Dialogue Social Science Review (DSSR)
www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 4 No. 3 (March) (2026)

Causes and Level of Corrosion in Late Kushan Copper Coins from Islamabad Museum, Islamabad, Pakistan

Dr. Attiya Malik*
PhD from Department of Archeology, Hazara University, Mansehra, KP, Pakistan. Corresponding Author Email: attiyamalik801@gmail.com

Abstract
The corrosion of copper objects over time can be unfair by a number of factors. One important factor is the contact with environmental components. The Islamabad Museum Islamabad keeps thousands of coins in its standby collection. Of these, 5 Late Kushan copper coins' samples were particular for the research purpose. In observation of design, style of figures, weight examination and physical disorder, they clearly belonged to the Late Kushan leaders. The coins of this era appearance comparable same but they were issued by diverse rulers. Therefore, this lot of coins was carefully chosen for causes and level of corrosion**.** The morphometric structures on this group of coins, through RBS (Rutherford Backscattering Spectrometry) were examined to recognize how and what kind of corrosion has occupied place. The study highlights the existence of corrosion mixtures such as malachite, azurite, and attacamite, alongside copper oxides like cuprite and tenorite, representing the environmental influence on these coins.
Keywords: Corrosion, Attacamite, Rutherford Backscattering Spectrometry, Tenorite, Late Kushan, Cuprite, Islamabad Museum

Introduction
The idea of corrosion is as earliest as the Earth itself, however it has been mentioned to by numerous names all over past. Generally documented as rust in current times, corrosion is an unwanted phenomenon that damages the luster and beauty of objects though also fading their durability (Naixin et al., 2002). Corrosion is the disintegration of metal over an accidental chemical or electrochemical action, characteristically initial at its surface. This phenomenon is intrinsic to all metals, while approximately are extra prone to corrosion than others. The deterioration procedure mainly includes electrochemical reactions, similar to the mechanisms of a sequence. When metal atoms come into interaction with an atmosphere comprising water molecules, they may abandon electrons, therefore converting into definitely stimulating ions, providing there's a accomplished electrical circuit. This result can apparent locally, foremost to the formation of depths or cracks, or it can feast across a wider part, resulting in common deterioration. Corrosion attitudes as the main mechanism through which metals damage. When metals come into interaction with water (or even moisture in the air), acids, bases, salts, oils, and exact chemicals, they naturally go through corrosion. Moreover, contact to gaseous elements such as acidic vapors, formaldehyde gas, ammonia gas, and sulfur-containing gases can also persuade corrosion in metals (Matthew, 2013).

Bronze, made up of copper and tin, differences with brass, which consists of copper and zinc. Sympathetic the oxidation of copper alloys needs knowledge of copper's chemistry. Copper, the initial member of the group 1B in the periodic table, displays negligible chemical reactivity and oxidizes gradually in air due to its moral place in the electrochemical sequences. Copper and its alloys grow a

ISSN Online: 3007-3154
ISSN Print: 3007-3146

Vol. 4 No. 3 (March) (2026)

protective green covering, such as elementary $CuSO_4.3Cu(OH)_2$, that performances as a wall against additional oxidation, separating the metal from the air (Agrawal, 1987). In spite of its exposure to corrosion, copper retains the significant capacity to form constant corrosion crusts or passivation layers on the surfaces of objects. These protective coatings help as a barrier in contrast to additional corrosion in various environments. When exposed to oxygen or hydrogen sulfide, copper experiences oxidation processes, yet the development of this protective layer benefits alleviate further damage. Therefore, copper alloy objects dating back thousands of years can quiet be studied and exposed, despite showing a coating or patina subsequent from corrosion. This preservation of copper objects showcases the strength and flexibility of copper alloys above extended periods, allowing for their continued investigation and gratitude by researchers and the community comparable (Huisman et al, 2022).

Copper gradually oxidizes in the existence of oxygen to form cuprite ($Cu2O$), which can additional convert into tenorite (CuO). Moreover, the existence of chlorine ions can rush corrosion and principal to the formation of numerous copper mixtures. For example, copper can respond with chlorine to yield nantokite ($CuCl$). Furthermore, the mixture of copper with hydroxide ions and chlorine can consequence in the formation of minerals like atacamite, paratacamite ($Cu2(OH)3Cl$), and malachite ($CuCO3Cu(OH)2$). These responses demonstrate how environmental factors such as oxygen and chlorine ions give to the corrosion procedure of copper objects, foremost to the formation of diverse compounds over period (Elsayed, 2016). In archaeometry, coins stand out as the most widely studied metallic substances due to their capacity to yield productive outcomes. Characteristically, coins are composed of alloys through well-controlled compositions, frequently minted by known establishments and occasionally manner inscriptions such as dates of concern. This characteristic documentation makes coins appreciated for researchers, as references can be initiate in early documents, and their typology, metrology, and chronology have been systematically examined. Though, experiments arise in cases where written documentation is missing, leading to investigational problems for researchers in understanding the origins and backgrounds of these coins.

One of the maximum important logical tests in archaeometry turns around the investigation of patina, the coating of erosion and oxidation that forms on metallic substances over time. While gold, electrum, and pure silver coins naturally lack important corrosion and oxidation and can be examined by means of numerous sampling procedures, but coins made of "billon" (a silver/copper alloy) and copper alloys current difficulties due to surface phenomena that limit investigation. These surface phenomena, with enhancement and reduction effects, consequence in sample inhomogeneity, foremost to possibly accidental systematic outcomes. Therefore, the focusses of elements such as silver, zinc, tin, and lead measured on the external of copper alloy coins may not precisely reproduce their inner composition. This difference poses a task for researchers determined to understand the metallurgical properties and historical backgrounds of these objects (Guerra, 1995).

Archaeological coins support as valued chronological records but are vulnerable to corrosion over time, which interrupts their physical and chemical structures. This investigation highlighting on calculating how patina and protective coverings consequence the corrosion technique, helping to reserve their dependability and ancient importance (Saleh et. al, 2025). The research designed to well appreciate in what way alloying elements outcome patina growth and the early-stage degradation procedure in archaeological atmospheres (Boccaccini, et al. 2024).

Methodology

The investigation methodology engaged in this study is vital to its achievement, with specific importance on the careful implementation of the research and following scientific analysis. The early phase elaborate comprehensive fieldwork, as well as the collection of coins, comprehensive sampling procedures, full documentation, careful observation, nuanced understanding, thorough measuring, and exact recording of information. This stage was essential as it placed the groundwork for the following scientific analysis. Subsequent the fieldwork, a difficult scientific investigation was conducted, paying several procedures and methods to analysis deeper into the composed data. This examination was characterized by its careful consideration to part, devotion to scientific procedures, and application of state-of-the-art implements and technologies. By participating robust research with difficult scientific analysis, the study certified a complete understanding of the substance matter, yielding insights that pay meaningfully to the body of information in the field. Thus, the investigation methodology served as the basis of the study, behind its integrity, consistency, and scholarly accuracy.

In Pakistan, the background for scientific laboratories dedicated to the conservation of coins is comparatively insufficient, with only two practical facilities known to happen. One of these laboratories works within the ancient limits of Lahore Fort and was recognized by the Department of Archaeology and Museums, Govt. of the Punjab, back in 2011. In spite of its occurrence, this lab's abilities are rather limited; it mainly depend on on chemical treatments for the cleaning and action of archaeological objects, including coins. Though, a prominent absence is the deficiency of a preservation chamber, which is vital for combining objects post-conservation.

In contrast, the second laboratory located inside the Sir Syed Memorial at Islamabad Museum offerings a more promising picture. This newer ability claims better equipment and resources associated to its Lahore complement. Particularly, the Islamabad Museum lab houses a well-established Digitalization and Conservation Section, a feature that demonstrated precious for the present research attempt. The digitalization abilities facilitated the researcher to perfectly document a significant collection of coins, mainly focusing on the Late Kushans, thereby inspiring the scholarly understanding of this chronological age. In the Conservation Section, a variation of digital technologies are accessible to facilitate the cleaning and preservation of archaeological objects. These equipment comprise an ultrasonic machine (Ultrasonic Cleaning Bath), which uses high-frequency sound waves to eliminate dirt and remains smoothly. Moreover, an incubator helping in the accurate measurement and regulator of several environmental factors such as temperature and humidity, vital for optimal object preservation. Additionally, a dehydrator shows a vital role in eliminating humidity from objects, inhibiting deterioration caused by fungal growth or corrosion.

The current investigation is focused on examining causes and level of corrosion associated to Late Kushan copper coins. Initially, it aims to examine the morphometric features of these coins, looking for to understand their

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 4 No. 3 (March) (2026)

physical features and measurements in feature. Moreover, the analysis aims to recognize the major reasons and levels of corrosion disturbing these objects, flaking light on the environmental and historical factors paying to their deterioration. Copper coins, similar other metal objects, are subject to corrosion and corrosion over period due to environmental factors such as moisture, air, and contaminants.

Coins, obviously made of metal through traditional designs, sustain surface corrosion above time, mainly during conversation. Researchers have widely deliberate this deterioration presentation to distinguish in what way coin materials respond below such conditions. The investigation uncovered that corrosion coatings on suppressed copper alloys produce altered tin-rich inside and copper-rich outside layers. This multi-layered manufacture forms mostly over decuprification, a perceptive copper ending procedure determined by sustained interaction to moderately chloride-contaminated soil (Oudbashi et. al, 2024).

Morphometric Features of the Late Kushan Copper Coins through Stereo Microscope

External corrosion appears as a important factor contributing to the pattern damages detected on Late Kushan copper coins obtained from the Islamabad Museum. This study emphases on examining the morphometric features of these coins to explain their corrosion mechanisms. The results shed light on the connection between corrosion thickness and impression rates, enlightening a successive reduction in etching rates with reducing corrosion thickness. This phenomenon might be credited to the exclusive macro-features of the surface pattern of the coins.

The Late Kushan copper coins display visible deterioration, marked from the visible cracks and broken edges existing across their surfaces. Moreover, concretion has shaped, likely contributing to the presence of blue and green qualities on the coins. Investigation revealed a metallic core enclosed by a green-grey corrosion coating at the ends of the sample coins. These explanations provided vital insights for analyzing the situation of the coins earlier introducing any conservation methods. Understanding the amount and nature of the deterioration is vital for inventing suitable strategies to preserve and defend these historical objects.

The analysis of Late Kushan copper coins applying a stereo microscope has provided valuable insights into the situation of these objects. The examination exposed that the surface of the coins was mainly covered by Cuprite (Cu_2O), a copper oxide compound formed through the contact of the coins with oxygen in their environment. Moreover, black areas of Tenorite (CuO) were detected on some portions of the coins, showing a transformation from Cuprite due to increased oxygen intensities in the nearby medium.

Additionally, the stereo microscope analysis revealed additional details almost the physical state of the coins. Some coins were found to be followed to each other, signifying that corrosion procedures may have caused them to fuse over period. Moreover, numerous cracks were apparent on the surface of the coins, probable resulting from the growth and reduction of the metal throughout corrosion or due to mechanical pressure. Generally, the stereo microscope study provided a comprehensive opinion of the condition of the Late Kushan copper coins, importance the occurrence of corrosion products, physical changes, and

Dialogue Social Science Review (DSSR)
www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 4 No. 3 (March) (2026)

structural damage. These outcomes pay to a deeper understanding of the poverty procedures affecting these objects and can notify conservation approaches to reserve them for future study and gratitude.

Corrosion Mechanisms of Late Kushan Copper Coins

The corrosion mechanisms of Late Kushan copper coins were examined over the production of development models, providing vision into the creation and development of corrosion products on their surfaces. Primarily, the flat surfaces of the coins underwent corrosion upon constant exposure to oxygen in the air (Figure 11(a)). This procedure run to the construction of different corrosion products at variable rates in distinct areas, inducing surface stresses inside the coins (Figure 11(b)).

The internal stresses subsequently resulted in the sudden formation of external micro-cracks (Figure 11(c)), over which micro and nanoparticles, along with oxygen, entered and responded with the copper to form metallic corrosion. The constant development of corrosion products ultimately enriched the surface cracks (Figure 11(d)), somewhere different stages of corrosion products formed at variable rates in local areas (Figure 11(e)). Consequently, the corrosion products experienced extra stresses in numerous local domains, important to the arrival of new cracks at the connections of old ones (Figure 11(f)). These recently formed cracks provided favorable conditions for the infiltration of oxygen and carbon into the surface cracks of corrosion elements (Figure 11(g)), additional helping the growth of corrosion products. Considerable growth of corrosion products slowly led to the formation of new microcracks (Figure 11(h)), which sustained to rust and increase external, interconnecting the old cracks to form striated corrosion products (Figure 11(i)).

Due to the irregular growth of striated corrosion features, different microcracks constantly established along with the striated microstructures, ultimately forming dendritic microcracks (Figure 11(j)). As corrosion persevered, these microcracks prolonged, interconnecting older ones and producing the dendritic structures to change into sub-reticulate developments (Figure 11(k)). As the corrosion of Late Kushan copper coins strengthened, the sub-reticulate microstructures slowly transformed into compact reticulate structures (Figure 11(l)), with new cracks developing within the reticulate design (Figure 11(m)).

Sustained penetration of corrosion particles led to the progress of corrosion products through the whole surface of the coin, forming a compact layer in confined areas (Figure 11(n)). Inside these corrosion layers, prominent differences in phase difference, growth rate, and connection form of corroded surfaces resulted in important pressure variations. These irregular pressure distributions gave rise to new microcracks within the compact corrosion layers (Figure 11(o)) (Yin et. Al, 2022).

Dialogue Social Science Review (DSSR)
www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 4 No. 3 (March) (2026)

Fig 1: Examine coin under stereomicroscope

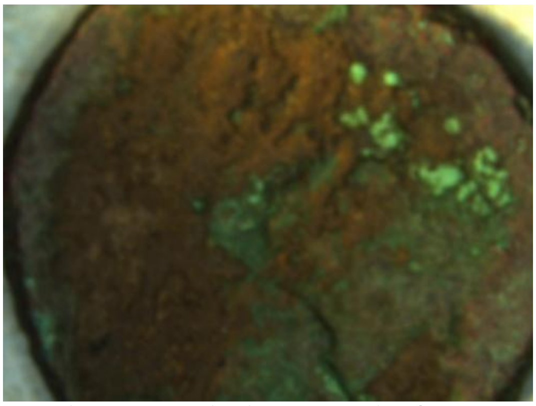

Fig 2: Stereomicroscopic image (before conservation)

Therefore, throughout the self-healing and self-degradation procedure of surface micro-cracks, modest mechanisms operated, influencing the corrosion thickness. This comprehensive progression explains the complex relationship of corrosion processes and structural variations, providing understandings into the mechanisms driving the growth of corrosion structures on Late Kushan copper coins. Appreciative these processes is vital for developing effective strategies for the protection and conservation of these historical objects.

Overall, this detailed analysis elucidates the complex and dynamic nature of corrosion processes affecting Late Kushan copper coins, providing valuable insights into the mechanisms driving their degradation over time. Understanding these mechanisms is crucial for developing effective preservation and conservation strategies for these historical artefacts.

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 4 No. 3 (March) (2026)

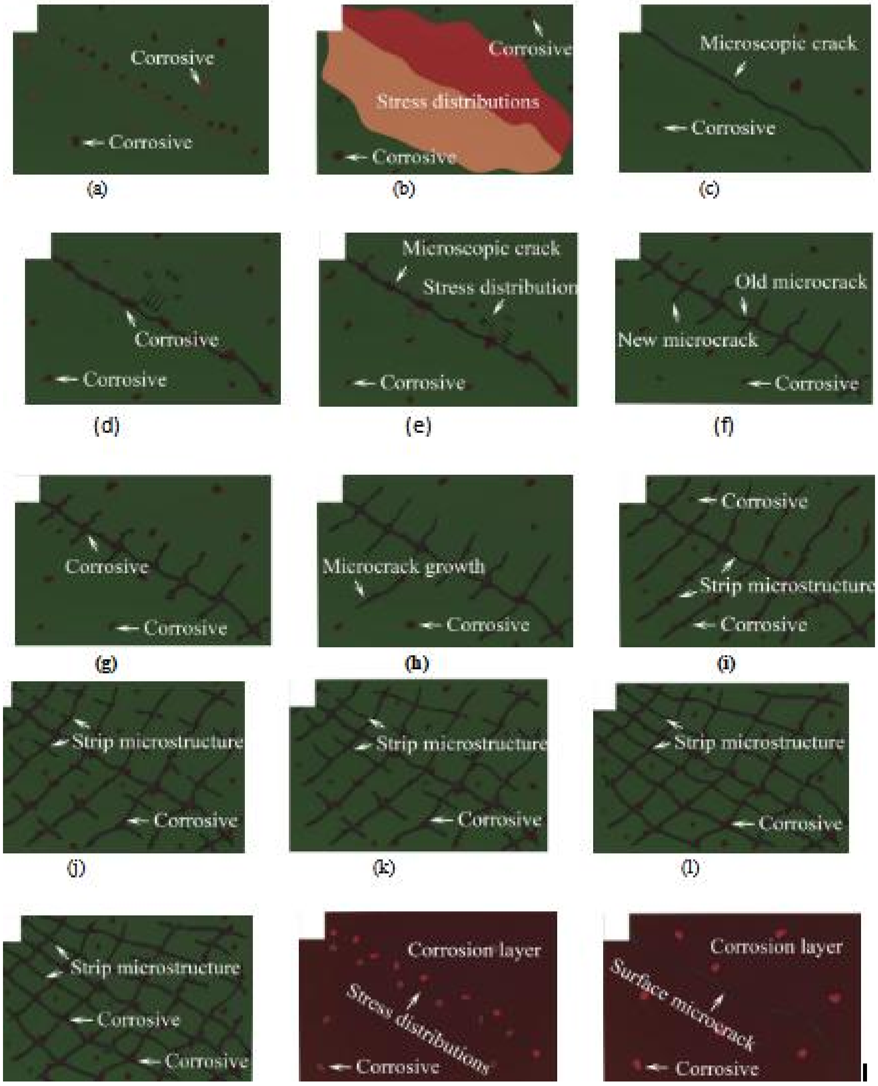

Fig 3: typical model established for the growth of corrosion layers starting from micro-cracks generation to formation of corrosion features of Late Kushan copper coin surface

Examine Corrosion Causes through Rutherford Backscattering Spectrometry(RBS)

Rutherford Backscattering Spectrometry (RBS) is a influential nuclear technique utilized for examining the near-surface layers of solid resources. In this method, a target material is bombarded with ions at energies characteristically extending from 0.5 to 4 MeV (Mega electron Volts). The backscattered projectiles are then identified, and their dynamisms are documented by means of an energy-sensitive detector, usually a solid-state detector.

One of the main benefits of RBS is its capacity to deliver quantitative determination of material arrangement and depth summarizing of specific elements. RBS is non-destructive, significance it does not cause harm to the sample being examined. RBS offers exceptional depth resolution, characteristically on the direction of several nanometers, permitting detailed characterization of thin surface coatings. The method also shows identical sensitivity for heavy elements, with exposure limits attainment down to the

Dialogue Social Science Review (DSSR)
www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 4 No. 3 (March) (2026)

parts-per-million (ppm) level. The depth of examination attainable with RBS depends on the event ion species, with He-ion attack typically penetrating depths of around 2 μm and proton attack reaching depths of about 20 μm (Mayer, 2013).

Rutherford Backscattering Spectrometry (RBS) hints its roots back to the influential experiments accompanied by Ernest Rutherford in 1911, where he applied the backscattering of alpha particles as of a gold film to expose the well structure of the atom, eventually leading to the finding of the atomic nucleus. Though, it wasn't up until 1957 that RBS appeared as a technique for materials study, with its formal explanation provided by Rubin et al. This revolutionary laid the foundation for the contemporary applications of RBS, which have since converted extensive in several fields of science and technology.

Rutherford Backscattering Spectrometry (RBS) includes a variety of flexible ion scattering methods paying event ion energies naturally on both sides of from 500 keV to several MeV. Protons, alpha particles (4He), and irregularly lithium ions help as mutual projectiles in RBS examines. These ions are absorbed towards the target material at backscattering approaches characteristically falling within the variety of 150 to 170 degrees, while differences in angles or the use of diverse projectiles may happen in particular claims. Through choosing precise event energies, positions, and projectile types, researchers can modify RBS experiments to suit the desires of their particular investigation, allowing detailed characterization of material arrangement and structure with exceptional depth determination and sensitivity (Ibid).

This procedure depend on on the principle of flexible scattering of ions, classically helium or hydrogen, from the atoms in the sample material. Though, it's significant to message that RBS can only investigation a surface layer of partial depth, typically reaching from a few micrometers to a insufficient tens of micrometers. Therefore, while RBS offers appreciated understandings into surface chemistry and elemental composition, it may not apprehension data approximately subsurface layers or bulk material properties. In spite of this restriction, RBS remains a influential tool for describing ancient coins and other objects, contribution appreciated evidence for archaeological and historical studies (Ibid).

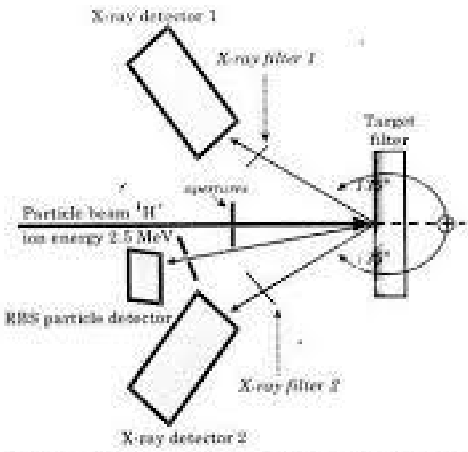

Fig 4: Schematic diagram of a Rutherford Backscattering Spectrometer (Mayer, 2003)

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 4 No. 3 (March) (2026)

DIALOGUE SOCIAL SCIENCE REVIEW

Material and Methods

5 copper coins of Late Kushans period were selected for RBS analysis which were collected from the reserve collection of Islamabad Museum. These coins displayed severe corrosion, often concealed beneath thick layers of patina. Late Kushan Copper Coins have been submitting to the National Centre for Physics **(NCP)** Laboratory known as Data Analysis Lab. All the coins were analyzed for the elemental composition of surface layer. The coins were then subjected to Rutherford Backscattering Spectrometry (**RBS)** analysis.

Experimental Set-up

The experiments were performed at the Data Analysis Labs of the National Centre for Physics **(NCP) 'Islamabad'.** The detection limit of RBS has been derived theoretically and representation of trace element analysis has been calculated. It has been shown that the best detection limit obtained with 4 MeV alpha ion beams which only depend on the sample matrix.

Results of Rutherford Backscattering Spectroscopy (RBS) Technique

In the present research, the backscattering spectrum from Late Kushan copper coins are discussed. Five Late Kushan copper coins were selected randomly for the analysis of corrosion level and their causes. This spectrum likely showed peaks corresponding to the backscattering of ions from the different elements present in the Late Kushan copper coin sample.

Typically, analysts rely on the characteristic energy levels or "front edges" of the elements to determine their presence and concentration in the sample. By analyzing the energy distribution of the backscattered ions, researchers inferred the composition of the material and the relative amounts of each element present.

Data Analysis

The ancient period of Late Kushan Dynasty approximately ends in fourth century CE. A research study on the deterioration of Late Kushan copper coins. The study utilized various analytical methods to investigate the corrosion nature and its effects on the coins.

Corrosion Process

The corrosion of Late Kushan copper coins over time is influenced by various factors, each playing a significant role in the degradation process as different metals exhibit varying degrees of susceptibility to corrosion. Exterior characteristics, such as roughness or smoothness, as well as the existence of limitations or coatings, can also effect corrosion rates. The thickness of the coin is additional crucial consideration; as thicker coin possibly will rust extra slowly due to a higher capacity of material to damage.

Environmental factors show an essential role in corrosion procedures. The burial environment, with factors such as soil structure, moisture stages, and temperature variations, can rush or slow corrosion rates. The pH value of the nearby environment is similarly dangerous; as acidic or alkaline circumstances can encourage corrosion.

The existence and focus of precise ions in the environment, such as oxygen, chlorine, and carbon, can meaningfully affect corrosion rates. Oxygen ions, for sample, are regularly concerned in the oxidation of these coins. The investigation focused on the corrosion procedure of copper coins produced by

ISSN Online: 3007-3154
ISSN Print: 3007-3146
DIALOGUE SOCIAL SCIENCE REVIEW
Vol. 4 No. 3 (March) (2026)

factors like oxygen in the environment. This mains to the development of copper oxides on the surface of the coins.

In the current sample Late Kushan copper coins, the reaction between metallic copper and carbon dioxide lengthways with moisture in the air produces a greenish layer to producing a situation recognized as bronze disease. These Late Kushan copper coins unearthed from earth are frequently adorned with a green or blue crust named patina. This moral patina formation, reaching its extreme basicity within about 70 years, not simply satisfies the eye but also helps as a protective shield against additional deterioration of the copper objects.

This external greenish coating of the patina on the Late Kushan copper coins mainly contains of elementary copper carbonate, though underneath it lies reddish-colored copper oxide, with the metal core at its base. This encrusted composition contributes to the exclusive presence and protective properties of the patina, preservation the fundamental metal from more corrosion (Agrawal, 1987).

Physical Examination

These coins have suffered insufficient storage practices, missing any precautionary treatments to stop the corrosion procedure. As a end result, they have established completely mineralized within their plastic attachments, representing important poverty over time. The absence of suitable storage practices has allowed environmental factors to speed up the corrosion of the coins. Without involvement to alleviate corrosion, the copper surfaces have experienced extensive chemical reactions, most important to the formation of corrosion layers. These coatings likely include several compounds, as well as copper oxides such as Cuprite (Cu_2O) and Tenorite (CuO), as well as additional elements present in the surrounding environment.

The coins' whole mineralization within their plastic bags highlights the harshness of the erosion damage they have suffered. This mineralization procedure recommends that the erosion has proceeded to a point where the unique copper material has undergone considerable conversion, impacting in cooperation the physical and chemical properties of the coins. Through investigating the corrosion layers and appreciative the environmental situations that led to their formation, this investigation purposes to offer respected understandings into the deterioration procedures disturbing Late Kushan copper coins. Moreover, it highlights the significance of suitable storage and conservation practices to avoid further degradation of appreciated cultural objects. The coins exhibited more cracks and various corrosion layers, indicating significant deterioration (Elsayed, 2016). The research establishes that cuprite forms as the major patina on copper-based alloys owing to disclosure to moist, oxygen-rich burial surroundings. Over time, minor patinas like malachite and azurite established, which were far along cooperated by "bronze disease," subsequent in the formation of destructive corrosion products like nantokite, atacamite, and paratacamite (Mayyas, et al. 2023).

Chemical Composition

To determine the RBS analytical results of the Late Kushan copper coins, all the coins which have been recovered from reserve collection of the Islamabad Museum having similar elemental composition. In the Late Kushan copper coins, the elements of Ca, O, Si, and Fe are the most important metallic impurities in

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 4 No. 3 (March) (2026)

relating the metal back to the original type of ore. The presence of iron (Fe) as impurity in the samples that can be related to the surface contaminations.

RBS analysis revealed the elemental composition of the coins. The primary element present was copper, along with traces of other elements like silicon, calcium, aluminum, oxygen, iron, lead, zinc, and nickel. The elements Ca, Fe, O, Si, Ni, Al, Pb and Zn were detected in the coin along with the major component Copper (Cu) by the present experimental set-up. According to the spectrum, the analyses results confirm the fact that copper was abundantly available during the time of Kushan dynasty. High concentration of Cu in coins indicates that, it has been added deliberately to show monetary policy or economic necessity.

Corrosion Compounds

The patina may contain compounds such as malachite (Basic $CuCO_3(OH)_2$), azurite (Basic $2CuCO_3Cu(OH)_2$), and attacamite (Basic $Cu_3(OH)2Cl_2$), mixed with corellite (CuS) and other salts depending on the burial environment of the coin object. The main compounds identified on the surface of the coins were copper oxides, specifically Cuprite (Cu_2O) and Tenorite (CuO).

Generally, the research provides awareness into the corrosion procedure and its effects on Late Kushan copper coins, contribution appreciated information for preservation and conservation determinations (Elsayed, 2016).

Rutherford Backscattering Spectroscopy Results

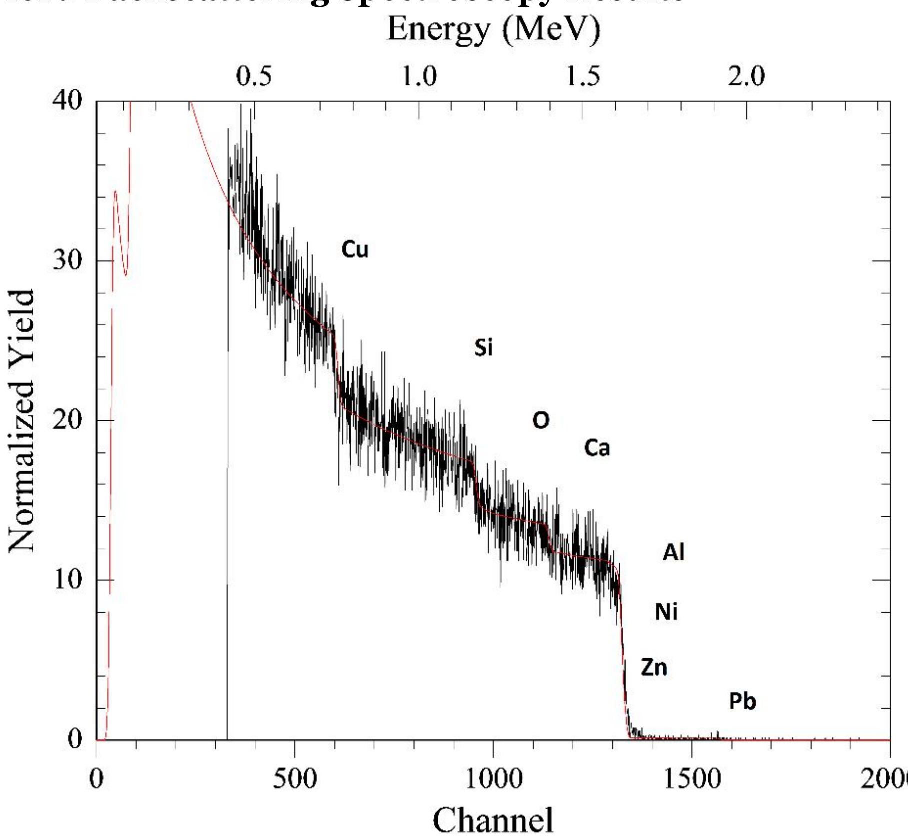

Fig 5: Calculated RBS spectrum of coin 217. 1.9 MeV 4He, 170◦

Dialogue Social Science Review (DSSR)
www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 4 No. 3 (March) (2026)

Description Coin 217
Sim Reset
Layer 1
Thick 4000 nm
Composition:

Elements	**Cu**	**O**	**Si**	**Pb**	**Ca**	**Ni**	**Al**	**Zn**
Composition	2.790352	0.918221	1.17296	0.00114656	0.256687	0.0284803	0.02904	
Percentage	54%..........	17.6%	22.66%	0.02%	4.8%	0.3%	0.561%	0.04%

Table 1: Elemental Composition of Coin217
Maxpth 200; Foil disable

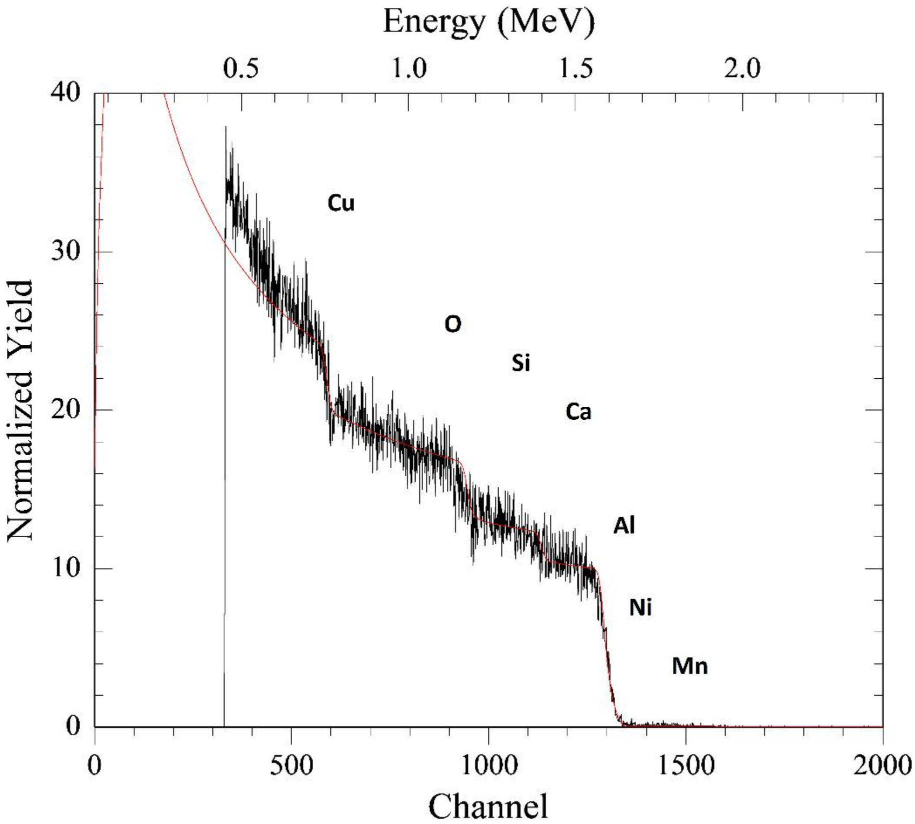

Fig 6: Calculated RBS spectrum of coin 231. 1.9 MeV 4He, 170◦

Description Coin 231
Sim Reset
Layer 1
Thick 4000 nm

Composition:

Elements	**Cu**	**O**	**Si**	**Pb**	**Ca**	**Ni**	**Al**	**Mn**
Composition	**4**	**1.7314**	**0.451037**	**0.00114656**	**0.184734**	**0.05176**	**0.06213**	**0.01124**
Percentage	**54%**	**26.6%**	**6.94%**	**0.017%**	**2.84%**	**0.79%**	**0.95%**	**0.17%**

Dialogue Social Science Review (DSSR)
www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 4 No. 3 (March) (2026)

Table 2: ***Elemental Composition of Coin231***

Maxpth 200; Foil disable

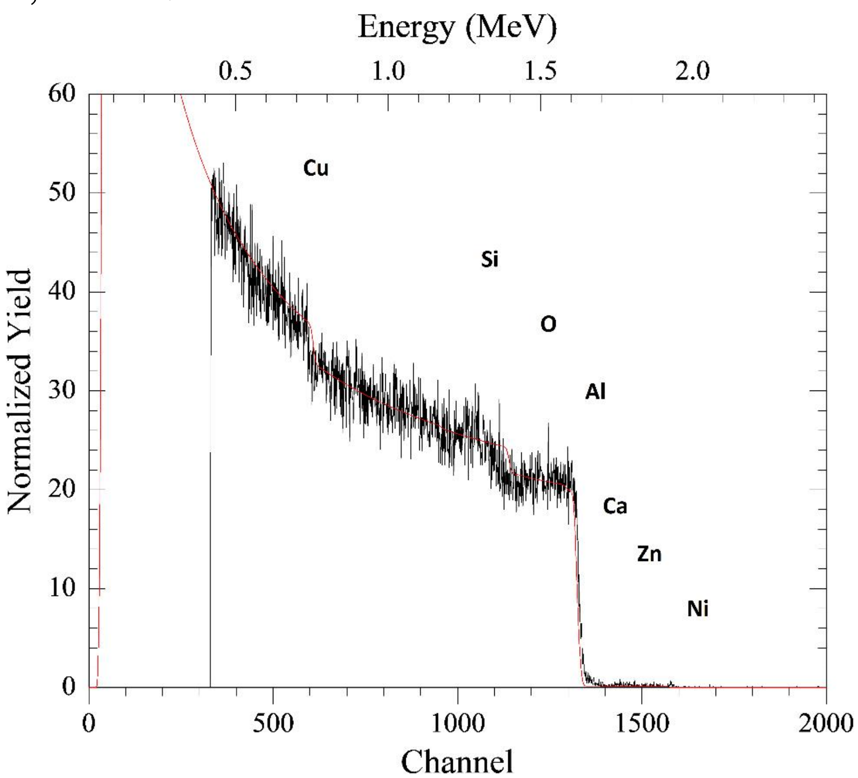

Fig 7: Calculated RBS spectrum of coin 287. 1.9 MeV 4He, 170◦

Description Coin 287

Sim Reset

Layer 1

Thick 4000 nm

Composition:

Elements	**Cu**	**O**	**Si**	**Ca**	**Ni**	**Al**	**Zn**
Composition	**4.3**	**0.5**	**1.83**	**0.1**	**0.00114656**	**0.2**	**0.06**
Percentage	**61.50%**	**7.15%**	**26.17%**	**1.43%**	**0.01%**	**2.86%**	**0.85%**

Table 3: ***Elemental Composition of Coin287***

Dialogue Social Science Review (DSSR)
www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 4 No. 3 (March) (2026)

Maxpth 200; Foil disable

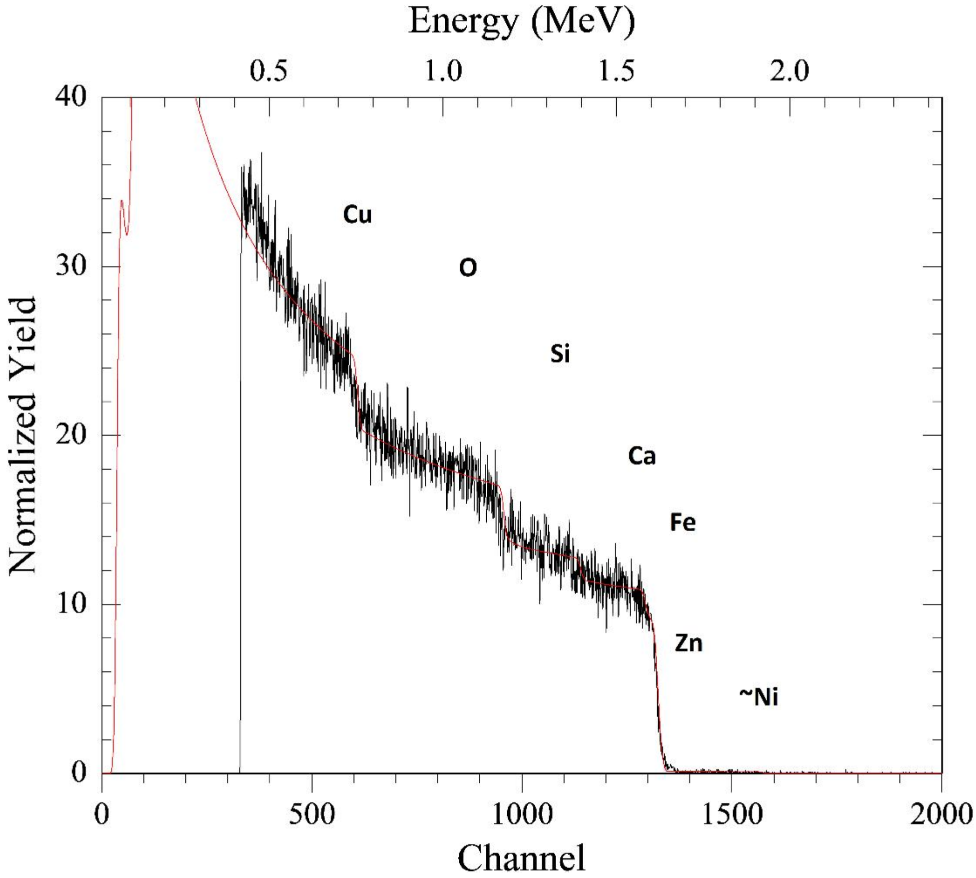

Fig 8: Calculated RBS spectrum of coin 340. 1.9 MeV 4He, 170◦

Description Coin 340
Sim Reset
Layer 1
Thick 4000 nm
Composition:

Elements	**Cu**	**O**	**Si**	**Ca**	**Ni**	**Fe**	**Zn**
Composition	**4.9**	**1.3**	**0.8**	**0.25**	**0.00114656**	**0.2**	**0.1**
Percentage	**64.89%**	**17.21 %**	**10.59%**	**3.31%**	**0.01%**	**2.64%**	**1.32%**

Table 4: ***Elemental Composition of Coin340***

Dialogue Social Science Review (DSSR)
www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 4 No. 3 (March) (2026)

Maxpth 200; Foil disable

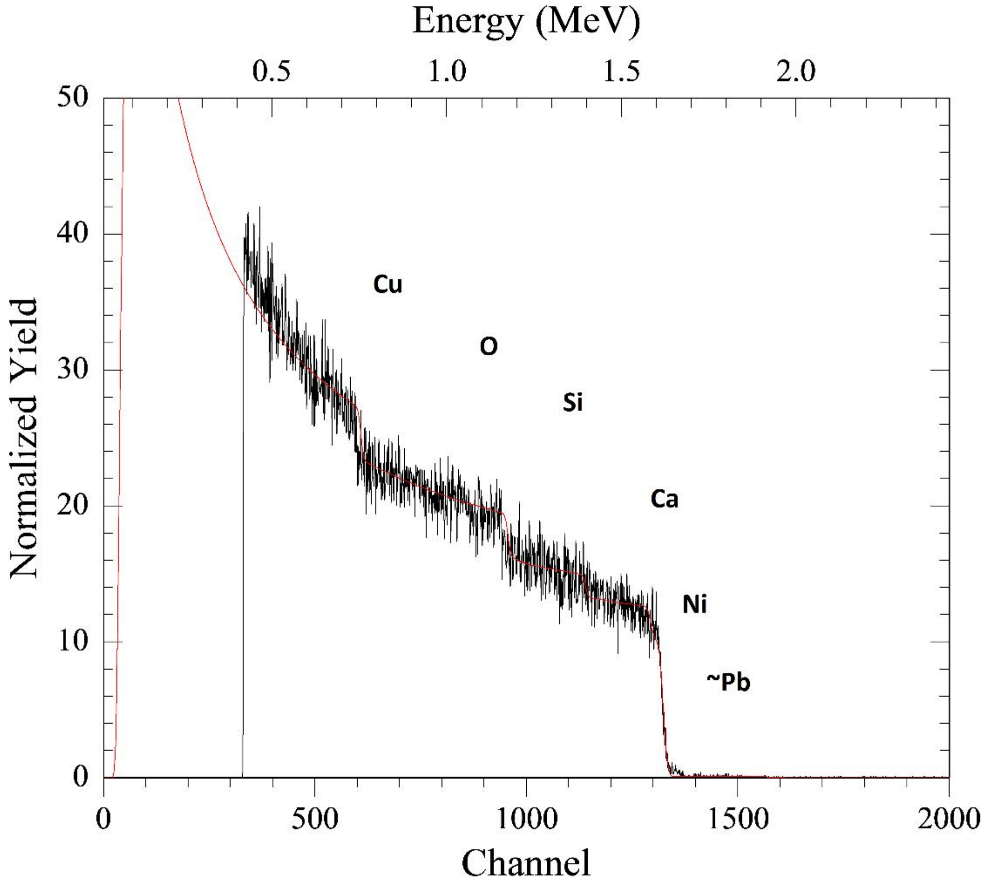

Fig 9: Calculated RBS spectrum of coin 372. 1.9 MeV 4He, 170◦

Description Coin 372
Sim Reset
Layer 1
Thick 4000 nm
Composition:

Elements	**Cu**	**O**	**Si**	**Pb**	**Ca**	**Ni**
Composition	**6**	**1.77201**	**1.2**	**0.00114656**	**0.438961**	**0.380271**
Percentage	**61.32%**	**18.08%**	**12.26%**	**0.01%**	**4.39%**	**3.88%**

Table 5: ***Elemental Composition of Coin372***

Dialogue Social Science Review (DSSR)
www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 4 No. 3 (March) (2026)

Maxpth 200; Foil disable

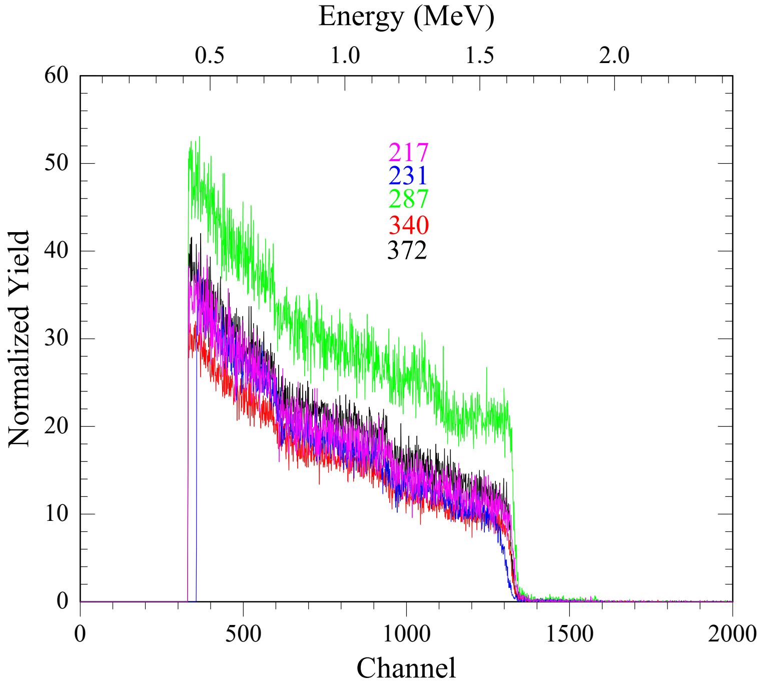

Fig 10: Calculated RBS combined spectrum of coins. 1.9 MeV 4He, 170

Result of Physical Cleaning
(Before mechanical cleaning)

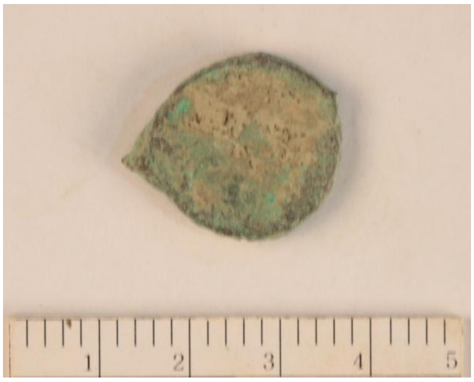

Fig 11: obverse

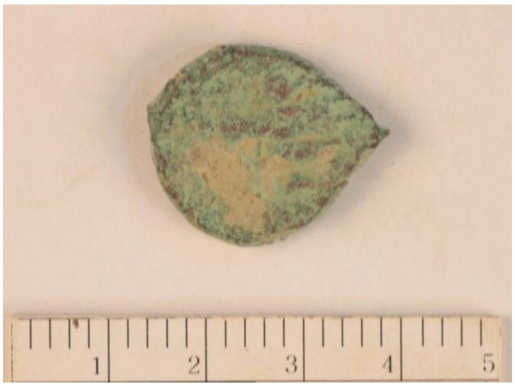

Fig 12: reverse

Dialogue Social Science Review (DSSR)
www.thedssr.com

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 4 No. 3 (March) (2026)

(After physical cleaning)


Fig 13: Obverse ***Fig 14: Reverse***

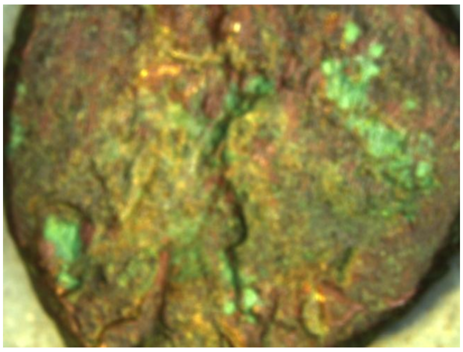


Fig 15: Stereomicroscopic image of the obverse side
Fig 16: Stereomicroscopic image of the reverse side

Conclusion

The investigation procedure employed in this research is inclusive and systematic, relating meticulous fieldwork with tough scientific study to investigate Late Kushan copper coins. Regardless of the partial accessibility of progressive conservation laboratories in Pakistan, the research influences the well-equipped facility at Islamabad Museum, which offers vital digital and physical tools for the conservation procedure. Through documenting the coins' physical qualities, applying non-destructive conservation methods, and examining their metallurgical composition, the study aims to preserve these historical objects though developing our understanding of Late Kushan coinage and earliest metallurgical practices. The study's method confirms that mutually the preservation and scholarly investigation of these coins are passed out with accuracy, paying suggestively to the meadow of archaeometallurgy and cultural heritage conservation.

The investigation successfully combines elemental investigation procedures such as Rutherford Backscattering Spectrometry (RBS) through practical conservation struggles. The coins revealed marks of deterioration, with compounds such as malachite, azurite, attacamite, and copper oxides (cuprite and tenorite) recognized. These findings show important environmental effects on the coins over time. The investigation on the deterioration of Late Kushan copper coins exposes the complex interaction of environmental and material factors manipulating their corrosion over period. The corrosion procedure is determined by several elements, such as oxygen, humidity, and carbon dioxide,

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 4 No. 3 (March) (2026)

important to the development of patina layers, with copper oxides like Cuprite and Tenorite. The study highlights the acute role of suitable storage and conservation practices, as the absence of these has caused in important degradation, including the whole mineralization of coins deposited under suboptimal situations. Systematic methods, such as Rutherford backscattering spectrometry (RBS), have recognized the elemental composition of these coins, with copper being the main element along with contaminations like iron, silicon, and calcium. The existence of these impurities and deterioration compounds like malachite and azurite underscores the requirement for targeted preservation policies. Finally, this research offers vital understandings into the corrosion mechanisms at play, as long as a substance for more effective conservation determinations to protect these valuable cultural objects.

Bibliography

Boccaccini, F. Riccucci, C. Messina, E. Pascucci, M. and Bosi, F. (2024). Early Stages of Metal Corrosion in Coastal Archaeological Sites: Effects of Chemical Composition in Silver and Copper Alloys. *Materials*, *17*(2), 442. https://doi.org/10.3390/ma17020442.

Bower, N. W. (2010). Chemical Attribution of Corroded Coins Using X-ray Fluorescence and Lead Isotope Ratios: A Case Study from First Century Judaea. *Applied Spectroscopy,* 64(4), 384-90.

Chakrabortity, S. (1931). Is Export Expansion of Manufactured Goods an Escape Route from Terms of Trade Deterioration of Developing Countries? Journal of South Asian Development. SAGE Los Angeles, London, 81-108.

Dillmann, P. Beranger, G. Piccardo, P. and Matthiessen, H. (2007). Corrosion of Metallic Heritage Artefacts: Investigation, Conservation and Prediction of Long Term Behaviour. *Woodhead publishing*, (48).

Elsayed, A. (2016). Investigations methods to study corrosion of some ancient Islamic copper coins at Faculty of arts museum, Sohag university, Egypt. *Department of Applied Science and Technology, Politecnico di Torino, 10126, Turin*. Italy, 197-202.

Huisman, H. Ackermann, R. Claes, L. Eijck, L. V. Groot, T. D. Joosten, I. Kemmersf, F. Kerkhoven, N. Jan-Willem de Kort, Sarah Lo Russo h, Ngan-Tillard, D. Bertil van Os, Peterj, M. Pümpin, C. Vaars, J. and Zhou, Z. (2023). Change lost: Corrosion of Roman copper alloy coins in changing and variable burial environments. *Journal of Archaeological Science: Reports*, (47), 1-21.

Martens, M. H. J. (2012). *Climate risk assessment in museums: degradation risks determined from temperature and relative humidity data.* Lpskamp Drukkers, Enschede, The Netherlands. Technische Universiteit Eindhoven.

Mayer, M. (2003). Rutherford Backscattering Spectrometry (RBS). 1-26, Garehing, Germany:Max-Planck-Institute fir Plasmaphysik, EURATON Association.

Mayyas, A. Al Sekhaneh, W. Al Fuqara, D. Seiseh, R. Al-Ajlouny, F. Al Muheisen, Z. and Popp, J. (2023). Microstructural and Compositional Characterization of Roman Bronze Coins from Khirbat Edh-Dharih in Jordan. *Arqueologia Iberoamericana,* (52), 69-86. ISSN 1989-4104. https://laiesken.net/arqueologia/.

Novak, P. (2007). Environmental deterioration of metals. Department of Metals and Corrosion

ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 4 No. 3 (March) (2026)

Novakovic. (2008). Corrosion of Ancient Silver Alloys. *17th International* Corrosion Congress, 1-13.

Oudbashi, O. Naseri, R. and Hasanvand, P. A. (2024). Long-term corrosion of copper alloys in the soil: new aspects of corrosion morphology in archaeological vessels from south-western Iran. Heritage Science, XII (73), 1-7.

Quaranta, M. (2009). On the degradation mechanisms under the influence of pedological factors through the study of archeological bronze patina. Alma Mater Studiorum - Università di Bologna, XXII, 1-206.

Reale. (2010). Ancient coins: Cluster analysis applied to find a correlation between corrosion process and burial soil characteristics. Chemistry Central Journal, 1-9.

Rita, R. (2012). Ancient coins: Cluster analysis applied to find a correlation between corrosion process and burial soil characteristics. Chemistry Central Journal, 26-29.

Saleh, S. M, Abd El-Hakim El-Badry, A. and Abdel-karim, A. M. (2025). Evaluation of the corrosion resistance of bronze patina or/and protective coating on the surface of the archaeological coins. Scientific Reports, 15(2361), 1-15.