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Article Title

Conservation and Stabilization of Late Kushan Copper Coins from the Islamabad Museum, Pakistan, Using Physical and Ultrasonic Methods

Abstract

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Keywords: Conservation, Stabilization, Copper Coin, Ultrasonic treatment, Corrosion

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Contents

Abstract

This study investigates the conservation and stabilization of Late Kushan copper coins using two different techniques i.e. physical and ultrasonic. The study insides on a hoard of 390 groups of copper coins from the reserve collection of the Islamabad Museum, recognized to the Late Kushan period ensuing the reign of Vasudeva I. The coins were issued under a number of rulers, reproducing the rich cultural and historical variety. The research highlights the critical importance of preserving metallic objects, mainly those compromised by corrosion and environmental contact. To certify the coins' structural reliability and significance, progressive non-destructive techniques were engaged for cleaning and stabilization. The conservation process included detailed pre-treatment analysis, stabilization protocols, and thorough documentation, all conducted within a specialized laboratory environment. The findings demonstrate the effectiveness of both ultrasonic and physical methods in conserving ancient copper coins and offer valuable insights into the broader field of heritage preservation.

Keywords:

Conservation, Stabilization, Copper Coin, Ultrasonic Treatment, Corrosion

Introduction

Coins hold significant historical importance, serving as invaluable artifacts that complement and authenticate information found in the literature. Crafted from various metals such as gold, silver, copper, or alloys, coins bear legends or simple marks that contribute to the rich tapestry of history. In the context of ancient Indian history, coins play a crucial role and are considered an integral part of archaeological sources (Gupta, 1969).

The diversity in metals and the presence of inscriptions on coins provide a unique window into the past. Coins are also related to history and

knowledge about paleography and archaeological epigraphy. Therefore, coins have much importance in history especially, in religious history because almost every ruler depicted his own religious perspective. Kushans, who ruled in north-western India dating back to the first century CE and second century CE; bear the Greek inscriptions and Buddhist god and goddesses. In their coins, they showed their religion and faith in the form of an iconographic perspective (Ibid).

The Kushan coinage shows its resemblance with contemporary coins not only in the design of royal figures and religious images but also in the form of languages, legends, symbols, and inscriptions.

The late Kushan copper coins from the reserve collection of the Islamabad Museum present a fascinating yet complex subject for research. These coins have no documented provenance. Typically, artifacts from well-excavated sites provide crucial context for understanding their historical significance, but in this case, the lack of clear origin complicates the task of historians and numismatists. The uncertain provenance of these coins—likely originating from illegal excavations or confiscations at airports—underscores the pervasive issue of antiquities trafficking and the significant challenges it presents to the preservation of cultural heritage. Despite the lack of a well-documented archaeological context, the coins retain considerable research value. They provide valuable insights into the economic, religious, and political dynamics of the Late Kushan period. However, the inability to fully contextualize these artifacts within their original settings highlights the critical role of provenance in archaeological interpretation.

As such, this study not only contributes to numismatic and historical scholarship but also serves as a call for stronger measures against the illicit trade of cultural property, advocating for the proper documentation and conservation of future discoveries (Rifai, et. al, 2023). Kushan copper coins are considered vital sources of historical documentation. Over time, they are exposed to deterioration procedures that steadily change their appearance, shape, and composition. This research aims to protect the original coin surface which was essential following the completion of the cleaning practice (Saleh, et. al, 2025).

Conservation of metallic objects is the practice of protecting the physical and chemical decay of objects and different techniques used for the art of cleaning these metal artifacts (Elmor & Becker, 2013). The efficiency of conservation management, mostly oil-based coverings, diverse with environmental situations, shows condensed value in soils with high chloride absorptions (Abdelbar & El-Shamy, 2024).

The cleaning and preservation of ancient metal artifacts from Europe and other parts of the world is a very worthwhile undertaking. Often though, they are discarded because they are considered too complicated and dangerous. As a result, not much development has been made in the use of this technique in the conservation and preservation of metal objects. There have been periods where few or no conservators specialized in archaeological conservation have been working. As a result, a large amount of both un-conserved artifacts and artifacts in need of re-conservation are badly damaged. This applies to most material categories but this research will focus on the problems concerning the Late Kushan copper coins.

Many copper coins in different museums of Pakistan are losing their originality due to constant decay as they have not been cleaned and treated in appropriate way. The Islamabad Museum also houses hundreds of copper coins including those of the Late Kushans which are yet to be cleaned and conserved.

Notably, the Islamabad Museum lab houses a well-established Digitalization and Conservation Section, a feature that proved invaluable for the present research endeavor. The digitalization abilities allowed the researcher to precisely document a extensive collection of coins, mostly focusing on the Late Kushans, in that way elevating the intellectual understanding of this historical age.

In the Conservation Section, a variation of digital machines is offered to simplify the cleaning and preservation of archaeological objects. The conservation procedure employed a series of specific equipment, as well as an ultrasonic cleaning bath, which pays high-frequency sound waves to slightly remove dirt and debris from the coin surfaces. A conservational incubator was

correspondingly used to exactly adjust conditions such as temperature and humidity factors critical to the effective preservation of metallic objects. Moreover, a dehydrator plays a crucial part in removing moisture, thereby preventing damage from fungal activity or corrosion. Various conservation-grade chemicals were applied as well, each selected for its specific role in cleaning, stabilizing, or protecting the artifacts from further deterioration.

Along with digital tools, traditional manual instruments were important to the conservation process. Brushes, scalpels, tweezers, and microscopes allowed conservators to perform gentle physical cleaning, confirming the removal of deterioration and encrustations without cooperating with the integrity of the coin surfaces.

This research arranges non-destructive, effective methods of cleaning and conserving cultural objects, with an emphasis on maintainable preservation. It not only increases our understanding of Late Kushan coinage but also offers a practical understanding of their lasting attention. Resulting in a comprehensive analytical stage, the study employed handmade conservation strategies planned to discourse detailed deterioration issues, eventually aiming to stop more destruction and confirm the sustained preservation of these valuable historical substances.

Methodology

The research methodology implemented in this study plays a vigorous role in its whole achievement, employing durable importance on the careful implementation of fieldwork and ensuing scientific analysis. The early stage included wide fieldwork, including the collection of coins, orderly sampling, comprehensive documentation, careful observation, considerate understanding, inclusive surveying, and precise data recording. In Pakistan, the accessibility of scientific laboratories devoted to coin conservation remains inadequate, with only two efficient facilities presently in process. One is situated within the historic Lahore Fort and was established in 2011 under the Department of Archaeology and Museums, Government of Punjab. Though this laboratory pays to the conservation of archaeological objects, including coins, its scope is mainly limited to chemical treatments. An important fault is the absence of a preservation chamber, which is dangerous for the post-treatment balance of conserved objects.

On the other hand, the second facility contained within the Sir Syed Memorial at the Islamabad Museum deals with a further advanced and better-equipped atmosphere. This laboratory structures a well-developed Digitalization and Conservation Section, which contributes to the present research. The digitalization abilities of the Islamabad lab allowed detailed documentation of a huge number of coins, mainly from the Late Kushan era, in that way developing scholarly understandings of this historically important period.

The Conservation Section is equipped with an extensive variety of digital machines intended to maintain the cleaning and preservation of archaeological objects. Among these is the ultrasonic cleaning bath, which works with high-frequency sound waves to moderately remove dirt and debris from gentle surfaces. An incubator is also offered, allowing for particular control of conservational conditions such as temperature and humidity aspects critical to the lasting preservation of objects. Moreover, a dehydrator plays a vital role in removing humidity, so facilitating to stopping of corrosion caused by deterioration or fungal development. A range of particular chemicals is used all over the conservation procedure, separately selected for precise tasks for example cleaning, stabilizing, and protecting artifacts from more degradation.

Along with these digital tools, manual instruments are essential for complete, hands-on work. These contain brushes, scalpels, tweezers, and microscopes, allowing conservators to wisely clean and observe artifacts without bargaining their structural integrity or chronological worth.

Additionally, the research purposes to explore non-destructive and more efficient methods for cleaning and conserving artefacts, through a durable importance on conservation these traditional resources for the advantage of upcoming generations.

Conservation Process of Late Kushan Copper Coins

The conservation treatment of metallic cultural

heritage helps a double determination: to return the unique presence of artifacts pretentious by deterioration and to confirm their continuing preservation by avoiding more corrosion. In this learning, the conservation of Late Kushan copper coins was passed out over a structured and orderly approach planned to offer inclusive maintenance.

The procedure started with a pre-treatment valuation, which comprised complete photographic documentation and scientific analysis to calculate the situation of each coin. This was followed by careful washing and the exclusion of surface impurities, enlightening the exact state of conservation below layers of dust and crust. Stabilization treatment by means of corrosion inhibitors such as benzotriazole (BTA) was then useful to stop active deterioration and defend the metal from upcoming degradation. Systematic drying confirmed the removal of remaining moisture, a critical period in stopping further loss.

Where compulsory, reinforcement, and soothing interventions were completed to discourse structural weaknesses and increase the coins' physical integrity and graphical look. Upon conclusion of the treatment, high-resolution photographs were taken to document the restored state of the objects. A treatment record card was also assembled for individual coins, specifying the techniques carried out, materials used, and interpretations made during the conservation procedure. In conclusion, the coins were packed with archival-quality resources to confirm harmless storage and treatment.

This organized conservation approach effectively conserves the historical and cultural value of the copper coins, certifying their convenience and reliability for future generations (KCHF, 2022).

Pre-treatment Investigation

Pre-treatment investigation symbolizes a crucial initial step in the conservation of copper coins, providing a detailed understanding of their method, structural form, and level of corrosion. This complete valuation elaborates on several crucial works, containing complete photographic documentation, detailed physical dimensions, non-destructive scientific analysis, and the preparation of conservation record cards (Soyoung, 2021).

Photographing

Photography, equally as an art form and an expert tool, plays a vigorous part in documentation. In the current investigation, the conservation procedure started with the organized photographic documentation of the Late Kushan copper coins, taking their situation earlier to the solicitation of any conservation treatments.

Fig 1

Selected coins from the reserve collection of the Islamabad Museum

To start the photography method, the camera and lights were initially fixed on the photo stand. Through the system set, coins were systematically placed in sequence, alternating between obverse and reverse sides, each convoyed by name tags for identification (KCHF, 2022).

Actual Measurement

Scaling

After precisely documenting the Late Kushan copper coins, the researcher proceeded to measure them using a Vernier Caliper, a critical tool for ensuring accurate dimensions. Alongside the Vernier Caliper, the toolkit comprised conservation

record cards, pencils, and scales, among other essential instruments.

Reading the scale of the calipers, measurements were recorded in millimeters with precision. During the measurement process, particular attention was paid to measuring the front of the coin to account for potential variations in dimensions across its surface. In instances where different areas of the coin exhibited distinct dimensions, the researcher diligently noted both the minimum and maximum values observed (Ibid).

Fig 2

measurement of diameter

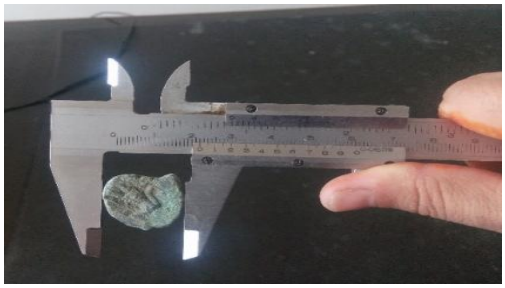


Fig 3

measurement of width

Weight

To measure the weight of the coins, researcher employed an Electronic Scale Machine (Weighing Balance) known for its sensitivity and accuracy (Ibid).

Cleaning and foreign substance removal

Cleaning coins is an art, not a science. This is because all the coins are not in equal size and present in the same condition. Some coins are cleaned with just only scrub of toothbrush, soap, and water but many coins need proper techniques and methods to clean them properly. Coins need to be cleaned depending on the coin metal and according to the dirt, crustation, and/or oxidation present on the coin (Sandes, 2017).

In the realm of cleaning and removing foreign substances, two primary methodologies prevail: physical and chemical methods. The physical approach involves tools such as toothpicks, scalpels, cotton swabs, and brushes. One notable advantage of the physical method is its minimal risk of secondary damage from the introduction of chemicals (Eladawy, et. al, 2025).

- Physical Technique
- Chemical Technique

Using olive oil as a cleaning agent for ancient coins is a practice that has garnered mixed opinions among numismatists and conservationists. While olive oil is indeed low in acid and can effectively penetrate encrustations and loosen dirt and grime, its long-term effects on coin surfaces can be concerning. Late Kushan copper coins were soaked in olive oil and allowing them to rest for a week (Sandes, 2017).

The procedure for cleaning the ancient coins after eliminating them from the olive oil involved liquid soap and a toothbrush to scrub away residual dust and dirt. Just once the mainstream of noticeable grime and dust has been detached, it's

normally suitable to stop cleaning to avoid any possible destruction (Ibid, 2017).

Appropriate drying methods are then important to stop humidity from producing further injury, such as deterioration or the growth of mold. In this circumstance, using an advanced dehydrator dish and employing the Late Kushan copper coins in a dehydrator chamber one-to-one is a practical methodology. A dehydrator is a device planned to remove humidity from artifacts, helping in their conservation. This method ensured that the Late Kushan copper coins were thoroughly dried, reducing the likelihood of moisture-related issues and contributing to their long-term stability and conservation (KCHF, 2022).

Fig 4

Late Kushan copper coins in Advance Dehydrator Chamber

Late Kushan Copper Coin after olive oil

Fig 5

obverse side

Fig 6

reverse side

The variability in soil conditions can pose challenges in cleaning ancient coins, as some may not fit neatly into previously established cleaning categories regardless of the soaking duration. At this stage, meticulous examination under a stereo-microscope is essential to assess the coins' condition and identify areas requiring further attention.

Fig 7

observe Late Kushan copper coin under a Stereo microscope

Physical Technique

A diversity of brushes, abrasives, and hand tools are useful to clean the surface of coins and expose the delayed engravings. Physical procedures must be employed at any time possible for the reason that they are manageable do not contain destructive chemicals, and have less effect on the metallic surface (Elsisi, Rifai, and Nasr, 2023).

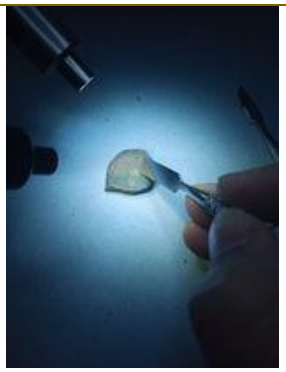
Physical Technique is a long and time-consuming method for cleaning ancient coins. This technique used various laboratory equipment for the mechanical cleaning process. It totally depends upon the scraping and brushing to clean coins (Sandes, 2017). Different steps which have been used during physical technique are discussed below:

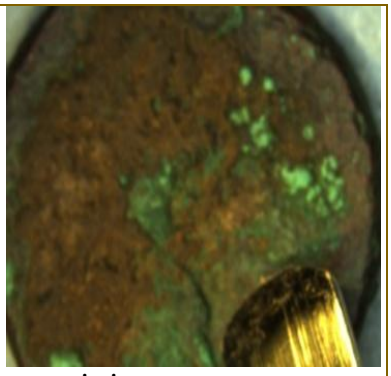
- The process of physically removing soil and foreign substances from ancient coins involves several meticulous methods tailored to preserve their integrity. Using a toothpick, conservators gently dislodge soil, carefully maneuvering to avoid damaging the coin's surface.
- Employing a scalpel for physical cleaning allowed for precise removal of soil and foreign substances, observed under a stereoscopic microscope to ensure accuracy.
- Another method involves using a cotton swab and ethyl alcohol for physical cleaning, ensuring the swab is replaced if contaminated to prevent cross-contamination.
- Similarly, cleaning with a brush and ethyl alcohol requires frequent cleaning of the brush to prevent contamination. As with other methods, the state of the coin's surface is carefully monitored, with any changes noted and addressed accordingly to preserve its integrity (KCHF, 2022).
- The diamond-dusted dental pick, with its sharp points and durable steel construction, serves as a valuable tool in the cleaning of copper coins. These tools offer the advantage of enhanced visual access during treatment, enabling conservators to navigate the intricacies of each coin with care and accuracy (Sandes, 2017).

Fig 8

Diamond-dusted dental pick tools

Equipment: X acto-knife
Function: X acto-knife is used to as a scalpel for cleaning technique. It is very simple craft knife also known as common house hold tool. It removed dirt over the plan surface area of the Late Kushan copper coins. Only used the curved blade seen right, rather that the flat blades and with all cleaning tools, this one is used for specific purposes only.

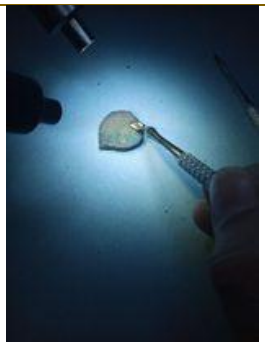




Stereomicroscopic image

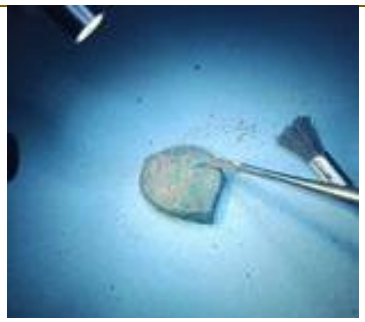
Equipment: Shovel tool
Function: Firstly, overall surface of coins cleaned from shovel tool. It helped to clear rust which was present in the most upper layer of the coin. Shovel clear smoothly the large surface rust at one time circulation.

Equipment: Pointed Shovel dental tool
Function: After surface cleaning, remove rust from the little depth of the Late Kushan copper coins with a pointed shovel dental tool. A pointed dental pick is used in coins from sideways rather than pointing first. Little pressure was applied and the tool was in a circular manner rather than a left-right or up-and-down manner.



Equipment: Spoon Excavator dental tool
Function: Another metal stick-type tool but designed with a tiny spoon-shaped cutting edge. Variations of this tool have allowed removing different levels of softened decay or temporary fillings.

Equipment: Discoid-Cleoid Carver
Function: Discoid cleoid is disk like shaped. It has pointed, sharp and carve end which remove rust from edge of the coins images by carving method.



Equipment: Pointed Dental Pick Tool
Function: Pointed tool removed the dirt from small depths and edge of the images. Pointed tool as flat as possible against the coin's surface and used only circular motion.

Equipment: Scalpel Handle with Blades

Equipment: Explorers Function: The common dental pick, with its hard steel, sharp and thin pointed tips has been used to probe and scrape off the dirt and corrosion surface of the coins. Used the tool on the coin's field, rather than the details. Little pressure has been applied in a circular manner rather than left-right or up and down. It removed all the remaining rusted surface edges which other tools could not clean.	Function: Scalpel Handles is a small and extremely sharp instrument used for surgery and anatomical dissection. Scalpel Handles have been intended to be used with surgical blades for separated or cuts the outer layer of coin's rust and encrustation easily (Sandes, 2017).

Each of these methods exemplifies the meticulous care and attention required in the cleaning process, balancing the removal of soil and foreign substances with the preservation of the coin's historical integrity and physical condition. Through precise techniques and close observation, conservators ensure that ancient coins are cleaned effectively while minimizing the risk of damage or alteration (Ibid, 2017).

Physical cleaning with Dremel Mini-Mite Tools

The Dremel Mini-Mite, a battery-powered tool known for its lightweight design and responsiveness, is a versatile precision tool suitable for various tasks including drilling, sanding, shaping, detailing, and rust removal. Specifically, when it comes to the cleaning and polishing of Late Kushan copper coins, the Dremel Mini-Mite proves to be a valuable asset. Its precise control and range of accessories make it well-suited for delicately removing excess rust and other surface imperfections from coins without causing damage.

Fig 9

diamond-dusted Dremel tools

Utilizing ten tiny diamond-dusted Dremel tools, along with rubber Dremel tools for surface smoothing, has proven effective in cleaning fixed coins of encrustations. However, their usage demands not only practice but also patience, as the delicate nature of coin surfaces requires careful handling.

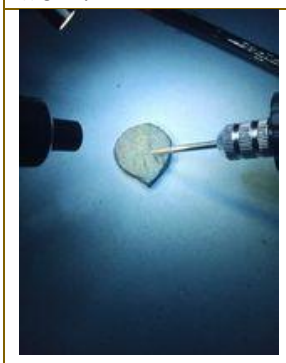
Fig 10

Cleaning ancient coins

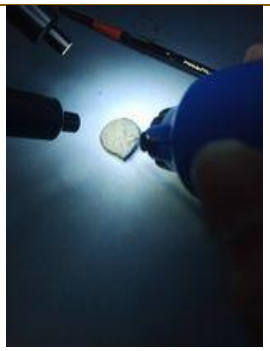
In the present study, the safer approach was consistently employed by utilizing diamond-dusted Dremel tools in circular motions. This technique allowed for a more controlled and gentle cleaning process, minimizing the risk of unintended abrasions or scratches on the coin's surface (Ibid).

Equipment: Bullet tip Dremel tool
Function: Bullet tip Dremel tool has removed encrustations or dirt and better see the legends, field, and details at low pressure. Only touch the bullet tip to the surface of the coins and let them do work.

Equipment: The Flame Tip
Function: The Flame Tip is a broad tip and I have used it for the encrustations, fields and specially coin's details. It could be harsh so have only used under some massive encrustation conditions.



Equipment: The flame-thin tip
Function: This Tip is thin and sharp than the previous flame tip. This tool is used for further cleaning and smoothing. Its sharp end was enough to cleaned legends and details of rusted coins.



Equipment: The point tip
Function: The point tip is best for cleaning between the details and legends. I have used point tip to remove the bulk of the remaining rust on the ancient coins. Point tip helped to clean dirt from the deep edges of the coins.

 **Equipment**: Bullet Tip Function: I have used Diamond dusted rubber tools for cleaning and smoothing portrait and the fields of the ancient rusted coins.	 **Equipment**: Bullet Arrow Function: The narrow arrow of the bullet defines the images or surface of the coins. For more smoothing stripped and sharp details have been brightened and shined.
 **Equipment:** Dremel Soft brass bristle cup brush Function: The Dremel soft brass bristle cup brush is a remarkable tool that can be used for many purposes. I did not develop any pressure on the coins and just touched the coin surface with the bristles. Never placed the bristles flat-wise against the coins surface. It is too abrasive and may cut thin patina layer.	 **Equipment**: Dremel soft cotton brush Function: Used soft tip of the brush on the surface of the coins. They did not use cleaning, they only used for polishing purpose. This tool makes ancient coins smooth and shining. It used at the end of this technique to polish the coin (Sandes, 2017).

Result of Physical Cleaning

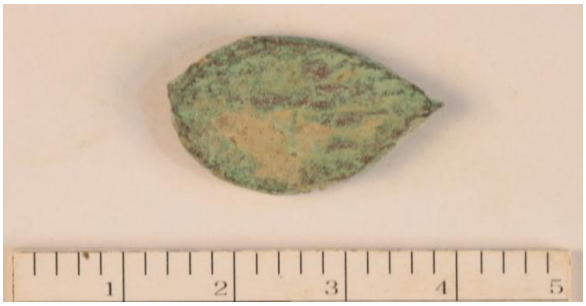
Before mechanical cleaning

Fig 11

obverse

Fig 12

reverse



After physical cleaning

Fig 13

The obverse side of the coin

Fig 14

The reverse side of the coin

Fig 15

Stereomicroscopic image of the obverse side

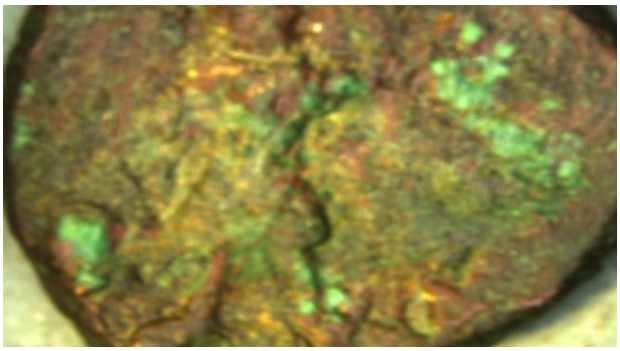
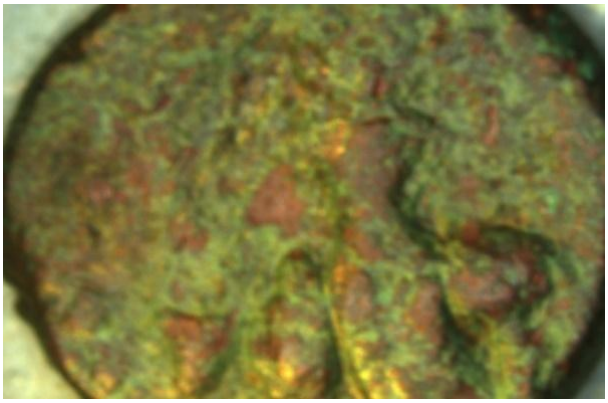


Fig 16

Stereomicroscopic image of the reverse side



Results of Physical Cleaning Technique

The use of common dental pick tools in the cleaning and conservation of Late Kushan copper coins is a meticulous process that underscores the importance of non-destructive methods in preserving historical artifacts. The primary advantage of using dental picks is their precision; these tools allow researchers to remove rust and dirt particles with minimal risk of damaging the Late Kushan copper coin's surface.

Regardless of its profits, physical cleaning with dental pick tools is not without boundaries. Although dental picks are operative for removing surface-level dust, they are unable of retreating the fundamental chemical changes produced by erosion. Therefore, Late Kushan copper coins may quiet seem dull or faded even subsequently physical cleaning, a consequence that can be discouraging for collectors and historians who search for to increase in value these artifacts in their original state.

The chemical nature of definite crusts reduces them hardy to physical tools such as dental picks, requiring the use of suitable chemical treatments to discourse such corrosion efficiently. This highlights the restrictions of depend on merely on physical cleaning approaches and give emphasis to the requirement for an additional inclusive method to the conservation of Late Kushan copper coins.

Inside the broader conservation outline, physical cleaning is a dangerous but integrally inadequate stage. To accomplish thorough preservation, it essential be combined into a multi-faceted conservation approach that chains equally physical and chemical procedures. Eventually, it turns out to be clear that physical procedures alone cannot certify the comprehensive stabilization and restoration of such historically substantial artifacts.

Chemical Techniques

The usage of olive oil by means of a cleaning agent is a well-established preparation among numismatists, appreciated for its capability to enter and unstiffen corrosion layers on coin surfaces. The inorganic content in olive oil can contribute to breaking down these layers, making it easier to disclose the coin's unique features. Though, while operative in releasing surface sums, remaining olive oil can posture tests for additional conservation treatments. If not appropriately detached, it may produce a barrier that stops following chemical agents from sufficiently obeying the coin's surface, thus falling the efficiency of those dealings.

Eliminating olive oil after the early cleaning point is thus important. As an organic material, olive oil is disposed to degradation over time, which can lead to more corrosion of the coin. In addition, it can obstruct cleaning agents and conservation materials from interacting directly with the coin’s surface or its patina, compromising the overall conservation outcome.

To address this, the use of mouthwash has been proposed as an effective method for removing oily residues. Most commercial mouthwashes contain alcohol, which acts as a solvent capable of breaking down and dissolving the oil. The alcohol not only

facilitates the removal of olive oil but also contributes to disinfection, ensuring that no residual organic matter remains that could damage the coin over time (Rezki & Halimah, 2020).

An effective procedure involves soaking the coins in mouthwash for a period of 12 to 18 hours. However, care must be taken to select a mouthwash with a neutral or mildly alkaline pH, as those with high acidity may cause surface damage if the coins are left submerged for extended periods. After soaking, the coins should be rinsed thoroughly with ethanol. Ethanol helps eliminate any remaining moisture due to its rapid evaporation rate, thereby reducing the risk of water-induced corrosion (Alshehri, 2017).

Fig 17

obverse side before mouthwash cleaning

Fig 18

obverse side after mouthwash cleaning

Fig 19

reverse side before mouthwash cleaning

Fig 20

reverse side after mouthwash cleaning

Ultrasonic Treatment

An ultrasonic cleaner is a device that employs high-frequency sound waves (ultrasonic waves) to effectively clean a wide range of objects and materials. Widely used in industrial, commercial, and household contexts, it is particularly efficient at removing dirt, grease, grime, and other contaminants from surfaces with precision and minimal physical intervention.

Ultrasonic Cleaner Components: An ultrasonic cleaner characteristically consists of more than a few basic components: a container or chamber to grip the cleaning solution, ultrasonic producers or generators that release high-frequency sound waves, and a switch panel to regulate limitations such as cleaning time, temperature, and ultrasonic frequency (Fuchs, 1992).

When used in amalgamation by a mixture of distilled water and ethyl alcohol, an ultrasonic cleaner suggests an erudite and real method for cleaning gentle artifacts, such as Late Kushan copper coins. The use of distilled water confirms that no unnecessary minerals are announced throughout cleaning, while ethyl alcohol supports melting organic impurities and hurries drying by dropping surface pressure. This approach is particularly beneficial for preserving the fine details and patina of the Kushan copper coins, as it minimizes the risk of physical damage and leaves the coins in a stable, clean condition suitable for further conservation or display.

The following steps outline the process in detail:

Materials Needed

- Ultrasonic cleaner
- Distilled water
- Ethyl alcohol (isopropyl alcohol can also be used)
- Plastic container
- Scientific tissue
- Artifact to be cleaned
- Brush
- Timer

Procedure:

Preparation of the Ultrasonic Cleaner

Made sure that the ultrasonic cleaner was clean and in good working condition. It's placement on a stable surface was ensured.

Filling the Ultrasonic Cleaner

Clean the late Kushan copper coin using ultrasonic sound waves. Fill the Ultrasonic Cleaner with distilled water at the operating line (KCHF, 2022).

Fig 21

level of water

Placement the copper coin on the plastic container

To clean the copper coins effectively using an ultrasonic cleaner, ethanol was poured into a float plastic container positioned within the ultrasonic cleaner tank. This setup ensured that the copper coins would be partially submerged in the ethanol when placed in the container. When the ultrasonic cleaner was activated, high-frequency sound waves generated cavitation bubbles in the ethanol, enhancing its cleaning action by dislodging dirt and corrosion from the coin surfaces without causing mechanical damage (Ibid).

Fig 22

Ethanol in a plastic container

Gently the copper coin was placed inside the container and ensure that the copper coin was not touching the sides of the container.

Setting the Timer and Turning it On

The timer on the ultrasonic cleaner was set on to the desired cleaning time. In this case, mentioned only 5 minutes. It was made sure the cleaner was set to operate at an appropriate ultrasonic frequency for the type of cleaning required.

Cleaning

The ultrasonic cleaner was then turned on. The ultrasonic waves created microscopic cavitation bubbles in the ethanol, which helped dislodge dirt and contaminants from the artifact's surface.

Monitoring the Cleaning Process

While the ultrasonic cleaner was running, the cleaning process was monitored to ensure the copper coin was not damaged or dislodged from the plastic container.

Drying After Ultrasonic Cleaning

After the 5-minute cleaning cycle was completed, turned off the ultrasonic cleaner. Carefully removed the plastic container with the copper coin from the ultrasonic cleaner's tank. Gently blotted/ air-dried the copper coin.

Inspecting and Storage

Inspected the late Kushan copper coin to ensure it's clean up to the satisfaction level. Where required, the ultrasonic cleaning process was repeated. Once satisfied with the cleanliness, the copper coin was stored appropriately, keeping it away from contaminants (Ibid).

Results of Ultrasonic Cleaning

Ultrasonic cleaning is a highly effective method for removing a wide range of contaminants from various materials, leveraging high-frequency sound waves in an aqueous medium to achieve thorough cleaning.

The effectiveness of this process depends significantly on the condition of the metal. For instance, with ancient coins such as the late Kushan copper coins, ultrasonic cleaning can remove corrosion but typically does so in a manner that is gentle enough to preserve the integrity of the coins. The process effectively removes soft and light rust and surface corrosion without stripping away significant material from the coins. This certifies that while the external impurities are removed, the primary historical and numismatic value of the coins is preserved.

Figure 23

Catalogue of Late Kushan Copper Coins Before Ultrasonic Treatment

Figure 24

Catalog of Late Kushan Copper Coins after Ultrasonic Treatment

Stabilization Treatment

The Benzotriazole (BTA) stabilizing procedure is a particular technique designed to stop further

deterioration, mainly for copper artifacts such as Late Kushan copper coins. This technique includes the use of Benzotriazole, an erosion inhibitor that responds with copper to form a defending Cu-BTA complex, efficiently uncertain constant rust (KCHF, 2022).

The procedure initiated with the training of crucial materials: a stainless steel vat, ethyl alcohol, Benzotriazole (BTA), and shielding wrap. The stainless steel vat helped as a non-reactive container for the treatment solution. Ethyl alcohol acts on behalf of as a solvent, enabling the dissolution and uniform distribution of BTA across the surface of the coins. Upon involvement in the solution, BTA reacted with the copper to form a stable Cu-BTA layer, which performs as a defensive barrier, conserving the metal from more oxidative destruction and environmental deterioration (Ibid).

This treatment is mainly valuable for copper coins that have established corrosion layers and show micro-cracks where corrosion can carry on to spread. The Cu-BTA membrane well penetrates these fine cracks and the border between the corrosion layer and the metal core, stabilizing the structure and avoiding more degradation (Ibid).

Fig 23

samples prepared for the stabilization treatment

Vacuum Impregnator for stabilization treatment

A vacuum impregnator is an important tool for stabilizing and reinforcing metal objects, mostly in the area of conservation and restoration. The procedure involves employing the artifact inside a vacuum chamber, where air is expatriated from the material's micro-pores and internal voids. When an abundant vacuum is attained, a liquid gum is familiarized into the chamber, filling the spaces and reinforcing the structure of the object. The vacuum situations permit the sealant to intensely penetrate and fill the porous structure of the metal. After impregnation, the artifact is exposed to pressure to confirm thorough penetration of the sealant. Finally, the sealant is cured, typically through heating, to solidify it within the artifact's structure. This process not only stabilizes the artifact by filling and sealing the internal voids, preventing further deterioration but also reinforces its structural integrity, making it more durable and resistant to environmental factors (Ibid).

A vacuum impregnation unit, a vat was prepared, including vat with a lid, gloves, dust mask, Paraloid 15% and other reagents, tools. The power was connected to the vacuum impregnation unit to prepare for operation. The switch was pressed in the panel to turn on the power and cold trap then waited till temperature of the impregnator reached 60 degrees to facilitate the operation of vacuum pump on and vent close.

Fig 24

Impregnator under process for stabilization treatment

Then, rotate the latching device anti-clockwise on both sides of the cover for release. Opened the cover to put the vat where the Late Kushan copper coins were held, closed the cover, and locked the latch (Ibid).

Fig 25

Late Kushan copper coins on impregnator unit

The decompression valve was turned anti-clockwise to reduce the pressure. When the pressure has reduced to 70cm/Hg, turn back the valve to discontinue the process. The vacuum state was maintained for one hour for vacuum impregnation. When the process was completed, the decompression state was released by turning the valve anti-clockwise. Then, the Late Kushan copper coins were soaked by leaving them at normal pressure for 2 hours. The stabilizing treatment was conducted after immersing Late Kushan copper coins in a 3% solution of BTA. It is most important that the BTA solution binds to the metal surface, and if the rust layer of the copper coin is thick, impregnation should be preceded until bubbles rise. When this process was over, the latch was released to open the cover, took out the vat, and closed the cover to turn off the power (Ibid).

Dry Oven

Upon completing the stabilization treatment of the Late Kushan copper coins, it is essential to ensure that all residual moisture is thoroughly removed to prevent any further corrosion or deterioration of the metal. The drying process was carried out by allowing the coins to air dry for a minimum of three hours. The exact drying time may vary depending on environmental factors and the specific conditions of each coin (Ibid).

Fig 26

Late Kushan copper coins in Dry Oven at 80 ℃

Removing white BTA solution

Throughout the drying procedure of the Late Kushan copper coins preserved with an important amount of Benzotriazole (BTA) solution, a white BTA powder formed on the surface. If absent or unaddressed, this residue could reduce the photographic and historical value of the coins. To take away the BTA powder, ethyl alcohol was applied. Using a brush and cotton swab, the alcohol was wisely applied to dissolve the residue, permitting detailed and organized cleaning. This process ensured that the BTA powder was slightly removed without damaging the coin's surface or patina. As a solvent, the alcohol effectively dissolved the BTA powder, facilitating its removal while preserving the integrity of the protective treatment (Ibid).

Reinforcement Process

The reinforcement process for Late Kushan copper coins, by means of defined, elaborate a cultured technique designed at justifying the properties of erosion through the use of synthetic resins i.e. Paraloid B72. The complete stages including the vacuum impregnation method highlight the accuracy and care required to avoid destructive the elusive artefacts throughout the procedure.

The method to provide physical strength to Late Kushan copper coins that are probable to be damaged by deterioration is known as the reinforcement process. This has resulted in obstructive corrosion issues by adding synthetic resin into deteriorated metal coins to make stronger the surface. The method of reinforcement process included a vacuum impregnator, natural impregnator, and Paraloid B72. A 3-20% solution was made using Paraloid B72 (10%) and solvent (Acetone, Xylene). Materials required for the reinforcement process include stainless steel vat, Acetone, Paraloid B72, wrap, and vacuum impregnator machine (Ibid).

The reinforcement process was divided according to the vacuum impregnation system. After putting the Late Kushan copper coins into the vacuum impregnation system and creating a vacuum state, when the vacuum state was released, the synthetic resin penetrated into the inside of the microscopic voids of the Late Kushan copper coins where air was present. As the resin dried, the surface of Late Kushan copper coins was coated. Where there was no impregnation system, reinforcement work was done by natural impregnation method and application method.

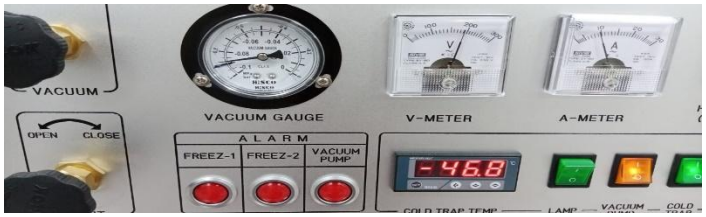
The vacuum impregnation system consisted of a power button, a vacuum release valve, a vacuum valve, and a measuring plate. The Late Kushan copper coins were put into the impregnation system and locked. Turned on the vacuum release valve clockwise (close) and the vacuum valve counterclockwise (open). At this time the air escaped and it became a vacuum state. When the measuring plate reads cmHg 60, turn the vacuum valve clockwise (close) (Ibid).

Fig 27

The measuring plate reads cmHg 60, turn the vacuum valve clockwise (close).

Fig 28

Release the valve clockwise (close) and the vacuum valve counterclockwise (open).



The impregnation proceeded for about 1 hour. Turned the vacuum release counterclockwise (open). At this time, the vacuum release valve was released slowly. When cmHg reached 0, the vacuum release valve was turned clockwise (close). The vacuum impregnation system was then turned off and the Late Kushan copper coins inside the vacuum impregnation system were.

Fig 29

Deposit Late Kushan copper coins on the impregnator for the reinforcement process

Fig 30

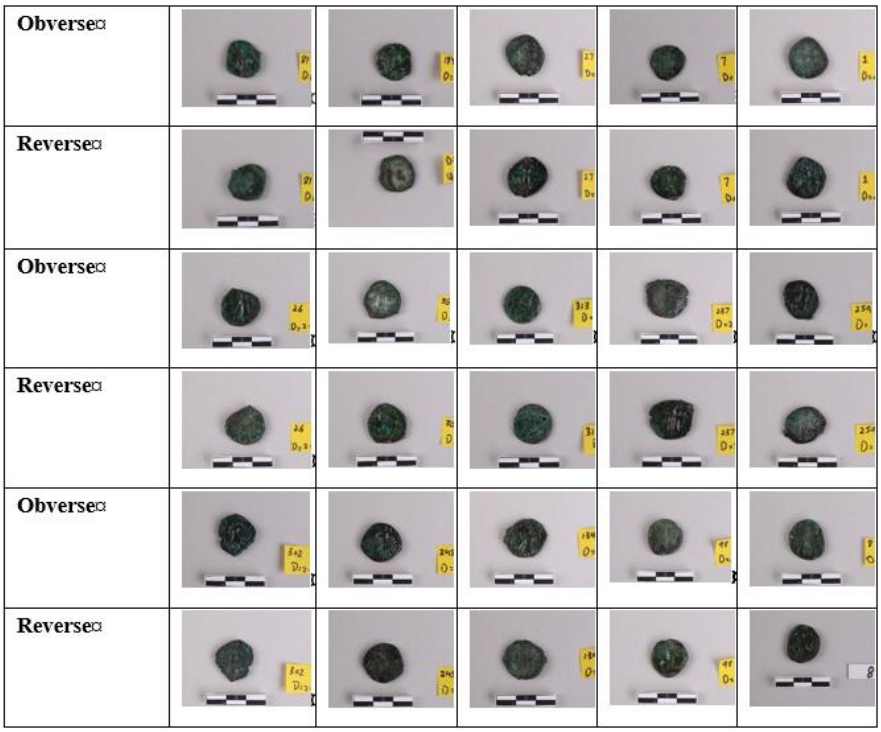
Dried copper coins after the reinforcement process

Result of Stabilization and Reinforcement process

The BTA (Benzotriazole) dealing process for Late Kushan copper coins is a refined and effective method of corrosion inhibition, vital for conserving the historical and cultural integrity of these objects. Through forming a protecting Cu-BTA membrane, the technique stabilizes the coins, mainly those with current corrosion and micro-cracks, efficiently preventing additional damage. The reinforcement procedure for Late Kushan copper coins by Paraloid B72, especially through the vacuum impregnation technique, is an extremely dedicated and effective method for enhancing the stability and preservation method to preserving these ancient artifacts. A 3-20% solution of Paraloid B72, dissolved in a solvent for example acetone or xylene, is applied through a vacuum impregnation method. This procedure confirms the resin deeply enters the microscopic holes and cracks inside the metal. It meaningfully increases the physical integrity of the coins by providing a defending barrier compared to further erosion. The usage of a vacuum impregnator is predominantly beneficial, as it suggests accurate control, reducing the threat of damage throughout the reinforcement method and confirming the resin spreads even the maximum unreachable parts of the coins.

Figure

Catalog after Reinforcement of Late Kushan Copper Coins



Wrap-up After Treatment

When the treatment procedure for the Late Kushan copper coins is complete, the facts of the treatment and the chemicals used are documented on a record card. Photographs of the coins are occupied before they are covered. The Late Kushan copper coins are formerly deposited under suitable temperature and humidity conditions to confirm their preservation.

Packing

The materials compulsory for packaging contain ESCAL film, humidity indicator, oxygen indicator, silica gel, RP Agent-A, and a sealing machine. To package the Late Kushan copper coins, place the coins, silica gel, RP agent, oxygen indicator, and humidity indicator into the ESCAL film. Cover the package with the sealing machine to confirm the best protection. The Late Kushan copper coins are at that time stored under suitable temperature and humidity conditions to preserve their reliability.

Fig 31

Sealed Late Kushan Copper Coin

Conclusion

The research of Late Kushan copper coins from the Islamabad Museum symbolizes an important involvement in the field of archaeometallurgy, posing appreciated perceptions into the financial, industrial, and material culture of the Kushan Era. Concentrating on the conservation and cleaning of these coins, which were struck throughout a period of weight decrease and metal degradation, the study discourses the major corrosion they have suffered due to insufficient preservation methods. Employing the modern conservation laboratory at the Islamabad Museum, the research put on modern, non-invasive cleaning approaches and offers a consistent method to preserving alike coins, in that way paying to the comprehensive field of archaeometallurgy.

This study uses a complete and methodical procedure, relating particular fieldwork with scientific analysis to observe the Late Kushan copper coins. Regardless of the restricted accessibility of modern conservation laboratories in Pakistan, the research profits from the well-equipped capability at the Islamabad Museum, which delivers important digital and physical apparatuses for conservation. By documenting the physical characteristics of the coins and using non-destructive techniques, the study objectives are not only to preserve these historical artefacts but correspondingly to improve our understanding of Late Kushan coinage and ancient metallurgical performance.

The planned conservation method contains pre-treatment investigations, stabilization treatments, and detailed documentation, all of which are vigorous for confirming the long-term preservation of these artifacts. This research highlights the use of non-destructive procedures anywhere possible to clean and conserve the coins, therefore conserving their historical importance. Though dental pick tools are helpful for the detailed and non-destructive cleaning of these coins, their confines highlight the requirement for a further complete conservation approach. Hence, a mixture of physical cleaning and chemical actions is essential for the complete conservation and protection of the Late Kushan copper coins.

Ultrasonic cleaning, an extremely operative and useful method, is mainly suitable for removing impurities from materials like metal. For ancient artifacts such as Late Kushan copper coins, ultrasonic cleaning is chiefly helpful, as it can eliminate corrosion and surface deterioration without cooperating with the coins' reliability. This technique attacks a perfect stability between effective impurity exclusion and preservation, confirming the coins' historical and numismatic value is sustained.

The BTA usage and Paraloid B72 reinforcement approaches are also essential for the preservation of Late Kushan copper coins, efficiently inhibiting erosion and enhancing physical integrity. BTA usage forms a protecting layer that stabilizes the coins, however, it needs careful treatment due to condition threats related to benzene. Likewise, the Paraloid B72 vacuum impregnation procedure delivers deep reinforcement but increases anxiety near long-term reversibility due to its dependence on unstable solvents. These methods elaborate the elusive stability between operative conservation and protection, highlighting the essential for cautious supervision and the examination of harmless alternatives to confirm the coins' conservation while preserving their historical and cultural veracity.

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