Trends in Social Sciences and Humanities Research
Print ISSN: 2959-992X
Online ISSN: 2959-9938
DOI: https://doi.org/10.61784/tsshr3190

CONSERVATION AND UTILIZATION OF THIRD-LINE INDUSTRIAL HERITAGE: A CASE STUDY OF THE CROW CAVE

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Abstract: The material and intangible remains of Third-line Construction industrial heritage collectively constitute its unique historical, social, scientific, economic, ideological, and emotional values. Within the current context, adopting "museumification" as an academic and practical pathway facilitates the systematic integration of standardized museum concepts and conservation experience, thereby exploring protection and utilization models suited to the characteristics of such heritage. Taking China's First Aero-engine Manufacturing Plant as an example, its musealization should integrate digital museum technologies and the conceptual framework of the industrial ecomuseum, while adhering to the dual logic of cultural heritage conservation that combines "holistic and scientific approaches" with "authenticity and living preservation." At the level of utilization, it is necessary to establish a systematic thinking that integrates scientific research, cultural-tourism synergy, and cultural-education fusion. Hence, from a methodological perspective, a "systematic-living" approach is the prerequisite for achieving effective conservation and value activation. Third-line industrial heritage in the new era should assimilate new concepts and practical experiences, fully manifest the heritage form shaped by the interplay of people, time, and space, and ultimately realize the return and fulfillment of its resource value in contemporary development.
Keywords: Third-line construction; Industrial heritage; Musealization; Crow cave; Aero-engine

1 INTRODUCTION

Musealization serves as both a crucial means to systematically present the historical formation, development, and transformation of Third-line Construction industrial heritage, and an effective method to adapt to the needs of preserving and utilizing its value in the new era. The heightened emphasis on value elements and the demands of contemporary progress have jointly created practical opportunities for the musealization of this heritage. Furthermore, museums can provide a cultural space for spiritual enrichment, further promoting the emotional value associated with the Third-line Construction. Therefore, selecting the musealization of Third-line Construction industrial heritage as a research topic holds significant academic value and practical importance.

Currently, the protection and utilization of Third-line Construction industrial heritage are in a phase of growth. Relevant research primarily includes: 1) Conceptual and review studies [1-7], which have established the interpretive and research scope of this heritage, with reviews synthesizing the evolving research landscape over time. 2) Regional conservation and utilization studies [8-11], predominantly focused on key geographical areas that historically supported the Third-line Construction. 3) Innovative research on activation and utilization strategies [12,13], mainly exploring how the Third-line Construction can be revitalized, protected, and utilized today.

However, research examining Third-line Construction industrial heritage specifically from a musealization perspective remains insufficient [14-17]. Furthermore, related research themes are relatively fragmented and have not yet yielded systematic and comprehensive results. Consequently, to further enable the creative reinvention of Third-line Construction industrial heritage resources and the reproduction of cultural resources, it is necessary to leverage the relevant characteristics and advantages of museums. This involves strengthening the rational protection and utilization of the historical, social, scientific, economic, ideological, and emotional values inherent in these heritage resources, fully activating their resource attributes, and thereby constructing new concepts and methods suited to the study of China's Third-line Construction industrial heritage. This effort will contribute Chinese wisdom to extending the systematic research and active utilization of cultural heritage.

2 FEASIBILITY ANALYSIS FOR THE MUSEALIZATION OF CHINA'S FIRST AERO-ENGINE MANUFACTURING PLANT

The site of China's First Aero-engine Manufacturing Plant, also known as the Dading Aero-engine Factory or Yunfa Machinery Manufacturing Company, is located north of Yangchang Village in Dafang County, Bijie City, Guizhou Province. The plant's main workshops were situated within a natural karst cave named "Crow Cave," approximately 900 meters in depth and 30 meters in height, featuring an internal plaza covering about 4,000 square meters. The primary factory building was a three-story timber-and-stone structure integrating warehouses, machining workshops, and an assembly workshop, with a total area exceeding 5,000 square meters. The unique cave environment provided distinct locational advantages for production, ensuring security and concealment [18]. The plant rigorously adhered to American blueprints and technical processes, successfully developing distinct locational advantages for

production, ensuring security and concealment [18]. The plant rigorously adhered to American blueprints and technical processes, successfully developing aero-engines that met all performance standards utilizing advanced technology. Furthermore, through eight technical training sessions conducted between 1943 and 1948, it systematically trained approximately 350 technicians, over 260 engineers, and 23 equipment managers, thereby establishing a solid talent foundation for the development of China's aviation industry and national defense.

A brief review of the plant's historical development reveals two primary phases: the period of the War of Resistance Against Japan and the subsequent period of socialist construction. Moreover, the formulation of strategic policies in response to the era's demands, coupled with the profound emotional and spiritual dedication of its personnel, constitutes critical heritage resource elements. The plant fully aligns with the typology and value system defining Third-line Construction industrial heritage. Its resource attributes are imbued with profound historical accumulation, rendering research into its musealization particularly significant from historical, typological, and operational perspectives.

The musealization of China's First Aero-engine Manufacturing Plant must adhere to three fundamental principles. The primary principle is conservation first, with rational development and utilization. The core principle emphasizes systematic-living protection and utilization. The innovative principle advocates keeping pace with the times through scientific and rational conservation practices. These pre-established principles, derived from the plant's specific heritage resources and musealization context, not only align with the typology and value framework of Third-line Construction industrial heritage but also comply with the core requirements of museological knowledge. Consequently, the musealization of the plant is both justified and grounded, making the integration of modern museum development advantages into the protection and utilization concept of Third-line industrial heritage both feasible and necessary.

Following the feasibility analysis and the clarification of these principles, it is essential to reconcile the conceptual correspondence and practical integration between industrial heritage and musealization. This ensures that the core purpose of heritage protection and utilization is not lost during the process. Firstly, as industrial heritage possesses historical resource elements, the musealization process must leverage the narrative function of museums to comprehensively describe its historical development trajectory. For the plant, this involves delineating its distinct historical stages according to its developmental characteristics. Secondly, given that the paramount value of industrial heritage lies in its associated scientific, technological, and human resources, the musealization must employ advanced digital technologies to simulate historical production and development scenarios. This provides the public with relevant knowledge dissemination and immersive learning experiences. Thirdly, industrial heritage, particularly that of the Third-line Construction, embodies distinct era-specific ideologies. Therefore, musealization needs to highlight the spirit and ethos of the period. The specific approach should remain people-centered: museums should utilize human activities and deeds to restore the spiritual and emotional values of the time, enabling the public to understand and empathize with past aspirations and realize the functional value of reflective education. For the plant, this could involve interviewing former workers, technicians, and local villagers to recall specific situations, or utilizing historical reenactments—a format widely adopted by museums—to perform past historical contexts, thereby enhancing contemporary relevance.

In essence, the musealization of China's First Aero-engine Manufacturing Plant necessitates a balanced consideration of both subjective and objective dimensions. It must respect the historical authenticity of the human subject ("the people") while adhering to the developmental realities of the physical site ("the object"). The conditions for feasibility, the adherence to core principles, and the fundamental objectives are all developed based on this subject-object duality. Therefore, by examining the forms and values inherent within the concept of industrial heritage, and supported by methodologies from cultural heritage and museology, a comprehensive and systematic construction of the musealization practice for the plant represents a scientific, theoretical, and systematic endeavor. This effort also provides a fresh museological perspective for developing China's heritage conservation system. Consequently, building upon the previously established theoretical framework, it is imperative to formulate more practical application plans for the conservation and utilization of the plant through musealization.

3 CONSERVATION THROUGH MUSEALIZATION OF CHINA'S FIRST AERO-ENGINE MANUFACTURING PLANT

The digital museum represents a rapidly evolving form of museum development in recent years, dedicated to the preservation, documentation, and digital exhibition of cultural relics. Digital museums primarily comprise four components: digital collections, storage platforms, processing platforms, and interactive display platforms. The application of technology is intrinsically linked to its conceptual framework, emerging from the derivation and selection of technical pathways within a systematic conceptual structure. Currently, exemplary models include the Palace Museum's "Digital Duobao Ge," which employs high-precision 3D modeling to recreate artifacts in meticulous detail, and the Dunhuang Mogao Caves' "Digital Dunhuang" platform, offering immersive online cave exploration and mural viewing experiences, supplemented by the "Cloud Tour Dunhuang" WeChat mini-program for enhanced accessibility. Additionally, the National Museum of China has established a digital exhibition hall, providing realistic viewing experiences that transform audience engagement. Other institutions, including the Shaanxi History Museum, Nanjing Museum, and Sanxingdui Museum, are also actively advancing digital museum initiatives.

The development of a digital museum for China's First Aero-engine Manufacturing Plant should be guided by two core principles and five key dimensions. The principles are: authenticity and integrity, ensuring the original, rich, and dynamic presentation of historical and cultural memories. The five dimensions include: comprehensive collection of

cultural relics and historical documentation; parallel pursuit of protective development and scientific research; balance between social benefits and economic considerations; integration of historical presentation with interactive exchange; and fusion of material representation with the transmission of ideological and spiritual values. In summary, the digital museum initiative must transcend mere digitization, actively incorporating experiences and technologies from exemplary domestic and international cases to effectively preserve and perpetuate the Third-line Construction industrial heritage that significantly contributed to China's industrialization.

Furthermore, the musealization of Third-line Construction industrial heritage requires innovative approaches integrating scientific concepts and practical inheritance. The ecomuseum concept, emphasizing holistic protection of the heritage site's original ecology and its sustainable development within the natural environment, offers relevant insights. This concept finds particular resonance in the digital museum development for the Plant, where the natural karst cave constitutes a distinct ecological setting, and the historical human-nature interaction represents a valuable socio-ecological dimension, both aligning with ecomuseum foundation requirements.

Therefore, it is necessary to first define the boundaries and scope of ecological protection for musealization based on the original purpose of ecomuseums. Secondly, drawing upon ecomuseum construction experience, identify suitable entry points and adaptable practices for ecological protection. Thirdly, establish a foundational plan for ecological conservation tailored specifically to industrial heritage typologies. Finally, formulate a comprehensive ecomuseum conservation and construction plan based on the Plant's unique resource endowment. This approach not only safeguards and presents the authenticity, integrity, and non-renewable nature of the natural and industrial cultural heritage, along with the dynamic relationships between people, place, and industrial legacy, but also provides innovative perspectives and methods for the musealization of Third-line industrial cultural heritage.

Authenticity has long been emphasized in cultural heritage conservation principles, while the concept of living conservation has gained significant attention in recent years. As part of Third-line Construction industrial heritage, the Plant should adhere to both authenticity and living conservation principles. However, historical changes have rendered its heritage resources unsuitable for "productive preservation." Nonetheless, the diverse forms, values, and other elements of the Plant's heritage resources provide a solid foundation for excavating authentic value and exploring living heritage connotations, supported by scientific, systematic theoretical frameworks and distinctive, targeted practical experiments.

The living conservation concept for the Plant's musealization necessitates a foundation in the heritage ontology combined with dynamic preservation. Focusing on the ontology entails the integrated protection of both tangible and intangible elements. Living conservation involves rationally planning protection strategies based on this ontology, utilizing museum conservation methods and concepts to achieve systematic preservation. However, beyond the physical remains, the Plant encompasses a sphere of human-centered activities that has often been neglected in living conservation efforts. Traditional conservation approaches predominantly focused on the tangible ontology, leading to a limited understanding that recognizes "the object but not the context," potentially overlooking the living history embodied by the heritage. Therefore, the living conservation concept for the Plant's musealization must be firmly rooted in the ontology while actively pursuing dynamic preservation, exploring new pathways and concepts for Third-line industrial heritage protection, and identifying sustainable and innovative developmental relationships for the Plant.

4 UTILIZATION THROUGH MUSEALIZATION OF CHINA'S FIRST AERO-ENGINE MANUFACTURING PLANT

The utilization of China's First Aero-engine Manufacturing Plant through musealization is predicated on its effective conservation. Rational utilization not only enhances the scientific and practical aspects of cultural heritage preservation but also infuses greater vitality into its transmission. The musealized utilization of the plant primarily focuses on three dimensions: in-depth sustainable scientific research, the appropriate application of cultural-tourism integrated development models, and inheriting innovation through cultural-educational integration in practical education. These aspects essentially represent the integrated utilization of scientific research with economic and social development. Such an approach ensures that cultural heritage research and protection are more grounded, secures broader support, and bridges the gap between conservation efforts and public memory. It enables the musealized utilization of the plant to proceed on a scientific trajectory while remaining connected to the realities of socio-economic development. Ultimately, successful implementation depends on the coordinated efforts and full development engagement among national and local authorities, alongside the inherent endowment conditions of the heritage resource itself.

Scientific research is integral to cultural heritage conservation, aiming to address practical challenges. The current research concerning China's First Aero-engine Manufacturing Plant faces three primary issues: 1) the "over-commercialization" of heritage utilization; 2) the "simplification" of utilization approaches; and 3) the "disorderliness" of utilization practices. These challenges, identified from the current state of scientific research related to the plant, also prompt reflection on the in-depth sustainable development of Third-line Construction cultural heritage.

"Over-commercialization" is the primary issue requiring prudent management. Conceptually, commercialization itself is not inherently problematic. However, when applied to cultural heritage themes, excessive commercial exploitation often sidelines the humanistic concerns of the heritage, amplifies the space for commercial profit, and to some extent neglects the intrinsic space of the cultural heritage itself and the experiential space of human subjectivity—effectively compressing both the core heritage space and its associated cultural sphere. Therefore, the plant must identify appropriate research directions and rational utilization parameters.

"Simplification" primarily refers to narrow approaches in both conservation and the objects of utilization. Singular conservation focus often subjectively prioritizes specific elements, overlooking the nested and integrated ecological integrity of resources beyond that singularity. For the plant, all related functional structures and the holistic elements of the human-land and human-heritage relationship should be targets for conservation and utilization, not merely the isolated factory building foundations.

Currently, the integration of culture and tourism has become a prevalent approach in cultural heritage development, with museums demonstrating considerable success in this regard. However, the cultural tourism potential of Third-line Construction heritage remains underexplored, presenting significant opportunities for growth. For the First Aero-engine Manufacturing Plant, three strategic dimensions for in-depth and rational development can be identified:

Firstly, the planning of highly interactive experiential scenarios that align with the heritage's core values. This involves creating immersive environments that allow visitors to directly engage with historical production and living conditions. Complementing this, the development of themed dining experiences reflecting the local lifestyle of the period can be established. This approach not only serves as a site for historical and cultural education but also provides a tangible, lived experience that contextualizes the technological level of that era.

Secondly, the integration of surrounding ecological resources with heritage utilization. This entails coordinated development of the natural environment and adjacent natural wonders such as Qingxu Cave (a natural karst cave), in line with the strategic requirements of rural revitalization. This achieves a win-win situation where heritage conservation and utilization synergize with regional socio-economic development. Such an approach not only helps address the current three challenges—over-commercialization, simplification, and disorderliness—in research and utilization but also fosters resonance between heritage conservation and tourism demands. It further facilitates the harmonization of systematic protection and rational utilization, thereby contributing to the refinement of evaluation indicator systems for the scientific conservation and appropriate use of Third-line Construction cultural heritage.

Thirdly, the design of distinctive branding elements representative of the plant's identity, specifically through cultural creative product development. Design inspiration can be drawn from historical archival materials or iconic factory machinery and instruments. Most crucially, these products must accentuate the ideological and spiritual values emblematic of the Third-line Construction period. This requires not only well-crafted promotional narratives but also powerful visual imagery that conveys the ethos of the era. Therefore, cultural creative products must deeply explore the connotations of these spiritual values, ensuring they authentically reflect the scientific rigor and long-term strategic vision upheld by the state during the Third-line Construction initiative [19].

"Disorderliness" manifests as chaotic utilization methods and development concepts. This situation often treats the cultural heritage as the sole object of exploitation without considering the wider cultural ecology beyond it. Exploiting the heritage in isolation can create numerous conflicts between development efforts and local communities. Consequently, the plant must establish a sound mechanism for protection and utilization, proactively addressing the challenge of disorderliness to identify a suitable musealization pathway. In confronting this issue, the principles of holistic and scientific conservation design, alongside concepts of authenticity and living conservation, can still provide valuable guidance for its musealized utilization.

Today, cultural-tourism integration is prevalent in cultural heritage development, and museums have performed notably well in this area. However, Third-line Construction cultural heritage remains underdeveloped in this regard, possessing significant potential for growth. Furthermore, the inheriting innovation achieved through cultural-educational integration and practical education reflects the connotative utilization of the plant's site, demonstrates its social utilization value, and underscores the integrated relationship between its protection and utilization. These interacting innovative approaches to inheritance align with our contemporary understanding of perceiving the human spirit through material objects—they are conceptually interconnected.

In summary, cultural-educational integration and practice prioritize educating people. Its essence lies not merely in emphasizing the uniqueness of the plant as cultural heritage, but in highlighting the interactive relationships and vivid scenarios between "people," their labor in creating history, and nature, geography, and space. The aim is to reveal how the "human" spirit resonated with the era and how individuals transcended self-interest for the collective good within this process. This approach not only highlights the historical context of "human" labor and practice but also illuminates the interaction between the "human" spirit and societal development.

5 CONCLUSION

The preservation and utilization of Third-line Construction industrial heritage demonstrate multifaceted dimensions of engagement. These efforts involve, to varying degrees, multiple values—historical, social, scientific, economic, ideological, and emotional—and encompass both tangible and intangible heritage elements. Although these two aspects represent distinct thematic foci, they are intrinsically interconnected in their underlying logic. The protection and utilization of Third-line Construction industrial heritage necessitate a systematic-living approach. Using the musealization of China's First Aero-engine Manufacturing Plant as an example, this not only requires leveraging established museum concepts and methods—achieving systematic protection through digital museum technologies, industrial ecomuseum practices, holistic and scientific conservation design, and principles of authenticity and living conservation—but also demands activating its significance through in-depth sustainable scientific research, the rational application of cultural-tourism integrated development models, and inheriting innovation via cultural-educational integration in practical education.

Furthermore, the preservation and utilization of Third-line industrial heritage require transcending the cultural heritage paradigm formed by the interweaving of people, time, and space. Its optimal development should be achieved through systematic, practical, and innovative methodological pathways. Currently, there is a pressing need to systematically construct a framework for this purpose. Primarily, this involves establishing a "Typology and Value Structure of Third-line Construction Industrial Heritage." Subsequently, building upon past theoretical paradigms in cultural heritage, it is essential to develop more practical application plans for its protection and utilization, thereby proposing a holistic thinking system for these efforts.

Therefore, this paper, using the musealization of China's First Aero-engine Manufacturing Plant as a case study, aims to strengthen the systematic-living protection and utilization of Third-line Construction industrial heritage. By supplementing the connotation and value of this heritage through a concrete case, it seeks to achieve comprehensive research, conservation, and utilization, ultimately providing a specific case study pathway for the protection and utilization of Third-line Construction industrial heritage.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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