Photograph Conservation Practices in Egypt Applied on Francis Amin's Photo Collection: Low Budget Options

ممارسات حفظ الصور الفوتوغرافية في مصر تطبيقا على مجموعة صور فرانسيس أمين: خيارات الميزانية المنخفضة

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Abstract

Photographic collections form a fundamental part of Egypt's cultural heritage for their documentary and artistic value. Photography reached Egypt in 1839, the very same year it was invented. Many pioneer photographers were attracted to Egypt's beauty and the mystery of its ancient treasures. Today, these images are held by archives, libraries, and museums all across Egypt, from Cairo to Nubia. Damaged photographs present a challenge in the conservation field. Since photo conservation is a relatively new field in Egypt, the work of a photo conservator is not clear to conservation institutions and collection holders. In this paper, the authors have selected different photographs suffering from various damage forms with the aim of sharing the current photograph conservation practices in Egypt with other professionals and scholars through discussing what we do, what we do not do, and why. The authors believe that this would assist in developing criteria and better strategies for the preservation of our photographic heritage. When handling damaged photographs, each case is unique and has specific conservation needs.

Keyword: Photographs, Egypt, deterioration, conservation practices, pros and cons.

الملخص

تشكل مجموعات الصور الفوتوغرافية جزءًا أساسيًا من التراث الثقافي المصري لقيمتها الوثائقية والفنية. وصل التصوير الفوتوغرافي إلى مصر عام 1839م ، وهو نفس عام اختراعه. انجذب العديد من المصورين الرواد إلى جمال مصر وغموض كنوزها القديمة. اليوم ، هذه الصور محفوظة في الأرشيفات والمكتبات والمتاحف في جميع أنحاء مصر ، من القاهرة إلى النوبة. تمثل الصور الفوتوغرافية التالفة تحديًا في مجال الحفظ. نظرًا لأن صيانة الصور الفوتوغرافية يعد مجال جديد نسبيًا في مصر ، فإن دور أخصائي صيانة الصور الفوتوغرافية غير واضح لمؤسسات الحفظ والترميم وكذلك أصحاب المجموعات. في هذا البحث ، اختار المؤلفون صورًا فوتوغرافية مختلفة تعاني من مظاهر تلف متنوعة بهدف مشاركة ممارسات علاج وصيانة الصور الفوتوغرافية المطبقة حاليا في مصر مع المتخصصين في المجال من خلال مناقشة ما نفعله ، وما لا نفعله ، ولماذا. نعتقد أن هذا من شأنه أن يساعد في تطوير معايير واستراتيجيات أفضل للحفاظ على تراثنا الفوتوغرافي. يجب التعامل مع كل صورة من الصور الفوتوغرافية علي أنها حالة فريدة ولها احتياجات صيانة وحفظ خاصة.

الكلمات الدالة: الصور الفوتوغرافية، مصر، التلف ، ممارسات الحفظ ، السلبيات والايجابيات

1. Introduction

Photograph collections have acquired a progressive value over the years enriching our knowledge of past realities that have, in many cases, been lost [1]. Institutions have been collecting photographic images from the very beginning, charmed by their artistic and research values, yet rarely interested in their preservation [2,3]. Overtime, institutions and individuals dealing with photographs have become aware of the significance of preserving these valuable and powerful resources and outstanding form of contemporary art for future generations [4]. Historical photographs hold significant visual and, in some

cases, written information on individuals, social groups, places, and events that have shaped the history, identity, and values of the specific nation they were created in [5]. Today, photography has found application in almost every field (i.e., science, technology, medicine, education, etc.) [6]. In fact, everyone can relate to photographs, every family owns a private collection holding its most cherished moments of a long gone past. The reliance on photographs to document, depict, entertain, and persuade is undeniable [7].

Photography reached Egypt in 1839, the same year it was invented, presumably through François Arago's presentation of the daguerreotype process to the French Academy of Science [8]. At the time, Egypt was among the most desired destinations for daguerreotypists who raced to capture the beauty and mystery of its ancient treasures. In

[1] Spanish National Plan for the Conservation of Photographic Heritage, 2015. Retrieved from: https://www.culturaydeporte.gob.es/planes-nacionales/gl/dam/jcr:e4470178-f713-4244-baee-949f862a86e7/11-conservacion-del-patrimonio-fotografico-eng.pdf [accessed 15/1/2022]

[2] Buchanan, S., and Domer, M., 1995. *Writing with light*, Wilson Library Bulletin, 69(10), p. 68.

[3] McLaughlin, R., 1989. The Evaluation of Historical Photographs: Considerations for Visual Resource Curators and Librarians in Museums and Archives, *Art Documentation: Journal of the Art Libraries Society of North America*, 8(2), pp. 55-60.

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1839, Frédéric Goupil-Fesquet travelled from Marseille to Egypt with his Uncle Orientalist painter Horace Vernet, director of the French Academy in Rome to capture photographs. They landed in Alexandria, where the French consul presented them to Egypt's Ottoman ruler Muhammad Ali Pasha who showed great interest in learning about the new photographic instrument. The next day, Vernet and Goupil-Fesquet returned to Ras el-Tin palace on the edge of Alexandria's harbor to demonstrate the daguerreotype. This image is the first documented photograph of Egypt and the African continent [9]. The Pasha introduced photography in the activities of his army, and practiced it himself, with his Pashas and relatives [10]. After 1915, the Armenian community played a leading role in spreading photography in the Ottoman Empire. Many Armenian photographic studios were established in most cities in the Ottoman Empire and Egypt, and remained in practice for decades [11,12]. Among the notable photographers who photographed Egypt are Maxime Du Camp, Félix Teynard, J.B. Greene, Francis Frith, Antonio Beato, Fratili Alinari, Abdullah Freres, Pascal Sebah, Heneri Bechard, Bonfis, Paul Dietrich, the Zangaki Brothers, Gabriel Lekegian, Louis Saboungi, Luigi Foirilli, Heinz and Georges Leichter, and W. Hanselman [13].

Early photographs of Egypt remain witness to the evolution of photography in the Middle East and to a time long gone. Today, these images are held by archives, libraries, palaces, and museums all across Egypt, from Cairo to Nubia exhibiting different conditions of preservation. Globally speaking, as the importance of photographic heritage has become apparent, the focus on their preservation has also greatly intensified. Until recently, Egypt had a slight interest in safeguarding photograph collections. Fortunately, several institutions among which is the Faculty of Archaeology, Cairo University, have developed courses dedicated to the conservation of photographic materials at undergraduate and postgraduate levels. Additionally, with a number of Egyptian scholars dedicating their studies to the significance of photograph preservation, the concern for historical photographs has significantly increased. Nevertheless, the preservation of photographic collections in Egypt is very challenging mainly due to the lack of photograph conservators and because of the economic situation.

[9] Koehler, J., 2015. Capturing the Light of the Nile, *ArmcoWorld*, 66(6), pp. 16-23.

[10] Perez, N., 1988. Focus East: Early Photography in the Near East (1839-1885), Abradale, Abrams.

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[12] Ozendes, E., 2013. Photography in the Ottoman Empire 1839-1923. Istanbul, Yem Publicatons.

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Photographs exist in many forms; ranging from rare prints and glass negatives to photo albums, 35mm slides, and color snaps [14]. Accordingly, many different materials have been used since the invention of photography to produce these various forms of photographs. Anyhow, photographs are composed of three main components: the primary support (i.e., metal, glass, plastic film, paper, or resin-coated paper); the binder that holds the final image material (i.e., albumen, collodion, or gelatin) and the final image material (i.e., silver, color dyes, or pigment particles) [15]. A fourth component that may be included is an interlayer between the support and the image layer (i.e., the baryta layer which is composed of barium sulfate, with small amounts of strontium sulfate impurities in gelatin) [16, 17]. A secondary support may also be present [15]. The complexity and multiplicity of the materials that make up photographs are largely responsible for their long-term stability characteristics [18]. Being vulnerable, photographs frequently display damage forms and problems which reflect their manufacture, processing, and the display and storage conditions in which they are housed. Photographs with their complex structure are prone to both deterioration and degradation by numerous factors

(i.e., natural aging, poor manufacture, poor processing, improper temperature and relative humidity levels, air pollution, improper levels of light and irradiation, biological threats, inappropriate handling and misuse, and disasters) [19]. Resultant damage forms can be divided into four categories: i) physical forms, these describe forms resulting from inappropriate handling and misuse (e.g., tears, losses, and dog-eared corners); ii) chemical forms caused by the occurrence of undesirable chemical reactions (e.g.,

[14] Nickell, J., 2009. Real or Fake: Studies in Authentication, the University Press of Kentucky.
[15] Roosa, M., 2006. Caring, Handling and Storage of Photographs, Information Leaflet, the Library of Congress. Retrieved from: http://www.loc.org/preserv/care/photolea.html#Storage
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[17] Martins, A., Daffner, L., Fenech, A. Mcglinchey, C. and Strlič, M., 2011. Non-destructive Dating of Fiber-based Gelatin Silver Prints using Near-infrared Spectroscopy and Multivariate Analysis, *Analytical and Bioanalytical Chemistry*, 402(4), pp. 1459-69.
[18] Reilly, J., 1986. Stability Problems of 19th and 20th Century Photographic Materials, Rochester Institute of Technology, New York.
[19] Pitnick, R., Part Six: The Display and Preservation of Black and White Photographs, ABC of Collecting.

discoloration); ii) biological damage caused by a variety of living organisms (e.g., fungal stains); and iv) deposited matter [20].

Due to their complex nature, photographs have special conservation requirements, and since photograph conservation is a relatively new field in Egypt, the work of a photograph conservator is not as clear to conservation institutions and collection holders as might be assumed. In many cases, when photographs deteriorate, there is a strong desire to restore them to their original appearance and condition. Many treatments may be employed to restore the physical and chemical stability of damaged photographs as well as improve their aesthetic appearance. However, there are ethical issues that must be taken into consideration when treating photographs to ensure that their integrity is not compromised. One also must take into account that almost all treatments can do much harm as good. Selected treatments must honor the images' integrity, and the chemicals used must be stable, reversible, and not harmful.

In this study, the authors have selected different types of photographs, from Francis Amin's collection and private collections, suffering from various damage forms with the aim of sharing the current photograph conservation practices and discussing what we do, what we do not do, and why. The authors believe that this would greatly assist in developing criteria and better strategies for the preservation of our photographic heritage.

2. Collection description, condition and conservation

2.1. The photo collection

The photo collection consists of 3 cellulose acetate negatives; 3 gelatin dry plate negatives; 1 polyester negative; 4 albumen prints; 2 collodion prints; 9 silver gelatin prints; 2 chromogenic prints; and others.

Table 1 summarizes the photographic processes used and their characteristics, as well as the damage forms found in each case [21, 22].

[20] Stanco, F., Ramponi, G. and De Polo, A., 2003. Towards the Automated Restoration of Old Photographic Prints: A Survey, in Proc. IEEE-EUROCON 2003, Ljublijana.

[21] Graphics Atlas, 2022. The Image Permanence Institute. Retrieved from: http://www.graphicsatlas.org/

[22] Hill, G., 2020. Care of Plastic Film-based Negative Collections, *Technical Bulletin*, 35, the Canadian Conservation Institute (CCI), Ottawa. Retrieved from: https://www.canada.ca/en/conservation-institute/services/conservation-preservation-publications/technical-bulletins/care-plastic-negative.html#a4b1

Table 1 Collection description and condition

Photographic process used	Structure, characteristics, time of popularity	Image no.	Image description	Forms of damage
Cellulose acetate negatives **(Fig. 1)**	Structure: An image layer (image silver embedded in gelatin) adhered to the cellulose acetate base with a subbing layer of cellulose nitrate and, in later films, an anti-curl layer on the opposite side of the base. Characteristics: • Neutral gray and black tone. • Vinegar syndrome. • Bubbling. • Channeling. • Silver mirroring. • Curling Time of popularity: 1950s	1	Deteriorated images of an archaeological site from M. Abuzeid's collection. Approx. date: 1940	• Dust. • Channeling. • Yellowing. • Mirroring. • Fragility.
		2		
		3		
Gelatin dry plate negatives **(Fig. 2)**	Structure: image layer (image silver embedded in gelatin) on a glass support. Characteristics: • Neutral gray and black tone. • Silver mirroring. • Weeping glass. Time of popularity: 1880 – 1925.	4	The image is of an ancient Egyptian statue and was taken by Georges Leichter. Approx. date: 1930	• Dust. • Broken into pieces.
		5	An image of a girl and a dog. Approx. date: 1920	• Dust.
		6	Unclear image. Approx. date:1920	• Dust. • Mirroring. • Binder loss.
Polyester negative **(Fig. 3)**	Structure: An image layer (image silver embedded in gelatin) adhered to the polyester base with a subbing layer of cellulose nitrate and, in later films, an anti-curl layer on the opposite side of the base.	7	The image is of a landscape. Approx. date: 1955.	• Dust. • Mirroring.

Table 1 Collection description and condition (continued)

Photographic process used	Structure, characteristics, time of popularity	Image no.	Image description	Forms of damage
	Characteristics: • Stable to a degree. • Mirroring. Time of popularity: was introduced in 1960 and is still used today.			
Albumen prints **(Fig. 4)**	Structure: image layer (image silver embedded in albumen) on a paper support. Characteristics: • Warm image tone. • Image discoloration and fading. • Overall yellowing. • Visible paper fibers. • Semi-matte to glossy surface. • Mold. Time of popularity: 1855-1895.	8	A group of men and children. The image is fixed to a secondary support. Approx. date: 1880.	• Dust and dirt. • Degraded tape. • Yellowing. • Tears. • Losses. • Stains.
		9	A stereoscopic view of the statue of the three graces in Versaille museum. The image is printed on a hand-colored thin translucent paper mounted in a card frame. Approx. date: 1860.	• Dust and dirt. • Tears.
		10	Images of the sphinx and the funerary Khanqah of Sultan Al-Nasir Faraj Ibn Barquq from Luigi Fiorillo's album. Approx. date: 1895.	• Dust and dirt. • Yellowing. • Tears. • Ink marks. • Deteriorated tape.
		11	An image of a man sitting on a rock. The image is fixed to a secondary support. Approx. date: 1895.	• Dust and dirt. • Insect attack (i.e. holes).
Collodion prints **(Fig. 5)**	Structure: image layer (image silver embedded in collodion) on a paper support. A baryta layer is found between the image and the support. Characteristics: • Warm image tone. • Paper fibers are not visible.	12	This image of a girl and a boy was taken by a Greek Photographer. Approx. date: 1900.	• Dust. • Abrasions. • Binder loss.

Table 1 Collection description and condition (continued)

Photographic process used	Structure, characteristics, time of popularity	Image no.	Image description	Forms of damage
	• Matte and glossy surfaces. • Iridescent sheen may be seen. • Abrasions. Time of popularity: 1895 – 1905.	13	An image of a seated old man and a boy. The image was taken by the Sabongi Brothers, the assistants of Félix Bonfils. Approx. date: 1890.	• Dust and dirt. • Abrasions. • Ink stains.
Silver gelatin prints **(Fig. 6) and (Fig. 7)**	Structure: image layer (image silver embedded in gelatin) on a paper support. A baryta layer is found between the image layer and the paper support (i.e., fiber-based paper). Resin-coated paper, paper sandwiched between two layers of polyester, was also used. The top layer is pigmented with titanium dioxide. Characteristics: • Untoned: neutral black and white image tone. • Toned: varying shades of brown, blue-black, purple-black, reddish • Paper fibers are not visible. • Silver mirroring. • Image discoloration. • Gelatin yellowing. • Mold. Time of popularity: 1905 – 1960.	14	A group of silver gelatin prints affected by water. Approx. date: 1950.	• Dust. • Stuck together. • Binder loss.
		15	An image of a man and a lady. Approx. date: 1950.	• Dust and dirt. • Binder loss.
		16	An image of a man holding a Tambourine. Approx. date: 1940.	• Dust. • Mirroring.
		17	A group photo in Ahmed Maher Secondary School, fixed to a support. Approx. date: 1951.	• Dust. • Mirroring. • Foxing.
		18	A photo of a bride and groom. Approx. date: 1938.	• Dust. • Losses. • curling
		19	An image taken in Beni Suef by Engineer John P. Mitchell. Approx. date: 1925.	• Dust and dirt. • Losses.
		20	Family photo album with a leather cover. Approx. date: 1910.	• Dust. • Mirroring.
		21	An image of photographer Henry Leichter in exile, in Saint Clement camp in Malta, where the patriotic Egyptians, and the foreigners (i.e., Italians, Germans, Austrians, and Turks) were exiled during World War I. There is a camp seal on the back.	• Dust and dirt. • Creases.

Table 1 Collection description and condition (continued)

Photographic process used	Structure, characteristics, time of popularity	Image no.	Image description	Forms of damage
		22	A hand-colored photograph of a boy and a girl dressed in Greek costumes, fixed to a secondary support. Approx. date: 1920.	• Dust. • Support losses. • Image loss.
Chromogenic prints **(Fig. 8)**	Structure: image layer (dye image embedded in gelatin) on a paper support. A baryta layer is found between the image layer and the paper support (i.e., fiber-based paper). Resin-coated paper, paper sandwiched between two layers of polyester, was also used. The dye image consists of three superimposed gelatin layers containing dye (i.e., cyan, magenta, and yellow). Characteristics: • Paper fibers are not visible. • Possible backstamp or backprint. • Dye fading. • Dye shifting. • Staining. • Mold. Time of popularity: 1960 – 1990.	26	A portrait of a man from a private collection. Approx. date: 1984.	• Dust and dirt. • Stuck to glass.
		27	A group photo from a private collection. The image shows the teachers and students of Arab Al-Atoula Primary School, Asyut Governorate. Approx. date: 1975.	• Dust and dirt. • Stains.

Fig. 1. Cellulose acetate negatives suffering from dust; also from A) and B) channeling, and C) silver mirroring and fragility.

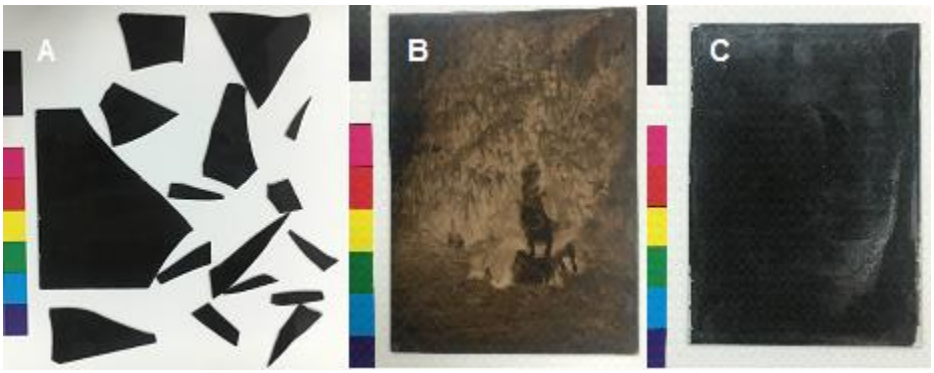

Fig. 2. Gelatin silver glass plate negatives suffering from A) breakage, B) dust, and C) silver mirroring and binder loss.

Fig. 3. A polyester negative suffering from dust and mirroring.

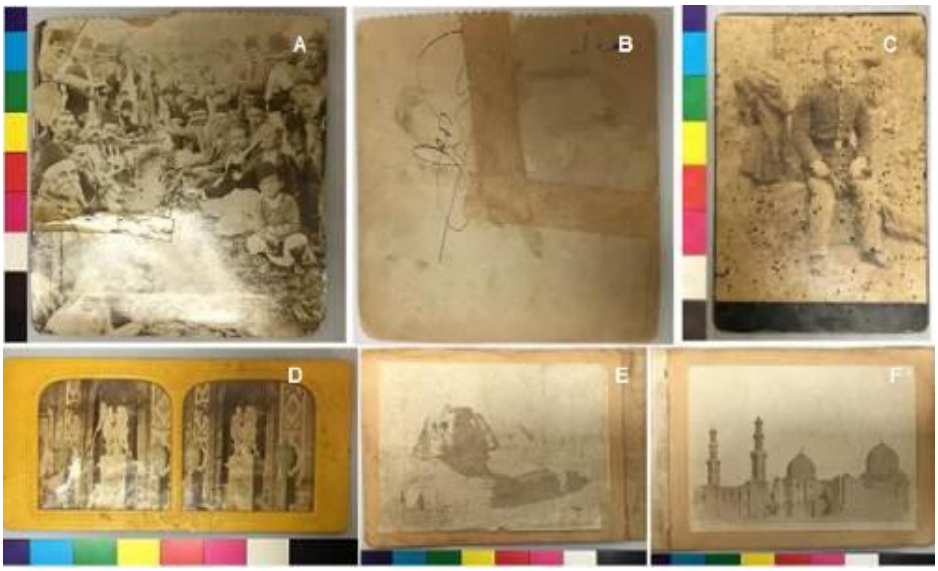

Fig. 4. Albumen prints suffering from dust, dirt, A) and B) damaged tape, C) insect damage, D) tears and mirroring, and E) and F) yellowing.

Fig. 5. Collodion prints suffering from dust, dirt, A) ink stains, B) acidity, and C) abrasions and binder loss.

Fig. 6. Silver gelatin prints (DOP) suffering from dust, A) adhesion of photographs to one another in a stack due to water damage, B) and C) dirt and binder loss, D) silver mirroring, E) foxing and silver mirroring, F) curling, G) losses, and H) silver mirroring.

Fig. 7. Silver-gelatin prints (DOP) suffering from dust, A) dirt, abrasions, and creases, B) dirt, and C) silver mirroring and binder loss.

Fig. 8. Chromogenic prints suffering from dust, dirt, A) glass stuck to the photograph's surface, and B) binder loss and staining.

In order to effectively conserve damaged photographic materials, accurate diagnosis of their preservation condition is crucial. Understanding how different photographs deteriorate significantly assists in making correct treatment choices. For this reason, the previous deterioration forms are thoroughly discussed below.

Generally, almost all photograph collections suffer from dust and dirt as a result of improper handling and misuse, poor housekeeping, air pollution, and other activities. Dust and dirt can abrade and/or stain photographic surfaces, depending on the nature of the particulates [23].

Cellulose acetate negatives are subject to a form of chemical damage known as channeling, which develops due to the shrinkage of the cellulose acetate base, while the

[23] Ali, M., Ali, M., Darwish, S., Saker, M., and Ciliberto, E., 2017. Solvent Cleaning of Antique Chromogenic Prints: An Analytical Comparative Study, *Mediterranean Archaeology and Archaeometry*, (3), pp. 1-12.

gelatin binder layer maintains its original size [24]. The base shrinkage is caused by two processes: deacetylation and depolymerization. Deacetylation occurs when the acetyl groups split off from the cellulosic polymer chain and react with water molecules, forming acetic acid (i.e., a hydrolytic reaction). The presence of the acid causes further splitting of the acetyl groups (i.e. an autocatalytic reaction). Depolymerization refers to breakage of main molecular chain lengths [25]. The β-acetal oxygen bridge joining the glucose molecules of cellulose together is susceptible to acid-catalyzed hydrolysis. This breaks the chains and weakens the fibers, causing the cellulose acetate base to become acidic and brittle [26, 27, 28]. Curling of cellulose acetate negative develops due to size differences of the two dominant layers (i.e., the base and the binder layer) [25], while the yellowing of the base is due to the oxidation of cellulose and the formation of aldehydes, ketones and carboxylic acids [29]. The abundance of oxidized functional groups act as chromophores that are responsible for the yellowing [30].

As for silver mirroring, also known as mirroring, it is a common form of damage affecting silver-based photographs. This phenomenon occurs when the image silver particles (Ag^0) are stripped off electrons and converted to invisible silver ions (Ag+) due to the occurrence of oxidation. These mobile silver ions migrate to the surface, where they react with an environmental sulfur-based compound. Generally,

[24] Vitale, T., 2009. History, Science and Storage of Cellulose Acetate Film Base. Emeryville, CA: Vitale Art. Conservation.

[25] Horvath, D., 1988. The Acetate Negative Survey: Final Report, Topics in Photographic Preservation, 2, pp. 25-39.

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[28] Fischer, M., 2020. Photographs: A Short Guide to Film Base Photographic Materials: Identification, Care, and Duplication, Preservation Leaflets, Northeast Document Conservation Center (NEDCC). Retrieved from: https://www.nedcc.org/free-resources/preservation-leaflets/5.-photographs/5.1-a-short-guide-to-film-base-photographic-materials-identification,-care,-and-duplication

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[30] Conte, A., Pulci, O., Knapik, A., Bagniuk, J., Del Sole, R., Lojewska, J., and Missori, M., 2012. Role of Cellulose Oxidation in the Yellowing of Ancient Paper, *Physical Review Letters*, 108, 169902.

mirroring appears as a bluish metallic sheen giving the shadow areas an iridescent appearance. However, in severe cases, it can appear green, violet or bronze in color [31].

The primary issues associated with glass negatives result from the physical and chemical nature of glass itself [32]. For historical glass negatives, the probable source of glass was soda lime cylinder glass and crown glass. Both glass types have many imperfections since both procedures physically altered the molten glass into one shape, then flattened it [33]. The fragility of such negatives makes them more prone to breaking when housed in correctly, or due to improper handling, and disasters (e.g. earthquakes) [34].

Albumen prints exhibit characteristic yellowing, noticeable in the highlights [35]. The discoloration of albumen prints is mainly due to the reactions initiated by the sugar content of the egg white; the reactions initiated by the sulfur content of the egg white; the tendency of proteins to bind silver; and the susceptibility of proteins to react with light [36].

In the past, pressure-sensitive tapes were used to mend tears and repair torn photographic prints [37]. A pressure-sensitive tape consists of the adhesive (e.g., a rubber-based adhesive); the carrier (e.g. paper and cellophane); the primer which is used to secure good adhesion between the two previous layers; and the release coat which ensures that the roll can be unwound without leaving any residual adhesive. Overtime, as oxidation progresses, the adhesive becomes yellow, sticky and oily. The oily adhesive then penetrates into the photograph and adjacent items. At this stage, the removal of the adhesive is difficult yet possible. The adhesive continues to oxidize, gradually losing its

[31] Yosri, A., Mohamed, N., Atef, A., Atef, O., Attia, R., and Ali, M., 2020. Analytical Study on the Effects of Pollutants on Silver Gelatin Prints, *International Journal of Conservation Science*, 11(1), pp. 39-50.

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[37] Smith, M., Jones, N., Page, S., and Dirda, M., 1984, *Journal of the American Institute for Conservation*, 23(2), pp. 101-113.

adhesive properties, the carrier may fall off, and the adhesive residues crosslink, becoming hard, brittle, and highly discolored. At this stage, the adhesive residues and the stain it has created are very difficult, sometimes impossible, to remove [38].

Floods, water sources and high relative humidity can cause photographs to stick to adjacent surfaces, whether they are other photographs, plastic enclosures, or glass [39, 40]. This results in a change in surface gloss, a phenomenon known as ferrotyping [41].

Curling is common among photographic collections. The main cause of this damage in silver gelatin prints is the aging of the gelatin binder under damp-heat cycles. Gelatin was found to play a dominant role in curling formation since it is highly hygroscopic, and has low thermal stability and poor mechanical properties. During alternate expansion and contraction, the aggregation behavior of gelatin supramolecules produces different contraction stress in each layer. The stress in the gelatin layer is greater than that of the primary paper support, causing the curling towards the gelatin layer [42].

Insects are attracted to photographic prints since they are composed of organic binders (e.g., albumen and gelatin), adhesives, and cellulose. Insects can cause serious damage to photograph collections through their eating habits (e.g., tunnels and holes); but also, through their nesting activities and bodily secretions [43].

[38] Iklé, G., 2017. Scientific Analysis and Treatment of a William Sawyer Photograph Album, *Topics in Photographic Preservation*, 17, pp. 155-183.
[39] Albright, G., 1999. Emergency Management: Emergency Salvage of Wet Photographs, Preservation Leaflets, Northeast Document Conservation Center (NEDCC). Retrieved from: https://www.nedcc.org/free-resources/preservation-leaflets/3.-emergency-management/3.7-emergency-salvage-of-wet-photographs
[40] Northeast Document Conservation Center (NEDCC), 2007. Photographs: Storage Enclosures for Photographic Materials, Preservation Leaflets. Retrieved from: https://www.nedcc.org/free-resources/preservation-leaflets/5.-photographs/5.5-storage-enclosures-for-photographic-materials
[41] Weaver, G., 2008. A Guide to Fiber-Base Gelatin Silver Print Condition and Deterioration, Adobe Calson, Pro, Catriel and Tandelle, p. 13.
[42] Liu, J., Li, Y., Hu, D., Chao, X., Zhou, Y., and Wang, J. 2021. An Essential Role of Gelatin in the Formation Process of Curling in Long Historical Photos, *Polymers*, 13, 3894.
[43] Teijgeler, R., 2001. Preservation of Archives in Tropical Climates: An Annotated Bibliography, Paris, pp. 62.

Foxing refers to the small reddish-brown, or yellowish brown irregular spots, found on paper heritage. The precise cause of these spots is unknown. However, some authors have associated it with bacterial or fungal growth and the presence of iron [44].

Abrasions, creases, tears, losses, ink marks, fingerprints, and stains are caused by improper handling and misuse. Stains can also occur due to the activities of living organisms, i.e., fungi, insects, rodents, etc. There are several factors leading to image and binder loss, namely, water damage, disasters, and improper handling and misuse.

2.2. Treatments and preservation measures

The aim here is to strengthen the physical structure of the photographs, improve their appearance and stabilize their condition to prevent further damage. Interventive conservation treatments were only carried out when necessary. Based on the condition of the collection, the selected conservation processes included: disinfection, mechanical cleaning, solvent cleaning, dismantlement of the secondary supports, deacidification, humidification, flattening, tear mending, loss compensation, separation of photographs from each other and from glass, re-mounting, minor retouching, and housing.

One of the main challenges that face photo conservators is the economic situation. The authors have established a small laboratory to carry out the required conservation treatments. We substituted the costly custom-made housing enclosures with materials from the local market, which highly reduced the budget. **(Fig. 9)** shows some of the used tools: i.e., brushes, spatulas, scalpels, bone folders, vinyl erasers, retouching color pencils, retouching coloring kit, tweezers, scissors, cotton swabs, thermometers, color target, empty plastic containers, graduated cylinders, beakers, spray bottles, ruler, weights, air-tight container, skewers, gloves, plastic bowls, thermometers, and magnifying glass, and materials: i.e., Klucel G, methyl cellulose, distilled water, cotton, and magnesium bicarbonate.

[44] Ardelean, E., and Melniciuc-Puică, N., 2013. Conservation of Paper Documents Damaged by Foxing, *European Journal of Science and Theology*, 9(2), pp. 117-124.

Fig. 9. Some tools and materials used in photograph conservation.

2.2.1. Disinfection

Fungicides have been widely used to disinfect infected historical records [45]. However, the use of these chemicals is harmful to the environment and human health; moreover, it can cause significant damage to different materials [46]. Alternatively, natural substances, i.e., essential oils, are used in the conservation field due to their antibacterial and antifungal properties [47]. Many studies have proved the efficiency of using essential oils such as garlic and clove in controlling the biodeterioration of documentary heritage [48]. Lavender, clove, anise, cinnamon, and thyme essential oils were found to be suitable for use with albumen prints, silver gelatin prints, and chromogenic prints [49].

[45] Strassberg, R., 1978. The Use of Fumigants in Archival Repositories, *The American Archivist*, 41(1), pp. 25-36.
[46] Velikova, T., Trepova, E., and Rozen, T., 2011. The Use of Biocides for the Protection of Library Documents: Before and Now. In: Science against Microbial Pathogens: Communicating Current Research and Technological Advances, A. Méndez-Vilas (Ed.), FORMATEX, 152-159.
[47] Rakotonirainy, M. and Lavédrine, B., 2005. Screening for Antifungal Activity of Essential Oils and Related Compounds to Control the Biocontamination in Libraries and Archives Storage Areas. International *Biodeterioration & Biodegradation*, 55(2), pp. 141-147.
[48] Borrego, S., Gómez De Saravia, S., Valdés, O., Vivar, I., Battistoni, P. And Guiamet, P., 2016. Biocidal Activity of Two Essential Oils on Fungi that Cause Degradation of Paper Documents. *International Journal of Conservation Science*, 7(2), pp. 369-380.
[49] Ali, M., 2021. Effect of Five Essential Oils as Green Disinfectants on Selected Photographic Prints: Experimental Study, *Conservation Science in Cultural Heritage*, 20.

In this study, thyme oil was used for the disinfection of all photographs. The essential oil is composed of thymol (68.91%), para-cymene (13.61%), g-terpinene (7.60%), ocimene (2.11%), carvacrol (1.55%), eucalyptol (0.89%), sabinene hydrate (0.80%), myrcene (0.76%), a-terpinolene (0.69%), caryophyllene (0.49%), 1-octen-3-ol (0.48%), camphor (0.45%), thymol methyl ether (0.45%), carvacrol methyl ether (0.34%), limonene (0.33%), a-phellandrene (0.30%) and a-pinene (0.24%). The essential oil (EO) was provided by the National Research Center (NRC) in Cairo, Egypt. The EO was prepared at a concentration of 0.5% and was applied in the vapor phase for higher efficiency [50].

2.2.2. Mechanical cleaning

Removal of dust and loose dirt particles was performed on the image side using a very fine brush, and a cotton ball, or swab to avoid scratching the image [51]. A PVC-free Faber Castell eraser was used to remove the disfiguring mirroring **(Fig. 10)**. Different erasers were tested prior to treatment on an invaluable photograph. Treatment of silver mirroring is a debatable issue since it is considered by some conservators to be a sign of authenticity; however, some suggest that it should only be removed if it disfigures the image [52]. A blower may be helpful in the case of severely damaged images [53]. The deteriorated tape was removed with a scalpel **(Fig. 11)**.

Cellulose acetate negatives were cleaned with a cotton swab due to their severe fragility, while the dry gelatin plates were cleaned with a soft brush. The deteriorated tape found on one of the cellulose acetate negative was mechanically removed with a spatula **(Fig. 12)**.

[50] Abdallah, M. Ali, M., Belal, A., Stanco, F., Mohareb, F. and Ali, M., 2020. Conservation of the Heinz and Georges Leichter Dry Plate Collection, Egypt: Case Study, *International Journal of Conservation Science*, 11(2).
[51] Preservation of Records, Code of Practice for the Mechanical Cleaning of Records, 2006.

[52] Abdel-Aziz, O., Mahmoud, M., Abo-Elfath, Y., Abdel-Aziz, S., Samir, M., Ali, M., 2019. Evaluation of Conventional Treatments for Mirrored Silver Gelatin Prints: An Experimental and Applied Study, *International Journal of Conservation Science*, 10(1), pp. 81-96.
[53] Agrawal, O. and Barkeshli, M., 1997. Conservation of Book, Manuscripts and Paper Documents, INTACH, Indian Council of Conservation Institutes.

Fig. 10. Mechanical cleaning using A), B), and C) a cotton swab, D) a brush, and E) a PVC-free eraser.

Fig. 11. Mechanical cleaning using A) a PVC-free eraser, and B) a brush. C) Tape removal using a scalpel.

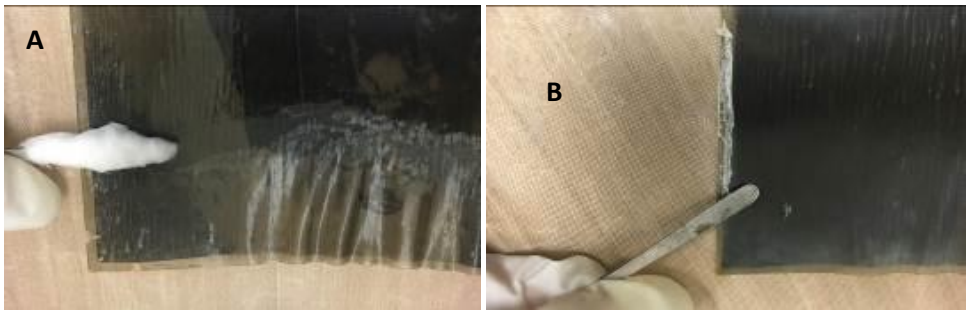
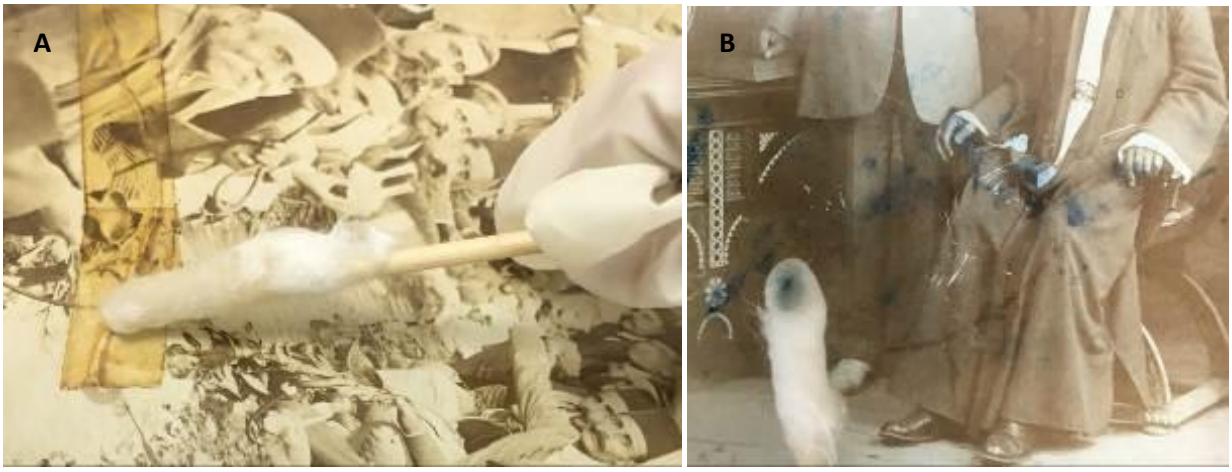


Fig. 12. Mechanical cleaning of cellulose acetate negatives using A) a cotton swab, and B) a spatula.

2.2.3. Solvent cleaning

The use of organic solvents such as toluene, ethyl alcohol, and others was reduced given that they are toxic to some degree [54]. Surface cleaning was carried out by slightly moistening a cotton ball, wrapped around a skewer, with toluene. The cotton was checked and changed continuously until the cotton no longer picked up dirt. Tape removal was carried out by applying a cotton poultice dampened with toluene and covered with a silicon sheet to prevent solvent evaporation **(Fig. 13)**.



[54] Ali, M., 2022. The Evaluation of Agarose-based Gel System for Surface Cleaning Albumen Prints vs. the Conventional Water Treatment, *Egyptian Journal of Archaeological and Restoration Studies*, 12(1). (Under publication).

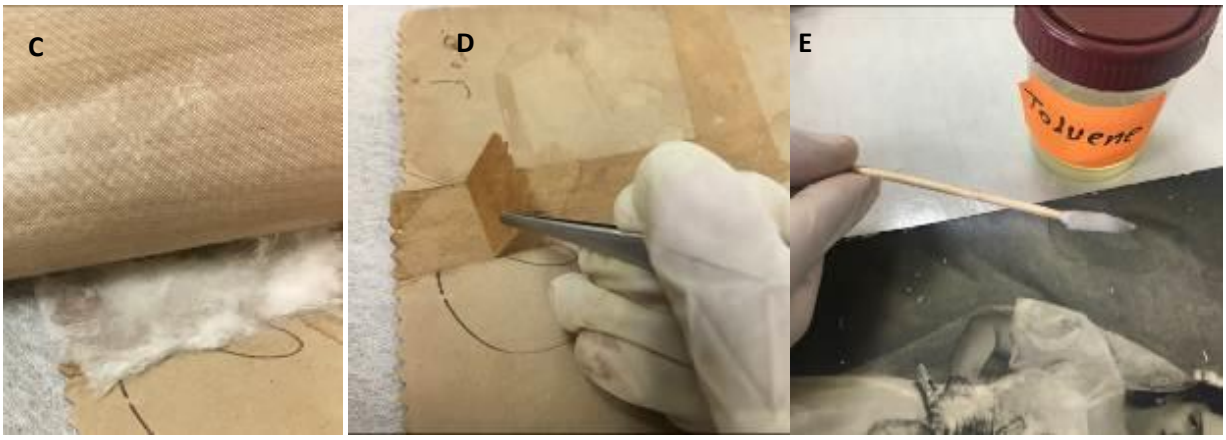


Fig. 13. Solvent cleaning using a cotton swab dampened with toluene to A) remove tape, and B) and C) reduce stains. D) Tape removal using a cotton poultice dampened with toluene. E) The lifting of the tape carrier with tweezers.

2.2.4. Separating photographs from each other and from glass

The separation of photographs, whether from each other or from glass, is very challenging. Conventionally, photographs are separated by applying localized humidity, application of steam, and immersion in a water or water/ethanol bath [55]. The authors simply separated the photographic prints from each other using dental floss **(Fig. 14)**. However, in the case of the chromogenic print which was severely stuck to glass, the authors had to perform several tests to decide which treatment is more efficient. The photograph was exposed to local steam using a kettle and to steam in a tight-sealed container since they are less aggressive treatments; yet, both were partially successful **(Fig. 15)**. Accordingly, the photograph was immersed in a warm distilled water and ethanol bath which did greatly assist in the removal of the glass from the photographic surface with the help of a spatula. The photograph was subsequently placed between blotting paper to remove excess water. Not all photographs would survive such treatment since, in some cases, the gelatin binder is negatively affected by the water and one can risk losing the image. After glass removal, the surface of the photograph was cleaned with a cotton swab dampened with ethyl alcohol (80%) in the same previous manner.

[55] Norris, D., 1989. The Removal of a Silver Gelatin Photograph Adhered to Glass, *Topics in Photographic Preservation*, 3, pp. 86-91.

Fig. 14. After separating the photographs from each other.

Fig. 15. Separating the chromogenic print from glass using water steam.

2.2.5. Dismantlement and deacidification of the secondary support

The presence of inscriptions on the verso of the secondary support made it necessary to preserve it; accordingly, it was carefully removed using a spatula. Then, the secondary support was treated in a 0.05 M of an aqueous solution of magnesium bicarbonate $Mg(HCO_3)_2$ [56]. Aqueous solutions of magnesium bicarbonate effectively neutralize the acidity of cellulose-based materials, creating a buffer for long-term preservation [57]. The duration time of the deacidification process was about 6 minutes **(Fig. 16)**. Prior to

[56] Wahba, W., Fahmi, A. and Nagaty, E., 2019. The Evaluation of the Efficacy of Two Magnesium Based Deacidification Methods on the Stability of Three Different Types of Papers, *International Journal of Conservation Science*, 10(2), pp. 233-248.

[57] Zidan, Y., El-Shafei, A., Noshy, W. and Salim, E., 2020. The Effectiveness of Aqueous and Nonaqueous Magnesium Hydroxide Nanopowder on the Color Stability of Dyed Cotton Paper Pulp, *International Journal of Conservation Science*, 11(3), pp. 657-668.

deacidification, the ink inscriptions were fixed with Klucel G in ethyl alcohol at a concentration of 1% [58].

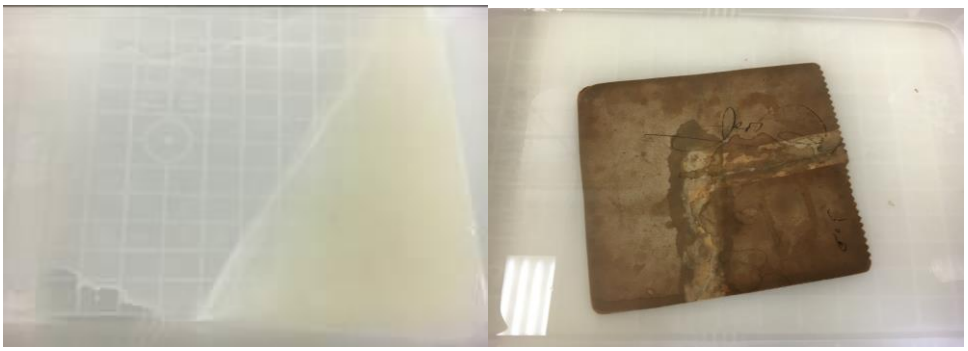


Fig. 16. The deacidification of the secondary support using an aqueous solution of magnesium bicarbonate.

2.2.6. Humidification and flattening

There are three basic steps to humidification: cleaning, humidifying, and flattening. Curled photographs were locally humidified by building a sandwich of blotting paper slightly dampened with distilled water and ethyl alcohol (50%). Sheets of Reemay were used to separate between the photographs and the blotting paper. Reemay is an acid-free, non-woven polyester fabric. The marked weave permits water to pass through without sticking to the material. These layers were placed under pressure using weights. The humidified photographs were then placed between sheets of an archival-quality blotting material and under pressure to prevent cockling [59,60]. Reemay sheets were also used for interleaving **(Fig. 17)** and **(Fig. 18)**. The blotting paper was replaced several times until the photographs were completely flat and dry.

[58] Moustafa, M., Abd Allah, M., Magdy, R., Abdrabou, A., Shaheen, I., Kamal, H., 2017. Analytical Study and Conservation Processes of Scribe Box from Old Kingdom, *Scientific Culture*, 3(3), pp. 13-24.

[59] National Park Service, 1993. How To Flatten Folded Or Rolled Paper Documents, *Conserve O Gram*, 13(2), pp. 1-4.

[60] The Local Records Preservation Program, Missouri State Archives, 2018. Humidification and Flattening of Documents. Retrieved from: https://www.sos.mo.gov/CMSImages/LocalRecords/HumidificationandFlattening.pdf

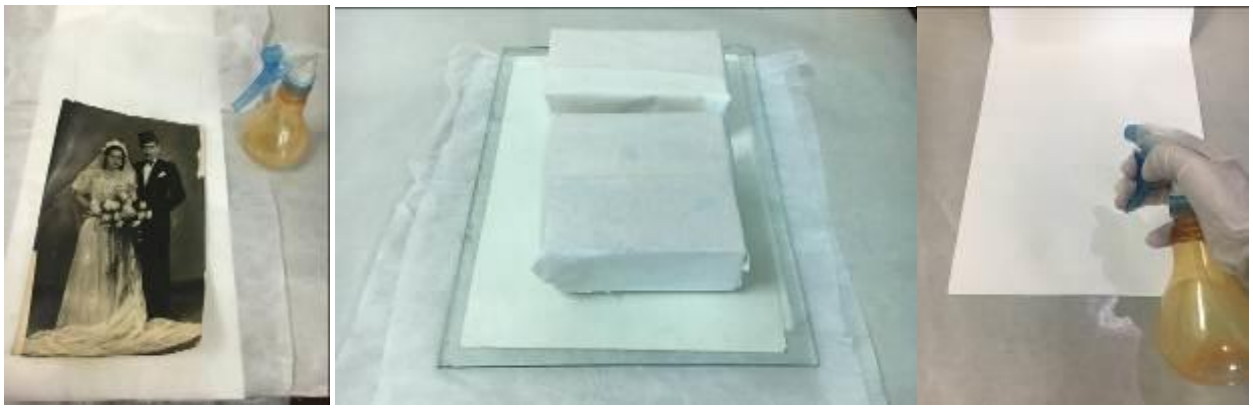


Fig. 17. Local humidification for treating curled photographs.

Fig. 18. The flattening of humidified photographs.

2.2.7. Tear mending and loss compensation

Sharp tears were repaired using a small strip of tissue paper and Klucel G in ethyl alcohol at a concentration of 5%. The adhesive was applied using a fine brush. Leafy tears were mended using an adhesive only **(Fig. 19)**. Repair paper, i.e., Japanese paper of appropriate thickness and color was used to compensate for losses. The outlines of the missing area were traced on the repair paper using a pin; then, the infill was cut leaving a little margin, and pasted in position using Klucel G in ethyl alcohol at a concentration of 5% [61] **(Fig. 20)** and **(Fig. 21)**.

[61] Hendriks, K., et al., op. cit.

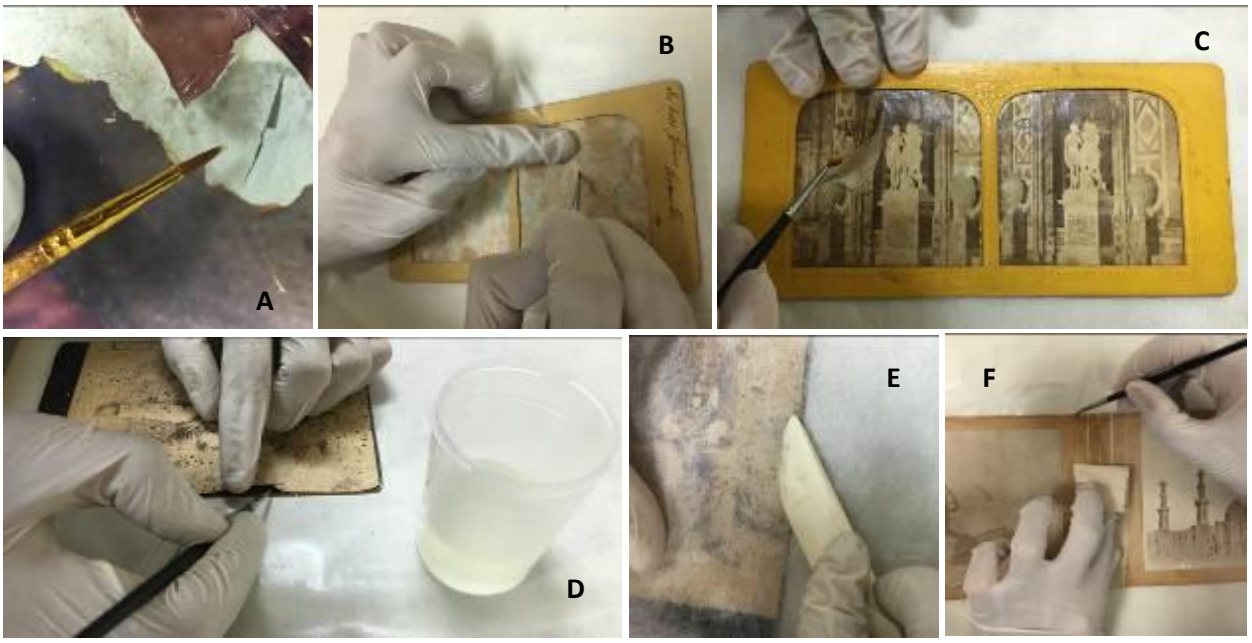


Fig. 19. A) and B) Tear mending using tissue paper and Klucel G in ethanol (5%). C) and D) The fixing of leafy tears into place using an adhesive. E) Applying slight pressure using a bone folder to fix the tears into place. F) Replacing the old tape that was removed from the album page.

Fig. 20. Loss compensation.

Fig. 21. The photo collection after conservation and before retouching.

2.2.8. Retouching

Fig. 22. Retouching the photographic prints using A) and B) color pencils, and C) and D) watercolors, both were applied following the stippling technique.

There are ethical issues involved in retouching photographs since it modifies the original in such a way that its integrity could be compromised; however, a good solution would be to retouch to the point where abrasions blend into their surrounds without covering the original [62]. It is challenging to retouch photographic images as the refractive index and texture of silver gelatin binder are difficult to simulate [63]. Because all conservation treatments must be reversible, an isolating layer of gelatin was applied to

[62] Ali, M. Ali, M., Darwish, S., Saker, M., Ciliberto, E., Greco, E. and Viscuzo, E., 2015. The Investigation and Conservation of El-Shenawy Palace Photographic Collection in Mansoura, Egypt, *Mediterranean Archaeology and Archaeometry*, 15(3), pp. 165-185.

[63] Yosri, M., Ali, M., Stanco, F., Taalat, K., 2018. Restoration of Silver Gelatin Prints in the Digital Era: An Innovative Approach, *International Journal of Conservation Science*, 9(2), pp. 375-388.

protect the underlying photograph from retouching materials. Retouching was carried out using a Faber-Castell Art and Graphic Poly-chromos set. Cotman Watercolours were also used. Color pencils are used to apply a series of minuscule dots of the required color (i.e., the stippling technique). The paint was also applied in small dots using a fine brush. In the retouching process, nothing appears to be happening at first, as the density is gradually built up in the area to be retouched. One must continue slowly dotting the area until the flaw gradually disappears **(Fig. 22)**. The use of a magnifying glass is preferred.

2.2.9. Housing

Proper enclosures are crucial preventive measures that protect photographs from physical damage. Moreover, they stabilize delicate materials and act as a barrier between the photograph and the potentially unstable surrounding environment [64]. Photograph conservators use varying enclosures for housing photographs: sleeves, folders, wrapping tissues, boxes, and others. There are two main materials for making enclosures: paper and plastic. The preferred types of paper for housing photographs are those made from cotton, linen, or wood pulp papers which have been treated to remove harmful chemicals, i.e., lignin-free and acid-free. Plastic enclosures should be made from polyester. Plastic enclosures have the advantage of allowing the image to be viewed without being removed from the enclosure [65].

To reduce the costs, the authors purchased paper and plastic materials from the local market to make the enclosures. Paper folders, four-flap folders, matboard folder, matboard folder with polyester front and back, polyester sleeve, and a sink mat were prepared for housing photographic prints, negatives, and the photo album. For assembling and housing the broken glass negative, the authors found it more appropriate to prepare a non-adhesive sink mat. Being transparent, it permits the viewing of the negative from both sides **(Fig. 23), (Fig. 24)** and **(Fig. 25)**.

[64] Roosa, M., Op. cit.
[65] Northeast Document Conservation Center (NEDCC), op. cit.

Fig. 23. Paper and plastic enclosures prepared by the authors for housing the photographs of Francis Amin's collection and a private collection. A) Paper folder; B) plastic sleeve; C) sink mat; D) matboard folder with a window mat, E) four-flap folder, and F) Plastic sleeve. Francis Amin is a well-known photo collector based in Luxor.

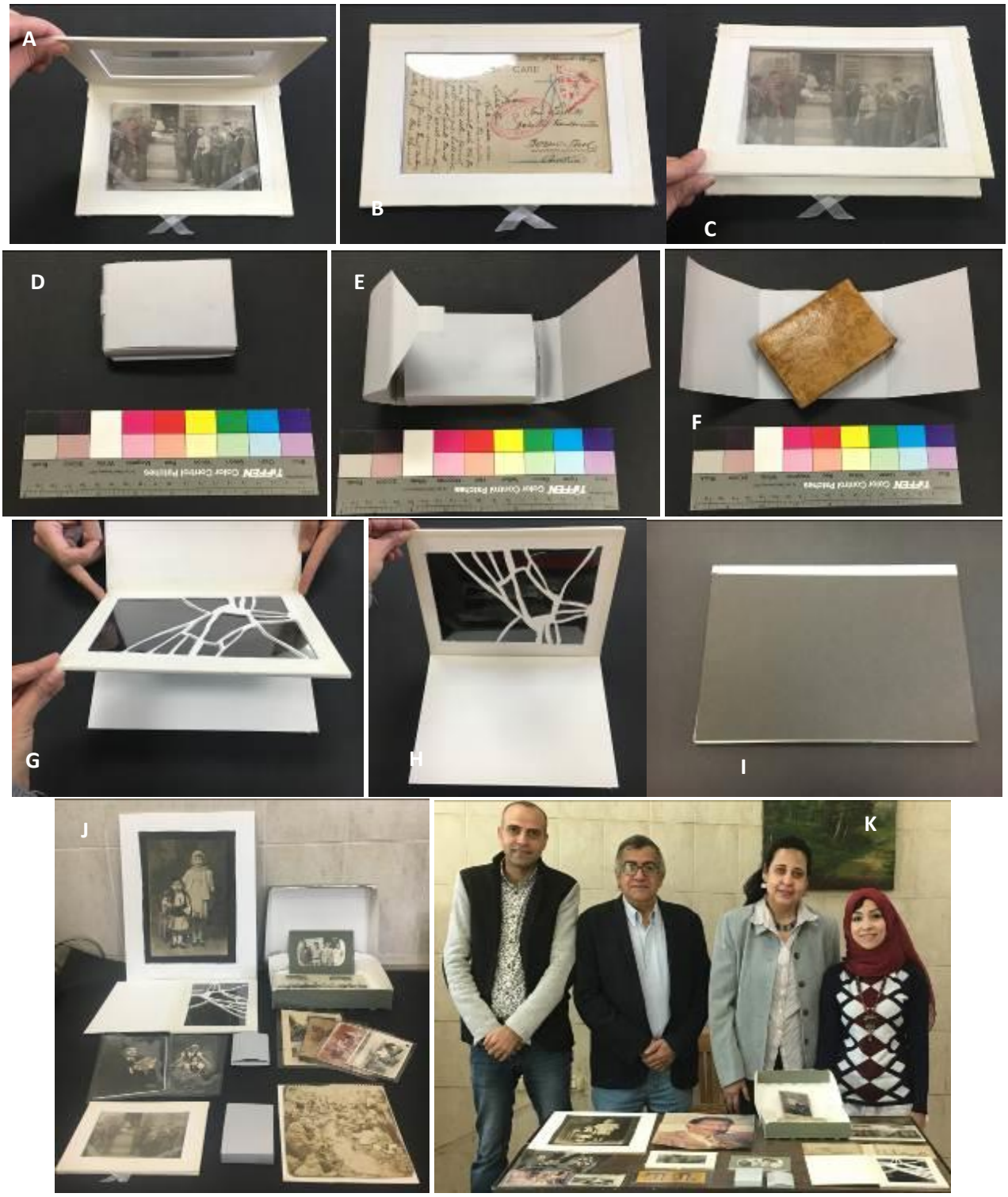


Fig. 24. The enclosures prepared by the authors for housing the photographs. A), B), and C) a matboard folder with a transparent front; D), E, and F) four-flap enclosure; G), H), and I) sink

mat; J) the collection after housing; and K) the conservation team in the presence of Francis Amin, the owner of the collection.

Fig. 25. The four-flap folder prepared for housing the chromogenic print, and the image after conservation and retouching.

3. Results and discussion

The preservation of photographic heritage in Egypt and in the Middle East region is very challenging, mainly, due to the existence of numerous photo collections, making their conservation time-consuming and material-hungry; the economic situation; and the lack of well-trained staff. Thanks to the Middle East Photograph Preservation Initiative (MEPPI), a strategic multi-year program launched in 2009 and designed to raise awareness about the importance of preserving the region's photographic heritage, many participants from different countries (i.e., Egypt, Palestine, Lebanon, Jordan, Turkey, the United Arab Emirates, Iraq, and others) received valuable training on how to safeguard their own collections. These trainees are very keen to spread their knowledge across their countries in hope to develop a vision for photo conservation. It is worth mentioning that MEPPI is led jointly by the Arab Image Foundation, the Art Conservation Department at the University of Delaware, The Metropolitan Museum of Art and the Getty Conservation Institute; and is supported by a generous grant from the Andrew W. Mellon Foundation and additional funding from the Getty Conservation Institute.

Nevertheless, photograph conservation is a relatively new specialism in Egypt; and the precise role of photo conservators is not clear as is the case with other materials.

Many of the conservators dealing with photographic collections do not have a photo conservation background, most of them are paper conservators. Therefore, the outcomes of the work often follow individual views of intervention. In this paper, the authors reported on the conservation of several glass plate negatives, cellulose acetate negatives, a polyester negative, albumen prints, collodion prints, silver gelatin prints, and chromogenic prints from Francis Amin's photo collection and private collections. The degree of damage varies among the collection. There are some photographs with considerable damage as shown earlier. These specific items were selected to provide a wide range of issues that photo conservators may face when dealing with photographic collections. Hopefully, this paper will serve as a guide to conservators, providing them with the knowledge of what to do and what not to do, and why.

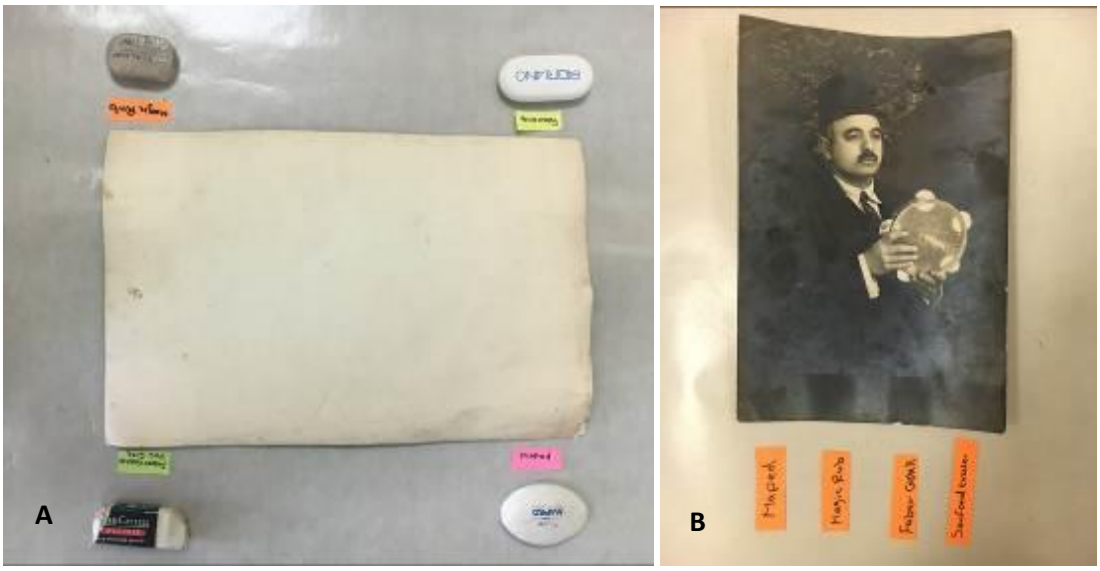


Fig. 26. Testing the efficiency of different erasers in A) cleaning the verso of a photograph, and B) silver mirroring removal.

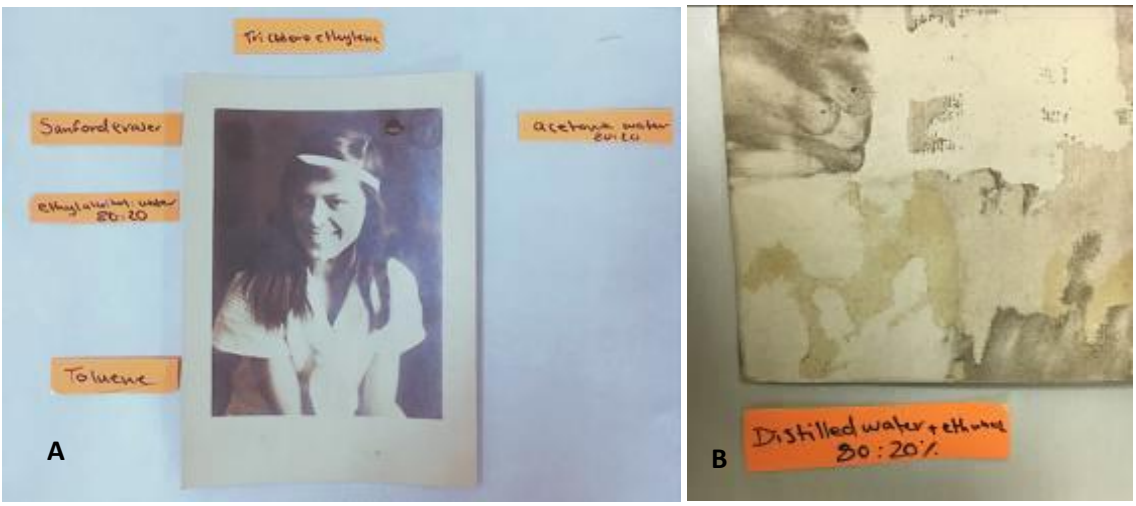


Fig. 27. Testing the efficiency of organic solvents in removing A) mirroring, and B) mount residues.

Photographs have special conservation requirements due to their complex structure and the diversity of photographic processes used to produce photographic materials. What is suitable for one photograph is not always suitable for another. Each item must be treated as a unique case; accordingly, it needs to be thoroughly studied to identify the type of photograph, diagnose its condition of preservation, select proper treatments; and finally perform preliminary testing to evaluate the suitability of the selected treatments **(Fig. 26)** and **(Fig. 27)**.

The purpose of cleaning treatments is to remove foreign materials which, overtime, can be harmful, without causing damaging or altering the physicochemical properties of the photographic surfaces [66, 67]. There are many treatments which are conventionally used by photo conservators to surface clean photographs including: mechanical cleaning, aqueous cleaning, solvent cleaning, enzyme cleaning and nowadays gel-based cleaning systems. Mechanical cleaning involves the use of brushes, cotton swabs, erasers, spatulas and vacuums. Several of these tools are abrasive; and therefore, are not recommended for cleaning the image side of the photographs or fragile materials (i.e. spatulas, erasers and scalpels) [68]. Erasers should only be used when necessary since they contain harmful compounds that are left behind even after brushing the surface. Erasing should be limited

[66] Ali, M., op. cit.
[67] Liang, X., Zheng, L., Li, S., Fan, X., Shen, S., Hu, D., 2017. Electrochemical Removal of Stains from Paper Cultural Relics Based on the Electrode System of Conductive Composite Hydrogel and PbO2, *Scientific Reports*, 7(8865), pp. 1-12.
[68] Baglioni, M., Giorgi, R., Berti, D. and Baglioni, P., 2012. Smart Cleaning of Cultural Heritage: A New Challenge for Soft Nanoscience, *Nanoscale*, 4, pp. 42-53.

to the verso of photographic prints and the secondary support [69]. Silver mirroring is efficiently removed or reduced by erasing; however, this remains a controversial issue among photo conservators [70]. As for aqueous cleaning, a spot test must be carried out prior to treatment since not all photographs can withstand such process. Albumen prints, for example, should not be exposed to aqueous cleaning since studies have proved that it increases the cracks of the albumen layer [71] and, in some cases, affects the surface sheen [72]. Many solvents are used within the conservation field due their efficiency in dirt and stain removal and low-cost. However, most of which are often aggressive, poorly

controllable, flammable and toxic [73, 74]. Accordingly, solvent cleaning should be only carried out when extremely necessary and after conducting the required tests to ensure that the selected solvent does not cause harm to the photographic surface [75]. For example, ethyl alcohol is among the most widely used organic solvent in the conservation field; yet, it severely damages the image layer of collodion prints. Saliva is efficient when used on photographic prints [76]. Currently, the use of gel-based systems is becoming more and more involved in the conservation field. Gels are eco- and user-friendly materials that have the advantage of gradually releasing solvents, reducing their solubilizing action, reducing the solvents' evaporation and consequently limiting their penetration within the original substrate. Accordingly, they are very suitable in cleaning sensitive surfaces. The

[69]Hendriks, K., et al.

[70] Abdel-Aziz, O., Mahmoud, M., Abo-Elfath, Y., Abdel-Aziz, S., Samir, M., Ali, M., 2019. Evaluation of Conventional Treatments for Mirrored Silver Gelatin Prints: An Experimental and Applied Study, *International Journal of Conservation Science*, 10(1), pp. 81-96.

[71] Baas, V., Foster, C. and Trentelman, K., 1997.The Effects of Multiple Wet Treatments on Cracking in Albumen Prints. *Topics in Photographic Preservation*, 7, pp. 38-42.

[72] Afifi, S., 2017. Physical and Chemical Effects of Water on Albumen Prints, International Institute for Conservation of Historic and Artistic Works. https://www.iiconservation.org/node/7168.

[73] Balliana, E., Ricci, G., Pesce, C. and Zendri, E., 2016. Assessing the Value of Green Conservation for Cultural Heritage: Positive and Critical Aspects of Already Available Methodologies, *International Journal of Conservation Science*, 7(1), pp. 185-202.

[74] Baglioni, M., Giorgi, R., Berti, D. and Baglioni, P., 2012. Smart Cleaning of Cultural Heritage: A New Challenge for Soft Nanoscience, *Nanoscale*, 4, pp. 42-53.

[75] Hendriks, K., et al.

[76] Oliver, R., 2006. May I spit on your photograph? A preliminary investigation into the effectiveness of saliva and a synthetic alternative for surface cleaning silver gelatin photographs, AICCM 4th Book, Paper & Photographs Symposium. Post-prints and Posters, 19-21 April 2006, Wellington, New Zealand, p174-193.

main concern here is the long-term effects of the gel residues [77]. Cleaning treatments can be aggressive; accordingly, the best approach is to limit this stage as much as possible and to suffice with using soft brushes.

As mentioned previously, all water sources can cause photographs to stick together or to glass. Wet photographs can be easily lifted away from each other, or from glass. However, if they dry out, the separation process becomes extremely challenging [78]. Application of local steam can be a good start if the photograph is not severely adhered to the adjacent surface. In severe cases, separation attempts can cause permanent damage to photographic images. Dealing with such cases can be very challenging and should only be handled by a very skilled photo conservator in order to avoid causing further damage [79].

Mount removal has been a part of traditional photograph conservation; however, the mount's historic or aesthetic value must be taken into consideration. Some mounts hold valuable information and elements that is helpful in dating the photograph, identifying the photographer and the subject of the image. Mounts should only be removed if the photograph or the mount requires interventive conservation. There are several methods that can be used for demounting: mechanical methods, aqueous-based methods, solvent-based methods and others. If the mount is of historical value, mechanical removal methods must be excluded; the best approach in this case may be using water steam [80], [81]. Again, removal method selection greatly depends on the condition of the mount and photograph, the type of adhesive used, and the degree of adhesion.

Deacidification is a fundamental process for the conservation of paper-based materials. It slows down the acid-catalyzed hydrolysis of cellulose, the main constituent of paper, by neutralizing its acidity and creating an alkaline buffer. Treatments should be limited to the mount (i.e. secondary support) or to the verso of the photograph. There are numerous alkaline substances, whether in their bulk forms or nano forms, that proved to

[77] Ali, M., op. cit.
[78] Lemmen, B., and Lowe, E., 2017. Blocked Photographic Prints: Adhesion and Treatment, *Topics in Photographic Preservation*, 17, pp. 29-50.
[79] Norris, D., 1998. Disaster Recovery: Salvaging Photograph Collections, Conservation Center for Art and Historic Artifacts, pp. 1-6. Retrieved from: https://ccaha.org/sites/default/files/attachments/2018-07/technical-bulletin-salvaging-photographs.original.pdf
[80] Hendriks, K., et al.
[81] Beauchamp, M., Casella, L., Edmondson, T., Escolano, A., Lewis, S., Maloney, A., Watkins, S., 2022. Unmounting, PMG Wiki, the Photographic Materials Group of the American Institute for Conservation. Retrieved from: https://www.conservation-wiki.com/wiki/PMG_Unmounting

be efficient such as calcium hydroxide in distilled water or alcohol and dispersions of calcium hydroxide nanoparticles [80, 82].

The original flat state of curled photographic prints can be restored by introducing controlled moisture through humidification, followed by careful flattening [83]. Humidification also reduces planar distortions and unfolds creased corners [84]. Given that photographic materials include very sensitive components (e.g., support, binder, inscriptions, signatures, etc.), one must take into consideration: the sensitivity of these components to moisture and pressure; the general condition of the photographs to be treated; and the ability to carry out humidification and flattening procedures given available equipment, space, and expertise [85]. Minimal moisture should be introduced to the photographs as photographs are very hygroscopic. Albumen and silver gelatin prints may be humidified. However, in the case of albumen prints, humidification can create fissures in the surface of the print. Therefore, it is greatly recommended to perform less interventive treatments. It is not recommended to humidify collodion prints since it may destroy the image [86]

Tear mending and compensating for losses is used to strengthen the object, but also to enhance its aesthetic appearance. The success of this procedure relies on selecting proper materials. Tissue paper and Japanese paper have great mechanical properties (i.e. strong and flexible); and the latter comes in a variety of thicknesses and colors. To reduce the cost, one can always use watercolors to produce the required tone. Klucel G, funori, and wheat starch paste are among the most used adhesives [87, 88, 89].

[82] Giorgi, R. & Dei, L., Ceccato, M., Schettino, C. and Baglioni, P., 2002. Nanotechnologies for Conservation of Cultural Heritage: Paper and Canvas Deacidification, *Langmuir*, 22.

[83] National Park Service, op. cit.

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[86] Crowley, N., op. cit.

[87] Northeast Document Conservation Center (NEDCC), 2012. Conservation Procedures: Repairing Paper Artifacts, Preservation Leaflets. Retrieved from:

Retouching, also known as inpainting, is perform to restore visual unity to a damaged photographic image. However, before application, one must take into consideration: the type of photograph; the sensitivity of its components; the intended use; the policy of the institution; the photographer's intent; and the suitability and reversibility of the treatment [90]. Retouching should be carried out by a skilled conservator and only when necessary for display purposes. If the photographs are to be kept in storage; then, there is no need to perform such procedure [91].

While housing photographs may seem simple, it is in fact very problematic since photographic materials exist in large numbers; and therefore, require an immense amount of housing materials; materials of specific qualities. Then, there is the economic issue. The authors turned to the local market for purchasing paper and plastic materials that are suitable for use and made the enclosures themselves. This measure greatly helped reduce the expenses. Different types of photographic materials should be stored separately to avoid physical and chemical damage [92]. Plastic enclosures should not be used to store cellulose acetate negatives [93].

Digitization of historical photographs makes photographs accessible and reduces the handling of the originals. However, it needs to be carried out with considerable planning

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[88] Hollander, L., 1997. Restoration of Losses in Old Master Prints and Drawings using the Historic Techniques of European Conservators, *The Book and Paper Group Annual*, 16

[89] Albright, G., Brown, H., Edmondson, T., Maloney, A., Panadero, L., and Watkins, S., 2009. Mending, Repair, and Filling, PMG Wiki, the Photographic Materials Group of the American Institute for Conservation. Retrieved from: https://www.conservation-wiki.com/wiki/PMG_Mending,_Repair,_and_Filling

[90] Albright, G., Andrews, T., Brown, B., Brown, H., Derby, D., Harnly, M., Hill, G., Hoffman, A., Hunter, M., Kennedy, N., Lee, M., Lemmen, B., Luke, J., Maxson, H., McCabe, C., McElhone, J., Messier, P., Orraca, J., Pinney, Z., Reinhold, N., Schenck, K., Turchan, C., and Wagner, S., 2014. PMG Wiki, the Photographic Materials Group of the American Institute for Conservation. Retrieved from: https://www.conservation-wiki.com/wiki/PMG_Inpainting

[91] Norris, D., Jürgens, M., Kennedy, N., Lavédrine, B., and Messier, P., 2012. From Russia to Laos: Building Global Partnerships to Preserve Photographic Heritage, The GCI Newsletter, 27(1), p. 6.

[92] Clark, S., 2021. Preservation of Photographic Material, British Library Board.

[93] Roosa, M., op. cit.

and care to ensure that the photographs are not damaged during the process. Digitization should not be considered as a cheap alternative to the preservation of the originals [92].

For long-term preservation, the ideal relative humidity for a collection containing different types of historical photographs (i.e., prints, slides, and negatives) is between 30% and 50% without cycling more than 5% a day. As for cellulose acetate negatives, the American National Standards Institute (ANSI) specifications recommend maintaining a relative humidity between 20-30%. Similarly, glass negatives should be stored at 30-35% RH to minimize glass decomposition. Temperature should be kept as low as possible. For black-and-white negatives, it should not exceed 18 - 20°C. Daily fluctuations greater than 5° should be avoided. Color photographs and cellulose acetate negatives should be kept in cool storage (i.e., 10 - 16°C), or in cold storage (i.e., 2 - 8°C). Light levels in display areas should be in the range of 30- 100 LUX, and ultraviolet radiation levels should not exceed 75 microwatts per lumen. Air entering the storage area should be filtered and purified to remove gaseous and particulate matter [93]. Good housekeeping and periodic inspection are crucial measures for avoiding, or limiting future damage; thus, prolonging the lifespan of photographic materials.

In brief, the role of photograph conservators involves examination, conservation and preservation of photographs following ethical guidelines, such as: minimal intervention; the use of proper and reversible materials and methods; testing prior to treatment to determine that it is efficient and safe; and full documentation of all work undertaken [94].

4. Conclusion

Remedial conservation involves extremely aggressive treatments such as aqueous and solvent treatments, mount dismantlement, separating photographs form adjacent surfaces (e.g. other photographs or glass), deacidification, etc. Overtime, these may have carried out by a professional. Accordingly, such treatments should be avoided or at least kept to a minimum whenever possible. Preventive conservation is the current global approach since it does not pose any serious risks to photo collections and it prolongs their lifespan by slowing down the deterioration rates. Finally, each case must be handled as a unique case requiring special conservation needs.

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Acknowledgements

The authors would like to thank the reviewers for their constructive comments and valuable suggestions which helped improve the quality of this research paper. They would also like to express their gratitude to Francis Amin for providing us with the photo collection used in this study.

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