Luxor International Journal of Archaeological Studies

PRINT-ISSN: 2535-1788 / **ONLINE-ISSN:** 2974-4121

HTTPS://LIJAS.JOURNALS.EKB.EG/

Volume 4, Issue 1, July 2021: pp. 11-29

The Scientific Methods of Recording and Documenting Archaeological Artifacts: An Analytical Study of Some Examples from the Album of Al-Aqsa Mosque - Jerusalem

Hebatallah S. El-Menshawy, [1,*] Mohamed Ahmed Helal [2]

[1] Conservation and Restoration Department, Bibliotheca Alexandria, Alexandria, Egypt

[2] Faculty of Fine Arts, Alexandria University, Alexandria, Egypt

Abstract

This research paper examines the scientific methods used in recording and documenting archaeological artifacts, with a specific focus on a selected group of artifacts from the Album of Al-Aqsa Mosque in Jerusalem. The study employs a multi-faceted approach that includes historical and archaeological documentation, photographic documentation, visual inspection, and advanced imaging techniques, including multispectral imaging using infrared and ultraviolet radiation, visible and polarized light microscopy, as well as scanning electron microscopy. Additionally, analytical methods such as energy-dispersive X-ray analysis (EDAX) and X-ray diffraction analysis are utilized, along with infrared spectroscopy, to identify components of photographic images and the technologies and techniques used in their execution. This research aims to identify the layers of photographic images, especially non-visible or subsurface layers, including the number of layers and the techniques used in image execution, as well as the factors contributing to the deterioration of the preservation state of these samples. Through the use of these methods, this study also seeks to shed light on the material composition and preservation challenges of photographic artifacts from the Album of Al-Aqsa Mosque, and the results of this research contribute to understanding archaeological methods and provide insights into restoration and preservation of cultural heritage.

Keywords

Archaeological Artifacts; Multi-spectra Imaging; Documentation; Al-Aqsa Mosque; Cultural Heritage.

Article History

Received: 7/4/2021

Accepted: 28/5/2021

DOI: 10.21608/lijas.2021.357297

* Correspondence Author: heba.elmenshawy@bibalex.org; heba.elmenshawy79@gmail.com

الأساليب العلمية في تسجيل وتوثيق المقتنيات الأثرية: دراسة تحليلية لبعض النماذج من ألبوم المسجد الأقصى – القدس

هبة الله صلاح المنشاوي، [1] محمد أحمد هلال [2]

[1] قسم الترميم والصيانة، مكتبة الإسكندرية، الإسكندرية، جمهورية مصر العربية

[2] كلية الفنون الجميلة، جامعة الإسكندرية، الإسكندرية، جمهورية مصر العربية

الملخص

تتناول هذه الورقة البحثية الأساليب العلمية المستخدمة في تسجيل وتوثيق المقتنيات الأثرية، مع التركيز بشكل خاص على مجموعة مختارة من القطع الأثرية من ألبوم المسجد الأقصى في القدس، حيث تعتمد الدراسة على نهج متعدد الجوانب يشمل التوثيق التاريخي والأثري، والتوثيق الفوتوغرافي، والفحص البصري، وتقنيات التصوير المتقدمة، بما في ذلك التصوير متعدد الأطياف باستخدام الأشعة تحت الحمراء وفوق البنفسجية، والضوء المرئي والضوء المرئي المستقطب، بالإضافة إلى الفحص بالمكروسكوب الضوئي والفحص بالميكروسكوب الإلكتروني الماسح، بالإضافة إلى ذلك، يتم استخدام أساليب تحليلية مثل التحليل بالميكروسكوب الإلكتروني الماسح المزود بوحدة تشتت الطاقة (EDAX)، والتحليل بحيود الأشعة السينية والتحليل بالأشعة تحت الحمراء، لتحديد مكونات الصور الفوتوغرافية والتكنولوجيا والتقنيات المستخدمة في تنفيذها، حيث يهدف هذا البحث إلى التعرف على طبقات الصور الفوتوغرافية وخاصة الطبقات غير الظاهرة أو تحت السطحية، بما في ذلك عدد الطبقات والتقنيات المستخدمة في تنفيذ الصور، وعوامل التلف المساهمة في تدهور حالة الحفظ لهذه النماذج، من خلال استخدام هذه الأساليب، كما تسعى هذه الدراسة إلى إلقاء الضوء أيضًا على تركيب المواد وتحديات الحفظ للقطع الفوتوغرافية من ألبوم المسجد الأقصى، وتساهم نتائج هذا البحث في التعرف على الأساليب الأثرية وتقديم رؤى حول الترميم والحفظ للتراث الثقافي.

الكلمات الدالة

المقتنيات الأثرية؛ التصوير متعدد الأطياف؛ توثيق؛ المسجد الأقصى؛ التراث الثقافي.

Introduction:

The archaeological collections are considered invaluable windows into humanity's past, providing tangible links to civilizations long gone. Accurate recording and documentation of these artifacts are crucial steps in preserving their historical significance and cultural context for future generations. These collections encompass a diverse array of artifacts and materials that offer priceless insights into past civilizations and human activities. Among these collections, photographs hold a particularly significant place. The introduction of silver gelatin prints in the late 19th century revolutionized photography due to their exceptional clarity, durability, and color range. These photographic images, produced through the gelatin silver process on paper, glass, or film, are widely used in documenting archaeological sites, artifacts, and excavations (Smith, 2005). Their detailed images capture not only the physical features of objects but also subtle differences in texture, patina, and context, making them indispensable sources for archaeological research and interpretation. Moreover, gelatin silver photographs often serve as primary sources for understanding the history of archaeological excavation and documentation practices. Therefore, preserving and studying them is essential for unlocking layers of information about past societies, archaeological methodologies, and the evolution of photography as both a scientific and artistic tool. Through meticulous analysis and documentation of gelatin silver images within archaeological collections, researchers can reconstruct narratives of the past, shed light on cultural landscapes, and safeguard priceless heritage for future generations.

This research paper examines the scientific methods used in recording and documenting archaeological collections, with a particular focus on a selected group of artifacts from the album of the Al-Aqsa Mosque in Jerusalem. The Al-Aqsa Mosque, located in the heart of the Old City of Jerusalem, is one of the most revered sites in Islam, with historical significance spanning several centuries. Its importance encompasses various periods of religious, cultural, and political developments. The Al-Aqsa Mosque album contains a wealth of visual and textual materials, offering insightful perspectives on the architectural, artistic, social, and cultural aspects of the mosque and its surrounding areas across different periods (Peters, 2008).

Examining and analyzing photographic images within archaeological collections require a multidisciplinary approach that combines expertise in photography, archaeology, preservation, and archival research (Smith, 2007). Initially, the images undergo visual inspection to assess their condition, identify any damage or deterioration, and determine the type of gelatin print and photographic process used. Advanced imaging techniques such as infrared and ultraviolet reflectance imaging can be utilized to detect hidden details, alterations, or underlying layers beneath the surface of the images (Jones et al., 2012). Additionally, spectroscopic analysis can provide insightful information about the composition of photographic materials and assist in identifying potential preservation risks.

In addition to visual inspection, contextual analysis plays a crucial role in understanding the significance of photographic images within archaeological collections. Researchers examine accompanying documents such as field notes, excavation reports, and correspondence to reconstruct the circumstances surrounding the creation of the images (Johnson, 2015). Historical and cultural context allows for a deeper interpretation of the images, shedding light on archaeological sites, artifacts, and the individuals depicted.

Furthermore, digital tools and software facilitate systematic organization, indexing, and creation of descriptive data for photographic images, enhancing accessibility and facilitating comparative analysis across collections (Smith & Brown, 2019). Image processing techniques, including digital enhancement and restoration, have enabled mitigation of deterioration effects and enhancement of image clarity while preserving their integrity. Overall, examining and analyzing photographic images within archaeological collections require a comprehensive approach that integrates traditional observation methods with advanced technology and scientific research. By employing these methods, researchers can unlock the wealth of information contained within these photographic treasures, enriching our understanding of the past and preserving cultural heritage for future generations.

The scientific methods for recording and documenting archaeological artifacts represent fundamental practices in cultural heritage preservation and the advancement of archaeological knowledge. However, despite their importance, there is a noticeable gap in understanding the specific methodologies used in this process, particularly concerning artifacts representing important cultural sites such as the Al-Aqsa Mosque. Therefore, this research paper aims to address this gap by conducting an analytical study focusing on selected samples from the Al-Aqsa Mosque album. It employs various scientific techniques used in recording and documenting these archaeological artifacts, shedding light on their historical context, material composition, and cultural significance. Additionally, this study seeks to clarify best practices and challenges associated with archaeological documentation of artifacts, while providing insights into the preservation and interpretation of cultural heritage, especially photographic images.

The historical and archaeological documentation of the case study Examples:

The artistic and historical study is one of the primary steps that should be undertaken by a restoration practitioner. It involves collecting and recording all data and information about the photographic images, both from an artistic and technical perspective. This includes studying the historical period, identifying the type of photographic image, and understanding the artistic expression conveyed by it. Additionally, it is essential to identify the photographer, study their artistic style, and analyze the photographic images they captured. This meticulous process ensures a high level of expertise in the restoration process.

The study focuses on an album of photographs of the Al-Aqsa Mosque preserved in the Central Library of Alexandria University. This album contains a collection of photographic images depicting the courtyard between the Al-Aqsa Mosque and the Dome of the Rock during an Islamic holiday. One of these examples is a silver gelatin photographic image mounted on secondary paper support. Beneath the image, there are scene details. The image is black and white and has a matte finish. The Al-Aqsa Mosque photo album was presented by the President of the Supreme Council of Palestine on the 27th of Ramadan, 1347 AH, and it is stored in the collections of the Central Library of Alexandria University under entry number 404. The album contains 14 plates of photographic images of the Al-Aqsa Mosque. It's worth noting that the dimensions of the album are 32.5 × 38 cm, with a spine width of 5 cm. The secondary support holder for the photographic image measures 36.6 × 32.4 cm, and the photographic image itself measures 29 × 23 cm. The image is documented as image number 5 inside the album.

	
Fig. No. (1) Shows one of the photographic images inside the Al-Aqsa Mosque album.	**Fig. No. (2) Shows the cover of the Al-Aqsa Mosque album.**
	
Fig. No. (3) Shows the interior of the Al-Aqsa Mosque album.	**Fig. No. (4) Shows one of the photographic images in the Al-Aqsa Mosque album.**
	
Fig. No. (5) Shows one of the photographic images in the Al-Aqsa Mosque album.	**Fig. No. (6) Shows one of the photographic images in the Al-Aqsa Mosque album.**

Materials and Methods:

- ***Photographic Documentation:***

Photographic documentation of the case study photographic images was conducted using a digital camera, along with computer software such as Photoshop, both before, during, and after restoration work. This phase is of utmost importance, aiming to locate the original image and document it thoroughly to enable reference for determining original lines and color gradations. Important principles are observed during this process, starting with capturing overall shots followed by detailed shots of each part individually. Complete documentation of all details of the image is carried out, including the secondary support, primary support, and photographic image itself.

- ***Multispectral Imaging Documentation:***

El-Rifai, Mahgoub, and Ide-Ektessabi (2016) explain that multispectral imaging devices can be used to extract information about the surface and other layers of artworks. This is achieved through visible imaging, near-infrared (IR) imaging, and ultraviolet (UV) imaging, confirming the results of the recording and documentation processes as well as preservation and conservation operations. Additionally, the device utilizes spectral reflectance imaging to improve color measurement accuracy. The device is characterized by its ease of transportation and non-destructive nature, making it suitable for imaging artworks.

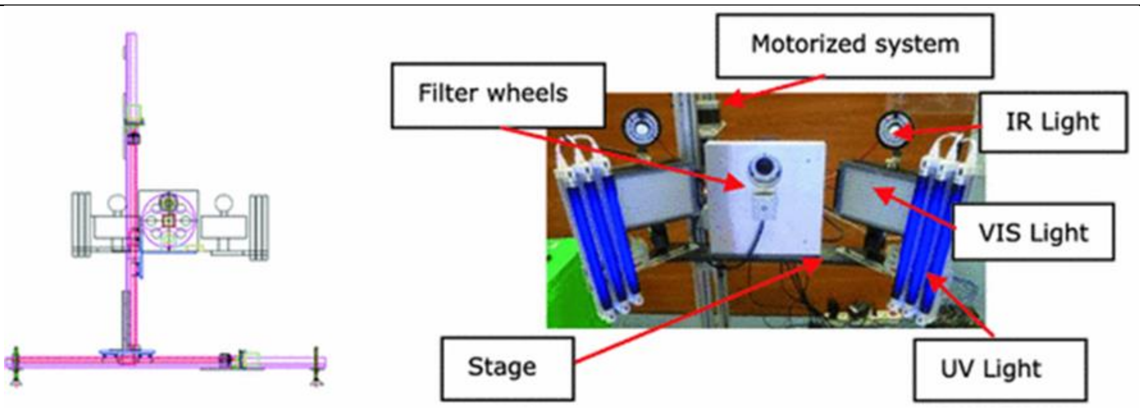


Fig. No. (7) Shows the spectral imaging device, adapted from: (El-Rifai, Mahgoub, Ide-Ektessabi, 2016).

The IWN (Integrated Workstation Network) system or multispectral imaging operates using two X, Y motors in two directions, along with two filters facing each other and other various light sources. It has the capability to utilize different sensor devices. Movement between each X, Y motor is controlled every 5 cm by a stepper motor. Regarding the lighting used in imaging, ultraviolet (UV) rays are employed, with six UV lamps, along with two infrared sources (at 850 nanometers) and two visible light sources (5000k).

Two filters are utilized, and a different set of filters is added, comprising (7) filters covering the visible spectrum at 420, 450, 500, 530, 550, 600, and 640 nanometers, in addition to (3) IR filters and ultraviolet rays. A wheel is used to pass either the infrared or the ultraviolet rays only, or to block both and allow visible light to pass. The multispectral imaging device

(Multi-Spectra Image) has been transferred to the Central Library at Alexandria University for imaging or documentation operations. The case study photographic images were captured using several Filter Wheels to identify the overlapping layers in the photographic image, as well as to detect color changes, silver oxidation and reduction phenomena (Silver Mirroring), and to identify both visible and invisible signs of damage.

- ***Examination Using Optical Microscopy:***

Examination using optical microscopy aids in magnifying to detect the fibers of the surface layers of the photographic image. Four different magnifications are employed: (6.7X), (12X), (30X), and (45X), all used in the same location for examination and to detect the fibers of the layers of the case study photographic images.

- ***Examination Using Scanning Electron Microscopy (SEM):***

According to Clark (2009), scanning electron microscopy allows us to see what cannot be seen with the naked eye, with magnification reaching up to 250,000 times. Therefore, it has been used to examine and study the surface structures in photographic image prints. It enables the examination and acquisition of significant information about the condition of the photographic image, including its structural composition, layers, fibers, colorants, coating layer, and any incidental deterioration phenomena occurring on the image.

Additionally, Giannoulaki (2003) added that it is possible to obtain three-dimensional images on a television screen that illustrate many fine details of the object under examination. The scanning electron microscope is equipped with an Energy Dispersive X-ray Analysis (EDAX) unit to provide precise results about the morphology of the materials under examination, in addition to detecting metals and compounds present in the sample. This analysis was conducted at the Scanning Electron Microscope Laboratory at the National Research Center in Cairo.

- ***Analysis using X-ray diffraction (XRD):***

Giannoulaki (2003) stated that X-rays are electromagnetic radiation with very short wavelengths. The X-ray wavelengths used in diffraction processes typically range within 2 to 5.5 angstroms. An angstrom equals 1x10^-10 meters and is the unit of measurement for these rays. X-ray diffraction analysis is non-destructive and can identify the types of compounds used, for example, in coloring processes. This allows for the identification of the colored materials used by ancient artists. Henry (2002) emphasized the importance of this analysis due to the minute size of the sample, which enables the identification of compounds present in its composition. This analysis was conducted at the X-ray diffraction laboratory at the Egyptian General Authority for Mineral Resources (Ministry of Petroleum).

- ***Analysis using Fourier Transform Infrared Spectroscopy (FTIR):***

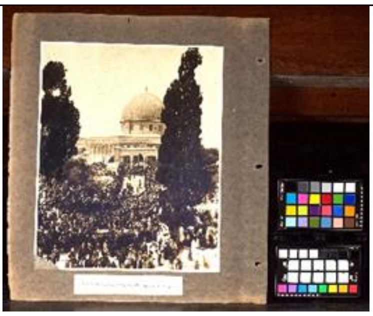
(Giannoulaki, 2003) emphasized the importance of conducting instrumental analysis to identify the organic compounds used in photographic images. The flexible and efficient technique for analyzing these organic compounds is Total Reflection Infrared Spectroscopy (FTIR). In this technique, the surface of the image is placed in close contact with the instrument's detector crystal, and the absorption spectrum in the infrared range is generated and displayed on a computer. The spectrum of the analyzed compound is then compared with reference spectra in the computer database. It's worth noting that this technique only analyzes the outer layer of the photographic image surface. This analysis was carried out at the Infrared Analysis Laboratory at the National Research Center in Cairo.

Results:

- **Multi-Spectral Imaging Results:**

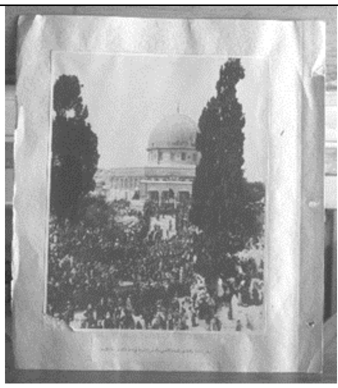
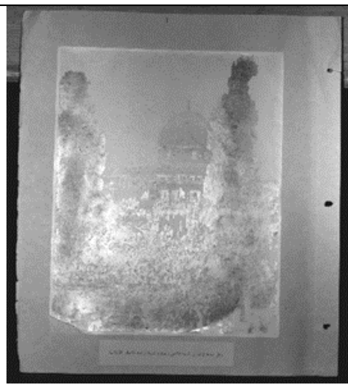
- ***Visible light imaging using the color chart (Vis-Scale):***

Visible light was used in imaging along with the assistance of a color chart, which minimizes color errors during imaging, to obtain an accurate representation of the original image with the closest match to the original color shades.

	
Fig. No. (8) Shows one of the photographic images from the Al-Aqsa album under visible light.	**Fig. No. (9) Shows one of the photographic images from the Al-Aqsa album under visible light.**

- ***Infrared imaging using two different filters: IR Reflected (IR.R) & IR False color image (IR.FC):***

The imaging using infrared with different filters revealed that the color shift apparent in the false-color image (IR.FC) turns the grayscale into a yellowish-green hue, resulting in a fading of color tones due to residual fixer left in the photographic print. Meanwhile, imaging using reflected infrared light (IR.R) indicated that silver ions migrated from the emulsion, accumulating on the outer surface of the gelatin, causing a phenomenon known as Silver Mirroring, especially in the darker and denser areas of the image. Additionally, small orange spots were observed, mostly attributed to the resin coating applied to the backing paper of the final print, which, combined with high relative humidity, increases acidity and promotes the growth of spots noticeably on the image surface.

		
Fig. No. (10) Shows the examination of one of the photographic images using (IR.FC).	**Fig. No. (11) Shows the examination of one of the photographic images using (IR.R).**	**Fig. No. (11) Shows the examination of one of the photographic images using (IR.R).**

- ***The visible light imaging using the polarized multi-spectral imaging system:***

When using visible light with the polarized system in three different shots, the gradual appearance and intensity of the silver mirroring phenomenon became evident. It appeared clearly and prominently on the outer surface of the photographic print, representing one of the deterioration aspects of the image executed in the gelatin silver print method.

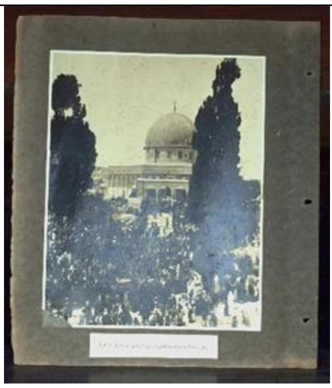


Fig. No. (13) Shows the imaging of one of the photographic prints using visible light with the polarized system (VIS. POL).	**Fig. No. (14) Shows the imaging of one of the photographic prints using visible light with the polarized system (VIS. POL).**	**Fig. No. (15) Shows the imaging of one of the photographic prints using visible light with the polarized system (VIS. POL).**

Through the previous presentation of multispectral imaging for the selected models, (7) filters were used in the range of 420-70 nanometers provided with UV and IR filters. This process was conducted in a darkroom, and the selected photographic prints were placed in a fixed vertical position to capture the footprint from 2 × 1.5 cm up to a maximum of 14.5 × 10.5 cm at a distance of 12-80 cm from the footprint. A wider capture can be achieved using the movable system of 60 cm X, Y. The system can also be fixed in various ways for horizontal or vertical shooting.

The use of the multispectral imaging system (IWN), which operates in the range of 1000-380 nanometers, was employed in documenting photographic prints and detecting incidental deterioration over the years. Reflective spectroscopy, visible light, infrared, and ultraviolet rays were utilized, along with the polarization imaging system. Visible light was used to document the original state of the images, employing colorimetric measurements during imaging to obtain a replica of the original image in terms of measurements and colors.

As for infrared (IR) and ultraviolet rays, they were used to explore hidden notes or unclear signs of damage and to document the state of the photographic prints under study. Moreover, using the polarization imaging system helped significantly in revealing the silver mirroring phenomenon, which other rays could not show.

- ***Digital camera imaging:***

Through visual inspection, recording, and digital camera documentation, it was observed that there is loss at the bottom left of the image, which is due to the erosion of the image edges. Weakness is also evident at the edges of the secondary support (paper support) on the left side of the image. Additionally, there are brownish-colored spots scattered on the surface of the photographic image, indicating the migration of gelatin and acidity from the secondary support to the outer surface of the photographic image. Furthermore, the presence of the Silver Mirroring phenomenon is noted, indicating the transfer and oxidation of silver onto the surface of the image, particularly noticeable in areas with darker hues.

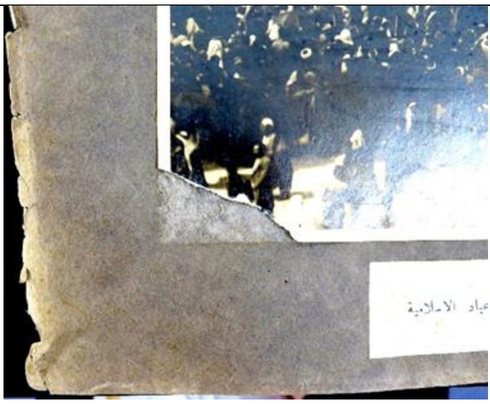


Fig. No. (16) Shows fungal discoloration and visible staining on the surface of the secondary paper support.	**Fig. No. (17) Shows the spread of brownish color spots on the surface of the image.**

- ***Optical microscope examination:***

The optical microscope examination, with magnification using the four different levels, reveals that the surface of the gelatin and barite image-bearing layer is stable on the resin-coated paper support. The surface appears smooth without showing any fibers of the paper support. The image color is neutral, ranging from black to gray, with a harmonious color gradient.

A: 6.7X	B: 12X	C: 30X	D: 45X

Fig. No. (18) Shows the result of the optical microscope examination at different magnifications of the image surface, conducted by the Conservation and Environmental Control Department at the Bibliotheca Alexandrina.

The result of the optical microscope examination reveals the presence of light-sensitive silver halide particles within the liquid gelatin emulsion, which forms the silver image and is visible. Upon examination of the base paper fiber, magnification shows the appearance of the white pigment of the barite layer above the paper surface, confirming that the photographic print consists of three layers: the base (paper), the bonding layer (barite and gelatin), and the final image layer (light-sensitive silver material).

A: 6.7X	B: 12X	C: 30X	D: 45X

Fig. No. (19) Shows the result of the optical microscope examination at different magnifications of the fibers at torn or lost areas, adopted from the Environmental Preservation and Control Department at the Library of Alexandria.

- ***The Scanning Electron Microscopy Examination:***

Through scanning electron microscopy examination of a sample from the front surface of one of the case study photographic images, it became evident that silver particles transformed into silver ions migrating to the surface of the photographic image due to exposure to a range of oxidants. This phenomenon leads to changes in the appearance of the image, especially in shadow areas. Silver grains appear as small particles on the surface and are highly illuminated in areas of intense brightness. In the silver image, the phenomenon of silver ions leads to changes in the appearance of the image, where silver mirroring appears in shadow areas. This phenomenon does not occur with prints without a binding agent. Additionally, the barite layer and the binding material layer containing silver chloride crystals are visible during examination.

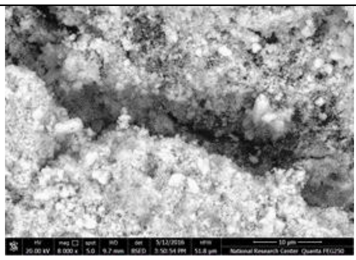
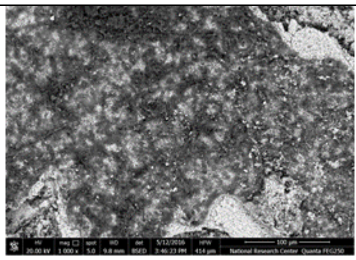
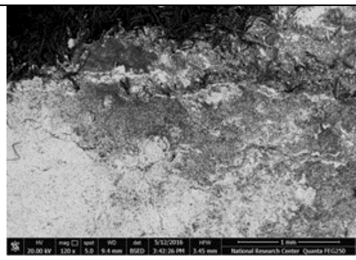
		

Fig. No. (20) Shows the appearance of the barite layer and the binder layer as a result of examination using a scanning electron microscope for a sample taken from the front surface of a photographic image.	**Fig. No. (21) Shows the appearance of silver grains on the surface of the image as a result of examination using a scanning electron microscope for a sample taken from the front surface of a photographic image.**	**Fig. No. (22) Shows the result of examination using a scanning electron microscope for a sample taken from the front surface of a photographic image.**

As revealed by the scanning electron microscopy examination of the back surface of one of the case study photographic images, the fibers of the paper support, which carry the binding material and serve as the foundation for the final image material, are apparent. Silver particles appear as twisted, fine, and large thread-like structures, ideal for light absorption, resulting in a neutral black color. This indicates the silver image printed through the D.O.P. (Developing-Out Paper) process. Additionally, the barite layer, present above the paper surface, is characterized by its white pigment, providing additional gloss and contrast in the prints.

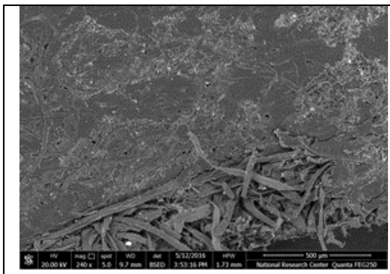
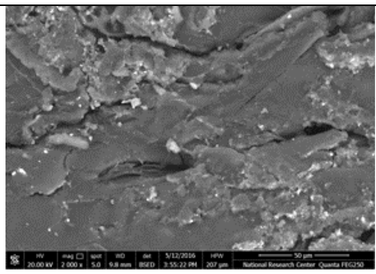
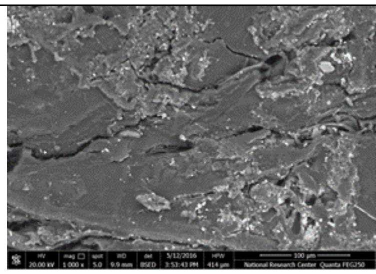
		

Fig No. (23) Shows the result of examination using a scanning electron microscope for the back surface of the image (the substrate).	**Fig No. (24) Shows the result of examination using a scanning electron microscope for the back surface of the image (the substrate).**	**Fig No. (25) Shows the result of examination using a scanning electron microscope for the back surface of the image (the substrate).**

- ***The analysis with the scanning electron microscope equipped with an energy-dispersive X-ray spectrometer (EDX):***

The analysis with the scanning electron microscope equipped with an energy-dispersive X-ray spectrometer (EDX) revealed the presence of a significant amount of barium on the surface of the front side of one of the case study photographic images. Additionally, lesser amounts of calcium, silver, and potassium were detected.

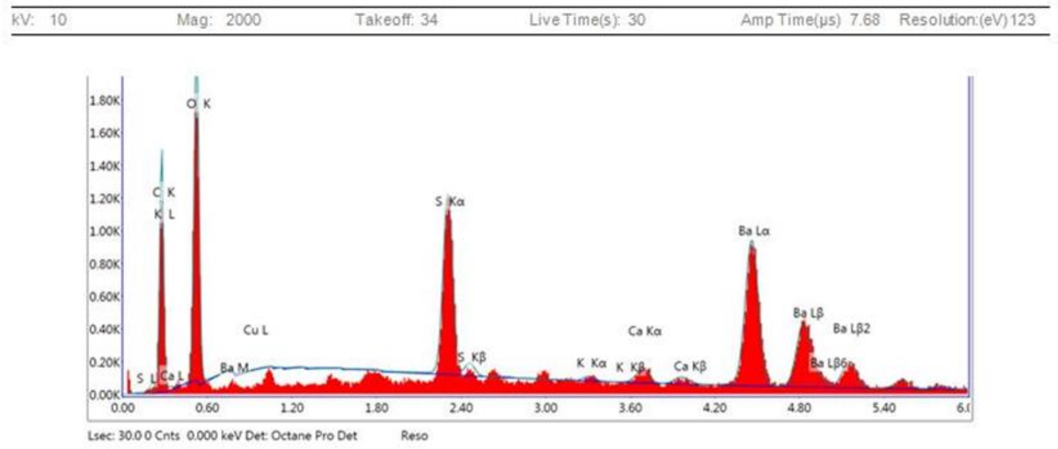


Fig. No. (26) Shows the result of the analysis using the scanning electron microscope equipped with energy-dispersive X-ray spectroscopy for a sample from the front surface of one of the case study photographic images.

Element	Weight %	Atomic %	Net Int.	Error %
C K	6.81	30.73	155.3	9.16
O K	6.9	23.37	293.31	7.71
CuL	0	0	0	99.99
S K	7.47	12.63	306.9	5.27
K K	0.46	0.64	12.03	33.86
CaK	1.79	2.43	36.85	15.23
BaL	76.56	30.21	341.25	6.28

Table No. (1) Shows the proportions of elements on the front surface of one of the selected photographic images.

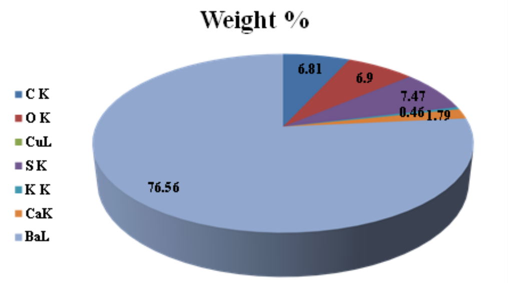


Fig. No. (27) Depicts a graph illustrating the proportions of elements on the front surface of one of the selected photographic images.

In addition, the analysis with the scanning electron microscope equipped with an energy-dispersive X-ray spectrometer (EDX) revealed the presence of sodium, aluminum, silicon, calcium, and potassium elements on the surface of the back side of one of the case study photographic images.

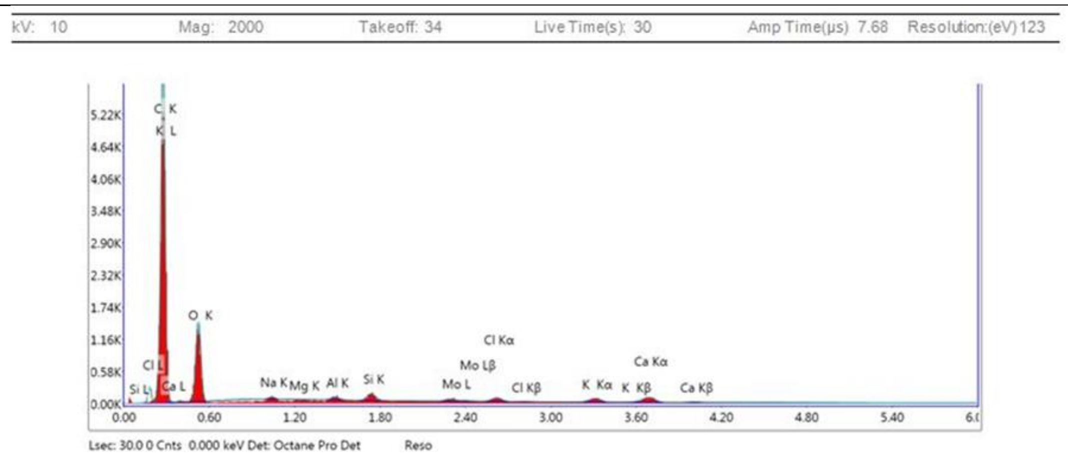


Fig. No. (28) Shows the results of the analysis by the scanning electron microscope equipped with an energy dispersive X-ray unit for a sample from the rear surface of one of the case study photographic images.

Element	Weight %	Atomic %	Net Int.	Error %
C K	61.31	72.36	680.95	5.86
O K	25.8	22.86	204.58	9.96
NaK	0.46	0.28	7.33	32.76
MgK	0	0	0.11	99.99
AlK	0.54	0.28	11.61	19.57
SiK	1.35	0.68	28.1	10.46
MoL	1.46	0.22	11.19	32.82
ClK	1.6	0.64	19.57	15.98
K K	2.57	0.93	21.67	14.29
CaK	4.91	1.74	30.77	14.3

Table No. (2) Shows the proportions of elements on the rear surface of one of the selected photographic images.

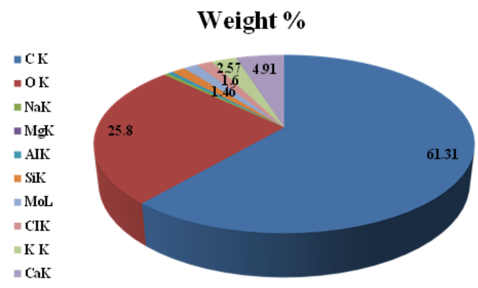


Fig. No. (29) Depicts a graph illustrating the proportions of elements on the rear surface of one of the selected photographic images.

- ***X-ray diffraction (XRD) analysis:***

The X-ray diffraction (XRD) pattern indicates the presence of the compound Barite, which is barium sulfate, in the Barite layer or the preparatory coating for gelatin. Gelatin silver prints and the white pigment (barium sulfate) emerged around 1880 and were among the most stable and satisfactory papers for photographic imaging. The Barite layer was applied on top of the paper surface, serving as an insulator between the sensitized coating and any impurities within the paper fibers. It provided extra gloss and contrast in the prints. The Barite coating in gelatin silver paper, whether glossy or matte, is relatively thick, effectively concealing the paper fiber traces during microscopic examination, resulting in a smooth appearance. This layer integrates with the structural composition of the three-layer photographic image. Additionally, the XRD analysis revealed the presence of the mineral compound Kaolinite $Al_2Si_2O_5(OH)_4$.

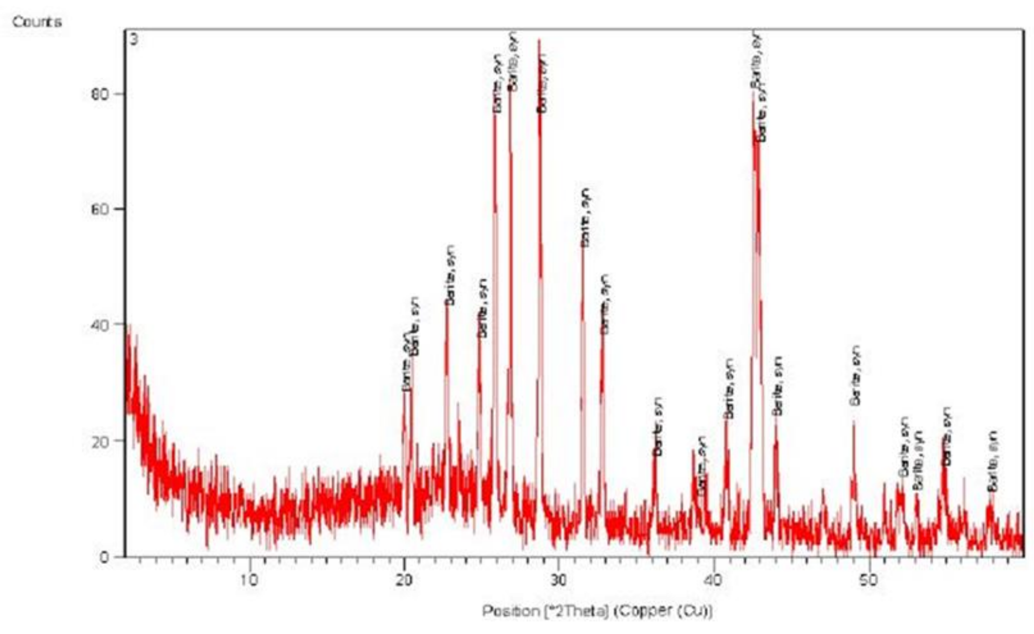


Fig. No. (30) Shows the X-ray diffraction pattern of the analysis result of a sample from one of the selected photographic images.

- ***Infrared Fluorescence (FTIR) Analysis:***

Through the result of the analysis using infrared fluorescence of a sample from the silver gelatin layer, the presence of active functional groups indicating the existence of a gelatin layer was demonstrated, as follows:

- Amide A band (around 3300 cm^-1)

- Amide I band (around 1650 cm^-1)

- Amide II band (around 1540 cm^-1)

- Amide III band (around 1235 cm^-1)

As for silver, there are no specific active functional groups for silver because it is a metallic compound that does not appear in the infrared analysis. Furthermore, the result of the infrared analysis of the paper base layer revealed the presence of active functional groups indicating cellulose and gelatin, along with the possibility of the existence of other coloring or filling materials such as calcium carbonate or talc, as follows:

- *The active functional groups indicative of cellulose are:*

- 3100-3600 cm^-1 (O-H stretching)
- 2900 cm^-1 (C-H stretching)
- 1640 cm^-1 (O-H bending)
- 1020 cm^-1 (C-O stretching)

- *The active functional groups indicative of Lignin are:*

- 1500-1700 cm^-1 (aromatic ring stretching)
- 1260 cm^-1 (C-O stretching)

- *The active functional groups indicative of fillers are:*

- 875 cm^-1 (CaCO3)
- 1030 cm^-1 (Si-O stretching for clay)

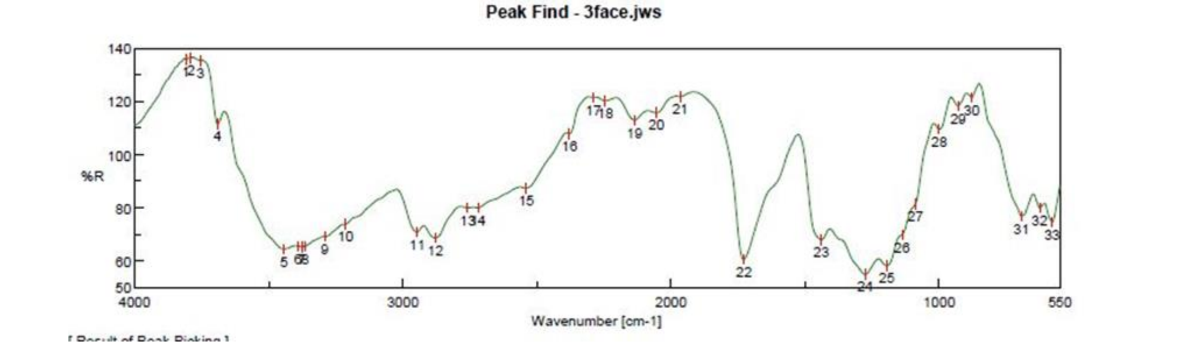


Fig. No. (31) Shows the infrared spectroscopy analysis pattern of a sample from the gelatin silver layer of one of the selected photographic images.

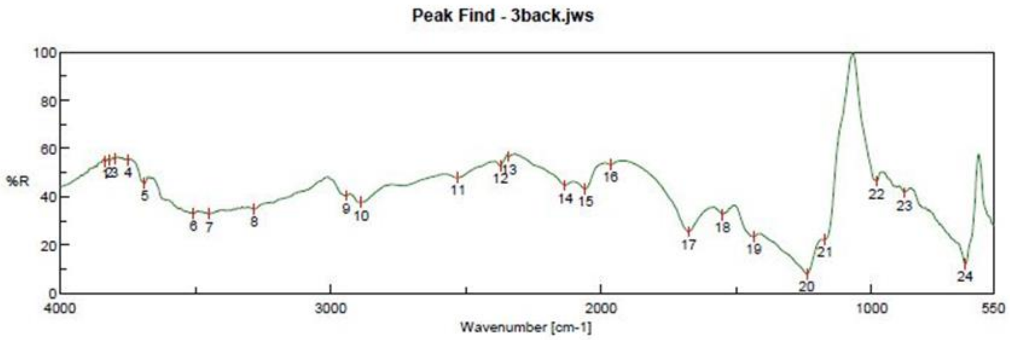


Fig. No. (32) Shows the infrared spectroscopy analysis pattern of a sample from the substrate layer of one of the selected photographic images

- **The technique used in executing the case study photographic images:**

Through presenting the characteristics of the selected samples, it was observed that each of the images is characterized as Silver Gelatin and non-glossy (Matt). The features of these images indicate that they are classified as Silver Gelatin prints. Clark (2009) argues that individual characteristics of photographic prints and features such as color, typical degradation patterns, and grain pattern help in identifying and classifying the identity of the photographic image. Eleonore and Vigneau (1999) explained that triple-layered prints (binder layer, barite layer, paper base layer) date back to after 1885. Printing can be either Printing Out (P.O.P) using sunlight or Developing Out (D.O.P) using chemical solutions during development. The color of the image is classified as either very warm (reddish-brown or purplish-brown) or semi-neutral (green or nearly neutral black), and this classification is evident in black and white prints, distinguishing printing paper from developing paper.

Giannoulaki (2003) explained that Gelatin Silver Printing Paper is characterized by its purple-brown image color. The barite layer can be seen upon magnification, appearing smooth and concealing paper fibers. There are two important indicators for identifying Gelatin Silver Developing-Out Paper: the presence of barite coating and the phenomenon of silver mirroring. This phenomenon appears as a metallic blue in shadow areas, particularly intensified at the edges of the image. The color may transition from neutral black to brown-yellow. Surfaces may be glossy or matte. Degradation manifests as yellowing and fading of bright tonalities in the image. Degradation can also result from the formation of sulfides (sulfiding) due to residual thiosulfates in the image after fixing and washing, leading to a faint greenish-black or yellow-green hue in the print. Gelatin Silver Printing Paper using sunlight (Gelatin Silver-Out Paper) has a highly polished surface and is characterized by the presence of barite, which stimulates paper fibers (paper base). The image-carrying layer contains silver particles suspended in the binder holding the photosensitive material. The silver particles in Gelatin Silver Developing-Out Paper appear larger than those in Printing-Out Paper (P.O.P).

- Through examinations and analyses of the selected samples, it was revealed that the images were executed using the following method:

• **Gelatin Silver Printing Out Paper (P.O.P):** Henry (2002) mentioned that these papers are hand-coated but manufactured mechanically. The paper is coated with barite mixed with a liquid emulsion sensitive to light, which consists of gelatin carrying suspended silver chloride particles. After coating, the paper is dried, making it ready and light-sensitive. It is then packaged and stored in light-tight conditions. Subsequently, the paper is exposed to full sunlight through the negative. The silver image gradually forms, followed by processing in a fixing and strengthening bath.

• **Gelatin Silver Developing Out Paper (D.O.P):** According to Hugh (1997), these papers feature a layer of gelatin and barite carrying the image on a resin-coated paper base. There are two types of developing out papers: silver bromide gelatin paper and silver chloride gelatin paper. In the process, two warm gelatin solutions are mixed, one containing bromide or chloride and the other containing silver nitrate. This results in a suspended white emulsion of light-sensitive silver halide particles in the liquid gelatin. This emulsion, known as the sensitizer, is applied to the barite-coated paper. After drying, the paper is polished and ready for exposure to light in contact with the negative. The paper is then immersed in a developing bath, followed by rinsing and fixing.

- The anatomical structure of the image:

(Kantarelou et al., 2007) clarified that the layered structure of the photographic image, or the image structure, consists of the following components as illustrated in the following figure: Layer (1) represents the paper, which serves as the base support and carries both the binder and the photosensitive material. Layer (2) is the barite layer, which acts as a preparatory coating for the gelatin. It is a white pigment (barium sulfate) applied on top of the paper surface to act as an insulating layer between the photosensitive material and any impurities within the paper fibers. Layer (3) is the gelatin layer, which is the binder that binds the photosensitive material to the paper support carrying the image. Layer (4) is the silver layer, which is the photosensitive material. It is the final image-forming substance that appears when exposed to light.

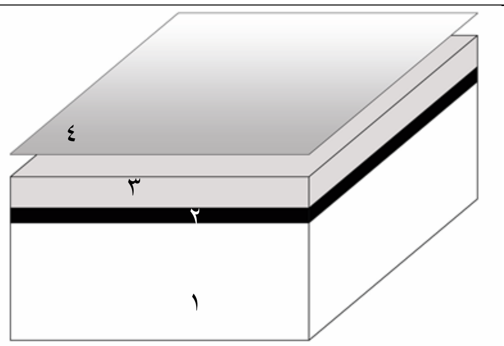


Fig. No. (33) Shows the layered structure of the case study photographic images, as per the researcher's work: 1- Paper, 2- Barite layer (Barium sulfate and gelatin), 3- Gelatin layer, 4- Silver.

Conculsion:

Through the examination and analysis of the photographic images under study, significant results have been revealed regarding their composition, execution techniques, and historical significance. Utilizing multispectral imaging and various examinations, whether through optical or scanning electron microscopy, X-ray diffraction analysis, and Fourier-transform infrared spectroscopy, a detailed understanding of the materials constituting these photographic images has been achieved. The X-ray diffraction analysis, along with scanning electron microscopy equipped with an energy-dispersive X-ray unit, showed the presence of various elements such as barium, calcium, silver, potassium, sodium, aluminum, and silicon, providing compelling evidence regarding the composition of the photographic images.

This information, coupled with the examination of X-ray diffraction patterns, elucidated the presence of barium sulfate (barite) and kaolinite, confirming the materials used in preparing the images. Furthermore, investigation into the execution technique revealed that the images are gelatin silver prints, distinguishing their matte appearance. Historical records dating back to after 1885 confirm the use of gelatin silver prints, with variations such as gelatin silver prints for sunlight printing and development by chemicals.

The multilayer structure of the photographic image, consisting of the base paper, barite layer, gelatin layer, and silver layer, was meticulously examined, shedding light on the complex process involved in creating these images. Techniques such as hand coating and automatic manufacturing were identified, highlighting the craftsmanship and technological advancements in photographic printing. Additionally, recognizing specific degradation patterns, such as the silver mirroring phenomenon, provides valuable insights into the challenges associated with preserving gelatin silver images.

References:

- Clark, S., (2009). "Preservation of photographic material", The Preservation Advisory Centre, the British Library, pp.25.

- Eleonore, K., and Vigneau, E., (1999). "Architectural Photo reproductions: A Manual for Identification and Care", New Castle DE and New York, Oak Knoll Press and The New York Botanical Garden, pp. 117.

- El-Rifai, I., Mahgoub, H., Ide-Ektessabi, A. (2016). Multi-spectral Imaging System (IWN) for the Digitization and Investigation of Cultural Heritage. In: Ioannides, M., *et al.* Digital Heritage. Progress in Cultural Heritage: Documentation, Preservation, and Protection. EuroMed 2016. Lecture Notes in Computer Science(), vol 10058. Springer, Cham. https://doi.org/10.1007/978-3-319-48496-9_19.

- Giannoulaki, M., (2003). "The feasibility of using portable X-Ray radiography for the examination of the technology and the condition of a metals collection housed in the Museum of Ancient Messene", Greece, Journal of Science & Technology, p. 62.

- Henry, W., (2002). "How Long Will They Last: An Overview of the Light-Stability", of Inkjet Prints and Traditional Color Photographs. In IS&T's 12th International Symposium on

Photofinishing Technology, Springfield, VA: The Society for Imaging Science and Technology, pp. 32-37.

- Hugh, P., (1997). "Preservation Matting for Works of Art on Paper", Picture Framers Magazine (8: February) Supplement, pp. 71.

- Johnson, E. (2015). *Archaeological Photography: Methods and Applications*. Academic Press.

- Jones, A., White, B., & Garcia, C. (2012). *Advances in Imaging Techniques for Archaeological Photography*. Archaeological Imaging Journal, 5(2), 87-104.

- Kantarelou, V., et al., (2007). "Micro - XRF Analysis of High Tin Bronze Mirrors at the Museum of Ancient Messene in Greece", International Conference Strategies For Saving Indoor Metallic Collection With a Satellite Meeting on Legal Issues In the Conservation of Cultural Heritage, pp. 99.

- Peters, F. E. (2008). *The Monotheists: Jews, Christians, and Muslims in Conflict and Competition, Volume II: The Words and Will of God.* Princeton University Press.

- Smith, J. (2005). *The Role of Photography in Archaeology*. Archaeological Press.

- Smith, J. (2007). *Conservation and Preservation of Photographic Materials*. Archaeological Press.

- Smith, J., & Brown, L. (2019). *Digital Archiving and Cataloging of Archaeological Photographs: Best Practices*. Digital Preservation Journal, 12(3), 231-245.

- Mohie, M. A., and Korany, M. S. (2017). *Study of Materials and Techniques for the Conservation of Two Miniature Paintings,* Conservation Science in Cultural Heritage Journal, 17(1), 101-116. https://doi.org/10.6092/issn.1973-9494/7943