

Paper-Based Disease Analysis and Restoration Practice Research: A Case Study of the Siku Quanshu

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Abstract: As the largest officially compiled encyclopedia in ancient China, the Siku Quanshu holds a significant position in the preservation of traditional Chinese literature and the system of cultural heritage transmission. This paper takes a fragmentary volume of the Siku Quanshu circulated during the Republic of China period as its research subject. Through disease investigation, material testing, scientific analysis, and conservation-restoration practices, it systematically addresses issues such as insect damage, acidification, folding damage, material loss, and staining. During the restoration process, the principles of cultural relic conservation—"minimal intervention," "reversibility," "authenticity," and "compatibility"—were strictly followed. Technical methods including digital documentation, microscopic examination, targeted wet cleaning, deacidification, paper repair, and lining reinforcement were employed to restore the structural stability of the artifact while preserving historical information to the greatest extent possible. The study shows that the restoration plan effectively improved the preservation condition of the artifact, enhanced the strength and durability of the paper, and provides a reference case for the restoration of similar ancient texts.

Keywords: Siku Quanshu; Paper-based cultural relics; Deacidification protection; Cultural relic conservation

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1. Introduction

Ancient texts serve as vital carriers of Chinese civilization, embodying a wealth of historical, cultural, and scholarly information. Due to the inherent aging characteristics of paper materials, combined with environmental factors, insect damage, mold, and human handling during long-term preservation, ancient books commonly suffer from issues such as acidification, embrittlement, damage, and loss of material. Scientific and rational conservation and restoration not only extend the lifespan of these documents but also help preserve their historical value and cultural information.

The Siku Quanshu (Complete Library in the Four Branches of Literature) is the largest and most

comprehensive collection of its kind in ancient China, and its preservation and dissemination have had a profound impact on the development of traditional Chinese scholarship ^[1]. Although the fragmentary volume of the Siku Quanshu studied in this paper dates from the Republican period, it still retains significant textual content and historical information. Conducting scientific restoration and conservation research in response to its existing deterioration holds practical relevance and scholarly value.

2. Basic information of the paper-based cultural relic in the collection

2.1. Basic condition of the relic

Item: Description

Title: Fragmentary volume of the Siku Quanshu (Complete Library in the Four Branches of Literature)

Period: Republic of China period

Material: Paper

Dimensions: 26 cm × 33 cm

Thickness (single page): Upper part: 0.07 mm; Lower part: 0.08 mm

2.2. Value assessment of the relic

2.2.1. Historical value

This fragmentary volume preserves part of the text of The Analects (Lunyu) from the Siku Quanshu, reflecting the circulation and use of ancient books during the Republic of China period. This era was marked by social upheaval, including the profound changes of the late Qing dynasty, the Xinhai Revolution, the Warlord Era, and the War of Resistance Against Japan. During these major historical events, a vast number of ancient texts were lost or destroyed amid the warfare and social transformation. Consequently, a surviving fragmentary volume of the Siku Quanshu from this period holds significant value for historical research.

2.2.2. Academic value

The Siku Quanshu brings together major classics from successive dynasties and serves as an essential document for the study of traditional Chinese thought and culture ^[2]. The textual content, marginalia and annotations, and edition characteristics preserved in this fragmentary volume can provide evidence for research in rare book bibliography, philology, and historical studies.

2.2.3. Technical/Artisanal value

This fragmentary volume preserves the characteristics of papermaking, printing, and binding techniques from the Republic of China period. The paper fiber structure, ink features, binding method, and layout design all reflect the level of ancient book production technology at that time.

2.2.4. Cultural value

The annotations, insect damage marks, traces of past repairs, and signs of use found in the document collectively constitute its complete historical information, which is of great significance for the study of the circulation of ancient texts and the history of reading.

3. Condition survey and deterioration analysis

Via visual observation, transmitted light examination, and microscopic inspection, the relic exhibits deterioration in multiple aspects: Severe insect damage is present, with numerous insect-bored holes visible on the pages, some of which are interconnected, resulting in reduced structural strength of the paper and a tendency toward edge breakage. The paper shows an overall yellowish-brown coloration with localized embrittlement; pH testing indicates a weakly acidic state, with a marked decrease in fiber strength, exhibiting characteristics of acidification and aging. There are also multiple creases, tears, edge losses, and damage to the spine/fold area, with some sections already broken. Dust, insect residues, and smoke stains are present on the paper surface, affecting legibility and preservation stability^[3]. In addition, localized residual mold staining is visible, though no active mold growth was detected^[4–5].

4. Restoration objectives

The restoration work aims to achieve the scientific conservation of the relic through the following measures: First, mitigate risks through scientific assessment and controlled intervention—eliminating major deterioration factors such as insect damage, acidification, mold, and mechanical damage, and preventing their further progression. Second, carry out scientific cleaning to remove surface contaminants and harmful deposits, reduce the degree of acidification, and slow the aging process. At the same time, implement reinforcement and repair to restore the structural integrity of the paper, enhance mechanical stability during handling and storage, thereby extending the lifespan of the relic and establishing a long-term stable preservation system^[6]. Throughout the entire process, the original ink writing, vermilion annotations, insect damage marks, paper texture, and layout features will be fully preserved, maintaining historical authenticity without altering the original historical appearance of the relic.

5. Restoration technical workflow

The overall restoration process follows^[7]:

Preliminary Documentation → Material Testing → Disassembly and Cleaning → Deacidification Treatment → Reinforcement and Patching → Lining and Mounting Repair → Binding and Conservation → Long-Term Preservation

6. Restoration implementation process

The main steps of the restoration work are as follows: First, preliminary preparation and documentation are carried out—establishing a deterioration distribution map using high-resolution and transmitted light photography, examining fibers with a microscope, measuring thickness and pH value, and testing ink stability using the water droplet method. Subsequently, disassembly and cleaning are performed—recording the original binding information before disassembly, dry-cleaning loose dust with a soft brush, applying localized treatment to mold residues (disinfecting active mold spots by spot-swabbing with 75% ethanol on cotton swabs), and consolidating areas of localized pigment/powder loss with a 0.5%–1% gelatin solution^[8–9]. Next, wet cleaning and deacidification treatment are carried out—flattening the paper through controlled humidification, using purified water with a pH of approximately 7.5 for float washing to remove acidic

substances and contaminants, and monitoring the pH value in real time to restore the paper to a neutral or slightly alkaline state ^[10]. Then, reinforcement and repair are implemented—patching insect holes with repair paper of similar fiber, color, and thickness, performing overlapping tear repairs according to fiber direction, focusing on reinforcing the damaged spine/fold area to improve the load-bearing capacity of the binding edge, and applying an overall lining after the repairs are completed to enhance flatness and structural strength.

7. Restoration quality testing and effectiveness evaluation

The quality evaluation after restoration was conducted from three aspects: In terms of physical properties, a comprehensive assessment was made of flatness, flexibility, page-turning strength, binding edge tensile strength, and completeness of hole repair. In terms of chemical stability, changes in pH value, color difference, and degree of acidification were measured before and after restoration. In terms of information preservation, the preservation status of text, annotations, printing textures, and historical marks was examined. The evaluation results show that the structural stability of the relic was significantly improved, the degree of paper acidification was notably reduced, the ink and vermilion annotations remained intact, historical information was not significantly affected, and the relic meets the requirements for long-term preservation.

8. Preventive conservation measures

Recommendations for the preservation and maintenance of the relic after restoration are as follows ^[11]: The storage environment should maintain a temperature of 18–22°C and a relative humidity of 50%–55%; the illumination in exhibition environments should not exceed 50 lux, and ultraviolet radiation intensity should be below 75 $\mu\text{W}/\text{lm}$. A comprehensive deterioration inspection shall be conducted at least once per year, with key monitoring of insect infestation, mold, pH value changes, and binding stability. Additionally, a complete restoration archive should be established, including pre-restoration records, testing data, restoration process photographs, material usage records, and a post-restoration evaluation report.

9. Conclusion

The restoration of this fragmentary volume of the Siku Quanshu was carried out on the basis of scientific testing and guided by the principle of minimal intervention. Through measures such as digital documentation, wet cleaning and deacidification, paper patching, structural reinforcement, and lining repair, the issues of insect damage, acidification, cracking and tearing, and soiling were effectively addressed. The treatments were carefully calibrated to the specific conditions of each folio, ensuring that after restoration, the overall structure of the relic has been restored, its preservation stability has been significantly improved, and its historical information has been fully retained, achieving the dual goals of preserving the physical artifact and safeguarding the cultural information it carries.

This case demonstrates that for paper-based ancient texts from the Republic of China period, personalized restoration plans should be developed based on material characteristics and deterioration conditions, enhancing their long-term preservability while ensuring authenticity. Such a tailored approach

not only mitigates immediate damage but also strengthens the artifact against future environmental stressors, providing a useful reference for the conservation and restoration of similar types of ancient texts.

Disclosure statement

The author declares no conflict of interest.

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