Media and Communication Research (2025)
Clausius Scientific Press, Canada

DOI: 10.23977/mediacr.2025.060317
ISSN 2523-2584 Vol. 6 Num. 3

Digital Protection and Inheritance: The Modern Way of Protecting Cangyuan Rock Painting

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Keywords: Cangyuan Rock Painting, Painted Rock Paintings, Cultural Heritage Revitalization, Digital Recording and Preventive Protection

Abstract: The Cangyuan rock painting, a precious prehistoric cultural heritage in southwestern China, document the social, economic, and spiritual life of the frontier ancestors from 3800 to 2700 years ago. With the rapid advancement of digital technology, the conservation efforts for the Cangyuan rock painting are transitioning from traditional methods to digital approaches. This article systematically reviews the historical value and current research status of the Cangyuan rock painting, delves into the practical applications of digital recording technologies, explores innovative models of digital technology in the protection and inheritance of rock painting, and proposes strategies to address the challenges currently faced in conservation efforts. The study shows that digital technology not only provides new methods for the scientific preservation of the Cangyuan rock painting but also opens up new pathways for the revitalization and utilization of cultural heritage, offering significant insights for the global conservation of rock art heritage.

1. Introduction: Cultural value and protection challenges of Cangyuan rock painting

The Cangyuan rock painting, located in Cangyuan Wa Autonomous County, Lincang City, Yunnan Province, are primarily found on the rock faces of the Lancang River Basin. They are among the oldest and best-preserved rock paintings discovered in China to date. On June 25,2001, the State Council designated them as a national key cultural relic protection unit, marking their significant status within the national cultural heritage system[1] .

The Cangyuan rock painting include over 1,200 identifiable images, primarily depicting feathered, horned, tailed, and eared figures, which make up 74% of the total images[2]. The paintings also feature animals such as cattle, monkeys, bears, elephants, and wild boars, as well as symbols like tree houses, villages, the sun, the moon, bows, and spears. These images depict activities such as hunting, warfare, rituals, nesting, migration, funerals, and music and dance[3]. These images provide a rare and comprehensive record of the societies and spiritual world of the ancestors in the prehistoric southwestern border region, offering important archaeological evidence for studying ancient ethnic exchanges, diffusion history, religious, and cultural and artistic history in southwestern China and the Lancang-Mekong River Basin countries[4].

However, for over 2,000 years, the Cangyuan rock painting have faced dual threats from natural weathering and human destruction. Over time, the patterns have become increasingly blurred. The old folks used to say that 'the colors of the Cangyuan rock painting would change with the time of day, weather conditions, and temperature, changing three times a day: red in the morning, pale by noon, and purple in the evening,' but this seems to be a legend. Among the 15 rock painting sites, only a few still retain relatively clear images; most have become indistinct, with some eroded by natural weathering, others severely damaged by human activities, and some completely lost[5].

Faced with this severe situation, traditional conservation methods are no longer sufficient to meet the long-term preservation and research needs of the Cangyuan rock painting. Since 2018, under the support and guidance of the Cultural Heritage Administration and the Yunnan Provincial Cultural Heritage Administration, the Yunnan Provincial Institute of Cultural Relics and Archaeology has collaborated with over ten domestic and international universities and research institutions to conduct systematic surveys, documentation, and digital protection of the Cangyuan rock painting[6]. This project marks a significant shift in the conservation efforts for the Cangyuan rock painting from traditional methods to digital means, offering new ideas and practical examples for the global conservation of rock art heritage[7].

2. Technical practice of digital recording of Cangyuan rock painting

The digital preservation of the Cangyuan rock painting began in 2018, led by the Yunnan Provincial Institute of Cultural Relics and Archaeology, in collaboration with over a dozen universities and research institutions from China and abroad. This comprehensive project adopted an interdisciplinary approach, integrating advanced methods from archaeology, chronology, materials science, and digital technology, laying a solid foundation for the scientific preservation and in-depth study of the rock painting[8].

2.1. High precision dating technology

Determining the absolute age of the Cangyuan rock painting is crucial for understanding their cultural significance and historical value[9]. The project team used uranium-series dating, an internationally recognized method for dating rock art, to systematically analyze 68 samples from 8 representative sites of the Cangyuan rock painting[10]. This method calculates the formation age of the sediment by measuring the ratio of uranium and its decay products in the secondary carbonate deposits covering the rock art, thereby determining the time frame in which the rock art was created. The primary advantage of this method is its ability to directly date the rock art itself, without relying on indirect evidence from nearby archaeological sites[11].

The research findings indicate that the Cangyuan rock painting span from 3800 to 2700 years ago, suggesting that the tradition of painting these rock painting in this region lasted approximately 1100 years[12]. This discovery not only fills a gap in the chronology of Cangyuan rock painting but also provides valuable insights into the relationship between the rock art traditions of southwestern China and Southeast Asia. Notably, the content of the rock painting exhibits distinct characteristics of different periods, showing similarities with some rock paintings in Southeast Asia, suggesting that the artists may have had interactions with ethnic groups in South China and Southeast Asia[13].

2.2. 3D scanning and digital modeling

To address the threats of natural weathering and human destruction to the Cangyuan rock painting, the project team employed high-precision 3D scanning technology to comprehensively document the murals[14]. This technology captures 3D point cloud data of the rock painting' surfaces

using laser or structured light scanning, and then generates high-resolution digital models through specialized software. Compared with traditional photography, 3D scanning not only captures the flat image information of the rock painting but also accurately records their surface morphology and texture details, including patterns that have become blurred due to weathering[15].

The completed 3D model not only captures the current state of the rock painting but also enhances the visibility of the patterns through computer processing, aiding researchers in identifying the already blurred image details. As Wu Yun, the project leader, stated, "We conducted a 3D scan of the Cangyuan rock painting to document this precious cultural heritage as soon as possible." Currently, only Point 1 of the Cangyuan rock paintings is open to visitors, and the digital records provide a virtual display for the other unopened points[16].

2.3. Pigment analysis and site survey

In addition to the digital documentation of the rock painting, the research team also conducted a scientific analysis of the pigment composition used in these paintings. By analyzing the pigments from the rock painting and related cultural layers, researchers gained insights into ancient painting techniques and the sources of materials. This information is crucial for the preservation and restoration of the rock painting and provides clues to understanding the technological capabilities and cultural exchanges of prehistoric humans[17].

Meanwhile, the team conducted a systematic archaeological survey of the area where the Cangyuan rock painting are located. They created a topographic map showing the distribution of the rock painting and related sites, and discovered new rock art sites in the basin of the Xiaohai River and its tributaries, as well as surrounding prehistoric sites. These efforts place the rock painting within a broader cultural context, aiding in the understanding of the living environment and social organization of the artists[18].

The digital documentation work also emphasizes integrating with the oral histories of local ethnic minorities. The research team has conducted oral history recording studies for the Wa ethnic group and other local ethnic groups, collecting folk legends and memories about rock painting. This 'living' documentation not only enriches the cultural significance of the rock painting but also provides vivid narrative materials for their digital presentation and dissemination[19].

3. Innovative application of digital technology in the protection and inheritance of rock painting

With the completion of digital documentation, the conservation of the Cangyuan rock painting has entered a new phase. Digital technology not only serves as a recording tool but also acts as an innovative platform for cultural heritage preservation and public education. Through various digital media and creative formats, this ancient cultural heritage is being revitalized in modern society.

3.1. Virtual display and immersive experience

Virtual reality (VR) and augmented reality (AR) technologies have opened up new possibilities for showcasing the Cangyuan rock painting. Using high-precision 3D scanning data, virtual scenes of the rock painting can be created, allowing visitors to 'step into' these sites through head-mounted devices, which are not open to the public due to conservation needs. This immersive experience not only satisfies the public's curiosity but also reduces the risk of damage from on-site visits. The relevant departments in Lincang City have considered introducing VR experience facilities in the Cangyuan rock painting scenic area as a supplement and extension to physical visits.

3.2. Cultural and creative products and digital art creation

The digital resources of the Cangyuan rock painting provide a wealth of material for the cultural and creative industry. Designers can develop local-themed tourism souvenirs, clothing, and home items based on these digital images. These products not only have economic value but also enhance the cultural influence of the rock painting. Furthermore, by integrating elements of the rock painting into modern art installations and digital animations, digital art can bridge the gap between tradition and modernity, giving ancient patterns new artistic life[20].

Cangyuan County has considered adding guide facilities, such as guide maps and audio guides, to the rock painting trail, which can briefly introduce the highlights of the other 14 sites. This will help visitors easily and enjoyably complete their exploration of the rock painting. The digital-based tour system is designed to enhance visitors' experience and deepen their cultural understanding.

3.3. Data sharing and research platform

The digitalization of the Cangyuan rock painting can establish a professional database and research platform for academic sharing. By creating databases for rock painting patterns, dating, and pigment analysis, researchers can conduct cross-regional comparative studies to explore the connections between the rock art traditions of southwestern China and Southeast Asia. Wu Yun stated, "The Cangyuan rock painting are an extremely exquisite prehistoric artistic legacy in southwestern China, distinct from the core areas of Chinese civilization's origin. They uniquely document the social, economic, and spiritual conditions of the early inhabitants in the border regions." These digital data will support a broader range of academic research.

Meanwhile, digital platforms facilitate “international cooperation”. The Cangyuan rock Painting Conservation Team recommends "collaborating with international organizations and conservation agencies from other countries to jointly advance the protection of rock painting. By exchanging experiences and sharing technologies, we can enhance the level of protection and collectively safeguard this cultural heritage of humanity." The sharing of digital resources can transcend geographical boundaries, fostering academic exchanges in global rock art research.

Through the use of these diverse digital applications, the Cangyuan rock painting have transformed from static archaeological sites into living cultural resources, achieving the broad dissemination and creative transformation of their cultural value while preserving the original artifacts. This "digital rebirth" not only extends the life cycle of cultural heritage but also injects new vitality into the local cultural tourism and creative economy.

4. Challenges and countermeasures for the protection of Cangyuan rock painting

Although digital technology has brought revolutionary changes to the protection and inheritance of the Cangyuan rock painting, many structural challenges remain in practice. These challenges include technical limitations, as well as comprehensive issues such as management mechanisms, financial support, and public participation. To address these challenges, a systematic response strategy is needed to ensure the long-term protection and sustainable use of the Cangyuan rock painting.

4.1. Main challenges facing current protection efforts

4.1.1. The dual threats of natural weathering and human destruction remain the most severe challenges to the protection of the Cangyuan rock painting

Over 2,000 years of exposure to wind, rain, and temperature changes have caused the pigments to fade and the rock surfaces to flake off, with some patterns becoming 'indistinct or eroded by natural weathering.' Additionally, unregulated tourism development, infrastructure construction in the surrounding areas, and the uncivilized behavior of a few tourists have further increased the risk of damage to the rock painting. As reported, 'Due to changes in the natural environment around the rock painting, coupled with weak conservation awareness among some units and individuals, limited conservation conditions, inadequate conservation efforts, and insufficiently scientific conservation measures, only a few of the 15 rock painting sites still have relatively clear patterns left.'

4.1.2. The shortage of specialized technical personnel is another bottleneck in the conservation efforts

The digital preservation of the Cangyuan rock painting involves a wide range of disciplines, including archaeology, cultural heritage protection, and digital technology, requiring a multidisciplinary team. However, Cangyuan County, located in a remote border area, faces significant challenges in attracting and retaining high-level professionals. Currently, the conservation efforts for the rock painting mainly rely on provincial institutions such as the Yunnan Provincial Institute of Cultural Relics and Archaeology, with relatively weak local professional capabilities.

The lack of adequate funding also hinders the in-depth development of conservation efforts. Cangyuan County, a border area with a minority population, has a relatively underdeveloped economy, and its cultural heritage protection funds mainly depend on support from higher-level governments. The acquisition of high-precision digital equipment, regular monitoring and maintenance, and professional talent training all require ongoing financial investment, but the current funding sources are limited. Without stable and sufficient financial backing, advanced conservation technologies are difficult to implement effectively.

4.1.3. Weak public awareness of protection is also a significant issue

Despite the implementation of the 'Regulations on the Protection of Cangyuan rock painting in Cangyuan Wa Autonomous County, Yunnan Province,' some local residents and tourists lack sufficient understanding of the cultural value and importance of protecting these rock painting. Reports indicate: 'Nowadays, various acts of damaging cultural relics are common... Some tour guides, to capture better special effects, trample on local cultural relics; some developers, for profit, continuously demolish and damage existing cultural relics.' This lack of awareness directly impacts the effectiveness of conservation efforts.

4.2. Suggestions for systematic protection measures

In view of the above challenges, it is necessary to build a comprehensive and multi-level protection system, which organically combines technical means, management mechanism and social participation, so as to form a joint force for the protection of Cangyuan rock painting.

4.2.1. Improving the construction of professional protection institutions is an urgent priority

The Standing Committee of the People's Congress of Cangyuan County has proposed establishing a specialized rock painting protection and management institution to handle daily protection, management, and research of rock painting, ensuring their professional protection and management and preventing damage caused by human factors. This institution should be equipped with professional technical personnel and utilize modern technology, such as drones and remote sensing, to monitor and protect the rock painting, promptly identifying inaccessible rock painting sites, addressing issues in the protection process, and enhancing the effectiveness of protection. Additionally, a regular cooperation mechanism with provincial research institutions should be established to leverage external intellectual resources and enhance the level of protection.

4.2.2. Diversified funding mechanisms are crucial for ensuring the sustainability of conservation efforts

In addition to government financial support, it is advisable to establish a 'Cultural Heritage Protection Fund' that can attract corporate donations and social crowdfunding. Reasonably developing cultural tourism resources and using part of the tourism revenue to support conservation efforts is also recommended. Applying for special funds from international organizations for cultural heritage protection is another option. These diversified funding sources can provide stable support for the maintenance and updating of digital equipment and the training and recruitment of professional talent.

4.2.3. The establishment of a digital monitoring and early warning system can effectively address the risks of both natural and human-induced damage

After completing the basic digital documentation, a real-time monitoring system for the rock painting and their surroundings should be set up. This system will use sensor networks to collect data on temperature, humidity, and vibration, assess the trends in preservation conditions, and promptly identify potential risks. Regular high-precision 3D scans can quantify the rate and extent of weathering, providing a scientific basis for targeted conservation measures. This 'preventive protection' approach is more cost-effective and effective than post-damage restoration.

4.2.4. Community Participation and Public Education serve as the social foundation for conservation efforts

It is essential to "encourage citizens, legal entities, and other organizations to legally participate in the protection of rock painting," establish a long-term mechanism for local community involvement, and cultivate a team of "rock painting protection volunteers." Additionally, public education should be strengthened by "setting up cultural education zones within the scenic area to showcase the techniques and cultural significance of the Cangyuan rock painting to visitors. Conducting cultural heritage protection education to enhance the awareness of local residents and tourists about cultural heritage protection." Special emphasis should be placed on "collaborating with educational institutions to organize cultural study tours, fostering young people's interest and love for traditional culture."

5. Conclusion

The digital preservation of the Cangyuan rock painting demonstrates that digital technology serves not only as a “recording tool” but also as a “cultural bridge”, linking the past with the present,

professionals with the public, and preservation with utilization. As research indicates, "For ethnic cultural heritage, we must protect and preserve them, and also reinterpret them through new methods and means, endowing them with new meanings, so that they remain relevant to our lives." The digital preservation of the Cangyuan rock painting is a vivid example of this philosophy, offering Chinese wisdom and solutions for the global protection and inheritance of cultural heritage.

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