A Study on the Deterioration and Conservation of Paper-Based Cultural Heritage

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Abstract. The Guizhou Provincial Museum houses a diverse and abundant collection of paper-based cultural relics. The preservation and restoration of these paper artifacts constitute a critical aspect of the museum's responsibilities. Central to this work is the emphasis on preventive conservation, alongside the continuous advancement and exploration of new technologies. By systematically summarizing and integrating traditional techniques with modern methodologies, the craftsmanship involved in paper relic preservation can be both revitalized and enhanced. Furthermore, the protection of paper-based relics must align with their collection and utilization practices to ensure the enduring transmission of their cultural and historical value.

Keywords: paper-based cultural relics; deterioration; preservation; restoration techniques; conservation

1 Introduction

As a vital component in the inheritance and preservation of historical artifacts, paper-based cultural relics hold a significant position within current conservation efforts. These artifacts not only bear historical, artistic, and cultural value, but also serve as tangible carriers of human civilization and social memory. However, due to their inherent fragility and organic composition, paper relics are particularly susceptible to various forms of degradation. The deterioration of paper relics arises from both intrinsic factors—such as the quality of the raw materials, the papermaking process, and the ink or pigments used—and external environmental conditions, including fluctuations in temperature and humidity, exposure to light, biological infestations, and air pollution. Over time, these factors can lead to acidification, embrittlement, discoloration, mold growth, and insect damage, severely compromising the legibility and structural integrity of the artifacts.

Ensuring the safe and proper preservation of museum-held paper artifacts is an inescapable responsibility for museums and cultural institutions. Therefore, adequate attention must be given not only to identifying the causes of damage but also to improving environmental conditions affecting paper relics. In particular, preventative

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conservation has become increasingly emphasized in modern museum practices as a cost-effective and sustainable approach.

Building upon the inheritance and refinement of traditional techniques, a proactive, scientific, and cautious approach should be adopted, effectively integrating modern scientific and technological methods—such as digital imaging, environmental monitoring, vacuum nitrogen disinfestation, and deacidification—to continuously advance the preservation and restoration of paper-based cultural relics. The Guizhou Provincial Museum, which houses a wide variety of paper artifacts including documents, paintings, certificates, and wartime publications, provides a representative case. Many of its holdings exhibit varying degrees of deterioration, ranging from minor discoloration to severe structural damage. Taking the Guizhou Provincial Museum as a case study, this paper analyzes the damage patterns and restoration methods for paper-based cultural relics, aiming to offer practical insights into the effective integration of traditional craftsmanship and innovative technologies in the long-term preservation of cultural heritage.

2 Causes of Damage to Paper-Based Cultural Relics

2.1 Raw Materials and Structural Characteristics of Cellulose

The primary component of paper relics is plant fiber, which can be broadly classified into four categories based on the part of the plant used: wood fibers (e.g., pine, spruce), seed hair fibers (e.g., cotton), stalk fibers (e.g., wheat straw, reed), and bast fibers (e.g., hemp, mulberry). Traditional Chinese handmade paper often employs bast fibers such as those from mulberry and paper mulberry trees, which are rich in long cellulose chains and possess excellent durability. Other common raw materials include vines, bamboo, and rice straw. These fibers are selected and processed for their strength, flexibility, and resistance to biological degradation.

From a chemical perspective, plant fibers mainly consist of cellulose, hemicellulose, and lignin. Among these, cellulose—a linear polysaccharide composed of β-D-glucose units—is the core structural component and largely determines the mechanical strength and aging resistance of paper. Long and well-ordered cellulose chains contribute to high tensile strength, better folding endurance, and reduced brittleness over time. However, cellulose is susceptible to degradation due to oxidation, acid hydrolysis, and photodegradation, especially when exposed to light, heat, or acidic environments. Hemicellulose, although structurally similar to cellulose, is more easily hydrolyzed and contributes less to mechanical stability. Lignin, a complex aromatic polymer, is mainly responsible for the yellowing and acidification of paper, particularly in wood-pulp-based modern papers. The presence of lignin accelerates cellulose degradation, especially under ultraviolet light.

2.2 Differences in Papermaking Techniques

The differences between handmade and machine-made paper significantly influence the long-term stability and preservation potential of paper-based cultural relics.

Handmade paper, which predominated in China until the late Qing dynasty[5] (19th century), involves a slow and artisanal process: pulping raw materials by fermenting, boiling with alkaline solutions, washing to remove non-cellulosic substances, and then using moulds to form sheets. This traditional method eliminates most lignin and acidic residues, producing paper that is chemically stable, tough, and resistant to microbial attack. As a result, many ancient documents, calligraphies, and paintings on handmade paper have survived for centuries in remarkably good condition.

In contrast, machine-made paper, which became widespread after the Industrial Revolution, is produced at high speed using industrial wood pulp that retains a significant amount of lignin and other impurities. The fibers used are typically shorter and less uniform than those in handmade paper, resulting in a product that is structurally weaker and more porous. The mechanical processes involved in papermaking—grinding, bleaching, and chemical sizing—often introduce acidic by-products, such as alum-rosin sizing agents, which remain within the paper and act as internal catalysts for acid hydrolysis. This causes the cellulose chains to break down more rapidly, leading to embrittlement, yellowing, and eventual disintegration. Moreover, because machine-made paper is optimized for mass production and cost-efficiency, rather than longevity, its resistance to environmental stressors such as humidity, temperature fluctuation, and airborne pollutants is significantly lower.

Furthermore, the introduction of synthetic additives and optical brighteners in modern paper manufacturing, while improving aesthetic appeal and printability, can create new conservation challenges. These substances may become unstable over time, react with ambient gases, or fluoresce under certain lighting conditions, potentially interfering with both preservation and digitization efforts.

In summary, understanding the raw materials and manufacturing processes behind paper artifacts is critical to formulating effective conservation strategies. The chemical and physical vulnerabilities of different types of paper require tailored approaches in preventive care, environmental control, and restoration treatment to ensure the long-term preservation of paper-based cultural heritage.

2.3 Temperature Anomalies

Temperature reflects the thermal energy that promotes the physical and chemical deterioration of organic materials, including cellulose-based paper relics. High ambient temperatures can significantly accelerate the rate of cellulose hydrolysis, oxidation, and acid-catalyzed degradation reactions, leading to rapid loss of paper strength and flexibility. Conversely, low temperatures can effectively slow down these aging processes and thus extend the lifespan of paper artifacts. However, it is not merely the absolute temperature but the degree and frequency of temperature fluctuation that most adversely affect paper-based materials.

Frequent or abrupt temperature changes disrupt the internal moisture equilibrium of paper. Elevated temperatures increase the rate of moisture evaporation, often resulting in localized dryness and subsequent contraction of paper fibers. On the other hand, sudden drops in temperature can increase relative humidity, leading to condensation or unexpected absorption of moisture from the environment. These cyclical changes cause

paper fibers to alternately swell and contract, weakening hydrogen bonding within the fiber matrix and eventually leading to warping, cracking, and delamination. Over time, this instability compromises the structural integrity of paper relics, especially those that are already brittle or aged.

In museum environments, therefore, maintaining a stable thermal environment is paramount. According to the International Council of Museums (ICOM) and the American Institute for Conservation (AIC), the recommended storage temperature for paper-based artifacts generally ranges between 18–22°C, with daily fluctuations not exceeding ±2°C. Advanced HVAC systems equipped with precise sensors and feedback controls are commonly employed in professional institutions to meet these requirements.

2.4 Humidity Imbalance

Humidity is another critical environmental parameter that directly influences the preservation of paper relics. Excessive relative humidity (RH)—typically above 65%—creates favorable conditions for hydrolytic reactions, promoting acid formation and enhancing the mobility of harmful water-soluble substances such as metallic ions and acidic residues. High humidity also poses severe biological risks, facilitating the growth of mold, fungi, and insects, especially silverfish and booklice, which are notorious for feeding on cellulose and starch-based adhesives.

Moreover, ink and pigments used in historical manuscripts and paintings, particularly those based on plant extracts or water-soluble minerals, are highly sensitive to moisture. In humid conditions, these inks may bleed, fade, or migrate, resulting in the irreversible loss of textual or visual information. In addition, atmospheric pollutants such as carbon dioxide (CO_2), sulfur dioxide (SO_2), and nitrogen oxides (NO_x), when combined with moisture, form weak acids like carbonic acid and sulfurous acid, which penetrate paper fibers and corrode them over time.

Conversely, environments that are too dry—typically with RH below 35%—cause paper fibers to desiccate and shrink, leading to brittleness, cracking, and curling. Therefore, international conservation standards typically recommend maintaining RH at 45–55%, with no more than ±5% daily variation.

2.5 Light Exposure

Light exposure, particularly in the ultraviolet (UV) spectrum, is a major cause of photochemical and photothermal damage to paper relics. UV radiation possesses high energy due to its short wavelength and can initiate chain reactions of oxidation within the cellulose matrix, leading to embrittlement, discoloration, and a progressive loss of mechanical properties. Pigments and dyes, especially organic ones used in traditional calligraphy and paintings, are highly photosensitive and tend to fade or change hue upon prolonged exposure to light.

Moreover, visible light and even certain artificial lighting systems, such as halogen and fluorescent bulbs, can emit heat and low-level UV rays that cumulatively degrade paper over time. Exposure to light not only causes direct degradation of paper fibers but

may also contribute to secondary effects, such as the yellowing of lignin-containing papers or the darkening of certain conservation materials used in previous repairs.

To mitigate these effects, museums and archival institutions follow strict illumination guidelines. For example, UNESCO and ISO 11799 recommend limiting UV radiation to below 75 μW/lm and maintaining exhibition light levels for paper materials under 50 lux. The use of UV-filtering glazing, LED lighting, timed display protocols, and rotation of sensitive exhibits are widely practiced measures to reduce cumulative light exposure.

In summary, temperature, humidity, and light act synergistically in influencing the chemical[3] stability and physical integrity of paper-based artifacts. Effective preventive conservation depends on not only controlling these factors individually but also monitoring their interactive effects through comprehensive environmental management systems and regular risk assessments.

2.6 Pollution by Harmful Gases

Air pollution, increasingly driven by industrial development, vehicular emissions, and urban expansion, has become a critical factor endangering the long-term preservation of paper-based cultural relics. Atmospheric pollutants can infiltrate indoor environments through ventilation systems, open doors and windows, or even via visitors' clothing. Particularly detrimental to paper relics are acidic gases such as sulfur dioxide (SO_2), nitrogen dioxide (NO_2), hydrogen sulfide (H_2S), and carbon dioxide (CO_2), which contribute to acidification of cellulose fibers. When absorbed by paper under humid conditions, these gases react with moisture to form corrosive acids such as sulfurous acid and nitric acid, which progressively break down the β-1,4-glycosidic bonds of cellulose molecules. The resulting decrease in pH weakens the hydrogen bonding between fibers, ultimately leading to a loss in tensile strength, embrittlement, and surface powdering.

In addition, oxidizing gases like ozone (O_3) and chlorine (Cl_2) react directly with organic components in paper, including cellulose, lignin, and inks, causing fading, yellowing, and chemical instability. These reactions are especially pronounced in papers containing high levels of residual lignin or synthetic dyes. Modern display cases and storage rooms must therefore incorporate gas filtration systems, such as activated carbon or potassium permanganate filters, and materials with low volatile organic compound (VOC) emissions to create an inert and controlled microenvironment.

2.7 Insect Damage

Biological infestation, especially by insects, remains a pervasive threat to paper artifacts across museums, archives, and libraries. Numerous insect species feed on cellulose, starches, sizing agents, and organic adhesives found in historical papers and books. Among the most destructive are booklice (Psocoptera), silverfish (Lepisma saccharina), drugstore beetles (Stegobium paniceum), tobacco beetles (Lasioderma serricorne), and subterranean termites (Isoptera). These pests not only chew through

paper, creating perforations and losses, but also deposit waste and secretions that cause staining and promote mold growth.

Observations from the Guizhou Provincial Museum indicate that insect activity peaks during the summer months, particularly from June to August, when ambient temperatures (above 25°C) and high relative humidity (above 60%) create ideal conditions for egg hatching and larval development. Storage spaces located in basement levels, which tend to retain higher humidity and limited air circulation, are especially vulnerable to infestations.

To mitigate these risks, institutions must adopt integrated pest management (IPM) strategies, including regular inspections, use of pheromone traps, environmental monitoring, and application of non-invasive treatments such as freezing, anoxic chambers, or inert gas fumigation. Additionally, preventive measures such as sealing cracks, isolating infested materials, and ensuring proper sanitation are vital to long-term biological control.

2.8 Mold Problems

Fungal contamination presents one of the most challenging threats in the conservation of paper relics due to its irreversible impact on both physical structure and visual integrity. Mold is closely linked to fluctuating microclimates, particularly high relative humidity (>65%), stagnant air, and poor lighting control. Spores of common molds such as Aspergillus, Penicillium, and Cladosporium are ubiquitous in the air and can germinate within 24 to 48 hours under favorable conditions. Once established, mold colonies produce visible spots and discoloration, release enzymes that break down cellulose, and release acidic metabolic byproducts that accelerate paper degradation.

At the Guizhou Provincial Museum, surveys show that paper artifacts stored in poorly ventilated or humid zones exhibit higher rates of mold infection. Beyond aesthetic damage—such as staining and obscuring of text or imagery—mold growth results in weakening of paper fibers and may even pose health risks to staff and visitors, particularly individuals with respiratory sensitivities.

Modern preventive strategies include strict environmental control through HVAC systems with humidity regulation, HEPA filtration, and UV sterilization, alongside frequent environmental data logging. Once mold appears, dry cleaning with vulcanized rubber sponges, micro-vacuuming, and localized ethanol treatments are commonly used methods, though great care must be taken to avoid further mechanical damage or solvent diffusion.

In conclusion, the multifactorial environmental threats of air pollution, insect activity, and mold growth must be systematically addressed through preventive conservation frameworks, combining technological solutions with interdisciplinary management to ensure the safe preservation of paper-based cultural heritage.

2.9 Human Factors

Improper handling, pollution, and inadequate restoration during storage, circulation, exhibition, or consultation contribute to damage. For example, frequent unrolling and

rolling of scrolls cause creases and tears. Ancient books often suffer from damaged edges, open spines, broken threads, or missing corners due to frequent use. Additionally, inappropriate restoration materials or unskilled techniques can lead to irreversible damage during repair and mounting.

3 Effective Strategies for Museums to Protect Paper-Based Cultural Relics

3.1 Comprehensive Inventory and Condition Assessment

With ongoing advances in science and technology, challenges in the conservation of paper relics have become increasingly apparent. A fundamental step is to conduct a thorough inventory to ascertain the condition of each paper artifact, recording detailed information systematically. Only by fully understanding the current status can museums develop informed conservation priorities. Artifacts should be classified according to criteria such as cultural value, degree of deterioration, and frequency of use, enabling differentiated treatment. Items with higher importance and more severe damage, especially those requiring urgent or emergency restoration, must be addressed promptly. Establishing comprehensive and systematic restoration plans is essential to prevent irreversible loss. Additionally, conservation staff should perform regular condition surveys and document the findings to maintain an up-to-date understanding of the paper collections' preservation status.

The diversity of paper artifacts is considerable, encompassing items such as rubbings, epigraphs, paper currency, imperial decrees, documents, contracts, letters, paintings and calligraphy, propaganda leaflets, certificates, official documents, scrolls, awards, bulletins, reports, licenses, manuscripts, regulations, notices, diplomas, commemorative albums, manuals, diaries, slogans, registration forms, confessions, newsletters, summaries, calls to action, and eulogies.

3.2 Cultivation of Specialized Conservation Professionals

Building a team of skilled professionals specialized in paper relic restoration is critical for effective preservation. Paper conservation is meticulous, demanding, and often solitary work, requiring practitioners to have a strong sense of responsibility and professional dedication. Currently, the field suffers from insufficient societal recognition, leading to suboptimal working conditions and environments, which contribute to talent attrition and shrinking teams. Addressing this issue requires fostering a positive professional ethos that acknowledges the value of conservation work. Furthermore, establishing systematic training and talent development mechanisms is imperative. Museums[6] should prioritize recruiting and nurturing conservation professionals while providing supportive work conditions and career development pathways. The age distribution and knowledge composition within teams should be well-balanced to ensure sustainable talent succession. Since paper conservation[1] demands specialized technical expertise, practical experience, and interdisciplinary knowledge, providing

continuous opportunities for learning and professional exchanges is vital. This approach enhances the integration of traditional craftsmanship with modern scientific methods, progressively improving restoration outcomes.

For instance, the Cultural Relics Science and Technology Protection Center at Guizhou Provincial Museum currently employs nine specialized staff, including four with senior or mid-level professional titles, representing disciplines such as history, archaeology[2], fine arts, calligraphy, and chemistry. The team includes personnel dedicated to analytical testing, painting and calligraphy restoration, metal artifact conservation, ancient and modern cultural relics conservation, stone and ceramic restoration, painting reproduction, and administrative support. Each year, staff participate in various training programs and workshops organized by the State Administration of Cultural Heritage. These cover topics such as innovative restoration techniques, application of new technologies in cultural heritage preservation, and digital conservation methods. Training curricula span areas including cultural relic protection, archaeology, materials science, computer science, environmental science, physics, and geology. Specific training related to paper relics involves workshops on conservation and restoration of calligraphy and paintings, ancient book preservation, epigraphy identification and restoration, and calligraphy authentication.

3.3 Emphasizing Preventive Conservation of Paper-Based Relics

Preventive conservation refers to measures taken to protect cultural relics without altering their physical characteristics or original forms. It focuses on improving storage conditions and creating an environment conducive to the long-term preservation of paper artifacts, thereby slowing their deterioration. The design and construction of storage facilities should take into full account the specific properties of paper relics, including factors such as natural lighting, temperature and humidity control, and equipment installation. The guiding principle is "prevention first, combined with treatment," with attention to fire prevention, moisture control, protection from direct strong light, dust and pollution prevention, as well as mold and insect control.

At Guizhou Provincial Museum, preventive conservation efforts currently include environmental monitoring, micro-environmental regulation, and the use of specialized protective storage cabinets and boxes for valuable artifacts. Real-time online environmental monitoring systems have been installed in main and temporary exhibition halls, covering important display cases. The monitoring data has been stable, providing a sound basis for subsequent environmental regulation. For storage areas, due to various constraints, offline monitoring is employed with periodic data checks. Following funding approval, by 2018 environmental monitoring systems had been implemented in storage facilities. Micro-environmental regulation systems currently cover key areas such as the Sixth Temporary Exhibition Hall and important display cases in the permanent exhibition. In December 2018, the museum's second phase of mobile artifact preventive conservation and environmental[4] control project was approved and received a special subsidy of 4.26 million RMB from the State Administration of Cultural Heritage. The next phase will extend micro-environmental control to exhibition halls and storage areas.

Moreover, the Conservation Science and Technology Center implements regular monitoring protocols, routinely checking temperature and humidity in exhibition halls, display cases, and storage rooms. They also monitor pollutant gases (formaldehyde, volatile organic compounds, acidic gases) and lighting conditions (both visible and ultraviolet light) to ensure timely detection and remediation, thereby maintaining a safe environment for artifact preservation and display.

3.4 Inheritance and Application of Traditional Techniques

The development of cultural relic conservation techniques is a long historical process. Ancient practitioners relentlessly explored and innovated restoration methods, which enabled many paper artifacts to survive to the present day. This demonstrates that China's traditional conservation technologies are both rich and valuable. Protecting paper relics requires learning from the long-accumulated experience of predecessors, while also fully utilizing modern scientific achievements and adopting new processes and methods.

Traditional paper conservation mainly includes classical mounting techniques for calligraphy and paintings, as well as ancient bookbinding. Renowned mounting methods have made indelible contributions to preserving and restoring numerous precious documents and works of art, and should be systematically summarized and promoted. Historical practices have accumulated many effective protective measures, such as the "Ten Methods of Book Protection" for preventing insect damage to ancient books and paintings. During the Han and Wei dynasties, paper was dyed with yellow-dye extracted from the Amur cork tree to deter bookworms. In addition, traditional storage often involved placing insect-repellent substances like musk, camphor, realgar, and cloud grass in book cabinets. Historical records mention over a dozen medicinal herbs with insect-repelling effects, demonstrating significant efficacy.

On the foundation of inheriting and improving traditional techniques, it is important to adopt a proactive and scientific attitude, correctly absorbing and utilizing modern scientific and technological advances, to continuously develop and enhance conservation and restoration technologies.

3.5 Emphasizing the Application of New Technologies

(1) Vacuum Nitrogen Fumigation for Pest Control, Sterilization, and Disinfection.

The selection of vacuum nitrogen fumigation and disinfection equipment must be based primarily on the characteristics of the paper-based collections. The main threats to paper relics are pest insects and molds. A comprehensive technical evaluation and comparison should be conducted to determine the most suitable method. The principles for selecting vacuum nitrogen fumigation for paper relics include: (1). Achieving 100% eradication of pests, including all life stages such as eggs and spores. (2). Effectively inhibiting and destroying mold growth and reproduction. (3). Ensuring that the fumigation process causes no damage whatsoever to the paper artifacts. (4). Guaranteeing that the fumigation process and its aftermath pose no harm to humans or the environment.

Proper disinfection is conducive to the long-term management and preservation of paper relics. The quality of disinfection directly affects the longevity of the artifacts. Improper methods have been shown to cause severe damage not only to the paper but also to the environment and human health.

(2) Deacidification Treatment of Paper Relics.

Measuring the pH (acid-base level) of paper artifacts is crucial. The acidity may arise either from natural aging and degradation or be residual from manufacturing processes, especially in machine-made paper. Acidic conditions accelerate corrosion and deterioration of paper. Typically, three samples are tested at three points each to obtain an average pH value. A pH below 5.6 indicates a need for deacidification with specialized alkaline solutions to promote long-term preservation. Before treatment, ink stability tests (bleeding tests) must be conducted, as immersion-based deacidification is unsuitable for water-sensitive inks.

At Guizhou Provincial Museum, a nanometer magnesium hydroxide solution prepared by Nanjing Museum in a 1:6 ratio is used for deacidification. Paper sheets are separated by polyester films and immersed in the solution for 20 minutes, then rinsed twice with distilled water, and finally dried on absorbent paper.

(3) Deoxygenation Conservation Technology.

The principle of deoxygenation conservation is to remove oxygen within a sealed space, creating an anoxic microenvironment dominated by inert nitrogen gas, which can be maintained long-term. This environment prevents pest infestation, kills existing insects at all developmental stages (adult, pupae, larvae, eggs), inhibits mold growth and reproduction, prevents oxidation, corrosion, aging, discoloration, and controls humidity.

In an oxygen-free environment, pests and molds cannot survive or reproduce. The goal is to provide a stable, clean "microenvironment" that slows further degradation and aging, effectively creating a "time-frozen" preservation space for the relics.

The method uses RP conservation materials (high-barrier protective bags combined with specialized deoxygenators and oxygen indicators) with the following advantages: (1). Simple implementation — conservation can be carried out anytime without complex equipment or specialized facilities, requiring minimal labor and only basic training (a single session). It is portable and flexible. (2). Cost-effective — flexible budgeting allows institutions to conduct treatments according to available funds without waiting for large budgets. The method is especially suited for small and medium museums. (3). Reliable and low-maintenance — quickly addresses fundamental risks such as pest infestation, mold, moisture, discoloration, and harmful gas corrosion. Under stable storage conditions, treated artifacts can be safely preserved for several years without concern.

(4) Silk Mesh Reinforcement Technology.

Silk mesh reinforcement technology, awarded the First Prize of the Ministry of Culture's Science and Technology Progress Award and developed by the Nanjing Museum, has been widely promoted and applied in museums, archives, and libraries across China. This technique effectively addresses the challenge of reinforcing fragile paper artifacts, especially those with text and images on both sides. The method employs a mesh made from single silk fibers coated with hot-melt adhesive. During re-

inforcement, the paper artifact is placed on a heat-resistant mat, followed by the silk mesh and a polytetrafluoroethylene (PTFE) film. Using a heated iron, the silk mesh is evenly bonded to the paper. This process preserves the clarity of the text and images, without affecting readability or photography. The technology is simple to operate, utilizes materials with excellent aging resistance, and maintains the physicochemical properties of the paper, offering good reversibility. Beyond paper artifacts, this technology is also applicable for reinforcing fragile ancient textiles. Several revolutionary war-era paper artifacts in the Guizhou Provincial Museum's collection have successfully undergone reinforcement using this technology.

(5) Application of Digital Imaging Technology.

Advanced digital imaging systems have been incorporated into the conservation and restoration of paper artifacts. High-resolution digital photography is employed to comprehensively document the original condition and damage of artifacts, including detailed close-ups of severely affected areas and both front and back surfaces. This facilitates rigorous before-and-after comparisons throughout the restoration process. Two-dimensional and planar three-dimensional digital capture and replication technologies enable effective storage, retrieval, transmission, and reproduction of paper documents, thereby minimizing physical handling and potential damage. In 2018, the Guizhou Provincial Museum acquired a CRUSE scanner featuring vacuum suction control to match the physical characteristics of the scanned item, flexible lighting configurations for optimal imaging, authentic surface texture reproduction through adjustable shading effects, patented CCD offset technology for capturing reflective materials such as gold and silver inks, and specialized infrared and ultraviolet filters enabling truly non-destructive scanning. The system architecture supports modular upgrades, ensuring integration of the latest international technological advancements.

4 Conclusion and Future Prospects

The key to effective paper artifact conservation and restoration lies in prioritizing preventive protection and advancing the application of emerging technologies. It is essential to systematically summarize and enhance traditional conservation techniques through the integration of modern scientific methods. The protection of paper artifacts must align with their collection and utilization strategies to ensure the perpetuation of their cultural and historical value. This represents a vital and urgent responsibility of museums.

Looking ahead, the future development of paper artifact conservation will emphasize scientific protection paired with rational utilization, aiming to fully exploit the intrinsic value of these materials and ensure their long-term preservation and accessibility. Achieving this goal requires strengthened management, deepened research, ongoing problem-solving in response to emerging challenges, and continual improvement of professional restoration skills. Only through such concerted efforts can paper artifacts continue to play a crucial role in cultural heritage transmission and societal development.

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