural sustainability rooted in visual tradition, social interaction, and environmental integration. As such, the typological diversity of the Dazu Rock Carvings not only testifies to artistic innovation, but also underscores their role in fostering cultural resilience and long-term heritage continuity.

2.1. Monumental narrative reliefs

Monumental narrative reliefs—most notably at Baodingshan under the direction of the monk Zhao Zhifeng—embody a didactic visual tradition designed to convey Buddhist cosmology, karmic causality, and ethical principles. These large-scale carvings, often extending over ten meters, utilize sequential storytelling and hierarchical composition to guide viewers through complex spiritual journeys. The rhythm and coherence of the imagery evoke the experience of reading sacred texts, transforming the cliff face into a sustainable medium of visual scripture.

A representative example is the "*Three Lives and Causality*" relief, which narrates a moral arc from past misdeeds through present suffering to future rebirth. The composition fuses allegory with striking depictions of heavenly reward and infernal punishment. In particular, the *Ten Courts of Hell* scene delivers a vivid moral warning, making abstract doctrines tangible through emotionally resonant imagery.

This genre of relief carving served multiple sustainable functions: it preserved religious knowledge across generations, facilitated public moral education in a largely illiterate society, and reinforced collective ethical norms. By embedding spiritual lessons in durable stone, these narrative tableaux became instruments of ethical governance and social cohesion. Their monumental scale, visual clarity, and emotive expressiveness reflect how religious art functioned not only as a form of spiritual edification, but also as a mechanism for sustaining communal identity, resilience, and long-term cultural continuity.

2.2. Votive niches and donor shrines

Situated primarily along the lower and central tiers of Beishan's Fowan Cliff, votive niches represent one of the earliest and most standardized sculptural typologies within the Dazu Rock Carvings. Typically centered on sacred figures such as Amitābha, Avalokiteśvara (Guanyin), or Kṣitigarbha, these niches were commissioned

by individual patrons or collective groups, and frequently accompanied by inscriptions that detail donor names, kinship ties, and devotional intentions. Their symmetrical compositions and accessible scale—often organized around triadic or centrally enthroned figures—underscore their role in everyday spiritual practice.

As material embodiments of lay piety, votive niches functioned as socially inclusive spaces for merit-making, ethical aspiration, and intergenerational remembrance. Their inscriptions not only anchor the carvings within specific historical and familial contexts, but also offer insight into local networks of religious patronage, gender roles, and communal belief systems. In this way, votive shrines served as durable interfaces between private devotion and public memory, sustaining moral values, identity narratives, and cultural continuity over time. By embedding belief, biography, and social structure into the cliff face, these niches contributed to a form of cultural sustainability rooted in community engagement and long-term visual presence. As such, they reflect how localized religious practice and vernacular artmaking reinforced shared ethical frameworks and spiritual resilience in premodern society.

A representative example is Niche No. 245 at Beishan (as shown in Figure 2), which presents an iconographic scheme derived from the Amitāyurdhyāna Sūtra. At its center, Amitābha Buddha is seated in serene composure, flanked by Guanyin and Mahāsthāmaprāpta to form a canonical Pure Land triad. Surrounding the central deities are rows of donor figures carved in proportionally smaller scale, depicted kneeling or standing in gestures of devotion.

Figure 2. Visualization of the Amitāyurdhyāna Sūtra Amitāyus visualization sutra relief

The accompanying inscriptions provide detailed information about the donors—including names, gender, and familial relationships—thereby transforming the niche into a social document as well as a spiritual one. These records anchor the artistic production within a concrete historical and communal context, revealing the participatory nature of lay patronage and the interweaving of religious merit-making with kinship identity and collective memory.

The precise carving, iconographic clarity, and narrative structure of this niche exemplify how sculptural practice functioned as a vehicle for both devotional expression and cultural sustainability. It demonstrates how visual form was mobilized to preserve not only spiritual aspiration but also the lived realities of the communities who commissioned it—sustaining ethical values, social ties, and religious continuity through time-anchored stone media.

2.3. Ritual Feast Shrines

Emerging during the Northern and Southern Song dynasties, ritual feast niches—also referred to as Ritual Feast Shrines or Feast Offering Niches—represent a significant evolution in both sculptural form and liturgical function. Designed to accommodate communal rites such as the Shui-Lu (Water and Land) ceremonies, these niches are characterized by expanded interiors, integrated altars, and circumambulatory spatial arrangements. Figures are often organized around central altars or along curved interior walls, encouraging ritual interaction and immersive engagement. The proliferation of such shrines reflects the growing involvement of lay communities and the embedding of religious performance within the rhythms of local social life.

Figure 3. Niche No. 165 at Fowan Cliff, Beishan – Ritual Feast Shrine

A compelling example is Niche No. 165 at Beishan's Fowan Cliff (see Figure 3), which features a spatially dynamic composition centered on a carved altar platform. A seated Buddha occupies the focal position, flanked by bodhisattvas, guardian kings, and donor inscriptions. The open architectural layout and multi-directional figural arrangement clearly support communal ritual activity, including chanting, incense offerings, and potentially the recitation of repentance texts. The presence of ritual implements and spatially engaged iconography suggests that this niche functioned not merely as a site of visual devotion, but as a performative environment where image, body, and action were closely intertwined.

As living religious spaces carved in enduring stone, ritual feast niches exemplify how sculptural environments sustained intangible cultural practices—ritual gestures, community gatherings, and ethical reflection—across generations. Their architecture facilitated embodied participation, fostering social cohesion and reinforcing a shared moral framework. In this way, feast niches offer a compelling example of cultural sustainability, where material design and ritual continuity work in tandem to preserve and transmit collective values over time.

2.4. Protective Deity Niches

During periods of political unrest and collective anxiety, a distinct sculptural category emerged within the Dazu Rock Carvings: Protective Deity Niches, featuring fierce guardian figures drawn primarily from Esoteric Buddhist traditions. These niches visually articulated divine protection, serving as spiritual bulwarks against calamity, disease, warfare, and social upheaval. They not only safeguarded physical well-being but also symbolically reinforced moral order and communal solidarity.

The guardian deities—often wrathful in expression and dynamic in posture—include Mahāmāyūrī (the Peacock King), Mārīcī, and the Eight Great Dharmapālas. Characterized by multiple arms, flaming halos, ritual weapons, and animal mounts such as lions, peacocks, or boars, these figures embodied supernatural efficacy and visual intensity. Their iconographic complexity was designed to evoke awe, reverence, and emotional assurance amid instability.

One powerful example is Niche No. 130 at Beishan, where Mārīcī is depicted with three heads and eight arms, standing atop a chariot pulled by boars. Flanked by the Eight Dharmapālas in high relief, the figures are adorned with elaborate armor and captured in motion, amplifying the niche's visual rhetoric of militant protection. The spatial composition and monumental scale emphasize the niche's function as a site of ritual activation and communal defense. Another exemplar is found at Baodingshan, where Mahāmāyūrī (the Peacock King) appears enthroned atop a vibrantly fanned peacock, encircled by flames and ritual instruments. Her serene meditative pose contrasts with the intense visual language of protection, symbolizing the balance between compassion and force—an ethical duality central to Esoteric Buddhist cosmology.

These niches served not only as devotional spaces but also as culturally embedded mechanisms of spiritual resilience, translating collective fears into materialized iconographies of safety and moral boundary. Their enduring presence in stone reflects how visual culture responded to existential threats by offering communities a sustainable framework for protection, emotional catharsis, and moral anchoring during turbulent times.

Figure 4. Niche No. 6 at Baodingshan: Samantabhadra with filial piety scenes

2.5. Hybrid and syncretic forms

A compelling example of religious syncretism is found in Niche No. 6 at Baodingshan (see Figure 4), where the bodhisattva Samantabhadra is portrayed in solemn composure above a series of Confucian-themed filial piety scenes. At the base of the niche, smaller sculpted vignettes depict sons tending to ill parents, sacrificing personal well-being, or honoring ancestral obligations—narratives drawn from the Confucian Twenty-Four Filial Exemplars. The serene bodhisattva figure presides above these acts of earthly virtue, visually integrating Buddhist compassion with Confucian morality. This juxtaposition within a unified sculptural composition exemplifies the broader social aspiration toward spiritual inclusivity and ethical harmony.

More broadly, hybrid compositions within the Dazu Rock Carvings incorporate iconographic elements from Buddhism, Daoism, and Confucianism, reflecting the inclusive religious ecology of the time. These syncretic niches often pair Daoist immortals with Buddhist protectors or frame Buddhist deities within Confucian ethical narratives. Rather than signaling theological contradiction, such visual synthesis represented a deliberate cultural strategy—meeting the spiritual needs of diverse lay communities while promoting values such as filial piety, reciprocity, and moral integrity.

These visual convergences reflect a sustainable cultural logic rooted in coexistence and mutual reinforcement. By integrating multiple belief systems into single sculptural programs, the Dazu artisans created spaces where diverse identities and moral frameworks could find resonance and unity. The resulting

hybridity not only enriched religious expression but also reinforced cultural cohesion, ensuring that the site remained spiritually accessible and socially meaningful to a broad spectrum of worshippers.

Taken together, the five artistic typologies discussed—narrative reliefs, votive niches, ritual feast shrines, protective deity niches, and hybrid forms—demonstrate the rich multidimensionality of the Dazu Rock Carvings. They reveal how sculptural art served as a sustainable medium for religious devotion, ethical education, ritual activation, and social governance. In doing so, the carvings embody the dynamic interplay between visual culture and cultural continuity in medieval Chinese society.

2.6. Iconography and the mechanism of cultural transmission

Figure 5 visualizes the conceptual logic through which iconography at the Dazu Rock Carvings operated as a system of cultural transmission. Beginning with foundational visual strategies, the diagram traces how carved imagery conveyed moral instruction, integrated syncretic belief systems, reinforced social hierarchies, and facilitated embodied ritual practice—ultimately forming a cohesive framework for sustaining and communicating cultural values across generations.

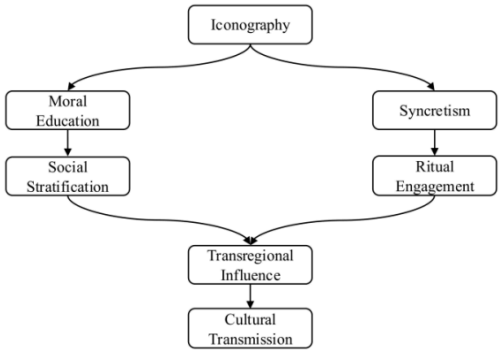

Figure 5. Conceptual flow of iconography

The iconography of the Dazu Rock Carvings was not created solely for devotional purposes; it also functioned as a sophisticated visual medium for encoding and disseminating ethical norms, philosophical ideas, and collective identity. Carefully curated across the site, the visual programs were designed to reflect and harmonize the core teachings of Confucianism, Buddhism, and Daoism. By translating these doctrinal principles into accessible and emotionally resonant forms, the carvings created a shared visual language that was intelligible to both common villagers and literate elites.

Through this integrated iconographic approach, the site served as a sustainable conduit for cultural education and moral reinforcement—transmitting belief systems not only through text and ritual, but through visual storytelling that could endure physically and resonate socially. In doing so, the carvings embodied a model of culturally embedded sustainability, where spiritual wisdom, social ethics, and artistic expression converged to maintain coherence within a diverse and evolving society.

2.7. Visual literacy and moral education

The carvings at Dazu functioned not only as objects of religious devotion, but also as vital instruments of public moral education. Through carefully composed narrative reliefs and accessible devotional sculptures, viewers encountered ethical teachings embedded in visual form. Themes such as karmic causality, filial piety, and the cyclical nature of rebirth were communicated through vivid, emotionally charged imagery that invited contemplation and reflection.

In a historical context where textual literacy was limited, particularly among the lower classes, these carvings provided an inclusive and sustainable channel for ethical instruction. Visual motifs—such as the *Ten Kings of Hell*, scenes of divine judgment, and tales of virtuous sacrifice—offered a common symbolic vocabulary that transcended linguistic and social boundaries. By linking Buddhist cosmology with Confucian moral values, the iconography helped standardize behavioral expectations and reinforce communal norms.

This visual pedagogy reflects a sustainable model of knowledge transmission in which religious doctrine and social ethics were preserved and disseminated across generations through emotionally resonant and cognitively accessible imagery. As such, the Dazu Rock Carvings exemplify how sacred art can function as a medium of cultural education, enabling communities to internalize complex moral systems without reliance on formal instruction or written texts.

2.8. Syncretism as cultural strategy

A defining feature of the Dazu iconographic program is its intentional fusion of Confucian, Daoist, and Buddhist traditions—an approach that transformed potential doctrinal divergence into a coherent visual narrative. Within a single niche, one might encounter Confucian sages, Daoist immortals, and Buddhist bodhisattvas depicted side by side—not in competition, but as complementary agents of ethical and metaphysical insight. This visual harmony was not merely aesthetic; it embodied a strategic response to the complex religious and social landscape of the time.

Such syncretism functioned as a cultural strategy aimed at promoting spiritual inclusivity, social cohesion, and ethical convergence. By visually uniting the Three Teachings into a shared symbolic language, the carvings enabled viewers from different backgrounds—be they officials, monks, or laypersons—to find resonance and relevance within a common spiritual framework. This inclusivity was particularly vital during periods of political instability and ideological fragmentation, when symbolic integration helped maintain societal continuity.

Figure 6. Syncretic imagery at Shimenshan: the western trinity and ten manifestations of Guanyin

The result was a flexible yet enduring system of cultural sustainability, in which diverse worldviews were not erased, but visually harmonized to meet the collective needs of a pluralistic society. Through this iconographic strategy, the Dazu Rock Carvings did more than represent belief—they actively shaped a resilient moral ecology, making abstract doctrines visible, relatable, and socially durable.

Figure 6 presents Niche No. 6 at Shimenshan, Dazu, as a vivid example of visual syncretism, where Buddhist, Daoist, and Confucian elements are seamlessly integrated within a single sculptural composition. At its center stands a Pure Land triad—Amitābha Buddha flanked by Guanyin and Mahāsthāmaprāpta—representing the doctrinal core of Mahāyāna Buddhism. Surrounding this triad are the Ten Manifestations of

Guanyin, each characterized by distinct gestures, attributes, and postures that draw from Daoist iconography and localized folk traditions. These figures emphasize Guanyin's responsive, protective roles, extending beyond the canonical Buddhist framework to embrace popular and Daoist modes of devotion.

This compositional approach exemplifies visual syncretism as a deliberate cultural strategy—bringing together religious figures from different traditions not in contradiction, but in symbolic harmony. Rather than enforcing doctrinal boundaries, the niche offers a visual environment in which Confucian officials, Daoist practitioners, and Buddhist laypeople could all find spiritual relevance. By accommodating diverse devotional expectations, this hybrid iconography enhanced accessibility while reinforcing core ethical ideals such as compassion, loyalty, reciprocity, and moral responsibility.

3. Ritual, space, and art: lay feasting as visual practice

Figure 7 illustrates the conceptual framework for this section, titled "Ritual, Space, and Art: Lay Feasting as Visual Practice". At its center lies a pivotal innovation within the Dazu Rock Carvings: the development of lay feast niches—architectural and sculptural ensembles that transformed static devotional imagery into immersive, participatory ritual environments. These niches exemplify how religious art and spatial design converged to support communal worship, embodied piety, and ethical reinforcement.

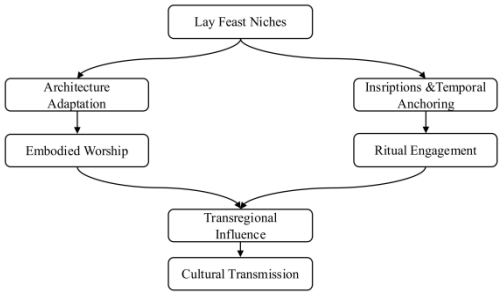

Figure 7. Conceptual structure for "ritual, space, and art: lay feasting as visual practice"

Radiating from this core are five interrelated analytical domains that together articulate the sustainable social and spatial logic of lay ritual practices:

• Architectural Adaptation: Feast niches feature intentional spatial modifications—such as increased depth, integrated altar platforms, and radial figure arrangements—specifically designed to facilitate liturgical functions, embodied movement, and immersive engagement.

• Inscriptions and Temporal Anchoring: Epigraphic records of dates, patrons, and ritual purposes embed the sculptures within cyclical temporal frameworks, linking them to seasonal festivals, civic calendars, and intergenerational memory practices.

• Embodied Worship: The architectural layout of the niches promotes physical and sensory interaction—through processions, chanting, and circumambulation—thereby transforming the site into an emotionally charged and participatory sacred environment.

• Social Cohesion and Ethical Integration: Communal sponsorship and collective ritual performance translated abstract ethical values—such as filial piety, compassion, and reciprocity—into concrete, visible practices of shared moral identity.

• Visual-Ritual Hybridity: These elements converge in a hybrid mode of religious expression, in which visual iconography is activated through performance. Worshippers are not mere observers but co-participants, sustaining cultural memory through ritualized visual engagement.

One of the most distinctive innovations in the stylistic and functional evolution of the Dazu Rock Carvings is the emergence of ritual niches specifically designed for lay Buddhist feasting. Especially prominent during the Northern and Southern Song periods, these spaces marked a transformative shift in religious sculpture—from static icons of veneration to dynamic, participatory environments of ritual practice. Unlike conventional devotional niches intended for passive contemplation, these feast-oriented carvings were fully integrated into communal ritual performances involving offerings, chanting, and shared meals. The spatial arrangement—often featuring figures encircling a central altar platform—was deliberately crafted to encourage bodily movement and multisensory engagement, transforming the carved space into a fully embodied spiritual experience.

These lay feast niches not only supported the pursuit of individual spiritual merit, but also served as communal platforms for ethical reinforcement, social cohesion, and intergenerational memory. Their visual and architectural design reveals how sculpture at Dazu evolved to accommodate the lived dimensions of religious life—blending sacred art with communal participation. As such, they exemplify a sustainable model of ritual space-making, where spiritual meaning is continuously renewed through shared practice, cultural inclusion, and spatial immersion.

3.1. Architectural adaptation to ritual use

Feast shrines at Beishan—particularly those along the middle tiers of the Fowan Cliff—exemplify deliberate architectural modifications designed to support the embodied dimensions of Buddhist ritual practice. Many niches were carved with increased depth and spatial openness, allowing small groups of worshippers to enter, move within, or perform offerings at the threshold of the sacred space.

A common feature of these shrines is the presence of centrally carved altar platforms, which served dual functions: visually anchoring the surrounding deity figures and physically accommodating ritual objects and offerings. The spatial configuration of figures—often arranged in radial, symmetrical, or procession-like formations—reflects intentional alignment with the performative logic of Buddhist liturgies, such as the Shui-Lu (Water and Land) Rite.

This careful choreography of architecture and image transformed the niche from a passive viewing structure into an interactive ritual stage. The sculptural layout encouraged multisensory, movement-based engagement, integrating religious iconography with bodily participation. Such architectural adaptations demonstrate how sacred space at Dazu evolved to sustain ritual performance and foster participatory spiritual experiences, making the carved environment a site of living religious and communal practice.

3.2. Inscriptions and temporal anchoring

Many lay feast niches at Dazu include inscriptions that meticulously record the dates, ritual purposes, donor names, and kinship affiliations associated with their creation. These epigraphs transform the niches from abstract devotional icons into historically situated artifacts, linking sculptural form to the temporal rhythms of religious, civic, and familial life.

Some inscriptions reference specific festivals, agricultural cycles, or ancestral commemorations, revealing how these ritual practices were deeply embedded within seasonal, calendrical, and communal structures. As such, the textual layer functions as more than an annotation—it serves as a temporal and social anchor, embedding the niche within the lived experiences and ritual timeframes of its sponsoring community.

Through the integration of inscription and image, these feast niches transcend their material form to become multivalent records of memory, identity, and religious continuity. They not only preserved acts of devotion but also inscribed them within the socio-temporal fabric of local culture, offering a sustainable means

of transmitting values and histories across generations. In this way, the epigraphs underscore how religious art at Dazu functioned as both spiritual medium and documentary mechanism—a fusion of sacred intention and temporal specificity.

3.3. Visual participation and embodied worship

The spatial and figural design of lay feast niches at Dazu was intentionally crafted to foster active visual participation and embodied ritual engagement. Worshippers were not positioned as passive viewers, but as physically engaged participants who moved through, around, and within the sculptural space. The openness and scale of many niches suggest that they were purposefully designed to accommodate ritual processions, circumambulation, chanting, and incense offering.

Through these multisensory and kinetic practices, the carved space was not merely observed—it was ritually activated, filled with sound, scent, gesture, and collective emotion. In this context, sculpture transcended its function as a static visual artifact and operated as a ritual catalyst—a spatial medium through which devotion was enacted, amplified, and made personally meaningful.

These immersive environments enabled worshippers to internalize religious teachings through the full sensorium—engaging not only sight, but also movement, breath, voice, and proximity. As such, the feast niches exemplify a sustainable model of sacred space, where embodied worship reinforces cultural memory, ensures the continuity of practice, and transforms carved stone into a living vessel of communal spirituality.

3.4. Social cohesion and ethical integration

The lay feast shrines at Dazu played a critical role in cultivating social cohesion and ethical solidarity. Families, neighborhood associations, craft guilds, and other community groups frequently co-sponsored niches as public expressions of shared piety, intergenerational responsibility, and collective identity. These collaborative acts of patronage transformed intangible moral values—such as filial piety, karmic reciprocity, and compassion—into tangible, ritualized expressions of social virtue.

By embedding ethical narratives directly into the sculptural and performative fabric of the shrine, the carvings gave moral teachings both material visibility and communal legitimacy. Worship thus extended beyond personal devotion to become a public enactment of ethical ideals, reinforcing bonds between individuals and community, and between memory and action.

In this way, the feast niches exemplify a sustainable moral ecology, in which religious practice serves not only spiritual needs, but also collective ethical formation. The visual and ritual convergence of belief and behavior sustained shared values across time, embedding morality within the very architecture of communal life.

3.5. Visual-ritual hybridity in lay buddhism

The ritualized carvings of the Dazu feast niches embody a broader aesthetic and devotional tendency in Song Dynasty lay Buddhism: the integration of text, image, space, and embodied practice. These niches exemplify a visual-ritual hybridity, wherein iconography is not a static object of veneration, but a performative script activated through communal liturgy. The niche becomes a ritual stage, the sculpture a materialized liturgical text, and the worshipper both actor and audience in a shared sacred performance.

This participatory model dissolves conventional distinctions between sacred image and sacred action. Within this immersive framework, seeing, doing, and believing are interdependent modes of religious engagement—ritual meaning emerges not from passive observation, but from physical interaction, spatial

movement, and collective rhythm. The visual thus becomes kinetic, and the carved form becomes a living vessel for performative devotion.

In sum, the lay feast niches at Dazu exemplify a holistic mode of religious experience, in which sculpture, architecture, and ritual practice are seamlessly interwoven. Far from being mere decorative or symbolic spaces, these environments actively shaped moral perception, community identity, and spiritual continuity. As such, they offer a sustainable model of devotional art as participatory heritage, where meaning is continually renewed through use, memory, and embodied presence.

4. Digital preservation and cultural sustainability in the 21st century

In the digital age, the preservation and revitalization of cultural heritage sites such as the Dazu Rock Carvings face both unprecedented threats and transformative opportunities. Climate change, environmental degradation, urban encroachment, and mass tourism have collectively intensified the urgency for innovative, sustainable strategies in heritage management.

Simultaneously, rapid advancements in digital technologies—including 3D scanning, AI-assisted restoration modeling, Virtual Reality (VR), and digital archiving—have opened new frontiers for the safeguarding, study, and reinterpretation of historic sites. These tools not only enhance the precision, efficiency, and non-invasiveness of documentation and conservation, but also expand public access and engagement through immersive virtual environments and open-access platforms.

By bridging cutting-edge innovation with cultural stewardship, digital preservation enables heritage sites like Dazu to be reimagined as dynamic knowledge systems—not confined to physical geography, but accessible across time, space, and social boundaries. This technological integration marks a shift from static conservation to interactive sustainability, ensuring that cultural memory is not only protected but transmitted, experienced, and renewed for future generations.

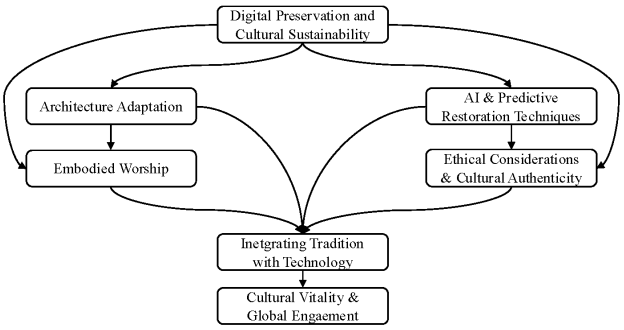

Figure 8. Digital preservation and cultural sustainability logic diagram

Figure 8 presents an integrated framework for the digital preservation and cultural sustainability of heritage sites such as the Dazu Rock Carvings. At the center of the diagram lies the core concept of Digital Preservation and Cultural Sustainability, supported by six interrelated components that operate in synergy:

• 3D Scanning and Digital Modeling: High-resolution scanning technologies allow for detailed documentation and the generation of precise digital replicas, supporting long-term monitoring, non-invasive analysis, and accurate restoration planning.

• AI and Predictive Restoration Techniques: Artificial intelligence tools enable predictive modeling and virtual reconstruction of damaged or inaccessible areas, expanding conservation possibilities while reducing physical intervention risks.

• Virtual Reality and Public Engagement: Immersive VR technologies democratize access to cultural heritage by allowing remote and inclusive exploration, thereby enhancing global awareness, education, and participatory experience.

• Integrating Tradition with Technology: Hybrid approaches that combine traditional craftsmanship with digital tools ensure that preservation remains culturally grounded while embracing innovation.

This framework underscores the necessity of a collaborative, multi-disciplinary approach that harmonizes modern technological capacity with ethical heritage stewardship and community-based knowledge systems. By doing so, sites like the Dazu Rock Carvings can become living cultural assets—preserved not only materially, but socially, spiritually, and intergenerationally.

4.1. 3D scanning and digital modeling

High-resolution 3D scanning technologies have become indispensable tools in the systematic documentation and sustainable conservation of the Dazu Rock Carvings. By capturing fine-grained topographic and surface data, these technologies allow conservators to construct precise, scalable digital models that serve dual purposes: as permanent archival records and as analytical platforms for restoration planning. These digital surrogates facilitate longitudinal analysis, enabling researchers to track subtle changes in surface erosion, structural stress, and material degradation—often beyond what the human eye can detect. Moreover, they offer the unique benefit of simulating conservation strategies in virtual space, allowing interventions to be tested, adjusted, and optimized before any physical action is taken.

By minimizing physical intervention and maximizing precision, 3D scanning not only safeguards the structural and material integrity of heritage sites but also transforms them into durable digital cultural assets. These virtual models can be archived, studied, and disseminated across generations, independent of environmental degradation, natural disasters, or geopolitical instability.

4.2. AI and predictive restoration techniques

Artificial Intelligence (AI) and machine learning are increasingly transforming the field of heritage conservation by enabling predictive restoration of damaged or inaccessible elements. By training algorithms on large datasets of iconographic, stylistic, and morphological patterns from comparable artworks, AI can generate historically plausible reconstructions of eroded statues, missing fragments, or mural surfaces. This approach is especially valuable when physical access is limited, or where irreversible deterioration precludes traditional restoration techniques. AI-powered models can simulate multiple reconstruction scenarios virtually, allowing conservators to compare alternatives and make informed, non-invasive decisions.

Moreover, these tools offer deeper insight into the underlying structure and stylistic intent of the original works—revealing patterns and symmetries that may be obscured to the human eye. In this way, predictive restoration not only enhances technical accuracy but also contributes to a sustainable conservation paradigm, where data-driven reconstruction coexists with ethical preservation standards, ensuring the integrity and interpretive richness of heritage artifacts for future generations.

In recent years, generative models have emerged as a transformative tool in digital heritage research, offering new possibilities for the virtual restoration of damaged cultural artifacts, including rock carvings. Techniques such as Generative Adversarial Networks (GANs) [24], Variational Autoencoders (VAEs) [25], and more recently, Diffusion Models [26], are being actively explored for their capacity to learn from intact historical datasets and synthesize stylistically coherent and morphologically plausible reconstructions of missing or eroded components.

Among these, diffusion-based approaches have demonstrated particular effectiveness in inpainting tasks, as they generate visual content through a step-wise probabilistic denoising process. This allows for iterative refinement and high visual fidelity, making them ideal for the non-invasive digital simulation of restoration scenarios. Such methods not only help preserve the material authenticity of the original artifact but also enrich interpretive access, comparative analysis, and data-driven conservation planning.

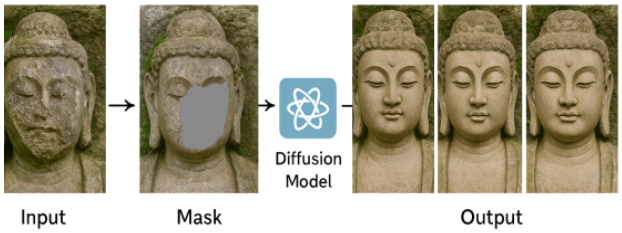

Figure 9. Diffusion Model Example

Figure 10. VR examples

Figure 9 presents a conceptual flowchart illustrating how diffusion models can be applied in AI-assisted restoration workflows—specifically within the context of culturally significant but physically deteriorated sites like the Dazu Rock Carvings.

4.3. Virtual reality and public engagement

Virtual Reality (VR) [27] and immersive media technologies have profoundly transformed how the public interacts with cultural heritage. Through high-fidelity VR reconstructions of the Dazu Rock Carvings, global audiences can now remotely access and explore this sacred landscape—overcoming traditional barriers of geography, mobility, and preservation restrictions. These digital environments go beyond passive display: they offer interactive storytelling, guided tours, and ritual simulations that engage users cognitively, emotionally, and even spiritually. For younger generations in particular, VR enables meaningful encounters with ancient artistic traditions through familiar digital formats, thereby cultivating cross-generational cultural continuity.

Moreover, by democratizing access to cultural heritage, immersive platforms foster broader public awareness, deepen cultural appreciation, and help build collective support for long-term preservation initiatives. In this context, Virtual Reality (VR) is not merely a medium for digital tourism; it becomes a vehicle for ethical engagement, inclusive education, and sustainable heritage stewardship. It allows users across generations and geographies to experience endangered cultural sites in ways that are both accessible and emotionally resonant. Figure 10 illustrates the conceptual fusion of physical presence and virtual

simulation in the context of heritage engagement. On one side, the visitor's embodied experience is grounded in a physical environment, while the other side reveals a digitally reconstructed heritage space—such as a cave temple or rock carving complex—enabled by VR technologies. This visual metaphor highlights the evolving relationship between tangible heritage and immersive digital access, emphasizing how technological integration can extend cultural memory and participatory preservation beyond physical limitations.

4.4. Ethical considerations and cultural authenticity

While digital technologies provide powerful tools for the preservation and revitalization of cultural heritage, they also introduce critical ethical challenges—particularly regarding authenticity, authorship, and material integrity. Digital reconstructions, if not properly contextualized, risk being misinterpreted as definitive historical truths, thereby obscuring the uncertain or interpretive nature of restoration hypotheses. To mitigate these risks, conservation professionals, digital humanists, and heritage communities must engage in interdisciplinary collaboration to ensure that digital interventions are designed to supplement—not supplant—the embodied, site-specific experience of cultural heritage. This involves transparent documentation of digital processes, clear differentiation between original and reconstructed elements, and careful communication of interpretive boundaries.

Ultimately, the responsible integration of digital tools requires a balance between innovation and cultural accountability. By foregrounding ethical stewardship, such practices can help sustain not only the physical artifacts themselves, but also the cultural meanings, values, and relationships embedded within them.

4.5. Integrating tradition with technology

The sustainable preservation of the Dazu Rock Carvings depends on a holistic, interdisciplinary approach—one that bridges traditional craftsmanship and emerging digital technologies. Rather than replacing ancestral knowledge, innovative tools should be used to extend, support, and reinterpret it. Examples include training local artisans in digital documentation techniques, integrating oral histories and intangible heritage into 3D models, and using augmented reality to visualize past ritual practices in situ. In this context, digital heritage is not a rupture, but a continuation and augmentation of cultural memory. It represents an evolving interface where past wisdom meets future innovation, ensuring that traditional practices are not only archived, but revitalized and recontextualized for contemporary relevance.

Ultimately, the goal of digitally preserving the Dazu Rock Carvings is not merely survival, but cultural vitality. By respecting the symbolic and historical integrity of the site while embracing new tools for engagement and transmission, these masterpieces can remain living heritage—resonant across generations and meaningful within a rapidly changing global context.

5. Conclusion

The Dazu Rock Carvings stand as a powerful testament to the enduring interplay between artistic expression, spiritual devotion, and cultural identity in Chinese history. Over the centuries, their stylistic evolution has mirrored broader transformations in political authority, religious practice, and social values—from the protective votive imagery of the Late Tang, to the lay-sponsored ritual niches of the Song, to the syncretic visual narratives integrating Confucian, Buddhist, and Daoist traditions. More than static artifacts, these carvings functioned as dynamic instruments of cultural transmission. Their iconography conveyed moral instruction, their spatial design facilitated communal ritual, and their presence offered emotional catharsis and spiritual reassurance—especially during periods of uncertainty and crisis. In this way, the Dazu Rock Carvings

have long served as material anchors of cultural resilience and ethical cohesion. In the digital age, new technologies—from 3D scanning and AI-assisted restoration to immersive VR environments—have expanded the possibilities for preserving, interpreting, and sharing this invaluable heritage. These tools allow us to safeguard the material site while revitalizing its cultural meanings for contemporary and future audiences.

The legacy of the Dazu Rock Carvings is thus not static but dynamic—a living expression of cultural sustainability. By embracing both tradition and innovation, we ensure that these masterpieces continue to speak across generations, bridging the past with the future and sustaining a profound dialogue between stone, spirit, and society.

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